

STUDIES ON THE ECOLOGY AND SYSTEMATICS OF THE DIATOMS
(BACILLARIOPHYTA) FROM SOME SOUTH AFRICAN RIVERS.

by

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the degree of Master of Science in the Faculty of Science of
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SUMMARY.

This report contains the results of some ecological and systematic studies on the diatoms from the Vaal Dam catchment area in the Transvaal, and the Bloukrans River in the Eastern Cape Province.

In Part 1 the effects of high concentrations of nitrogen were studied in relation to the composition of the diatom associations. Water samples from four stations on the Bloukrans River were analysed chemically at certain intervals during the months of April and August 1967. Diatom samples collected from these stations at the beginning and end of each of these sampling periods were subjected to a "Thomasson Analysis" to determine the relative densities of the various species in the diatom associations. A statistical analysis of the results reflected a poor but positive correlation between the two variables, i.e. high numbers of nitrogen heterotrophic Nitzschiae were correlated with high concentrations of nitrogen, while low numbers were correlated with low concentrations.

Part 2 presents the results of the ecological studies on the diatom associations of the Vaal Dam Catchment Area. In this section the diatom associations from each sampling point or station were subjected to a "Thomasson Analysis" to determine the relative densities of the different species in the associations. Employing already known correlations between environment and association, the results of this analysis were discussed and the ecological conditions for each sampling station were assessed. The associations were similar in composition over the entire catchment area, and indicated on the whole water of good quality. Points of pollution were detected, but were generally localised and the effects of the pollution were soon removed. Only the Waterval River showed evidence of more constant pollution. The associations provided

evidence for some seasonal variation in their composition.

Finally in Part 3 the systematics and taxonomy of the diatoms in the Vaal Dam catchment area are discussed. References are made to the original and more recent descriptions of each species found in this study, and a list of synonyms is given wherever possible. Comments on the systematics, taxonomy and autecology of each species are given, and the distribution of the species in South Africa and the Vaal Dam catchment area is discussed. A number of species, varieties and forms have been recorded for the first time in South Africa. During the course of this study 20 species have been described as new to science; the descriptions of some have been published, while the descriptions of the others will be published formally in the future. All species described as new or having interesting features are illustrated in the plates.

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INTRODUCTION.

In October 1955 the "Special Sub-Committee on Stream Surveys in the Witwatersrand Area" (Malan 1960) recommended that hydro-biological surveys, at that time conducted on the Vaal River below the Vaal Dam, should be extended to the catchment area of the Vaal Dam.

Consequently Malan (1960) made a survey of the chemical composition of the main tributaries of the Vaal River, while Chutter (1967) studied the ecology of the faunal component of the rivers in the catchment area. On joining the National Institute for Water Research, the author was presented with a collection of diatom material from the catchment area made by Dr. Chutter and Dr. B.J. Cholnoky. This diatom material was analysed and investigated, and the results of this study completed the hydrobiological investigations of the Vaal Dam Catchment Area.

The objects of the diatom investigations were to establish the nature of the associations living in the catchment area, and, since the associations are the resultant of the environmental conditions, to assess the prevailing ecological conditions in the Vaal Dam catchment area. Changes in the environment due to the effects of changing industrial and agricultural processes could therefore be detected. To accomplish this aim a knowledge of the systematics of the diatoms is required, and the second object of this study was to gain some experience in the systematics and taxonomy of the diatoms.

Permission was granted by the National Institute for Water Research to submit the results of this study as a thesis for the degree of Master of Science at Rhodes University. However to fulfil the requirements for the degree, an ecological study of the Bloukrans River was undertaken. The object of this project was to determine whether water

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composition, in particular the concentration of nitrogen, influenced the diatom associations, i.e. whether specific associations developed under high concentrations of nitrogen.

As a result of this, the report on these diatom studies has been divided into three parts:-

Part 1. - The ecological studies of the diatoms in the Bloukrans River.

Part 2. - The ecological investigations of the diatoms in the Vaal Dam catchment area.

Part 3. - The systematics and taxonomy of the diatom species present in the diatom associations found in the rivers of the Vaal Dam catchment area.

(3).

PART 1.

The Ecological Study of the Bloukrans River.

A. INTRODUCTION.

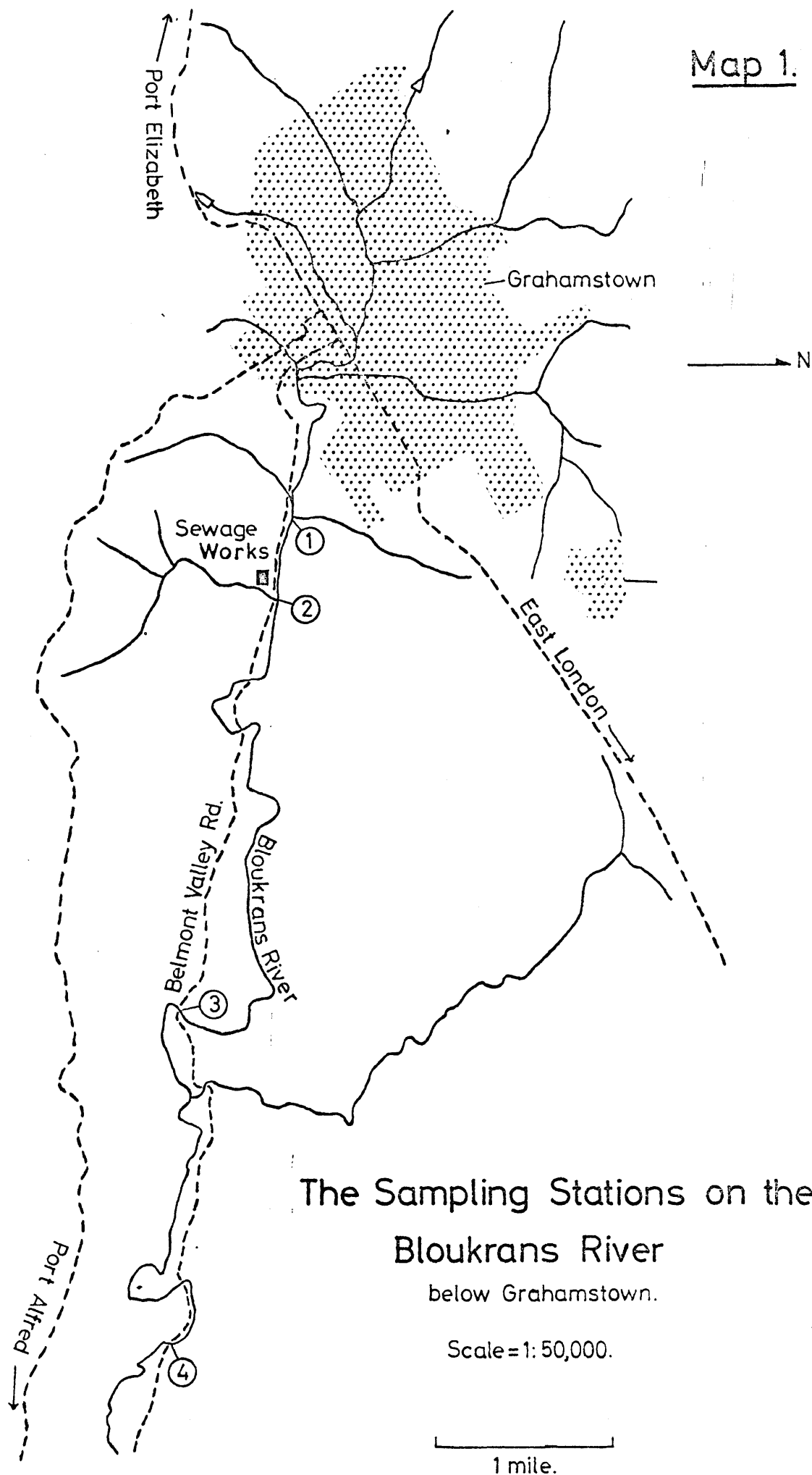
In present times the problem of water pollution is receiving great attention in South Africa. The detection of pollution is therefore of great importance in the protection of our limited water supplies. The reliability of chemical analyses for the detection of pollution has been questioned (Butcher 1946), and biological criteria of stream conditions have been proposed as direct evidence of pollution (Butcher l.c.; Patrick 1950). In this respect the diatoms are a very important group of algae, since not only are they cosmopolitan in their distribution, but they also often form the greater part of the algal component both in number and volume.

It is well known that certain algae can utilise organic nitrogenous compounds as a source of nitrogen, and, furthermore, in some cases as their only source of nitrogen (Fogg 1953: 81). Certain species of the genus Nitzschia have been found to play an important role in water purification, and are regarded as nitrogen heterotrophic. According to Cholnoky the genus Nitzschia, with the exception of the following groups, Tryblionellae, Grunowiae, Sigmoidae, Obtusae (Cholnoky 1960B: 278) and the Scapulae (Cholnoky: personal communication), are nitrogen heterotrophic. On further exception to this is Nitzschia linearis W. Smith. It follows from this that in waters containing high concentrations of organic nitrogenous compounds, these nitrogen heterotrophic Nitzschiae will thrive and will be found in very high numbers. The results of Cholnoky's investigation on the Bon Accord Dam near Pretoria (Cholnoky 1953B) appear to support this conclusion. This dam receives the effluent from the Pretoria sewage works via the Apies River, and Cholnoky found that, in nearly all the samples from the dam, the diatom associations consisted mainly of nitrogen

heterotrophic Nitzschiae. Nitzschia palea (Kützing) W. Smith, and N. thermalis (Ehrenberg) Auerswald which deaminates organic nitrogen (Saubert 1957: 338), were in most cases the dominant diatom species of the associations; Gomphonema parvulum (Kützing) Grunow being dominant in the other samples. These three species were regarded by Cholnoky as indicative of organic nitrogen pollution. He thus concluded that the Bon Accorde Dam was a highly polluted water, and in certain places it occasionally suffered oxygen depletion (N.thermalis dominant in the associations). Similar diatom associations, indicating polluted conditions, have been found in the Jukskei River (Cholnoky 1958A), and from the Zwartkops River near Port Elizabeth (Cholnoky 1960B: 281). Furthermore in America N. palea was regarded by Patrick (1950: 933) as a qualitative indicator of organic pollution due to sanitary wastes, while in England Butcher (1946: 93; 1947: 187) found that N.palea and G.parvulum were the dominant organisms in the mesosaprobic zones of the Tame, Trent and Churnet Rivers. It should, however, be emphasised that, while individual species are important as indicators, the whole assemblage of species in the associations must be studied in assessing the quality of the water.

With this background in mind an experiment was designed to test the general hypothesis that high numbers of nitrogen heterotrophic Nitzschiae are associated with high concentrations of nitrogenous material. Consequently the Bloukrans River, which is thought to be polluted, was chosen as the experimental stream. The Bloukrans River (Map 1) drains the entire city of Grahamstown, and this includes the African and Coloured locations. The Municipal Sewage Dispersal Works, which lies just outside the city, discharges its final effluent in the stream about 1 mile below the town.

Map 1.



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Four sampling points were chosen below the city along the course of the river.

Station 1:- This was situated about $\frac{1}{4}$ mile above the effluent outfall (Map 1). It was a relatively deep, long and fairly wide pool with a sludge bottom. The banks supported a rich growth of Pennisetum clandestinum Hochst. ex Chiov., which extended to below the water level. The water flowed relatively slowly through this pool, except after rain. On one or two occasions in both April and August the pool had a bad odour, and at the beginning of August the water had turned black in colour, with a black floc clinging to the marginal vegetation. Samples were collected from the margin of the pool.

Station 2:- This station was located at the outfall of the Sewage Works effluent. At this point the river formed a fairly deep, narrow pool about 3 ft. long formed by the scouring effect of the effluent. The stream had a relatively strong flow as a result of the confluence of the river and the effluent. Water samples were collected in the current from this deep pool; the diatom samples were collected from the muddy verges about 5 - 6 ft. downstream. Very often this station was covered by a large blanket of detergent foam, which had to be removed before sampling.

Station 3:- Station 3 was cited on the farm Belmont, where the Belmont Valley road crosses the Bloukrans road. The samples were collected from the lower end of a long, relatively deep pool and directly below the railway

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bridge. Water samples were collected in the slowly flowing water, and the diatom samples from the muddy layer covering the stony bottom. The pool was well shaded by marginal bush.

Station 4:- This station was situated on the farm Varnum where the Belmont Valley road crosses the Bloukrans River. Water samples were collected from the relatively quickly flowing water in a pool immediately below the concrete pipes under the road. The strong flow prevented the formation of a muddy bottom, and diatom samples were therefore collected from the muddy banks about 6 ft. downstream.

These stations were sampled regularly for chemical analysis of the water in April and August, 1967, corresponding to autumn and late winter respectively. The diatoms were sampled twice at each station in autumn and late winter.

B. METHODS AND TECHNIQUES.

1). Collection and Preparation of the Samples.

The effect of storage of water samples for chemical analysis at room temperature is well known (Hellwig 1964: 215). In order to avoid the problem the sampling stations were selected so that a period of not longer than 45 minutes elapsed between collection of the samples and the start of their analysis. Further all the analyses were completed on the day of collection. To obviate the effects of diurnal variation on the chemical constitution of the water, the stations were sampled in the same sequence at approximately the same time of the day. The sampling sequence began with Station 4 and proceeded upstream to Station 1.

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Samples for chemical analysis were collected at intervals of between two and six days, so that eight samples were obtained during each of the months of April and August 1967. With the exception of Station 1, all the water samples were collected as near as possible from the flowing water in the middle of the stream; at Station 1 the samples were collected from the margin of the pool. Sampling commenced at 8.00 a.m. and the same procedure was followed at each station. First a measurement of the water temperature was made. This was followed by the measurement of the pH value, and the collection of water samples for dissolved oxygen determinations and further chemical analysis. On reaching the laboratory the water samples were filtered under vacuum through two thicknesses of Whatman's No. 1 filter paper in the Buchner Funnel, and the analysis of the samples was commenced immediately.

2). Methods.

(a) Physical Measurements.

Water temperatures were measured in the flowing water with a mercury thermometer graduated from -10° to 110°C made by Baird and Tatlock.

pH measurements were recorded using a portable Metrohm Battery pH Meter, model E 280A, which has a measuring range of pH 0 - 14. The measurements were made by immersing the glass electrode directly in the flowing stream water.

(b) Chemical Analyses.

Unless stated otherwise the analytical procedures followed in this study were those described in "Standard Methods for the Examination of Water, Sewage and Industrial Wastes" (American Public Health Association 1955).

The dissolved oxygen content of the water was measured using the unmodified Winkler Method. The principle used in this procedure

is the oxidation of manganous hydroxide in a highly alkaline solution. When this is acidified in the presence of iodide, free iodine is liberated with the solution of manganic hydroxide. The iodine is liberated in a quantity equivalent to the oxygen dissolved in the sample. This free iodine is titrated with a standard sodium thiosulphate solution, using starch as an indicator for the final determination of the end point of the titration. The sample was collected in a 250 - 300 ml. ground glass stoppered flask, and 2 ml. manganous sulphate was added to the sample in the field. On return to the laboratory 2 ml. alkaline iodide was added, and the subsequent acidification with 2 ml. of concentrated sulphuric acid and titration was carried out about two hours later. Care must be taken to keep the flask tightly stoppered, with the exclusion of all air bubbles, until the sample is needed for titration.

Determinations of the ammonium nitrogen and organic nitrogen can be discussed together as they form part of the same process. A 300 ml. aliquot was distilled in the presence of a phosphate buffer, which maintained the pH slightly above neutral (pH 7.4). The ammonia was collected in 50 mls. boric acid solution, and distillation continued until about 200 mls. had been collected. Sufficient concentrated sulphuric acid was added to the ammonia free fraction of the water sample, remaining after the ammonia distillation, to digest the organic nitrogen, using copper sulphate as a catalyst to raise the boiling point of the sulphuric acid. In this digestion process, which continues until the mixture is colourless or a pale straw colour, ammonium bisulphate is formed by conversion from the amino-nitrogen of the organic materials in the presence of sulphuric acid and the copper sulphate catalyst. The ammonium nitrogen thus obtained is distilled into 50 ml. boric acid solution until 200 mls. had been collected. The boric acid

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solutions from both the ammonia distillation and the organic nitrogen digestion were then titrated with a 0.02N. sulphuric acid solution, using a screened bromocresol green - methyl orange indicator.

Nitrites were determined by the Diazotisation Method, in which diazotised sulphanilic acid coupled with 1 naphthylamine produces a reddish-purple azo dye at pH 2.0 - 2.5. A 1 ml. aliquot, diluted to 50 mls., was treated with 1 ml. sulphanilic acid, 1 ml. 1 naphthylamine hydrochloride and 1 ml. of sodium acetate buffer solution. Between 10 and 30 minutes after addition of the 1 naphthylamine hydrochloride the optical density of the reddish-purple colour was determined at 520 $m\mu$ on a Beckman DB Spectrophotometer. This instrument was used in all other determinations requiring colorimetric measurements.

The Phenoldisulphonic Acid Method was used for measuring the concentration of nitrate in the water. In this method the basic reaction between nitrate and 1, 2, 4- phenoldisulphonic acid produces 6- nitro- 1,2,4- phenoldisulphonic acid. This acid produces a yellow alkaline salt. The optical density of this yellow colour was measured at 410 $m\mu$ to determine the concentration of nitrate. An aliquot of either 5 or 1 ml. was used depending on the concentration of nitrate in the sample. In this method small concentrations of chloride cause interference in the reaction, and must therefore be determined and reduced to a minimum in the sample to be tested. Having determined the chloride concentration, sufficient silver sulphate was added to precipitate the chlorides as silver chloride.

Values for the total nitrogen concentrations were obtained by the addition of the ammonia, organic, nitrite and nitrate fractions.

Chlorides were determined by the method developed by R.J. Best and described by Piper (1950: 40). When a solution of chloride is

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titrated with silver nitrate, silver chloride is precipitated. At the endpoint of this titration, the chloride ion concentration is very small being about 1.0×10^{-5} , and the potential of a silver - silver chloride electrode in this solution is -0.521 volts. A quinhydrone half cell made from a buffer solution of pH 3.03 produces a potential equal and opposite to the silver - silver chloride electrode, i.e. + 0.521 volts. Therefore at the endpoint of the titration a galvanometer measuring the potential difference between the half cell and the electrode, connected by an agar - potassium nitrate bridge, would read zero. On this principle a 50 ml. aliquot of the sample was titrated with a 0.0141N silver nitrate solution (1 ml. = 0.500 mg. Cl).

The procedure used in the determination of the phosphate content is a modification of the sensitive molybdenum blue colorimetric method (Steyn 1958: 21). The method is based on the intense blue colour formed when a reducing agent, stannous chloride, is added to a phosphomolybdate complex. This colour is not very stable and all colorimetric measurements must be made after exactly the same time interval, i.e. 15 minutes. Maximum absorption by the blue complex is found to occur at 700 m μ . In these analyses a 10 ml. aliquot, diluted to 45 mls., was treated with a 1.25% ammonium molybdate solution (2 mls.) to form the phosphomolybdate complex. The blue colour was then formed by the addition of 1 ml. stannous chloride solution. The contents of the flask were made up to 50 mls., and the percentage absorption by the blue colour was determined exactly 15 minutes after addition of the stannous chloride.

The concentration of silica was measured colorimetrically using the silicomolybdate method for intermediate concentrations of silica. The principle underlying this method is the formation of a yellow solution of silicomolybdic acid. This is formed when ammonium

molybdate is added to a sample containing silica, when the medium is at approximately pH 1.2. The yellow colour is proportional to the silica present in the sample. Phosphomolybdic acid is also formed in this reaction, but this is destroyed by the addition of oxalic acid to the treated sample. In silica determinations glassware must be used as little as possible to avoid interference due to silica contributed by the glassware. A blank determination should be carried out to correct for this introduced silica. A 25 ml. aliquot, diluted to 50 mls., was required for treatment in these determinations. 1 ml. of a 1+1 solution of hydrochloric acid and 2 ml. ammonium molybdate solution was added to the sample in rapid succession to form the silicomolybdic acid. 1.5. ml. oxalic acid was added to the sample and after 2 minutes, but not longer than 15 minutes after the addition of the oxalic acid, the optical density of the yellow colour was determined on the spectrophotometer at a wave length of 410 mμ.

Calibration curves and standard solutions were prepared once at the beginning of each April and August,

(c). Collection, Preparation and Investigation of the Diatom Samples.

Diatom samples from each locality on the Bloukrans River were collected on the 21st April, 1967; 1st May, 1967; 4th August, 1967; 6th September, 1967. These periods correspond to Autumn and the end of winter in South Africa.

Scrapings of the thin algal film on the stones and mud were placed in a collecting tube, preserved with 1 ml. 40% Formalin, and labelled with the sample serial number. The raw diatom material collected in this manner was cleaned and prepared using the method described by Welsh (1964: 39). The samples, preserved in formalin, were dried over night in an oven at 80°C to drive off the water and formalin. Concentrated sulphuric acid was then added to the dried material, and this reduced all the organic matter in the sample.

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The residue from this was bleached by the addition of concentrated nitric acid and boiling the mixture on a hot plate until it had turned a pale white or cream colour. The diatom residue was then centrifuged off and washed twice with distilled water to remove the acid by centrifuging at 3000 r.p.m. for 10 minutes for each washing. The fine white residue was then resuspended in distilled water, stored and used for making the slides.

Permanent slides from this material were made in the following manner:-

The diatom material was diluted to a pale milky white suspension, and enough material was placed on a clean, polished coverslip to extend over the whole area of the coverslip. This was left to dry over night at room temperature: more rapid drying causes the material to dry in concentric rings. When dry the coverslip was inverted on to a drop of Hyrax mounting medium (R.I. 1.65) on a slide. The solvent of the hyrax was driven off by placing the slide on a hot plate until the bubbling ceased. The coverslip was then centred on the slide, and the mounting medium allowed to dry. When dry the excess hyrax was chipped away, and the slide finally cleaned and polished. The completed permanent slide was then labelled on the left hand side with the serial number of the sample, the collector's name and the date of collection of the sample. The information recorded on the right hand side of the slide contained the name of the mounting medium and the date of preparation of the slide.

The investigation of the slide consisted of two phases,
(a) drawing up a list of species present in the sample, and
(b) calculating the relative density of each species. The relative density was calculated by using the so-called "Thomasson Analysis" (Thomasson 1925), which was modified by Cholnoky (1955: 84)

(14).

to eliminate some of its difficulties. Using this method between 350 and 500 individuals were counted by traversing the slide, ensuring that each individual was only recorded once. The relative density of each species observed in this analysis was then calculated as a percentage of the total number of individuals counted according to the following formula (Curtis and McIntosh 1950: 437):-

$$\text{Relative Density of Species A} = \frac{\text{No. of individuals of species A.}}{\text{Total no. of individuals of all species.}} \times 100.$$

C. RESULTS.

A summary of the chemical analyses of the Bloukrans River for the months of April and August are shown in Tables 1 and 2 respectively. The average values for the month and the range of variation occurring at each sampling station is given for each factor. The averages are also illustrated by means of histograms in Graph 1.

1). Nitrogen.

Higher concentrations of Total Nitrogen occurred at all stations in August than in April, while the greatest increases in concentration were observed at Station 3 and 4. The higher values in August resulted from proportionately much larger increases in the nitrite and nitrate fractions (see Graph 1A). The average increase in the nitrite values was about 7.6 times the April value, and for nitrate 2.6 times the April value. In contrast the concentrations of the ammonia and

TABLE 1. - THE CHEMICAL ANALYSIS OF THE BLOUKRANS RIVER FOR APRIL.

April.

Chemical Compound	Station No.											
	1			2			3			4		
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Total Nitrogen	41.65	9.89	21.67	44.55	18.05	31.27	16.99	9.33	13.06	9.45	5.77	7.01
Ammonia N.	33.14	2.61	13.51	29.18	10.31	19.52	7.56	0.00	3.89	2.24	0.0	0.45
Organic N.	7.00	3.27	4.50	8.07	3.78	5.63	5.27	2.89	3.98	4.02	2.43	3.07
Nitrite N.	1.55	0.04	0.47	2.13	0.49	0.99	0.49	0.08	0.28	0.39	0.02	0.13
Nitrate N.	8.22	1.20	3.20	7.90	2.96	5.13	7.94	2.10	4.92	4.86	2.20	3.54
Chlorides	436.6	95.3	250.25	274.8	83.90	173.66	183.9	65.06	129.01	143.00	59.65	93.36
Phosphates	0.18	0.004	0.06	0.71	0.05	0.25	0.18	0.00	0.09	0.06	0.00	0.03
Silica	5.52	2.65	4.07	5.12	3.48	4.41	5.05	2.40	4.37	4.30	2.40	3.49
D.O. % Saturation	71.55	23.32	(6) 50.17	91.16	71.03	(6) 77.38	77.38	54.06	(6) 62.72	84.80	76.32	(6) 81.44
pH	7.60	6.15	(6) 7.26	7.45	6.10	(6) 7.13	7.45	6.30	(6) 7.03	7.31	6.80	(6) 7.10
Temperature	18.00	13.00	(6) 15.50	18.40	14.20	(6) 16.03	18.0	14.0	(6) 15.83	18.0	13.6	(6) 15.76

N.B. 1). All concentrations are expressed in parts per million (ppm.).

2). Except where indicated by the number in brackets, the average value is the mean of 8 samples.

TABLE 2. - THE CHEMICAL ANALYSIS OF THE BLOUKRANS RIVER FOR AUGUST.

August.

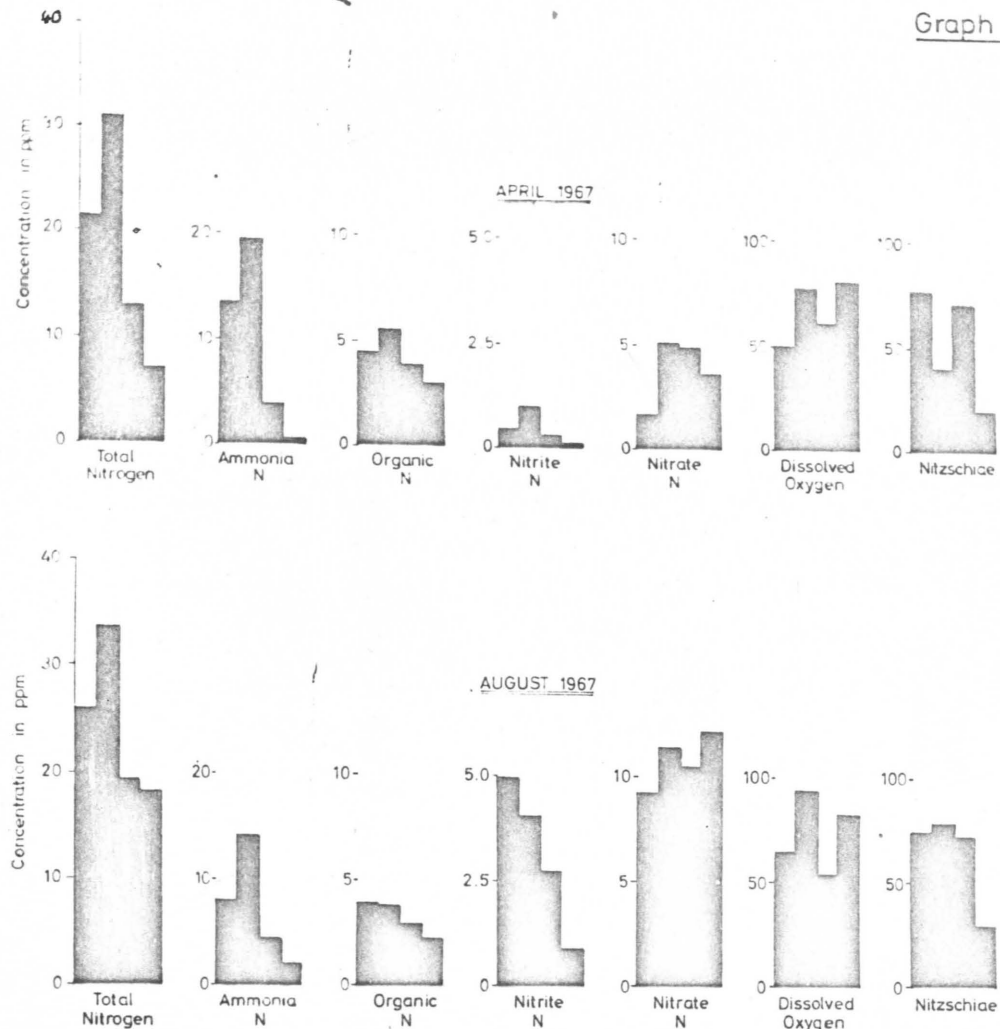
Chemical Compound	Station no.											
	1			2			3					
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Total Nitrogen	56.32	14.78	(7) 25.97	52.26	27.16	(7) 33.40	22.72	12.67	(6) 19.13	25.73	12.67	(7) 18.03
Ammonia N.	31.60	2.38	(7) 7.92	32.00	8.40	(7) 14.01	12.50	0.37	(7) 4.19	4.20	0.00	(7) 1.95
Organic N.	11.34	1.40	(7) 3.84	8.20	2.05	(7) 3.80	6.58	1.45	(7) 2.91	4.62	1.59	(7) 2.20
Nitrite N.	6.04	3.07	4.92	5.12	3.11	4.08	3.60	1.53	2.73	2.51	0.05	0.83
Nitrate N.	12.00	6.20	9.14	13.40	8.95	11.43	12.70	6.30	10.47	16.40	5.60	12.03
Chlorides	502.0	329.6	460.5	390.1	289.1	322.9	329.6	162.3	282.40	324.5	212.9	291.3
Phosphates	0.12	0.00	0.04	0.25	0.00	0.15	0.20	0.03	0.11	0.15	0.03	0.09
Silica	6.65	3.97	4.96	6.50	4.91	5.55	5.36	3.83	4.59	4.90	3.23	4.20
D.O. % Saturation	76.85	37.10	64.41	118.70	71.03	92.67	66.77	41.34	52.93	94.34	68.37	82.04
pH	7.80	7.58	7.66	7.93	7.50	7.70	7.45	7.21	7.37	7.74	7.49	7.60
Temperature	12.30	7.20	9.95	13.40	9.00	10.86	12.30	8.30	9.39	11.70	8.50	9.96

N.B. 1). All concentrations are expressed in parts per million (ppm.).

2). Except where indicated by the number in brackets, the average value is the mean of 8 samples.

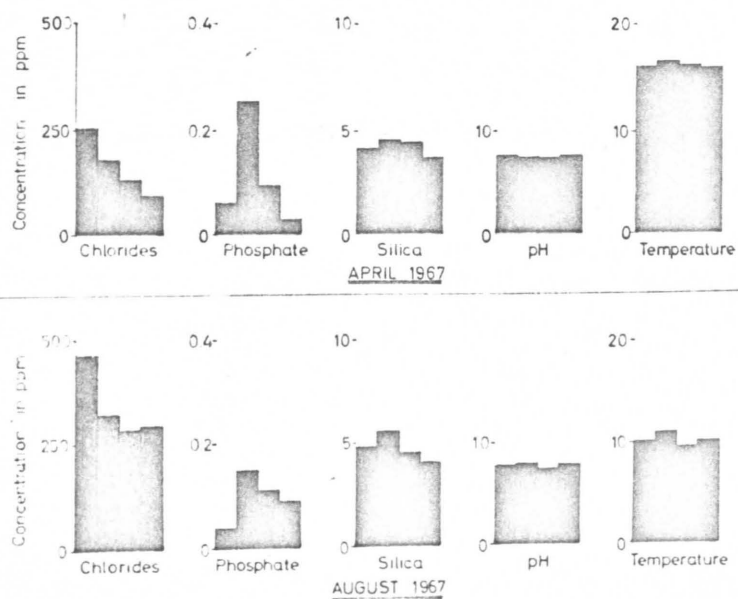
A

Graph 1.



The Monthly Averages of the Chemical and Diatom Analysis of the Bloukrans River.

B.



The Monthly Averages of the Chemical Analysis of the Bloukrans River.

organic nitrogen fractions showed slight decreases in the August values. The highest concentrations of the different nitrogen forms were almost always found at Station 2, while the lowest values generally occurred at Station 4.

The samples of the 11th April, 1967 are interesting since they were collected after more than 1 in. of rain had fallen in the previous two days. The chemical analysis revealed a flushing out of the higher stations (the minimum values for Total Nitrogen recorded at Stations 1 and 2 were measured on this date) and the subsequent increase in concentration of Total Nitrogen lower down the river at Station 4, where its greatest value (9.45 ppm) was recorded at this time.

On 3rd August, Station 1 had a foul odour, and the water was black in colour. Chemical analysis showed that the maximum values for Total Nitrogen (56.32 ppm.), ammonium nitrogen (31.60 ppm.) and organic nitrogen (11.34 ppm) observed at this station, were measured on this particular day. The high concentrations of nitrogen at Station 1 appeared to have affected the whole river, since at each station the August maxima for the nitrogen compounds named above were measured at this time.

2). Chlorides.

In April the chlorides showed an almost linear decrease in concentration with distance downstream. This trend was not apparent in August, when the concentrations were double the April values, the greatest increases occurring at Station 3 and 4. The highest values in August occurred at Station 1, while lower values of about equal magnitude were found at Stations 2, 3, and 4.

3). Phosphate and Silica.

The concentrations of phosphate and silica exhibited no great change between April and August. In most cases the highest values occurred at Station 2. The lowest phosphate concentrations recorded

(16).

in April were found at Station 4, while in August Station 1 had the lowest phosphate value. In both April and August the silica concentrations were lowest at Station 1.

4). Dissolved oxygen.

The dissolved oxygen concentration presented a picture rather different from the expected. Low saturation values were measured at Stations 1 and 3, and a high values at Stations 2 and 4. Although it would be expected to have a low oxygen concentration on account of the large concentrations of nitrogen, Station 2 produced the highest values of oxygen saturation (ave. value 92.76% saturation). This high saturation resulted from good aeration of the effluent due to turbulence as it flows swiftly down a narrow channel.

5). pH and Temperature.

The pH values did not vary significantly from station to station. The average value for April was about pH 7.1, and the average for August was about pH 7.6. Water temperatures in April ranged between 15.50 and 16.03°C, and in August between 9.39 and 10.86°C. At Station 2 the temperature readings were always slightly higher than at other stations.

Table 3 shows the average values obtained by the Grahamstown Municipality for the chemical analysis of the water from the Bloukrans River just above the sewage effluent outfall, and of the final effluent from the Sewage Works. The averages were calculated from a monthly analysis over a 23 month period, from January 1966 to November 1967. No figures were available for December, 1967. The detailed results of this analysis are shown graphically in Graph 2. It can be seen from these graphs that the chloride concentration in the Bloukrans River was high (ave. 350 ppm) and was extremely variable, following the fluctuations of the Total Dissolved Solids concentration. The

Table 3.

Chemical Analysis from the Grahamstown Sewage Dispersal Works.

Samples taken monthly over a 23 month period (Jan. 1966 - Nov. 1967).

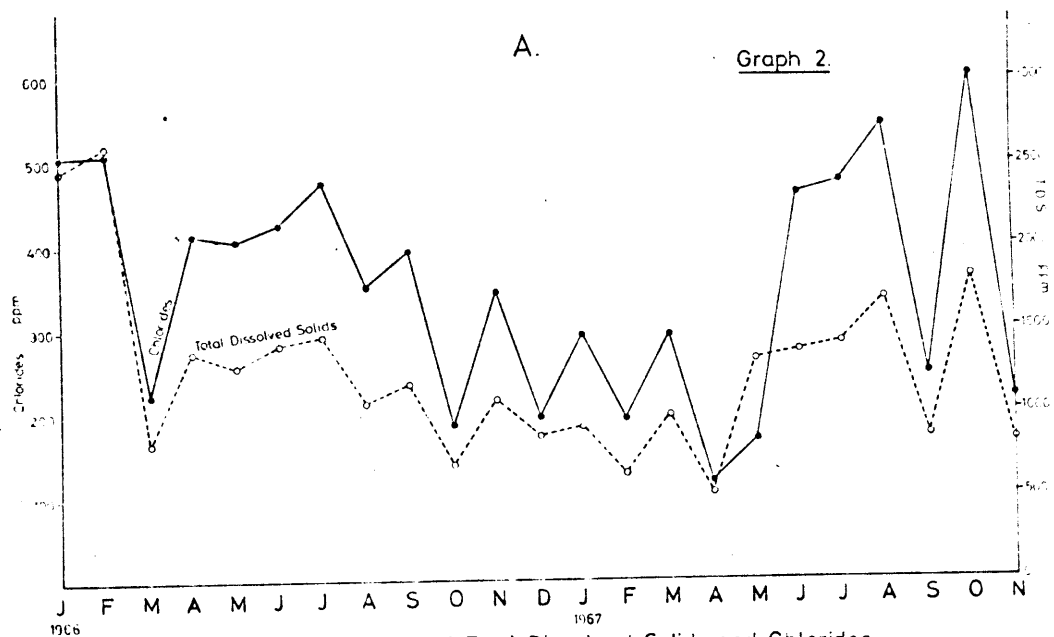
1). The Bloukrans River just above the Sewage Works Effluent Outfall.

	Max.	Min.	Ave.
Total Solids	2578	520	1250
Total Dissolved Solids	2574	505	1242
Suspended Solids	41	1	8
Chlorides	601	116	350
pH	9.1	7.2	7.9

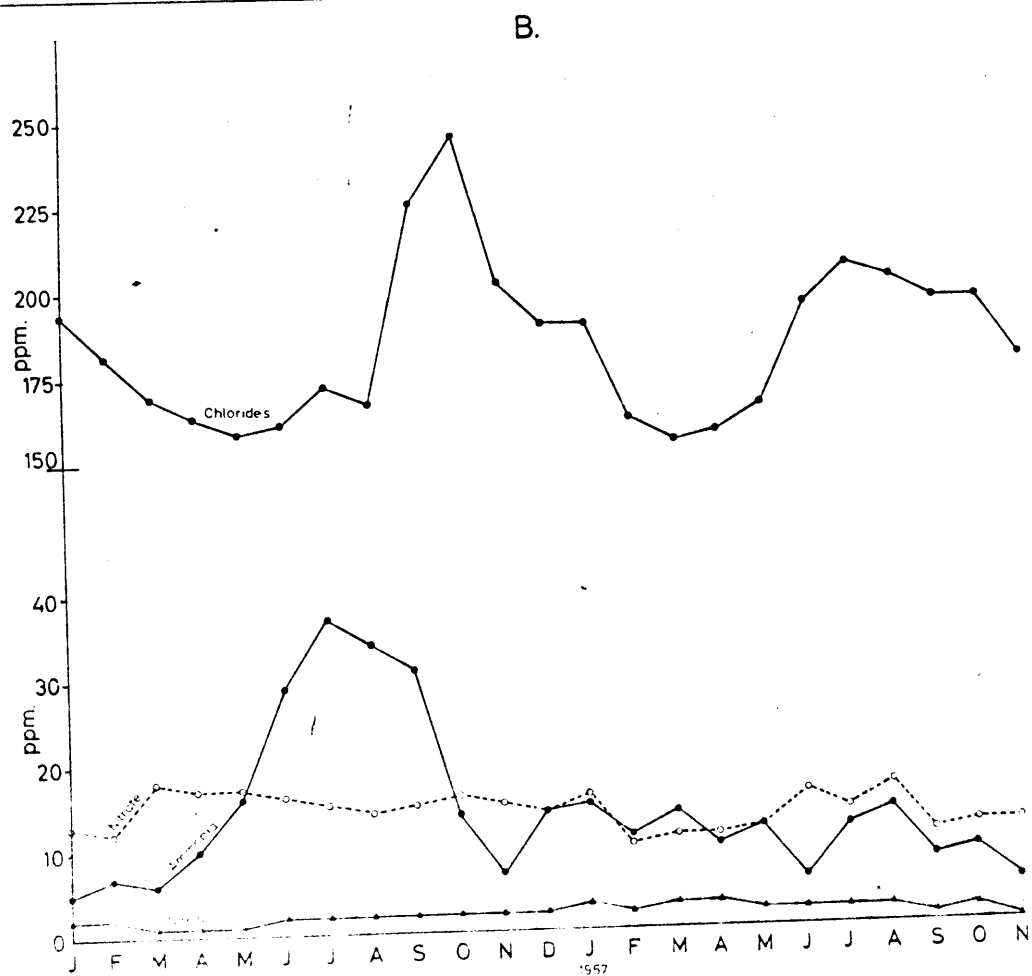
2). The Final Effluent of the Sewage Dispersal Works.

	Max.	Min.	Ave.
Free and Saline Ammonia	37	5	14.2
Nitrite N.	3	0.2	1.88
Nitrate N.	18	10	14.1
Chlorides	245	155	184.1
pH	10.1	3.1	7.07

N.B. All concentrations are expressed as parts per million (ppm.).



The Concentrations of Total Dissolved Solids and Chlorides
in the Bloukrans River just above the Sewage Outfall.



Detailed Results of the Chemical Analysis of the
Final Effluent of the Grahamstown Sewage Works.

chloride concentrations showed the same order of magnitude as those found in August at Station 2 in this study. The concentration of the nitrogen compounds in the final effluents were comparable to those found in the river water at Station 2 of this investigation.

6). Diatom Analysis.

The results of the Thomasson Analysis of the diatom samples are reflected in Tables 4 and 5. The tables show that generally the diatom associations collected at Stations 1, 2 and 3 in both April and August, consisted mainly of nitrogen heterotrophic Nitzschiae. The average relative densities of this group of Nitzschia species for Stations 1, 2 and 3 in April were 75.2%, 39.2% and 70.9% respectively, and in August 73.6%, 77.9% and 71.1% respectively. In contrast the numbers of nitrogen heterotrophic Nitzschiae at Station 4 were much lower (14.8% in April, 28.5% in August). The relationship between the nitrogen concentration and the relative density of the nitrogen heterotrophic Nitzschiae has been illustrated in histogram form in Graph 1A. The relative densities of the nitrogen heterotrophic Nitzschiae at Stations 1 and 3 maintained the same level in both April and August. At Station 4 the numbers of nitrogen heterotrophic Nitzschiae had doubled in August. No proper comparison can be made at Station 2, as only one analysis was made in April. Nevertheless the figures appear to indicate an increase in the nitrogen heterotrophic Nitzschiae in August. No Thomasson Analysis was made on the sample collected at Station 2 on the 1st May, 1967 because there were too few diatoms. In most of these associations Nitzschia palea (Kützinger) W. Smith and N. thermalis (Ehrenberg) Auerswald were the dominant species.

7). Scatter Plots.

The validity of the hypothesis under examination was tested by the use of scatter plots, indicating the degree and nature of

Table 4.

Analysis of the Diatom Associations collected on 21st April, and 1st May, 1967.

	1		2		3		4	
	21.4.67	1.5.67	21.4.67	1.5.67	21.4.67	1.5.67	21.4.67	1.5.67
<i>Achnanthes lanceolata</i> (Brebisson) Grunow.					1.2			
<i>Achnanthes lanceolata</i> var. <i>rostrata</i> Östrup						0.2	2.1	0.9
<i>Achnanthes pseudohungarica</i> Cholnoky-Pfannkuche			3.8		3.5		4.8	0.9
<i>Amphora veneta</i> Kützting							2.4	
<i>Cocconeis</i> (a).							3.1	0.2
<i>Gomphonema parvulum</i> (Kützting) Grunow	20.8	0.5	26.2		11.6		8.2	30.3
<i>Melosira varians</i> Agardh							14.7	2.6
<i>Navicula cinctaeformis</i> Hustedt	0.5	1.2			0.7			
<i>Navicula confervacea</i> (Kützting) Grunow					4.6		7.7	
<i>Navicula cryptocephala</i> Kützting	10.5	4.8	4.1		20.6	2.0	5.3	3.2
<i>Navicula muralis</i> Grunow.			1.0				1.2	2.0
<i>Navicula perparva</i> Hustedt	2.4	1.0	15.9		6.8	3.5	8.2	17.9
<i>Navicula Schroeteri</i> Meister							11.5	9.3
<i>Navicula seminuloides</i> Hustedt			2.3					
<i>Navicula seminulum</i> Grunow	0.2		5.3				1.2	2.1
<i>Navicula submolesta</i> Hustedt	1.2	2.8				1.0		
<i>Navicula tantula</i> Hustedt							2.9	1.6
<i>Navicula Twymaniana</i> Archibald							1.2	0.5
<i>Nitzschia amphibia</i> Grunow			0.5		25.5		6.5	9.3
<i>Nitzschia fonticola</i> Grunow	0.7	0.8			3.2	14.5	0.7	1.9
<i>Nitzschia hungarica</i> Grunow	0.5	1.0	1.0		1.4	0.5		
<i>Nitzschia Kütztingiana</i> Hilse	3.4							0.5
<i>Nitzschia palea</i> (Kützting) Grunow	19.2	13.8	9.2		8.6	74.0	1.0	0.5
<i>Nitzschia perminuta</i> Grunow	4.9	3.8	3.1		0.7		1.7	7.2
<i>Nitzschia romana</i> Grunow	4.2	7.0	2.8		6.5	3.8		0.2
<i>Nitzschia thermalis</i> (Ehrenberg) Auerswald	30.2	61.8	22.7		3.5	0.5		
<i>Surirella angusta</i> Kützting							1.0	0.2
<i>Synedra ulna</i> (Nitzsch) Ehrenberg.							11.8	7.4
Nitrogen heterotrophic <i>Nitzschiae</i> combined.	62.6	87.7	39.3		48.0	93.8	9.9	19.6
	ave 75.2		39.3		ave 70.9		ave 14.8	

Table 5.

Analysis of the Diatom Associations collected on 4th August, and 6th September, 1967.

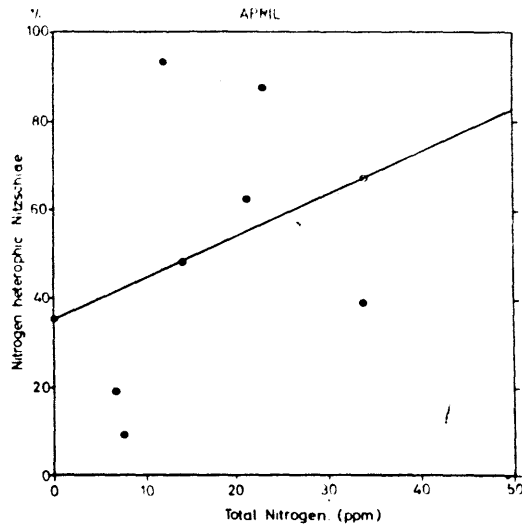
	1		2		3		4	
	4.8.67	6.9.67	4.8.67	6.9.67	4.8.67	6.9.67	4.8.67	6.9.67
Achnanthes Hauckiana Grunow								1.0
Achnanthes lanceolata(Brebisson) Grunow var. rostrata Ostrup	0.5					5.7	1.0	4.8
Achnanthes minutissima Kützing	0.5	0.9	1.0	0.5				1.5
Amphiprora paludosa W. Smith								1.0
Amphora veneta Kützing						0.5	0.6	1.3
Cocconeis (a).								1.0
Cyclotella Meneghiniana Kützing	1.0			0.2			0.8	2.5
Gomphonema parvulum (Kützing) Grunow	2.8	0.5		4.5	0.5	12.3	11.6	12.2
Navicula cryptocephala Kützing	30.9	4.4	16.3	4.0	1.2	14.3	21.2	13.0
Navicula muralis Grunow		0.9		0.5				2.0
Navicula perparva Hustedt	1.2	0.5	1.5	4.3	0.2	9.0	4.9	10.7
Navicula seminulum Grunow			0.2	2.6		1.4		0.5
Navicula submolesta Hustedt	0.8	1.4	1.0		0.2	1.4	0.3	
Nitzschia amphibia Grunow					0.2	12.3	3.5	16.0
Nitzschia amphioxoides Hustedt	4.5		5.7				4.9	
Nitzschia apiculata (Gregory) Grunow	0.2		1.8		1.2	1.9	6.1	6.4
Nitzschia capitellata Hustedt		2.5						2.5
Nitzschia communis Rabenhorst	0.5		1.0					
Nitzschia fonticola Grunow	1.4		10.5	1.4	0.9	9.0	11.3	10.4
Nitzschia hungarica Grunow	2.6		1.8		3.6	3.3	2.2	
Nitzschia Kützingiana Hilse			4.5					
Nitzschia linearis W. Smith		0.5	0.5				14.8	2.5
Nitzschia palea (Kützing) W. Smith	30.4	85.9	18.5	29.0	90.9	25.6	4.4	2.5
Nitzschia perminuta Grunow	5.0	0.5				0.9		0.8
Nitzschia romana Grunow	9.0	0.9		0.5		1.2		
Nitzschia sigma (Kützing) W. Smith								2.0
Nitzschia thermalis (Ehrenberg) Auerswald	6.4	0.2	32.4	52.0	0.7	0.5	0.6	
Surirella angusta Kützing			0.5	0.5	0.2		7.2	1.5
Synedra ulna (Nitzsch) Ehrenberg							1.7	0.5
Nitrogen heterotrophic Nitzschia combined	57.2	90.0	72.6	82.9	92.7	49.5	24.7	32.2
	ave 73.6		ave 77.9		ave 71.1		ave 28.5	

correlation between nitrogen concentration and the numbers of nitrogen heterotrophic Nitzschiae (Croxtan 1953: 109). Scatter plots were constructed to compare the relative densities of the nitrogen heterotrophic Nitzschiae with the concentrations of the different forms of nitrogen. These scatter plots are shown in Graphs 3, 4 and 5B. In these plots the nitrogen values were regarded as the independent variable (X axis), while the numbers of nitrogen heterotrophic Nitzschiae were taken as the dependent variable (Y axis). Theoretically, if the hypothesis is correct, a positive correlation would be expected, i.e. the points of the scatter plot should lie on a line ascending from left to right. This would indicate that low concentrations of nitrogen are generally associated with low numbers of nitrogen heterotrophic Nitzschiae, while high concentrations of nitrogen generally correspond with high numbers of nitrogen heterotrophic Nitzschiae.

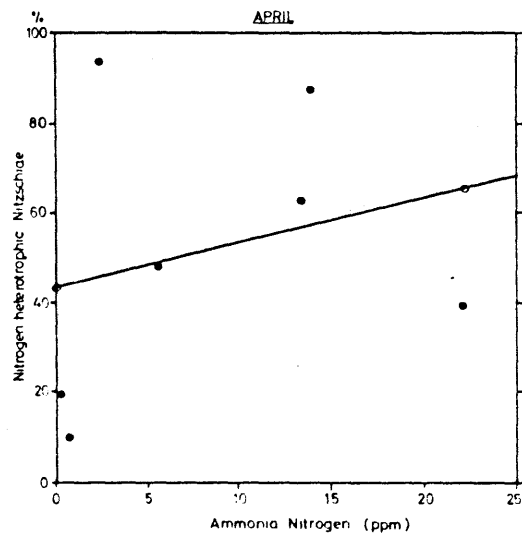
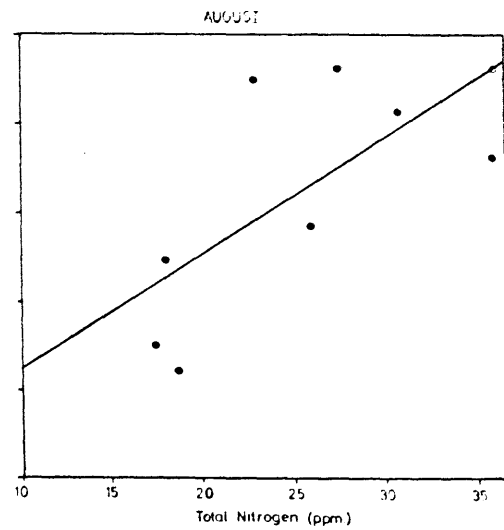
The scatter plots in most cases showed a low correlation, and it was sometimes difficult to indicate where the best correlation lay. The estimating equations were therefore calculated from the two sets of data, X and Y, in Table 6, and were drawn for each of the scatter plots. This equation gives the theoretical value of the dependent variable corresponding to any chosen value of the independent variable.

Table 6 shows the values used for determining the points in the scatter plots. These values were derived in the following manner:- The value for the concentration of nitrogen or dissolved oxygen (column X) found in the rows marked (a) is the average of the first four readings of the month concerned; and the value found in the rows marked (b) is the average of the last four readings of the month. The detailed readings for each month are shown in Tables 55-57

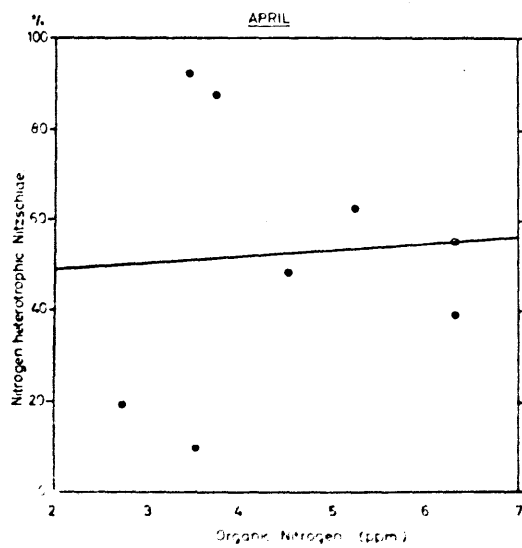
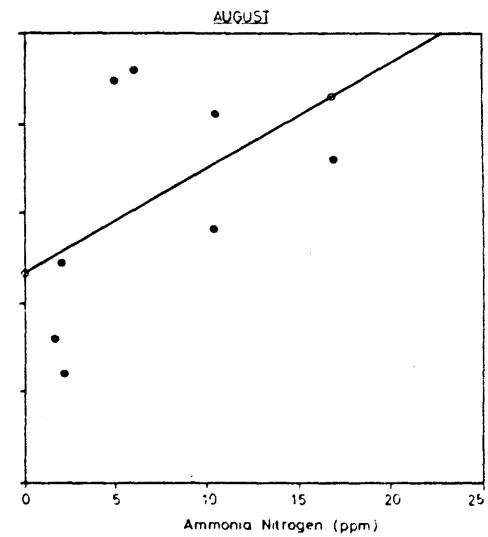
Graph 3.



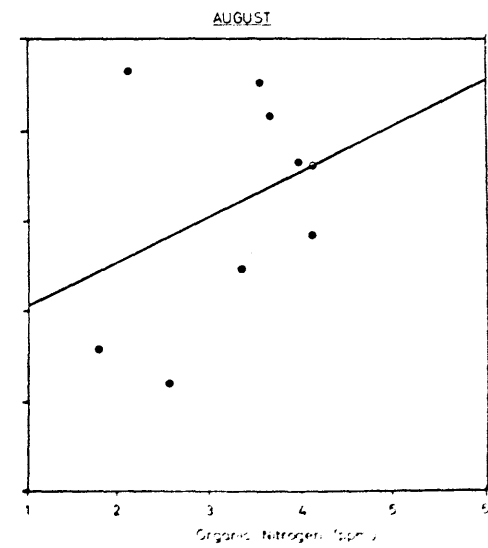
A



B

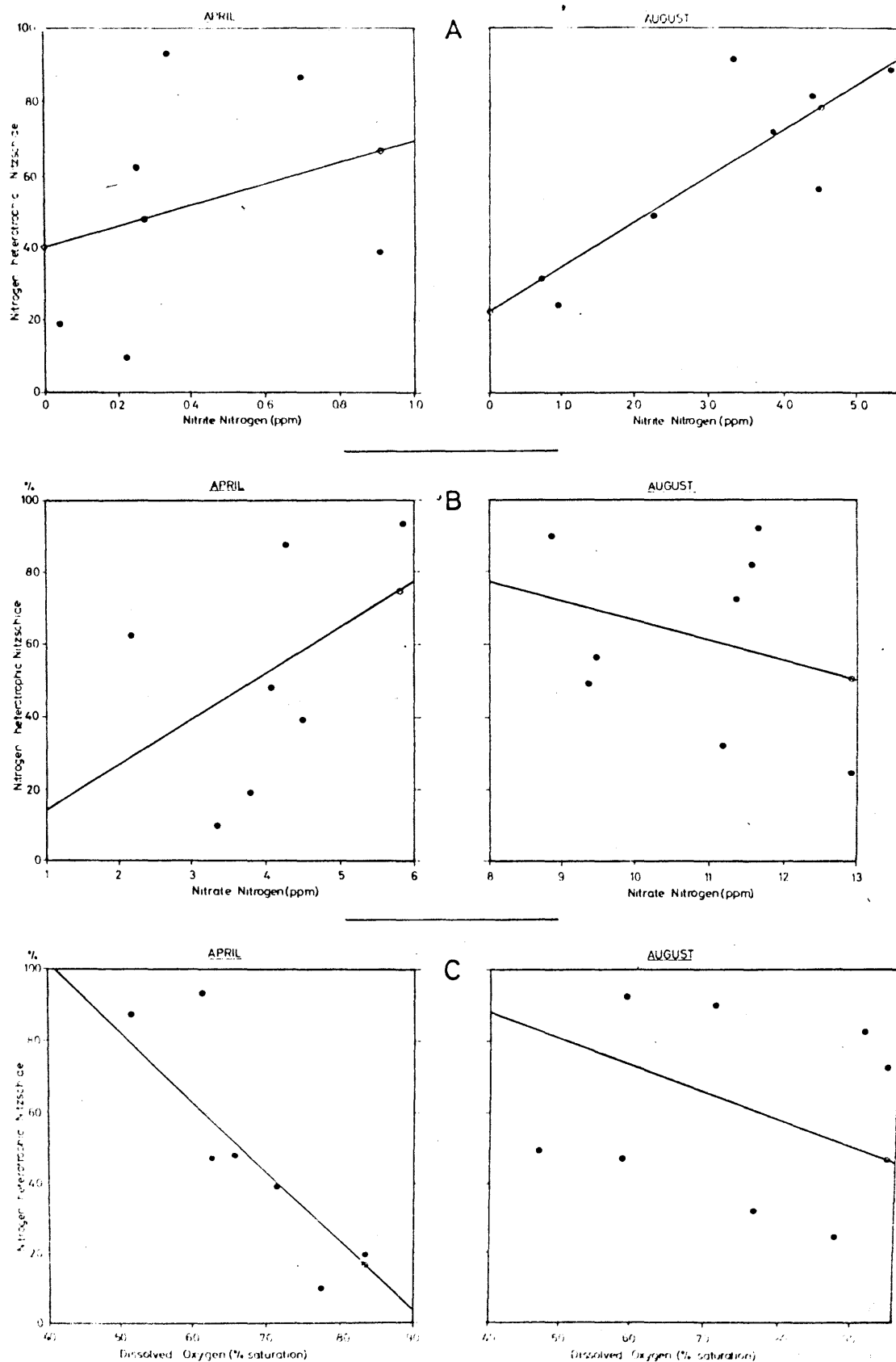


C



The Correlation between the Nitrogen Concentration and the Nitrogen heterotrophic Nitzschiae.

Graph 4.

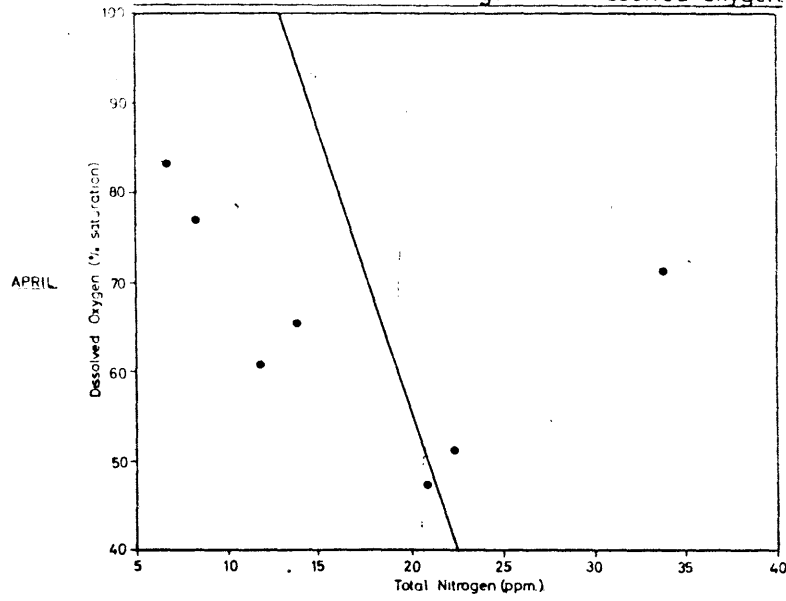


The Correlation between the Nitrogen and Dissolved Oxygen Concentration and the Nitrogen heterotrophic Nitzschiae

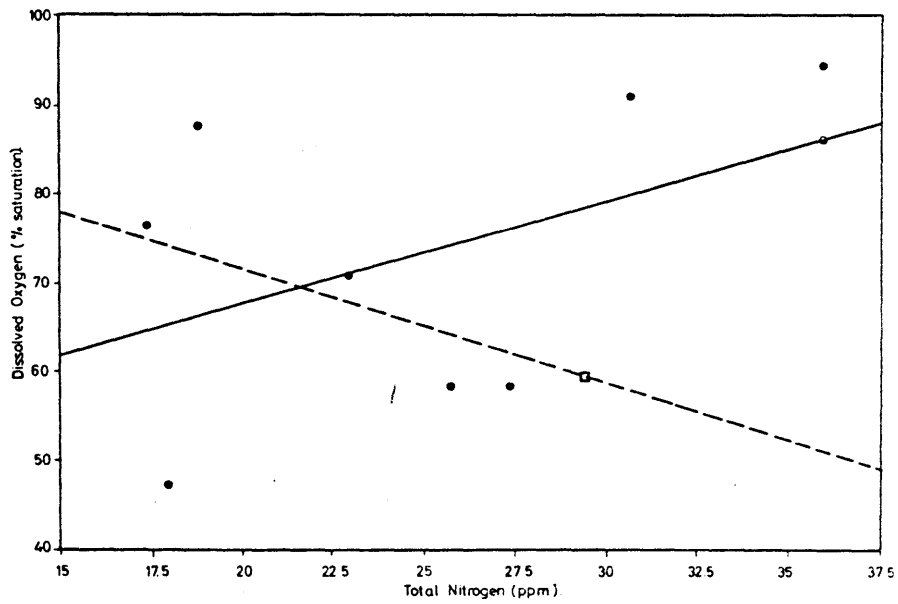
Graph 5

A.

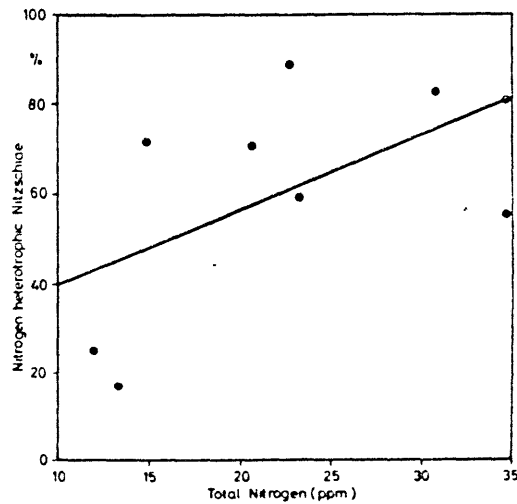
Correlation between Total Nitrogen and Dissolved Oxygen



AUGUST



B.



Correlation of Nitrogen Concentration with Nitrogen heterotrophic Nitzschiae irrespective of Season

Table 6.

The Values of nitrogen concentration and dissolved oxygen percentage saturation (X axis) and the relative densities (%) of nitrogen heterotrophic Nitzschiae (Y axis) used in fixing the points of the scatter plots.

Station Numbers.	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
<u>Total</u>								
<u>Nitrogen</u> April	(a	20.88 62.60	33.86 39.30		13.84 48.00		8.37 9.90	
	(b	22.47 87.70			11.74 93.80		6.64 19.60	
August	(a	25.71 57.20	35.84 72.60		27.36 92.70		18.55 24.70	
	(b	22.91 90.00	30.61 82.90		17.91 49.50		17.35 32.20	
<u>Ammonia N</u>								
April	(a	13.22 62.60	22.08 39.30		5.50 48.00		0.83 9.90	
	(b	13.79 87.70			2.24 93.80		0.09 19.60	
August	(a	10.32 57.20	16.75 72.60		5.81 92.70		2.15 24.70	
	(b	4.93 90.00	10.36 82.90		2.05 49.50		1.65 32.20	
<u>Organic N.</u>								
April	(a	5.26 62.60	6.36 39.30		4.51 48.00		3.51 9.90	
	(b	3.73 87.70			3.45 93.80		2.73 19.60	
August	(a	4.09 57.20	3.94 72.60		2.07 92.70		2.53 24.70	
	(b	3.52 90.00	3.62 82.90		3.36 49.50		1.77 32.20	
<u>Nitrite N.</u>								
April	(a	0.25 62.60	0.91 39.30		0.27 48.00		0.22 9.90	
	(b	0.69 87.70			0.33 93.80		0.04 19.60	
August	(a	4.43 57.20	3.82 72.60		3.24 92.70		0.95 24.70	
	(b	5.42 90.00	4.34 82.90		2.21 49.50		0.70 32.20	

Table 6.

- 2 -

Station Numbers.		1		2		3		4	
		X	Y	X	Y	X	Y	X	Y
<u>Nitrate N.</u>									
April	(a	2.14	62.60	4.49	39.30	4.02	48.00	3.31	9.90
	(b	4.26	87.70			5.82	93.80	3.78	19.60
August	(a	9.43	57.20	11.33	72.60	11.62	92.70	12.90	24.70
	(b	8.85	90.00	11.53	82.90	9.33	49.50	11.16	32.20
<u>Dissolved Oxygen.</u>									
April	(a	47.44	62.60	71.29	39.30	65.73	48.00	77.38	9.90
	(b	51.55	87.70			61.22	93.80	83.48	19.60
August	(a	58.22	57.20	94.39	72.60	58.42	92.70	87.58	24.70
	(b	70.59	90.00	91.01	82.90	47.04	49.50	76.43	32.20

(19).

in the appendix. The value found in the column Y is the relative density of the nitrogen heterotrophic Nitzschiae collected at the following times (see Tables 4 and 5):-

April, row (a) - 21.4.67.

April, row (b) - 1.5.67.

August, row (a) - 4.8.67.

August, row (b) - 6.9.67.

To eliminate the effects of season a further scatter plot was constructed (Graph 5B) in which the Total nitrogen was correlated with the Relative Density of nitrogen heterotrophic Nitzschiae irrespective of the time of year. Values for this scatter plot were obtained from the data in Table 6 in the following manner:-

(a) Total Nitrogen Concentrations: Two values for each station were obtained by first summing the April and August values in row (a) and taking the average; and then similarly summing the values in row (b) and taking the average.

(b) Relative Densities of nitrogen heterotrophic Nitzschiae: Two corresponding values were obtained for each station by following the same procedure as for the Total Nitrogen concentration.

With one exception, the estimating equations of these scatter plots indicated a positive correlation between the nitrogen concentrations and the numbers of nitrogen heterotrophic Nitzschiae.

The exception occurred in August, when the estimating equation showed that the nitrogen heterotrophic Nitzschiae had a negative correlation with the nitrate nitrogen concentration. This means that in August, low concentrations of nitrate were associated with high numbers of nitrogen heterotrophic Nitzschiae, and conversely, high concentrations of nitrate correspond with low numbers of nitrogen heterotrophic Nitzschiae.

Bacterial breakdown of organic material usually results in deoxygenation of the water (Hynes 1963: 65), and it would therefore be expected that high concentrations of nitrogen would be associated with low concentrations of dissolved oxygen. It follows from this that high numbers of nitrogen heterotrophic Nitzschiae might also be associated with low concentrations of dissolved oxygen. This was also tested by means of scatter plots (Graphs 4C and 5A).

In correlating the percentage saturation of dissolved oxygen with the amount of nitrogen in the water, the relevant values were extracted from Table 6. Thus the values of X for Total Nitrogen were plotted against the values of X for the dissolved oxygen.

The estimating equations for these scatter plots indicated a negative correlation between the nitrogen heterotrophic Nitzschiae and the dissolved oxygen saturation level. At first glance two completely opposite trends were indicated when Total Nitrogen concentrations were correlated with the dissolved oxygen saturation level. In April the correlation was negative, while in August the correlation was positive. If, however, the two values (abscissa = 35.84, co-ordinate = 94.39; and abscissa = 30.61, co-ordinate = 91.01) from Station 2 are disregarded in view of the entry at this point of highly aerated effluent due to turbulence in a narrow channel, and a new estimating equation calculated from the remaining values, a negative correlation would be indicated for the August values. This was shown by a broken line in Graph 5A. It is obvious that the whole correlation was affected by the two values at Station 2.

D. DISCUSSION.(1). Confirmation of the Hypothesis.

A comparison of the nitrogen concentrations found in the Bloukrans River with those of the highly polluted Jukskei River (Allanson 1961; Tables 10, 11, and 12), and with those of the relatively clean and unpolluted Berg River (Harrison and Elsworth 1958: 160, Table 13) established conclusively that the Bloukrans River was a highly polluted stream. The nitrogen concentrations were high and similar in magnitude to those found in the Jukskei River at Stations 9a, 9b and 20a (see Table 7).

If the hypothesis is correct, it follows that high numbers of nitrogen heterotrophic Nitzschiae would be expected in the Bloukrans River. The analysis of the diatom associations (Tables 4 and 5) confirmed this expectation, since at Stations 1, 2 and 3 nitrogen heterotrophic Nitzschiae composed between 40 and 95% of the diatom associations. As would be expected, lower numbers of nitrogen heterotrophic Nitzschiae were found at Station 4, where the lowest concentrations of nitrogen were recorded. However even here, with the exception of the sample collected on 21.4.67 (9.9% of the association), the numbers of nitrogen heterotrophic Nitzschiae indicated organic pollution (cf. Cholnoky 1958A: 210, Table 3).

The information obtained from the scatter plots in Graphs 3 - 5 provide further evidence in support of the hypothesis. However, while the evidence from the scatter plots should not be discarded entirely, too great an emphasis should not be placed on this statistical treatment of the results. The scatter plots revealed poor correlations of the two variables, nitrogen concentration and numbers of

Table 7.

Summary of the Chemical Analysis of three Stations on the Jukskei River.
(from Allanson 1961: Tables 10, 11 and 12).

	<i>9a</i>			<i>9b</i>			<i>20a</i>		
	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
Ammonia N. ppm.	103.50	0.95	37.60	59.40	0.00	19.77	36.10	0.40	13.81 (17)
Nitrite N. ppm.	12.00	0.70	2.75	8.00	0.03	1.41	3.80	0.01	0.81
Nitrate N. ppm	70.00	8.00	36.84	43.00	4.00	20.63	36.00	0.00	19.3 (17)

N.B. Except where stated averages were derived from 19 samples.

nitrogen heterotrophic Nitzschiae. However, with the help of the estimating equations, it was evident that a definite trend, indicating a positive correlation between the variables, did exist. A number of reasons can be given to account for the low degree of correlation in the scatter plots:-

- (a) because too few values were available for the construction of the plots,
- (b) because other factors were influencing the composition of the diatom associations, i.e. it was not a simple linear correlation of two variables, and
- (c) because the four sampling points did not show enough contrast between two extremes.

Additional indirect evidence supporting the hypothesis arises from the negative correlations existing between the numbers of nitrogen heterotrophic Nitzschiae and the dissolved oxygen concentration (Graph 4C), since bacterial breakdown of organic matter is accompanied by deoxygenation of the water. This breakdown provides the necessary nitrogenous compounds utilized by the nitrogen heterotrophic Nitzschiae. Evidence that the dissolved oxygen concentration in the Bloukrans River did in fact decrease with increasing concentrations of nitrogen is found in Graph 5A, where negative correlations between the two variables were indicated.

It is apparent from the discussion above that the chemical and diatom evidence from the Bloukrans River fulfils the premises of the hypothesis, viz. that high numbers of nitrogen heterotrophic Nitzschiae are associated with high concentrations of nitrogen.

(2). The Diatom Associations.

The diatom associations observed in the Bloukrans River were highly similar to those found in other highly polluted waters in

South Africa, e.g. the Bon Accord Dam near Pretoria (Cholnoky 1953B), and the Jukskei River near Johannesburg (Cholnoky 1958A: Allanson 1961: 64). In such associations the greater part was composed of nitrogen heterotrophic Nitzschiae, with Nitzschia palea and N. thermalis the dominant species in the associations. Occurring in smaller numbers, but still important ecologically and characteristic of polluted waters, were species such as Gomphonema parvulum, Navicula confervacea, N. cryptocephala, N. muralis, N. perparva, N. seminulum, and Nitzschia amphibia. A few comments on some of the more important species in this association should be made.

On many occasions Cholnoky (1958A: 246; 1960B: 263; 1966B: 205) has made a distinction between Nitzschia thermalis and N. palea on the basis of their oxygen requirements. N. thermalis, according to Cholnoky, requires almost anaerobic conditions, i.e. low dissolved oxygen concentrations, and its growth is curtailed by high concentrations of dissolved oxygen. In contrast N. palea requires well aerated water, and replaces N. thermalis when the dissolved oxygen concentration of a water is high. Observations made in this study did not substantiate this distinction. Although N. thermalis was found to be dominant at Station 1 in April (ave. % saturation = 50.17%), it was also observed as the dominant species at Station 2 in August, when the average percentage saturation was extremely high (92.67%). This suggested a much wider range of tolerance to the level of oxygen saturation, which is in contradiction to Cholnoky's observations. Nitzschia palea, on the other hand, while occurring in relatively high numbers at most stations, was observed to be dominant at Stations 1 and 3. These two stations normally showed the lowest values of dissolved oxygen saturation. Apparently N. palea has a wider range of tolerance than N. thermalis (Cholnoky 1953B: 349).

The relatively high numbers of Gomphonema parvulum, Navicula confervacea and N.seminulum suggested large fluctuations in the concentrations of nitrogen at the various stations (Cholnoky 1962B: 90). This was confirmed by the relatively high variations observed from the chemical analysis of the water (Tables 1 and 2). The presence of Navicula muralis and the relatively high numbers of N.perparva at most stations confirmed this still further. The presence of these two species also suggested that a certain amount of self-purification of the water was taking place, since the optimal nitrogen requirements for these two species lies below the concentration necessary for the good growth of the nitrogen heterotrophic Nitzschiae (Cholnoky 1960B: 252, 253; 1962B: 87; 1966A: 39). In other words these two species indicated the removal of some of the nitrogen of the water, thus lowering the concentration.

E. CONCLUSIONS.

- 1). The chemical analysis of the Bloukrans River revealed that it was a highly polluted stream.
- 2). Analysis of the diatom associations showed that high numbers of nitrogen heterotrophic Nitzschiae were present at Station 1, 2 and 3, while at Station 4 smaller, but nevertheless relatively high numbers were found.
- 3). Scatter plots, comparing the concentration of the various nitrogen compounds of the water with the relative densities of the nitrogen heterotrophic Nitzschiae, indicated a trend towards a positive correlation between the two variables, and thereby confirmed

(25).

the hypothesis that high numbers of nitrogen heterotrophic Nitzschiae are associated with high concentrations of nitrogen.

4). The diatom associations found in the Bloukrans River were characteristic of polluted waters having a high concentration of nitrogen, which was subject to large fluctuations. A small degree of self-purification was also evident. Similar diatom associations have been found in other polluted waters in South Africa (Cholnoky 1953B: 1958A).

(26).

PART 2.

The Ecology of the Diatoms of the Vaal Dam Catchment Area.

A. INTRODUCTION.

The Vaal Dam ensures a good supply of water to the Witwatersrand complex, South Africa's most important industrial and mining centre. The problem of pollution and protection of waters flowing into the Vaal Dam is therefore of very great importance. Consequently the "Special Sub-committee on Stream Surveys in the Witwatersrand" (organised by the National Institute for Water Research) in 1955 recommended that a survey of the Vaal Dam Catchment Area should be undertaken (Malan 1960: 1). The objects of this survey were to gather background knowledge of the conditions in this area, and to study the factors that affect the quality of the water in the rivers and streams running into the Vaal Dam.

Subsequently Malan (1960) undertook a survey of the area with regard to the chemical quality of the surface waters. In his report Malan made the recommendation that from a biological point of view "the flora and fauna of the main river systems should be evaluated with a view to assessing pollution effects accurately and determining the effects of changing industrial and agricultural activity". In fulfilment of Malan's recommendation Chutter (1967) has completed the studies of the fauna, and this report on the diatoms is presented as the final contribution towards the whole survey of the Vaal Dam Catchment Area.

In the study of the diatoms the main aim was to investigate the diatom associations of the Vaal Dam Catchment Area, against a background of available physical and chemical data on the water, and thus assess the quality of the water prevailing in the catchment area during the period of survey. Using this as a basis, it would then be possible to detect any changes in the quality of the water due to future industrial and agricultural development.

A secondary aim was to build up a knowledge of the systematics and taxonomy of the diatoms, and to contribute towards the knowledge of the distribution of the diatom species in South Africa.

B. DESCRIPTION OF THE VAAL DAM CATCHMENT AREA.

The catchment area of the Vaal Dam, covering approximately 14,700 sq. miles, is a large, relatively shallow basin, of which the greater part is flat gently undulating grassland. The highest ground is found in the south, where the Elands River has its source on the northern slopes of Mont-aux-Sources; for the most part the catchment area lies at an altitude of between 4,750 ft. and 5,750 ft. above sea level (Chutter 1967: 47).

Rocks of the Karroo System underlie practically the entire catchment area (Map 1)*, except for isolated places near the Vaal Dam where the Witwatersrand and Ventersdorp Systems are found in small outcrops. Most of the area drained by the Vaal River and its tributaries is underlain by the shales of the Eccca Series, while nearly all the area drained by the Wilge and Liebenbergsvlei Rivers is underlain by the shales and sandstones of the Beaufort Series. The Elands River and the Liebenbergsvlei River with its tributaries have their sources in the basalt and sandstones of the Stormberg System. The Klip River and its tributaries rise in the Beaufort Series, but flow for the most part in the Eccca Series. In the lower reaches of the Wilge and Liebenbergsvlei Rivers, the two rivers flow over beds of the Eccca Series.

*All maps are found in the appendix.

The Vaal Dam catchment area falls into a summer rainfall area, in which most of the rain falls on the high lying parts in the south and south-east. In these areas the annual rainfall ranges between 50" and 60" per annum. The rainfall over a narrow band along the southern and eastern borders of the catchment area has an annual range of 32" to 50" per annum. Over the greater part of the catchment, however, the area receives only 24" to 32" per annum. According to Chutter (1967: 48) about 90% of the summer rainfall is the result of thunderstorms, which produce heavy downpours for short periods of time. The flows of the streams and rivers in summer are, as a result, very variable; this variability decreasing until in winter it is smaller and more constant. In most winters snowfalls occur on the high lying areas.

There are two main water courses in the catchment area, the Vaal River and its tributaries, and the Wilge River and its tributaries (Map 2). The Vaal River rises in the east and flows westwards. On the northern bank there are three main tributaries, the Kaffirspruit River, draining the Ermelo area, the Blesbok River which drains the area south of Bethal, and the Waterval River which drains the Leslie, Kinross and Trichardt areas. On the southern bank there are again three tributaries, the Kleinvaal River and the Skulpspruit River which drain the Amersfoort district, and the Klip River draining the large area in the Orange Free State in the Vrede and Memel districts.

In the Orange Free State the Wilge River rises in the south and flows northwards to the Vaal Dam. There are three main tributaries on its eastern bank, the Molen, Cornelius and Holspruit Rivers, which drain the area around Warden. On the west bank there are also three tributaries, the most southerly being the Elands River and its

tributary, the Klerkspruit River, which drain the Witziesshoek and Kestell areas; The Russespruit River, and the Liebenbergsvlei River with its tributaries. The Bethlehem and Reitz districts are drained by the Liebenbergsvlei River.

In the catchment area of the Vaal River the main towns are Standerton, Bethal, and Ermelo, and some minor industries are situated in and around these towns. The South African Torbanite plant is found near Breyten, which lies near the headwaters of the Vaal River. In the Ermelo district a few scattered coal mines are found. At Standerton there is a milk processing factory, and a textile factory. During the course of the survey some gold mines were in the process of being developed in the Kinross region. Finally the Springfield Colliery is situated on the Kalk River, which flows directly into the Vaal Dam. In the Orange Free State the main towns in the Wilge River catchment area are Harrismith, where there is a milk processing factory and a textile factory, and Bethlehem on the Liebenbergsvlei River, has a milk processing factory. Although these minor industries are found, the main economy of the region is based on agriculture. In the Vaal River valley and the lower Wilge valley there are large areas under maize and sunflower cultivation, while in a strip from Ermelo to Bethlehem stock farming predominates.

C. SAMPLING POINTS AND STATIONS.

The material for this investigation was collected on different occasions by Cholnoky, Chutter and the author. A list of the samples, together with a short description of the locality and the date of collection of each sample, is found in Table 8. The samples in the series Vaal 200 - 299 were collected by Cholnoky in July 1957 and July 1958. Chutter made irregular collections of a large number of samples from his sampling stations (Chutter 1967: 57 and Table 11), in the whole catchment area during the period of the survey, i.e. 1958 - 1960; these samples are numbered in the Series Vaal 300 - 399. In August 1960 Cholnoky made a further collection of samples, the series Vaal 400 - 500, from the Vaal River system only. Finally the author, while on a trip round the catchment area in March 1965, made a small collection of diatom material (Vaal 500 - onwards), of which only a few samples were analysed.

In Map 2 the distribution of the sampling points is depicted. Each sampling point is indicated by a black dot with the sample number or numbers next to it. If such a sampling point should fall on one of Chutter's stations, the black dot is replaced by a square containing the number of the station, next to which is written the number of the sample or samples collected at that point. In the text, any sampling point designated "Station" refers to Chutter's sampling stations.

D. METHODS.1). Chemical and Physical Analyses.

The chemical analyses quoted in this study were undertaken by Malan and Chutter.

The methods used by Malan in his chemical analysis were described in his report on the chemical survey of the Vaal Dam Catchment Area (Malan 1960: 9 and 10). With a few exceptions he followed the methods set out in "Standard Methods for the Examination of Water, Sewage and Industrial Wastes (American Public Health Association 1955).

In most of his chemical analysis Chutter followed the methods described by Allanson (1961). There were, however, some changes which he described in his report on the fauna of the Vaal Dam Catchment Area (Chutter 1967: 45).

2). Diatom Samples.

With one or two minor exceptions, the methods used for the collection, preparation and investigation of the diatom samples were the same as those described in Part 1, the Bloukrans River study.

The diatom samples were collected from a number of different habitats by scraping the algal film from rocks, marginal mud, submerged trailing or marginal vegetation and other debris. Wherever pH values were recorded at the time of collection of the samples, the readings were made with a Lovibond Comparator. Chlorophenol red, bromo-thymol blue, phenol red and thymol blue indicators were used to cover the pH range 4.8 to 9.6.

3). Biological Assessment of the Water Quality.

In biologically assessing the quality of the water, the structure of the diatom associations at each sampling point was used. Cholnoky's method for determining the structure of the diatom association (a modification of the Thomasson Analysis) has already been described in Part 1.

By studying the relative densities of the various species, or groups of species, it is possible to evaluate the ecological conditions of a river, by making use of already known correlations between the organisms living in the river and the factors affecting their growth and distribution. Cholnoky has made extensive ecological studies on South African rivers and has discussed these correlations in detail in his publications. Some of the more important correlations are set out below.

It is well known that the chemical and physical properties of water play a selective role on the organisms living in it (Round 1965: 82). Furthermore, Ruttner (1963: 98) has pointed out that the appearance of certain species has been observed to be related to certain levels of impurities. Thus it is possible for the degree of pollution to be indicated by the appearance of these species. Amongst the diatoms the most important group, indicating pollution of the water, is the nitrogen heterotrophic Nitzschiae. This group of Nitzschiae, and particularly Nitzschia palea and N. thermalis, have been discussed in relation to the organic nitrogen concentration in Part 1 of this dissertation.

In a short study on the polluted Bloukrans River (Part 1), the correlation between the nitrogen heterotrophic Nitzschiae and the concentration of nitrogen was tested experimentally. The results of this experimental work showed that there was a positive correlation between the numbers of nitrogen heterotrophic Nitzschiae and the nitrogen concentration of the water, i.e. high numbers are associated with high concentrations, and low numbers with low concentrations. This experimental evidence and Cholnoky's studies (e.g. 1953B; 1958A; and 1960B) were used as a basis for the assessment of the concentration of organic nitrogen in the rivers of the Vaal Dam Catchment Area.

Further information about the nitrogen concentration is derived from knowledge of the specific ecological requirements of other species. In studying the succession of diatom associations in relation to the stages of water purification, Cholnoky (1958A: 209) found that Gomphonema parvulum was characteristic of unstable conditions, finding its optimum development in water subjected to large fluctuations of the nitrogen concentration. Navicula confervacea and N. seminulum have been shown to have similar ecological requirements (Cholnoky 1958A: 209; 1960B: 282), and are closely associated with G. parvulum.

The two small Navicula species, N. muralis and N. perparva are very similar to each other in regard to their autecology. In his studies on the Pretoria Sewage Works, Cholnoky (1962B: 87) found that N. muralis was abundant at the end stages of the process of self-purification, where the concentration of organic nitrogen is low, and the oxygen is high. It can therefore be assumed that the presence of these two species in significant numbers in the diatom association indicates the end stages of self-purification in a body of water or river.

In determining the dissolved oxygen concentration of a water Cholnoky employed certain species which are regarded as oxygen indicators. In this regard the most important genera are Achnanthes, Cymbella and Fragilaria. Cholnoky has dealt with the associations of species indicating high concentrations of dissolved oxygen in various papers (Cholnoky 1958A: 216 and 239; 1960B: 276; 1962B: 110; 1966A: 77), and has found that the most commonly occurring indicators are Achnanthes microcephala, Achnanthes minutissima, Cymbella ventricosa and Fragilaria Vaucheriae. The occurrence of Cymbella microcephala (Cholnoky 1962B: 68; 1966B: 180) also indicates high concentrations of dissolved oxygen. Most species in these groups

are katharobic and are seldom seen in highly polluted water.

Depending on the pH of the water, either acidophilic or alkaliphilic associations will develop. In South Africa acidic waters occur less frequently than alkaline waters, and as a result acidophilic associations are more restricted. Hustedt (1930: 59) stated that most species in the genera Eunotia, Pinnularia and Frustulia are acidophilic. This is supported by Round (1965: 208) who added the genera Anomoeoneis and Tabellaria to this group. In the acidic streams around Rustenburg in the Transvaal, Cholnoky (1957B) found the associations to be characterised by Eunotia spp., Frustulia rhomboides and F. vulgaris, Pinnularia spp., Surirella delicatissima and Tabellaria flocculosa. Similar associations have been observed from other acidic waters in South Africa by Cholnoky (1960B: 270; 1962B: 112; 1965: 80; 1966B: 231). The associations of alkaline water, on the otherhand, are far too large to permit discussion here, since the majority of diatom species can be regarded as alkaliphilic.

In a recent paper Patrick (1968: 182) produced experimental evidence that "under very similar conditions, steady state communities with great similarity can be produced". On this basis the correlations, observed by Cholnoky in South African rivers and discussed above, were applied to the diatom associations found in the Vaal Dam catchment area in order to assess the quality of the water.

E. RESULTS.

Table 9 ^{*} presents a summary of the chemical analysis made by Malan (1960). This survey indicated quite clearly that the rivers in the Vaal Dam catchment area carried a low mineral content (Malan l.c.: 33). Calcium and magnesium bicarbonates constituted the greater part of the dissolved solids, and as a result the waters were nearly all alkaline and well buffered. At most places sodium, chlorides and sulphates were found in low concentrations. It is also clear from this table that the concentration of dissolved solids increased from the headwaters of the rivers to the dam itself. This increase is brought about by an increase in the calcium and magnesium bicarbonates rather than any other dissolved salts.

Chutter (1967: 62) felt that certain biologically important aspects of the chemistry of the water had been neglected by Malan. As a result Chutter undertook a second chemical survey, mainly of the Vaal River and its tributaries, the Kaffirspruit, Kleinvaal and Waterval Rivers. A summary of this analysis is found in Table 10^{*}. In the remainder of the catchment area the chemical analysis of the water is scanty. Table 11^{*} shows the results of the analysis of single samples from several stations on the Klip and Wilge River systems. These results, based on a single sample, can only indicate the possible trend of the conditions which exist at these sampling stations.

Chutter's chemical analysis showed some points of interest. At Station 1, although the main chemical constituents were still calcium and magnesium bicarbonates, they were not present in sufficient concentrations to buffer the water adequately. Consequently there were large fluctuations of the pH.

^{*} The tables are found in the appendix.

Chutter (1967: 66) remarked that there was chemical, biological or circumstantial evidence that the chemical quality of the water was altered by effluents at Station 4, 5, 11A, 11B, 11C and 17.

The results of the Thomasson Analysis of the diatom associations at each sampling point are recorded in Tables 12 - 52 in the appendix. In these tables only those species with a relative density of 1% or more in at least one sample in the relevant table have been reflected, since Chohnoky (1962: 342) found that relative densities of less than 1% fell into the range of error of the method, and are thus unreliable for ecological conclusions. The plus sign (+) in the tables indicates that the species was recorded in the species list, but was not observed in the association analysis.

The results of the Thomasson Analysis are discussed below. The chemical information associated with each sampling point was extracted from Tables 9, 10 and 11. The concentration values in this information were recorded in parts per million (ppm.). The symbols N.D. indicate concentrations so low that they were not detectable.

1). The Vaal River System.

(a). The Vaal River.

Station No. 1.

Locality: This station is situated in a marshy sponge near Breyten at the source of the Vaal River. Sheep and cattle make use of this sponge as a drinking trough in the dry season (Chutter 1967: 63). Two samples were collected from this station in the late winter (Vaal 301, 479), and one in summer (Vaal 370).

Chemical Data: Cholnoky:- pH 6.8; 6.0; 6.3.

	No. of samples.	max.	min.	ave.
Chutter:- pH	9	6.8	5.8	6.3
Total Nitrogen.		21.21	0.83	4.81
Kjeldahl N.	7	21.0	0.8	4.7
Ammonia N.	8	0.67	0.01	0.40
Nitrite N.	10	0.03	N.D.	0.004
Nitrate N.	9	0.18	0.03	0.11
O ₂ Absorbed	10	17.7	1.3	7.9

Diatom Analysis: Table 12.

Comments: The diatom associations found here were characterised by Eunotia spp., Frustulia rhomboides var. saxonica, Pinnularia spp. and Surirella delicatissima var. africana. These associations were similar to those reported by Cholnoky (1957B: 1960B: 270; 1962B: 112; 1966B: 231) from other localities in South Africa having low pH values. This suggested that the water was acidic, and chemical measurements of the pH (ave. 6.3) confirmed the diatom evidence. The fairly high relative densities of Achnanthes microcephala and A. minutissima indicated a reasonable aeration of the water. In the winter or dry season the associations (Vaal 301, 479) were very similar and showed high numbers of nitrogen heterotrophic Nitzschiae, which implied some organic enrichment of the water. This was confirmed by the high average figure for Kjeldahl nitrogen and the very high average value for oxygen absorbed by potassium permanganate in four hours. The enrichment with organic materials could be due to the sheep and cattle. In the wet season, or summer, (Vaal 370) the relative density of the nitrogen heterotrophic Nitzschiae was low, thus indicating only small quantities of organic nitrogen in the water. This could be attributed to the seasonal effect of summer rains flushing out the sponge.

Station No. 2.

Locality: This station is found where the Lake Chrissie - Ermelo road crosses the Vaal River. At the time of Cholnoky's collection (11.8.60) the water was flowing slowly over a rocky river bed.

Chemical Data: Cholnoky:- pH 8.0.

	max.	min.	ave.
Malan:- Total Dissolved Solids	99	53	67
Total alkalinity (as CaCO_3)	52	19	31
Total Hardness (as CaCO_3)	48	15	27
Chlorides (as Cl)	16	6	11
Sulphates (as SO_4)	13	1	5.4
Sodium (as Na)	14	5.2	9

Diatom Analysis: Table 13.

Comments: This station was sampled once in 1960, and it was immediately apparent that the association was rather different from that found at Station 1. The association was dominated by two oxygen indicating species, Achnanthes minutissima (45.9%) and Fragilaria pinnata (28.9%), and this suggested a good oxygenation of the water at this point. The absence of any acid water species led to the conclusion that the pH of the water was above neutral, particularly as Cholnoky (1962B: 73) has found the pH optimum of Fragilaria pinnata to be between pH 7.2 and 8.0. This conclusion was supported by Cholnoky's measurement of the pH (= 8.0). Since the relative densities of the nitrogen heterotrophic Nitzschiae were very low (4.5%), only small concentrations of organic nitrogen were present in the water. This suggested an improvement of the quality of the water at Station 2, and that some self-purification had taken place between Stations 1 and 2.

Station No. 2A.

Locality: Station 2A was found where the Vaal River is crossed by the Ermelo - Amsterdam road. The two samples were collected from different habitats, Vaal 306 from marginal mud and Vaal 307 from the stones in current.

Chemical Data:

	No. of samples.	max.	min.	ave.
Chutter:- pH	7	8.1	6.4	7.2
Total Nitrogen		1.72	N.D.	0.54
Kjeldahl N.	7	1.1	N.D.	0.4
Ammonia N.	8	0.50	N.D.	0.15
Nitrite N.	11	0.015	N.D.	trace.
Nitrate N.	11	0.60	N.D.	0.14
O ₂ Absorbed	11	8.6	1.2	3.3

Diatom Analysis: Table 14.

Comments: The two samples showed rather different associations, but whether this was the result of the long time interval between the two collections, differences in season, or differences in habitat is not clear. In sample Vaal 306 the association was completely dominated by the oxygen indicators Achnanthes minutissima (90.5%) and Fragilaria familiaris (4.3%). This undoubtedly pointed to an excellently aerated water, which was free of pollution by organic nitrogenous compounds. Chutter's chemical analysis appeared to confirm this assumption as the nitrogen concentrations were extremely low, and at times not detectable (N.D.). In contrast to this the sample collected in the summer (Vaal 307), while still showing good aeration (A.minutissima 37.9%), showed an increase in the numbers of nitrogen heterotrophic Nitzschiae (23.1%), indicating an increase in the organic nitrogen concentration of the water. This rise in the concentration in the summer could be related to a seasonal variation, as similar situations have been observed at other points in the catchment area.

Sample Vaal 477.

Locality: This sampling point occurred just above the confluence of the Vaal and Kleinvaal Rivers, south-east of Ermelo.

Chemical Data: Chohnoky:- pH 7.9.

Diatom Analysis: Table 15.

Comments: The association found here was almost the same as that of Vaal 306 from the previous station (see above). Here again the association indicated extremely well oxygenated, slightly alkaline water (pH 7.9), containing negligible amounts of organic nitrogenous material. The water therefore, at this point and at Station 2A appeared to be of very good quality in the winter months.

Station No. 3.

Locality: This locality was found where the Morgenzon-Amersfoort road crosses the Vaal River. Chutter (1967: 84) remarked that this station was subject to large floods heavily laden with silt. Algal growth was never heavy. The samples were collected in the late winter months of 1958, 1959, and 1960. Sample Vaal 312 was collected from the stones in the current.

Chemical Data: Chohnoky:- pH 8.5.

	No. of samples.	max.	min.	ave.
Chutter:- pH	8	8.4	7.2	7.9
Total Nitrogen		1.58	0.54	1.09
Kjeldahl N.	4	1.1	0.5	0.9
Ammonia N.	5	0.80	N.D.	0.39
Nitrite N.	7	0.01	N.D.	trace.
Nitrate N.	7	0.47	0.04	0.19
O ₂ absorbed	7	3.3	1.3	2.4

Diatom analysis: Table 16.

Comments: The remarkable similarity between the three associations suggested a stability of the ecological factors in the Vaal River at Station 3 during the winter. The three associations showed very little change in either the species composition or the proportions in which the

species occurred. This conclusion was supported by the chemical data for this station (given above), since the range of fluctuation of the various chemical factors was relatively small. The large proportions of Achnanthes minutissima and Cymbella spp. indicated a well aerated, clean water. The small numbers of nitrogen heterotrophic Nitzschia in the associations, indicating low concentrations of organic nitrogen, supported the assumption that the water was unpolluted. This fact was further confirmed by the chemical analysis of the water at this point, which showed small concentrations of nitrogen in solution (ave. Total N. - 1.09 ppm.). At Station 3 the first appearance of an interesting diatom association was recorded. In this association the Cymbella spp. were dominant, and were closely linked with A.minutissima, N.interrupta, and N.linearis. This type of association will be discussed in more detail later.

Station No. 4.

Locality: This sampling point was found on the Vaal River at Standerton, below the old railway bridge. Just above this station the river receives the can washing effluent from a milk processing factory. Sample Vaal 417 was collected from a small stream in this vicinity, which probably drains the area around the condensed milk factory. Samples Vaal 315 and 316 were collected from stones in the current; no information is available concerning the habitats sampled in the other samples.

Chemical Data: Cholnoky:- pH 8.2 (Vaal 416); pH 8.2 (Vaal 417).

	No. of samples.	max.	min.	ave.
Chutter:- pH.	7	8.4	7.1	7.8
Total Nitrogen		1.0	N.D.	0.22
Kjeldahl N.	13	0.5	N.D.	0.11
Ammonia N.	9	0.40	N.D.	0.21
Nitrite N.	13	trace	N.D.	trace.
Nitrate N.	13	0.50	N.D.	0.11
O ₂ Absorbed	13	5.6	1.0	2.9

Diatom Analysis: Table 17.

Comments: Neither the chemical analysis of Chutter (quoted above) nor that of Malan (1960: 13) could detect any obvious effect of the can washing effluent on the chemical quality of the water. Malan attributed this to the masking of pollution by dilution in the Vaal River.

The diatom associations, on the otherhand, indicated rather unstable conditions. At times the numbers of nitrogen heterotrophic Nitzschiae were very high (66.8% in September 1959), and on other occasions they were very low in number (4.4% in August 1960). This indicated that there was some considerable variation in the organic nitrogen concentration. Chutter's study of the fauna (Chutter 1967: 206) confirmed that the water quality was affected by pollution at this station, where he found the most marked changes of the fauna, particularly the sediment fauna, due to an effluent. These observations on the diatoms and fauna did not appear to agree with the chemical analysis of the water.

The diatom associations found in Vaal 417 were very reminiscent of those found in the Bloukrans River, where Nitzschia palea is the dominant species of the association. The water in this small stream was probably highly polluted with nitrogenous compounds. However on account of its small size, the pollution effects were probably eliminated by dilution in the greater volume of the Vaal River.

Nevertheless it cannot be discounted entirely as a source of pollution at this point. The dissolved oxygen concentrations appeared to have fluctuated in response to the variations of the organic nitrogen concentrations, being highest in sample Vaal 416 (Achnanthes minutissima 27.5% and Cymbella Kappii 48.2%), when the concentration of organic nitrogen is lowest.

Station No. 5.

Locality: Station 5 is situated below Station 4, and lies below the Standerton Sewage Works. Chutter (1967: 64) reported that at this station treated sewage was irrigated on to fields sloping towards the river. He was, however, unable to find any evidence for surface run off. Diatom growth was apparently abundant in winter and early summer. The river bed consisted of mainly dolerite rock. Sample Vaal 319 was collected from the stones in the current, while all the samples were collected during the winter months of 1958, 1959 and 1960.

Chemical Data: Chohnoky:- pH 8.5.

	No. of samples.	max.	min.	ave.
Chutter:- pH	9	8.5	7.2	7.8
Total Nitrogen		15.47	0.20	2.94
Ammonia N.	12	2.0	N.D.	0.34
Nitrite N.	12	0.3	N.D.	0.01
Nitrate N.	12	1.87	N.D.	0.42
O ₂ Absorbed	11	6.0	1.1	3.1

Diatom Analysis: Table 18.

Comments: The diatom associations found here were very similar to those found at Station 3, and would therefore reflect similar environmental conditions. The high relative densities of Achnanthes minutissima and Cymbella spp., particularly C. microcephala, indicated stable, well aerated katharobic conditions during the winter months.

The low numbers of nitrogen heterotrophic Nitzschiae, suggesting only small concentrations of organic matter, support this conclusion. However, the presence of Gomphonema parvulum, sometimes in fairly high numbers (12.7% in 1959), gave an indication of a relatively large fluctuation of the organic nitrogen concentration at certain times. Evidence from the diatom associations suggested that the Standerton Sewage Works had little deleterious effect on the quality of the river during the winter.

Chutter (1967: 109) observed that the fauna at this station was little changed, supporting the evidence obtained from the diatoms. The chemical analysis on the otherhand strongly suggested some enrichment of the water by organic material (note high Kjeldahl figures).

Station No. 5A.

Locality: This station is situated where the Vaal River is crossed by the Standerton - Villiers road. Chutter's samples were collected below a dolerite sill. Samples Vaal 321, 324 and 406 were collected from stones in the current, while samples Vaal 322, 323 and 375 were collected from algae trailing in the current.

Chemical Data: Cholnoky:- pH 8.7. Archibald:- pH 8.2.

	No. of samples.	max.	min.	ave.
Chutter:- pH	9	8.7	7.2	7.8
Total Nitrogen		1.58	0.5	0.84
Kjeldahl N.	5	0.88	0.5	0.70
Ammonia N.	6	0.42	0.20	0.27
Nitrite N.	8	trace	N.D.	trace
Nitrate N.	8	0.70	N.D.	0.14
O ₂ Absorbed	8	4.0	1.2	2.1

Diatom Analysis: Table 19.

Comments: The large numbers of species present and the variability between each association suggested a rather unstable ecological environment. While the chemical evidence showed very small concentrations of nitrogen in solution, with a narrow range of fluctuation, the diatom analyses reflected periods of relatively heavy enrichment of the water with organic nitrogen compounds. Evidence for this was obtained in samples Vaal 321, 323, 324 and 552, where the numbers of nitrogen heterotrophic Nitzschiae were relatively high (15.1%, 21.7% 29.0% respectively) suggesting high concentrations of organic nitrogen at these times. On other occasions the concentrations appeared to be low, and more in keeping with the chemical analysis. The oxygen concentration, reflected by the numbers of Achnanthes and Fragilaria spp., was also subject to fluctuation; generally the concentration followed the opposite trend to the organic nitrogen concentration. As in most other samples, the diatom associations were alkaliphilic, thus indicating an alkaline water. This was confirmed by the numerous pH readings recorded at this station (ave. 7.8).

Station No. 6.

Locality: Station 6 occurred at Villiers on the Vaal River, where the samples, diatoms and chemical, were collected from just below the national road bridge on the northern boundary of the village. Malan (1960: 13) regarded the Vaal River at this point as already forming part of the Vaal Dam.

(47).

Chemical Data: Cholnoky pH 8.6.

	max.	min.	ave.
Malan:- Total dissolved solids	185	78	133
Total alkalinity (as CaCO ₃)	152	40	93
Total Hardness (as CaCO ₃)	140	44	86
Chlorides (as Cl)	18	4	9
Sulphates (as SO ₄)	10	3	6
Sodium (as Na)	19	8	15

Diatom Analysis: Table 20.

Comments: It is unfortunate that, at the point where the Vaal River enters the Vaal Dam, only one sample should have been collected. The high numbers of Gyrosigma scalproides (17.7%), Navicula cryptocephala (18.2%), and N.rostellata indicated a high pH value and oligotrophic water. However the complete absence of any Fragilaria spp. and the low numbers of Achnanthes and Cymbella species indicated a rather poorer oxygenation of the water than at other points in the catchment area. This did not appear to be due to effects of pollution, since the relatively low numbers of the nitrogen heterotrophic Nitzschiae (8.7%) indicated small quantities of organic matter in solution. The diatom association of sample Vaal 406 suggested, therefore, that the water entering the Vaal Dam from the Vaal River was of good quality. This conclusion was supported by Malan (1960: 14) through his chemical analysis of the water (see above).

(b). The Tributaries of the Upper Vaal River.

The Kaffirspruit River.

Locaility: The Kaffirspruit drains the area around Ermelo and has been sampled at a number of different points. Station 19 lies where the Ermelo - Standerton road crosses the river. Here the river bed was sandstone rock, and four samples were collected from this point (Vaal 342, 343, 344 and 493). The samples Vaal 489, 491 and 492

were collected from the tributary streams above Station 19, and were all collected in August 1960.

Chemical Data: Cholnoky:- pH 8.1 (Vaal 493); 9.2 (Vaal 489); 8.6 (Vaal 491); pH 8.4 (Vaal 492).

	max.	min.	ave.
Malan:- Total Dissolved Solids	292	175	230
Total alkalinity (as CaCO_3)	255	124	185
Total Hardness (as CaCO_3)	228	112	167
Chlorides (as Cl)	20	8	15
Sulphates (as SO_4)	14	6.2	9.2
Sodium (as Na)	28	14.5	22

	No. of samples.	max.	min.	ave.
Chutter:- pH	8	8.4	7.1	7.9
Total Nitrogen		5.07	0.05	1.58
Kjeldahl N.	7	4.20	N.D.	1.24
Ammonia N.	10	0.60	N.D.	0.15
Nitrite N.	12	0.05	N.D.	0.01
Nitrate N.	12	0.82	0.05	0.33
O_2 Absorbed	12	8.0	1.3	3.1

Diatom Analysis: Table 21.

Comments: It is obvious from the chemical data available for Station 19, that the water at this station was well buffered and alkaline.

As a result no traces of any acid water species were found in the association. The diatom associations at Station 19 were interesting since they reflected a possible seasonal variation. The associations found in the winter samples (Vaal 342, 343 and 493) suggested stable well oxygenated conditions with very small concentrations of organic nitrogen, since the katharobic species (Achnanthes minutissima and Cymbella spp.) were present in large numbers. This was supported by the very low relative densities of the nitrogen heterotrophic Nitzschiae in these samples. In contrast the water in summer

supported a much larger proportion of nitrogen heterotrophic Nitzschiae (50.6%), which led to the conclusion that in summer the water contained much greater concentrations of organic nitrogen. Chutter's chemical analysis did show a relatively large fluctuation of the concentrations, but it is not clear whether there was any seasonal pattern in these variations.

The samples Vaal 491 and 492 had associations which reflected conditions similar to those found at Station 19 in the winter. However, the sample collected from the tributary just outside Ermelo (Vaal 489) indicated an increased organic nitrogen concentration (nitrogen heterotrophic Nitzschiae 48.4%). This was possibly the result of pollution due to the town's wastes. This increase in concentration appeared to have been eliminated through the processes of self-purification before reaching Station 19. The winter samples from the Kaffirspruit River were of further interest because here again the *Cymbella* dominant associations observed at Station 3, were recorded.

The Blesbok River - Station 18.

Locality: This station lies at the point where the Morgenzon - Standerton road crosses the Blesbok River. The river bed is composed of sandstone. The Blesbok River drains the region around and to the south of Bethal.

Chemical Data: Cholnoky:- pH 8.5.

	max.	min.	ave.
Malan:- Total Dissolved Solids	270	127	194
Total alkalinity (as CaCO_3)	220	82	141
Total Hardness (as CaCO_3)	190	75	128
Chlorides (as Cl)	22	9	15
Sulphates (as SO_4)	22	5.6	12
Sodium (as Na)	32.5	13	20

Diatom Analysis: Table 22.

Comments: The water in the Blesbok River at the time this sample was collected appeared to have been of excellent quality. The high numbers of Achnanthes minutissima (59.3%) indicated an extremely well oxygenated water. The high numbers of the katharobic Cymbella spp. and the absence of any nitrogen heterotrophic Nitzschia suggested very clean water with no organic nitrogen in solution. Once more a similar association to that of Station 3 was present, but in this case A.minutissima was the dominant species.

The Kleinvaal River - Station 20.

Locality: Station 20 occurred on a headwaters tributary of the Kleinvaal River, and samples Vaal 347, 348 and 463 were collected from this point. Sample Vaal 345 has been included with this station, although it was actually collected some distance away in the vicinity of Station 20.

Chemical Data: Cholnoky:- pH 8.5.

	No. of sample.	max.	min.	ave.
Chutter:- pH	9	8.5	6.7	7.8
Total Nitrogen		2.6	0.31	1.33
Kjeldahl N.	4	2.10	0.30	1.12
Ammonia N.	5	0.42	N.D.	0.17
Nitrite N.	8	0.1	N.D.	trace
Nitrate N.	8	0.40	0.01	0.21
O ₂ Absorbed	8	4.0	0.50	1.8

Diatom Analysis: Table 23.

Comments: Being in the headwaters region of the Kleinvaal River it might be expected that the sources of water supply would be marshy sponges, such as found at Station 1. Enrichment of the water with organic materials of animal and plant origin could, therefore, be expected, together with some acidification of the water derived from the humic acid produced on plant decay.

This idea was supported by the presence in small numbers of some acidophilic species, such as Frustulia vulgaris var. angusta, Navicula subhamulata and Pinnularia acoricola. These acidophilic species in a predominantly alkaliphilic association suggested an alkaline water, which was not very well buffered, and therefore subject to fluctuations of the pH. These fluctuations sometimes went below the neutral point. Chutter's measurement of the pH at Station 20 confirmed this (max. 8.5 and min. 6.7).

The high numbers of the nitrogen heterotrophic Nitzschia indicated an enrichment of the water, particularly in the winter of 1959. In the winter of 1960 the large increases of the numbers of the katharobic species Cymbella Kappii (31.9%) and Cymbella ventricosa (21.6%) showed an improvement in the quality of the water. In the summer months of 1958 and 1960 the diatom associations indicated that the organic nitrogen concentration was lower than in the winter of 1960, but still sufficient to enrich the water. A seasonal variation with a summer flushing out effect, similar to that of Station 1 could possibly occur here. This will be discussed in more detail later. Chutter's chemical analysis provided no evidence for any heavy enrichment of the water with nitrogenous organic materials.

The Kleinvaal River - Station 21A.

Locality: This station was found between Stations 20 and 21 in the Amersfoort district. At this site the river passes over a dolerite sill. Only two samples were collected in the winter, one in September, 1959 and one in August, 1960.



Chemical Data: Cholnoky:- pH 8.3.

	No. of samples.	max.	min.	ave.
Chutter:- pH	5	8.3	7.3	7.7
Total Nitrogen				0.82
Kjeldahl N.	1			0.07
Ammonia N.	2	0.84	0.30	0.57
Nitrite N.	2	N.D.	N.D.	N.D.
Nitrate N.	2	0.2	0.16	0.18
O ₂ Absorbed	8	4.6	1.2	2.3

Diatom Analysis: Table 24.

Comments: Here again the great similarity between the two associations of 1959 and 1960 reflected a stability of the environment in the winter months. The extremely high numbers of Achnanthes minutissima (73.0% and 75.2%) suggested very well oxygenated alkaline water, containing very little organic nitrogen in solution. This was supported by the very low numbers of nitrogen heterotrophic Nitzschiae (5.5% and 4.9% respectively). The chemical analyses did not reveal much, and were not very reliable as only one or two analyses were made.

The Kleinvaal River - Station 21.

Locality: Station 21 was found on the farm Goedehoop on the road from Amersfoort to Sheepmoore. This point is very near the confluence of the Kleinvaal River with the Vaal River. Chutter (1967: 118) observed large growths of diatoms in the winter and dry early spring.

<u>Chemical Data:</u>	No. of samples.	max.	min.	ave.
Chutter:- pH	7	9.0	7.2	7.7
Total Nitrogen		2.48	0.75	1.05
Kjeldahl N.	3	2.30	0.25	0.98
Ammonia N.	6	0.42	N.D.	0.19
Nitrite N.	8	N.D.	N.D.	N.D.
Nitrate	8	0.18	N.D.	0.07
O ₂ Absorbed	8	3.6	1.2	2.3

Diatom Analysis: Table 25.

Comments: At this sampling point both the winter (Vaal 353) and the summer (Vaal 356) associations were highly similar, and therefore would reflect a more or less stable environment throughout the year. The low numbers of nitrogen heterotrophic Nitzschiae in both these samples (7.6% and 0.7% respectively) indicated that the high organic nitrogen content at Station 20 had been reduced in concentration by self-purification until very little was left in the water at Station 21. In the chemical data given above it can be seen that the nitrogen concentration was very low, and nitrites were not detected at all. This confirmed the evidence given by the diatom associations. The very high numbers of Achnanthes minutissima and Fragilaria familiaris pointed to extremely well aerated water.

The Skulpspruit and Rietspruit Rivers.

Locality: The Skulpspruit stream (Vaal 465) was sampled once on the outskirts of the village of Amersfoort. One sample was also collected from the Rietspruit stream (Vaal 468) about 5 miles further east on the same road. Both samples were collected in August 1960.

Chemical Data: Chohnoky:- pH 8.2 (Vaal 465) and pH 8.5 (Vaal 468).

Diatom Analysis: Table 26.

Comments: Here again the samples contained the Cymbella dominant associations, which reflect stable well oxygenated katharobic conditions. The poor development of the nitrogen heterotrophic Nitzschiae (2.0% and 2.3%) indicating little or no organic nitrogen supported the conclusions drawn from the Cymbella dominance of the association. Therefore it does not appear that the small village of Amersfoort polluted the waters of the Skulpspruit River.

(c). The Klip River.The Upper Klip River - Station 24.

Locality: Station 24 was situated on the road up Müller's Pass between Memel and Newcastle; two samples were collected from this point, the one in winter (Vaal 437) and the other in summer (Vaal 358). A short distance upstream another sample (Vaal 438) was collected in August 1960. Sample Vaal 358 was collected from stones in the current.

Chemical Data: Cholnoky:- pH 7.4 (Vaal 438); 8.1 (Vaal 437).

Chutter:-	pH	8.3
	Total Nitrogen	2.6
	Kjeldahl N.	1.6
	Nitrite & nitrate N.	1.0
	O ₂ Absorbed	6.6

Further details can be found in Table 11.

Diatom Analysis: Table 27.

Comments: At Station 24 in the summer (Vaal 358) the nitrogen heterotrophic Nitzschiae (50.9%) suggested a very high organic nitrogen concentration of the water, and the low numbers of Achnanthes minutissima (4.2%) reflected a low dissolved oxygen concentration. On the otherhand the winter samples (Vaal 437 and 438) provided a complete contrast. The numbers of nitrogen heterotrophic Nitzschiae dropped considerably (1.5% and 4.3%), with a corresponding rise in the numbers of Achnanthes minutissima (64.6% and 29.2%). This suggested a substantial decrease in the organic nitrogen content, while the dissolved oxygen concentration rose steeply. The great similarity between samples Vaal 437 and 438 suggested that the ecological character of the two points were very similar. Not much reliance can be placed on the chemical analysis of the station since only one sample was analysed.

The Klip River at Memel - Station 25.

Locality: Station 25 is found on the Klip River just above Memel.

The close proximity of Memel to Station 25 might result in some organic pollution of the water. Two samples were collected, one in winter (Vaal 434) and the other in summer (Vaal 359).

Chemical Data: Cholnoky:- pH 8.4.

Chutter:-	pH	8.3
	Total Nitrogen	3.1
	Kjeldahl N.	1.2
	Nitrite & Nitrate N.	1.9
	O ₂ Absorbed	2.6

Diatom Analysis: Table 28.

Comments: Conditions very similar to those of Station 24 were observed here. The apparent seasonal difference in the organic nitrogen concentration was again very clear, and it would appear that the summer organic nitrogen load, carried down from higher up the river, had been augmented to some degree (Nitrogen heterotrophic Nitzschiae 74.2%). This additional organic nitrogen might be derived from the village of Memel, since even in winter the numbers of nitrogen heterotrophic Nitzschiae were relatively high (12.1%) suggesting a mild enrichment of the water with organic nitrogen. The chemical analysis, based on only one sample, was unable to show any great difference in the chemistry of the water between Stations 24 and 25.

The Middle Klip River - Station 26.

Locality: Station 26 was situated on the Klip River, where it is crossed by the Vrede - Volksrust road. Included with this station was one sample (Vaal 261), which was collected from the Seekoeivlei below Memel. The vlei has long since dried up and at present times

it is drained by the Klip River running through it (Chutter: personal communication).

Chemical Data: Cholnoky:- pH 8.3 (Vaal 449).

Chutter:-	pH	8.2
	Total Nitrogen	2.7
	Kjeldahl N.	1.5
	Nitrite & Nitrate N.	1.2
	O ₂ Absorbed	4.7

Diatom Analysis: Table 29.

Comments: The association observed at Seekoeivlei was somewhat different from the associations previously experienced in the Vaal River. Although the numbers of Achnanthes and Cymbella were small, the well oxygenated and unpolluted character of the water was reflected by the dominance of the katharobic species Nitzschia linearis (Cholnoky 1960B: 261; 1962A: 56; 1962B: 97). There was some indication that the pH of the water at the Seekoeivlei occasionally dropped below the neutral point, since Frustulia vulgaris var. angusta and Pinnularia acoricola, which are acidophilic species, were present in small numbers.

At Station 26 the good development of A.linearis and A.minutissima (28.3% and 21.0% respectively) indicated an oxygen rich water, while the low numbers of nitrogen heterotrophic Nitzschiae (3.2%) indicated only small concentrations of organic nitrogen in solution.

The Lower Klip River - Station 27.

Locality: This station was found near the road bridge at De Lange's Drift between Standerton and Vrede. This was the lowest point on the Klip River to be sampled, and only one sample was collected from this point.

Chemical Data: Cholnoky:- pH 8.3.

	max.	min.	ave.
Malan:- Total Dissolved Solids.	285	65	135
Total alkalinity (as CaCO_3)	220	25	92
Total Hardness (as CaCO_3)	170	30	80
Chlorides (as Cl)	24	5	10
Sulphates (as SO_4)	24	2.5	6.5
Sodium (as Na)	48	4	16

Diatom Analysis: Table 30.

Comments: The diatom association found here was rather similar in composition to that found at the Seekoeivlei (Table 29 - Vaal 261). The high numbers of Nitzschia linearis (19.6%) and the presence of Achnanthes minutissima (9.8%) and Fragilaria Vaucheriae (2.6%) in smaller numbers indicated a moderate oxygenation of the water. Since small numbers of nitrogen heterotrophic Nitzschiae were present in the association, very little organic nitrogen was dissolved in the water. Thus it would appear that the water entering the Vaal River from the Klip River was of good quality. Any instances of organic pollution in the upper reaches of the Klip River appear to have been eliminated by self-purification.

Small Tributaries of the Klip River.

Locality: The samples reviewed under this heading were collected by Cholnoky in August 1960 from small tributary streams of the Klip River in the Memel and Volksrust districts. One tributary (Vaal 436) entered the Klip River above Memel (Station 25), while the remainder entered the river just above or below Station 26.

<u>Chemical Data:</u>	Sample No.	436	433	447	451	453
	Cholnoky:- pH	7.4	7.0	8.6	8.2	8.5

Diatom Analysis: Table 31.

Comments: The general characteristics of the diatom associations from these tributaries were very similar. The high numbers of the oxygen indicators, such as Achnanthes and Fragilaria spp. indicated a general high level of dissolved oxygen, probably the result of the high surface to volume ratio of these small streams. Only one sample (Vaal 436) provided evidence for a high concentration of organic nitrogen, since the numbers of nitrogen heterotrophic Nitzschia (46.3%) were high. In all the other samples the numbers of nitrogen heterotrophic Nitzschia suggested only a mild enrichment of the water with organic nitrogen. The relatively small amounts of organic nitrogen in these tributary streams, had no apparent effect on the quality of the water in the main river, probably on account of the dilution factor.

The Sand River - Station 8.

Locality: This station occurred where the road from Volksrust to Standerton or Amersfoort crosses the Sand River. Included with this station is a sample (Vaal 455) collected from a small tributary, to the west of Volksrust, running into the Sand River just above Station 8. All the samples were collected in late winter.

Chemical Data: Chloknoky:- pH 8.2 (Vaal 455); 8.3 (Vaal 456).

Diatom Analysis: Table 32.

Comments: The numbers of Achnanthes minutissima (14.8%) and nitrogen heterotrophic Nitzschia (12.3%) in the small tributary of the Sand River indicated a reasonably well oxygenated water, slightly enriched with organic nitrogenous material. The poor development of the katharobic Cymbella species emphasised this slight enrichment.

The small amounts of organic nitrogen in the tributary, did not apparently affect the Sand River to any extent, since the association

observed at Station 8 (collected on the same day) was indicative of clean unpolluted water. The very high numbers of Achnanthes linearis (43.1%) and other members of this genus suggested a good aeration of the water. The paucity of the nitrogen heterotrophic Nitzschia (5.3%) reflected the very small concentrations of organic nitrogen in the Sand River. Little can be said with regard to the ecological conditions at Station 8 in September 1960, since the autecology of one of the main species in the association, Nitzschia silica Archibald (24.6%), is not known having only recently been described (Archibald 1966C: 234). However the dominance of Achnanthes minutissima (50.6%), and the presence of Cymbella spp. would suggest well aerated and reasonably clean water.

The Kommandospruit River - Station No. 30.

Locality: The Kommandospruit River is one of the main tributary streams of the Klip River, draining the area between Vrede and Memel. Station 30 was situated where the Vrede - Memel road crosses the river. At this point the river is not very wide and has a sandy bottom, containing few or no aquatic macrophytes.

Chemical Data: Chelnoky:- pH 8.6.

Chutter:- pH	8.4
Total Nitrogen	2.6
Kjeldahl N.	1.8
Nitrite & Nitrate N.	0.8
O ₂ Absorbed	0.8

Diatom Analysis: Table 33.

Comments: The absolute dominance of the katharobic Cymbella microcephala (64.4%), in association with Achnanthes species, reflected a very stable environment, comprising well aerated water with only small concentrations of organic nitrogenous material.

Although very little reliance can be placed on a single chemical analysis, the result of Chutter's analysis made in August 1961 reflected very low concentrations of nitrogen.

The Kommandospruit River - Station No. 31.

Locality: Station 31 lies approximately 12 miles down stream of Station 30 where the Vrede - Volksrust road crosses the river. About halfway between the two stations a small stream, the Maddenspruit, enters the Kommandospruit River. The Maddenspruit was sampled at the spot where the road from Vrede to Memel crosses the stream.

Chemical Data: Chohnoky:- pH 8.5 (Vaal 431); 8.4 (Vaal 445).

Diatom Analysis: Table 34.

Comments: The association found in the Maddenspruit was very similar to that found in the Seekoeivlei near Memel (Vaal 261: Table 29). The high numbers of Nitzschia linearis (63.9%) reflected a well oxygenated, slightly mesotrophic water. The numbers of nitrogen heterotrophic Nitzschiae (12.3%) confirmed this.

At Station 31 evidence in support of a seasonal variation of the organic nitrogen concentration was again provided. As at Stations 24 and 25 the high numbers of nitrogen heterotrophic Nitzschiae at Station 31 (Vaal 360) indicated very large concentrations of organic nitrogen in the water in summer. During the winter the numbers of these Nitzschiae (3.4%) had been greatly reduced, indicating less organic nitrogen. At the same time a corresponding increase in the numbers of Achnanthes minutissima (16.5%) and Fragilaria Vaucheriae (24.2%) in the winter of 1960 suggested a better oxygenation of the water in the absence of large concentrations of organic nitrogen.

The Vrede Stream.

Locality: An odd assortment of samples falls under this heading.

The river, which drains the area around Vrede, has been named the Vrede Stream since the maps of the area do not give it a name. Cholnoky collected four samples from this stream and its tributaries. Two samples (Vaal 429 and 441) were collected above the village of Vrede, one (Vaal 427) from a small tributary on the northern boundary of Vrede, and the last (Vaal 422) from a small tributary stream between Vrede and Station 27.

<u>Chemical Data:</u>	Sample No.	429	441	427	422
	Cholnoky: pH	8.7	8.5	9.0	8.5

Diatom Analysis: Table 35.

Comments: Generally the four associations indicated similar conditions in all the streams. Very much in evidence here were the Cymbella dominant associations, similar to Station 3. These associations indicated stable, well oxygenated water, which, with the exception of Vaal 427, contained very small concentrations of organic nitrogen in solution. In sample Vaal 427 the high numbers of nitrogen heterotrophic Nitzschiae (26.4%) indicated organic enrichment of the water. This enrichment probably arose from waste materials discarded by the village of Vrede. In sample Vaal 429, the relatively high numbers of nitrogen heterotrophic Nitzschiae (14.1%) indicated some mild enrichment of the water.

(62).

(d). The Waterval River.

The Waterval River - Upper Regions.

Locality: Sample Vaal 511 was collected from the Waterval River just below Leslie, and Sample Vaal 512 was collected from a small tributary of the Waterval River, about 17 miles from Leslie.

Chemical Data: Archibald:- pH 8.0.

Diatom Analysis: Table 36.

Comments: These two samples, collected in 1965, are of value only since they give some idea of the conditions which were found in this area in March 1965. In both samples the relatively high numbers of nitrogen heterotrophic Nitzschiae (12.4% and 14.9% respectively) suggested a mild enrichment of the water. The high numbers of Navicula cintaeformis (37.5%) might indicate a raised salt concentration, since Cholnoky (1963D: 254) found this Navicula species in waters containing very high concentrations of salt. In both samples the numbers of Achnanthes spp. reflected an apparently very low concentration of dissolved oxygen.

The Waterval River - Station 17.

Locality: Station 17 was found on the Waterval River at Roodebank, where the Leslie - Standerton road crosses the river. During the period of the survey the development of gold mines was taking place in the Leslie - Kinross - and Trichardt area. This station lies about 12 miles below the entry of effluent from a sewage works and a gold mine effluent. Algal growths were profuse in the winter and dry early summer.

Chemical Data: Cholnoky:- pH 9.4 (Vaal 497); Archibald:- pH 8.4 (Vaal 552).

	max.	min.	ave.
Malan:- Total Dissolved Solids	431	60	186
Total alkalinity (as CaCO ₃)	238	24	110
Total Hardness (as CaCO ₃)	188	29	93
Chlorides (as Cl)	102	8	25
Sulphates (as SO ₄)	25	4.5	10.1
Sodium (as Na)	94	6.0	29

	No. of samples.	max.	min.	ave.
Chutter:- pH	5	9.4	7.6	8.2
Total Nitrogen		5.46	0.26	1.97
Kjeldahl N.	8	1.3	N.D.	0.7
Ammonia N.	10	0.84	N.D.	0.24
Nitrite N.	13	0.164	0.010	0.068
Nitrate N.	13	4.0	0.25	1.2
O ₂ Absorbed	13	16.8	1.6	5.1

Diatom Analysis: Table 37.

Comments: The impression gained from the long list of species observed, and the great variability of the proportions in which they occurred in the association, was one of a very unstable ecological environment. From the numbers of nitrogen heterotrophic Nitzschiae in most of the samples it was clear that the water at Station 17 was practically always polluted by organic nitrogenous materials. This organic matter probably arose as a result of the gold mining activities in the headwaters region, and from the sewage works effluent which enters the river above Station 17. Only one sample (Vaal 337) provided an association indicative of only small concentrations of organic nitrogen. The high numbers of Gomphonema parvulum in most samples, and the presence of Navicula confervacea indicated a fluctuation of the nitrogen concentration, while the

presence N.muralis and N.perparva suggested the occurrence of self-purification to some degree. The chemistry of the water at this point showed that the water was enriched with nitrites and nitrates, which are the end products of bacterial oxidation of ammonia nitrogen derived from organic nitrogenous substances. This substantiated the evidence for self-purification. The Kjeldahl nitrogen was low in concentration, and ammonia nitrogen was of the normal level for the Vaal River catchment area. However, Chutter (1967: 64) remarked that no Kjeldahl nitrogen analyses had been made on the two samples containing the highest nitrate concentration. Further chemical evidence in support of organic pollution at this point is obtained from the oxygen absorbed in 4 hours from potassium permanganate, which showed the highest values of the catchment area at this station.

With the exception of sample Vaal 337, the low numbers of the oxygen indicators, Achnanthes and Fragilaria spp. reflected poor oxygenation of the water, which probably was the result of the high oxygen requirement for the oxidation of the organic matter. There was, however, no indication of any anaerobic conditions, since no trace of Nitzschia thermalis were observed in any of the samples. Sample Vaal 337 was again the only sample to show better oxygenation of the water (Achnanthes minutissima 37.9%).

The presence of Navicula cinctaeformis, Navicula pseudohalophila and Nitzschia apiculata indicated a rise in the concentration of dissolved salts. This would be expected as a result of the gold mining activities in the area. Malan's chemical analysis reflected rather higher than normal concentrations of total dissolved solids, which tended to support the diatom evidence. Unpublished results of an analysis carried out by the National Institute for Water Research

showed that during 1960 - 1961 the concentrations of total dissolved solids were often between 900 and 1000 ppm (Chutter 1967: 62), which confirmed this conclusion still further.

The high numbers of Navicula Schroeteri and N.rostellata indicated the possibility of sugars in solution. Cholnoky (personal communication) has found almost pure cultures of N.Schroeteri in the Nonoti River in Natal, where the river is polluted by sugar wastes from a sugar mill.

Sample Vaal 377 was interesting since the diatom association was dominated by a small hyaline species of Navicula, which was assigned to the species N.permitis. If this identification was correct, no further conclusions can be drawn with regard to the ecology of this sample, since the autecology of N.permitis is not known.

Two other samples of interest were those collected from different habitats on the same day. Sample Vaal 339 was collected from the stones in the current, while sample Vaal 340 was collected from the marginal vegetation. The two samples showed almost the same type of association, but differed in two respects:-

- 1). the presence of Achnanthes and Fragilaria spp. in relatively high numbers in the stones in current habitat (Vaal 339) indicated a better aeration of the water here than in the marginal vegetation habitat, where neither of the above mentioned oxygen indicators were observed.
- 2). The marginal vegetation habitat was more suited to the epiphytic Gomphonema parvulum, and therefore gave rise to greater numbers of this species in Vaal 340 than in Vaal 339.

The Waterval River - Station No. 7.

Locality: Station 7 occurred on the Waterval River at the point where the Balfour - Standerton road crosses the river. Two samples (Vaal 325 and 412) were collected from this station. Just above Station 7 two samples were collected from two tributaries of the Waterval River (Vaal 411, the Grootspuit and Vaal 413).

Chemical Data: Cholnoky:-

Sample No.	412	411	413
pH.	8.7	8.7	8.8

Diatom Analysis: Table 38.

Comments: The effects of the organic pollution at Station 27 were still evident at Station 7, although very much reduced. The diatom associations from Station 7 indicated a slight enrichment of the water in 1959 (nitrogen heterotrophic Nitzschiae 12.6%) and more so in 1960 (nitrogen heterotrophic Nitzschiae 23.5%). The numbers of Achnanthes minutissima (2.7%) were lower in 1959 than they were in 1960 (21.5%), which would indicate a better oxygenation of the water in 1960. The numbers of Nitzschia sigma (6.6%) reflected the presence of an increased salt concentration in 1959 (Vaal 325).

The two samples collected from the tributaries showed very similar associations. The high relative densities of the nitrogen heterotrophic Nitzschiae in both the samples indicated an enrichment of the water with organic nitrogenous materials. The major difference between the two samples was the greater number of Achnanthes minutissima (22.1%) in sample Vaal 413, indicating better oxygenation of the water in this tributary than in the Grootspuit. Whether the organic nitrogen contained by these tributaries has any great effect on the Waterval River is difficult to gage.

The Waterval River - Lower Regions.

Locality: Three samples were collected from a point on the Waterval River above the confluence of the Silverbank River, where the road from Villiers to Greylingstad crosses the river. One other sample (Vaal 409) was collected from a small tributary entering the Waterval just below this locality. Sample Vaal 554 was collected from a seepage water on the banks of the river.

Chemical Data: Cholnoky:- pH 8.5 (Vaal 410).

Diatom Analysis: Table 39.

Comments: The association of sample Vaal 410 indicated that, from the low numbers of Achnanthes minutissima (3.0%) and relatively high numbers of nitrogen heterotrophic Nitzschiae (23.5%), the water in 1960 was still poor in its oxygenation and slightly enriched in character. The high numbers of Cyclotella comensis (47.0%) suggested that at this point the river formed a large relatively quiet pool, which, in the winter months, allowed a good development of this planktonic form. In 1965 (Vaal 553) the association presented a picture of a rather better quality water. Although the paucity of Achnanthes and Fragilaria spp. indicated very poor oxygenation of the water, the presence of Gomphonema parvulum (7.2%) and Navicula muralis (16.7%) suggested a fluctuating nitrogen concentration due to the processes of self-purification. The small numbers of nitrogen heterotrophic Nitzschiae (5.9%) indicated low concentrations of organic nitrogen. The lack of Achnanthes spp. in the seepage waters (Vaal 554) in 1965, and the relatively high numbers of nitrogen heterotrophic Nitzschiae (20.8%) indicated a poorly oxygenated and mesotrophic water. Organic pollution would easily be effected in the small volume of the seepage water, but it had no apparent effect on the main river, on account of dilution in the greater volume in the Waterval River.

Finally sample Vaal 409 collected in a small tributary also produced an association containing few specimens of Achnanthes minutissima (4.2%), and high relative density of the nitrogen heterotrophic Nitzschiae (30.3%). This reflected poorly oxygenated water with relatively large concentrations of organic nitrogen. Again dilution on entering the main river would probably eliminate any ill effects on the water quality of the Waterval River derived from this tributary.

(e) The Lower Vaal River.

Tributaries of the lower Vaal River.

Locality: The samples grouped in this category were collected from the small tributaries of the Vaal River below Standerton. Three tributaries were found in the Standerton district (Vaal 414, 415 and 419 and 420), and three much smaller streams were sampled in the vicinity of Villiers (Vaal 404, 405 and 408). All the samples were collected by Cholnoky in August 1960.

<u>Chemical Data:</u>	Sample No.	404	405	408	414	415	419	420
	Cholnoky:- pH.	8.6	8.7	8.6	9.6	8.5	8.7	-

Diatom Analysis: Table 40.

Comments: With the exception of sample Vaal 408, the low numbers of Achnanthes minutissima indicated that all these small tributaries had low concentrations of dissolved oxygen. In sample Vaal 408 the dominance of A.minutissima (66.2%) indicated a very well aerated stream.

The organic nitrogen concentrations in the streams under review differed considerably from stream to stream. The small stream entering the Vaal River just above Station 5 at Standerton was sampled twice, once from the stream itself (Vaal 420) and once

from a small tributary of this stream (Vaal 419). At these points there was some difference in the organic nitrogen concentration. In the main stream the low numbers of nitrogen heterotrophic Nitzschia (8.6%) indicated small organic nitrogen concentrations. On the otherhand the relatively high numbers of nitrogen heterotrophic Nitzschia (33.2%) in sample Vaal 419 indicated that the tributary was reasonably well enriched with organic nitrogen. However the effects of this enrichment were not apparent at Station 5 (see Table 18). Of the remaining samples, only sample Vaal 414 (nitrogen heterotrophic Nitzschia 26.5%), showed any large concentration of organic nitrogen. The remaining streams showed associations which indicated meso- to oligotrophic conditions of the water. All the associations reflected alkaline water; this was confirmed by Cholnoky's measurements of the pH value. The dominance of Amphora veneta (54.6%) in sample Vaal 414 pointed to a very high pH. Cholnoky's measurement of the pH (pH 9.6) confirmed this.

The Kalk River - Stations 15 and 16.

Locality: These two stations were situated on the Kalk River which flows directly into the Vaal Dam, and has been included with the lower Vaal River for convenience. Station 16 was the Grootvlei Dam, which acts as a sedimentation basin for the effluent of the Springfield Colliery effluent. Station 15 was situated on the Kalk River, below Grootvlei Dam, where the Villiers - Heidelberg road crosses the river. According to Malan (1960: 26) the Grootvlei Dam discharges very little effluent into the Kalk River, as most of the effluent was recirculated to the mine for coal washing purposes.

Chemical Data: Cholnoky:- pH 8.5 (Vaal 401); pH 8.7 (Vaal 402).

	Station 16.			Station 15.		
	max.	min.	ave.	max.	min.	ave.
Malan:- Total dissolved Solids	606	400	503	334	175	256
Total alkalinity (as CaCO_3)	392	261	503	334	175	256
Total Hardness (as CaCO_3)	115	70	95	201	80	127
Chlorides (as Cl)	96	52	72	38	14	23
Sulphates (as SO_4)	56	13.5	28	105	13.6	29.6
Sodium (as Na)	180	105	151	76	28	45

Diatom Analysis: Table 41.

Comments: The low oxygen content at Station 16, indicated by the absence of any oxygen indicators, did not appear to be caused by large concentrations of organic nitrogen, since the numbers of nitrogen heterotrophic Nitzschiae (18.0%) indicated only mild enrichment of the water with organic materials. Very evident in this association were the brackish water species Nitzschia apiculata (36.7%) and Nitzschia sigma (5.4%). These two species reflected high concentrations of dissolved solids in the water. This has been shown to be the case by Malan's chemical analysis, where the average concentration of dissolved solids in the colliery dam was over 500 ppm. The high numbers of Cyclotella comensis (20.5%) reflected the suitability of the Grootvlei Dam for planktonic growth.

The association found at Station 15, below the Grootvlei Dam, indicated the same sort of conditions, but in more diluted concentrations. The nitrogen heterotrophic Nitzschiae (9.8%) represented small concentrations of organic nitrogen, while the reduced numbers of Nitzschia apiculata (4.5%) and absence of Nitzschia sigma indicated the presence of more dilute concentrations of dissolved salts than were observed in the Grootvlei Dam. This was supported by Malan's chemical analysis and his observation (Malan 1960: 27) that very little of the mineralised

water from the Grootvlei Dam gained access to the Kalk River. Here also the lack of oxygen indicators reflected poorly oxygenated water. The large numbers of Navicula cryptocephala (44.3%) and Rhopalodia gibberula (13.0%) were indicative of highly alkaline water. This was confirmed by Chohnoky's measurement of the pH (8.7).

(2). The Wilge River System.

(a). The Wilge River.

Station 9.

Locality: This station occurred near the headwaters of the Wilge River where it is crossed by the road from Harrismith to Colling's Pass. Sample Vaal 328 was collected from the stones in the current.

<u>Chemical Data:</u>	Chutter:- pH.	8.3
	Total Nitrogen	3.4
	Kjeldahl N.	2.4
	Nitrite & Nitrate	1.0
	O ₂ Absorbed	2.8

Diatom Analysis: Table 42.

Comments: The associations collected in October and December 1958 were very similar, and therefore reflected conditions which remained unchanged over the two month period. The high numbers of both Achnanthes and Fragilaria suggested a high oxygen concentration, which, judging from the relatively low numbers of nitrogen heterotrophic Nitzschia (9.8% and 6.6% respectively), contained very little organic nitrogenous material. The high numbers of Gomphonema parvulum, particularly in Sample Vaal 328 (27.2%) indicated, however,

that there was apparently some fluctuation of the nitrogen concentration, which occasionally reached relatively high values. No reliance can be placed on the chemical data, as only one sample was analysed.

Station No. 10.

Locality: Station 10 was the Wilge River at the village of Swinburne, where the samples were collected just above the road bridge. A hotel was situated on the banks of the Wilge River a little above the station. One sample was collected in September 1958.

<u>Chemical Data:</u>	Chutter:- pH	8.4
	Total Nitrogen.	3.4
	Kjeldahl N.	1.7
	Nitrite & Nitrate N.	1.7
	O ₂ Absorbed	6.6

Diatom Analysis: Table 43.

Comments: The general quality of the water had deteriorated slightly at this station. The high numbers of nitrogen heterotrophic Nitzschiae (20.7%) indicated a rise in the organic nitrogen concentration over the previous station. A corresponding decrease in the numbers of Achnanthes minutissima (18.0%) and Fragilaria Vaucheriae (2.1%) showed a lowering of the dissolved oxygen concentration. Although no great weight can be placed on the chemical analysis the amount of oxygen absorbed from potassium permanganate in 4 hours (6.6 ppm), although in itself not a very reliable measure, did lend some support to the conclusion of an increased organic nitrogen concentration at this station.

Station Nos. 11A, 11B, and 11C.

Locality: All three stations in this group occurred at or near Harrismith. Station 11A was found near the bridge where the Wilge River enters Harrismith. This station lay below ponds next to the river in which the effluent from a milk processing factory was treated. Station 11B occurred where the Wilge River left Harrismith. This station lay below some ponds in which a textile factory effluent was treated. Station 11C was situated a little way below Harrismith. No diatom collections were made from Station 11C which lay about 300 yards below Station 11B. The samples were collected in September and October 1958.

Chemical Data:

Station 11A.

	max.	min.	ave.
Malan:-Total Dissolved Solids.	81	27	57
Total alkalinity (as CaCO_3)	42	14	27
Total Hardness (as CaCO_3)	36	13	23
Chlorides (as Cl)	12	3	7
Sulphates (as SO_4)	7	1.3	3.6
Sodium (as Na)	11.5	3.5	7.0

	Station 11A	11B
Chutter:- pH	6.8	7.1
Total Nitrogen	3.2	4.0
Kjeldahl N.	1.2	3.4
Nitrite & Nitrate N.	2.0	0.6
O_2 Absorbed	9.4	8.6

Diatom Analysis: Table 44.

Comments: The presence of large numbers of Achnanthes minutissima and Fragilaria Vaucheriae reflected well oxygenated water at all three sampling points, 11A, 11B and 11C. At Station 11A the relatively large numbers of nitrogen heterotrophic Nitzschiae (25.0%) indicated some enrichment of the water with organic nitrogenous compounds. Such organic material could possibly have been derived

from seepage water from the milk factory effluent ponds. Lower down at Station 11B there were fewer nitrogen heterotrophic Nitzschiae (11.1%), which suggested that some self-purification had apparently taken place between these two stations, resulting in only a mild enrichment of the water at Station 11B. In this regard Hynes (1963: 102) remarked that milk wastes are readily decomposed. At Station 11C there were once more high relative densities of the nitrogen heterotrophic Nitzschiae (21.8%) indicating organic nitrogen enrichment of the water. It was possible that seepage water from the textile factory effluent ponds had affected the river at this point, however, no effects from these ponds could be detected at Station 11B. Chutter's chemical analysis shown above suggested that at 11A and 11B there was some seepage of organic material into the river at these two stations. This supported the diatom evidence. Further evidence in support of the conclusions drawn from the diatoms was obtained from Chutter's faunal observations. Chutter (1967: 65) claimed that the fauna strongly suggested an abnormal chemical quality of the water.

Station No. 12.

Locality: This station occurred just below the confluence of the Cornelius River, where the Warden - Reitz road crosses the Wilge River. One sample was collected in September 1958.

Chemical Data: Nil.

Diatom Analysis: Table 45.

Comments: At this station, also, the Cymbella dominant association of Station 3 was observed. This association, with its high numbers of katharobic Cymbella species, and the high relative density of

Achnanthes minutissima (22.6%), indicated a stable and unpolluted water. The relatively low numbers of nitrogen heterotrophic Nitzschiae (10.2%). The organically rich water at Harrismith was apparently no longer detectable at Station 12, the river having undergone self-purification.

he Wilge River before the Confluence of the Liebenbergsvlei River.

Locality: This sampling point occurred just before the confluence of the Liebenbergsvlei River with the Wilge River, where the road from Frankfort to Reitz crosses the Wilge River. One sample was collected in July 1958.

Chemical Data: Nil.

Diatom Analysis: Table 46.

Comments: 84.4% of the diatom association was composed of oxygen indicators, Achnanthes and Fragilaria, this led to the conclusion that the water was very well oxygenated. The correspondingly low relative densities of the nitrogen heterotrophic Nitzschiae (6.0%) indicated very small concentrations of organic nitrogen present in solution. The water at this point in July 1958 was therefore of excellent quality.

Station No. 13.

Locality: Two samples were collected from this locality. Vaal 335 was collected at the actual site of Station 13; but the precise locality of Vaal 231 is not known although it was collected by Chelnoky from Frankfort.

Chemical Data:

	max.	min.	ave.
Malan:- Total Dissolved Solids	212	65	124
Total alkalinity (as CaCO_3)	170	35	86
Total Hardness (as CaCO_3)	150	35	75
Chlorides (as Cl)	15	4	9
Sulphates (as SO_4)	20	8	14
Sodium (as Na)	13.5	2.3	5.4
Chutter:- pH	8.6		
Total Nitrogen	3.5		
Kjeldahl N.	1.7		
Nitrite & Nitrate N.	1.8		
O ₂ Absorbed	3.9		

Diatom Analysis: Table 47.

Comments: In both samples the numbers of Achnanthes minutissima (21.6% and 48.3%) indicated a good oxygenation of the water, with a greater concentration of oxygen in September 1958. The relative densities of the katharobic Cymbella microcephala in the two samples (15.4% and 22.5%) supported this conclusion. However while showing similarities in this factor, they were quite widely different in respect to the nitrogen heterotrophic Nitzschiae. In July 1958 the nitrogen heterotrophic Nitzschiae (37.2%) were plentiful and this indicated a fairly heavy pollution due to organic nitrogenous materials. On the otherhand in September 1958 nitrogen heterotrophic Nitzschiae numbers had decreased to 1.7% of the association, thereby indicating a sharp drop in the concentration of organic nitrogen. What caused this sudden decrease in concentration was not clear.

(b). The Tributaries of the Wilge River.

The Elands River.

Locality: The precise locality of these sampling points is not known, but Cholnoky's samples, Vaal 203 and 204, were collected from the Witzieshoek area in the vicinity of Station 38, either from the Elands River itself or from its tributaries. Both samples were collected in July 1957.

Chemical Data: Nil.

Diatom Analysis: Table 48.

Comments: The associations of both samples were somewhat similar in their general characteristics, and again the Cymbella dominant association was present, although not so well developed. The katharobic Cymbella species in association with Achnanthes minutissima were indicative of stable environmental conditions, in which the water was alkaline, well oxygenated and comparatively unpolluted with organic material. In one sample (Vaal 203), however, the nitrogen heterotrophic Nitzschiae (11.3%) indicated a concentration of organic nitrogen, which was raised to a slight degree. In sample Vaal 204 the low relative density of nitrogen heterotrophic Nitzschiae concurred more with the indications given by the katharobic species.

The Klerkspruit River - Station No. 40.

Locality: The Klerkspruit River is a tributary of the Elands River, and Station 40 was situated near Kestell, where the river is crossed by the Harrismith - Kestell road. One sample was collected at this station in October 1958.

(78).

Chemical Data:

	max.	min.	ave.
Malan:- Total Dissolved Solids	239	106	168
Total alkalinity (as CaCO_3)	194	64	133
Total Hardness (as CaCO_3)	157	55	110
Chlorides (as Cl)	18	7	10
Sulphates (as SO_4)	10	3.2	5.4
Sodium (as Na)	30	10	19

Diatom Analysis: Table 49.

Comments: Here also the high relative densities of Achnanthes minutissima (32.5%), Cymbella amphicephala (14.7%) and C.microcephala (32.5%) indicated alkaline, well aerated and clean water, and a stability of the environment. The low numbers of nitrogen heterotrophic Nitzschiae (6.3%) indicating very small concentrations of organic nitrogen supported this conclusion. Malan's chemical analysis suggested a well buffered alkaline water, which supported the diatom evidence.

The Russespruit River.

Locality: Two samples were collected from the Russespruit River, a tributary of the Wilge River. Sample Vaal 249 was collected in July 1958 near the source of the Russespruit River, where the Bethlehem - Warden road crosses the river, and sample Vaal 363 was collected from Station 41 in February 1959 near its confluence with the Wilge River, where the Warden - Reitz road crosses the Russespruit River.

<u>Chemical Data:</u> Chutter:- pH	8.5
Total Nitrogen	3.8
Kjeldahl N.	2.8
Nitrite & Nitrate N.	1.0
O ₂ Absorbed	7.8

Diatom Analysis: Table 50.

Comments: At the headwaters of the Russespruit River (Vaal 249) in July 1958, the numbers of Achnanthes minutissima (11.8%) indicated a reasonable concentration of dissolved oxygen in the water. The relatively low numbers of nitrogen heterotrophic Nitzschiae (10.3%) together with the high relative density of Gomphonema parvulum (21.0%) and the presence of Navicula seminulum (2.2%) indicated fairly low, but fluctuating organic nitrogen concentrations, which sometimes reach quite high values.

Near its confluence, however, in February 1959 (Vaal 363) the quality of the water was not as good. Here the large numbers of nitrogen heterotrophic Nitzschiae (43.7%) suggested a relatively heavy enrichment of the water by organic nitrogenous compounds. As a result there was a corresponding decrease in numbers of oxygen indicators so that Achnanthes minutissima (0.0%) had disappeared. However while this indicated a very low oxygen concentration, the presence of Nitzschia palea (21.9%) and absence of N.thermalis indicated that anaerobic conditions were not experienced.

The Molen, Cornelius and Holspruit Rivers.

Locality: These three rivers flow from east to west to join the Wilge River and drain the district around Warden, through which the Cornelius River flows. One sample was collected from each of these rivers. In September 1958 Chutter collected a sample (Vaal 336) from the Molen River at Station 14, where the Harrismith - Warden road crosses the river. The remaining two samples were collected by Cholnoky in July 1958, one from the headwaters region of the Cornelius River, where it is crossed by the Harrismith - Memel road, and the other (Vaal 253) from Station 36 on the Holspruit River,

where it is crossed by the Warden - Vrede road.

Chemical Data: Nil.

Diatom Analysis: Table 51.

Comments: The diatom association from the Molen River was composed mainly of (a) Cyclotella comensis (25.3%) which may indicate the presence of a relatively quiet pool, promoting the growth of plankton, and (b) a variety of katharobic species such as Achnanthes, Cymbella and Fragilaria species, which indicated a relatively stable, well oxygenated and clean environment. The low numbers of nitrogen heterotrophic Nitzschiae (8.4%), pointing to low organic nitrogen concentrations, supported this conclusion.

The Cornelius River near its headwaters was dominated by Navicula cryptocephala, which indicated an alkaline slightly mesotrophic to oligotrophic water. Evidence for a mesotrophic nature of the water was enhanced by the relatively high numbers of nitrogen heterotrophic Nitzschiae (13.9%).

At Station 26 on the Holspruit River the association was rather confusing as it provided elements for a clean water with a reasonably high oxygen concentration (Cymbella Kappii 12.0% and Nitzschiae linearis 22.9%), and elements for an organically polluted water (nitrogen heterotrophic Nitzschiae 32.6%). The reasons for this were not clear, but it may be the early stages of a transition of a clean water association to a polluted water association.

The Liebenbergsvlei River.

Locality: All the samples in this group were collected from small tributaries of the Liebenbergsvlei River. Vaal 236 was a small tributary just outside the village of Tweeling on the road to Frankfort. Vaal 239 and Vaal 364 were two samples collected from the As River,

near its confluence with the Liebenbergsvlei River (Vaal 239), and near its source (Vaal 364: Station 43). Vaal 242 was collected from a tributary of the As River, and finally Vaal 245 was collected from a tributary of the Tier River, which flows into the Liebenbergsvlei River.

Chemical Data: Nil.

Diatom Analysis: Table 52.

Comments: On account of the large numbers of Achnanthes and Cymbella spp. in sample Vaal 236 the water appeared to be of good quality, containing a high concentration of oxygen, and little or no organic nitrogenous matter in solution. The relatively small numbers of nitrogen heterotrophic Nitzschiae (11.2%) confirmed this.

The associations found in the As River reflected apparently good quality water. The high numbers of Nitzschia linearis (64.2%) in sample Vaal 239, and the relatively high numbers of Achnanthes linearis (21.5%) and A. minutissima (36.4%) in Vaal 364, indicated a high dissolved oxygen concentration in the water. Correspondingly low relative densities of the nitrogen heterotrophic Nitzschiae in both samples (3.2% and 5.7%) indicated small concentrations of organic nitrogen.

In sample 242 the high numbers of Nitzschia linearis (44.8%) indicated well oxygenated water, while the relative density of the nitrogen heterotrophic Nitzschiae (39.7%) indicated enrichment of the water with organic materials. This high organic nitrogen content had, however, no effect on the main stream of the As River.

In sample Vaal 249 the presence of Navicula cryptocephala (43.6%) in high numbers indicated an alkaline and relatively mesotrophic water. This was confirmed by the high numbers of nitrogen heterotrophic Nitzschiae (39.9%) which reflected a reasonably high concentration of organic nitrogenous materials.

F. DISCUSSION.

1). General Summary.

In the preceding paragraphs the ecological conditions at each sampling point or station have been discussed in detail. It remains only to summarise the conclusions drawn from the chemical and diatom analysis, and evaluate the conditions found at these points. In this way an attempt will be made to draw up a co-ordinated picture of the conditions which prevailed at the time of the survey.

(a). pH. The evidence presented by the diatom associations indicated that the river water in practically the whole of the Vaal Dam catchment area was alkaline and well buffered. This was confirmed by the predominance of calcium and magnesium bicarbonates in all the rivers (Table 9). The mean pH value for each station ranged between pH 7.2 and pH 8.2 (Table 10). At certain points in the catchment area the diatom associations suggested differences in the mean pH range from that generally found in the catchment area.

The acidophilic association found at Station 1 led to the conclusion that the pH of the water was below pH 7.0. Chutter's measurement, maximum - pH 6.8 and minimum - pH 5.8, confirmed this conclusion. The acidic conditions were probably due to a large extent to the marshy nature of the locality. Certain acidophilic species, present in small but significant numbers, were also found at Station 20. This suggested that marshy conditions occurred at the headwaters of the Kleinvaal River influencing the pH at Station 20 so that it occasionally dropped to below neutral point (Table 10).

At Station 17 and in a small tributary of the Vaal River near Standerton (Vaal 414) the numbers of Amphora veneta (54.6% in Vaal 414) suggested that the pH occasionally rose well over pH 8.0. Measurement of the pH revealed that this was true.

(b) Organic nitrogen concentration and Water Quality.

Map 3 shows the distribution of the nitrogen heterotrophic Nitzschiae, each dot representing one sample. Since the nitrogen heterotrophic Nitzschiae are regarded as indicators of organic nitrogen pollution, this map reflects the quality of the water in the catchment area.

(i) The Vaal River.

Evidence from the diatom associations indicated that the quality of the water in the Vaal River was, on the whole, good. However, there were certain points which showed evidence of localised pollution or enrichment. At Station 1 and 2A the diatom associations provided evidence for a natural enrichment of the water with organic materials. This enrichment was probably dependant on a seasonal variation in the organic nitrogen concentration; this will be discussed later. The diatom associations from Station 4, showed that at Standerton the organic nitrogen concentrations were variable, but generally high. The organic pollution was probably derived from the can washing effluent, which is pumped into the river at this point. Chemical analysis of the water at Station 4, however, was unable to confirm this conclusion, since the effects of the effluent on the chemical quality of the water could not be detected. On the otherhand Chutter's observation that "the most marked changes in the fauna of a sediment, due to an effluent, was found at Station 4" (Chutter 1967: 206), supported the diatom evidence.

Similarly at Station 5A the chemical analysis of the water was unable to confirm the diatom evidence of large fluctuations in the organic nitrogen concentration.

Station 5 was interesting since here the opposite case was observed. While the chemical analysis of the water showed higher

than normal concentrations of nitrogen, the diatom associations indicated a stable environment which was not polluted, containing little or no nitrogen. Chutter (1967: 109) supported the diatom evidence by observing that the fauna of this station showed little change.

(ii). Tributaries of the Vaal River.

In considering the tributaries of the Vaal River, the Waterval River will be dealt with as a separate entity. In the remaining tributaries, Kaffirspruit, Blesbok, Kleinvaal and Klip Rivers, the diatom associations showed some evidence for a possible seasonal variation.

During the winter months the quality of the water at most sampling points on the tributaries of the Vaal River was good, the diatom associations showing low organic nitrogen concentrations. Exceptions to this, however, were found at one or two places. On the Kaffirspruit near Ermelo (Vaal 489) and at Memel on the Klip River the diatoms indicated organic pollution, particularly at Ermelo, where the relative density of the nitrogen heterotrophic Nitzschiae was 48.4%. The source of pollution in both these instances was probably organic waste matter derived from the town or village concerned. Station 20 near the headwaters of the Kleinvaal River also appeared to contain large concentrations of organic nitrogen in winter (Table 23). A similar situation was observed at Station 1.

Many of the smaller tributaries of the Klip River, and some of the smaller tributaries of the Vaal River (e.g. Vaal 414, 415, 419 and 478), were observed to have diatom associations indicating enrichment of the water with organic nitrogen during the winter months. In this regard it must be remembered, however, that in the winter or dry season many of these small streams are either reduced to a mere

trickle, or dry up completely leaving only isolated pools.

Under such circumstances small amounts of organic nitrogenous materials could give rise to highly magnified concentrations of organic nitrogen. On entry into the main stream with subsequent dilution, these small amounts of organic matter would have little effect on the quality of the water. If this is the case the winter pollution aspect of these tributaries was not as ominous as it appeared at first glance.

The diatom associations from the samples collected in the summer months, led to the conclusion that at certain sampling stations the organic nitrogen concentration increased during the rainy season of the year. Thus at Stations 19, 24, 25 and 31 the diatoms indicated very much larger concentrations of organic nitrogen in the summer or wet season than in the winter or dry season. At Station 20 the picture was not clear, and it is possible that, although the organic nitrogen concentration is high in summer, the concentrations in winter were generally relatively higher than in summer. This would again parallel the situation at Station 1.

The available chemical evidence from stations on these tributaries provided no real support for any seasonal variation, nor could it show any unduly high concentrations of organic nitrogen at any of these stations. At Station 19, however, the chemical analysis showed a reasonably large fluctuation of the nitrogen concentrations, in which some of the highest values were recorded in the summer months.

(iii). The Waterval River.

The diatom associations found in the Waterval River indicated that the whole river was to some extent organically polluted. Effluents from the developing gold mines, and sewage works effluents from the mine settlements in the headwaters region of the Waterval River, appeared to have caused the high pollution at Station 17, the point just below the gold mines. The diatom associations indicated a variable organic nitrogen concentration, which was generally high. The relative densities of the nitrogen heterotrophic Nitzschiae in many of the samples from Station 17, particularly Vaal 497, were comparable to those found in the highly polluted Bloukrans River (see Part 1). The chemical analysis of the water at Station 17 lent support to the idea of pollution at this point since the water was enriched with nitrites and nitrates. Furthermore the mean value for the 4-Hour oxygen absorbed from potassium permanganate test at Station 17 was, with the exception of Station 1, the highest recorded in the catchment area.

The high organic nitrogen concentrations at Station 17 appeared to influence the lower regions of the river, since at Station 7 the organic nitrogen concentration, although reduced, was still relatively high. The presence of Gomphonema parvulum and Navicula muralis provided evidence for the processes of self-purification. The quality of the water some distance below Station 7 (Vaal 410, 553) was very similar to that of Station 7. The influence of some of the smaller tributaries of the Waterval River on the main stream itself was probably slight, although in some cases they might serve to maintain the high level of organic nitrogen in the river.

Polluted as the Waterval River may have been, it did not appear to have affected the quality of the water entering the

Vaal Dam, since at Villiers (Station 6) below the confluence of the two rivers, there was no evidence for any high concentration of organic nitrogen. Although Chutter (1967: 206) observed the largest and most permanent changes in the chemical quality of the water in the Waterval River, he was unable to demonstrate any effects of this change on the fauna.

(iv). The Kalk River.

The diatom analysis showed that, although there was evidence for some organic enrichment of the water in Grootvlei Dam (Station 16), this had been removed from the water by the time it had reached Station 15.

(v). The Wilge River System.

In the Wilge River System most of the samples were collected in winter, resulting in general impressions of the winter conditions only. In general the quality of the water in the Wilge River System, as indicated by the diatom association, was good. Some isolated points of enrichment were, however, evident. Station 10 at Swinburne provided evidence for some enrichment, which was probably caused by the hotel situated on the river bank just above the sampling station.

At Harrismith enrichment of the water due to seepage from the effluent ponds of the milk processing factory, and lower down due to seepage from the effluent ponds of a textile factory, was indicated by the diatom associations. The scanty chemical evidence available (Table 11), and the results of Chutter's faunal analysis also indicated the alteration of the chemical quality of the water. However, whatever organic enrichment occurred at Harrismith, it did not appear to affect the quality of the water below Harrismith to any extent. At Station 12 only small concentrations of organic

nitrogen were indicated.

The conditions of the water at Frankfort (Table 47) was confusing, since the two samples collected at this point reflected the opposite conditions; the one sample (Vaal 231) indicated high organic nitrogen concentrations, while the other reflected low concentrations (Vaal 335).

The diatom associations from the tributaries of the Wilge and Liebenbergsvlei Rivers (no diatom analysis available for the Liebenbergsvlei River itself) indicated a few isolated points of organic enrichment. Since these points were not in the immediate vicinities of any town or villages, the organic enrichment was probably natural in origin, and apparently had little effect on the quality of the water in the Wilge and Liebenbergsvlei Rivers.

The paucity of diatom samples did not permit an accurate assessment of the quality of the water entering the Vaal Dam via the Wilge River System. However with the limited information available it would appear that the quality of the water in the Wilge River System is fair.

(c). Dissolved Oxygen Concentration.

The dissolved oxygen concentration of the water in the Vaal Dam catchment area rivers was generally high. This was indicated by the large numbers of samples in which the oxygen indicators Achnanthes, Cymbella and Fragilaria were dominant in the associations. Wherever low oxygen concentrations were observed, they were normally the result of high organic nitrogen concentrations, which require greater amounts of oxygen for their oxidation. However at no point in the catchment area were conditions ever anaerobic, since no samples reflected the presence of any specimens of Nitzschia thermalis in

the Thomasson Analyses. In the Waterval River which has been shown to be organically enriched throughout its course, the oxygen concentrations at all sampling points appeared to be low.

(d). Salt Concentration.

Diatom and chemical evidence both showed that only two localities had salt concentrations which were higher than normal. One was Grootvlei Dam, whose water was mineralised due to the effluents from the Springfield Colliery. The other was the Waterval River, which received effluents from the developing gold mines, whose mineralised effluents caused a rise in the salt concentration in the Waterval River. In all other parts of the catchment area salts were found in small concentrations only.

It is clear from the points discussed above that the water, entering the Vaal Dam via its two main river systems, The Vaal and Wilge Rivers with their tributaries, was of good quality. Points of pollution in the catchment area did occur, but were localised, and the organic nitrogenous materials were soon removed either by self-purification or by dilution on entering the main river of the system, where it encountered larger volumes of water.

In the results the diatom associations were discussed in relation to available chemical evidence, and Chutter's observations on the fauna of the catchment area. It became apparent that conclusions drawn from the diatom associations agreed well with Chutter's observations on the quality of the water using the fauna as indicator organisms, but was at variance with the chemical evidence. It was therefore evident that biological indicators were more reliable in determining the chemical quality of the water than the chemical

analyses of the water, since chemical analyses were very often unable to reflect sources of pollution (e.g. Station 4). However in view of Chutter's comment that the faunal changes due to the effects of the effluents were only minor (Chutter 1967: 204), it might be true to say that the diatom associations were more sensitive to changes in the chemical composition of the water, thus reacting to changes in a relatively shorter period of time. This might account for the discrepancies found at Station 5 and 5A between the conclusions of this survey, and the findings as indicated by Chutter's faunal survey.

2). Seasonal Variation.

In the course of this investigation it became apparent that there was some evidence for a seasonal variation of the species in the diatom associations at certain stations. The evidence for this was admittedly slender as no proper investigation into seasonal variation was planned. However at a number of stations it so happened that at least one sample was collected from these points in both summer and winter. Table 53 reflects the analysis of the winter and summer associations of various stations. It is clear from the dates of collection of the samples that, while the samples were collected in summer or winter, the year of collection and the time period elapsing between two associated samples, was very variable. In some cases the time interval was six months between collections, while in others the time interval was eighteen months. For this reason the evidence was not regarded as foolproof, but rather as an indication of a seasonal variation.

A study of Table 53 revealed that the two groups most affected by the apparent seasonal variation were firstly, the oxygen indicators Achnanthes, Cymbella and Fragilaria, and secondly the organic nitrogen indicators, i.e. the nitrogen heterotrophic Nitzschia. The other species in the associations showed no apparent seasonal trend, but in some instances species of Cymbella showed slight indications of higher numbers in winter than in summer. The table also revealed that the trend at Station 1 was the reversal of the trends found in the other samples. Furthermore Station 21 was the only sample which did not reflect a seasonal variation.

At Station 1 the greater numbers of nitrogen heterotrophic Nitzschia in winter (Vaal 479) indicated that the organic nitrogen concentration of the water was higher in winter than in summer. This has already been explained by Chutter, who claimed that in the dry season (winter) cattle and sheep used this marshy sponge as a drinking trough and source of food, and in so doing polluted the water with their waste products. A similar situation probably existed at the headwaters of the Kleinvaal River near Station 20.

At all other stations, except Station 21 which showed no seasonal variation, the opposite trends were observed. In the winter or dry season it was found that Achnanthes and Fragilaria species were present in the associations in relatively greater numbers than in the summer or rainy season. On the otherhand the nitrogen heterotrophic Nitzschia composed the greater part of the diatom associations in summer, while the proportions were considerably reduced in the winter periods. Thus the diatom associations indicated the following seasonal pattern:- In winter the water contained greater amounts of dissolved oxygen and a relatively low concentration of organic nitrogen. In summer the concentrations of organic nitrogen rose to high levels, and was accompanied by a corresponding decrease in the dissolved oxygen concentrations of the water.

Can this seasonal variation be explained? The following hypothesis is put forward as an attempted explanation of the trends described above. During the dry season many of the smaller streams dry up, leaving only the marshy sponges, from which most of these small streams originate, as the only natural source of water for livestock. Waste products from the livestock, enriching the water with organic nitrogen, are accumulated in the sponges as there is no water flow to carry this enrichment away. This accumulation is further supplemented by organic matter derived from plant decay in the sponges. Such conditions would give rise to high organic nitrogen concentrations, such as were observed at Station 1, and possibly Station 20. This results in high numbers of nitrogen heterotrophic Nitzschiae during the winter in the sponges.

Meanwhile in the surrounding countryside plant material undergoes organic decay during the winter, but due to the low rainfall in winter only small amounts of this organic matter reach the streams through surface run off. This would explain the low numbers of nitrogen heterotrophic Nitzschiae found in many of the samples collected from the streams and rivers in the winter.

However with the coming of the heavier summer rainfall, the accumulated organic nitrogen in the sponges would be flushed out, decreasing the organic nitrogen concentration in the sponges, while increasing the concentration in the streams. The increased organic nitrogen content of the streams is supplemented by the greater loads of organic matter carried into the streams by the increased surface run off from the surrounding country-side. Consequently in the sponges, such as at Station 1, the numbers of nitrogen heterotrophic Nitzschiae drop in summer, while in the streams and rivers the numbers increase considerably.

Since oxygen is required for bacterial decomposition of organic material (Hynes 1963: 58), greater amounts of oxygen would be required in summer when the organic nitrogen content is highest. This increased oxygen demand in summer could reduce the concentration of oxygen available to the diatoms to a level below the optimal requirements of the oxygen indicators, resulting in a decrease of their numbers in summer. This could explain why the numbers of Achnanthes and Fragilaria were lower in summer than in winter.

The hypothesis as set out above appeared to fit the observations of a seasonal variation in the species composition of the diatom associations. This seasonal variation appeared to be indirectly influenced by the climate and particularly the rainfall of the Vaal Dam catchment area. However this whole question of seasonal variation needs greater and more intensive investigation before any definite opinions can be formed. At present all that can be said is that, in the Vaal Dam catchment area, there is some evidence, which points to a seasonal variation of the species composition in the diatom associations.

3). The Diatom Associations of the Vaal Dam Catchment Area.

The Vaal Dam catchment area developed two distinct types of diatom associations, the one an alkaliphilic association and the other an acidophilic association. While the alkaliphilic associations were found over practically the whole catchment area, there was only one locality which produced a true acid water association, viz. Station 1.

The acid water associations at this station were characterised by the typical acidophilic - acidobiontic species such as species of

Eunotia, Frustulia rhomboides var. saxonica, Surirella delicatissima var. africana, and some Pinnularia species. These acid water indicators were further supported by the presence of the less common acidophilic species such as Achnanthes microcephala, Caloneis Chasei, Cymbella gracilis, Navicula subtilissima and Nitzschia gracilis, all of which occurred in relatively significant numbers in the associations. This type of association was limited to Station 1, and although some of these acid water species were observed at other sampling points in the catchment area, a true acid water diatom association was not found elsewhere.

With the exception of Station 1, all the diatom associations found in the Vaal Dam catchment area were alkaliphilic. These diatom associations differed from sampling point to sampling point depending on the environmental factors prevalent at the station concerned. On the whole the species composition of the associations was similar throughout the catchment area, and it was therefore mainly the proportions in which the species occurred, which were affected by the environmental factors.

One of the most interesting diatom associations observed in the catchment area was first seen at Station 3 (Table 16). This type of association was dominated by species of the genus Cymbella, and was in most cases accompanied by relatively high numbers of Achnanthes minutissima. Other species such as Navicula cryptocephala, N.rhynchcephala, N.tenella, N.Zanonii, Nitzschia interrupta, and N.linearis were almost invariably present in the same association. The numbers of nitrogen heterotrophic Nitzschiae were always very low. The katharobic nature of many of these species, and the low numbers of nitrogen heterotrophic Nitzschiae in this type of association would

indicate a stable, unpolluted and alkaline environment. Similar associations were observed by Cholnoky (1958A: 239) in the Jukskei - Crocodile River system near Johannesburg; and these, he claimed, were indicative of stable, katharobic conditions.

The Cymbella dominant associations were found at many stations in the catchment area, and Table 54 reflects the composition of the associations found at these stations. It is clear from this table that the most important Cymbella species were Cymbella amphicephala, C.Kappii and C.microcephala, and in most cases at least one of these three examples was the dominant species in the association. A similar type of association was observed at other sampling points. In these associations the species composition remained the same, but Achnanthes minutissima was the dominant species, and the Cymbella species, while still present in high numbers, were reduced in importance. Examples of this type of association can be seen at Station 13 (Vaal 335), Station 17 (Vaal 337) and Station 18. Ecological conclusions drawn from the latter type of association would be very similar to those drawn from the former associations.

Table 54 also showed that the Cymbella dominant associations were all collected in the winter months of August and September. It is therefore possible that these Cymbella dominant, and sometimes Achnanthes dominant, associations composed a basic association, which would be found at any stable unpolluted and alkaline sampling point in the catchment area during winter. Any changes away from the stable winter conditions at any point would be reflected by a change in the relative proportions of the different species in this basic association.

This suggested the following hypothesis, which, it must be remembered, is set up only for the diatom associations found in the

Vaal Dam catchment area. During the winter months, wherever stable, unpolluted and alkaline environmental conditions are experienced, a basic association of diatoms, which acted as a species pool, is developed. This basic association is composed firstly of those species which are dominant; secondly certain species, which, although present in smaller proportions, are also indicative of the stable unpolluted conditions; and finally of other species, such as the nitrogen heterotrophic Nitzschiae, which are present in very small numbers. In the Vaal Dam catchment area this basic association consists of Cymbella species or Achnanthes minutissima as dominants, together with the less common constituents, Navicula cryptocephala, N.rhynchocephala, N.Zanonii, Nitzschia interrupta and N.linearis, and finally low numbers of nitrogen heterotrophic Nitzschiae. As long as the conditions remain the same, stable and unpolluted, this basic association is found.

When a change of the quality of the water due to natural or human agencies is encountered, it appears that the first group to be affected is the Cymbella species. As the organic nitrogen concentration increases the numbers of nitrogen heterotrophic Nitzschiae rise to the detriment of the Cymbella species which are reduced in numbers. This process continues until the nitrogen heterotrophic Nitzschiae become dominant and the Cymbella species are reduced in numbers or eliminated completely. These processes can be seen to work at a number of places in the catchment area. At Station 4 on two occasions during winter this basic winter association was found (Table 17: Vaal 313 and 416), however, when the quality of the water changed, the numbers of Cymbella species decreased, with a corresponding increase in the numbers of nitrogen heterotrophic Nitzschiae (Vaal 315 and 316).

Similar situations were observed at Station 19 (Table 21), where the change was induced by the apparent seasonal increase in the organic nitrogen concentration in summer, and at Roodebank (Table 37; Station 17), where the change was probably due more to pollution of the water by mine and sewage works effluents.

Alteration of this basic association can proceed in a different direction. This was observed whenever the water, for some reason, was extremely well oxygenated. The basic association is changed by an increase in the proportions of the oxygen indicators, and Achnanthes minutissima becomes quite clearly the dominant species of the associations. The numbers of Fragilaria species also rise and are sometimes found to be co-dominant with Achnanthes minutissima. Once again the increase in the proportions of the oxygen indicators resulted in a very marked drop in the proportions of the Cymbella species. Examples of this can be found in Tables 13, 14, 15, 22, 24, 25.

At the sampling points where this basic association has been altered due to organic pollution effects, the resulting associations were dominated by or composed to a large extent of the nitrogen heterotrophic Nitzschia. Nitzschia fonticola, N. Kützingiana, N. palea, N. perminuta and sometimes N. romana form the bulk of this group, and were all indicators of eutrophic water caused by organic materials. In many cases, although the organic pollution appeared to be high, the relatively high numbers of Achnanthes minutissima in the associations indicated a good degree of dissolved oxygen in the water. In the associations indicating organic pollution Gomphonema parvulum was frequently found in high numbers. However the development of Cholnoky's G. parvulum, Navicula seminulum, N. muralis association, indicating a fluctuating organic nitrogen concentration due to self-purification processes, was poor. Evidence

for this type of association was observed in very few samples.

Although the composition of the diatom associations varied from sampling point to sampling point within the catchment area the associations found in both the major basins of the catchment area, i.e. the Vaal River basin and the Wilge River basin, were extremely similar. This provided evidence for the presence of more or less similar environmental conditions in both major basins.

G. CONCLUSIONS.

1). The diatom evidence has shown that similar environmental conditions were experienced in both the Vaal River and Wilge River Systems. These associations indicated further that the water entering the Vaal Dam from the catchment area was of good quality.

2). With the exception of the Waterval River, sources of pollution were found at Ermelo, Standerton and Harrismith. However the effects of this pollution were localised, and were soon removed by self-purification, or by dilution in the main river. The Waterval River was organically enriched by the effluents of the gold mines throughout its length, but this enrichment did not appear to affect the quality of the water in the Vaal River, as very little organic nitrogen was detected at Villiers (Station 6).

3). Evidence for mineralisation of the water was found only in the Grootvlei Dam, receiving effluents from the Springfield Colliery; and in the Waterval River, which received mineralised effluents from the gold mines.

4). Conclusions drawn from the diatom evidence were not always supported by the chemical analysis of the water. However Chutter's faunal studies confirmed much of the diatom evidence. Thus it appeared

that in the Vaal Dam catchment area, biological analyses were more reliable than chemical analyses for the detection of pollution.

5). Evidence for a possible seasonal variation of the species in the diatom associations was observed. This seasonal variation was dependent on the organic nitrogen in the water, which in turn was dependent on the rainfall.

6). A study of the diatom associations suggested a basic association which is found at any stable, unpolluted and alkaline environment. Changes in the environment resulted in the alteration of the proportions in which the species occurred in the associations; and in this manner changes in the quality of the water could be detected.

(100).

PART 3.

The Systematics and Taxonomy of the Diatoms of the
Vaal Dam Catchment Area.

A. INTRODUCTION.

One of the basic requirements in an ecological study is the necessity of identifying the organisms being studied as accurately as possible. Without an accurate definition of the subject organisms, an ecological study is practically valueless, since different conclusions can be drawn from two different species, even though, morphologically, they may appear to be quite closely related. The science of systematics and taxonomy deals with the precise description and naming of organisms, and their inter-relationships.

Part 3 deals with the systematics and taxonomy of the diatom species found in the Vaal Dam catchment area. In this section each species was discussed in relation to its systematics, as well as its autecology. In commenting on the various species the reference to the original description of the taxon was given wherever possible. This was followed by references to more recent and more complete descriptions of the taxon. Following these references a list of synonyms was cited for the taxon, and where the synonyms were extremely numerous a note has been made stating where a complete list of synonyms can be found. Any taxonomic or systematic comments on the taxon followed the list of synonyms. In the case of a new taxon the description was written directly after the taxonomic comments. In this regard the Latin diagnoses for the new species have been omitted, so that these descriptions are not to be regarded as the valid descriptions of the species. The formal description containing the Latin diagnoses will be published later in a recognised journal. Wherever possible comments on the autecology of each taxon came after either the taxonomic comments or the description of a new species. Drawings of taxa having interesting features, or which were described as new, have been made, and these have been illustrated in the

plates (Figs. 1 - 276).

Since most of the literature used in the identification of the diatoms was written by Hustedt and Cholnoky, who follows Hustedt's system, the classification set out by Hustedt in "Die Süßwasserflora Mitteleuropas", Heft 10; Bacillariophyta (Hustedt 1930) has been followed. However, following Cholnoky (1960A: 13), in commenting on the diatoms the arrangement of the genera and the species within the genera is alphabetical. This arrangement was adopted for two reasons:-

1) because on practical grounds it is a simpler method for later use in seeking information on any particular species, and,

2) since Cholnoky (l.c.) did not regard the phylogeny of many of the genera to be satisfactorily determined.

In an attempt to clarify the concept of variety and form within the diatoms, Hustedt (1937B) has reviewed the variability of diatoms and the underlying causes of this variation, and has summarised his findings as follows (Hustedt l.c.: 192):-

- 1). Diatom variations can only be regarded as varieties, when they remain constant in a hereditary sense; i.e. under different environmental conditions, the abnormal character does not show a series of transitional forms to the typical form of the species. The majority of abnormalities which have hitherto been described as varieties do not conform to this requirement and should therefore be retracted into the species or regarded as forms.
- 2). Abnormalities resulting regularly from the mode of division are differentiated neither as varieties nor as forms, but should be regarded as within the species range.
- 3). In an ecological variation series only the outer extremes (Grenzformen) should be designated as forms. Structural variations

should be treated in this manner, or should remain disregarded.

4). Anomalies should remain unnamed.

During the course of the early part of this study two papers dealing with the systematics of the diatoms from the Vaal Dam catchment area were published (Archibald 1966A and C). Species described in these two papers have been acknowledged in this report under the author's name with the reference to the original description. The descriptions of these species have been repeated here, but with amendments due to further information acquired by observing additional specimens. No species have been described without prior consultation with Dr. B.J. Chohnoky.

B. SYSTEMATICS AND TAXONOMY.

The following species have been recorded from the Vaal Dam catchment area:-

ACHNANTHES Bory 1822.

A.adamantiformis Archibald nov.comb.

Synonyms: Navicula adamantiformis Archibald.

This species was first described as a small Navicula, N. adamantiformis (Archibald 1966:256,F.6,5.), since only the rapho valve had been studied. Later, however, some cells were found which contained both areo- and rapho valves. It was quite evident, therefore, that this was not a Navicula and must be redescribed as a new Achnanthes species. This new species bears a resemblance to A.latissima A.Cleve but differs from it in shape, having slightly produced poles, size and finer sculpturing of the valve wall. It has also some slight similarity to A.montana

Krasske and A.lacunarum Hustedt, but again the new species differs in the structure of the valves and its dimensions.

The valves of A.adamantiformis are broadly rhombic-elliptical, with in most cases slightly apiculate or rostrate poles. The length of the valves is 6 - 6.5 μ , and the width 4.5 - 5.0 μ . The rapho valve: the raphe branches are straight and filiform and have extremely widely separated central pores (about one third of the valve length between the two central pores); due to the shortening of the transapical striae the axial area and central area combine to form a large wide lanceolate area; the transapical striae are radial throughout, extending about one third of the way into the valve, and becoming more radial towards the poles, about 21 - 24 striae in 10 μ ; irregularly shortened striae are usually present. The areo valve; in contrast with the rapho valve, the areo valve has a narrow linear central area or pseudoraphe; the transapical striae are radial throughout and extend right to the apical axis thus forming a very narrow pseudoraphe, about 21 - 24 in 10 μ ; there are no shortened striae in the areo valve. The longitudinal costae are occasionally just visible.

Not enough is known of the ecology of this species to be able to make any comment on this aspect. It was found in small numbers from the Waterval River and one sample from the Vaal River.

Figs. - 1 - 5.

Samples - 316, 324, 339, 340, 401, 403, 553.

A.coarctata (Brebisson) Grunow

1880 - Grunow: Kongl. Sv.Vet. Akad. Handl. 17(2):20.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil
2:419, F.872 a-c.

1930 - Hustedt: Bacillariophyta. P.210, F.308a.

Synonyms: Achnanthidium coarctatum Brebisson;

Achnanthidium otrantinum Rabenhorst; Achnanthes binodis Ehrenberg;

Achnanthes coarctata var. elliptica Krasske.

This species has been found over quite a widespread area of South Africa, particularly in the Oligotrophic rivers with low pH values; under such conditions this species finds its optimum development. In this study it occurred in the Kaffirspruit and Kleinvaal Rivers as single isolated specimens and cannot, therefore, be regarded as autochthonous.

Samples - 353, 489.

A.cogitata n.sp.

This species can only be related to A.adamantiformis nov. comb., which is described above. It might be better to describe these two valves as a variety of A.adamantiformis; however, it differs from A.adamantiformis in two respects. In the rapho valve of A.cogitata, the axial area is narrowly linear with no indication of a central area, while in A.adamantiformis the axial area and central area combine to form a very wide lanceolate area covering one third of the valve surface. The areo valve also differs in structure and has a linear axial area, which widens out into an oval central area; this is not present in A.adamantiformis, in which the linear axial area does not widen into a central area. A.cogitata cannot be associated with any other species of Achnanthes known to the author.

The valves are rhomboidal in shape with rounded ends, and are not protracted; they are about 6 μ in length and 4 μ broad. The rapho valve has a straight filiform raphe which has very short branches, so that the central pores are relatively very widely separated (about one third of the length of the apical axis of the valve). The central pores and terminal pores are inconspicuous. The areo valve has a narrower linear axial area which widens at the centre into an oval central area. On both valves there are 24 transapical striae in 10 μ , which are radial throughout. In the rapho valve there are one or two shortened striae. The longitudinal costae are too fine to be observed.

Figs. - 6 - 7.

Sample - 412.

A.Engelbrechtii Cholnoky.

1955 - Cholnoky: Salzhaltigen Binnengewässern Ber.d.Deutsch.
Bot. Ges. 68: 16, F. 1 - 8.

This small Achnanthes species bears a similarity to A.pinnata Hustedt (1937-1939, Suppl.15:201,T.13,F.54-57), with which it can easily be mistakenly identified. It differs in having more lanceolate valves and a finer structure of the valve surface.

According to Cholnoky (1962 B:60) this species prefers waters with a high pH value and a high osmotic pressure; he has found it in coastal river waters and inland brackish waters (Cholnoky 1960 A:14). It was of rare occurrence in a few samples from the whole catchment area.

Fig. - 8

Samples - 253, 307, 326, 327, 411, 449, 477, 512, 554.

A. exigua Grunow.

1880 - Grunow: Kongl. Sv.Vet.Akad.Handl. 17(2):21.

1930 - Hustedt: Bacillariophyta. P.201, F.286.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil
2:386, F.832.

Synonyms: Stauroneis exilis Kützing; Stauroneis quadrata
Heribaud; Stauroneis tylophora Reichelt; Microneis exigua Cleve;
Cocconeis exigua Torka; Achnanthes exigua var. tenuirostrata
Guermeur; Achnanthes exigua var. tenuistriata Guermeur
(ex Woodhead & Tweed).

Cholnoky (1960 A:14) reported this as a katharobic species
living in neutral to weakly alkaline waters; sometimes found
abundantly in waters in which the pH does not fluctuate to any
great extent (Cholnoky 1966 B:171). It was found in two samples
from the Waterval River as isolated specimens.

Samples - 409, 412.

A. exigua var. heterovalvata Krasske.

1923 - Krasske: Bot.Arch. 3:193, F.9.

1930 - Hustedt: Bacillariophyta. P.202, F.288.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil
2:386, F.832 c-f.

Hustedt (1949:75) has reunited this variety with the
typical form, but in neither Cholnoky's researches nor in this
present study have any transitional forms been seen, which linked
the variety with the typical forms. In the description given by
Hustedt (1927-1964: 386) the rapho valve has about 25 striae in
10 μ and the areo valve 22 striae in 10 μ . The examples of the
var. heterovalvata observed here were found to have 28 - 32 and
20 - 24 striae per 10 μ on the rapho valve and areo valve respec-
tively. On these grounds and on the arguments set out by

Cholnoky (1957 A:39), it is preferable to maintain the var. heterovalvata as distinct from the typical forms.

This variety was observed more commonly than the typical form in many samples. In South Africa it has been found in neutral to weakly alkaline waters, and was able to tolerate small fluctuations of the pH value towards the acid side (Cholnoky 1960A: 14)

A.lanceolata (Brebisson) Grunow.

1880 - Grunow: Kongl. Sv.Vet.Akad.Handl. 17(2):23

1930 - Hustedt: Bacillariophyta. P.207, F.306a

1927 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2: 408, F. 863 a-d.

Synonyms: Achnanthidium lanceolatum Brebisson; Achnanthes Haynaldi var. oblongo-elliptica Schaarschmidt; Stauroneis truncata Schumann; Achnanthes pseudoantiqua Peragallo; Achnanthes Pagesi Peragallo. For further synonyms c.f. Hustedt 1927-1964, Teil 2:408.

Hustedt (1930: 207) erroneously cited Brebisson as the sole author of this species; Brebisson, however, placed this species in the genus Achnanthidium and only later did Grunow (cf. Hustedt 1927-1964, Teil 2: 408) correct this and transfer it to the genus Achnanthes. Hustedt (1937-1939, Suppl. 15:203) described A.lanceolata as "krenophil", but Cholnoky working on the springs of South West Africa and Bechuanaland (Cholnoky 1966 B: 171) found this species in very small numbers (0.3% of the diatom association) in one sample. In this present study in which no springs were investigated, the species although in small numbers occurs over a relatively wide area. A.lanceolata has been reported from neutral waters with fluctuations of the pH toward the acidic side (Cholnoky 1960A: 16; Cholnoky 1962A: 6);

this probably accounts for its scarcity in the samples, as most of the rivers in which it was found had pH values above 8.0.

Samples - 239, 261, 266, 307, 316, 411, 454, 498.

A.lanceolata var. elliptica

1891 - Cleve: Acta Soc. Proc. et Fl. Fenn. 8(2):51, T.3, F.10,11.

1930 - Hustedt: Bacillariophyta. P.208, F.306c.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
410, F.863n,o.

Synonyms: Achnanthes lanceolata var. elliptica f. minor.

This variety has been recorded only from the Hennops River by Cholnoky (1953:139); and was found in the Vaal Dam Catchment Area in five places. Cholnoky's record was the first for this variety from South Africa.

A.lanceolata var. rostrata (Östrup) Hustedt.

1911 - Hustedt: Abh. Natur. Ver. Bremen 20: 279, T.3, F.34.

1930 - Hustedt: Bacillariophyta. P.208, F.306b.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
410, F.863 i-m.

Synonyms: Achnanthes rostrata Östrup; Achnanthes lanceolata var. crassa Cleve-Euler; Achnanthes lanceolata var. dubia Grunow.

In contrast with Cholnoky's observations in Natal (Cholnoky 1960A: 16) and in the Cape Province (Cholnoky 1962A: 6), this variety occurred in the region under investigation far more commonly than the typical forms, and over a wide area.

Figs. - 9 - 11.

A.linearis (W.Smith) Grunow.

1930 - Hustedt: Bacillariophyta. P.198, F.276.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
378, F.821a, b.

Synonyms: Achnanthidium lineare W. Smith; Achnanthidium Jackii Rabenhorst; Achnanthes linearis var. Jackii Grunow; Microneis linearis Cleve.

This small Achnanthes species bears a strong similarity and is closely related to A.minutissima Kützing. A.linearis, however, differs from A.minutissima ecologically and by having a relatively broader valve and a more pronounced central area. The transapical striae are coarser and are clearly defined in A.linearis. Hustedt described a new variety of A.minutissima from the Sunda Islands, A.minutissima var. rostrata Hustedt 1937 - 1939, Suppl.15: 192, T.13, F.41 - 46) about which he comments in the following manner:-

"Schalen aber verhältnismässig breiter mit sehr stumpfen Polen. Die transapikale Streifung ist wesentlich gröber als bei der Art, es kommen etwa 26 Streifen auf 10 μ . Zentral Area der Raphenschale rundlich erweitert. Die Form nähert sich in manchen Hinsicht der Achnanthes linearis ist aber mit A.minutissima verbunden, während A.linearis in Gebiet nicht vorkommt".

Hustedt's variety, var. rostrata, is in fact the same as A.linearis and has nothing to do with A.minutissima, and the variety must therefore become a new synonym of A.linearis. In the same publication (cf. Hustedt 1937 - 1939, Suppl 15: 194, T. 13, F. 37 - 40) he also described a new species A. crassa Hustedt, which he described as being near to A.linearis from which it differs in its squat structure. According to Cholnoky (personal communication) A.linearis var. pusilla and A.crassa are the same

thing; and in his opinion they should be united, and remain as a separate taxonomical unit, A.crassa.

A.linearis has been reported from weakly acidic waters (Cholnoky 1960A: 16; 1962A:7; 1966B: 172). It was found commonly in the samples from the Klip and Wilge Rivers, and was sometimes present in relatively high numbers. These localities were all alkaline in character.

A.microcephala (Kützinger) Grunow.

1880 - Grunow: Kongl. Sv. Vet.Akad.Handl. 17(2): 22.

1930 - Hustedt: Bacillariophyta. P.198, F.273.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
376, F.819.

Synonyms: Achnanthidium microcephalum Kützinger; Navicula pachycephala Schumann; Achnanthes delicatula Brun; Microneis microcephala Cleve.

The distribution of this diatom species is limited to waters with a high percentage oxygen saturation. Its optimum development is found in such oxygen-rich waters with a neutral pH which fluctuates towards being acidic. Thus conditions were not often obtained in the rivers under investigation and as a result it was found in only a few samples.

Samples - 333, 338, 370, 403, 411, 456.

A.minutissima Kützinger.

1883 - Kützinger: Alg. Exs. Nr. 75.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 188.

1930 - Hustedt: Bacillariophyta. P.198, F.274.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
376, F.820 a - c.

Synonyms: Achnanthes exilis W.Smith; Achnanthes minutissima var. microscopica Östrup; Microneis minutissima Cleve; Microneis gracillima Meister.

Cholnoky (1957B: 343) no longer regards the var. cryptocephala as separate from the typical forms of the species on the grounds that there are transitional forms between the typical forms and the variety, which make a separation of the two forms superfluous. The many examples of A.minutissima studied in my samples certainly supported Cholnoky's conclusions in this regard. For a further discussion on the systematics of this species see the remarks on A.linearis (W.Smith) Grunow.

On account of the autecology of this species, A.minutissima is regarded as an indicator species of oxygen rich ketharobic water. Cholnoky (1962B: 61) stated that A.minutissima reproduces best in oxygen rich, weakly alkaline water, and cannot tolerate a high osmotic pressure or a high concentration of organic nitrogen compounds. Therefore when this species occurs in great numbers it indicates water of good quality. A.minutissima is very wide spread in its distribution in South Africa, and was one of the most frequently occurring species in the Vaal Dam Catchment Area. At some sampling points it was the dominant diatom species in the association.

A.pinnata Hustedt.

1922 - Hustedt; Bacillariales aus Inner-Asien.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl.15: 201.

As mentioned earlier this species is very similar to A.Engelbrechtii Cholnoky and it is very easy to misidentify A.Engelbrechtii as A.pinnata. It is a little doubtful whether

this one example occurring in one sample is in fact A.pinnata.
Sample - 412.

A.pseudohungarica Cholnoky-Pfannkuche.

1966 - Cholnoky-Pfannkuche: Eine neue Achnanthes-Art.

Nova Hedwigia 11: 413, F. 1 - 16.

This species was first discovered from a culture prepared from a diatom sample from the Bloukrans River. The examples, which were discovered in the Transvaal, agree in all respects with the smaller forms of the originally described species, and two valves have been drawn to illustrate this. (Figs. 12, 13).

This species was observed in one sample from the Klerkspruit stream near Kestell in the Orange Free State, in which it composed 3.2% of the diatom association.

Figs. - 12, 13.

Sample - 362.

AMPHIPLEURA Kützing 1844.

A.pellucida Kützing

1844 - Kützing: Bacill. P.103, T.3, F.52 & T.30, F.84.

1930 - Hustedt; Bacillariophyta. P.218, F.321.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
724, F.1095.

Synonyms: Frustulia pellucida Kützing; Navicula pellucida Ehrenberg.

In most cases the valves of A.pellucida observed in this study fell within the dimensions given by Hustedt

(1927 - 1964, Teil 2: 724; 1930: 218), but there were some isolated cases which agreed with Cholnoky's smaller dimensions (cf. Cholnoky 1957A: 41).

There appears to be some confliction of opinion concerning the autecology of this species as Cholnoky has found it, often abundantly, in neutral to weakly alkaline waters, which are poor in nitrogenous substances (Cholnoky 1960A: 20). On the other hand Hustedt (1937 - 1939, Suppl. 15: 213), although he found it in oligotrophic lakes, observed it in great quantities in "stärker eutrophierten Teilen der Uferregion". From the observations carried out in this survey no further comment can be made in this regard, as the species, although widespread in its distribution, was present in most cases as single specimens only.

AMPHORA Ehrenberg 1840.

A. coffaeiformis (Agardh) Kützing.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 120.

1930 - Hustedt: Bacillariophyta. P.345, F.634.

Synonyms: Frustulia coffaeiformis Agardh; Amphora aponina Kützing; Amphora salina W. Smith; Amphora lineata Gregory; Amphora Neupaueri Pantocsek; Amphora Taylora Grunow.

Since Agardh described this species in the genus Frustulia, Cholnoky is quite correct in remarking that both Cleve and Hustedt have incorrectly written the author of this species as Agardh only. Kützing was the first to place this species in the genus Amphora, and therefore should be acknowledged in the author's names; thus the correct name for this species should be Amphora coffaeiformis (Agardh) Kützing.

Cholnoky regards this species as autochthonous in neutral to slightly alkaline waters, and in waters in which the osmotic pressure is of a small value (Cholnoky 1957A: 42; 1960B: 234; 1962A: 10; 1962B: 63). This species occurs fairly commonly in many localities, but never in great numbers.

A. fontinalis Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol. Suppl. 15: 414, T.24, F.4, 5.

This species of Amphora has been reported from South Africa only three times, twice in Natal (1956:57; 1957A: 42) and once from the Eastern Cape Province (Giffen 1963: 217). In the sample Vaal 412 one single valve was found which conformed in all respects but one with Hustedt's original description (l.c.). The only difference between this specimen (illustrated in Fig. 14) is that it had 20 transapical striae compared with 24 in the original description. This difference is so negligible that the correctness of this identification is without doubt.

Cholnoky (1956: 57) reported that this species was acidobiontic from the Tugela area of Natal. On the basis of one valve no further comments on the autecology of Amphora fontinalis can be added.

Fig. - 14.

Sample - 412.

A. ovalis Kützinger.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 104.
1930 - Hustedt: Bacillariophyta. P.342, F.628.

Although A.ovalis has been reported from all over South Africa, it never occurred frequently at any one place. In the Vaal Dam Catchment Area it was found, in most cases, as single specimens and consequently no conclusion can be drawn with regard to its autecology.

A.ovalis var. libyca (Ehrenberg) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kong.Sv.Vet.Akad.Handl.

27: 104.

1930 - Hustedt: Bacillariophyta. P.342.

Synonyms: Amphora libyca Ehrenberg; Amphora affinis Kützing; Amphora ovalis var. affinis (Kützing) Grunow; Amphora abbreviata Bleisch; Amphora Szontaghii Pantocsek; Amphora Staubii Pantocsek; Amphora verrucosa Pantocsek; Amphora svavii Pantocsek.

In a discussion on A.ovalis var. libyca (cf. Cholnoky 1962A: 10) it is evident that Cholnoky no longer regards this variety as being clearly differentiated from the species as he has always found a sequence of examples which provide transitional forms between the variety and the typical forms. Cholnoky, however, still reported the variety in his most recent papers as a separate entity with no further systematic comments. In this present study examples of the typical forms and of the variety have been seen but never with transitional forms linking the two forms together.

This species occurred as isolated examples in a number of samples.

A. ovalis var. pediculus (Kützing) Grunow.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 105.

1930 - Hustedt: Bacillariophyta. P.343, F.629.

Synonyms: Cymbella pediculus Kützing; Amphora minutissima

W. Smith; Amphora globosa Schumann; Amphora libyca var.

interrupta Pantocsek; Amphora borealis Schumann.

Cholnoky (1966B: 173) regarded this variety as intergrading with the typical forms of the species, and should, therefore, no longer be distinguished as a separate variety. However, no transitional forms have been observed in these samples, and for this reason it has been maintained as a distinct variety.

The autecology of var. pediculus is not completely known, and it was rarely found in the catchment area.

Samples - 326, 337, 338, 339, 340, 363, 364, 378, 412, 432, 476, 497.

A. submontana Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert,

Fasc. 8: 112, T.11, F.4.

The examples of this species, observed in this study, agreed with Hustedt's (l.c.) original description. However, in most cases the transapical striae were too fine to be seen with the light microscope and as a result probably number more than 40 in 10 μ . As with Cholnoky (1963C: 162) the transapical striae in the stauros were not seen.

Amphora submontana has been found over most parts of South Africa in water which ranges from weakly basic (Cholnoky 1960A: 25) to weakly acid (Cholnoky 1956: 57). According to Cholnoky it finds its optimum in neutral to weakly alkaline waters, in which a certain amount of dissolved organic nitrogen compounds were present

(Cholnoky 1962B: 64). As conditions' in the Catchment area do not suit the development of this species, it was found in small numbers, but over a wide area.

A.thermalis Hustedt

1949 - Hustedt: Kongo. Expl.du Parc National Albert, Fasc.8; 111, T.11, F. 1 - 3.

The specimen seen here was a little smaller (17 μ long and 3.5 μ wide) than the dimensions given in the original diagnosis (length 18 - 35 μ , breadth about 5 μ). However, Hustedt described it from only one locality and cannot, therefore, have given the full range of variation. To the author's knowledge this is the first record of this species in South Africa.

A.veneta Kützting.

1896 - Cleve; Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 118.

1930 - Hustedt: Bacillariophyta. P.345, F.631.

Synonyms: Amphora Hohenackeri Rabenhorst; Amphora quadricostata Rabenhorst; Amphora tumidula Grunow; Amphora hyalina var. parvula Grunow; Amphora coffaeiformis H. Smith; Amphora libyca H. Smith; Amphora Gouwsii Cholnoky.

In sample Vaal 498 some very small specimens were observed (Fig.15), which were only 4 μ long. These small forms intergraded gradually with the more typical specimens of the species.

This diatom species has been found in well buffered waters with a high pH value. Its optimum development is attained in waters with a high osmotic pressure (Cholnoky 1965: 67), and its occurrence, therefore, in high numbers in a sample, indicates a high osmotic pressure in the water. As a result of the high pH

value this species was found commonly all over the catchment area; and in samples Vael 414 (54.6%) and Vael 498 (25.3%) it was the dominant species.

ANOMOEONEIS Pfitzer 1871.

A.brachysira (Brebisson) Cleve.

1882 - Cleve and Möller: Diat. Nr. 324.

1930 - Hustedt: Bacillariophyta. P.264, F.427.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
748, F.1112 e - h.

Synonyms: Navicula brachysira Brebisson; Cymbella Beverleinii

A.Schmidt; Anomoeoneis zillensis var. subovata Cleve-Euler;

Anomoeoneis Frenguelli Manguin; Anomoeoneis serians var.

brachysira (Brebisson) Cleve; Anomoeoneis serians var. brachysira

f. thermalis (Grunow) Hustedt; For further synonyms see Hustedt

1927 - 1964: 748.

Cholnoky (1955B: 158; 1960C:352) no longer subscribes to Hustedt's opinion that A.brachysira is a variety of A.serians, on the grounds that not only is it ecologically different but also that it bears only a superficially morphological likeness. As only one specimen of A.brachysira and no examples of A.serians, have been observed, it is not possible to comment any further on the taxonomy and systematics of this particular species.

A.brachysira is a tropical-subtropical species occurring in waters with a low pH (Cholnoky 1954B: 206; 1956: 57; 1962B: 64). It occurred in one sample from the Klip River at Memel. Sample - 359.

A.exilis (Kützinger) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 8.

1930 - Hustedt: Bacillariophyta. P.264, F.429.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2: 751,
F.1114 a - c.

Synonyms: Navicula exilis Kützinger; Achnanthidium microcephalum W. Smith; Colletonema exilis Grunow; Gomphonema vitreum Grunow; Navicula gomphonemacea Grunow; Anomoeoneis exilis var. gomphonemacea Cleve; Anomoeoneis exilis var. genuina A.Mayer; Anomoeoneis microcephala A.Berg; Anomoeoneis seriens forma Berg.

The ecological term "indifferent" used by many authors implies that an "indifferent species" can reproduce equally well and thrive under all ecological conditions. With regard to A.exilis Jorgensen (1948:49) and Foged (1953: 40) consider the species, indifferent to pH. Cholnoky, however, disagrees with this opinion. From his observations in South Africa, Cholnoky has found that the pH optimum of this species lies between 6.7 and 7.0 (Cholnoky 1958: 249; 1960 A: 26; 1962 B: 65; 1962 C: 316; 1966B: 174) in well buffered water. A statement such as this (i.e. the pH optimum of the species lies between 6.7 and 7.0) does not preclude the possibility of observing the species in waters with pH values outside this range. They can be observed but in very low numbers and would certainly not be autochthonous in such conditions, or will be present as single valves which have been washed down stream from some other source. In the area under investigation the pH-values of the water are always high and as a result A.exilis is present as isolated examples in the samples.

Sample Nos - 233, 309, 312, 317, 324, 342, 344, 347, 350, 418, 422, 441, 468.

A.sphaerophera (Kützinger) Pfitzer.

1871 - Pfitzer: Bau und Entwicklung der Diatomeen. P.77.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 6.

1930 - Hustedt: Bacillariophyta. P.262, F.422.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
740, F.1108a.

Synonyms: Navicula sphaerophora Kützinger; Navicula biceps
Ehrenberg; Navicula denudata Pantocsek; Anomoeoneis rostrata
Frenguelli; Anomoeoneis Okadae Skvortzow.

The autecology of this species is not clear at present.
Hustedt (1937 - 1939, Suppl.15: 218) regards this species as
found in polluted water in the proximity of human settlements.
Cholnoky has also reported it from relatively alkaline springs
with a good buffer system (Cholnoky 1966B: 175). In the samples
investigated it was present only as isolated specimens.
Sample Nos. - 239, 344, 408, 412, 415, 511.

CALONEIS Cleve 1891.

C.bacillum (Grunow) Cleve.

1894 - Cleve: Diatomiste, Vol. 2, P.99.

1930 - Hustedt: Bacillariophyta. P.236, F.360.

Synonyms: Stauroneis Bacillum Grunow; Caloneis fasciata
(Lagerstedt) Cleve p.p.; Navicula Dartevillei Kufferath;
Caloneis bacillum f. inflata Hustedt; Caloneis bacillum var.
lancettula (Schulz) Hustedt.

The authorship of the binomial combination C.bacillum is
generally taken to be Mereschkowsky. However Hustedt (1937A: 184)
has found that Cleve had actually used this combination some years
before. The distinction between Caloneis bacillum and Caloneis
silicula (Ehrenberg) Cleve is very difficult to define, and indeed

more careful examination of the two species may result in the uniting of C.bacillum and C.silicula. Cholnoky has sunk var. lancettula (Schulz) Hustedt (cf. Cholnoky 1965: 68) and f. inflata (Cholnoky 1966B: 175) into the species, since he has found transitional forms which link them with the typical forms of the species. Hustedt (1949: 99) regarded the main distinction between C.bacillum and C.silicula to be the central area; C.bacillum has a large wide transapical band or fascia, while C.silicula the band is either narrow or absent. This is a very doubtful distinction, particularly as Hustedt describes the central area of C.bacillum as "eins bis an den Schalenrand reichende Querbinde von wechselnder Breite" (Hustedt l.c.). For further comments on the systematics of this group of diatoms see Caloneis fasciata (Lagerstedt) Cleve. Fig. 16 illustrates an abnormal form of C.bacillum, in which the valve has a slight constriction of the walls at the central nodule.

This is a tropical-subtropical species which has been found in neutral to weakly alkaline waters which are more or less oligotrophic (Cholnoky 1960A: 27; 1962B: 19). It was found to be widespread in the catchment area, particularly in the Vaal and Waterval Rivers.

Fig. - 16.

C.bacillum (Grunow) Cleve var. fontinalis Grunow.

1937 - 1939 - Hustedt: Java Bali und Sumatra. Arch. Hydrobiol. Suppl.15: 282, T.15, F.17 - 19.

This variety has previously been recorded from South Africa only in Natal (Cholnoky 1956: 58). In the catchment area it was recorded from Station 15 on the Kalk River.

Sample No. 402.

C.bacillum (Grunow) Cleve var. minima Cholnoky.

1954 - Cholnoky: Süd Rhodesien. Port. Acta Biol. 4: 206.

This small variety differs from the typical forms of the species only in its much smaller dimensions. In South Africa Cholnoky has recorded it only once and the type locality lies near Umtali in Rhodesia (Cholnoky l.c.). It was seen in very few samples.

Fig - 17.

Sample Nos. - 326, 327, 331, 362, 364, 411, 436, 451, 456.

C.Chasei Cholnoky.

1954 - Cholnoky: Süd Rhodesien. Port. Acta Biol. 4: 206, F. 4,5.

Most of the examples of C.Chasei, which were present in three samples, exhibited a series in which the number of transapical striae of the valve ranged from 36 to more than 40 in 10 μ . The original diagnosis should therefore be altered to accomodate these observations. It is interesting to note that in three samples from the upper reaches of the Wilge River (Vaal 328, 331, 333) in which the species was recorded the transapical striae were so fine that they were practically invisible (i.e. more than 40 in 10 μ). One specimen of these very finely striated specimens was illustrated (Fig. 18).

In South Africa the species is found to be widely distributed in weakly acid waters with a pH range of 6-7 (Cholnoky 1960 B: 237). It was found in a few samples from the catchment area, and never in great numbers.

Fig. - 18.

Samples - 261, 301, 307, 328, 331, 333, 345, 358, 359, 370, 479, 485.

C.Cleveii (Lagerstedt) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 51.

1930 - Hustedt: Bacillariophyta. P.236, F.359.

Synonyms: Navicula Cleveii Lagerstedt; Navicula Beccariana Grunow; Caloneis Beccariana (Grunow) Cleve; Caloneis aequatorialis Hustedt; Caloneis aequatorialis var. capitata Caloneis pseudocleveii Cholnoky.

Cholnoky (1963C: 162) has been able to show by means of transitional forms that Caloneis Cleveii, C.Beccariana and C.aequatorialis are in fact, all the same species and since C.Cleveii (Lagerstedt) Cleve is the oldest legitimate combination, all other combinations are younger synonyms. An unusually short form was illustrated in Fig. 19 (21 u long).

This is one of the most commonly found Caloneis species of the Vaal Dam Catchment Area, but it never occurs frequently in any one sample. Cholnoky has found it in neutral to weakly basic waters which are oligotrophic (cf. Cholnoky 1956: 59; 1962B: 65; 1966B: 176).

Fig. - 19.

C.Cleveii var. tugelae Cholnoky.

1956 - Cholnoky: Seltene ii - Tugela - Gebiete. Österr. Bot. Zeitschr. 103: 58, F. 7 - 10.

1962 - Cholnoky: Swaziland. Hydrobiologia 20: 317.

Synonyms: Caloneis aequatorialis var. tugelae Cholnoky.

Since Cholnoky originally described this variety, he has found further examples which broaden the range of variation within the variety. The transapical striae now range from being parallel at the poles to being strongly convergent (Cholnoky 1957A: 42), and they number from 22 - 30 in 10 μ (Cholnoky 1959: 14).

Nothing much is known about the autecology of the variety, but Cholnoky maintained that its distribution is apparently limited by low pH-values with a narrow range of fluctuation. It occurred in the Waterval River and its tributaries as isolated examples.

Samples - 401, 402, 404, 405, 406, 408.

C.fasciata (Lagerstedt) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 50.

Synonyms: Navicula fasciata Lagerstedt; Caloneis bacillum (Grunow) Cleve p.p.; Pinnularia fasciata (Lagerstedt) Hustedt; Caloneis Lagerstedtii (Lagerstedt) Cholnoky.

The systematics of this group of diatoms is extremely confusing and the comments of various authors have not clarified the position. In his Synopsis of the Naviculoid Diatoms (1894: 50) Cleve placed Navicula fasciata Lagerstedt in the genus Caloneis. At the same time Cleve regarded Stauroneis bacillum Grunow, which was described in 1863, as a synonym of Caloneis fasciata (Lagerstedt) Cleve. Cleve then changed the name to Caloneis bacillum (Grunow) Cleve (Diatomiste 1894, 2(17): 99), since Grunow described Stauroneis bacillum 10 years before Navicula fasciata was described by Lagerstedt. Hustedt was dubious about the position of Navicula fasciata Lagerstedt; in the Bacillariophyta (Hustedt 1930: 236) he stated that "Navicula fasciata Lagerst. muss infolge ihrer abweichenden Struktur aus dem Formenverbände ausscheiden, so dass der Sammelname Caloneis fasciata Cleve hinfällig ist". At this stage he placed Navicula fasciata Lagerstedt in the genus Pinnularia (Hustedt 1930: 316), but in a later publication he (Hustedt 1937: 184) changed his opinions and wrote the following:-

"Auf die verworrenen systematischen Verhältnisse gehe ich an anderer Stelle näher ein, hier will ich nur bemerken, dass ich Navicula fasciata Lagerstedt in Cal. bacillum einbegriffen habe".

Hustedt (1949: 99) once more changed his mind when, in commenting on C. bacillum, he said "..... Navicula fasciata Lagerst., die Cleve mit den zu Caloneis bacillum gehörenden Formen identifizierte und als Caloneis fasciata Lagst. bezeichnete (1894: 50). Diese Verbindung ist sehr wahrscheinlich ein Irrtum, wenngleich eine sichere Entscheidung über Lagerstedts Form kaum möglich sein wird". It is uncertain what Lund (1946: 58) believed the position to be, but it appears that he regarded Caloneis fasciata (Lagerstedt) Cleve as synonymous with Navicula fasciata Lagerstedt, and as a species separate from Caloneis bacillum (= Stauroneis bacillum Grunow), which two species differ in the arrangement of their transapical striae. Cholnoky (1957A: 43) adhered to the opinion that Pinnularia fasciata (Lagerstedt) Hustedt (= Navicula fasciata Lagerstedt) is a species distinct from Caloneis bacillum (Grunow) Cleve (= Stauroneis bacillum Grunow), but he reinstated Pinnularia fasciata in the genus Caloneis under a new specific epithet Caloneis Lagerstedtii (Lagerstedt) Cholnoky. Patrick and Reimer (1966: 586) adopted the opposite view and considered Navicula fasciata and Stauroneis bacillum Grunow to be the same species, correctly named Caloneis bacillum (Grunow) Cleve. From the review of the situation given above, it seems clear that the prime question to resolve is whether Navicula fasciata and Stauroneis bacillum are, indeed, one and the same species. As the original descriptions of Navicula fasciata and Stauroneis

bacillum were not available, it was not possible to compare the two species or verify the views of Patrick and Reimer (l.c.). Comparisons can, therefore, only be made from the literature at hand and the comments of others. In comparing the descriptions of Caloneis bacillum (Grunow) Cleve (sensu Hustedt 1930: 236: i.e. synonymous with Staureneis bacillum Grunow), with the descriptions of Pinnularia fasciata (Lagerstedt) Hustedt (1930: 316) and Navicula fasciata Lagerstedt (= Pinnularia fasciata) in De Toni (1891: 117), the only character that separates these two species is the arrangement of the striae. According to Lund (1946: 58), Lagerstedt's original description of Navicula fasciata stated that the striae are all parallel, and De Toni's description (l.c.) agreed with this; while the striae of Pinnularia fasciata (Lagerstedt) Hustedt are said to be parallel or slightly radial in the middle and convergent at the poles. Grunow's figure of Navicula fasciata in Van Heurck's Synopsis (1880: Pl.12, F.34), which Cleve cites under Navicula fasciata (Cleve l.c.) illustrates a specimen with convergent polar striae. In contrast with this the striae of Caloneis bacillum (Grunow) Mereschkowsky (sensu Hustedt 1930: 236) are radial except in the middle where they may be more or less parallel. Using this character, Cholnoky separated Caloneis Lagerstedtii (Lagerstedt) Cholnoky (= Pinnularia fasciata (Lagerstedt) Hustedt, which has convergent polar striae, from Caloneis bacillum (Grunow) Cleve, which has radial polar striae (cf. Cholnoky l.c.). Lund (l.c.) used the name Caloneis fasciata (Lagerstedt) Cleve (see comments above) for specimens, the polar striae of which range from weakly convergent to parallel, which links Lagerstedt's original description, where the polar striae are said to be parallel,

with later diagnoses in which the polar striae are convergent. No difference can be found between Caloneis fasciata (Lagerstedt) Cleve (sensu Lund) and Caloneis Lagerstedtii (Lagerstedt) Cholnoky. It seems clear then that there are two different species. The one species is Caloneis bacillum (Grunow) Cleve; and the other is Caloneis fasciata (Lagerstedt) Cleve. Cholnoky (l.c.) has, however, stated that Caloneis fasciata is a synonym of Caloneis bacillum; but from the argument set out above this does not appear to be the case, as they are two distinct species, which were erroneously united by Cleve (1894: 50). On these grounds Cholnoky's specimens, which he regarded as " mit der ursprünglichen Navicula fasciata Lagerstedt identisch", are considered to be the same as Caloneis fasciata (Lagerstedt) Cleve, and his combination, Caloneis Lagerstedtii (Lagerstedt) Cholnoky, is therefore a synonym.

In the course of the survey some abnormal forms have been observed. Figs. 20 and 21 illustrate two very small valves, of which the smallest was 12.5 μ long. Two other abnormalities have been illustrated in Figs. 22 and 23. These forms have triundulate walls, and according to Cholnoky (personal communication) are both members of C.fasciata. There is, however, no evidence that these triundulate forms constitute a new form.

The autecology of this species is not clearly known. It occurred fairly commonly in the Catchment area, but was never abundant.

Figs. - 20 - 23.

C.hyalina Hustedt.

1937 - 1939 - Hustedt: Java, Bali, und Sumatra. Arch.Hydrobiol.
Suppl. 15: 281, T.15, F. 8 - 10.

The specimen, which was illustrated in Fig. 24, did not entirely agree with the original description given by Hustedt. However, it corresponded more closely with this species than with any other Caloneis. This specimen was more lanceolate than the typical forms and had more acutely rounded poles (cf. Hustedt l.c. T.15, F.10). The central pores were widely spaced and agree with the description. In this specimen the transapical striae were not visible and must therefore number more than 40 in 10 μ ; where as Hustedt's specimens had 36 - 38 in 10 μ . The differences found in this specimen do not warrant its description as a new species.

Fig. - 24.

Sample - 307.

C.incognita Hustedt.

1910 - Hustedt: Bacillariales aus Dahome. Arch. Hydrobiol.
5: 373, T.3, F. 7.

In his studies on African diatoms Cholnoky has been able to establish a wider range of variation for this species than was originally described. Many of his examples reached a lower limit with regard to their length, the smallest being 22 μ long (Cholnoky 1962: 65); and the narrowest specimen was 8.5 μ wide (l.c.). One of the smaller specimens has been illustrated in Fig. 25.

C.incognita appears to favour waters with a neutral pH value with a range towards the acid side. Cholnoky however comments that he cannot say for certain much about its autecology

as he has seen only very few specimens. This species was found in only four samples from the Waterval, Kaffirspruit and Tier Rivers.

Fig - 25.

Samples - 245, 401, 419, 491.

C.Schumanniana (Grunow) Cleve. var. trinodis (Lewis) Cleve.
1894 - Cleve: Naviculoid Diatoms. Kong.Sv.Vet.Akad.Handl. 26: 53.
1930 - Hustedt: Bacillariophyta P.269, F.369 (as C.Schumanniana
var. biconstricta)

Synonyms: Navicula trinodis Lewis; Navicula biconstricta
Grunow: Navicula Schumanniana var. biconstricta Grunow.

This variety is not common in South Africa and is reported only twice by Cholnoky (1958A: 249; 1966A: 11). In the Catchment Area only one or two isolated examples of the variety were seen in a number of samples, mainly from the Vaal River. The typical forms of Caloneis Schumanniana (Grunow) Cleve, however, have not been observed.

C.silicula (Ehrenberg) Cleve.
1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 51.
1930 - Hustedt: Bacillariophyta. P.236, F.362.
Synonyms: Navicula silicula Ehrenberg; Navicula limosa Donkin;
Caloneis silicula var. truncatula Grunow; Caloneis silicula var.
cuneata Mangin.

The lines of demarcation between many species in the genus Caloneis and between varieties within a species are extremely difficult to determine. It is possible that C.silicula and C.bacillum (see above) form part of the same variational range.

Cholnoky's view that C.silicula var. truncatula should be sunk into the species was followed in this investigation.

C.silicula, whose autecology is unknown, occurred fairly commonly in the catchment area, but never in any abundance.

C.silicula f. intermedia Hustedt.

1942 - Hustedt:

This form has been reported only once from South Africa by Cholnoky in Natal (Cholnoky 1960: 29) , and it was recorded once from Station 19 on the Kaffirspruit River.

Sample - 342.

C.silicula (Ehrenberg) Cleve var. alpina Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 51.

1930 - Hustedt: Bacillariophyta. P.238, F.366.

The varieties of this species appear to be far less common than the typical forms. The var. alpina is very seldom seen and it was observed in one sample from the Grootvlei Dam (Station 16).

Sample - 401.

C.silicula (Ehrenberg) Cleve var. tumida Hustedt.

1930 - Hustedt: Bacillariophyta. P.238, F.367.

This is the first time this variety has been reported from South Africa. It was recorded in two samples, one from a tributary of the Vaal River, and the other from a sample collected near Tweeling in the Wilge River System.

Samples - 236, 420.

COCONEIS Ehrenberg 1838.

C.microscopica Cholnoky.

1959 - Cholnoky: Seltene iv - Kaap Provinz. Österr.Bot.Zeitschr.
106: 17.

The specimens of this very seldom seen species were slightly smaller than Cholnoky's original dimensions, and the original diagnosis should be altered:- length 6 - 9 μ breadth 3 - 4 μ and transapical striae of both valves 28 - 39 in 10 μ .

It was recorded from one sample near the source of the Vaal River.

Sample - 486.

C.placentula Ehrenberg.

1838 - Ehrenberg: Infusoria P.194.

1896 - Cleve: Naviculoid Diatoms Kongl.Sv.Vet.Akad.Handl. 27: 169.

1930 - Hustedt: Bacillariophyta. P.189, F.260.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 2: 347, F. 802 a, b.

Synonyms: Cocconeis punctata Schumann; Cocconeis Reicheltii
A.Schmidt; Cocconeis producta A. Schmidt; Cocconeis grovei
Östrup; Cocconeis Ostrupii Heribaud; Cocconeis Grosii Heribaud.

In this species, as in many others, there is no clear cut division between the typical and varietal forms. There is more often than not a gradation between the two and, if not particularly clear, it is left to the taxonomist to make a decision. Cholnoky (1963C: 164) has found transitional forms, which link the typical forms with variety, and he remarked that this makes the separation of the var. euglypta doubtful. In the examples which have been studied no answer to this uncertainty can be supplied, except to emphasise that the separation of the variety is debatable.

The typical forms were found in a number of localities in the Catchment Area but never in great quantities.

C.placentula Ehrenberg var. euglypta (Ehrenberg) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 169.

1927 - 64 - Hustedt: Rabenhorst Kryptogamenflora

Teil 2: 349, F.802, c.

1930 - Hustedt: Bacillariophyta. P.190, F.261.

Synonyms: Cocconeis euglypta Ehrenberg: Cocconeis trilineata Heribaud et Peragallo; Cocconeis placentula var. trilineata Cleve.

In this study the variety var. euglypta occurred more frequently than the typical forms, and in a few samples was relatively abundant in its occurrence.

C.placentula Ehrenberg var. klinoraphis Geitler

1927 - Geitler: Arch.Protistenkunde 59: 514, F.2a,b. T.12, F.1.

1930 - Hustedt: Bacillariophyta. P.190, F.263.

1927 - 1964: Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
348, F.803.

This variety differs from the typical forms only by a slight displacement of the raphe so that it is inclined at an angle of about 5° from the normal position. This variety was observed in four samples and to the author's knowledge this is the first time it has been recorded from South Africa .

Samples - 337, 375, 410, 449.

(134).

C.placentula Ehrenberg var. lineata (Ehrenberg) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 169.

1930 - Hustedt: Bacillariophyta. P.190, F.262.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora

Teil 2: 348, F. 802d.

Synonyms: Cocconeis lineata Ehrenberg; Cocconeis lineata

var. minor Pantocsek; Cocconeis lineata var. pygmaea

Pantocsek; Cocconeis Bonnierii Heribaud et Peragallo.

Giffen (1966: 129) has found this variety in only one sample from the Hogsback Area in the Eastern Cape Province.

It was found in two samples, one from the Vaal River (Station 5) and the other from Station 13 on the Wilge River.

Samples - 231, 319.

C.scutellum Ehrenberg.

1896 - Cleve: Naviculoid Diatoms Kongl.Sv.Vet.Akad.Handl. 27: 170.

1930 - Hustedt: Bacillariophyta P.191, F.267.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora

Teil 2: 337, F.790.

Synonyms: Rhaphoneis scutellum Ehrenberg; Cocconeis adriatica

Kützinger; Cocconeis mediterranea Kützinger; Cocconeis peruviana

Kützinger; Cocconeis Morrisii W. Smith; Rhaphoneis marginata

Grunow; Cocconeis Pethöi Pantocsek; Cocconeis Haradaae Pantocsek;

Cocconeis baldjickiana A. Schmidt; Cocconeis adjuncta A.Schmidt.

For further synonyms see Hustedt 1927 - 1964: 337.

This species is rare in South African waters since it is marine and only occurs in estuaries or river mouths. It has been found in only one sample and must be regarded as an intrusion and definitely not autochthonous.

Sample - 405.

COSCINODISCUS Ehrenberg 1838.

C.exentricus Ehrenberg.

1839 - Ehrenberg. Abb.Berl.Akad. 1839. S.146.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora

Teil 1: 388, F.201.

Synonyms: Odontodiscus excentricus Ehrenberg; Coscinodiscus labyrinthus Roper; Coscinodiscus minor A. Schmidt; Thalassiosira excentrica Cleve; Coscinodiscus heliozoides Siddall.

This is also a marine species which has been found in South Africa in marine and brackish habitats. It must be regarded as occurring here as an intruder, and definitely not autochthonous.

Sample - 401.

C.lacustris Grunow.

1880 - Grunow: Kongl. Sv.Vet.Akad.Handl. 17(2): 114.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:

432, F.235 a, b.

1930 - Hustedt: Bacillariophyta. P.113, F.90.

Synonyms: Cyclotella punctata W. Smith, Stephanodiscus punctata Grunow.

Although this diatom is mainly a marine or brackish water form it has been found to occur in freshwater (Hustedt 1927 - 1964: 432). In South Africa it has been reported from the mouths of rivers and sometimes from freshwater. In the Vaal Dam Catchment Area it is found in one sample from the Waterval River, and cannot be regarded as autochthonous in this area.

Sample - 410.

CYCLOTELLA Kützing 1834.

C.comensis Grunow.

1881 - Grunow: In V.H.Syn.T.93, F.16, 17.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 1: 353, F.182.

1930 - Hustedt: Bacillariophyta. P.102, F.70.

The specimens which have been placed in this species were in general smaller than the dimensions given for Cyclotella comensis, but there was a gradual transition to the typical forms. The minimum observed size was 4.5 μ in diameter. The striae are generally greater in number, being up to 20 in 10 μ . These specimens cannot be assigned to any other species but this.

In the catchment area, they occurred very commonly in the Waterval River, where sometimes it was found in abundance. In other places it was present and quite frequent in occurrence. Giffen (1963: 226, F.42, 43) illustrated two small Cyclotella specimens whose dimensions appear to be similar to the valves which were seen here. In all the specimens observed the structure of the central area and the length of the striae were very variable.
Fig. - 26.

C.Kützingiana Thwaites.

1848 - Thwaites: Ann.Mag.Nat.Hist.1 (2): 169.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:
338, F.171a.

1930 - Hustedt: Bacillariophyta. P.98, F.62.

Synonyms: C.operculata f. rectangula Kützing; C. Kützingiana var. cataractarum Grunow, C.Kützingiana var. pelagica Grunow; C.Kützingiana var. nobilis A. Cleve.

This small species occurs rarely in South Africa. In the Vaal Dam catchment area it was recorded once from a sample collected at Villiers (Station 6) on the Vaal River.

Sample - 403.

C. Meneghiniana Kützing.

1844 - Kützing: P.50, T.30, F.68.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:
341, F.174.

1930 - Hustedt: Bacillariophyta P.100, F.67.

Synonyms: Surirella melosiroides Meneghini; Cyclotella melosiroides Meneghini; Cyclotella salina Marsson; Cyclotella Meneghiniana var. vogesiaca Grunow; Cyclotella rectangula Brebisson; Cyclotella Meneghiniana var. binotata Grunow.

The diatom species has been reported from many localities in South Africa. In the area under investigation it was found at relatively few localities and never in great quantities. Cholnoky regarded this species as autochthonous in relatively eutrophic and alkaline water (cf. Cholnoky 1958A: 250; 1960B: 238; 1966B: 177).

C. pseudostelligera Hustedt.

1939 - Hustedt: Küstengebietes der Nordsee. Abh.nat.Verein
Bremen 31: 581, F.1, 2.

Synonyms: C. Woltereckii Hustedt.

Foged presumably misunderstood the differences between C. pseudostelligera and C. stelligera Cleve et Grunow, as he assigned to the species C. stelligera a specimen which he illustrated as possessing about 10 marginal spines in 10 μ

(Foged 1966: 50, Pl.1, F.3). His drawing and description, however, make it quite clear that this specimen has nothing to do with C.stelligera but is rather C.pseudostelligera, since the possession of marginal spines distinguishes C.pseudostelligera from C.stelligera, having no such spines (cf. Hustedt 1927 - 1964, Teil 1: 339). In the Vaal Dam Catchment Area only one damaged valve of this species (Fig. 28) was observed. This specimen had a slightly denser arrangement of the striae (22 in 10 μ) than was given in Hustedt's original description; this, however, does not warrant the description of this specimen as a new species. Fig. 27 illustrates a valve about which there is some doubt. Originally it was considered as a new species since nothing like it could be found in the available literature. However Belcher, Swale and Heron (1966: 335) photographed some valves which could be equated with the specimen illustrated in Fig. 27. Belcher et al., in studying the morphological variations of a clonal culture of C.pseudostelligera, observed a great variability of the morphology. They discovered that when the silica content of the culture was present in sufficient quantities typical C.pseudostelligera forms were present. However, when the silica content was low and there was a silica deficiency, cells of another form were found; these they identified as C.Woltereckii, and were weakly silicified. Since both forms were derived from the same clonal culture they must be the extreme morphological forms of the same species, which, by priority, should be called C.pseudostelligera Hustedt. The specimen illustrated in Fig. 27 is very similar to the weakly silicified forms of C.pseudostelligera (of Belcher, Swale and Heron l.c. Figs. 1,2,7,8 and 10 - 12), and on these grounds it was felt

that it should be included with C.pseudostelligera.

These two valves were the only two specimens of the species to be observed in the Vaal Dam Catchment Area, and constitute the first record of this species in South Africa.

Figs. - 27, 28.

Samples - 321, 445.

C.stelligera Cleve et Grunow.

1891 - Cleve et Grunow: V.H.Syn. T.94, F.22 - 27.

1927 - 1962 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 1: 339, F. 172.

1930 - Hustedt: Bacillariophyta. P.100, F.65

Synonyms: Cyclotella Meneghiniana var. stelligera Cleve et Grunow; Cyclotella Meneghiniana var. stel(lu)lifera Grunow.

As the many localities which have been sampled in Southern Africa have not been particularly favourable for planktonic diatoms the occurrence of such planktonic species is nowhere very common. Only one specimen was observed in a sample from the Vaal River near its source. Fogel erroneously records this species from Ghana; this has already been shown to be C.pseudostelligera Hustedt.

Sample - 486.

C.stelligeroides Hustedt.

1945 - Hustedt: Balkan-Halbinsel Arch.Hydrobiol 40: 899,
T.42, F.68, 69.

As far as is known this is the first record of this species for South Africa. Two specimens have been illustrated in Figs. 29, 30, and agree with Hustedt's original description of the

species. This species was recorded from the Vaal River at Station 5A, and from the Skulpspruit near Amersfoort.

Figs. - 29, 30.

Samples - 322, 465.

CYLINDROTHERCA Rabenhorst.

C.gracilis (Brebisson) Grunow.

Cholnoky, (1966C:164) maintained that the relative paucity of records for this species is due to its extremely weak silicification of the valve walls, making it difficult to observe. C.gracilis was present in two samples from the Vaal River at Station 3, and from the Vrede Stream.

Samples - 312, 429.

CYMATOPLEURA W. Smith 1851

C.solea (Brebisson). W. Smith.

1930 - Hustedt: Bacillariophyta. P.425, F.823, a.

Only this species of Cymatopleura was found in the Catchment Area, and it represents one of the more commonly occurring diatom species of this region. In a few samples it was observed as quite abundant. It has been found to tolerate nitrogen compounds relatively well (Cholnoky 1958A: 250); and has been observed from weakly alkaline waters in the Eastern Transvaal (Cholnoky 1962B: 67).

CYMBELLA Agardh 1830.

C.aequalis W. Smith.

1856 - W. Smith: Synopsis of the British Diatoms 2:84.

1955 - Hustedt: Neue und weniger bekannte Diatomen 8. Abh.
Naturw. Verein Bremen 34: 52, F.17 - 21.

Hustedt (1955A: 52, F. 17 - 21) showed conclusively that C.aequalis W. Smith and Cymbella obtusa Gregory are two distinct species, and was able to give a description of the C.aequalis W.Smith based on the original material. Cholnoky (1960C: 352) maintained that the earlier records from South Africa under the name C.aequalis actually referred to C.obtusa Gregory.

The species occurred in the Catchment area in a number of samples from the Vaal and Klip Rivers, but was never present in large numbers.

C.amphicephala Naegeli.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 164

1930 - Hustedt: Bacillariophyta. P.355, F.651.

Synonyms: Cymbella naviculiformis Heiberg (nec. C.naviculi-
formis Auerswald)

The specimens of Cymbella amphicephala, which have been observed in this study, support Cholnoky's findings (1953: 140; 1955B: 160; 1960A: 31) that there are, together with normal typical forms, much smaller forms. The valves observed here are generally between 20 and 24 μ long, and 6 - 7 μ broad.

The species appears in neutral to weakly alkaline water (cf. Cholnoky 1962B: 67) and in a personal communication Cholnoky stated that its optimum pH is 7.2. In this survey the species

was present in a relatively large number of samples, while in some it was found in great abundance. In a few samples it was the dominant or co-dominant diatom species.

C.aspera (Ehrenberg) Heribaud.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 175.

1930 - Hustedt: Bacillariophyta. P.365, F.680.

Synonyms: Cocconeis asperum Ehrenberg; Cymbella lanceolata var. aspera Brun; Cymbella gastroides Kützinger; Cymbella gigantea Pantocsek.

Cymbella aspera is very similar to C.bengalensis Grunow, but differs in possessing radial transapical striae at the poles, whereas in C.bengalensis the polar striae are convergent.

This species has been recorded rarely from South Africa, and in the Vaal Dam catchment area was found in small numbers at a few localities.

Samples - 266, 306, 328, 330, 331, 343, 344, 358, 437, 438, 441, 456, 477, 485, 486.

C.bengalensis Grunow.

1875 - Grunow: A.S. Atl. T.9, F. 12, 13, T.71, F. 79;

Hustedt: T.375, F. 23 and 6.

Synonyms: Cymbella aspera var. bengalensis (Grunow) Cleve.

Cholnoky (1953: 140; 1954: 410) has reported very small forms of this species, with valves measuring only 50 μ in length and 19 μ in width among normal forms. The specimens observed here were generally more than 100 μ in length, but one specimen measured only 79.5 μ .

C.bengalensis Grunow has been found to inhabit neutral to weakly alkaline waters in Africa (cf. Cholnoky 1954A: 410; 1956: 59; 1960A: 32; 1962B: 67). It is uncommon in the catchment area, where it is found in a few samples from the Vaal River, and once in the Klip River.
Samples - 350, 353, 422, 491, 492, 495.

C.cistula (Hemprich) Kirchner.

1878 - Kirchner: Die Algen Schlesiens.

1894 - Cleve: Naviculoid Diatoms Kongl.Sv.Vet.Akad.Handl.
26: 173.

1930 - Hustedt: Bacillariophyta. P.363, F. 676a.

Synonyms: Bacillaria cistula Hemprich; Cocconema cistula W. Smith; Cymbella cistula var. fusidium Heribaud et Peragallo; Cocconema arcticum A. Schmidt; Cocconema cornutum Gregory; Cymbella eburnea Zanon; Cymbella cistula var. maculata (Kützinger) van Huerck.

According to De Toni (1891: 365) Dr. O. Kirchner was the first to use the combination Cymbella cistula Hemprich which preceded Grunow's use of the same combination by two years. Correctly written the name of this species should be Cymbella cistula (Hemprich) Kirchner.

This species is widespread in neutral to weakly alkaline waters of South Africa (cf. Cholnoky 1960A: 32; 1962B: 67). It was one of the more commonly occurring Cymbella species of the catchment area, but with low percentage occurrence in the samples.

C.delicatula Kützing.

1849 - Kützing: Sp. Alg. P.59

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 161.

1930 - Hustedt: Bacillariophyta. P.352, F.642.

This Cymbella species is uncommon in South Africa; it was found in the Blesbok, Kaffirspruit and Skulpspruit Rivers, at Station 3 on the Vaal River and in two samples near Vrede. Samples - 427, 441, 465, 491, 495, 496.

C.gracilis (Rabenhorst) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 169.

1930 - Hustedt: Bacillariophyta. P.359, F.663.

Synonyms: Encyonema gracile Rabenhorst; Cymbella scotica W. Smith; Cymbella lunata W. Smith.

Hustedt (1937 - 1939, Suppl. 15: 428, T.25, F.15, 16) illustrated two valves under the name C.gracilis which he described as possessing an isolated stigma over the central transapical striae on the dorsal side. Having seen similar specimens in South Africa Cholnoky has described them as Cymbella turgida (Gregory) Grunow var. pseudogracilis Cholnoky (1958B; 112). None of the specimens of C.gracilis from the Vaal Dam catchment area showed any evidence for an isolated stigma, and in this agreed with Cholnoky's observations. According to Cholnoky (1960A: 32) many of the earlier records of this species for South Africa are dubious due to confusion with C.turgida var. pseudogracilis.

While Hustedt (l.c.) stated that C.gracilis is found in a pH range of 4 - 8.5, Cholnoky (1960B: 238) maintained that it inhabits relatively acid water. In the catchment area this species was recorded from three samples at Station 1, where the

water is acidic (see Part 2), and once from the Holspruit River in the Orange Free State. This observation supported the more limited range of tolerance to pH put forward by Cholnoky.

Samples - 253, 301, 370, 479.

C.Kappii Cholnoky.

1956 - Cholnoky: Seltene ii-Tugela-Gebiete. Österr.Bot. Zeitschr. 108: 61, F.17 - 20.

Synonyms: Cymbella turgidula var.Kappii Cholnoky.

C.Kappii has been found in subtropical areas in oligotrophic, neutral to alkaline waters of South Africa (Cholnoky 1960A: 33; 1962B: 68). In the Vaal Dam catchment area it is one of the most common Cymbella species, often occurring in association with C.amphicephala, C.microcephala and C.ventricosa, in high numbers.

C.Kolbei Hustedt.

1949 - Hustedt: Sinai-Halbinsel. Hydrobiologia 2: 46, F.20 - 26.

Synonyms: Cymbella sumatrensis Hustedt; (Geurmeur 1954: 70, T.16, F.15); Cymbella Hustedtii Krasske.

The species appears to be tropical-subtropical in distribution, and has been found by Cholnoky, who regarded it as a characteristic species of oligotrophic, alkaline water (Cholnoky 1962B: 68), in many different localities in South Africa having neutral to weakly alkaline waters (cf. Cholnoky 1954A: 410; 1958B: 108; 1960A: 33.) In the catchment area the species was found in relatively few samples in low numbers.

C.microcephala Grunow.

1880 - Grunow: in V.H. Syn. P.63, Pl.8, F.36 - 39.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 160.

1930 - Hustedt: Bacillariophyta. P.351, F.637.

Synonyms: C.minuscula (A.S. Atl.1X, f 58 - 61.)

C.microcephala appears to be limited to weakly alkaline to neutral waters with a pH fluctuation towards being slightly acid. In a personal communication from Cholnoky C.microcephala has a pH optimum of 7.2. It is also found in waters which have a high percentage oxygen saturation. It is not surprising, therefore, that in the catchment area it often occurred in great numbers, in some samples dominant, and in others in association with C.amphicephala, C.Kappii and C.ventricosa as co-dominant species. This species is one of the most commonly occurring Cymbella species in the Catchment area.

C.naviculiformis Auerswald.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 166.

1930 - Hustedt: Bacillariophyta. P.356, F.653.

Synonyms: Cymbella cuspidata W. Smith; Cymbella anglica Lagerstedt.

According to Cholnoky (1960B: 239; 1962B: 68) C.naviculiformis is found in neutral to weakly alkaline waters with a low nitrogen content. It is not a common species in the catchment area, and occurred mainly in the Vaal River.

C.Oliffii Cholnoky

1956 - Cholnoky: Seltene ii - Tugela Gebiete. Osterr. Bot.

Zeitschr. 103: 63, F.23 - 27.

Synonyms: Cymbella Oliffii var. minor Cholnoky; Navicula confusa Manguin; Cymbella aequaloides Archibald.

On closer examination some specimens described as C.aequaloides Archibald (1966A: 254) were found to be C.Oliffii Cholnoky (Fig.31), which Cholnoky had described earlier. C.aequaloides Archibald must, therefore, be reduced to a synonym of C.Oliffii.

The autecology of this species is not particularly well known but Cholnoky reported it to be generally widespread in the neutral waters of the plateau-edge (Cholnoky 1962B: 69). In the same note he mentioned that this species finds its optimum in waters where the pH does not rise above 7.0 i.e. it is acidophilic. In the area under study this species has been seen twice in samples from the lower Vaal River.

Fig. - 31.

Samples - 403, 408.

C.perpusilla A. Cleve - Euler.

1930 - Hustedt: Bacillariophyta. P.361, F.666.

Synonyms: Cymbella bipartita A. Mayer.

It is apparent from Cholnoky's researches that C.perpusilla is more variable in tropical and subtropical waters (cf.Cholnoky 1954B: 207). This species is found in a pH range of 5.5 - 6.8 (Hustedt 1937-39. Suppl. 15: 428) while Cholnoky (1962B: 69) reported the pH optimum to be pH 6. C.perpusilla was not found to any great extent in this study, and was recorded mainly from the Waterval and Vaal Rivers.

Fig. - 32.

C.raytonensis Cholnoky.

1955 - Cholnoky. Raytonvlei und Leeufontein. Hydrobiologia 7:
162, F. 19 - 21.

Synonyms: Cymbella Schubartii Hustedt.

Since Cholnoky (1955B: 162) first described this species the range of variation has changed immensely. The original description should be amended to cover this new range, viz. 10 - 44 μ long and 3 - 8 μ wide (cf. Cholnoky 1956; 1960C: 352). The single specimen observed here fell amongst the smaller examples of this species.

Cholnoky (1960A: 54) found this species in Natal in water with a low pH, fluctuating between 6 and 7 (and sometimes lower). As conditions in the catchment area do not suit this species, it was seen in one sample from Station 1.

Sample - 301.

C.Schweikerdtii Cholnoky.

1953 - Cholnoky: Hennops Rivier. Verh. zool-bot. Ges. Wien
93: 141, F. 6 - 11.

The specimens observed in this study agreed with the original diagnosis given by Cholnoky (1953: 141) without any deviation.

The species is rare in South Africa, and has been reported only from the Waterval River at Station 7, and in three samples from the upper Vaal River and its tributaries.

Samples - 325, 345, 465, 495.

(149).

C.turgida Gregory.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 168.

1930 - Hustedt: Bacillariophyta. P.358, F.660

Synonyms: Encyonema turgida (Gregory) Grunow.

Hustedt (1930: 358) incorrectly quoted the author's names as (Gregory) Cleve. However, Gregory himself in 1856 used the combination Cymbella turgida (cf. De Toni 1891: 372) in his original description. It was only later in 1880 that Grunow, in van Heurck's Synopsis, transferred it to the genus Encyonema, which was subsequently included as a subgenus by Cleve in the genus Cymbella. Cholnoky (1958B: 111, F.46) discovered an isolated pore at the end of the central transapical stria, which takes the form of a small oblique pore canal running into the central nodule. This structure had hitherto remained unobserved.

There are few references regarding the autecology of this species. Hustedt (1937-39, Suppl. 15: 427) claimed that the pH range was between 6.5 to over 8 and stated that "die Hauptentwicklung liegt jedenfalls bei einem pH um 8". Cholnoky (1960A:36) mentioned only that he had found the species to be widespread and often abundant in the neutral waters of Natal. C.turgida was present in a relatively small number of samples from widespread localities in the Catchment area.

C.turgida var. pseudogracilis Cholnoky.

1958 - Cholnoky: Diatomeenflora ii - Waterberg Gebiet.

Port.Acta.Biol. 6: 112, F. 49, 50.

Synonyms: Cymbella Mesiana Cholnoky.

A note on the systematics of this variety can be found in the comments on C.gracilis.

The variety apparently finds its optimum development in acidic waters, and consequently was recorded in very small numbers from one locality on the Waterval River, and at Station 12 on the Wilge River.

Samples - 334, 554.

C.ventricosa Agardh.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 168.

1930 - Hustedt: Bacillariophyta. P.359, F.661.

Synonyms: Encyonema ventricosa (Agardh) Grunow; Frustulia ventricosa Kützing; Encyonema prostratum Kützing; Encyonema caespitosum Kützing; Encyonema Auerswaldii Rabenhorst; Cymbella maculata W. Smith; Cymbella affinis var. semicircularis Lagerstedt; Cocconema lunula Ehrenberg; Cymbella silesiaca Bleisch; Cymbella variabilis Wartmann.

The author of this species is not Kützing as cited by Hustedt (1930: 359), but Agardh. Agardh described it first as Cymbella ventricosa in 1830 and later Kützing (1834) transferred it to the genus Frustulia. Grunow called this species Encyonema ventricosa, and it was finally Cleve who replaced the species in the enlarged genus Cymbella, and in so doing Cleve erroneously quoted Kützing as the author. Cymbella ventricosa and C.turgida Gregory are very closely related to each other, and indeed the smaller forms of the latter are sometimes very difficult to distinguish from C.ventricosa.

In South Africa the species has been reported from oligotrophic, neutral to weakly alkaline waters (Cholnoky 1960A: 36; 1962A:19; 1962B: 70) in which it finds its optimum conditions (Cholnoky 1962C: 319). For this reason it is found

in a great many samples from this area, and sometimes with high relative densities in the samples. This was one of the most commonly found diatoms in the catchment area.

DIPLONEIS Ehrenberg 1844.

D.marginestriata Hustedt.

1922 - Hustedt: Int.Rev.d.ges.Hydrobiol. Hydrogr. 10: 78, F.5.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora. Teil 2:
677, F.1068 b.

1930 - Hustedt: Bacillariophyta. P.250, F.1068 b.

One specimen of this species was observed in the catchment area. It differed from Hustedt's description (l.c.) only in its breadth, being relatively narrower (7 u). In all other respects it agreed with Hustedt's description. This is the first record of this species in South Africa.

This specimen was collected from the Grootspuit, a tributary of the Waterval River.

Fig. - 33.

Sample - 411.

D.ovalis (Hilse) Cleve.

1891 - Cleve: Diat. Finl. P.44, T.2, F.13.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 93.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora. Teil 2: 671,
F.1065 a - e.

1930 - Hustedt: Bacillariophyta. P.249, F.390.

Synonyms: Pinnularia ovalis Hilse; Navicula ovalis A. Schmidt;
Navicula elliptica A. Schmidt; Navicula carpathorum Pantocsek;
Diploneis ovalis var. Hilseana Meister:

This species is rare in South Africa, and Cholnoky (1962B: 70) maintained that many of the earlier records of this species for South Africa by others were in error, and should be assigned to D. subovalis instead.

In the Vaal Dam catchment area this species was found in small numbers from relatively few samples mainly from the Waterval and Vaal Rivers.

D.pseudovalis Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 2: 668, F.1063 c.

1930 - Hustedt: Bacillariophyta. P.253, F.403.

D.pseudovalis can very easily be mistaken for D.subovalis Cleve, being superficially very similar. The difference can only be observed on closer examination, when it can be seen that the two rows of poroids between the costae are arranged opposite each other and not diagonally ("quincunx") as in D.subovalis.

For this reason it is doubtful whether some of the specimens observed in the beginning of this study were in fact D.pseudovalis.

Cholnoky has reported this species mainly from waters in the coastal regions of the Cape Province (1959: 22; 1960B: 240) and of Natal (1960A: 37) where he also found it in localities removed from the sea. It was recorded from Stations 15 and 16 on the Kalk River, in samples from the Waterval and Vaal Rivers, and in a small tributary of the Klip River.

Samples - 401, 402, 406, 410, 447.

D.Smithii (Brebisson) Cleve var. pumila (Grunow) Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
650, F.1052 d.e.

Synonyms: Navicula ovalis var. pumila Grunow; Navicula puella
Schumann.

Single specimens of this variety were seen in samples from
two localities on the upper Waterval River, in one sample from a
tributary of the Vaal River near Standerton, and from the Vaal
River itself near Ermelo.

Samples - 419, 477, 511, 512.

D.subovalis Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 96.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
667, F.1063, a, b.

D. subovalis is the most commonly occurring species of the
genus in South Africa. According to Cholnoky it has often been
confused by other authors with D.ovalis. In the catchment area
it is frequently present, sometimes in high numbers, and is more
common than the other species of the genus.

EPITHEMIA Brebisson 1838.

E.sorex Kützing.

1930 - Hustedt: Bacillariophyta. P.388, F.736.

Synonyms: Cystopleura kamerunensis Gutwinsky et Chmielewsky;
Epithemia kamerunensis Woodhead et Tweed.

There is little information on the ecology of this species.
In two of the samples where it occurred in relatively high numbers

(9.9% in 405; 4.6% in 411) the pH values were 8.7, indicating that this species prefers relatively alkaline waters.

Samples - 323, 326, 365, 402, 405, 411, 412, 413, 420.

E.zebra (Ehrenberg) Kützing.

1930 - Hustedt: Bacillariophyta. P.304, F.729.

Synonyms: Eunotia zebra Ehrenberg; Navicula zebra Ehrenberg; Epithemia adnata Brebisson; Cymbella zebra Hassall; Frustulia adnata Kützing; Epithemia intermedia Wartmann; Cystopleura zebra (Kützing) Kunze; Epithemia zebra var. porcellus (Kützing) Grunow; Epithemia zebra var. saxonica (Kützing) Grunow.

Cholnoky (1962A: 21; 1962B: 71) no longer regards the varieties var. porcellus and var. saxonica as distinct from E.zebra as there are transitional forms making precise diagnosis difficult. In the catchment area E.zebra is recorded in low percentages from 13 samples. No data on its ecology is available.

Samples - 301, 306, 323, 326, 327, 405, 406, 411, 415, 420, 441, 477, 552.

EUNOTIA Ehrenberg 1837.

E.diodon Ehrenberg.

1848 - Ehrenberg: Infusoria, P.192, T.21, F.23.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 2: 276, F.742.

1930 - Hustedt: Bacillariophyta. P.173, F.207.

Synonyms: Eunotia minutula Grunow; Eunotia camelus Schumann; Eunotia diodon var. diminuta Grunow; Eunotia diodon f. minor Grunow; Eunotia diodon var. minutula v Schönfeldt.

E.diodon has been reported once from South Africa (Cholnoky 1955B: 164) and once from Ghana (Foged 1966: 55). As far as is known these are the only two records of this species from Africa. In the Vaal Dam catchment area this species occurred in one sample as a single record.

Sample-479.

E.exigua (Brebisson) Rabenhorst.

1864 - Rabenhorst: Fl.Eur.Alg. P.73.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora

Teil 2: 285, F.751, a - v.

1930 - Hustedt: Bacillariophyta. P.176, F.223.

Synonyms: Himantidium exiguum Brebisson; Eunotia minuta Hilse; Eunotia gracilis W. Smith; Eunotia paludosa Grunow; Eunotia monodon var. minuta Rabenhorst; Eunotia Nymanniana Grunow; Eunotia Smithii Gutwinsky; Eunotia exigua var. genuina A. Mayer; Eunotia pseudoelegans Cholnoky.

Cholnoky has quoted two different authorities for this species. In his earlier works he cited the authors (Brebisson) Grunow, while in later publications he changed to (Brebisson) Rabenhorst, without giving any reasons for this change. According to De Toni (1891: 792) Rabenhorst first used the specific combination E.exigua in 1864, and should therefore be regarded as the author of the species.

Cholnoky (1960B: 241; 1962A: 23; 1962B: 71) has reported this species from oligotrophic, acidic waters with a pH ranging between 6.0 - 6.5 (its optimum lying below 6.0). Of the five samples from which it was recorded, three (Vaal 301, 370 and 479) were collected at the headwaters of the Vaal River at Station 1, where the pH was recorded as fluctuating between 6.0 - 6.8. In

two of these samples the relative densities of this species was 0.7% and 0.8%. The remaining two samples were collected from two localities on the Wilge River, whose pH values were not measured.

Fig. - 34.

Samples - 301, 327, 331, 370, 479.

E.flexuosa (Brebisson) Kützing.

1849 - Kützing: Sp.Alg. P.6.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 2: 312, F.778.

1930 - Hustedt: Bacillariophyta. P.186, F.258.

Synonyms: Synedra flexuosa Brebisson; Synedra flexuosa var. angusta Brebisson; Eunotia pachycephala Kützing; Exilaria flexa Brebisson; Eunotia biceps Kützing; Synedra pachycephala Ralfs; Ceratoneis flexuosa Grunow; Ceratoneis pachycephala Grunow; Pseudoeunotia pachycephala De Toni; Pseudoeunotia biceps De Toni; Pseudoeunotia flexuosa De Toni.

Most Eunotia species are acidophilic and this species is no exception. In the Vaal Dam catchment area it was found only at the headwaters of the Vaal River where the pH was found to be around 6.5. One or two specimens were seen in each sample.

Samples - 301, 370.

E.garusica Cholnoky.

1952 - Cholnoky: Algenflora Portugiesisch Ost-Afrika.
Biol.Soc.Portug.Cienc.Nat.4:

E.garusica is found in relatively acid waters in South Africa and is fairly widespread throughout the country. In the catchment area it has been found only at the headwaters of the

Vaal River and in one sample from Lake Chrissie which lies just outside the Catchment area near the source of the Vaal River.

Samples - 301, 485.

E.gracilis (Ehrenberg) Rabenhorst.

1864 - Rabenhorst: Fl.Eur.Alg. P.72.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 2: 305, F.771.

1930 - Hustedt: Bacillariophyta. P.185, F.253.

Synonyms: Himantidium gracile Ehrenberg: Eunotia gracilis
var. fossilis Pantocsek; E.gracilis var. capitata Peragallo et
Heribaud; Eunotia gracilis f. minor Dippel; Eunotia glacialis
Meister; Eunotia maior var. genuina A. Mayer.

This species has been seen in relatively few localities in South Africa. Cholnoky has reported it from the Transvaal (Cholnoky 1955B: 166; 1957B: 348) and from Natal (1956: 66). Giffen (1966: 132) later found it in the Hogsback Region of the Eastern Cape Province. Only one other record of this species from Africa is available to me; this is from Ghana where it was discovered by Foged (1966: 55). In the catchment area it was found in a tributary of the Vaal River, the Kleinvaal River, where only one specimen was seen.

Sample - 464.

E.lunaris (Ehrenberg) Grunow.

1881 - Grunow: in V.H. Syn.T.35, F. 3,4,6.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 2: 302, F.769 a,b,d,e.

1930 - Hustedt: Bacillariophyta P.183. F.249.

Synonyms: Synedra lunaris Ehrenberg; Synedra bilunaris Ehrenberg;
Exilaria lunaris Hassall; Synedra falcata Brebisson; Exilaria

curvata Kützting; Ceratoneis lunaris Grunow; Eunotia curvata Lagerstedt; Pseudoeunotia lunaris var. falcata, var. bilunaris var. minor, var. cuspidata De Toni.

When Hustedt worked on the Congo material (Hustedt 1949A: 70) he discovered a small backward projecting appendage which was attached to the polar end of the rudimentary raphe of E.lunaris. This had hitherto been unknown in this species, although it does occur in others. On comparison with European material of the same species Hustedt found that the European material also possessed this appendage which in many instances was very difficult to see. This appendage has since become one of the main diagnostic characters of the species, E.lunaris. Cholnoky (1962C: 320) suggested a revision of the statement of the number of striae in this species since he found specimens with 19 striae in 10 μ . In all the examples seen in this study, the specimens fulfilled the description correctly, but possessed 18 striae in 10 μ .

Cholnoky (1962B: 71) maintained that this species is found in acidic and oligotrophic waters, and that its pH optimum lies around 6.0. The species occurred in small numbers from three localities, Station 1 on the Vaal River, Station 17 on the Waterval River, and once from Lake Chrissie, which lies just outside the catchment area near Ermelo.

Samples - 301, 340, 485.

E.pectinalis (Kützting) Rabenhorst.

1864 - Rabenhorst: Fl.Eur.Alg. P.73.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 2: 296, F. 763 a, k.

1930 - Hustedt: Bacillariophyta. P.180, F.237.

Synonyms: Fragilaria grandis Ehrenberg; Fragilaria pectinalis Ralfs; Eunotia depressa Ehrenberg; Himantidium pectinale Kützing; Fragilaria hiemale Duby; Himantidium Soleirolli Kützing; Himantidium strictum Rabenhorst.

There is some doubt concerning the authority of the specific epithet of this species. Both Hustedt (1927 - 1964, Teil 2: 296) and de Toni (1891: 793) quoted Conferva pectinalis Dillwyn? as a doubtful synonym of E.pectinalis; however there is some controversy over the systematic position of C.pectinalis.

According to Patrick and Reimer (1966: 205) Dillwyn attributed this species to O.F. Mueller, and Agardh (1824: 7) cited O.F. Mueller as the earliest author (1788) as well. If this is correct then the same species Conferva pectinalis has been cited by Hustedt as synonymous with two species in different genera. In the one case C.pectinalis Dillwyn? is synonymous with E.pectinalis (Hustedt l.c.: 296), while on the otherhand C.pectinalis O.F. Mueller is synonymous with Fragilaria capucina Desmazieres (Hustedt l.c.: 144). A study of the synonymy given by Agardh (l.c.) leads to the conclusion that C.pectinalis is the same as Fragilaria capucina on account of its synonymy with Fragilaria pectinalis Lyngbye. Thus it appears that C.pectinalis is completely unrelated to E.pectinalis, but rather to F.capucina.

Cholnoky (personal communication) maintained that the specific epithet is derived from Himantidium pectinale Kützing, and Kützing should, therefore, be recognised as the co-author of the species with Rabenhorst.

The pH optimum of this species lies a little higher than most other Eunotia species, about pH 6.0 - 6.5 (Cholnoky 1960B: 242; 1962A: 331; 1966A: 18; 1966B: 182), and according to Cholnoky the species will not reproduce at pH values above 6.5 - 6.6, and will die at pH values over 7. The distribution of

this species in the catchment area is limited to the Vaal River, where it occurred in the acidic waters at Station 1, and in one sample from lower down the river.

Samples - 301, 370, 477.

E.pectinalis var. minor (Kützinger) Rabenhorst.

1864 - Rabenhorst: Fl.Eur.Alg. P.74.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 22:
298, F.763 d - f.

1930 - Hustedt: Bacillariophyta. P.182, F.238.

Synonyms: Himantidium minus Kützinger; Eunotia pectinalis var. minor f. minutissima A.Mayer; Eunotia pectinalis var. minor f. impressa (Ehrenberg) Hustedt; Eunotia impressa Ehrenberg; Eunotia pectinalis var. impressa O. Müller; Eunotia impressa var. angusta Grunow.

E.pectinalis var. minor f. impressa is no longer regarded as a separate entity from the varietal forms, since a series of transitional forms have been found linking the variety with f. impressa.

This variety, like the typical form, is acidophilic and as a result is seldom seen in the Catchment area, as the conditions found in the area do not suit the growth of this species.

Samples - 350, 370, 485.

E.polydentula Brun.

1880 - Brun: Diat.Alp. P.51, T.2, F.27.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 2: 292, F.759, a,b.

1930 - Hustedt: Bacillariophyta. P.179 (under E.tridentula Ehrenberg).

Synonyms: Eunotia quinarum Ehrenberg; Eunotia quaternaria Ehrenberg; Eunotia tridentula Ehrenberg; Eunotia tridentula var. perminuta Grunow; Eunotia tridentula var. geniuna, var. perminuta, f. typica, f. quadridentata A. Mayer; Eunotia tridentula var. quadridentata A. Mayer.

E.polydentula (Fig.35) is one of those forms that, because its variable number of convex humps, has been given many synonyms, sometimes by the same author, e.g. A.Cleve-Euler (cf. Cholnoky 1960C: 354). Due to the variability of the species Cholnoky no longer regards the var. perpusilla as a separate taxon and has sunk it into the species (Cholnoky 1957A: 52; 1960A: 41).

This species like most other Eunotia species is stenotypically acidophilic (Cholnoky 1954C: 277) and according to Cholnoky it has been found in tropical - subtropical acidic and oligotrophic waters (Cholnoky 1960A: 41) in which the species appears to thrive when the pH of the water remains around pH 6.0. Its occurrence in the catchment area was extremely rare, one specimen being recorded at Station 11A at Harrismith.

Fig. - 35.

Sample - 331.

E.praerupta Ehrenberg.

1841 - Ehrenberg: Ber. Berl.Akad. P.414.

1927 - 1964 - Hustedt: Rothenhorsts Kryptogamenflora

Teil 2: 280, F.747, a - e.

1930 - Hustedt: Bacillariophyta. P.174, F.211.

Synonyms: Eunotia praerupta var. genuina and var. acuta Grunow; Eunotia praerupta var. laticeps Grunow and f. curta Grunow; Eunotia praerupta var. genuina f. subimpressa and f. curta A.Mayer;

Eunotia praerupta f. perminuta Fontell; Eunotia praerupta var. monodonoides and f. ventricosa A. Mayer.

This species has been recorded by Cholnoky from many localities in Rhodesia and in South Africa, but mainly from the Transvaal and Natal. In other parts of Africa, Foged records it from Ghana, Hustedt from the Congo and Cholnoky from the Ruwenzori Mountains. It has been recorded from one sample from Lake Chrissie which lies just outside the Catchment area. Sample - 485.

Eunotia pseudoveneris Hustedt.

1942 - Hustedt: Indomalayischen Archipels. Internat.Rev.d.Ges. Hydrob.Hydrogr. 42: 29, F. 24 - 29.

As the rivers in the catchment area are generally relatively alkaline, with very few places where the measured pH - values have been lower, the distribution of Eunotia species is extremely limited. E.pseudoveneris was present as odd records in three samples scattered over the catchment area. Samples - 328, 437, 485.

E.rhomboidea Hustedt.

1946 - 1950 - Hustedt: Norddeutscher Seen.

Arch.Hydrobiol. 43: 435, T.36, F.34 - 41.

Synonyms: Eunotia raytonensis Cholnoky; Eunotia tenella var. densestriata Cholnoky; Eunotia tenella var. capensis Cholnoky.

This small species (Fig. 36) has been found in many localities in South Africa, although it has not always been recorded under the same name. Cholnoky himself described this

species three times, once as a completely new species, E.raytonensis Cholnoky (1955B: 169) and twice as varieties of E.tenella Hustedt, var. densestriata (1955B: 169) and var. capensis Cholnoky (1959: 106). Cholnoky now regards these as synonyms of E.rhomboidea Hustedt.

E.rhomboidea is found in oligotrophic, acidic waters and particularly in the acid waters on Table Mountain Sandstone (cf. Cholnoky 1962B: 72). It was recorded from the acid waters of Station 1.

Fig. - 36.

Sample - 301.

E.Schweikerdtii Cholnoky.

1954 - Cholnoky: "de Hoek" Reservat. Bot.Not.1954(3): 278.F.46, 47.

To the author's knowledge this is the first record of this species since Cholnoky originally described it. In structure this specimen agreed with the description of Cholnoky (l.c.) but its dimensions were different. The length was 95 μ , and it was 8 μ wide, the transapical striae were also finer than the original specimens, being 16 in 10 μ . Cholnoky's original description must, on account of this new observation, be changed to accomodate the new dimensions.

Sample - 370.

E.similis Hustedt.

- Hustedt: in A.S.Atl. T.382, F. 11 - 24.

1937 - 1939 - Hustedt: Java, Bali and Sumatra.

Arch.Hydrobiol.Suppl.15: 165, T.12, F.5 - 8.

From the many localities in which Cholnoky has observed this species (Fig.37) it appears that it is widely distributed

over South Africa, where it inhabits acidic waters (cf. Cholnoky 1954C: 279; 1957A: 52; 1962B: 72). In the Vaal Dam Catchment Area it was recorded from the headwaters of the Wilge River.

Fig.- 37

Sample - 328.

E. subaequalis Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl. 15: 170, T. 12, F. 1 - 4.

- Hustedt: in A.S. Atl. T. 382, F. 5 - 10.

Synonyms: Eunotia sudetica O. Müller var. incisa Manguin; Eunotia veneris (Kützinger) O. Müller; Eunotia veneris var. rhynchocephala Manguin; Eunotia veneris var. subparallela Manguin.

This species is well known from South Africa and is regarded by Cholnoky as one of the commonest Eunotia species of acidic South African waters (Cholnoky 1954C: 279). This species is a characteristic epiphyte on submerged parts of aquatic macrophytes (Cholnoky 1954B: 211). It was found in only two samples from the catchment area.

Samples - 485, 464.

E. tenella (Grunow) Hustedt.

1913 - Hustedt: in A.S. Atl. T. 387, F. 20 - 25.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2: 284, F. 749.

1930 - Hustedt: Bacillariophyta. P. 175, F. 220.

Synonyms: Eunotia arcus var. tenella Grunow; Eunotia arcus var. hybrida Grunow; Eunotia minima Gutwinsky; Eunotia pectinalis var. pusilla A. Mayer.

Cholnoky (1960C: 355) after revision of the appropriate material has transferred the var. densestriata Cholnoky (1955B: 169) to the species E.rhomboidea Hustedt, (1946 - 1950: 435, T.36, F.34 - 41), considering it to be synonymous. He has also sunk the f. undulata Hustedt (1949A: 69, T.3, F.30 - 31) into the species on account of the transitional forms linking the typical forms and f. undulata (c.f. Cholnoky 1964: 64). Although quite widespread in South Africa, it was nevertheless, present in only two samples from this area.
Sample - 301, 358.

FRAGILARIA Lyngbye 1817.

F.brevistriata Grunow.

1881 - Grunow: in V.H. Syn. T.45, F.32, 34.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora

Teil 2: 168, F.676 a - e.

1930 - Hustedt: Bacillariophyta P.145, F.151.

Synonyms: Fragilaria acuta Ehrenberg; Fragilaria brevistriata var. subacuta and var. pusilla Grunow; Fragilaria rostrata Pantocsek; Fragilaria brevistrata var. linearis A. Mayer.

From the many references that Cholnoky has made with regard to observing abnormal forms, it would appear that the complete range of morphological variations for this species is still to be fully defined. One of the examples seen in this investigation was smaller than the dimensions given by Hustedt (8 μ long). Similar short forms have also been observed in Lake Sibayi (Archibald 1966B: 486).

Cholnoky reported it from weakly basic waters from the midlands of Natal (Cholnoky 1960A: 42). It was recorded from two localities in the catchment area, and once from Lake Chrissie.
Samples - 307, 431, 485.

F.brevistriata var. inflata Pantocsek.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 2: 169, F.676 h.

1930 - Hustedt: Bacillariophyta. P.145, F.152.

Synonyms: Fragilaria inflata Pantocsek.

On account of the great variability within this species, it would probably be better to sink this variety, and include it with the typical forms of the species. One isolated example of this variety was recorded from a small tributary of the Klip River near Memel.

Sample - 436.

F.construens (Ehrenberg) Grunow.

1862 - Grunow: Verh.zool -bot. Ges.Wien 12: 871.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 2: 156, F.670 a - c.

1930 - Hustedt: Bacillariophyta. P.140, F.135.

Synonyms: Staurosira construens Ehrenberg; Odontidium tabellaria W. Smith; Dimerogramma tabellaria Ralfs; Fragilaria construens var. genuina Grunow; Fragilaria construens f. biceps Ströse; Fragilaria rhombica Östrup; Fragilaria mutabilis var. assymetrica A. Cleve; Fragilaria construens var. venter (Ehrenberg) Grunow.

In this species Cholnoky (1964: 66; 1966A: 21) has in many instances seen so many transitional stages between var. venter and the typical forms that he has considered it best to sink the variety and include it with the typical forms of the species.

F.construens apparently thrives in oxygen rich water with a weak or relatively high alkaline pH value, and is unable to withstand salts. In the catchment area its occurrence was very small.

Samples - 306, 307, 360, 406, 485.

F.construens var. subsalina Hustedt.

1925 - Hustedt: Mit.Geogr.Ges.v.d.Naturlist.Mus.Lübeck,2.

Reihe 30: 106, F.5 - 8.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora

Teil 2: 159. F. 670 p - 8.

1930 - Hustedt: Bacillariophyta. P.141, F.139.

This is a rare variety of F.construens and, indeed, only one specimen was seen.

Sample - 322.

F.familiaris (Kützinger) Hustedt.

1957 - Hustedt: Flusssysteme der Weser. Abh.d.Naturw.Ver.

Bremen 34: 229.

Synonyms: Synedra rumpens var. familiaris (Kützinger) Grunow;

Synedra rumpens var. scotica Grunow.

This diatom species is found in neutral to weakly alkaline water (cf. Cholnoky 1962B: 73; 1962C: 321). Its distribution is fairly widespread in South Africa, and it was one of the most commonly occurring species of the genus Fragilaria in the catchment area. It was particularly common in the Vaal River and its tributaries, sometimes appearing in high numbers.

F.fonticola Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch.Hydrobiol.Suppl.15: 151, T.10, F.61, 62.

In Natal Cholnoky (1960A: 43) has found individuals which have up to 20 striae in 10 μ and are 4 μ broad. Thus a series of forms can be drawn up which provides a link between the typical forms and the var. angusta Hustedt. The distinction between the two variations was pointless and as a result the two have been united under the name Fragilaria fonticola Hustedt.

As it does not occur abundantly in South Africa, nor in the Vaal Dam catchment area, the autecology of the species is not properly known, but it apparently favours neutral to weakly alkaline waters (Cholnoky 1962B: 73).

Samples - 339, 377, 378, 410, 412.

F. fragilarioides (Grunow) Cholnoky.

1963 - Cholnoky: Holländisch-Neuguinea. Nova Hedwigia 5: 168.

Synonyms: Synedra rumpens var. fragilarioides Grunow.

In his paper on the Diatoms from Dutch New Guinea Cholnoky (1963C: 168) found evidence which led him to transfer Synedra rumpens var. fragilarioides Grunow to the genus Fragilaria.

This particular species of Fragilaria is uncommon in South Africa and occurred once in the catchment area.

Sample - 340.

F. pinnata Ehrenberg.

1843 - Ehrenberg; Mikrogeol.e.p.: T1, F. iii, 7; T.3, F. iii, 18; T.5, F.i, 32, iii, 48; T.6, F.i, 45.ii, 24. etc. (1854).

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 2: 160, F.671 a - i.

Synonyms: Fragilaria striolata Ehrenberg; Odontidium pinnatus Kützinger, Odontidium striolatus Kützinger; Odontidium mutabile W. Smith; Dimerogramma mutabile Ralfs; Fragilaria mutabilis Grunow; Odontidium ventriculosum Schumann; Fragilaria elliptica Schumann, Fragilaria minutissima Grunow; Odontidium minimum Naegeli.

This small species of Fragilaria, which was found in small numbers in the Vaal Dam catchment area, thrives in water having a

pH range of 7.2 - 8.0, with a constant high concentration of oxygen and a good buffering system, i.e. high alkalinity (cf. Cholnoky 1962B: 73). Cholnoky (1960B: 244; 1963D: 241) has found it in brackish waters indicating that it can withstand a high salt content.

Samples - 239, 306, 307, 409, 437, 441, 485, 486.

F.pinnata var. lancettula (Schumann) Hustedt.

1913 - Hustedt: in A.S. Atlas T.297, F.51, 59 - 64.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
161, F.671 m - o.

Synonyms: Fragilaria lancettula Schumann.

The autecology of this variety is the same as that of the typical forms of the species, since it is nearly always associated with it. This variety was recorded twice from the catchment area, once from Station 2 on the Vaal River, and once from the Seekoeivlei near Memel.

Samples - 261, 486.

F.Vaucheriae (Kützing) Boye Petersen.

1938 - Boye Petersen: Fragilaria intermedia - Synedra Vaucheriae?
Bot.Not.1938 (1/3): 167, F.1 c - g.

Synonyms: Exilaria Vaucheriae Kützing; Frustulia anceps Kützing; Frustulia parvula Kützing; Synedra minutissima Kützing; Synedra parvula Kützing; Synedra exilis Kützing; Synedra deformis W.Smith; Synedra Vaucheriae Kützing; Staurosira intermedia Grunow; Fragilaria mutabilis var. intermedia Grunow; Odontidium mutabile var. intermedia De Toni; Synedra Vaucheriae var. distans and var. deformis Grunow; Fragilaria intermedia Grunow.

Since the epithet Vaucheriae was firstly validly used in 1833 about 50 years before Grunow's epithet intermedia, it clearly has priority over the younger epithet intermedia. According to Patrick and Reimer (1966: 120), Boye Petersen was the first to use the combination Fragilaria Vaucheriae correctly. In sample Vaal 412 some abnormally short forms of this species were observed (Fig. 38, 39); these specimens were only 7 μ long and intergraded with the more typical forms.

The autecology of this species indicates that it has a preference for neutral to relatively alkaline waters, containing a good supply of oxygen. The waters of the Vaal Dam catchment area often fulfilled these conditions, with the result that this species was widely distributed, sometimes occurring in very high numbers.

Figs - 38, 39.

F.virescens Ralfs.

1843 - Ralfs: Ann.Mag.Nat.Hist. 12: T.2, F.6.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2: 162, F.672A. a, b.

1930 - Hustedt: Bacillariophyta. P.142, F.144.

Synonyms: Diatoma sulphurescens Agardh; Fragilaria confervoides Greville; Fragilaria pectinalis Ehrenberg; Diatoma virescens Hassall; Fragilaria virescens var. diatomacea Grunow; Fragilaria producta (Lagerstedt) Auct. nonnull. For further synonyms see Hustedt 1927 - 1964, Teil 2: 162.

F.virescens is a very variable species resulting in a superfluous differentiation of the species into varieties (Cholnoky 1960B: 245; 1960C: 355). The only specimen

(length 11 μ and width 3.5 μ) observed in the catchment area had the smaller dimensions mentioned by Cholnoky (1954A: 413).

Sample - 410.

FRUSTULIA Grunow 1865.

F.rhomboides (Ehrenberg) De Toni.

1891 - De Toni: Syll. Alg. P.277.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 122.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora. Teil 2:
728, F. 1098 a.

1930 - Hustedt: Bacillariophyta. P.220, F.324.

Synonyms: Navicula rhomboides Ehrenberg; Vanheurckia rhomboides Brebisson; Frustulia rhomboides var. genuina A. Mayer.

Hustedt (1937 - 1939, Suppl 15: 215) described F.rhomboides as an "indifferent" form, thriving in a pH range of 5.5 - 8.2. However, Cholnoky (1962B: 74; 1966B: 184) has found that in South Africa this species is limited to waters with a narrow pH range around 6.0. The species was observed in three samples from one locality, namely the head-waters of the Vaal River, where the waters are acidic, due to marshy conditions.
Samples - 301, 370, 479.

Frustulia rhomboides var. saxonica (Rabenhorst) de Toni.

1891 - De Toni: Syll.Alg. P. 277.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 123.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
729, F. 1099 a.

1930 - Hustedt: Bacillariophyta. P.221. F.325.

Synonyms: Frustulia saxonica Rabenhorst; Navicula crassinerva Brebisson; Frustulia torfacea Braun.

Both the two different forms of this variety f. undulata and the f. capitata (A. Mayer) Hustedt have been included with typical forms on account of the transitional stages between all these forms (cf. Cholnoky 1955B: 170). Cholnoky has observed specimens which he regarded as linking the variety var. saxonica with the typical Frustulia rhomboides, but no such transitional forms have been observed in the samples from the catchment area.

The autecology of the variety is the same as that for the typical forms of the species. In the catchment area, the variety has been recorded from a greater number of samples. It is interesting to note that all these samples were taken from the upper reaches of certain rivers and tributaries, e.g., the Vaal, Kleinvaal, Klipspruit and Wilge River, where the waters in some cases were acidic.

F. subvulgaris Cholnoky.

1959 - Cholnoky: Seltene iv - Kaap-Provinz. Ötserr. Bot. Zeitschr.
106: 27, F. 160.

Frustulia subvulgaris occurred rarely in the catchment area, being found mainly in the Waterval River.

Fig - 40.

Samples - 321, 324, 406, 410, 432, 477, 485, 497.

F. tugelae Cholnoky.

1956 - Cholnoky: Seltene ii - Tugela-Gebiete. Österr. Bot. Zeitschr.
103: 71, F. 69.

Giffen (1966: 135) found that specimens from the Hogsback Region showed a graduated series, from the typical forms of F. tugelae with constricted side walls, to a modified form with straight,

parallel sides without a constriction. In the Vaal samples the same range of form was observed (Figs. 41 - 43). In "Some new and rare Diatoms from South Africa" (Archibald 1966A) a specimen (Fig. 2) was erroneously assigned to the species F. subvulgaris Cholnoky; this was in fact the straight sided form of F. tugelae.

This species was uncommon in the catchment area, where it was found in a number of samples from the upper reaches of the Vaal, Klip and Wilge Rivers.

Figs. - 41 - 43.

Samples - 327, 328, 330, 434, 464, 485.

F. vulgaris (Thwaites) De Toni.

1891 - De Toni: Syll. Alg. P. 280.

1894 - Cleve: Naviculoid Diatoms. Kongl. Sv. Vet. Akad. Handl. 26: 122.

1927 - 1964 - Hustedt: Bacillariophyta. P. 221, F. 327.

Synonyms: Colletonema vulgare Thwaites; Navicula rhomboides var. obtusa Grunow; Navicula vulgaris Heiberg; Schizonema vulgare Rabenhorst; Navicula dirhynchus Donkin; Vanheurckia vulgaris Van Heurck.

In common with Cholnoky (1960B: 245) the typical forms were rarely seen in the catchment area. They appeared to be limited to the Waterval River where it occurred as single records in a small number of samples.

F. vulgaris var. angusta Cholnoky.

1954 - Cholnoky: Süd Rhodesien. Port. Acta Biol. 4: 214, F. 61.

In contrast with the typical forms of the species Cholnoky's variety, var. angusta occurs far more commonly in the Vaal Dam

catchment area than the typical form. Cholnoky has reported it many times from neutral to weakly alkaline waters of South Africa. These conditions were widespread in the catchment area, resulting in a widespread distribution of the variety in the catchment area. The paucity of records from the Waterval River might have resulted from some confusion with the typical forms.

F. Weinholdii Hustedt.

1927 - 1964 - Hustedt; Rabenhorsts Kryptogamenflora

Teil 2: 731, F.1101.

1936 - Hustedt: A.S.Atl. T.406, F.7, 8.

Cholnoky (1960A: 46) was extremely surprised to find typical examples of this species in South Africa. As far as is known Cholnoky's record was the first to be made outside Europe, where, even there, it is seldom seen. In the catchment area three specimens have been recorded, one of which was illustrated (Fig. 44) because of its slightly smaller length, 36 μ as compared with Hustedt's lower limit of 40 μ . However in all other aspects this specimen agreed with the description given by Hustedt (l.c.) It was recorded from Stations 9 and 10 on the Wilge River, and once from Station 24 on the Klip River.

Fig. - 44.

Samples - 327, 330, 437.

GOMPHONEMA Agardh 1824.

G.angustissima Hustedt var. africana Cholnoky.

1959 - Cholnoky: Seltene iv - Kaap Provinz.

Österr.Bot.Zeitschr. 106: 28, F. 161.

Due to its extremely narrow and long valves and larger punctae at the end of the striae near the raphe, this variety was identified without too much difficulty.

In the catchment area one example in full agreement with Cholnoky's description was recorded from Station 1 on the Vaal River.

Sample - 370.

G.Cleveii Fricke.

- Fricke: in A.S. Atl. T.234, F.44 - 46.

Synonyms: Gomphonema brachyneura O. Müller; Gomphonema rhombicum A. Schmidt and Fricke; Gomphonema navicella O. Müller; Gomphonema Frickei O. Müller.

G.Cleveii can easily be distinguished from the smaller G.Schweikerdtii by looking closely at the transapical striae. In each stria there are two rows of pores which are arranged in such a way as to form a "quincunx" or diagonal rows. In G.Schweikerdtii there is a simple single row of pores.

This species of Gomphonema is characteristic of neutral to weakly basic or alkaline waters, in which it shows a great variability. In the catchment area it was one of the most commonly occurring species of the genus, as the conditions found in the rivers were suitable over a wide area. Older authors have recorded this species on many occasions as G.brachyneura.

G.constrictum Ehrenberg.

1831 - Ehrenberg: Abh.Berl.Akad. P.63.

1895 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 186.

1930 - Hustedt: Bacillariophyta P.377. F.714.

Synonyms: Gomphonema pohliaeforme Kützing; Gomphonema subramosum
Kützing; Gomphonema constrictum var. subcapitata Grunow;

This species occurred in quite a number of samples but in
none was it ever very abundant.

G.constrictum var. capitata (Ehrenberg) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Hanl.
26: 186.

1930 - Hustedt: Bacillariophyta P.377, F.715.

Synonyms: Gomphonema capitatum Ehrenberg; Gomphonema turgidum
Ehrenberg; Gomphonema italicum Kützing; Gomphonema clavatum
Ehrenberg.

The autecology of this species cannot be properly
ascertained as the species and its varieties occur so infrequently.
This variety may sometimes provide a transitional stage to
G.constrictum var. Gautierii (van Heurck) Cholnoky. It was
recorded from the Sand River at Station 8, and from the Wilge
River near Frankfort.
Samples - 233, 456.

G.constrictum var. Gautierii (van Heurck) Cholnoky.

1957 - Cholnoky: Rustenberg. Bot.Not. 110: 350, F.43, 44.

Synonyms: Gomphonema augur Ehrenberg var. Gautierii van Heurck.

This variety, which Cholnoky (l.c.) transferred from the
species Gomphonema augur to the species Gomphonema constrictum,

seldom occurs in South Africa, or in the Vaal Dam catchment area. It was recorded from scattered localities on the Vaal, Klip and Wilge Rivers.

Samples - 301, 327, 335, 437, 486.

G.dichotomum Kützing emend. Archibald.

1966 - Archibald: New and Rare Diatoms. Nova Hedwigia Suppl.

21: 255, F.4.

Synonyms: Gomphonema intricatum var. dichotomum (Kützing) Grunow; Gomphonema intricatum var. pumila Grunow; Gomphonema gracillimum Schumann; Gomphonema pulvinatum.

Cholnoky (1962B: 75) maintained that there was only a superficial similarity between G.intricatum and its variety var. pumila. A close examination of the drawings in A. Schmidt's Atlas (pl. 234, F.47 - 50, 56 - 57, 58; Pl. 235, F. 15 - 17, 34 - 39; Pl. 236, F. 1 - 8) and Grunow's drawings in van Heurck (1880 - 1881: Pl. 24, F. 28 - 29, 35 - 36) confirms the truth of Cholnoky's contention. G.intricatum var. pumila, according to Cholnoky, is more commonly observed by far than the typical form G.intricatum. On account of its superficial similarity and its relatively greater frequency in the samples it is felt that the variety should be raised in rank to species. Before adopting a specific epithet for this resurrected species, the taxonomic position of G.intricatum var. dichotoma should be revised. Hustedt (1937 - 1939; Suppl. 15: 436) stated that "die Kleinen Formen var. pumila und var. dichotoma sind kaum voneinander zu trennen. Sie kommen im Material meistens nebeneinander vor,". The only difference that can be found between the two varieties is in the number of striae (cf.A.S.Atl.Pl.234, F.51-55;

Pl. 235, F.30 - 33). Hustedt's description (1930: 375) stated that var. pumila has 8 - 11 striae and var. dichotoma has 11 - 13 striae in 10 μ . Cholnoky (personal communication) found that var. pumila sometimes had up to 16 striae in 10 μ . It appears that the two varieties intergrade one with another and should, therefore, be united. Kützing's epithet dichotomum is the oldest valid epithet available, and the new combination is, therefore, Gomphonema dichotomum Kützing emend. Archibald. Its distribution in the Vaal Dam catchment area is wide spread. Fig - 45.

G.gracile Ehrenberg.

1838 - Ehrenberg: Infusionsthierchen P. 217, T.18, F.3.

1895 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 182.

1930 - Hustedt: Bacillariophyta. P.376, F.702.

Synonyms: Gomphonema gracile var. lanceolata (Kützing) Cleve;
Gomphonema turris var. apiculata Grunow.

An unusually short and broad form of the species has been illustrated in Fig. 46. Cholnoky (1962B: 75) has reported this species in oligotrophic, neutral waters, having fluctuations of the pH value towards the acid side. Its distribution in the catchment area appeared to be quite widespread, although never occurring in great abundance.

Fig. - 46.

G.gracile f. turris (Ehrenberg e.p.) Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl.15: 439.

This form of the species is very rare in the catchment area

and was reported from only two localities. As far as is known this is the first time that the f.turris has been reported from South Africa.

Samples - 306, 338.

G.javanicum Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch.Hydrobiol. Suppl. 15: 435, T. 27, F. 2 - 5.

G.javanicum Hustedt is very similar to G.parvulum(Kützing) Grunow and indeed it is sometimes difficult to distinguish the two species. G.javanicum differs in the shape of the valve and slightly in the structure of the transapical striae.

Two examples have been illustrated (Figs. 47, 48).

Cholnoky has recorded this species once from the de Hoek Forest Reserve in the Northern Transvaal. In the catchment area it occurs in a small number of samples taken mainly from the Klip River and its tributaries.

Fig. - 47, 48.

Samples -335, 354, 364, 431, 436, 445, 449, 451.

G.lanceolatum Ehrenberg

1843 - Ehrenberg: Sud-und Nord-Amerika. Abl.Berl.Akad.T.2, 1, F.37.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 183.

1930 - Hustedt: Bacillariophyta. P.376, F.700.

Synonyms: Gomphonema affine Kützing; Gomphonema Szaboi Pantocsek.

This is a rare species in South Africa and it was recorded from only three samples in the Vaal Dam catchment area. Nothing certain is known of its autecology.

Samples - 401, 414, 497.

G.longiceps Ehrenberg.

1930 - Hustedt: Bacillariophyta. P.375, F.704.

It is extremely rare to see the typical forms of this species. Cholnoky (1956: 92) has made one record of it, and it was present in one sample from Lake Chrissie.

Sample - 485.

G.longiceps var. subclavata Grunow.

1930 - Hustedt: Bacillariophyta. P.375, F.705.

Synonyms: Gomphonema subclavatum (Grunow) Cleve; Gomphonema longiceps var. subclavata f. gracilis Hustedt.

In his "Synopsis of the Naviculoid Diatoms", Cleve (1894: 183) raised the variety, var. subclavata, to the rank of species. This was, however, reduced once more to subspecific rank. Cholnoky (1966B: 185) has more recently queried the status of this variety, and appears to be reverting to Cleve's original opinion. Observations of this variety in the catchment area provide no answer to this question as only a single specimen of the typical form was recorded, thus preventing a proper comparison with the variety.

G.longiceps var. subclavata is extremely common in South Africa in oligotrophic, neutral waters. It was one of the most commonly occurring Gomphonema forms in the catchment area, where its distribution was widespread, sometimes occurring abundantly.

G.olivaceum (Lyngbye) Kützing.

1844 - Kützing. Bacillarien. P.85, T.7, F.XIII and XV.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.

26: 187.

1930 - Hustedt: Bacillariophyta. P.378, F.719.

Synonyms: Echinella olivaceum Lyngbye; Gomphonema sphaenelloides Schumann; Gomphonema subramosum Kützing; Sphenella vulgaris Kützing.

The first record of this species in Africa is from the Congo (Hustedt 1949A: 122). There is some doubt about the identification of this species in this sample, but if correct, it constitutes the first record of the species in South Africa. It occurred in a single sample from Roodebank (Station 17) on the Waterval River.

Sample - 339.

G.parvulum (Kützing) Grunow.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.

26: 180.

1930 - Hustedt: Bacillariophyta. P.372, F.713.

Synonyms: Sphenella parvulum Kützing; Gomphonema parvulum var. subcapitata Grunow; Gomphonema parvulum var. lanceolata; Gomphonema micropus Kützing; Gomphonema parvulum var. micropus (Kützing) Cleve; Gomphonema angustatum var. intermedia Grunow; Gomphonema angustum Brebisson; Gomphonema lagenula Grunow; Gomphonema parvulum var. lagenula (Grunow) Hustedt.

The variability of this species is so great, that transitional forms between all the varieties cited by Hustedt (1930: 373), can be found. It is clear that the demarcation into varieties is entirely superfluous and of no good purpose at all. There is a possibility that G.parvulum var. lagenula is only a phenotype found in slightly

more acid waters than the other forms (cf. Cholnoky 1962B: 77). The variety, var. lagenula, is sometimes still maintained purely on sentimental grounds.

The autecology of this species has been clearly set out by Cholnoky (1962B: 76). G.parvulum is found in great abundance in neutral to relatively alkaline water, and it has also been reported on occasions from weakly acid water (Cholnoky 1960A: 47; 1960B: 247; 1962A: 30; 1962B 77 under var. lagenula). A pre-requisite for the good development of this species is a fluctuating concentration of organic nitrogen compounds. It cannot, however, withstand high concentrations of salts.

Its distribution in the catchment area was widespread in many samples. It was one of the most commonly occurring diatom species, and was sometimes recorded in very high numbers.

G.Schweikerdtii Cholnoky.

1953 - Cholnoky: Hennops - Rivier. Verh.zool - bot.

Ges.Wien 93: 143, F.18, 19.

This small Gomphonema species is similar to G.Cleveii, but is easily distinguished by examination of the transapical striae. In G.Schweikerdtii the transapical striae are composed of a single row of simple punctae. In contrast to this G.Cleveii has a double row of punctae arranged in a 'quincunx' fashion. Sometimes in G.Schweikerdtii near the margin of the valve the striae are composed of indistinct double punctae which are never arranged in diagonals.

Cholnoky (1960A: 47) has reported the species from neutral to weakly alkaline water. In the Catchment area it was found in relatively few samples mainly from the Klip River System. Samples - 261, 331, 410, 434, 441, 445.

(183). .

G.sphaerophorum Ehrenberg var. parvum Cholnoky.

1954 - Cholnoky: Neue und seltene Diatomeen. Österr.Bot.Zeitschr.
101: 416, F.40.

This is the second time this variety has been observed;
it was recorded from one sample collected from the Grootvlei Dam
(Station 16).

Sample - 401.

G.subtile Ehrenberg.

1843 - Ehrenberg: Süd-und Nord-Amerika. Abh.Berl.Akad.
P 115, N.115.

1895 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 182.

1930 - Hustedt: Bacillariophyta. P.376, F.709.

Cholnoky (1954D: 126) has found specimens of G.subtile
which are much smaller than the dimensions given by Hustedt
(1930: 376): and in the Eastern Transvaal he has found other
examples which are very much larger than Hustedt's dimensions.
The dimensions should be altered then to include these examples;
Length 28 - 80 μ , breadth 4 - 5 - 10 μ . According to Hustedt
(1937 - 1939, Suppl. 15: 440) the pH influences the formation
of the capitate ends and the more acidic the water becomes the
more the capitate end disappears. Cholnoky (1957B: 350) has
reported evidence to substantiate this, and in this note he
reported that he could find no "var. sagitta (Schumann) Cleve
in the truly acidic waters."

Cholnoky (1962B: 77) reported that the optimum pH value for
this species was around pH 6.0. As a result of this it was found
in one sample from Lake Chrissie.

Sample - 485.

GYROSIGMA Hassall 1845.

G.acuminatum (Kützting) Rabenhorst.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.

26: 114.

1930 - Hustedt Bacillariophyta. P.222, F.329.

Synonyms: Frustulia acuminata Kützting; Pleurosigma acuminatum Grunow; Pleurosigma lacustre W. Smith; Pleurosigma transsilvanicum Pantocsek.

This Gyrosigma species is not common in South Africa and was found in only five samples. Cholnoky is of the opinion that many of the older records of this species were in fact G.Küzingii (Grunow) Cleve or G.Spencerii (W.Smith) Cleve, which are both very common in South Africa.

Samples - 405, 408, 432, 468, 491

G.acuminatum var. gallica Grunow.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.

26: 114.

1930 - Hustedt: Bacillariophyta. P.223.

Synonyms: Pleurosigma scalprum var. gallica; Pleurosigma gallica Peragallo.

Cholnoky (1962A: 31) has recorded this variety once from the Cape Province and before that Huber-Pestalozzi recorded it in 1929 from the Waterkloof Reservoir near Pretoria (cf. Cholnoky l.c.). It was recorded once from the catchment area from the Grootspuit, a tributary of the Waterval River.

Sample - 411.

G.Kützingii (Grunow) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 115.

1930 - Hustedt: Bacillariophyta. P.224, F.333.

Synonyms: Pleurosigma Kützingii Grunow; Pleurosigma Spencerii
var. Kützingii Grunow; Pleurosigma gracilentum Rabenhorst;
Pleurosigma Wormleyi Sullivan; Pleurosigma Spencerii var.
acutiuscula Grunow; Gomphonema distortoides Manguin.

This is one of the most common species of Gyrosigma
in South Africa, and also in the catchment area. Chelnoky
(1960A: 48; 1960B: 247; 1962B: 77) has reported it from
neutral to weakly alkaline waters. These conditions are
widespread in the catchment area.

G.scalproides (Rabenhorst) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 118.

1930 - Hustedt: Bacillariophyta. P.226, F.338.

Synonyms: Pleurosigma scalproides Rabenhorst; Pleurosigma
Spencerii var. scalproides Peragallo.

This species, in conjunction with G.Kützingii (Grunow)
Cleve, is very common in South Africa and the catchment area,
since the conditions under which the two species thrive are
similar. This species has a preference for neutral to weakly
alkaline waters.

G.Spencerii (W.Smith) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 117.

1930 - Hustedt: Bacillariophyta. P.225, F.336.

Synonyms: Pleurosigma Spencerii W. Smith; Pleurosigma Spencerii
var. Smithii Grunow; Pleurosigma Spencerii var. Arnottii Grunow;

(186).

Pleurosigma var. borealis Grunow; Pleurosigma Spencerii var. Antillarum Grunow; Pleurosigma curvula Grunow;

G.Spencerii was found in only two samples from the Vaal Dam catchment area, composing 1.0% of the diatom association in Vaal 413.

Samples - 403, 413.

HANTSZCHIA Grunow 1880.

H.amphioxys (Ehrenberg) Grunow.

1880 - Grunow: in Cleve et Grunow - Arctischen Diatomeen.

Kongl.Sv.Vet.Akad.Handl. 17: 103.

1930 - Hustedt: Bacillariophyta. P.394, F.747.

Synonyms: Hantzschia amphioxys var. africana Hustedt; Hantzschia amphioxys var. africana f. minuta Cholnoky.

In South Africa Cholnoky (1964: 67; 1966B: 186) has found transitional forms which provide the link between the typical form and the var. africana Hustedt (1922: 117); Cholnoky was also able to establish that his f. minuta Cholnoky (1955B: 171) was also linked to the typical forms through transitional examples. It would appear that the pH might have some influence over the size of the valve and the density of the striations. Cholnoky (1962A: 31) reported the typical forms from weakly alkaline to alkaline waters; the more densely striated examples ("var. africana") from neutral waters (cf. Cholnoky 1962B: 78); and the very small examples ("f.minuta") from weakly acid waters (cf. Cholnoky 1954D: 126; 1955A: 18).

The finely and closely striated specimens of the typical form were the most commonly occurring forms in South Africa, and also in the Catchment area, where this species was recorded in a relatively large number of samples.

(187).

H.amphioxys var. vivax (Hantzsch). Grunow.

1880 - Grunow: in Cleve et Grunow - Arctischen Diatomeen.

Kongl.Sv.Vet.Akad.Handl. 17: 103.

1930 - Hustedt: Bacillariophyta. P.394, F.750.

The var. vivax has not been recorded as commonly from South Africa as the typical forms of the species. In the catchment area it was recorded as isolated examples from only four samples. Cholnoky (1966A: 28) has stated that the var. vivax has been differentiated only on the basis of the shape of the valve, and in particular the shape of the poles, and not on the basis of the dimensions of the valve. In one sample (Vaal 479) the valve length of a specimen was only 72.5 μ long and contained 28 transapical striae per 10 μ .
Samples - 306, 353, 478, 479.

H.distinctepunctata Hustedt.

- Hustedt: A.S. Atl. T.329, F.21, 22.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl. 15: 462, T.40, F.4.

This is not a commonly observed species in South Africa. It has been recorded from neutral to weakly basic waters (cf. Cholnoky 1955A: 18), which have a slightly raised salt concentration (cf. Cholnoky 1966A: 28). In the Vaal Dam catchment area it occurred in only two samples, one from Station 2A, and the other from a headwaters tributary of the Kaffirspruit River.
Samples - 306, 492.

H.virgata (Roper) Grunow.

1930 - Hustedt: Bacillariophyta. P.395, F.752.

The variety var. capitellata has been sunk into the typical forms of the species on account of transitional forms which link the variety with the typical forms (cf. Cholnoky 1960B: 247).

Hantzschia virgata, according to Cholnoky (1955A: 18; 1960A: 49; 1966A: 29) is a brackish water form which can withstand high osmotic pressures. It prefers also waters with a constant high pH value. As a result H.virgata is probably an intruding species in the catchment area.

Sample - 362.

MASTOGLOIA Thwaites 1856.

M.elliptica (Agardh) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
27: 152.

1930 - Hustedt: Bacillariophyta. P.217, F.317.

Synonyms: Frustulia elliptica Agardh; Mastogloia Dansei var. elliptica Grunow; Mastogloia obtusa Pantocsek.

Hustedt (1930: 217) incorrectly quoted Agardh as the sole author of this species. Agardh, however, described the species under the genus Frustulia (cf. Agardh 1824: 311), and it was Cleve who transferred it to the genus Mastogloia.

The species is very uncommon in South African waters, and is regarded as a brackish water species. It occurred in one sample, where it cannot be regarded as autochthonous.

Sample - 420.

MELOSIRA Agardh 1824.

M. distans (Ehrenberg) Kützing.

1844 - Kützing: Bacillarien. T.2, F.12.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 1: 262, F.110a - f, i.

1930 - Hustedt: Bacillariophyta. P.92, F.53.

Synonyms: Gaillonella distans Ehrenberg; Coscinodiscus minor W. Smith; Melosira nivalis W. Smith; Orthosira nivalis Kitton; Melosira distans var. nivalis Grunow; Melosira solida var. Sarsii Gran; Melosira polymorpha subsp. distans Bethge; Melosira polymorpha subsp. distans var. nivalis Bethge; Gaillonella (Discoplea- Melosira-) gallica Ehrenberg?

Only two previous records of this species from Africa are known, one from Ghana (Foged 1966: 48) and the other from the Transvaal (Cholnoky 1955B: 173). This one specimen from the Vaal River is the second record of its occurrence from the Transvaal and South Africa.

Sample - 309.

M. granulata (Ehrenberg) Ralfs.

1861 - Ralfs: in Pritchard's History of Infusoria. P.820.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:

248, F.104, a - c, e, f.

1930 - Hustedt: Bacillariophyta. P.87, F.44.

Synonyms: Gaillonella granulata Ehrenberg; Gaillonella decussata Ehrenberg; Melosira decussata Kützing; Melosira granulata var. maxima Ehrenberg; Orthosira punctata W. Smith; Melosira lineolata Grunow; Melosira punctata Juhlin-Dannfeldt.

Cholnoky (1963C: 175) was of the opinion that the var. angustissima O.Müller is separated from the typical forms for reasons that are no longer tenable, i.e. the measurements of

the cell. In his work on diatoms from Dutch New Guinea (Cholnoky l.c.) he claimed to have found transitional forms linking the variety with the typical forms. In this present study so few examples of M.granulata have been seen that it is not possible to substantiate his observations.

M.granulata, according to Cholnoky (1962B: 78), is a true plankton diatom inhabiting relatively eutrophic, weakly alkaline water. This species was found in only three samples. It could only have developed properly as a planktonic species in Lake Chrissie, from which the sample Vaal 485 was taken. In both the remaining samples it was probably washed down from higher up the river, where conditions for planktonic growth were better.

Samples = 306, 485, 486.

M.granulata var. angustissima O. Müller.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:
250, F.104 d.

1930 - Hustedt: Bacillariophyta. P.38, F. 45.

Synonyms: Gaillonella tenerrima Ehrenberg; Melosira arundinacea Castracane; Melosira granulata var. procera f. tenerrima O. Müller.

This variety, which Cholnoky now prefers to unite with the species (see above) occurs far more frequently in the catchment area than the typical forms. Because no transitional forms have been seen from the catchment area it seems preferable to retain the variety.

M.varians Agardh.

1817 - Agardh: Synopsis Algarum. P.78.

1832 - Agardh: Conspectus criticus Diatomacearum. P.64.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:
240, F.100.

1930 - Hustedt: Bacillariophyta. P.85, F.41.

Synonyms: Conferva hiemalis Roth; Conferva fasciata Dillwyn;
Nematoplata quadrata Bory; Melosira aequalis Agardh;
Gaillonella varians Ehrenberg; Melosira coarctata Ehrenberg;
Melosira varians var. aequalis Kützinger; Vesiculifera composita
Hassall; Lysigonium varians De Toni.

According to Giffen (1966: 137) this species is abundant in neutral to slightly acid waters of the Hogsback Region of the Cape Province. Cholnoky (personal communication) maintained that M.varians was nitrogen-heterotrophic, and therefore, is found in rivers where some organic nitrogenous material is present. In the Vaal Dam Catchment area this species was found in a small number of samples, and in some cases in relatively high numbers. It was recorded mainly from the Klip River system.

NAVICULA Bory 1824.

N.adsidua n.sp.

In the sample Vaal 338 there are a large number of valves which were very variable with regard to their valve shape and the shape of the central area. From their structure they belong to the group of diatoms in the section Naviculae Orthostichae. In some specimens, however, the central area is relatively well developed for this group of Naviculas. This new species is most like N.pseudohalophila Cholnoky (1960A: 74, F.231, 235), but

differs quite widely in its morphology.

The valves are very variable in shape, linear-lanceolate to broadly elliptical; the poles are in all cases rostrate, but vary in degree, the elliptical forms having less rostrate and broader poles than the more lanceolate valves, in which the poles are relatively acutely rounded and rostrate; the length of the valves is 18 - 24 μ , and the width 5.5 - 7.5 μ . The raphe is straight and filiform; the central pores are not too widely spaced and the terminal fissures are not clear enough to determine their structure. The axial area is narrow and linear and clearly demarcated. The central area is very variable, from circular in some specimens, through elliptical shapes, to entirely absent in others. The transapical striae are quite characteristic of this species; they are fine and the punctae are difficult to distinguish; the striae are slightly radial in the middle and convergent at the poles; the striae are also slightly arcuate, more prominently so at the poles, which probably indicates that the valve surface is slightly concave between the margin of the valve and the raphe; they are slightly wider apart in the middle, about 20 - 21 in 10 μ , and slightly denser at the poles, about 24 in 10 μ . Occasionally at the central nodule shortened striae are found. Figs. 49 - 51.

The species was recorded in a small number of samples from all over the catchment area. It occurred most frequently at Station 17, where it was one of the most abundant species in sample Vaal 338. This might suggest that the new species favours waters rich in organic nitrogen (see Part 2: The Waterval River, Station 17).

Figs. - 49 - 51.

Samples - 317, 326, 336, 338, 339, 377, 378, 427.

N.agrestis Hustedt.

1927 - 1964 - Hustedt: Rabenhorst Kryptogamenflora.

Teil 3: 235, F. 1358.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.

Suppl. 15: 246, T.20, F.21, 22.

This small Navicula species has been reported very rarely from South Africa. Chohnoky (1957C: 67, F.65) recorded it from the Pienaars River near Pretoria and from the Okavango and Cunene Rivers from South West Africa (1966A: 29, F. 70 - 73). From the Okavango Chohnoky illustrated three specimens (Figs. 70 - 72) which he regarded as being definitely N.agrestis. Chohnoky was doubtful whether the specimen illustrated in Fig. 73 was in fact N.agrestis, as it was different in structure. He could find no other specimens, so thought it more convenient to call it N.agrestis. However, this specimen agrees with the description of Navicula diuturnoides Archibald, which will be found below.

The species was not common in the Veal Dam catchment area. Two specimens, one of which differs slightly from Hustedt's original description in the possession of a relatively thicker axial costa, enclosing the raphe (Fig. 53), have been illustrated. Figs. - 52, 53.

Samples - 358, 403, 410, 411, 412, 455, 512, 552.

N.aquosa Archibald.

1966 - Archibald: Some new and rare Diatoms from South Africa.

Nova.Hedwigia Suppl. 21: 256, F. 7, 8.

This species belongs to the Naviculae bacillares Cleve emend. Hustedt since it has an axial rib running down the centre of the valve, although in this species the rib is not very well developed. It shows a close affinity to N.omissa Hustedt

(194).

(1927 - 1964, Teil 3: 160, F.1295) but differs from this species in the possession of parallel transapical striae at the poles, which are not produced. Since the species was first described, other examples of the species have been discovered which makes it necessary to redescribe the species taking into account any changes in morphology or dimensions.

The valves are elliptical, linear-elliptical, to lanceolate with blunt and broadly rounded poles in the elliptical forms, and more acutely rounded poles in the lanceolate forms. The length of the valve is 9 - 13 μ and the breadth 3 - 5 μ . The raphe is filiform with slightly curved branches. The axial area is, narrow and linear and does not widen, or widens only very slightly into a central area round the central nodule. The transapical striae are radial in the middle and parallel in the vicinity of the poles, 24 - 26 in 10 μ . Longitudinal costae are present, but not very prominent. Figs. 54 - 57.

N.aquosa was not particularly common in the area under investigation but was found throughout the region in small numbers.

Figs. - 54 - 57.

N.arvensis Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 86, F. 1229.

1936 - Hustedt: A.S. Atl. T.401, F. 22 - 26.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol. Suppl.15: 249. T.17, F.40, 41.

According to Cholnoky (1957A: 58) and Cholnoky and Claus (1961: 333) N.arvensis inhabits weakly acid, oligotrophic waters of South Africa. In the catchment area the species was

(195).

recorded only once from the Waterval River. This specimen was illustrated in Fig. 58.

Fig. - 58.

Sample -,410.

N.atomus (Kützing) Grunow.

1860 - Grunow: Verh.zool.-bot. Gesell.Wien 10: 552, T.4, F.6.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Akad.Handl.27: 4.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
169, F.1303.

1930 - Hustedt: Bacillariophyta. P.288, F.484.

Synonyms: Amphora? atomus Kützing; Synedra atomus Naegeli;
Navicula caduca Hustedt; Navicula pseudatomus Lund; Navicula
spicoides Fusey.

The systematics of this species is very confusing. In the first place there appears to be some discrepancy as to which author the species should be attributed. De Toni (1891: 166) regarded the description of Amphora? atomus Kützing in 1844 to be the original description, while Naegeli only described Synedra atomus five years later in 1849. According to Patrick and Reimer (1966: 488) Kützing himself in his Species Algarum (1849:40) gave Synedra atomus Naeg. in litt = Amphora? atomus Kützing. Hustedt (1930: 288) at first attributed the authorship to Naegeli, but later gave Kützing the honour (1927 - 1964, Teil 3: 169) From the foregoing it appears that the epithet atomus was first used by Kützing in 1844 in the genus Amphora, and that Synedra atomus Naegeli is a synonym of this combination. Kützing should therefore be regarded as the author of the specific epithet atomus in this case. There is apparently full agreement by all authors that

Grunow was the first to place this species in the genus Navicula. The second point of discrepancy is found in the morphology of the species. The older descriptions gave the number of striae as 30 in 10 μ , which led to the description of two new species Navicula caduca Hustedt and Navicula pseudatomus Lund, which had 18 - 20 transapical striae. However, Hustedt had the good fortune to study Van Heurck's type material and was able to establish from this that N.caduca and N.pseudatomus were actually synonyms of N.atomus and that there was a very large variation in the number of striae in 10 μ . According to Cholnoky (1964: 69) the description of the species should be altered to read, "19 bis uber 30" transapical striae in 10 μ . The specimens found in this survey generally contained 28 - 30 transapical striae in 10 μ .

According to Cholnoky (1958C: 817) N.atomus is found in weakly basic waters of South Africa. In the catchment area it was found quite frequently over the whole area under survey. In some samples it was present in relatively high numbers.

N.avenacea Brebisson.

1896 - Cleve: Naviculoid Diatoms. Kong.Sv.Vet.Akad.Handl.

27: 15.

1957 - Hustedt: Diatomeenflora der Flusssysteme der Wesen.

Abh. naturw. Ver.Bremen. 34 (3): 288.

Synonyms: Navicula viridula var. avenacea (Brebisson) Grunow;
Pinnularia silesiaca Bleisch: Schizonema Smithii (Agardh) Grunow.

According to Cholnoky (1960B: 249; 1962B: 79) N.avenacea is found in alkaline water, and the species can tolerate a weak salt content of the water. As in the rest of South Africa, the species occurs sparingly in the catchment area and was normally observed as isolated specimens. It was recorded from Stations 3 and 5A on the Vaal River, and in a small tributary of the

(197).

Klip River.

Samples - 309, 325, 451, 554.

N.bacilloides Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 3: 117, F.1250.

1945 - Hustedt: Balkan Halbinsel. Arch.Hydrobiol.40: 922,
T.42, F.29.

This appears to be the first record of this species (Figs. 58, 59) in Africa. While there is no doubt of the correctness of the identification, there appears to be a wider range in the number of transapical striae in 10 μ . The specimens observed from the catchment area contained 18 - 24 striae in 10 μ ; there were, however, intermediate forms making the creation of a new taxon unnecessary.

The specimens occurred in a few samples from the whole catchment area, but was never abundant.

Figs. - 58, 59.

Samples - 236, 251, 334, 344, 363, 422, 429, 432, 441, 493,
495, 511.

N.bacillum Ehrenberg.

1843 - Ehrenberg: Ber.Berl.Akad.P.130, T.4, F.V, 8.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 137.

1927 - 1964 - Hustedt: Rabenhorst Kryptogamenflora Teil 3:
113, F.1248 a - d.

1930 - Hustedt: Bacillariophyta P.280, F.465.

Synonyms: Navicula laevissima Donkin; Navicula bacillum var.
genuina Grunow; Navicula pseudobacillum Grunow.

This species is not common in South Africa and only a single specimen was found in the Vaal River at Villiers. Nothing can be said about its autecology for this reason.

Sample 403.

N.barbarica Hustedt.

1949 - Hustedt: Kongo. Exp.du Parc. National Albert 8:
97, T.4, F. 14 - 17.

N.barbarica has not previously been found outside the Belgian Congo, where it was originally described by Hustedt (l.c.). The specimen illustrated in Fig. 60 agreed in every detail with Hustedt's original description, and is therefore undoubtedly N.barbarica. This specimen was recorded from a small stream near Villiers.

Fig. - 60.

Sample - 404.

N.belliatula n.sp.

This new species undoubtedly belongs to the Naviculae orthostichae and is very closely similar to N.halophila (Grunow) Cleve f. tenuirostris Hustedt (cf. Patrick and Reimer 1966: 467, T.44, F.5). It differs, however, from this species by the finer striation which is convergent at the poles. The axial area in N.belliatula has also a slight constriction at the central nodule.

The valves are lanceolate with narrow capitate poles, 36.5 - 40 μ long, and 6.5 - 8.0 μ broad. The raphe is straight and filiform with indistinct polar fissures; the central pores are not more widely spaced than the others. The axial area is narrow and linear, and is slightly constricted at the central

(199).

nodule; as a result there is no central area. The transapical striae are parallel in the middle and slightly convergent at the poles, 24 - 28 in 10 μ in the middle becoming denser towards the poles. The longitudinal costae are visible. Fig. 61.

This species was very rare and was observed from only three samples from the Kaffirspruit and Wilge Rivers.

Fig. - 61.

N.brevissima Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
238, F.1362.

1936 - Hustedt: A.S. Atl. T.401, F.41 - 43.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.
Suppl.15: 273. T.19, F. 22 - 24.

This small diatom species is not common in South Africa. Cholnoky recorded it once from Natal (1956: 76) and twice from the Cape Province. (1959: 34; 1962A: 35). In the catchment area it was found in four samples only, from Station 2A on the Vaal River, and from the Klip River System.

Samples - 307, 359, 431, 449.

N.bryophila Boye Petersen.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora. Teil 3:
91, F. 1237.

1928 - Petersen: Botany of Iceland 2: 388, F.13.

Synonyms: Navicula subtilissima var. bryophila A.Cleve-Euler;
Navicula subtilissima var. minor Magdeburg.

In the plates two small examples of this species (Figs. 62, 63) exhibiting capitate poles were illustrated. This characteristic

is reminiscent of N.bryophila var. lapponica Hustedt (1927 - 1964, Teil 3: 93, F.1238.) The transapical striae of these specimens were only visible in the central part of the valve, where they numbered about 38 in 10 μ . In all other characteristics they agreed with the description of the species, and so they have been assigned to N.bryophila. The other examples of this species found in the Catchment area have been typical forms.

N.bryophila occurs quite frequently over a wide area of South Africa and according to Cholnoky (1960B: 249; 1962A: 35) the species has a pH optimum of below pH 6.0. This probably accounts for the paucity of numbers.

Figs. - 62, 63.

N.bushmanorum Cholnoky.

1957 - Cholnoky: Südafrikanischen Diatomeenflora. Port.Acta. Biol.6: 67, F.67.

This small species of Navicula has previously been reported twice, once from Northern Natal in the Bushmans River, and the other from Zululand near Mtubatuba. The specimens in two samples from the upper reaches of the Vaal River undoubtedly belonged to this species. Fig. 64 illustrates one example of N.bushmanorum.
Fig. - 64.

Samples - 312, 492.

N.cari Ehrenberg.

1838 - Ehrenberg: Infusionsthierchen als vollkommene Organismen.
Leipzig. P. 179.

1930 - Hustedt: Bacillariophyta. P.299, F.512.

Synonyms: Navicula cincta var. cari (Ehrenberg) Cleve.

N.cari has been widely observed in South Africa from alkaline waters (Cholnoky 1962B: 80) and can apparently withstand high salt concentrations. In the catchment area it was observed in three samples, one of which showed evidence for slightly higher than normal salt concentrations.

Samples - 402, 404, 485.

N.cari var. angusta Grunow.

1880 - Grunow: in V.H.Syn. T.7, F.17.

1930 - Hustedt: Bacillariophyta P.299.

Synonyms: Navicula cincta var. angusta (Grunow) Cleve.

This variety was found as infrequently in the catchment area as the typical forms, and as only one or two specimens were observed it is not possible to comment on the variety from an ecological point of view, or to throw light on the systematic relationships of this variety.

Samples - 485, 493.

N.chrissiana Cholnoky.

1965 - Cholnoky: Chrissie-Sees. Arch.Hydrobiol.61: 69, F.13, 14.

As the name implies Cholnoky (l.c.) first described the species from Lake Chrissie. In this survey it has again been recorded from Lake Chrissie (Figs. 65, 66) and from four other

samples. It always occurred as isolated specimens, and as a result nothing can be said of its autecology. Its distribution is limited to the upper reaches of the Vaal and Kleinvaal Rivers, and one sample from the Cornelius River in the Orange Free State. Fig. - 65, 66.

Samples - 266, 307, 348, 350, 485.

N.cincta (Ehrenberg) Kützing.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
27: 16.

1930 - Hustedt: Bacillariophyta. P.298, F.510.

Synonyms: Pinnularia cincta Ehrenberg; Pinnularia Heufleri Pedicino; Navicula Kützingiana H.L. Smith; Pinnularia nana Gregory.

The species, although quite common in South Africa, occurred in the Catchment area in only two samples as isolated examples. According to Cholnoky the species is found in water with a constantly high pH value.

Samples - 408, 418.

N.cinctaeformis Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.
Suppl. 15: 265, T.19, F.11, 12.

Cholnoky (1957C: 68; 1958B: 119; 1962A: 36) has recorded specimens of N.cinctaeformis which were smaller than Hustedt's original dimensions. Similar specimens with smaller dimensions have also been observed in the samples from the catchment area. Two examples (Figs. 67, 68) which are very much smaller than normal, have been illustrated.

This species is one of the commonest occurring in the catchment area, and in some samples it was present in relatively high numbers. Not much is known of its autecology, but apparently it inhabits waters with a weakly alkaline to neutral pH. Such conditions are prevalent in the catchment area.

Figs - 67, 68.

N.citrus Krasske.

1923 - Krasske: Bot. Arch. 3: 199, F.14.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
780, F.1753.

1930 - Hustedt: Bacillariophyta. P.303, F.529.

In a sample collected from the Waterval River at Roodepoort (Station 17 of Chutter) this single valve of N.citrus (Fig.69) was discovered. As far as is known this is the first time this species has been recorded outside Europe and probably outside the type locality. It is a new record for South Africa. This specimen was undoubtedly N.citrus as it agreed in every detail with Hustedt's description (Hustedt 1927 - 1964, Teil 3: 780. Fig. - 69.

Sample - 513.

N.confervacea (Kützing) Grunow.

1880 - Grunow: in V.H. Syn. T.14, F.36.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
205, F. 1324 a - d.

1930 - Hustedt: Bacillariophyta. P.278, F.460.

Synonyms: Diadesmis confervacea Kützing; Diadesmis peregrina W.Smith; Navicula confervacea var. peregrina Grunow; Navicula confervacea var. hungarica Grunow; Navicula semivirgata Krasske; Navicula confervacea var. nipponica Skvortzow; Navicula confervacea var. baikalensis Skvortzow.

Hustedt in the Bacillariophyta (l.c.) erroneously quoted the author of this species as Kützing only. Kützing, however, described the species in the genus Diademsis, and Grunow later transferred it to the genus Navicula. Fig. 69 illustrates an extremely large specimen of N.confervacea. The dimensions are much larger than those given in the description, but in all other respects it fulfilled the requirements for the species. The valve was 35 μ long and 10 μ wide.

According to Cholnoky (1960B: 250; 1962B: 80) the species is found in alkaline water, and is characteristic of water which has a large fluctuation of the organic nitrogen content. Hustedt has put forward a hypothesis maintaining that N.confervacea is a tropical species which has invaded Europe by transportation on waterplants into glass houses. Hustedt gave no evidence or proof for this hypothesis, and Cholnoky (l.c.) did not agree with this theory. In the catchment area the species was not common and was found in small numbers in five samples.

Fig. - 70.

Samples - 405, 409, 414, 415, 513.

N.contenta Grunow f. parallela Boye Petersen.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
209, F.1328 e - g.

1928 - Boye Petersen: Danske. Bot.Ark. 5: 15, F.2.

1930 - Hustedt: Bacillariophyta. P.277, F.458 b.

Synonyms: Navicula contenta f. elliptica Krasske.

One example of this small Navicula species (Fig. 71) was observed from Station 24 on the Klip River. Although it has been recorded from different localities from most of South Africa nothing much is known of its autecology.

Fig. - 71

N.cryptocephala Kützing.

1844 - Kützing: Bacill. P.95, T.3, F.26.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 14.

1930 - Hustedt: Bacillariophyta. P.295, F.496.

Synonyms: Navicula cryptocephala var. exilis (Kützing) Grunow;
Navicula veneta Kützing; Navicula cryptocephala var. veneta
(Kützing) Grunow.

During the investigation of the samples in this survey it became quite clear that there was a very large range of variation in the morphology of this species. In numerous cases series of forms were found that showed quite plainly that the separation of this species into the varieties var. exilis and var. veneta was impracticable and that all forms should be regarded as the typical N.cryptocephala. Two examples of this species (Figs. 72, 73) having unusually thick striae around the central nodule have been illustrated.

N.cryptocephala is one of the commonest diatoms found in the catchment area. It was observed in nearly every sample over the whole region; and in some cases it was present in very high numbers. Cholnoky (1960B: 250) regarded the species as an inhabitant of alkaline waters, with an optimum value lying around pH 7.8. The species is also capable of tolerating fairly high concentrations of salts (Cholnoky 1962B: 82). Although N.cryptocephala is not nitrogen heterotrophic, it is usually found in relatively mesotrophic waters (Cholnoky 1962C: 325).

Fig. - 72, 73.

N.cryptocephala var. intermedia Grunow.

1930 - Hustedt: Bacillariophyta. P.295, F.497 b.

Cholnoky has recorded this variety from numerous localities in South Africa. He has however, made no comment on its systematics or its autecology. Only one specimen was observed from Grootvlei, the Springfield Colliery Dam (Vaal 401).

Sample - 401.

N.cuspidata Kützing.

1844 - Kützing: Bacill. P.94, T.3, F.24 and 37.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 109.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
59, F.1206 a.

1930 - Hustedt: Bacillariophyta. P.268, F.433.

Synonyms: Bacillaria fulva Nitzsch; Cymbella latefasciata Agardh; Frustulia cuspidata Kützing; Navicula fulva Ehrenberg; Navicula Reinickiana Rabenhorst; Vanheurckia cuspidata Brebisson. For further synonyms see Hustedt in Rabenhorst (l.c.).

It is interesting to note that the nomenclatural rules of priority have not been applied in this case. Cleve in his Synopsis (Cleve 1894: 110) remarked that it would have been more correct to call this species Navicula fulva, as Bacillaria fulva was described by Nitzsch in 1817. Cleve maintained the name Navicula cuspidata purely because it was the most generally accepted name.

According to Cholnoky (1962B: 82) the species thrives best in well buffered neutral to weakly acidic waters. It has been recorded from only five samples from the Vaal River, twice in the acidic waters of Station 1, twice from Station 2A, and once from Station 3.

N.cuspidata var. ambigua (Ehrenberg) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 110.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
62, F. 1203 b.

1930 - Hustedt: Bacillariophyta. P.268, F.434.

Synonyms: Navicula sphaerophora Donkin; Navicula birostrata
Gregory; Navicula quarnerensis Grunow; Vanheurckia ambigua
Brebisson.

It would appear that it is merely on sentimental grounds
that var. ambigua is maintained as a variety of N.cuspidata. The
differences between the two are so trivial that it is probably
better to sink the variety into the typical form of the species.

Not much is known of the autecology of the variety. In the
region under investigation the variety is far more common than the
typical forms and was recorded from a relatively large number of
samples.

N.cuspidata var. Heribaudii Peragallo.

1893 - Peragallo: in Heribaud, Diat. d'Auvergne P.108, T.4, F.16.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26:
110.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 60,
F.1207.

1930 - Hustedt: Bacillariophyta. P.268, F.435.

Synonyms: Navicula ambigua var. craticula Van Heurck; Navicula
semota A.Schmidt; Navicula Elsae Thum Pantocsek; Navicula cuspidata
var. Mayeri Cleve-Euler; Navicula cuspidata var. ambigua f.
Heribaudii A.Cleve-Euler.

This variety is most uncommon in South Africa, being reported
once from Natal by Cholnoky (1960A: 57). Foged (1966: 72) has
recorded it from Ghana. It was found in the catchment area in one
sample from a small stream near Vrede.

Sample - 422.

N.dicephala (Ehrenberg) W. Smith.

1853 - W. Smith: Brit. Diat. Vol.1. P.87, T.17, F.157.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 21.

1930 - Hustedt: Bacillariophyta. P.302, F.526.

Synonyms: Pinnularia dicephala Ehrenberg; Navicula undula Schumann.

Hustedt (1937 - 1939, Suppl. 15: 274) regarded this species as living entirely in alkaline water. It has a general distribution in freshwater, but in the Vaal Dam catchment area it is not common. It is usually found singly or in very small numbers.

N.dicephala var. undulata Östrup.

1930 - Hustedt: Bacillariophyta. P.303, F. 527. (Under N.dicephala var. neglecta).

This variety occurred far more frequently than the typical forms. The Waterval River System was the only system in which it did not occur. Hustedt (1937 - 1939, Suppl. 15: 275) claimed that the variety was recorded from water with a pH-range of 4.8 - over 8 with approximately the same frequency. Cholnoky (1962B: 83) refuted this statement and said that the pH optimum for this species is found in weakly acid to neutral water. As the water in the Catchment area is normally of a weakly alkaline nature, it is not surprising that this variety does not occur in any sample in large numbers.

N.difficillima Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
85, F.1227.

1950 - Hustedt: Norddeutscher Seen. Arch.Hydrobiol. 43:
436, T.36, F.86 - 88.

The small thin-walled hyaline Navicula species are extremely difficult to identify with certainty. Since no sculpturing of the valve surface can be recognised, the only characteristics separating the species from each other are the dimensions of the valve and its shape. In Fig.74 a diatom valve has been drawn, which does not quite fit the description of N.difficillima, and yet at the same time is more like this species than any other species known to the author. It differs in the shape of the valve, which in this specimen was linear lanceolate, with broadly rounded poles that were not produced. The poles were slightly thickened agreeing with the description. One other specimen of this species was recorded from the Vaal River.

Fig. - 74.

Samples - 253, 307.

N.digitulus Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
252, F.1378.

1943 - Hustedt: Internat. Rev.d. Hydrobiol. 43: 162, F.26 - 30.

The two specimens illustrated in Figs. 75 and 76 were undoubtedly N.digitulus. This apparently constitutes the first record of this species in South Africa.

Hustedt (l.c.) commented that this species is a "Süßwasserform, in neutralen bis humussauren Gewässern lebend, vielleicht nordisch montan". This species was recorded in two samples (Vaal 370 and 479) from the headwaters of the Vaal River,

where the marshy conditions are suitable for humic acid production. The pH-values for this sampling point remain constant at about pH 6.0. The specimens found in Lake Chrissie have probably been washed into the lake, as the lake itself is alkaline. Fig. - 75, 76.
Samples - 370, 479, 485.

N.diuturna Cholnoky.

1962 - Cholnoky: Ost Transvaal. Hydrobiologia 19: 83, F.8, 9.

This small species has only been recorded from the Eastern and Southeastern Transvaal. Due to its rarity nothing is known of its autecology. One example of this small diatom (Fig. 77) has been illustrated so that it can be compared with the following species.
Fig - 77.

N.diuturnoides Archibald.

1966 - Archibald: Rare Diatoms from S.A. Nova Hedwigia Suppl.21: 258, F.17 - 23.

Since first describing the species many other specimens have been observed which make it possible to improve on the description of the species by noting the greater range of variation in form and dimensions. As the name suggests this species has a great similarity to N.diuturna Cholnoky (see above), but differs from that species by the more coarsely striated valves and because it is not protracted at the poles. N.diuturnoides also bears a resemblance to N.tenellaeformis Hustedt (1937 - 1939, Suppl.15: 269, T.19, F.14, 15.) but differs from this species in that the valve is more elliptical, has no central area, and the striae

which are parallel at the poles are greater in number than in N.tenellaeformis.

The valves are linear, linear-elliptical to lanceolate; the poles in the linear to linear-elliptical forms are broadly rounded, while in the lanceolate forms the poles are more acutely rounded; the valves are 7.5 - 13.0 μ long, and 2.5 - 3.5 μ broad. The raphe is straight and filiform, with small relatively closely situated central pores. The axial area is narrow and linear, and does not widen into a central area in the region of the central nodule. The transapical striae are delicate but easily seen, radial in the middle and parallel or slightly convergent at the poles, 24 - 28 in 10 μ , (usually 24); in the region of the central nodule there are sometimes one or two irregularly shortened striae, usually the two central striae. Figs. 78 - 90.

The Latin diagnosis will be found with the original description of the species.

In the Vaal Dam catchment area this new species is quite common but never occurs in large numbers. This seems to indicate that it never experienced its optimal growing conditions. As the species is so little known it is not possible to comment on its autecology. It was recorded mainly from the Waterval and Vaal Rivers.

Fig. - 78 - 90.

N.elginensis (Gregory) Ralfs.

1861 - Ralfs: Diatomaceae in Pritchard's Infusoria.

London. P.902.

1930 - Hustedt: Bacillariophyta. P.303. (under N.dicephala
var. elginensis).

Synonyms: Pinnularia elginensis Gregory; Navicula dicephala var.
elginensis (Gregory) Cleve.

According to De Toni (1891: 57) Ralfs described N.elginensis in 1861, which is some time previous to Grunow, and he is, therefore, the correct and valid author of the species together with Gregory. Cholnoky (1960A: 58) recognised this, but later reverted once more to the incorrect combination of authors, (Gregory) Grunow (cf. Cholnoky 1962A: 39).

This species was not particularly common in the rivers under study, and never occurred in great numbers in any sample. Little is known of the autecology of this species.

N.esamangensis Foged.

1966 - Foged: Freshwater Diatoms from Ghana.

Biol.Skr.Dan.Vid.Selsk. 15: 74, T.8, F.20.

Synonyms: Navicula helensoides Archibald.

A new Navicula species, N.helensoides Archibald (1966A: 259, F.25), was described in the early period of this survey, but was subsequently regarded to be better equated with N.vasta Hustedt (1937 - 1939, Suppl. 15: 273, T.19, F.19 - 21). However on further examination of this species certain differences were found warranting a distinction between N.helensoides and N.vasta. The diagnostic features separating this species from N.vasta are the prominent axial rib which encloses the raphe in N.helensoides,

and the markedly different central area. According to Hustedt (l.c.) N.vasta has a very narrow axial area, which is slightly lanceolately widened around the central nodule. In the specimens observed in the catchment area the central area is distinct, round or rectangular in outline. Furthermore the arrangement of the striae around the central nodule in these specimens was different, being widely spaced and irregularly shortened. In view of these differences it was felt that N.helensoides should be retained as a separate species. However on receiving a recent paper by Foged (1966) on the diatoms from Ghana, it was found that N.esamangensis Foged (1966: 74) was identical to N.helensoides (Figs. 91 - 93), and that Foged's species had priority by one month. Accordingly N.helensoides becomes a synonym. The specimens of N.esamangensis observed in this study serve to widen the range in dimensions, and should be included in any future descriptions of the species. The valves were 10 - 26 μ long and 3.5 - 6 μ broad, and contained 20 - 28 striae in 10 μ .

N.esamangensis was recorded from a number of samples, mainly from the Vaal River, but was not common in any of them. Figs. - 91 - 93.

N.exigua (Gregory) O.Müller.

1930 - Hustedt: Bacillariophyta. P.305, F.538.

Synonyms: Pinnularia exigua Gregory; Navicula gastrum var. exigua (Gregory) Grunow.

Cholnoky (1960A: 58) stated that he found this species in neutral to weakly alkaline waters of Natal. Here the species was found in samples from all over the catchment area, but it never occurred in great numbers; it was usually found as isolated records.

N.exiguiformis Hustedt.

1945 - Hustedt: Balkan-Halbinsel. Arch.Hydrobiol. 40: 929,
T.42, F.21, 22.

Synonyms: Navicula tenebrata Hustedt; Navicula von Hauseniae
Cholnoky.

Before Cholnoky received Hustedt's paper on the Congo material (Hustedt 1949A), he described a species, N.von Hauseniae (Cholnoky 1954A: 419), which he subsequently found to belong to N.exiguiformis Hustedt. Hustedt, working with rich material from the Congo, was able to extend and amplify the range of variation of this species. Cholnoky's species fell into this new range of dimensions and thus it became a synonym of N.exiguiformis.

N.exiguiformis lives in neutral to weakly alkaline waters (Cholnoky 1960A: 58; 1960B: 252), and has an optimum around pH 7.8 (Cholnoky 1966A: 34). It was uncommon in the catchment area, being found in only seven samples.
Samples - 312, 321, 362, 364, 403, 412, 422.

N.exilissima Grunow.

1880 - Grunow: in V.H. Syn. T.14, F.30.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.27: 3.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
261, F.1389.

1930 - Hustedt: Bacillariophyta. P.288, F.487.

The one very small example of this species, seen here, had very fine transapical striae which were just visible, and therefore probably number more than 40 in 10 μ . Cholnoky (1966A: 34) has illustrated a specimen which has shortened striae on either side of the central nodule.

As there have been so few records of this species, nothing much is known of its autecology.

N.fluens Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
258, F. 1386.

1930 - Hustedt: Bacillariophyta. P.285, F.474.

Synonyms: Navicula exilissima var. dubia Hustedt.

Two examples of specimens (Figs. 94, 95), which are slightly narrower than normal (4 μ wide), have been drawn. In all other respects they agreed with Hustedt's description. Again this is a very little known species, and was found in only three samples from the catchment area.

Figs. - 94, 95.

N.Fritschii Lund.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
181, F.1315 a - h. (under Navicula insociabilis Krasske).

1946 - Lund: Observations on Soil Algae. The New Phytologist
45: 77, F.7 A - G.

There has been some confusion over the systematics and taxonomy of this species. However, both Lund (l.c.) and Cholnoky (1957A: 62; 1960A: 59) have clearly refuted Hustedt's (l.c.) contention that N.Fritschii is identical to N.insociabilis Krasske. On the basis of these arguments it is preferable to follow Lund's systematics with regard to this species.

In South Africa the species has been found in weak to relatively alkaline waters. In the Vaal Dam catchment area it

was not common and was recorded from only three samples, two coming from Station 5A on the Vaal River, and one from Station 9 on the Wilge River.

Samples - 322, 323, 328.

N.Fritschii var. dissipatoides Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
181, F.1315 i, k.

1957 - Hustedt: Abh.naturw.Ver.Bremen 34: 303, F.27.

While analysing these samples some specimens of Navicula were identified as N.tenera Hustedt (1937 - 1939, Suppl.15: 259, T.18, F.11, 12). On a reconsideration of the specimens it is thought best to call them N.Fritschii var. dissipatoides although it does not quite fit the description for this variety. The main reasons for assigning these specimens to var. dissipatoides are because the valves are linear with more or less parallel sides and broadly rounded ends, the raphe branches are slightly curved, and the terminal fissures are situated at a distance from the poles. The examples observed here differ slightly in their dimensions, being in general smaller than the dimensions in the description and being more coarsely striated. However these differences do not warrant the creation of a new variety as there is a progressive series linking my specimens with this variety. The valves are generally from 11 - 15 μ long, and 4.5 - 5 μ broad, and contained 18 - 20 transapical striae in 10 μ . I have illustrated an example in Fig. 96.

As far as is known this is the first record of this variety for Africa. It was found in a number of samples from the Waterval and Vaal Rivers, but in very small numbers, usually only one or two in a sample.

Fig. - 96.

N.Geitleri Hustedt.

- Hustedt: in A.S. Atl. T.400, F.16 - 18.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch.Hydrobiol.Suppl. 15: 263, T.18, F.34.

Synonyms: Navicula irreversa Cholnoky.

In sample Vaal 449 one specimen (Fig.105) fitting the description of both N.Geitleri Hustedt and N.irreversa Cholnoky (1965: 71, F.23) equally well, was illustrated. This posed the question whether these two species are essentially different. In the table below the descriptions of the various characters as written by Cholnoky and Hustedt have been compared:-

N.irreversa CholnokyN.Geitleri Hustedt.

Die beobachteten wenigen Schalen waren breitlanzettlich, mit ziemlich spitz vergezogenen, gleichmässig gerundeten Enden. 18 - 23 μ lang, etwa 8 μ breit.	Schalen waren breit elliptisch-lanzettlich mit kurz und spitz geschnäbelten Enden. 16 μ lang, 7 μ breit.
Raphe gerade, fadenförmig, mit kleinen voneinander mässig entfernt gestellten Zentralporen und einseitig abgebogenen, in der Schalenfläche beinahe gerade erscheinenden Endspalten.	Raphe gerade.
Axialarea schmallanzettlich in der Mitte nicht zu einer Zentralarea erweitert.	Axialarea schmal linear, in der Mitte kaum erweitert.

N.irreversa CholnokyN.Geitleri Hustedt.

Transapikalstreifen durchwegs radial, in der Nähe des Mittelknotens oft mit einzelnen verkürzten zwischengeschobenen in der Mitte 15 in 10 μ , gegen die Pole nur unbedeutend dichter werdend.	Transapikalstreifen stark radial, 16 - 18 in 10 μ , von der Mitte gegen die Enden etwas enger werdend, in der Mitte des Schalenrandes mit einigen (meistens 3-4) eingeschobenen kurzen Streifen.
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Apart from small differences in dimensions (Cholnoky stated that he had not seen the full range of variation) and the number of transapical striae in 10 μ , there seems little evidence to justify two species, and should therefore, be united. Following the rules of priority N.Geitleri Hustedt is the most valid name for this species. N.irreversa Cholnoky is therefore a synonym.

This species was recorded from Station 26 on the Klip River, and from one sample from the Witziesshoek area.

Fig. - 105.

Samples - 204, 449.

N.gilva n.sp.

This new species belongs to the group of diatoms similar to N.omissa Hustedt (1927-1964, Teil 3: 160, F.1295) and N.aquosa Archibald (1966A: 256, F.7, 8), but differs from these two species in its valve shape, and in the number and arrangement of the transapical striae. In N.aquosa the polar striae are parallel

while in the new species they are radial throughout. N.gilva differs from N.omissa in the shape of the valve and the much coarser striation.

The valve is elliptical to linear-elliptical with broadly rounded ends which are not rostrate, about 7.5 - 10 μ long and about 4 μ broad. The full range of variation cannot be given as so few specimens have been seen. The raphe, which lies in a relatively well developed axial rib, is filiform with slightly arcuate branches; the central pores are not widely separated and the polar fissures have not yet been observed. The axial area is narrow and linear, and the central area is absent. The transapical striae are radial throughout and do not become more dense towards the poles, about 18 in 10 μ .

Figs. - 97, 98.

This small species was rare in the catchment area and was found only in two samples from the Vaal River (Station 5A) and from a small stream near Standerton.

Figs. - 97, 98.

Samples - 375, 420.

N.gregaria Donkin.

1861 - Donkin: Marine Diat. of Northumberland. Q.J.M.S. 1: 10, T.6, F.10.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 108.

1930 - Hustedt: Bacillariophyta. P.269, F.437.

Synonyms: Navicula cryptocephala W. Smith (nec N.cryptocephala Kützing); Navicula lanceolata W.Smith; Navicula veneta Schumann; Navicula Granum Avenae Schumann; Navicula kaikonkiensis Woodhead et Tweed.

Hustedt (1957: 265) has described this species as being halophilous, but Cholnoky (1955C: 81; 1960A: 62; 1960B: 251; 1962B: 84) has shown conclusively through his studies on fresh water material in South Africa, that N.gregaria is not halophilous. It has been found in waters which are relatively alkaline in nature. It was recorded from one sample collected from a small stream near Villiers.

Sample - 404.

N.Grimmei Krasske.

1925 - Krasske: Abh.u.Ber.Ver.f.Naturk.Cassel 56: 45,
T.1, F.14.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
769, F.1742.

1930 - Hustedt: Bacillariophyta. P.274, F.448.

Synonyms: Navicula bicapitellata Hustedt; Navicula Grimmei var. rostellata Hustedt; Navicula elephantis Cholnoky.

The valve shape of this species is very variable indeed. It is so variable that Cholnoky (1963A: 34) described some forms from the one end of the variation range as a completely new species, N.elephantis. However subsequently Cholnoky (1966B: 189) discovered transitional forms which linked N.elephantis with N.Grimmei. N.elephantis thus became a synonym of N.Grimmei. In the same paper Cholnoky gave a series of drawings (Figs. 28 - 30 and 32 - 40) which illustrated the transition from N.elephantis through N.Grimmei var. rostellata Hustedt (1937 - 1939, Suppl.15: 236, T.17, F.13) to the typical forms of N.Grimmei. This showed conclusively that all three taxonomic entities were in fact the same thing. N.Grimmei var. rostellata is, therefore, also a synonym. Further Cholnoky (1963D: 242) has pointed out a discrepancy between Hustedt's description of N.Grimmei

(Hustedt 1930: 274) and his drawings in A.S. Atlas T.405, F.26 - 29. In his description the number of striae is given as about 25 in 10 μ , while his drawings depicted from 20 - 22 in 10 μ . Both Cholnoky and the author have found specimens possessing most commonly from 22 - 24 transapical striae in 10 μ . Most specimens in this series of samples were of the type with capitate poles, one of which has been illustrated (Fig.99).

According to Cholnoky (1960A: 63) N.Grimmei is widespread in neutral to weakly alkaline waters, and has a pH optimum of around pH 7. In the catchment area the species was found in many samples, but with low percentage occurrences. This would indicate that the pH of the water in the catchment area is generally higher than pH 7.

Fig. - 99.

N.halophila (Grunow) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 109.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 64, F.1209.

1930 - Hustedt: Bacillariophyta. P.268, F.436.

Synonyms: Navicula cuspidata var. halophila Grunow; Brebissonia Boeckii Pantocsek; Navicula halophila var. maior Heribaud; Navicula halophila var. Eusebioi Heribaud; Navicula halophila var. arvernensis R.d'Aubert; Navicula halophila var. minuta R.d'Aubert; Navicula halophila f. minor Hustedt; Navicula halophila var. brevis Skvortzow.

As its name implies this species find its optimum in brackish or saline waters. It is therefore not surprising that this species was found in such small numbers. The specimens were probably washed down stream from waters where

there is a higher salt concentration. It was found in five samples only, as isolated specimens. One example, Fig. 100, has been illustrated.

Fig. - 100.

Samples - 330, 343, 468, 477.

N.halophila f.robusta Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
65, F.1210.

1959 - Hustedt: Österr. Bot.Zeitshr. 106: 401, F.1 - 3.

A specimen from the Waterval River (Fig. 101) was assigned to this form of the species N.halophila as it fits the description of this form most closely. The only real difference was that the longitudinal costae were not clearly visible in this specimen. The f.robusta has not previously been reported from South Africa.

It was found in only one sample from the Waterval River (Vaal 554).

Fig. - 101

Sample - 554.

N.halophila f.tenuirostris Hustedt.

1942 - Hustedt: Internat. Rev.d.Ges.Hydrobiol. 42 (1): 52, F.76.

1966 - Patrick and Reimer: Diatoms of the U.S. P.467, T.44, F.5.

Fig. 102 illustrates a specimen which agrees with the description of this form given by Patrick and Reimer (l.c.), and on this basis there was no hesitation in assigning it to this form of the species.

As far as is known this is the first record of this form in South Africa, and it occurred in one sample from the Groot-

spruit stream, which is a tributary of the Waterval River.

Fig. - 102.

Sample - 411.

N.Hambergii Hustedt.

1925 - Hustedt: Bacill.Sarekgebirges. P.562, T.17, F.2.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.
Suppl. 15: 263, T.18, F.35 - 37. (under
N.quadripartita Hustedt).

1943 - Hustedt: Neue und wenig bekannte Diatomeen. Ber.d.Deutsch.
Bot.Ges. 61: 282.

Synonyms: Navicula quadripartita Hustedt.

Cholnoky (1954C: 283) has reported the occurrence of small forms of this species (12 μ long) in South Africa. The small specimen (Fig. 103) observed in this study supported Cholnoky's observations. This specimen was 14 μ long and 6 μ broad.

Although Cholnoky (1960A: 64) has stated that this well defined species appears to be widely distributed in South Africa, it occurred in only two samples from the catchment area.

Fig. - 103.

N.hungarica Grunow var. capitata (Ehrenberg) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
27: 16.

1930 - Hustedt: Bacillariophyta. P.298. F.508.

Synonyms: Pinnularia capitata Ehrenberg; Pinnularia signata Ehrenberg; Pinnularia garganica Rabenhorst; Navicula inflata W. Smith; Navicula globiceps Lagerstedt; Navicula humilis Donkin.

The variety occurs more commonly than the typical forms of the species, and in the catchment area only the variety was observed. It is usually found in weakly alkaline waters (Cholnoky 1962B: 85), and as a result it occurred in many samples from the catchment area, but never in great abundance.

N.Hustedtii Krasske.

1923 - Krasske: Bot.Arch.3: 198, F.3.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
150, F.1281.

1930 - Hustedt: Bacillariophyta. P.274, F.449.

This species is seldom seen in South Africa, and only a single specimen was observed in the catchment area from the Grootspuit, a tributary of the Waterval River.

Sample - 411.

N.indifferens Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
84, F.1226.

1942 - Hustedt: Ber.d.Deutsch.Bot.Ges.60: 67, F. 27 - 30.

The small hyaline species of Navicula are extremely difficult to identify with certainty. The main diagnostic characters in these diatoms are the shape and dimensions of the valve. The valve shape can, however, be very variable. It is therefore possible that some of these hyaline species have been described under different names, and it might only require transitional forms to unite them. In this regard Cholnoky (1964: 69; 1966B: 190) put forward the idea that N.indifferens, with slightly protracted poles, might in fact be

N.arvensis Hustedt (1937 - 1939, Suppl. 15: 249, T.20, F.19, 20).

Cholnoky has however not been able to confirm this. The specimens from the catchment area conform to Hustedt's description of N.indifferens and no transitional forms were seen.

The distribution of this species in the catchment area was widespread, occurring, however, in low numbers in the samples.

N.insociabilis Krasske.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora, Teil 3: 183, F.1317 (under N.monoculata Hustedt).

1932 - Krasske: Diatomeenflora der Alpen. Hedwigia 72: 114, F.17.

Synonyms: Navicula monoculata Hustedt; Navicula pseudagrestis Lund.

According to Cholnoky (personal communication) the iconotypes of N.insociabilis are the figures in A.S.Atlas T.400, F.103 - 105, which were drawn by Hustedt from marked specimens on the original slide of Krasske. Cholnoky is of the opinion that N.insociabilis Krasske and N.monoculata Hustedt (1927 - 1964, Teil 3: 183) are the same species, and therefore N.monoculata must fall away and become a synonym. Hustedt (l.c.) quite correctly regarded N.pseudagrestis Lund (1946: 76) as synonymous with N.monoculata = N.insociabilis. In this survey a few specimens of this species were observed, one of which was illustrated (Fig.104).

Little is known of its autecology. It was recorded from samples collected at Stations 3, 5, and 19 in the Vaal River system, from near Memel, and some scattered localities in the Wilge River system.

Fig. - 104.

Samples - 240, 332, 365, 417, 422, 429, 441, 493, 495.

N. letulenta n.sp.

The examples illustrated in Figs. 106, 107 fall into the N. Hambergii group of Naviculae. The new species, however, differs quite widely in its structure from N. Hambergii Hustedt (1924: 562, T.17, F.2), and the other species of its group.

The valve is lanceolate with relatively acutely rounded and rostrate poles, 17.5 - 20 μ long, and 5 - 6 μ wide. The raphe is straight and filiform with relatively long slightly lunate polar fissures. The axial area is narrow at the poles, but widens into a lanceolate area occupying about one third of the valve width. The central area is consequently absent. Due to the lanceolate axial area the transpical striae are relatively short, projecting about one third of the way into the valve. In the central part of the valve there are many shortened striae sometimes giving an alternately longer and shorter pattern, and sometimes at irregular intervals; the striae around the central nodule are also somewhat curved in no defined manner; they number about 18 in 10 μ , and are radial in the middle and parallel to very slightly convergent at the poles.

In the catchment area only three specimens of this species were observed, one from the Waterval River, one from the Kaffirspruit stream and the other from the Russespruit stream.
Figs. - 106, 107.

N. longicephala Hustedt.

1943 - Hustedt: Neue und wenig bekannte Diatomeen.

Ber.d.Deutsch.Bot.Ges. 61: 277, F.17.

Synonyms: Navicula bicephala Hustedt.

Cholnoky (1962A: 41) has shown that N. longicephala and

N.bicephala Hustedt (1952: 398, F.106) are synonymous. In the catchment area only two specimens were seen. One of them was slightly aberrant in the shape of the valve, having slightly undulate margins to the valve instead of the normal straight wall (Fig. 108). This species is widespread in alkaline waters (Cholnoky 1959: 44).

Fig. - 108.

Samples - 301, 485.

N.manubialis Archibald.

1966 - Archibald: Rare Diatoms from S.A. Nova Hedwigia Suppl. 21: 260, F.29.

This species falls into the group Naviculæ bacillares Cleve emend. Hustedt, on account of the raphe lying in a well developed axial rib. The general appearance of the valve is similar to N.fluviatilis Hustedt (1927 - 1964, Teil 3: 158, F.1291). It differs from this species by the absence of the constricted middle section of the axial area. During the course of the study further specimens were observed, with the result that the range of variation of the species can now be enlarged.

The valve is linear-elliptical with fairly broadly rounded ends, about 12 μ long and 4.5 μ wide. The raphe is straight and filiform, and lies in a well developed axial rib. The axial area is narrow and linear, and does not widen around the central nodule to form a central area. The transapical striae are radial throughout, 21 - 24 in 10 μ , wider apart in the middle than at the poles. Fig. 109, 110.

This species was recorded from two samples in the catchment area.

Figs. - 109, 110.

Samples - 406, 512.

N. Mengeae Cholnoky.

1954 - Neue und seltene Diatomeen. Österr. Bot. Zeitschr. 101: 418, F.58 - 60.

Cholnoky (personal communication) no longer believes this species to be a Navicula. He now maintains that what he described as a "scharf umgrenztes, bandförmiges Feld, das bis zum Schalenrand reicht" (Cholnoky 1954A: 418) is a stauron, and that this species would be better placed in the genus Stauroneis. However, these views have not yet been published and for this reason this species has been retained as a Navicula.

A single specimen (Fig. 273), slightly narrower than normal (3 μ instead of 4.5 μ), was recorded from Station 24 on the Klip River.

Fig. - 273.

Sample - 358.

N. microcephala Grunow.

1880 - Grunow: in V.H. Syn. T.14, F.29

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad. Handl. 27: 4.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 258, F.1385.

1930 - Hustedt: Bacillariophyta. P.289, F.491

Synonyms: Achnanthidium microcephala W. Smith.

There is some doubt attached to the correctness of the identification of this species. A few forms assigned to the new species N.subarvensoides Archibald (1966A: 262, F.39) are now thought to be better placed with this species. These forms were generally weakly silicified, linear-lanceolate in shape and slightly protracted at the poles. The transapical striae were sometimes too fine to be seen (Fig. 114), while in others they numbered about 36 in 10 μ (Figs. 111 - 113).

N.microcephala was found in a relatively large number of samples, but, due to its preference for a neutral to acid pH-value of the water, it did not occur in very high numbers.

Fig. - 111 - 114.

N.minima Grunow.

1880 - Grunow: in V.H. Syn. T.14, F.15, 16.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 128.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
249, F.1374.

1930 - Hustedt: Bacillariophyta. P.272, F.441.

Synonyms: Navicula minutissima Grunow; Navicula Saugerii var. Grunow; Navicula atomoides var. subserians Grunow; Synedra pusilla Kützinger; Navicula minima var. atomoides Cleve; Navicula minima var. genuina Cleve-Euler.

In the catchment area the specimens of this species were very small, ranging from 5.5 - 6.0 μ in length.

It has not been possible to gather much information about the autecology of this species. In this region it has been found in **small** numbers in samples from a widespread area.

N.minuscula Grunow.

1880 - Grunow: in V.H. Syn. T.14, F.3

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 4.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
254, F.1381.

1930 - Hustedt: Bacillariophyta. P.288, F.483.

Synonyms: Navicula importuna Hustedt; Navicula paucivisitata
Patrick.

Some irregular forms, one of which is illustrated (Fig. 115), have been assigned to this species since they are more akin to N.minuscula than any other species. These forms were elliptic-lanceolate, 8.5 μ long and 3.5 μ broad, and had convergent trans-apical striae at the poles. Cholnoky has also found similar small examples.

Cholnoky (1960A: 70) reported this species from neutral, unpolluted waters, having a high oxygen concentration. In the catchment area it was recorded in the Kalk River (Station 15), the Vaal River (Station 5A), the Waterval River (Station 17) and a small tributary of the Vaal River near Station 5A.

Fig. - 115.

Samples - 321, 337, 402, 408.

N.molesta Krasske.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
252, F.1379.

1938 - Krasske: Arch. Hydrobiol. 33: 528, T.11, F.20.

There is little doubt that the specimens assigned to this species are indeed N.molesta, since they agree with Hustedt's description (Hustedt l.c.) very well. Some specimens, were however, a little longer, being up to 21 μ long, and some had

protracted but not capitate poles, Two examples are illustrated in Figs. 116 - 118.

The species, until now, has only been reported as an arctic freshwater form found by Krasske in the Spitzbergen. In the catchment area it was recorded twice from Station 1, once from Lake Chrissie and in a sample from Station 17 on the Waterval River. This constitutes a new record for South Africa. Figs. 116 - 118.

N. montisatrae Cholnoky.

1959 - Cholnoky: Seltene iv - Kaap-Provinz.

Österr. Bot. Zeitschr. 106: 45, F. 239, 240.

The specimen (Fig. 119) assigned to this species does not quite conform to Cholnoky's description, but it agreed more with this species than with anything else. The only difference here was that this specimen has slightly less radial to almost parallel striae at the poles. In all other respects it agrees with Cholnoky's description.

As this species has only rarely been seen, the autecology of the species remains unknown. The species was recorded from only one sample from the Vaal River.

Fig. - 119.

N. muralis Grunow.

1880 - Grunow: in V.H. Syn. T. 14, F. 26 - 28.

1896 - Cleve: Naviculoid Diatoms. Kongl. Sv. Vet. Akad. Handl. 27: 3.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
236, F. 1359.

1930 - Hustedt: Bacillariophyta. P. 288, F. 482.

Synonyms: Navicula atomus Schumann (nec N. atomus (Kützting) Grunow).

Cholnoky (1960B: 252; 1962B: 87) studied the diatom associations in relation to the purification of sewage water at the Pretoria and Johannesburg Sewage Works. He followed the succession of one diatom association to another as the water was progressively purified. As a result he was able to determine, among others, the autecology of N. muralis in fairly close detail. In contrast with Hustedt's allegations that the species is "Oligohalob (indifferent), pH-indifferent, aerophil" (Hustedt 1957: 277), Cholnoky (l.c.) has found that N. muralis was able to reproduce at pH values between 7.5 - 8.5. Furthermore Cholnoky discovered that the species was not nitrogen autotrophic, but thrived best in conditions where there was a decline in the concentration of the organic nitrogen compounds (below 5.0 mg.N/litre), replacing the nitrogen heterotrophic Nitzschia as the concentration of organic nitrogen diminishes. As Navicula muralis also requires a high oxygen content it is generally the dominant diatom species at the end of a purification process, when the oxygen content is high and the organic nitrogen content of the water lies between 1.0 and 5.0 mg.N/litre. It is replaced by other algae at concentrations of nitrogen less than 1.0 mg.N/litre. In the catchment area the species was relatively common and widespread over the whole area.

N.mutica Kützing.

1844 - Kützing: Bacill. P.93, T.3, F.32.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 129.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
583, F.1592 a - f.

1930 - Hustedt: Bacillariophyta. P.274, F.453 a.

Synonyms: Stauroneis semen Ehrenberg; Stauroneis Cohnii
Schumann; Navicula Charcottii Peragallo; Placoneis mutica
Mereschkowsky.

The systematics of this species seems to be particularly muddled and confused. In later years Hustedt has added to the confusion by regarding the forms and varieties, as set out in the Bacillariophyta (Hustedt 1930: 274), as separate species, or as forms of other species. For instance the case of N.mutica var. ventricosa appears to be very confused. Hustedt transferred the description of var. ventricosa given in the Bacillariophyta (Hustedt 1930: 275) to N.Heufleriana (Grunow) Cleve (cf.Hustedt 1927 - 1964, Teil 3: 618); while the illustration of var. ventricosa in the Bacillariophyta refers to an entirely different species, N. palaeartica Hustedt (1927 - 1964, Teil 3: 613). It appears that this species with its many related forms and varieties is in need of a thorough revision. Cholnoky (1954D: 127) maintained that more delicately structured forms in acid waters were due to the physical conditions of the water. Normal forms were commonly observed in alkaline water.

According to Cholnoky (1966B: 191) N.mutica is found in well buffered water with a pH optimum near pH 8. Oxygen rich water is also a prerequisite for good growth. In the catchment area the species, although found in a number of samples, was never abundant in any of the samples.

N.mutica var. nivalis (Ehrenberg) Hustedt.

1911 - Hustedt: Abh. naturw. Ver. Bremen 20: 290.

1930 - Hustedt: Bacillariophyta. P.275, F. 453 c.

Synonyms: Navicula nivalis Ehrenberg; Navicula nudosa Donkin; Naviculè mutica var. quinquenodis Grunow; Navicula mutica var. subundulata Grunow; Navicula mutica var. pulchra McCall; Navicula mutica var. capitata Wislouch et Poretzky; Navicula mutica var. capitata Hustedt; Navicula mutica var. distinguenda Hustedt.

Hustedt in Rabenhorst (1927 - 1964, Teil 3: 620) has reinstated this variety as Navicula nivalis Ehrenberg on the basis that these capitate forms have nothing to do with N.mutica. It seems surprising that N.mutica, being such a variable form, should have no variations with capitate poles, particularly as there are many forms exhibiting protracted ends to the valves. At the moment it is preferable to retain these specimens as var. nivalis. Cholnoky (1962B: 87) was of the opinion that f.nivalis may prove to be an ecological phenotype, since its autecology differs slightly from the typical forms of the species. In a sample from the Kommandospruit River (Vaal 445) a specimen (Fig. 151) differing from the normal varietal forms was observed. This specimen conformed in most respects to the description of var. nivalis, but differed in the density of the striae, possessing about 28 striae in 10 μ in the middle of the valve and about 34 at the poles. This falls outside the range of variation (16 - 24 striae in 10 μ) given for this variety by Bock (1963: 236). It is therefore possible that this specimen enlarges the range still further.

The var. nivalis was not as common in the catchment area as the typical forms of the species. It occurred mainly in the Vaal River.

Fig. - 151.

N.muticoides Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 3: 598, F.1602.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
82, T.4, F.33 - 36.

Due to the position of the pore on the valve edge, and the much finer striation, this species is relatively easy to distinguish from N.mutica Kützinger. There is no doubt that the three specimens which were seen were Hustedt's N.muticoides.

Its autecology is not properly known, due to the rare occurrence of this species. It was recorded from Station 31 on the Komandospruit River, and from Stations 10 and 11C on the Wilge River.

Samples - 330, 333, 445.

N.nyassensis O. Müller.

1910 - O. Müller: Bacill. aus dem Nyassalande. Engl.Bot.
Jahrb. 45: 83, T.1, F. 5, 6.

Synonyms: Navicula Mereschkowskii O. Müller; Navicula nyassensis f. minor O.Müller; Navicula nyassensis var. longirostris O. Müller; Navicula nyassensis var. elliptica O. Müller; Navicula Mereschkowskii f. minor O.Müller; Navicula Mereschkowskii var. recta O. Müller; Navicula Mereschkowskii var. recta f. minor O. Müller.

Cholnoky (1966A: 40: 1966B: 192) has drawn attention to the fact that the systematics of this species is in need of revision. The distinctions between N.nyassensis, N.pupula Kützinger are minimal. In this study the criteria used to distinguish N.nyassensis from N.pupula were the number of striae at the central nodule, i.e. 18 in 10 μ for N.nyassensis, and 21 or more for N.pupula, and the shape of the central area. The central area

of N.pupula is normally clearly demarcated and rectangular, while in N.nyassensis it is not so clear and more oval in outline.

Cholnoky has reported the species from neutral to weakly basic waters in South Africa. In the catchment area it was not common and was found in only a relatively small number of samples.

N.pascuorum Cholnoky.

1965 - Cholnoky: Chrissie-Sees. Arch. Hydrobiol. 61: 72, F. 24, 25.

This small Navicula falls into that group of small hyaline diatoms which are most difficult to identify. The shape of the valve is rhombic-lanceolate and the weakly silicified valve has a prominent axial rib which demarcates the axial area clearly. These two characteristics make it relatively easy to identify. Fig. 120, 121.

As the species has so seldom been observed, the autecology remains unknown. In the catchment area it was found in small numbers in a few samples, mainly from the Vaal River system. Figs. - 120, 121.

Samples - 307, 447, 453, 464, 465, 485, 486, 512.

N.permitis Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 174, F.1306.

1945 - Hustedt: Balkan-Halbinsel. Arch.Hydrobiol. 40: 919, T.41, F. 8, 9.

N.permitis is yet another of these small hyaline Navicula species. It is very closely related to N.pelliculosa (Brebisson)

Hilse (cf. Hustedt 1927 - 1964, Teil 3: 173) from which Hustedt separated it because N.permitis has narrower valves and the axial rib is not so well developed. Hustedt (l.c.) also pointed out that N.nolens Simonsen (cf. Hustedt 1927 - 1964, Teil 3: 174) differed from N.permitis only in its physiology; N.nolens being a freshwater species. In this survey some unusually small hyaline diatoms, whose length was more or less constantly $6\ \mu$, and whose width was about $2\ \mu$, were observed (Fig. 122). Generally only the raphe and axial area were clearly visible, as the valve was very weakly silicified. The valves, when just visible, were linear-elliptical to lanceolate. On the basis of the shape of the valve these small Naviculas have been referred to this species. If this identification is correct then these measurements enlarge the range of variation of the species.

The autecology of this species is not known and the few typical forms of this species which were seen do not throw any light on the subject. However, mention must be made of the small unusual forms. In the sample Vael 377 they composed 88.7% of the association and in Vael 378 about 14.4% of the association. Both these samples were taken from the Waterval River at Roodebank (Station 17) where, from the diatom associations found at that point, there is evidence of large concentrations of nitrogenous compounds. This then might indicate that these small forms are nitrogen heterotrophic.

Figs.- 122 - 124.

N.perparva Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora
Teil 3: 283, F.1355.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl. 15: 246, T.20, F.16 - 18.

Chelnoky (1960B: 253; 1962B: 88) recorded this uncommon species from polluted waters and remarked that its autecology was similar to N.muralis. This means that the species is found where the trophic conditions are no longer optimal for Nitzschia palea (Kützing) W. Smith, but where the water still contains some organic nitrogen in solution. The distribution of the species in the catchment area substantiates this, as it is found mainly in the Waterval River, where the water apparently contained plenty of organic nitrogen.

N.promota n.sp.

N.promota belongs to the group Naviculae orthostichae (Cleve) Hustedt, and has some affinity to N.cuspidata Kützing var. ambigua (Ehrenberg) Cleve (cf. Hustedt 1927 - 1964, Teil 3: 62). It differs from this species in the possession of finer striae and a central area. This new species cannot be associated with any other species of this group known to the author.

The valves are lanceolate with rostrate to slightly capitate poles, 32.5 - 40 μ long, and 7 - 9 μ wide. The raphe is straight and filiform; the central pores are inconspicuous and are not hooked; the terminal fissures are small, lunate and are turned towards the same side. The axial area is narrow and linear; at the central nodule it widens to form an oval to circular central area, in width about one third of the valve breadth.

(239).

The transapical striae are slightly radial in the middle and convergent at the poles, 20 - 24 in 10 μ ; the longitudinal costae are indistinct. Fig. 125.

This new species was found in a number of samples from the Vaal River System, and in two others, from Station 24 on the Klip River, and in a sample from the Cornelius River. In none of the samples was the species common.

Fig. - 125.

N.pseudohalophila Cholnoky.

1960 - Cholnoky: Natal. Nova Hedwigia 2: 74. F.231 - 235.

This species has been reported by Cholnoky from Natal (Cholnoky l.c.), the Cape Province (1962A: 44) and the Okavango River (1966A: 42), and by Giffen from the Eastern Cape Estuaries (Giffen 1963: 240) and the Hogsback Region (1966: 140). These specimens are therefore the first to be recorded from the Transvaal. It was found in the Waterval River.

N.pseudomuralis Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 236, F.1360.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol. Suppl. 15: 245, T.19, F.25 - 27.

This small Navicula species is very rarely seen; and was recorded from the Vaal Dam catchment area in one sample from the Waterval River. Nothing much is known of its autecology.

Sample - 498.

N.pseudoventralis Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
153, F.1285.

1934 - Hustedt: in A.S. Atl. T.401, F.116 - 118.

Synonyms: Navicula modica Hustedt e.p. (Hustedt 1950: Arch.
Hydrobiol. 43: T.38, F.71 - 73); nec Navicula modica Hustedt
(1945: 916, T.41, F.21 - 23); Navicula curta Hustedt.

In this survey the small specimens of this species were easily recognised, and no difficulty was experienced in assigning them to N.pseudoventralis. This species has only rarely been seen in South Africa and therefore two specimens (Figs. 126, 127) were illustrated. Cholnoky (1960A: 44) has recorded N.pseudoventralis from South Africa under the name N.curta Hustedt, but Hustedt himself has united N.curta with N.pseudoventralis (Hustedt 1927 - 1964, Teil 3: 154).

This species was observed from six samples, predominantly from the Waterval River.

Figs. - 126, 127.

Samples - 324, 337, 339, 340, 436, 485.

N.pupula Kützing.

1844 - Kützing: Bacill. P.93, T.30, F.40.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 131.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
120, F.1254 a - g.

1930 - Hustedt: Bacillariophyta. P.281, F.467 a.

Synonyms: Navicula pupula f. minuta Grunow; Navicula pupula
var. genuina Grunow; Stauroneis tatrika Gutwinski;
Schizostauron tatrika De Toni; Sellaphora pupula Mereshkowsky;
Navicula pupula var. subcapitata Hustedt; Navicula pupula var.
sinica Skvortzow; Navicula pupula var. minutula Cholnoky.

In the catchment area the species was amongst the commonest found. Cholnoky (1960A: 75; 1960B: 253; 1962A: 45; 1962B: 88) has recorded N.pupula from neutral to weakly alkaline water, which contains very little nitrogenous compounds.

N.pupula f. rostrata Hustedt.

1911 - Hustedt: Abh.naturw. Ver. Bremen 20: 211, T.3, F.39 (as a variety).

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 121, F.1255.

1930 - Hustedt: Bacillariophyta. P.282. F.467 e.

There is some discrepancy between the description and figures of f.rostrata given by Hustedt in the Bacillariophyta (Hustedt l.c.) with those given by him in Rabenhorst (l.c.). In the Bacillariophyta F. 467 e (f.rostrata) is more like the figures of N.pupula var. mutata (Krasske) Hustedt given in Rabenhorst. The description of f.rostrata differs in the two books as well; in the Bacillariophyta there is no mention of capitate poles, while in Rabenhorst the poles are described as being capitate. However, Hustedt (1946 - 1950: T.37, F.21 - 23) illustrated some small specimens of f.rostrata from the Nord-deutscher Seen, in which the poles are produced but not capitate. Two specimens have been tentatively assigned to this form, one showing slightly capitate poles (Fig. 129), while the other being only 9 μ long and 4 μ broad, is similar to the small forms without capitate poles (Fig. 128).

This form has not been reported from South Africa before. It was recorded from Lake Chrissie and from a tributary of the Sand River.

Figs. - 128, 129.

Samples - 455, 485.

N.pupuloides Cholnoky.

1955 - Cholnoky: Raytonvlei und Leeufontein. Hydrobiologia
7: 175, F.62, 63.

This is a small and very little known diatom and in this survey was found as a single specimen in one sample from Station 3 on the Vaal River. Nothing is known of its ecological requirements.

N.pygmaea Kützing.

1849 - Kützing: Spec. Alg. P.77.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 65.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
538, F.1574.

1930 - Hustedt: Bacillariophyta. P.312, F.561.

Synonyms: Navicula minutula W. Smith; Navicula rotundata
Hantzsch.

All the specimens in this study were quite typical and thus provided no problems with regard to their identification.

N.pygmaea has been recorded in South Africa from both freshwater and in water containing higher concentrations of dissolved salts. Cholnoky (1958B: 121; 1960A: 76; 1962B: 88) recorded it from alkaline waters and remarked that in the Swartkops River (Cholnoky 1960B: 253) "Die Art erweist sich hier als eine richtige Salzwasserart". Previously he had recorded it from freshwater samples only. In the catchment area it was generally found as single specimens, although in one or two samples it was relatively abundant. In many of the samples its presence may, however, be due to carriage downstream from a brackish source.

N.rhynchocephala Kützing.

1844 - Kützing: Bacill. T.30, F.35.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 15.

1930 - Hustedt: Bacillariophyta. P.296, F.501.

Synonyms: Navicula cryptocephala var. rhynchocephala Strösse;
Navicula rhynchocephala var. amphiceros (Kützing) Grunow.

Cholnoky (1960A: 78; 1962A: 45; 1962B: 89) has reported N.rhynchocephala as widely distributed from alkaline waters in South Africa. The alkaline conditions prevailing in the catchment area appeared to suit the development of this species. It was found in nearly all the samples, and on some occasions was relatively abundant.

N.rostellata Kützing.

1844 - Kützing: Bacill. P.905, T.3, F.65.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 15 (under N.viridula var. rostellata).

1930 - Hustedt: Bacillariophyta. P.297, F.502.

Synonyms: Navicula rhynchocephala var. rostellata Grunow;
Navicula viridula var. rostellata (Kützing) Cleve.

This is one of the most commonly occurring diatom species in the Vaal Dam catchment area. It is found, according to Cholnoky (1960A: 78; 1962B: 89) in weakly alkaline waters of South Africa with a poor nitrogen compound content. This accounts for its wide distribution in the catchment area, where it sometimes occurred in relatively high numbers.

N. Ruttneri Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl. 15: 238, T.17, F.18 - 23.

There is some difference of opinion over the autecology of this species of Navicula. Hustedt (l.c.) in his comments on the ecological character of the species remarked that it has a preference for alkaline water with a pH range from 6.7 to 8.3. Cholnoky on the other hand has recorded it on a number of occasions from South Africa and has regarded it as an acidophilic species (Cholnoky 1955B: 176; 1958B: 121; 1960B: 254). In the catchment area a single example was found in the Kommandospruit stream near Vrede.

Sample 432.

N. Schroeteri Meister.

1932 - Meister: Kieselalgen aus Asien, Berlin. P.38, F.100.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol.

Suppl. 15: 267, T.18, F.16.

Synonym: Navicula sudanensis Bastow.

Among the many specimens of this species two types of valve have been observed. While the dimensions of both types remain the same, and a complete range of intermediates exists, one type was more strongly silicified with larger punctae, whereas the other was weakly silicified with smaller punctae. This may be the result of different physical conditions in the water.

The species apparently inhabits alkaline waters and has a pH optimum of about pH 8. Cholnoky (1962B: 89) remarked that this species cannot tolerate fluctuations of the pH towards the acid side. On the otherhand Giffen (1966: 141) has recorded it

as plentiful in neutral to slightly acid waters of the Hogsback Region. In the Vaal Dam catchment area the pH values of only one or two stations were below pH 7, and N.Schroeteri was not present at these acidic stations. On the whole the pH value of the rivers in the catchment area remain above and around pH 8. The species was present in many samples, and in some had high relative densities. Cholnoky (personal communication) has put forward the theory that this species is influenced by the presence of sugars in the water, as it is of common occurrence in the Nonoti River in Natal, where wastes from a sugar mill pollute the water.

N.Scottiae Cholnoky.

1961 - Cholnoky: Wemmershoek Dam. Österr. Bot. Zeitschr. 108: 334, F.15, 16.

There is no doubt that the specimen found in the Vaal River is N.Scottiae. It conformed to the morphological characteristics given by Cholnoky in all details. The dimensions, however, were slightly larger than those given in the description. The length of this specimen (Fig. 130) was $16.5\ \mu$ and its breadth $5\ \mu$, the striae in the middle were 18 in $10\ \mu$, becoming a little denser towards the poles.

N.Scottiae has previously only been recorded from its type locality, and as a result very little is known of its autecology. One specimen was recorded from the catchment area at Station 3 on the Vaal River.

Fig. - 130.

Sample - 495.

N.seminuloides Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
244, F.1369.

1936 - Hustedt: in A.S. Atl. T.401, F.68 - 71.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol.
Suppl. 15: 239, T.17, F.29 - 33.

Synonyms: Navicula seminuloides var. sumatrana Hustedt.

Both Hustedt (l.c.) and Cholnoky have found that the elliptical var. sumatrana cannot be separated from the typical form, and so have sunk the variety into the species. Cholnoky has, until 1966, recorded this species mainly as the variety var. sumatrana and has stated that the typical forms occurred far more seldom than the variety (cf. Cholnoky 1958B: 122).

N.seminuloides is apparently acidobiontic (Cholnoky 1958B: 122; 1960B: 255), and this probably accounts for its relatively small occurrence in this region.

N.seminulum Grunow.

1860 - Grunow: Verh. zool.-bot. Ges.Wien 10: 552, T.4, F.3.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 128.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
241, F.1367.

1930 - Hustedt: Bacillariophyta. P.272, F.443.

Synonyms: Navicula Saugerri Desmazieres; Navicula seminulum
var. fragilaroides Grunow; Navicula seminulum f. maior Grunow.

Two examples of this species have been illustrated (Figs. 131, 132) one of which (Fig. 132) had a slightly denser striation. In all other respects this irregular form conformed to the description of the species.

Cholnoky (1962B: 90) has stated that this species together with N.confervacea and Gomphonema parvulum (Kützing) Grunow are characteristic of waters with a considerable fluctuation of the organic nitrogen concentration of the water. It was recorded from a relatively small number of samples from scattered localities. Figs. - 131, 132.

N.simplex Krasske var. minor Cholnoky.

1954 - Cholnoky: Neue und seltene Diatomeen. Österr.Bot.Zeitschr. 101: 419, F.62.

Hustedt (1949A: 93, T.5, F. 6 - 8) illustrated a very small example of N.simplex, but did not comment on its smallness. Cholnoky (l.c.) also found similar small examples in Rhodesia, and thought them sufficiently different to warrant the creation of a new variety. An example (Fig. 135) showing slightly longer valves than Cholnoky's specimens has been illustrated. The dimensions of this specimen were more like those depicted by Hustedt from the Congo (Hustedt l.c.).

This variety occurred in a few samples from the catchment area, and always in low numbers.

Fig. - 135.

N.söhrensis Krasske f. capitata (Krasske) Hustedt.

1925 - Krasske: Abh. u. Ber. Ver. f. Naturk. Cassel 56: 47, T. 2,
F. 37 (as Var.)

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
215, F. 1331 e.

1930 - Hustedt: Bacillariophyta. P. 289.

Synonyms: Pinnularia söhrensis var. capitata Krasske.

This small form of N.söhrensis is rare in South Africa, and has been recorded only twice before. It is apparently a pan-tropical form, and in South Africa it has not been found further south than the Transvaal. In the catchment area it was found as isolated specimens in only two samples from the Vaal River. Samples - 403, 477.

N.söhrensis f. muscicola (Boye Petersen) Krasske.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
215, F. 1331 f - h.

1929 - Krasske: Bot. Arch. 27: 373 (as Var.)

1930 - Hustedt: Bacillariophyta. P. 289 (as var.)

Synonym: Pinnularia muscicola Boye Petersen.

In his comments on N.söhrensis var. muscicola from the Cape Province Chohnoky (1962A: 46) wrote as follows:- "Die Variabilität der Schalenform war, wie die Fig. 60 - 63 zeigen, sehr gross, näherte sich aber nicht dem Formenkreis der typischen N.söhrensis. Krasske verband die beiden wahrscheinlich nur auf Grund einer einzigen morphologischen Merkmals, uzw. der Streifung, meines Erachtens nach liegen aber hier zwei voneinander verschiedene Vermehrungsgemeinschaften vor, deren spezifische Trennung kaum abwegig wäre. In diesem Falle müsste die jetzige Varietät den Namen Navicula muscicola (Boye Petersen) comb. nova tragen."

From this it can be concluded that the variety and the type are two different things and Cholnoky has raised the status of the variety to species, N.muscicola. However in a later comment on N.söhrensis f. muscicola (= N.söhrensis var. muscicola) from the Ruwenzori Mountains (Cholnoky 1964: 73) Cholnoky gave the opposite and completely different opinion on this subject. Here he wrote "Die Unterscheidung dieser Form, die in reichlichen Proben immer gleitend in dem Typus übergeht, ist zwecklos, demzufolge muss die Benennung der Art verändert werden." Here Cholnoky has reversed his earlier opinion and now claimed that the form and the type are the same thing, and a separation of the two is purposeless. Cholnoky also called this new combination N.muscicola (Boye Petersen) n. comb. (= Pinnularia muscicola Petersen 1928: 407, F.27). Cholnoky, however, did not follow the rules of priority here and the nomenclature of this new combination is incorrect. N.söhrensis was described by Krasske in 1923 (cf. Hustedt 1927 - 1964, Teil 3: 214) and therefore following the rules of priority N.söhrensis is the oldest legitimate name for this species and all other combinations are synonyms. For the present it is better to maintain the forms of this species as set out in Hustedt 1927 - 1964, Teil 3: 215. One further comment should be made on the illustrations which Cholnoky drew from his Cape material (Cholnoky 1962A: 46, F. 60 - 63). Fig. 60 with its straight walls and capitate ends belongs, in my opinion, to N.söhrensis f. capitata rather than to N.söhrensis f. muscicola, which has no capitate poles. Figs. 133, 134 illustrate examples of this form found in the catchment area.

N.söhrensis f. muscicola, an aerophytic acidobiont

(Cholnoky 1955B: 177), was found as isolated specimens in a small number of samples.

Figs - 133, 134.

Samples - 203, 309, 331, 334, 359, 360, 434, 436, 456.

N.spirata Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
237, F.1361.

1936 - Hustedt: in A.S. Atl. T.401, F.114, 115.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl. 15: 240, T.17, F.34, 35.

Besides a single record from its type locality, this small species has been recorded twice from South Africa by Cholnoky (1962A: 47; 1962B: 90). In the Vaal Dam catchment area a single specimen was recorded from Station 2A on the Vaal River.

Sample 307.

N.Standeriella Archibald.

1966 - Archibald: Rare Diatoms from S.A. Nova Hedwigia Suppl. 21:
262, F.37, 38.

The range of variation of this new species is extended by the discovery of further specimens from three localities in the catchment area. This species shows a very close similarity to N.insociabilis Krasske (cf. Hustedt 1927 - 1964, Teil 3: 183, F.1317, under N.monoculata Hustedt), and because of its very well developed axial rib it belongs to the group Naviculae bacillares Cleve emend. Hustedt. It differs from N.insociabilis in the shape of the valve, the central area and the number of transapical striae.

The valves are linear to linear-elliptical with blunt and broadly rounded ends, $9.5 - 19 \mu$ long, and $4 - 5 \mu$ wide. The raphe branches are slightly arcuate, and the small polar fissures curve towards the same side of the valve. The raphe lies in a relatively well developed axial costa. The axial area is narrow and linear and due to a shortening of the central transapical striae, a more or less rectangular central area is formed. The transapical striae are delicate and radial throughout, $20 - 22$ in 10μ . Between the axial costa and the valve edge, a hyaline line, probably a thickened longitudinal rib, cuts across the striae; this line bulges out towards the valve edge in the region of the central nodule. Closer to the axial costa, and on either side of the central nodule, a further short hyaline line cuts across the first two or three striae. As the valves become shorter this second line tends to disappear. Figs. 136 - 138.

The species was recorded from the Kalk River and the Water-val River.

Figs. 136 - 138.

Samples - 321, 402, 553.

N.subatomoides Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
271, F.1400.

1936 - Hustedt: in A.S. Atl. T.404, F. 33 - 35.

1950 - Hustedt: Arch Hydrobiol. 43: 437, T.38, F. 77- 89.

This diatom, although very small, is nevertheless relatively easy to recognise, and it is certain that the specimens seen here were N.subatomoides.

(252).

Cholnoky (1957A: 67; 1957B: 355; 1960C: 359) has recorded it from acidic waters. This probably accounts for its small occurrence in this area.

Samples - 333, 359, 437, 485.

N.subbacillum Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
117, F.1251.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.
Suppl.15: 256, T.18, F. 3 - 6.

Three specimens from tributaries of the Vaal River have been identified as N.subbacillum. They provide the first record of this species in Africa.

Samples - 465, 468, 491.

N.subcoccus Cholnoky.

1960 - Cholnoky: Natal. Nova Hedwigia 2: 80, F.247, 248.

The specimens of this species, seen in the catchment area, agreed well with Cholnoky's description.

Cholnoky (l.c.) recorded N.subcoccus from the Oribi Gorge in Natal. The records of this species from three localities near the source of the Vaal River provides the first record outside the type locality. Its occurrence in the samples was rare.

Samples - 301, 479, 485, 486.

N.subcostulata Hustedt var. avittata Cholnoky.

1959 - Cholnoky: Seltene iv - Kaap-Provinz. Österr.Bot.
Zeitschr. 106: 51, F. 265 - 269.

One specimen from the Kalk River has been identified as
N.subcostulata var. avittata. Little is known of its ecological
requirements.

Fig. - 141.

Sample - 402.

N.subhamulata Grunow.

1880 - Grunow: in V.H. Syn. P.106, T.13, F.14.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 138.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
126, F. 1258.

1930 - Hustedt: Bacillariophyta. P.282, F. 468 a.

This diatom, easily recognised by the long terminal
fissures and the slightly sunken portion of the valve surface,
occurred in a number of samples in its typical form, usually
as single specimens, but sometimes with relatively high
percentages. N.subhamulata is found in neutral to weakly
alkaline waters, and has a pH optimum around pH 7 (Cholnoky
1957A: 62; 1962B: 90).

N.submolesta Hustedt emend. Archibald.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
253, 1380.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
86, T.5, F.16 - 18.

1966 - Archibald: Rare Diatoms in S.A. Nova Hedwigia Suppl. 21: 263.

A series of specimens from the catchment area (Figs 142 - 150)
show a gradation from the typical N.submolesta (Fig. 148) with
17 striae in 10 μ in the middle and 24 at the poles, through

intermediate forms to the typical N.molestiformis (Hustedt 1949A: 86) containing 27 striae in 10 μ in the middle and 34 striae at the poles. From this evidence it appears that the two species are linked, and should therefore be united. As both species were described in the same paper (Hustedt l.c.) the name N.submolesta has been adopted, since its description preceded that of N.molestiformis. N.molestiformis therefore becomes a synonym. This same series of specimens also showed a wide range in the dimensions of the species. The description of this species should, in consequence of the observations mentioned above, be amended. The valves of N.submolesta are thin walled, linear, linear-lanceolate to elliptical-lanceolate, with short rostrate poles, 14 - 21 μ long, and 3.5 - 6.5 μ wide. The raphe is straight and filiform, sometimes with the central pores widely separated. The axial area is narrow and linear, and there is no central area. The transapical striae are parallel throughout, sometimes slightly convergent at the poles, in the middle 17 - 30 striae in 10 μ , and more dense at the poles 21 - 35 in 10 μ .

This species was relatively common throughout the catchment area, but never occurred with any great abundance in any sample. Figs - 142 - 150.

N.subrotundata Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 272, 1402 a - m.

1945 - Hustedt: Arch. Hydrobiol. 40: 917, T.41, F. 30 - 33.

Synonyms: N.rotundata var. lanceolata.

Two specimens (Figs. 152, 153) have been assigned to

N.subrotundata, as they fulfil the requirements of the description for this species.

Cholnoky (1966A: 48; 1966B: 197) has recorded it from South West African alkaline waters. In the catchment area it was reported from the Waterval River (Station 17), the Vaal River (Stations 2 and 2A), the Klerkspruit River near Kestell and Lake Chrissie.

Figs. - 152, 153.

Samples - 306, 340, 362, 485, 486.

N.subtilissima Cleve.

1891 - Cleve: Act.Soc.Fauna et Flora Fenn. 8: 37, T.2, F.15.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 141.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
89, F.1235, 1236.

1930 - Hustedt: Bacillariophyta. P.285, F.475.

Synonyms: Navicula dutoitana Cholnoky.

Cholnoky has recorded this species from many localities in South Africa. However owing to the very low pH optimum of the species (around and below pH 6) it was found in only two samples, one from the headwaters of the Vaal River where the pH is low, and the other from a sample lower down the river.

Sample - 307, 479.

N.tantula Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
250, F.1375.

1934 - Hustedt: in A.S.Atl. T.399, F.54 - 57.

1943 - Hustedt: Internat.Rev.d.Hydrobiol. 43: 162.

Among the many examples of this species some very short

forms showing a more elliptically shaped valve (Fig. 154) were observed. Generally the specimens were typically linear. (Fig. 156).

The autecology of this species has yet to be determined accurately. Cholnoky has found it widespread in certain acid waters (1957A: 67) and occasionally in neutral to weakly alkaline water (1960A: 64). From the distribution of the species in the Vaal Dam catchment area it would appear that this species can thrive equally well in waters that are generally slightly alkaline.

Figs. - 154 - 156.

N. temeraria Cholnoky.

1965 - Cholnoky: Chrissie-Sees. Arch. Hydrobiol. 61: 73,
F.28, 29.

Two specimens of this species were observed in the catchment area. A small form (Fig. 157) whose dimensions were 10 μ long and 6.5 μ broad, was recorded from Station 2A on the Vaal River, while a form with a prominent axial rib enclosing extremely thick raphe branches (Fig. 158) was found in Lake Chrissie, the type locality of the species.

Figs. - 157, 158.

Samples - 307, 485.

N.tenella Brebisson.

- 1849 - Brebisson: in Kützing - Spec. Alg. P.74.
 1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
 27: 17 (under N.radiosa var. tenella).
 1930 - Hustedt: Bacillariophyta. P.299. (under N.radiosa
 var. tenella).

Some clarification concerning this species is necessary.

Cholnoky (cf. Cholnoky and Claus 1961: 335; Cholnoky 1962B: 88) has put forward the idea that N.tenella has little to do with N.radiosa Kützing, except that it is superficially similar. He therefore resurrected Brebisson's species, N.tenella. This concept has been followed in this study. However the definition of the species does not appear to be quite clear. Some examples were drawn (Figs. 159 - 161) which were thought to depict the true N.tenella Brebisson. The valves are lanceolate with acutely rounded poles. The axial area is linear and narrow, and widens very slightly at the central nodule to form a small lanceolate central area. The transapical striae are prominent and number about 14 in 10 μ . They are radial in the middle and convergent at the poles. Generally the central striae are long and reach almost to the axial area. On either side of these striae there are generally shortened striae, which give the appearance of alternating longer and shorter striae, which is quite characteristic for N.tenella.

During this survey Cholnoky assisted the author in the identification of some problematical specimens. Figs. 176 - 178 show some examples of a relatively common species, which Cholnoky maintained belonged to N.tenella. However the author has not been able to agree with him on this point, as in the author's opinion the two forms are completely different and should be regarded as two different species. These forms have, therefore,

been described as a new species, N.venezuelensoides, and further comments on this species may be found below.

N.tenella is widespread in the neutral to slightly alkaline waters of the Vaal Dam catchment area, where it sometimes occurred in very high numbers in the samples. It was one of the commonest species found here.

Fig. - 159 - 160.

N.tenellaeformis Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.
Suppl. 15: 269, T.19, F.14, 15.

This small and seldom seen species was observed in only three samples. Fig. 164 shows the more typical form of N.tenellaeformis. There is some uncertainty concerning the identities of Figs. 162 and 163. These two specimens have been placed in this species because they are more like this species than any other. Fig. 163 shows forms which have very strongly radiate central striae.

Figs. - 162 - 164.

N.tenelloides Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol.
Suppl. 15: 269, T.19, F.13.

This species is apparently widespread in neutral to weakly alkaline waters of South Africa. According to Cholnoky (1962B: 91) its optimal development is in weakly alkaline water. It is therefore not surprising to find it in so many samples, and sometimes occurring in relatively high numbers.

N.tenuissima n.sp.

N.tenuissima belongs to the group Naviculae subtilissimae Hustedt, and is very similar to N.subtilissima Cleve (cf.Hustedt, 1927 - 1964, Teil 3: 89, F.1235). It differs from N.subtilissima in its dimensions and the arrangement of the striae. It is also reminiscent of N.subarvensis Hustedt (1927 - 1964, Teil 3: 87, F.1230) from which it differs in the shape of the valve and the direction of the striae.

This new species has a linear-lanceolate valve with small capitate poles, 11.5 - 16.5 μ long, and 2.5 - 4 μ broad. The raphe is straight and filiform with unclearly defined polar fissures. The axial area is narrow and linear and does not widen at the central nodule to form a central area. The trans-apical striae are fine and parallel throughout, about 32 - 36 in the middle and becoming more dense towards the poles, where they number about 40 in 10 μ . Figs. 165, 166.

This small species had quite a wide distribution in the catchment area. It occurred in a few samples as single specimens in others it was found to be more abundant.

Figs - 165, 166.

N.terrestris Boye Petersen.

1915 - Boye Petersen: Danske aerofile Alger. D.Kgl.Danske Vidensk. Selskrift, 7 Raekke, Naturw. og Math Afd. 12: 285, F. 7, 8.

1930 - Hustedt: Bacillariophyta. P.285, F.477 (under N.gibbula Cleve).

1946 - Lund: Observations on Soil Algae. New Phytologist 45: 80, F. 7 M - X.

Synonyms: Navicula gibberula Lagerstedt; Navicula gibbula Cleve (sensu Östrup, Bachman, Hustedt and McCall); Navicula terricola Bristol; Navicula relictata McCall; Navicula gibbula Cleve var. terrestris Boye Petersen; Diploneis van der Merwei Cholnoky.

Lund (1946: 80) has given a very clear picture of the systematics and taxonomy of this particular species, and pointed out quite clearly that N.terrestris has nothing to do with N.gibbula Cleve (1894: 140). Cleve apparently missed the longitudinal line near the axial area, and the two projections of the raphe at the central nodule; these features according to Cholnoky (1962A: 48) are easily seen at lower powers of magnification and in dry systems. The Vaal specimens were quite in agreement with Lund's description of N.terrestris, and were found as isolated examples at three localities, where the water was acidic in nature.

Samples - 251, 301, 331, 370, 479.

N.towutiensis (Hustedt) Cholnoky.

1942 - Hustedt: Indomalayischen Archipels und Hawaaii Inseln. Internat. Rev. d. Hydrob. u Hydrogr. 42: 68.

1963 - Cholnoky: Swakop-Flusses in S.W.A. Rev. de Biol. 3: 245 (under N. Woltereckii var. rostrata).

The systematics of this species is a little confusing. Hustedt first described a species, Navicula Woltereckii, later uniting it with N.helvetica (Hustedt 1942: 68). However, according to Cholnoky (1959: 279) in doing so, Hustedt actually stated sufficient characteristics and differences which would warrant a specific division between the two species. Cholnoky (l.c.) also maintained that the f.rostrata should really be a variety of N.Woltereckii, because only this variety had been

found and not the typical forms. Later having seen many other examples Cholnoky (1963D: 245) became convinced that this variety should in fact be a distinct species of its own. In consequence thereof he renamed it N.towutiensis after the locality from which it was found.

This species is apparently a tropical - subtropical alkaline water form. In the catchment area it was seen in one sample, so that it is not possible to comment any further on the species.

N.tridentula Krasske.

1926 - Krasske: Abh. u. Ber. Ver. f. Naturw. Cassel 56: 46
T.2, F.31.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
82, F.1223.

1930 - Hustedt: Bacillariophyta. P.276, F.456.

Synonyms: Navicula bidentula Boye Petersen; Navicula quadriundulata Manguin.

This small hyaline species, has been recorded on a few occasions from South Africa. Cholnoky claimed that it is an acidophilic species confined to oligotrophic waters (Cholnoky 1960B: 256; 1962B: 91). Conditions of this kind are rare in the catchment area, which may explain why it was found in only three samples.

Samples - 403, 412, 456.

N.Twymaniana Archibald.

1966 - Archibald: Rare Diatoms from S.A. Nova Hedwigia Suppl.
21: 264, F.41 - 43.

Since first describing this species the opportunity to observe many more examples has arisen. It is now possible to define the species more precisely. Due to its structure it belongs to the group Naviculae minusculae Cleve emend. Hustedt, but it cannot be equated to any other species in this group.

The typical form of Navicula Twymaniana (Figs. 167 - 169, 173 - 175) has a lanceolate to rhombic-lanceolate valve, 10 - 22 μ long, and 3 - 5.5 μ broad; the poles are rounded and not produced. The raphe is straight and filiform. The axial area is narrow and linear, and does not widen at the central nodule to form a central area. The striation of the valve is variable; the striae are fine, about 27 - 32 in 10 μ in the middle, where they are parallel; towards the poles they become more dense and are generally invisible under the microscope. In some valves, however, the polar striae are visible and are convergent numbering about 40 or more in 10 μ . This species is named in honour of Professor E.S. Twyman, Head of the Department of Botany, Rhodes University.

Two other valve shapes were seen and could possibly be considered as forms of the species. However there is at present insufficient evidence to describe them as forms. The one was relatively narrower and distinctly rhombic in outline, having more acutely rounded poles (Figs. 170, 171), and the other had slightly produced rostrate poles (172).

The autecology of N.Twymaniana is at present unknown. It was widespread in the Vaal Dam catchment area, and this suggests

that it prefers waters which are alkaline. It did not occur in any abundance in the samples.

Figs. - 167 - 175.

N.vanidica Cholnoky.

1962 - Cholnoky: Diatomeenflora iii - Kaap-Provinz.

Rev. de. Biol. 3: 49, F. 69, 70.

This species has previously been recorded from localities in the Cape Province. A single specimen of this species was recorded from the Waterval River.

Sample - 410.

N.variostriata Krasske.

1923 - Krasske: Bot. Arch. 3: 197, F.12.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
201, F.1320.

1930 - Hustedt: Bacillariophyta. P.273, F.447.

Synonyms: Navicula bacillum var. densestriata Östrup.

Cholnoky (1954B: 219) has recorded this species from Rhodesia. A single specimen was observed in the catchment area at Station 5 near Standerton.

Sample - 317.

N.venezuelensoides n.sp.

Figs. 176 - 178 illustrate examples of a species of Navicula which Cholnoky (personal communication) regarded as N.tenella. However on careful examination it was decided that these specimens

could not be equated with N.tenella, and have therefore been described as a new species, N.venezuelensoides. The new species differs from N.tenella in the following points:-

- 1). The poles of the new species are broadly rounded while in N.tenella they are acute and relatively narrow.
- 2). The striae in N.venezuelensoides consist of distinct slightly elongate punctae, while in N.tenella they are indistinct.
- 3). The central area of the new species is well developed, sometimes almost reaching the margin of the valve, whereas in N.tenella the central area is a slight lanceolate widening at the central nodule.

N.venezuelensoides is very similar to N.venezuelensis Hustedt (1952B: 115, F. 33 - 36), from which it differs in the shape of the valve and the shape of the central area. The new species also has some affinity to N.Schubarti Hustedt (1952A: 396, F.104) from which it differs in its finer structure and the absence of the large structureless areas found at the poles of N.Schubarti.

The valves of the new species are lanceolate with broadly rounded poles, 30 - 38 μ long, and about 7 μ wide. The raphe is straight and filiform with relatively large lunate polar fissures, both curving in the same direction. The axial area is narrow and linear, and widens more or less abruptly at the central nodule to form an irregularly shaped central area, which almost reaches the margin of the valve. The transapical striae are punctate with linear punctae (Naviculae lineolatae); in the middle they are radial while at the poles they are convergent, 12 - 14 (usually 12) in 10 μ . The longitudinal costae are visible running parallel to the raphe, except at the central

nodule where they curve towards the margin of the valve, about 30 in 10 μ . Figs. 176 - 178.

N.venezuelensoides was relatively widely distributed in the catchment area. At some localities it was relatively abundant. Little is known at present about its ecological requirements.

Figs. - 176 - 178.

N.ventosa Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3: 234, F.1357.

1957 - Hustedt: Abh. natur. Ver. Bremen 34: 281, F. 28 - 31.

Two examples of the typical N.ventosa have been illustrated (figs. 179, 181). The third example (Fig. 180) differed slightly by having slightly rostrate poles.

The only previous records of this species from Africa have been from South West Africa (Cholnoky 1966A: 50: 1966B: 198). In the catchment area it was observed from seven localities scattered over the catchment area.

Samples - 242, 321, 401, 410, 449, 455, 511.

N.ventosoides n.sp.

Specimens from sample Vaal 324 bear a strong resemblance to N.ventosa Hustedt of the Naviculae minusculae group, but differs from this species in the shape of the valve. These specimens could not be equated with any other species of this group.

The valves are linear-lanceolate to rhombic-lanceolate with short more or less acutely rostrate poles, 7.5 - 8.5 μ long,

and 2.5 - 3.5 μ wide. The raphe is straight and filiform; the central pores are not widely separated and the terminal fissures are too small to detect the detail of their structure. The axial area is narrow and linear and does not widen in the region of the central nodule into a central area; there is however an indication of a central area, as in some specimens one or two shortened striae are present at the central nodule. The transapical striae are radial throughout the valve with a more or less constant spacing from the middle of the valve to the poles, about 28 in 10 μ . Figs. 182, 183.

This species was observed from one sample collected from the lower reaches of the Vaal River.

Figs. - 182, 183.

Samples - 324.

N. viridula Kützing.

1844 - Kützing: Bacill. P.94, T.30, F.47.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
27: 15.

1930 - Hustedt: Bacillariophyta. P.297, F.503.

Synonyms: Schizonema Thwaitesii Grunow.

Hustedt (1937 - 1939, Suppl. 15: 264) has reverted to Cleve's opinion that N. rostellata Kützing should be regarded as a variety of N. viridula. In the course of these studies no evidence has been found to substantiate this opinion and for the moment it is preferred to keep them separate.

As Cholnoky (1962B: 92) has remarked this species has been found only rarely in South Africa, and little is known of its autecology. In the catchment area it was found as isolated records from widely separated localities.

N.viridula var. slesvicensis (Grunow) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
27: 15.

1930 - Hustedt: Bacillariophyta. P.297. F.503.

Synonyms: Navicula slesvicensis Grunow; Navicula viridula
f. minor; Pinnularia silesiaca Fresenius.

This variety differs from the typical forms by being smaller in its dimensions and more coarsely striate. It has been recorded only twice from South Africa by Cholnoky (1953: 145; 1957C: 74) and once more from Ghana by Foged (1966: 95). In the catchment area it was recorded from four samples. Samples - 353, 411, 456, 478.

N.Wittrockii (Lagerstedt) Cleve-Euler.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 3:
124, F.1256.

1934 - Cleve - Euler: Soc.Sci.Fenn.Comm.Biol. 4 (14): 86.

Synonyms: Stauroneis Wittrockii Lagerstedt; Navicula bacilliformis Grunow; Navicula bacilliformis var. bullata Ostrup; Navicula Wittrockii var. fennica Cleve-Euler; Navicula bacilliformis var. genuina Mayer; Navicula bacilliformis var. nuda Mayer; Navicula Wittrockii var. spitzbergensis Cleve-Euler.

The species was not common in the Vaal Dam catchment area, being found in only two samples. Cholnoky has recorded it from the Okavango River (Cholnoky 1966A: 51).

N.Zanonii Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc. National Albert 8:
92, T.5, F. 1 - 5.

In this series of samples N.Zanonii was present in the typical form and was easily distinguished from other related forms.

The species is apparently very common in South Africa, and according to Cholnoky (1960A: 87; 1960B: 256; 1962B: 92; 1962C: 330) the species is a "Characterpflanze" of neutral to weakly alkaline water, poor in nitrogen content. Consequently this species is also very common and widespread in the Vaal Dam catchment area, occurring in some samples in relatively high numbers.

NEIDIUM Pfitzer 1871

N.affine (Ehrenberg) Pfitzer.

1871 - Pfitzer: Bot. Abh.Geb.Morph.Phys. 2: 39.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 68.

1930 - Hustedt: Bacillariophyta. P.242, F.376.

1959 - Reimer: The Diatom Genus Neidium. Proc.Acad.Nat.Sc.
Phila. 111: 7, T.1, F.1.

Synonyms: Navicula affinis Ehrenberg; Neidium affine var. genuina Mayer; Neidium affine var. genuinum f. minor Mayer; Neidium affine var. genuinum f. minor subfo. subrostratum Mayer; Neidium affine var. genuinum f. media Mayer.

Reimer (1959: 7) in his paper on the genus Neidium has ascribed to Pfitzer the combination Neidium affine, which he formed in 1871. Cholnoky and Hustedt have both quoted Cleve in their use of this combination. This error probably arises from Cleve who does not quote Pfitzer in his Synopsis of

Naviculoid Diatoms (1894: 68). Pfitzer appears to be the correct author of the combination.

Although it has been recorded quite frequently from South Africa, no comments on its autecology can be found. In the Catchment area the species was recorded from three localities. Samples - 306, 412, 495.

N.affine var. amphirhynchus (Ehrenberg) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 68.

1930 - Hustedt: Bacillariophyta. P.243, F.377.

1959 - Reimer: The Diatom Genus Neidium. Proc.Acad.Nat.Sc.
Phila. 111: 7, T.1, F.2.

Synonyms: Navicula amphirhynchus Ehrenberg; Navicula affine var. amphirhynchus Grunow; Neidium amphirhynchus (Ehrenberg)Pfitzer; Navicula iridis var. amphirhynchus Van Heurck.

Cholnoky (1957A: 69; 1960A: 88; 1962A 51; 1962B: 92) considers the species Neidium affine a very variable one, with so many intergrading series of forms that any distinction between the forms is unnecessary. Furthermore Cholnoky is of the opinion that the boundary lines between the species Neidium affine and N.productum (W.Smith) Cleve (cf. Hustedt 1930: 245) are not clearly marked and that the position of N.productum as a separate species is questionable (Cholnoky 1957A: 69). Cholnoky finds no clear boundary line between N.affine and N.iridis (Ehrenberg) Cleve (cf. Hustedt 1930: 245). On the other hand Reimer in his study of the genus Neidium (1959: 9) has preferred to maintain the varieties as distinct entities and made no comment on the relationship of N.affine, N.productum and N.iridis.

According to Cholnoky (1960A: 88; 1960B: 257; 1962A: 51; 1962B: 92; 1962C: 330) the species has a preference for neutral waters with fluctuations of the pH value towards the acid side. In the catchment area this variety was recorded from a relatively large number of samples, but was never present in great quantities in the samples.

N.affine var. longiceps (Gregory) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.26: 68.

1930 - Hustedt: Bacillariophyta. P.244, F.378.

1959 - Reimer: The Diatom Genus Neidium. Proc.Acad.Nat.Sc.Phila.
111: 13, T.1, F.3.

Synonyms: Navicula longiceps Gregory.

In Cholnoky's opinion this variety cannot be distinguished from var. amphirhynchus (Cholnoky 1957A: 69). Reimer (1959: 13 commented as follows:- "The variety is very similar to, but does not seem to intergrade with var. amphirhynchus." He distinguishes var.longiceps by its narrower valves and parallel sides. It would appear from the comments on this variety, the typical forms, and the var. amphirhynchus that there is a great need for a systematic and taxonomic revision of this species.

In the catchment area this variety occurred far more commonly than N.affine var. amphirhynchus.

N.gracile Hustedt f.aequalis Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.
Suppl. 15: 406, T.16, F.10.

1959 - Reimer: The Diatom Genus Neidium. Proc.Acad.Nat.Sc.
Phil. 111: 23, T.3, F.4.

Synonyms: Neidium dubium var. triundulatum Cholnoky.

Hustedt (l.c.) distinguished this form from the typical forms on the basis of its equidistant undulations. In N.gracile Hustedt the central undulation is much longer than the others.

A single example of this form has been observed from Lake Chrissie.

Sample - 485.

N.inconspicuum Hustedt.

1922 - Hustedt: Zellpflanzen Ostafrikas VI. Bacillariales.
Hedwigia 63: 149, T.1, F.21.

Synonyms: Neidium Hermannii Hustedt.

Cholnoky (1960A: 89) considered N.inconspicuum and N.Hermannii Hustedt (1937 - 1939, Suppl. 15: 408, T.16, F.11) to be the same species, believing that Hustedt had described the same thing twice. However, Patrick and Reimer (1966: 399) noted the similarity between the two species, but, on account of the slightly denser striation in N.inconspicuum (38 instead of 34), considered it best not to unite them. Cholnoky's opinion has been followed in this study. Cholnoky (1957A: 71, under N.Hermannii) has recorded some small specimens which were 22 - 27 μ long, 4 - 5 μ wide and contained about 36 striae in 10 μ . A single specimen (Fig. 184) recorded from a locality near the source of the Wilge river has been illustrated. In this example

the striae in the middle of the valve numbered about 35 in 10 u; towards the poles they gradually became denser until resolution was difficult and they became invisible.

Fig. - 184.

Sample - 328.

N.iris (Ehrenberg) Cleve f. vernalis Reichelt.

1930 - Hustedt: Bacillariophyta. P.245, F.380.

The distinction between the varieties and forms of Neidium iris is very small, and Cholnoky (1966A: 53) finds the separation of N.iris from N.affine extremely difficult. A single specimen of this particular form of the species has been recorded from the acid waters at Station 1 on the Vaal River near Breyten.

Sample - 370.

N.iris var. amphigomphus (Ehrenberg) Van Heurck.

1880 - Van Heurck: Syn.Diat.Belgique. T.13, F.2.

(Text P.104 (1885)).

1930 - Hustedt: Bacillariophyta: P.245, F.382.

Synonyms: Navicula amphigomphus Ehrenberg; Navicula firma Donkin; Navicula affinis var. amphirhynchus Grunow; Navicula dilatata.

The systematics of this variety is confusing. In 1843 Ehrenberg described two species Navicula iris and Navicula amphigomphus. Later Van Heurck considered that N.amphigomphus was a variety of N.iris, and therefore formed the new combination N.iris var. amphigomphus (Ehrenberg) Van Heurck. In the Synopsis of the Naviculoid Diatoms Cleve (1894: 68 and 69) transferred the species Navicula iris to the genus Neidium. At the same time

Cleve reconsidered the status of Navicula iridis var. amphigomphus and supported Ehrenberg's earlier contention that they were two different species; Cleve therefore also transferred Navicula amphigomphus to the genus Neidium. Cleve agreed with Pfitzer in this. Therefore according to Cleve there were two species Neidium iridis and Neidium amphigomphus. However later workers, e.g. Hustedt and Cholnoky, have returned to Van Heurck's treatment of the subject retaining Neidium iridis and regarding Neidium amphigomphus as a variety of Neidium iridis. Thus finally we obtain the correct combination Neidium iridis (Ehrenberg) var. amphigomphus (Ehrenberg) Van Heurck. It is uncertain why Patrick and Reimer (1966: 387) quoted A. Mayer as being the original author of this combination.

In the catchment area only two specimens of this variety have been recorded.

Samples - 343, 441.

N. productum (W. Smith) Cleve.

1894 - Cleve: Naviculoid Diatoms. Kongl. Sv. Vet. Akad. Handl. 26: 69.

1930 - Hustedt: Bacillariophyta. P. 245, F. 383.

Synonyms: Navicula producta W. Smith; Navicula iridis var. producta Grunow; Navicula affinis Van Heurck.

Cholnoky made it abundantly clear that in his opinion the boundary lines between N. productum and N. affine (Ehrenberg) Pfitzer and particularly the variety var. amphirhynchus are very indistinct. He recorded many specimens (Cholnoky 1957B: 355; 1965: 74) which in his opinion were transitional forms between this species and N. affine var. amphirhynchus.

He also cited other examples which provide connecting links between N.productum and N.iridis var. amphigomphus (Cholnoky 1954D: 129). It is apparent that there are very close connections between the three species N.affine, N.iridis, and N.productum. Cleve himself commented that "this form (N.productum) graduates into N.affinis var. amphirhynchus". The uncertainty that exists in the differentiation of these various forms points to the great need of a thorough revision of the whole genus Neidium.

Only a few specimens of this species were observed in two samples from the Waterval River and Lake Chrissie.
Samples - 325, 485.

NITZSCHIA Hassall 1845

N.accomodata Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
139, T.12, F. 27 - 31, 34, 35.

This Nitzschia species is very similar to N.palea (Kützing) W. Smith, but differs from it in the coarser structure of the valve, which makes the striae more easily resolved. In the opinion of Cholnoky it is often mistaken for N.palea (Cholnoky 1956: 81; 1957A: 71; 1958A: 126). Cholnoky (1956: 81) has recorded specimens which enlarge the range of variation of the species, his specimens being 22 - 40 μ long. He has found further specimens in which the number of transapical striae varied from 32 - 38 in 10 μ , and these he regarded as transitional forms between this species and N.capitellata.

This species in its typical form was relatively widespread in the Vaal Dam catchment area, but never occurred in very large numbers in any of the samples.

N.acicularis (Kützing) W. Smith.

1853 - W. Smith: Brit.Diat.Vol.1. P.43, T.15, F.122.

1930 - Hustedt: Bacillariophyta. P.423, F.821.

Synonyms: Synedra acicularis Kützing; Ceratoneis acicularis Pritchard; Nitzschiella acicularis Rabenhorst; Nitzschia acicularis var. africana Cholnoky.

This species has been incorrectly ascribed solely to W.Smith. According to De Toni (1891: 549) Kützing first described the species in the genus Synedra. This was later transferred to the genus Nitzschia by W. Smith in 1853. Cholnoky (1957A: 72, F.197) described smaller forms of this species (40 - 50 μ long, 2 μ broad) which he later united with the species as he found many transitional stages. Although most of the specimens observed in this survey were typical examples, a few of Cholnoky's smaller forms were seen. One such small form has been illustrated in Fig. 185.

In the Vaal Dam catchment area this species was widespread in its distribution but was never observed in any great numbers in any samples. Cholnoky (1962B: 93; 1966B: 199) made the following observations concerning the autecology of this species. N.acicularis is a nitrogen heterotrophic planktonic diatom species, which is usually found in still standing waters or sluggishly flowing portions of the rivers. During the dry seasons of the year conditions approaching those suitable for N.acicularis are obtained, and thus they are found to be widespread, but not occurring in great numbers. Fig. - 185.

N.acuta Hantzsch.

1880 - Hantzsch: in Cleve et Grunow - Arc. Diat.

Kongl.Sv.Vet.Akad.Handl. 17: 90.

1930 - Hustedt: Bacillariophyta. P.412, F.790.

Synonyms: Nitzschia dissipata var. acuta Van Heurck.

Hustedt (l.c.) has stated that the name N.acula Hantzsch was a typographic error and changed the spelling to N.acuta. Cholnoky (1959: 55) however strongly criticised Hustedt for this change in the spelling as he maintained that "nach den Nomenklaturregeln hat selbst Hustedt kein Recht, diesen vermutlichen "Druckfehler" richtigzustellen". If, however, Hustedt had reasonable ground to assume that N.acula was a spelling mistake, then in terms of Article 73 of the International Code of Botanical Nomenclature he may make the necessary alteration in the spelling. Cholnoky (l.c.) himself admits that "Es mag richtig sein, dass das Wort "acula" nur auf einem "Überlieferten Druckfehler" beruht,". De Toni (1891: 527) also calls the species N.acuta. Unfortunately access to Hantzsch's original description is not possible, and Hustedt's statements cannot therefore be verified. However Hustedt's spelling of the name N.acuta Hantzsch has been followed.

This species has seldom been recorded from South Africa, and was observed in one sample from the catchment area.

Sample - 343.

N. adapta Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
135, T. 12, F.3 - 6.

Cholnoky (1956: 81; 1957A: 72) has observed specimens which were much smaller in dimensions than those cited by Hustedt (l.c.). Cholnoky gave the following dimensions:- 65 - 85 μ long, 3 - 3.5 μ broad, carinal pores 13 - 16 and transapical striae 33 to over 44 in 10 μ . Most specimens observed in this study agree with Cholnoky's dimensions but some were smaller. The specimens ranged from 47 - 86 μ long, about 3 μ broad and generally had 14 carinal pores and 36 transapical striae in 10 μ . The smaller examples intergrade very gradually with the larger forms.

This was one of the most common species in the samples from the catchment area. It was, however, never found very abundantly in the samples. The autecology of the species is still unknown.

N. Agnewii Cholnoky.

1962 - Cholnoky: Ost Transvaal. Hydrobiologia 19: 94, F.18, 19.

This small species of Nitzschia which Cholnoky described from the Eastern Transvaal can easily be overlooked due to its small size and weakly silicified valve walls. In general the typical forms of the species were observed in the catchment area. However an atypical form has been illustrated (Fig. 186). Morphologically this specimen agrees with Cholnoky's description, but it is much larger and has fewer carinal pores (25 μ long, 2.5 μ wide and 13 carinal pores in 10 μ). It was, however, not considered to be N. agnita on account of the weakly silicified valve

walls and smaller dimensions.

This species was recorded from a few samples in which its occurrence was rare. Nothing is known of its autecology.

Fig. - 186.

Samples - 316, 322, 324, 339, 344, 408, 410, 465, 512, 552.

N.agnita Hustedt.

1957 - Hustedt: Diatomeenflora der Weser. Abh.d.naturw.

Ver.Bremen 34: 347, F.51.

Cholnoky (1962B: 94) has recorded this species once in South Africa from the Eastern Transvaal. The only difference between this species and N.Agnewii appear to be the larger dimensions and more strongly silicified valve walls in N.agnita. Cholnoky, however, could find no transitional forms. The few examples seen in this survey provide no answer to this problem either. Records of this species were made from the Grootvlei Dam, Waterval and Vaal Rivers.

Samples - 340, 353, 377, 401, 412, 493.

N.Allansonii Cholnoky.

1958 - Cholnoky: Jukskei - Crocodile Rivers.

Hydrobiologia 11: 257, F.24 - 27.

This species has been recorded twice outside its type locality by Cholnoky (1960A: 91; 1960B: 257). In the Swartkops River near Port Elizabeth the species seems to be very much more variable than the type material. In the Vaal Dam catchment area one specimen from the Grootvlei Dam has been recorded.

Sample - 401.

N.amphibia Grunow.

1862 - Grunow: Verh. zool.-bot. Ges. Wien 12: 574, T.12, F.23.

1930 - Hustedt: Bacillariophyta. P.414, F.793.

Synonyms: Denticula decipiens Arnott; Nitzschia amphibia var. acutiuscula Grunow; Nitzschia amphibia var. intermedia Mayer.

Cholnoky (1963A: 35) has reported specimens from Windhoek which were abnormally long and broad (65 μ long, 6 μ broad), but intergraded with the typical forms. On the other hand some small specimens have been recorded from Lake Sibayi (Archibald 1966B: 491) being only 9.5 μ long and having lanceolate valves with protracted poles.

From Cholnoky's observations (Cholnoky 1962B: 94; 1966B: 199) N.amphibia is a nitrogen heterotrophic species with a high pH optimum (above pH 8). It can also tolerate fairly high salt concentrations as the protoplast has a relatively high permeability. This species has been recorded most frequently from the Waterval River, which has a raised salt concentration and mesotrophic water.

N.amphioxoides Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8: 140, T.13, F.65 - 72.

N.amphioxoides is one of the less common species of this genus to be found in South Africa. Cholnoky has recorded it from the Cape Province (1959: 55), Lake Chrissie (1965: 74), and the Okavango River (1966A: 54). In the Vaal Dam catchment area it was found scattered here and there over a fairly wide area, but was never observed in large numbers. The autecology of this species is not known.

N.angustata (W.Smith) Grunow.

1880 - Grunow: in Cleve et Grunow - Arc. Diat. P.70.

1930 - Hustedt: Bacillariophyta. P.402, F.767.

Synonyms: Tryblionella angustata W. Smith.

Cholnoky (1961B: 314) maintained that it was impossible to make a distinction between N.angustata and its variety var. acuta, but gave no reasons for this statement. Among the few specimens of both the typical and the varietal forms found in the catchment area there was no evidence for any transitional forms between the two forms. Hustedt's (1930: 402) systematic treatment of the species has been followed. This species was recorded from a tributary of the Kaffirspruit River.

Sample - 491.

N.angustata var. acuta Grunow.

1880 - Grunow: in Cleve et Grunow - Arc. Diat. P.70.

1930 - Hustedt: Bacillariophyta. P.402, F.768.

The variety was present as isolated specimens at Station 3 on the Vaal River, Station 19 on the Kaffirspruit River, and from the Vrede Stream. Both the typical forms and the variety were rare in the catchment area.

Samples - 309, 342, 344, 427, 429, 493.

N.angustecarinata Hustedt.

1952 - Hustedt: Lago de Maracaibo. Ergebnisse d. Deutsch.

Limnol. Venezuela Expedition 1: 126, F.62.

Synonyms: Nitzschia crassepunctata Archibald.

Having recently received Hustedt's report on the diatoms collected in Venezuela by a German limnological expedition, it

was discovered that N. crassepunctata Archibald (1966A: 266, F.49) is synonymous with N. angustecarinata. The specimen from the catchment area does not entirely agree with Hustedt's description, but since Hustedt saw only a few examples of N. angustecarinata the complete range of variation for this species might not have been observed. The Vaal specimen (Fig. 196) is slightly shorter and narrower than Hustedt's examples, being 48.5 μ long and 4.5 μ broad, and the striation of the valve is denser having 40 striae in 10 μ . In all other respects it agrees with Hustedt's description. This therefore constitutes the first record of this species for South Africa.

A single specimen of N. angustecarinata was recorded from the Vaal River at Villiers.

Fig. - 196.

Sample - 403.

N. apiculata (Gregory) Grunow.

1880 - Grunow: In Cleve et Grunow - Arc. Diat. P.73.

1930 - Hustedt: Bacillariophyta. P.401, F.765.

Synonyms: Tryblionella apiculata Gregory; Synedra constricta Kützinger; Nitzschia constricta Rabenhorst.

Hustedt (l.c.) regarded this species as a marine form, which is found in inland brackish waters. Cholnoky (1960A: 91) remarked that the distribution of this diatom species was limited by its sensitivity to the pH value and not to a sensitivity to osmotic pressure. It appears therefore that this species inhabits waters containing a relatively high concentration of salts and whose pH is on the alkaline side. In the Vaal Dam catchment area it was recorded mainly from the Waterval River where the total dissolved solids value was found to be higher than elsewhere in the Catchment area.

N.bacata Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch. Hydrobiol. Suppl. 15: 485, T.41, F. 30 - 33.

Synonyms: Nitzschia bacata f. linearis Hustedt.

Cholnoky (1956: 81; 1966A: 54) has shown that the f.linearis cannot be clearly differentiated from the typical forms of the species and should therefore be sunk into the species.

N.bacata was recorded in small numbers from a relatively small number of samples from the catchment area.

N.capitellata Hustedt.

1930 - Hustedt: Bacillariophyta. P.414, F.792.

An abnormally short example of this species (Fig. 187) has been illustrated. Its length was 25 u.

N.capitellata is a nitrogen heterotrophic species and is therefore found in waters which contain large quantities of organic nitrogen compounds, and whose pH value is relatively alkaline (Cholnoky 1962A: 52; 1962B: 95). Cholnoky (1960A: 91; 1960B: 258) has found that the species is not particularly tolerant of the presence of salts in the water. The species was fairly widespread in the catchment area, and was reasonably common. In some samples it was recorded in relatively high numbers.

Fig - 187.

N.Chasei Cholnoky.

1954 - Cholnoky: Süd Rhodesien. Port.Acta Biol. 4: 220, F.98.

In his original material Cholnoky (l.c.) was unable to determine how many carinal pores were present in 10 μ in this species. He came to the conclusion that they appeared to be the same in number as the transapical striae (Fig. 190), but did not correspond with the transapical striae because of their irregular spacing. Only later was Cholnoky (1960A: 91) able to ascertain that there were 10 carinal pores in 10 μ . The specimens observed in the samples from the catchment area agreed with Cholnoky's description of the species, but the same difficulties in regard to the number of carinal pores were experienced. In some specimens the number of carinal pores were difficult to determine and appeared to be the same as the number of transapical striae (Fig. 190), while in others the carinal pores were more readily resolved and numbered between 8 and 10 in 10 μ . (Figs. 188, 189, 191). The specimens observed in these samples enabled the range of variation to be broadened. The dimensions of these specimens were 7 - 12 μ long, 2 - 2.5 μ broad and they had 16 - 20 striae in 10 μ . An atypical example (Fig. 192) has been assigned to this species on account of its similarity, but the striation was denser (24 striae in 10 μ) than the typical forms and the carinal pores were difficult to resolve.

Cholnoky (1957A: 74) maintains that this species is widespread in tropical to sub-tropical weakly acidic waters. It was fairly common in the Catchment area, and was present in some samples in fairly large numbers.

Figs. - 188 - 192.

N.Chutteri Archibald.

1966 - Archibald: Rare Diatoms from S.A. Nova Hedwigia Suppl.
21: 265, F. 47, 48.

On account of the longitudinal folds in the valve wall, this species belongs to the group Nitzschiae tryblionellae Grunow. It is very similar to N.punctata (W.Smith) Grunow (cf. Hustedt 1930: 401, F.762), particularly the formae minores of this species (Hustedt 1937 - 1939, Suppl. 15: 466), but differs from the formae minores primarily in the number of striae and carinal pores, and in the number of folds of the valve surface. This species also closely resembles N.subpunctata Cholnoky (1960A: 104, F.314) but differs from that species in having longitudinal folds of the valve surface, which are not present in N.subpunctata.

The valve is linear-elliptical to lanceolate-elliptical with very short protracted poles, 15 - 19 μ long, and about 6.5 μ wide. The keel is excentric and not prominent, the carinal pores are indistinct and appear to be the same number as the transapical striae. The transapical striae are parallel in the middle, and slightly arcuate towards the poles, 16 - 18 in 10 μ . The striae are very clearly punctuate. There are two longitudinal folds of the valve surface, the larger and more prominent fold lying near the keel and the smaller one very close to the margin of the valve opposite the keel. This species was named after Dr. F.M. Chutter, who very kindly collected many of the samples in this survey.

This new species was recorded from three localities, two on the Kalk River and once from a small stream near Villiers. At Station 15 N.Chutteri composed 8% of the diatom association.

This may suggest some tolerance of this species to salt concentration since the salt concentration of the water at this point was slightly higher than normal.

Figs. - 193, 194.

Samples - 401, 402, 404.

N.Clausii Hantzsch.

1859 - Hantzsch: Hedwigia 2(4): T.6, F.7.

1930 - Hustedt: Bacillariophyta. P.421, F.814.

This species has in the past been related to N.sigma W.Smith. This however is not feasible since the two species differ in the structure of their keels. N.Clausii has a keel which is slightly sunken in the middle, while in N.sigma the keel never exhibits this feature. Hustedt (1937 - 1939, Suppl. 15: 488) was of the opinion that, since he had found some specimens without this depression, he had evidence for the reduction of the central nodule in this species. In the course of this study some specimens (Fig. 195) were observed having almost completely linear valves with only the poles curving in opposite directions.

In contradiction to Hustedt's views (Hustedt 1930: 421) Cholnoky has found this species in alkaline freshwater (Cholnoky 1957A: 74; 1960A: 92). It is also a nitrogen heterotrophic species (Cholnoky 1962B: 95). The species is relatively common in the catchment area and sometimes occurred in high numbers. Generally speaking however conditions in the region were not ideal for this species.

Fig. - 195.

N.communis Rabenhorst.

1930 - Hustedt: Bacillariophyta. P.417, F.798.

According to Cholnoky (1966B: 200) N.communis is a nitrogen heterotrophic species, with a pH optimum above pH 7, and which requires a fairly high oxygen content in the water. Conditions found in the catchment area would apparently be unsuitable for this species as it was rarely seen in seven samples. Samples - 245, 312, 334, 342, 413, 433, 493.

N.commutata Grunow.

1880 - Grunow: in Cleve et Grunow - Arc. Diat. P.79.

1930 - Hustedt: Bacillariophyta. P.405, F.774.

N.commutata is a brackish water species (Hustedt l.c.; Cholnoky 1966B: 53), and is nitrogen heterotrophic. This may be the reason for its single occurrence in the catchment area. Sample - 412.

N.confinis Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
145, T.11, F. 49 - 54; T.13, F. 84 - 90.

Synonyms: Nitzschia Erlandsonnii Cholnoky.

The species is nitrogen heterotrophic and inhabits neutral waters. In the catchment area it was quite widespread and in some samples it was relatively abundant.

N.debilis (Arnott) Grunow.

1880 - Grunow: in Cleve et Grunow - Arc. Diat. P.68.

1930 - Hustedt: Bacillariophyta. P.400, F.759.

Synonyms: Tryblionella debilis Arnott; Tryblionella ovata Lagerstedt; Tryblionella Sauteriana Grunow; Nitzschia tryblionella var. debilis (Arnott) Mayer.

In the Bacillariophyta (Hustedt 1930: 400) this species is regarded as a variety of Nitzschia tryblionella Hantzsch. Later, however, Hustedt (1937 - 1939, Suppl. 15: 466) reverted to Grunow's ideas and called it a species on its own, N. debilis. Cholnoky also follows Grunow's taxonomy.

The species does not appear to be very common in South Africa. In the Vaal Dam catchment area, it was recorded twice. Samples - 417, 420.

N. diluta Archibald.

1966 - Archibald: Rare Diatoms from S.A. Nova Hedwigia Suppl. 21: 266, F.50.

This species of which only a few specimens have been seen, falls into the group Nitzschiae lanceolatae Grunow and has a likeness to N. palea (Kützinger) W. Smith. It differs from N. palea in having fewer transapical striae and in the structure of the carinal pores. It also shows some similarity to N. accommodata Hustedt (1949A: 139) but differs from this species in its dimensions. N. accommodata is shorter and relatively broader than the new species. Since first describing this species another four examples have been examined from the catchment area thus enabling the range of variation to be extended.

The valve is linear with short cuneate and more or less capitate poles, length 37 - 51 μ , and width 3 - 4 μ . The keel is strongly excentric, not depressed in the middle, with about 13 carinal pores in 10 μ , of which the central two are not wider apart than the others. The transapical striae are fine, 33 - 36 in 10 μ . Figs. 197, 198.

N. diluta was recorded from a small stream near Villiers,

Station 19, on the Kaffirspruit, from the Witzieshoek area, and from near the source of the Russespruit River.

Figs. - 197, 198.

Samples - 203, 249, 405, 493.

N. diserta Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
139, T.12, F.32, 33.

Two specimens of this species (Figs. 199, 200) were illustrated to show some small forms. Morphologically they agree with the description given by Hustedt (l.c.). Although they are smaller they exhibit a series extending to the lower limit given by Hustedt. The dimensions of the Vaal specimens ranged from 21 - 39 μ in length, 3.5 - 4.5 μ in breadth, and the valves contained 12 - 16 carinal pores and 36 - 40 transapical striae in 10 μ .

Outside the Congo, the type locality, Cholnoky (1958B: 128) has recorded it from the Waterberg area in the Transvaal. It was recorded from four localities in the catchment area, all of which presented evidence of high concentrations of organic nitrogen.

Figs. - 199, 200.

Samples - 313, 377, 417, 489, 493.

N. dissipata (Kützing) Grunow.

1880 - Grunow: in Cleve et Grunow - Arc. Diat. P.90.

1930 - Hustedt: Bacillariophyta. P.412, F.789.

Synonyms: Synedra dissipata Kützing; Nitzschia minutissima W.Smith.

N. dissipata, according to Cholnoky (1962B: 95) is nitrogen autotrophic, and is found in well oxygenated alkaline waters.

To a certain degree these conditions are found all over the catchment area; and as a result this species has been recorded from all over the region. It was, however, normally present in small numbers, indicating that optimal conditions for its reproduction were seldom found.

N.elliptica Hustedt var. alexandrina Cholnoky.

1958 - Cholnoky: Jukskei - Crocodile Rivers. Hydrobiologia 11: 258, F. 29, 30.

Cholnoky (l.c.) described these forms as a variety of N.elliptica on the grounds of their relatively narrower valves. His later thoughts on the systematics of this species revealed that he is now of the opinion that there is only a morphological similarity and that this variety should really be a separate species. As so few specimens of the variety and none at all of the typical forms of the species have been seen it is not possible to comment critically on the systematics of the variety.

The variety was recorded from five samples only.

Samples - 377, 402, 438, 489, 497.

N.epiphytica O. Müller.

1905 - O. Müller: Engl.Bot.Jahrbuch 36: 176, T.2, F.17, 18.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8: 143, T.13, F. 56 - 64.

Working on the Congo material Hustedt (1949A: 143) discovered two very similar Nitzschia species fitting O. Müller's description of N.epiphytica. The one he retained as N.epiphytica, while the other he described as N.epiphyticoides.

In South Africa Cholnoky (1957A: 74; 1958A: 259; 1962A: 54) has recorded this species, N.epiphytica, from three

localities, while in the catchment area it occurred at four localities in the Waterval River area and in the headwaters region of the Kleinvaal River.

Samples - 412, 414, 464, 497.

N.epiphyticoides Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
144, T.13, F. 48 - 55.

This species, as in the case of the preceding species, has only rarely been seen in South Africa. The autecology of the species is insufficiently known; but from Cholnoky's observations it is probably nitrogen heterotrophic (Cholnoky 1962B: 96) and has a pH optimum lying near or below pH 7 (Cholnoky 1966A: 55). N.epiphyticoides was recorded a little more commonly than the previous species and was found in seven samples.

Samples - 375, 401, 410, 411, 412, 417, 468.

N.exilis Archibald.

1966C - Archibald: New Nitzschiae. Port. Acta Biol. 8: 230.

Since describing this species further specimens increasing the range of variation of the species have been observed. This new species is very similar to N.mediocris Hustedt (1949A: 149, T.13, F.21 - 24) but differs in its more linear valves and very much greater length. It differs quite considerably from N.gracilis Hantzsch (cf. Hustedt 1930: 416, F.794) in the lack of capitate poles and by being relatively narrower.

N.exilis is long and narrowly linear with gradually tapering ends, the poles being regularly and sharply rounded and not capitate, 82 - 102 μ long, and 1.5 - 2 μ broad. The keel is excentric and has 12 - 16 (generally 14) carinal pores in 10 μ , of which the central two are not more widely spaced than the others. The transapical striae are too fine to be visible under the light microscope. The valve walls are relatively well silicified. Figs. 201, 202.

As it was only rarely seen in the catchment area nothing is known about its autecology.

Fig. - 201, 202.

Samples - 266, 306, 312, 315, 336, 410, 431.

N.fonticola Grunow.

1930 - Hustedt: Bacillariophyta. P.415, F.800.

N.fonticola, according to Hustedt (1949A: 142, T.11, F. 75 - 83, 91 - 93) and Cholnoky (1959: 56) is a species, variable in its morphology and the numerous examples observed here have confirmed this. In the sample Vael 498 the great variability was well illustrated. Figs. 203, 208 show some very small examples with transitional forms intergrading with the more typical forms of this species. The smallest specimens in this series were 5 μ long and 3.5 μ wide. Due to irregular spacing of the carinal pores some of these small examples were very similar to N.epiphytica O. Müller since they sometimes appeared to have the two central pores more widely spaced than the others. The description of N.fonticola should be altered to accomodate these small specimens.

For its optimal development N.fonticola requires a pH around about pH 8 and a relatively high concentration of nitrogenous compounds in the water (Cholnoky 1960B: 258; 1962A: 54; 1962B: 96). It also requires a relatively high oxygen content of the water (Cholnoky 1966B: 202). As these requirements are quite often fulfilled in the catchment area, N.fonticola was very widely distributed in the region and sometimes was recorded with high relative densities. This species, in association with other nitrogen heterotrophic Nitzschiae was one of the most commonly occurring species in the more eutrophic and mesotrophic waters of the region.

Fig. - 203 - 208.

N.frustulum (Kützing) Grunow.

1880 - Grunow: in Cleve et Grunow - Arc Diet. P.98.

1930 - Hustedt: Bacillariophyta. P.414, F.795.

For comments on the systematics of N.frustulum var.

perpusilla (Rabenhorst) Grunow see the comments on N.perpusilla.

N.frustulum is a brackish water diatom (Cholnoky 1962A: 55; 1966B: 202) and was found in small numbers in two samples from the Springfield Colliery Dam, Grootvlei, and the Kalk River, where the total dissolved solids were generally high. Samples - 401, 402.

N.gracilis Hantzsch.

1859 - Hantzsch: Hedwigia 2: T.6, F.8.

1930 - Hustedt: Bacillariophyta. P.416, F.794.

Nitzschia gracilis is apparently a nitrogen heterotrophic species which has a pH optimum lying around 5.8 - 5.9 (Cholnoky - 1960B: 259; 1962A: 56; 1962B: 96; 1966B: 202).

It thrives in waters with low concentrations of nitrogenous material, and is not often found in waters in which the nitrogen concentration is higher. N.gracilis was recorded from a number of samples, but never attained large numbers in any of them. One specimen is illustrated in the plates, Fig. 209.
Fig. - 209.

N.hungarica Grunow.

- 1862 - Grunow: Verh. zool.-bot. Ges.Wien. Zweite Folge 12:
568, T.22, F.13.
1930 - Hustedt: Bacillariophyta. P.401, F.766.

This species was found in very small numbers over a wide area of the catchment area. In only two samples was it relatively abundant, forming in Vaal 485 - 6.6% and Vaal 245 - 4.5% of the association. The species did not reach full development in this region because it is a brackish water species and generally speaking there are very few localities where the water in the Vaal Dam catchment area had a high total dissolved solids content. The species also requires alkaline conditions for good growth and is nitrogen autotrophic (Cholnoky 1960B: 260; 1966B: 202).

N.intermedia Hantzsch.

- 1880 - Hantzsch: in Cleve et Grunow - Arc. Diat. P.95.
1949 - Hustedt: Kongo. Expl. du Parc National Albert 8: 136,
T.12, F. 21 - 23.

Synonyms: Nitzschia regula Hustedt; Nitzschia reguloides Cholnoky.

Hustedt (1937 - 1939, Suppl. 15: 477, 1949A: 136) has commented in detail on the systematics of this species. He has shown that the variable nature of this species is to a degree

dependant on the locality in which it was found. Cholnoky (1963C: 188) reported specimens which were abnormally small in length (52 μ long) and the specimens observed here agreed with this, the smallest being 52.5 μ long. These specimens were also finer in their structure, having 12 carinal pores and 24 - 30 transapical striae in 10 μ .

No information with regard to its autecology can be found and because only two specimens from the Waterval River were seen, no further information can be added.

N.intermissa Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8: 136, T.12, F.11 - 14.

There is some doubt whether all the species recorded under this species were in fact N.intermissa since in the earlier parts of this study it might have been confused with N.adapta Hustedt (1949A: 135).

The species was recorded only from the Waterval River, and was nowhere common.

N.interrupta (Reichelt) Hustedt.

1927 - Hustedt: Bacill. aus dem Aokikosee. Arch. Hydrobiol. 18: 168.

Synonyms: Denticula interrupta Reichelt; Nitzschia moissacensis var. Heideni Meister.

Cholnoky (1960B: 260) regarded this species as an indicator species of neutral to weakly alkaline, oligotrophic waters. He commented further that N.interrupta is nitrogen autotrophic

and cannot tolerate poorly oxygenated water, or live in water with a raised osmotic pressure (Cholnoky 1966B: 203). In the catchment area the species was widely distributed over the whole area, and was found particularly in the Vaal River and Waterval River. In some samples N.interrupta was present with a relatively high abundance. In many cases where this occurred, but not in all such cases, N.interrupta was found to be present in association with Cymbella species (dominant in the association) particularly C.amphicephala Naegeli, C.microcephala Grunow and C.Kappii Cholnoky. It was also associated with Nitzschia linearis W. Smith in relatively high numbers.

N.irremissa Cholnoky.

1959 - Cholnoky : Seltene iv. Kaap-Provinz. Österr. Bot. Zeitschr. 106: 57, F.298 - 300.

Cholnoky (l.c.) distinguished this species from N.spiculum Hustedt and N.spiculoides Hustedt on the basis that the keel in N.irremissa is not sunken. In other respects the species are very similar in appearance.

The species has only rarely been seen in South Africa by Cholnoky (1959: 57; 1960A: 97) and by Giffen (1966: 143).

A few specimens were recorded from Station 21A, a tributary of the Kleinvaal River.

Sample - 350.

N.Kützingiana Hilse.

1860 - Hilse: Berl. Schl. Ges. väterl. Cult (Bot.Sect.) P.67.

1930 - Hustedt: Bacillariophyta. P.416, F.802.

Hustedt (1937 - 1939, Suppl. 15: 483) stated that the main difference between this species and N.palea (Kützing) W.Smith was the lanceolate valve of N.Kützingiana. In the Vaal Dam catchment area the shape of the valve of N.Kützingiana was extremely variable as is shown in Figs. 210 - 213. In general these two species can be distinguished from each other by the differences in structure of the carinal pores (longish in N.palea) and the number of carinal pores. In most cases N.Kützingiana contained about 16 carinal pores in 10 μ .

The species is strongly nitrogen heterotrophic with a pH optimum around 7.6 - 7.8, and thrives in oxygen rich water (Cholnoky 1966B: 203). N.Kützingiana, together with other nitrogen heterotrophic Nitzschiae was present in high numbers at sampling points wherever the concentration of organic nitrogen in the water was high. Under other conditions the species was present, but not in large numbers.

Figs. - 210 - 213.

N.lauenbergiana Hustedt.

1945 - Hustedt: Nordeutscher Seen. Arch. Hydrobiol. 41: 402, T.40, F.6, 7, 9 - 11.

In sample Vaal 411 one specimen of N.lauenbergiana was observed (Fig. 214). Although it is very much larger than Hustedt's original dimensions (192 μ as compared with 150 μ) it conformed in all other respects with his description. It is a new record for South Africa.

Fig. - 214.

Sample - 411.

N.levidensis (W.Smith) Grunow.

1930 - Hustedt: Bacillariophyta. P.399, F.760 (under

N.tryblionella var. levidensis).

Synonyms: Tryblionella levidensis W. Smith; Nitzschia calida Grunow; Nitzschia tryblionella var. levidensis (W.Smith) Grunow.

In recent times both Hustedt (1957: 338) and Cholnoky (1957C: 78; 1960A: 56) maintained that N.levidensis should be specifically separated from N.tryblionella.

N.levidensis is an alkaline water form and is rarely found in South Africa. In the catchment area, however, it was found in a number of samples but never in great numbers.

N.levidensis var. victoria (Grunow) Cholnoky.

1966 - Cholnoky: Okavango. Nova Hedwigia Suppl. 21: 57.

Cholnoky (l.c.) regarded the variety var. victoriae to be more closely connected with N.levidensis than N.tryblionella Hantzsch.

This variety is not common in South Africa. It is nitrogen heterotrophic and has an optimum pH value over pH 8 (Cholnoky 1962B: 100). In the catchment area the variety occurred in a number of samples as isolated examples.

N.linearis (Agardh) W.Smith.

1853 - W.Smith: Brit.Diat. Vol. 1. P.39, T.13, F.10, and Suppl. T.31, F.10.

1930 - Hustedt: Bacillariophyta. P.409, F.784.

Synonyms: Frustulia linearis Agardh; Synedra praemosa Ehrenberg.

In the sample Vaal 321 one abnormally short specimen, 50 μ in length, was observed (Fig. 215). Otherwise it matched the description given by Hustedt (1930: 409).

(298).

N.linearis is apparently nitrogen autotrophic and its optimum pH value lies around pH 8 (Cholnoky 1962B: 97; 1966B: 204). It is also found in well oxygenated waters. In the Vaal Dam catchment area the species was very common, and was distributed over the whole of the region. It was found in most samples and in some was present in very high numbers; it was dominant in Vaal 239 (64.2%) and Vaal(63.9%). This was one of the commonest species in the region.

Fig. - 215.

N.mediocris Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
149, T.13, F. 21 - 24.

The chief difference between N.mediocris and N.bacata Hustedt (see above) is the structure of the keel. The keel of N.bacata shows a depression at the centre of the valve, which is not found in N.mediocris. This species is also similar to N.exilis Archibald but differs in its very much smaller valves. Fig. 216 illustrates an example of this species.

In South Africa the species has been rarely seen. Cholnoky has recorded it from the Tugela River Basin (1957A: 75: 1960A: 99). It is rare in the catchment area where it was seen in very few samples.

Fig. - 216.

Samples - 245, 251, 253, 324, 330, 331, 333, 353, 411, 478.

N.microcephala Grunow.

1880 - Grunow: in Cleve et Grunow - Arct. Diat. P.96.

1930 - Hustedt: Bacillariophyta. P.414, F.791.

This small Nitzschia is easily distinguished by its valve shape. According to Cholnoky (1960A: 261) the species thrives best in water with a high pH value. It can also tolerate a considerably high osmotic pressure; and it is nitrogen heterotrophic like so many other species of its group. In the Vaal Dam catchment area it was reasonably widely distributed over the whole region, but was not particularly common in any of the samples.

N.obligata Archibald.

1966C - Archibald: New Nitzschiae. Port. Acta Biol. 8: 233.

Examination of several specimens of N.obligata from samples 307, 417 and 463 makes it possible to supplement the original diagnosis. The shape of the valve dissociates the new species from N.Kützingiana and it cannot be associated with N.palea on account of the structure of the carinal pores.

The valve is lanceolate, gradually tapering to the poles which are narrowly and acutely rounded and slightly capitate; 30.5 - 45 μ long and 2.5 - 3 μ wide; the full range of variation cannot be given as few specimens have been seen. The keel is excentric and has 14 - 16 small carinal pores in 10 μ , of which the two central pores are not more widely spaced than the remainder. The transapical striae are very fine (possibly about 48 in 10 μ) usually invisible under the microscope. Figs. 217, 218.

(300).

The species was recorded in the catchment area from Stations 2A, 4, 17 and 20, but at none of these points was this the species ever abundant.

Figs. - 217, 218.

Samples - 307, 412, 417, 463.

N. obsidialis Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
148, T.13, F.25.

N. obsidialis has a superficial similarity to the previous species, but differs from it in its more widely spaced carinal pores. An unusual form showing visible striation of the valve (numbering about 40 striae in 10 μ) was included with N. obsidialis as it is more like this species than any other.

Two specimens were observed from the catchment area, one from a small stream near Standerton and the other from Lake Chrissie.

Fig. - 219.

Samples - 415, 485.

N. obsoleta Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
146, T.13, F. 94 - 99.

As far as is known this species has only been recorded outside its type locality from Natal in South Africa by Cholnoky (1960a: 100). In sample Vaal 486 a specimen only 18 μ long was recorded.

Little is known of its autecology, and the species was only

recorded from the acid waters of Station 1 on the Vaal River,
and from Lake Chrissie.

Samples - 479, 485.

N.Oliffii Cholnoky.

1956 - Cholnoky: Seltene ii - Tugela-Gebiete. Österr.Bot.Zeitschr.
103: 84, F.116, and 117.

Typical forms of N.Oliffii were observed in most cases,
but one example had slightly more closely spaced carinal pores
(8 in 10 μ).

Cholnoky (1962B: 97) maintained that N.Oliffii is apparently
associated with high pH values and is nitrogen autotrophic. The
observations from the catchment area in this regard supported
Cholnoky's findings, since all the samples from which this
species were recorded contained very little organic nitrogen.
(see Part 2).

Samples - 306, 309, 312, 322.

N.palea (Kützinger). W. Smith.

1856 - W. Smith: Brit. Diat. Vol. 2. P.89.

1930 - Hustedt: Bacillariophyta. P.416, F.801.

Synonyms: Synedra palea Kützinger; Nitzschia minuta Bleisch;
Nitzschia palea var. tropica Hustedt; Nitzschia palea var. tenui-
rostris Grunow.

While Cholnoky found that in most cases the striation of
the valve in N.palea was invisible under the microscope, Lund
(1946: 102) stated that he had observed 30 - 36 striae in 10 μ
and only occasionally were the striae invisible. In the catch-
ment area it was unusual to detect the striation of the valve

surface in N.palea, being in most cases invisible. Three abnormal valves were observed, one with visible striae (Fig. 222), and two with morphological differences (Figs. 220, 221).

Nitzschia palea is one of the most important indicator species of water carrying large quantities of nitrogenous material (Cholnoky 1962B: 98; 1966B: 205). Cholnoky (l.c.) maintained that N.palea is strongly nitrogen eutrophic preferring alkaline water (pH optimum around pH 8) with a high oxygen concentration. N.palea therefore will be found in very large numbers wherever strongly flowing water with a high concentration of organic nitrogen is found. In the Vaal Dam catchment area N.palea was present in nearly every sample, generally in low numbers, but it was dominant in samples Vaal 417 (82.2%) and Vaal 497 (83.8%).
Figs. - 220 - 222.

N.parvula Lewis.

1930 - Hustedt: Bacillariophyta. P.421, F.816.

This species has been recorded twice from South Africa by Cholnoky (1957C: 77; 1962A: 58). It was present in only five samples from the catchment area. Hustedt (l.c.) remarked that this is a brackish water diatom, and this may be the reason for its limited distribution in the catchment area, where the total dissolved salts of the rivers were usually very low.
Samples - 301, 307, 328, 350, 370.

N.parvuloides Cholnoky.

1955 - Cholnoky: Raytonvlei und Leeufontein. Hydrobiologia 7:
179, F. 72 - 73.

Cholnoky (1955B: 179) distinguished this species from N.parvula Lewis, mainly on the basis of its rounded and non-capitate poles. The two species also differ in their ecological requirements. Cholnoky (1962B: 98) regarded this species as nitrogen autotrophic whose optimum pH value lies around 6.5. A few isolated specimens were found in a small number of samples, mainly from the Vaal River.

Samples - 249, 301, 327, 330, 370, 479, 485, 486, 553.

N.perminuta Grunow.

1930 - Hustedt: Bacillariophyta. P.415 (under N.frustulum var. perminuta Grunow).

Synonyms: Nitzschia frustulum var. perminuta Grunow.

This species is very variable and Cholnoky (1957A: 75) has reported a series of specimens in which some show the central carinal pores slightly wider apart than the others. These forms intergrade with the more typical forms. Specimens observed from the Vaal material showed the same type of valve with slightly wider central carinal pores (Figs. 224, 225) amongst the normal arrangement of the pores (Fig. 223).

N.perminuta is a nitrogen heterotrophic species found in neutral to weakly alkaline waters (pH optimum about pH 7.6), and is sometimes found in water whose pH value fluctuated towards the acid side (Cholnoky 1960B: 262; 1962B: 98; 1966B: 206).

N.perminuta was found in most of the samples collected in the catchment area but generally in small numbers, sometimes merely

as a single record. However at some points where the organic nitrogen concentration was high fairly large numbers of this species were recorded.

Figs. - 223 - 225.

N.perpusilla Rabenhorst.

1930 - Hustedt: Bacillariophyta P.415 (under frustulum var. perpusilla).

Synonyms: Nitzschia frustulum var. perpusilla (Rabenhorst) Grunow.

Although there are many contrasting opinions concerning N.perpusilla and N.frustulum (Cholnoky 1960B: 258; 1962A: 55; 1962B: 96; 1966A: 56; 1966B: 202; 1966C: 167), in this survey N.perpusilla has been considered a separate species on ecological grounds. Some of the smaller forms of this species were very similar in appearance to N.epiphyticoides Hustedt, and can easily be confused with this species (Figs. 226, 227).

N.perpusilla is a freshwater species which is nitrogen heterotrophic, living in alkaline waters. It was recorded from a large number of localities in the catchment area, but was never abundant in the samples.

Figs. - 226, 227.

N.perspicua Cholnoky.

1960 - Cholnoky: Swartkops-Bache nahe P.E. Hydrobiologia 16: 262, F. 36.

In a recently received paper Sovereign (1963: 365) described a species of Nitzschia using this same epithet, which was preoccupied by Cholnoky (l.c.) three years earlier. This necessitates a change in name for Sovereign's new species.

No name will be proposed here as it is unknown whether it has already been renamed or not.

This very rare species has been recorded from the type locality (Cholnoky 1960B: 262) and from three samples in the Catchment area. One example (Fig. 228) agreeing in all details with Cholnoky's original description, is illustrated.

Fig. - 228.

N.proxima Hustedt.

1955 - Hustedt: Marine Littoral Diatoms. Duke University
Marine Station Bull. 6: 46, T.16, F.13.

Cholnoky (1959: 58) reported specimens with smaller dimensions than those given by Hustedt (l.c.) in his original description. The examples from the catchment area agreed more with Cholnoky's measurements, and one specimen is illustrated (Fig. 229).

In South Africa this species has been recorded once from the western Cape Province (Cholnoky l.c.). In the catchment area it was recorded from two small tributaries of the Waterval River.

Fig. - 229.

Samples - 405, 411.

N.pseudobacata Cholnoky.

1958 - Cholnoky: Diatomeenflora ii - Waterberg-Gebiet.
Port. Acta Biol. 6: 129, F.130, 131.

This species is very rare in South Africa. Outside the type locality one or two specimens from Lake Sibayi (Archibald 1966B: 492), and isolated examples from two localities in the

(306).

catchment area have been recorded.

Samples - 306, 485.

N.Rautenbachiae Cholnoky.

1957 - Cholnoky: Seltene iii - Tugela Flusssystem. Österr.
Bot. Zeitschr. 104: 76.

N.Rautenbachiae has been recorded from Natal and the Cape Province and Cholnoky (1960A: 102) maintained that it was a coastal water form. In a recent personal communication Cholnoky stated that it was a marine or brackish water species. However in the catchment area the species was found fairly widely distributed, but was only present in significant numbers in two samples (Vaal 419 - 17.9%; Vaal 447 - 7.8%). It is possible that at the time these samples were collected, the small rivers, from which they were collected, were drying up and the salt concentration was higher than normal.

N.recta Hantzsch.

1930 - Hustedt: Bacillariophyta. P.411, F. 785.

Although N.recta has been recorded on numerous occasions from South Africa, nothing is known of its ecology. In the catchment area it was recorded from Station 2A on the Vaal River and from the Grootspuit River.

Samples - 307, 411.

N.romana Grunow.

1880 - Grunow: in V.H. Syn. T.69, F.12 - 13.

1930 - Hustedt: Bacillariophyta. P.415, F. 799.

As sample Vaal 409 was rich in N.romana specimens, it was possible to observe a wide range of variation in the species. The valves range from linear to lanceolate in shape; the small linear forms having conical and slightly produced poles, which are sometimes slightly capitate (Figs. 231, 232, 235). The more lanceolate specimens either, taper gradually to acute slightly capitate ends, or are conically protracted (Figs. 230, 234, 236). In sample Vaal 429 a linear form with a median constriction (Fig. 233) was observed.

It does not appear that this species is particularly common in South Africa. It was found in association with N.palea (Kützting) W. Smith and N.perminuta Grunow and from this it can be deduced that N.romana, like others of its group, is nitrogen heterotrophic. It was widely distributed over the catchment area and in some samples was relatively abundant in its occurrence.

Fig. 230 - 236.

N.rufitorrentis Cholnoky.

1960 - Cholnoky: Natal. Nova Hedwigia 2: 103, F. 308.

The specimens from the Vaal Dam catchment area all fell within the length limits, 35 - 46 μ long, but one or two exhibited slightly narrower valves than usual, being 4.5 μ broad. One of these small forms has been illustrated (Fig. 237).

The distribution of this species appears to be quite widespread in South Africa, since Cholnoky has found it in Natal (l.c.), the Cape Province (1962A: 59) and the Eastern Transvaal

(1962B: 98). In the catchment area it was recorded from the Grootspuit, Klip, Wilge and Holspruit Rivers.

Fig. - 237.

Samples - 253, 334, 359, 411, 434.

N.sigma (Kützting) W.Smith.

1853 - W. Smith: Brit. Diet. Vol. 1. P.39, T.13, F.108.

1930 - Hustedt: Bacillariophyta. P.420. F.813.

Hustedt (1937 - 1939, Suppl. 15: 486: 1949A: 152)

maintained that N.sigma is a brackish water form, sometimes found in inland waters containing high salt concentrations. In the Grootvlei Dam where the salt concentration is known to be high, N.sigma composed 6.6% of the association found in the dam. At Station 7 on the Waterval River, also having high salt concentrations, this species formed 5.4% of the diatom association. In the rest of the catchment area the species was rare in its occurrence.

N.sigma var. fonticola Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.Hydrobiol.

Suppl. 15: 486, T.40, F. 16, 17.

Hustedt (l.c.) regarded this variety as provisionally endemic to the Sunda Islands. Records of it from three localities in the catchment area and other parts of South Africa (Cholnoky 1959: 59) extend its range of distribution considerably. Samples - 233, 421, 554.

N.silica Archibald.

1966 - Archibald: Rare Nitzschiae. Port.Acta Biol. 8:
234, F. 22 - 24.

These weakly silicified specimens show a strong resemblance to N.bacata Hustedt (1937 - 1939, Suppl. 15: 485, T.41, F. 30 - 33), but they differ in size of the valve and the number of carinal pores. Observations of further specimens from the catchment area enable the original description to be extended.

The valves are linear to lanceolate in shape; the larger forms have a linear central portion with parallel sides, while the ends are relatively long with acutely cuneate poles; the smaller forms are more lanceolate and in consequence the ends are less cuneate but still produced and sometimes slightly capitate. The valves are 13 - 29.5 μ long and 2 μ wide. The keel is excentric and hardly visible, there are 16 - 18 (usually 18) carinal pores in 10 μ ; and the two central carinal pores are more widely spaced than the rest. The transapical striae are not visible under the microscope. The valve structure is very delicate and the whole diatom cell is weakly silicified. Figs. 238 - 243.

This species was found at scattered localities in the catchment area generally in low numbers. However, at Station 8 on the Sand River the species formed 24.6% of the diatom association, and at Grootvlei Dam (Station 16) it composed 2.4% of the diatom association. The autecology of this species is unknown.

Figs. - 238 - 243.

Samples - 239, 326, 336, 401, 436.

N.siliqua Archibald.

1966 - Archibald: New and Rare Diatoms from S.A. Nova Hedwigia
Suppl. 21: 267, F.62.

The species belongs to the group of Nitzschiae which are similar to N.amphibia Grunow, but it has not been possible to relate it to N.amphibia or any other member of this group. Since describing the species further specimens have been examined and the range of variation can be extended. One specimen (Fig. 245) was included with this species, but on account of its coarser arrangement of the striae and carinal pores (in both cases 12 in 10 μ) it is uncertain whether it belongs to this species or not.

The typical forms of the species are linear with parallel margins and short cuneate ends which are protracted into slightly capitate poles, 18 - 23.5 μ long, and 3.5 μ wide. The keel is excentric and not easily distinguished from the rest of the structure. The carinal pores are usually, though not easily, distinguishable, but are sometimes quite distinct and number the same as the transapical striae, 16 in 10 μ . The transapical striae are coarse and easily seen, 16 - 18 (usually 16) in 10 μ . The longitudinal costae are visible and straight, about 27 in 10 μ .

N.siliqua was rare in the catchment area and was generally present as isolated examples in a few samples.

Figs. - 244, 245.

Samples - 340, 344, 402, 493, 511, 513.

N.spiculoides Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
151, T.13, F.5, 6.

Two specimens conforming in most details with Hustedt's description but differing in the striation of the valve were assigned to this species. In these specimens the striae were visible, and, although difficult to resolve, numbered about 40 in 10 μ . One example (Fig. 246) has been illustrated. The specimens were recorded from the Waterval and Kleinvaal Rivers.
Fig. - 246.

Samples - 356, 498.

N.spiculum Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
150, T.13, F. 1 - 4.

Synonyms: Nitzschiae acicularioides Archibald.

In sample Vaal 242 a series of forms (247 - 254) were observed linking the smaller N.acicularioides Archibald (1966C: 229, F. 2 - 4) with the larger N.spiculum. There was a gradation between the parallel sided linear valves with very long rostrate ends (N.acicularioides) to the typical lanceolate valves with shorter protracted ends of N.spiculum. The Vaal specimens extended the range of variation of the species to the following; length 37 - 100 μ , breadth 1.5 - 2.5 μ , carinal pores 14 - 18 in 10 μ .

N.spiculum was fairly well distributed over the catchment area, but seldom in high numbers. In a small tributary of the As River (Vaal 242) it composed 33.2% of the diatom association and in a headwaters tributary of the Kleinvaal River it composed

54.6% of the association. As insufficient information about the chemical and physical conditions at these two widely spaced points is available, it is not possible to comment on the autecology of this species.

Figs. - 247 - 254.

N.stricta Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8: 136,
T.12, F. 9, 10.

Synonyms: Nitzschia pilum Hustedt.

By comparing the descriptions of N.stricta and N.pilum Hustedt (1957: 353) it appears that Hustedt has described the same species under two different names. In the author's opinion these two species should be united, and following the rules of priority the oldest valid name, N.stricta, should be adopted. Nitzschia pilum therefore becomes a synonym.

N.stricta was uncommon in the catchment area, occurring in small numbers in the samples.

Fig. - 255.

N.subacicularis Hustedt.

- Hustedt: in A.S. Atl. T.348, F.76.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol.
Suppl. 15: 490, T.41, F.12.

The examples of this species from the catchment area conformed more with Hustedt's original description and drawings (Hustedt l.c.) than with the more recent illustration in his Congo paper (Hustedt 1949a: T.11, F.61). An unusually long specimen (62.5 μ long and 3 μ broad as compared with 42 μ long

(313).

and 2.5 μ broad) has been illustrated (Fig. 256).

Hustedt (1957: 357) maintained that this species was "Oligosaprob" implying that the species prefers waters with a low organic nitrogen content. Cholnoky (1962B: 99) however, strongly disagreed on this point claiming that he had observed this species at sampling points where there were large quantities of organic nitrogen. In the catchment area it was recorded in low numbers from the Waterval and Vaal River systems. Fig. - 256.

Samples - 321, 324, 348, 350, 404, 408, 410, 411, 513.

N. subvitrea Hustedt.

1922 - Hustedt: Bacill. Innerasien. (Sven Hedin, Southern Tibet VI, 3, Bot).

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol. Suppl. 15: 471, T.40, F.12.

Cholnoky (1966A: 59) maintained that the illustrations of this species from the Tibet material showed only 28 transapical striae in 10 μ , while Hustedt (1937 - 1939, Suppl. 15: T.40, F.12) illustrated a specimen with 38 striae in 10 μ . The specimens observed in this study appeared to be intermediate forms since the number of transapical striae ranged between 30 - 36. An abnormal form (Fig. 258) with a curved valve has been compared with a typical example (Fig. 257).

In both South Africa and the Vaal Dam catchment area this species is rare. It was recorded from five localities scattered over the catchment area.

Figs. - 257, 258.

Samples - 238, 344, 410, 415, 447.

N.tarda Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
138, T.12, F.24, 25 (26?)

Cholnoky (1965: 74) has reported examples of this species which have between 30 and 32 striae in 10 μ . Among the specimens observed here the majority have about 28, and some 30 striae in 10 μ , which agreed with Hustedt's description. Occasionally, however, some specimens were more like Cholnoky's more thickly striated examples, having 32 striae in 10 μ . As Cholnoky (1957A: 76) has remarked, these more thickly striated examples may be regarded as transitional forms between this species and N.capitellata Hustedt (see above).

Cholnoky (1956: 84) claimed that N.tarda is associated with weakly alkaline water. In the catchment area it was found in a relatively large number of localities but never in great abundance.

N.thermalis (Ehrenberg) Auerswald.

1930 - Hustedt: Bacillariophyta. P.403, F.771.

Synonyms: Nitzschia stagnorum Rabenhorst.

N.thermalis is a species characteristic of water containing high concentrations of nitrogenous compounds and with a low oxygen content. (Cholnoky 1960B: 263; 1962A: 60; 1962B: 99) and Saubert (1957) has shown that it is nitrogen heterotrophic. It was seldom seen in the catchment area, being recorded as single specimens from three samples collected from Station 17 on the Waterval River. Samples - 338, 497, 498.

N.transvaalensis Cholnoky.

1958 - Cholnoky: Diatomeenflora ii - Waterberg-Gebiet.

Port.Acta Biol. 6: 131, F.139.

This very rare but quite easily distinguishable species was present in two samples as single specimens. One specimen, 60 μ long, was slightly shorter than normal, and the original description should be amended with the addition of this information.

Samples - 340, 344.

N.tropica Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:

147, T.11, F.34 - 48.

Synonyms: Nitzschia pseudotropica Manguin; Nitzschia subtropica Manguin.

This species is rare in the catchment area, and was recorded in small numbers from seven localities in the Vaal River System. An example (Fig. 259) has been illustrated.

Samples - 401, 410, 411, 412, 417, 418, 485.

N.tryblionella Hantzsch.

1930 - Hustedt: Bacillariophyta. P.399, F.757.

This species is uncommon in South Africa, and in the catchment area was found in small numbers in a few samples collected in the Waterval and Vaal River systems.

Samples - 342, 344, 401, 402, 405, 415, 417, 489, 493.

N.umbilicata Hustedt.

1949 - Hustedt: Kongo. Expl. du Parc National Albert 8:
129, T.11, F.65.

This species is very similar to N.levidensis Grunow but differs from it in the shape of the valve and its much finer structure. In this survey some of the examples agree fully with Hustedt's original description, while others differed in their dimensions, thus enlarging the range of variation of the species. The following observations give the new range of variation:- length, 27 - 40 μ ; breadth 7 - 8 μ ; carinal pores 8 in 10 μ ; transapical striae (Rippen) 18 - 22 in 10 μ . These are the first records of this species in South Africa. Two examples have been illustrated, one showing a typical form (Fig. 261) and the other (Fig. 260) showing one of the smaller examples with shorter protracted poles.

This species was recorded mainly from the Waterval River, but never in great numbers.

Samples - 340, 363, 378, 511, 513, 553, 554.

N.valdestriata Aleem et Hustedt.

1951 - Aleem et Hustedt: Diat. Südküste Englands. Bot.Not.
1951 (1): 19, F.5.

This is a marine species and it is very surprising that it should be found present in these two samples. It can only have been present here by accident. Cholnoky (1959: 61; 1962A: 60) has recorded it only from marine habitats in the Western Cape Province.

Samples - 404, 406.

(317).

N.vandermerwei Cholnoky.

1957 - Cholnoky: Südafrikanischen Diatomeenflora. Port. Acta
Biol. 6: 78, F. 113 - 115.

One very typical specimen was found in sample Vaal 422;
this was illustrated in Fig. 262. This species has rarely been
seen in South Africa.

Fig. - 262.

Sample - 422.

N.vermicularis(Kützing) Grunow.

1930 - Hustedt: Bacillariophyta. P.419, F.811.

This species is also very seldom seen in South Africa.
Cholnoky (1956: 94; 1957C: 78) has recorded it twice, while a
single specimen was recorded from Station 5A on the Vaal River.
Sample - 323.

N.vitrea Norman var. salinarum Grunow.

1862 - Grunow: Verh. zool.-bot. Ges. Wien 12(2nd Part): 566.

1930 - Hustedt: Bacillariophyta. P.411.

Cholnoky (1957A: 77) was doubtful whether this species
is a marine or brackish water form. In the Vaal Dam catchment
area it was found in only two samples. One specimen (Fig. 263)
was illustrated in the plates.

Fig. - 263.

Samples - 409, 478.

PINNULARIA Ehrenberg 1840.

P. adoricola Hustedt.

- Hustedt: A.S. Atlas T. 390, F. 13 - 16.

- Hustedt: Foss. Diat. de Tobasees. P. 159, T. 3, F. 24 a, b.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol.
Suppl. 15: 293, T. 21, F. 11 - 16.

This species has been recorded from many acidic waters in South Africa (Cholnoky 1954B: 221; 1956: 85; 1960A: 106). In the Vaal Dam catchment area it was not particularly common, being found in significant numbers in only three samples. Two were from the headwaters of the Vaal River (Vaal 301, 479) where the average pH value was about pH 6. The other (Vaal 345) was from a headwater tributary of the Kleinvaal River.

P. acrosphaeria (Brebisson) Rabenhorst.

1896 - Cleve: Naviculoid Diatoms. Kongl. Sv. Vet. Akad. Handl. 27: 86.

1930 - Hustedt: Bacillariophyta. P. 330, F. 610.

Synonyms: Frustulia acrosphaeria Brebisson; Navicula acrosphaeria Kützing; Navicula var. sandvicensis.

This species is relatively common in South Africa. However in the catchment area only a few typical specimens were observed from Station 2A on the Vaal River and Station 17 on the Waterval River.

Samples - 307, 339.

(319).

P.brevicostata Cleve var. sumatrana Hustedt.

- Hustedt: in A.S.Atl. T.389, F. 7 - 9.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol.

Suppl. 15: 398, T.22, F. 4 - 6.

The specimen figured in the illustrations (Fig. 264) was the only one of this species observed in this study. It was found in a sample from Lake Chrissie (Vaal 485). This variety is rare in South Africa, and Cholnoky has recorded it only twice (Cholnoky 1962B: 101; 1966A: 61).

Fig. - 264.

Sample - 485.

Pinnularia eburnea (Carlson) Zanon.

1941 - Zanon: Diatomea dell'Africa occidentale Francese.

Pont. Acad. Sci. Comm. 5: 29, T.3, F. 16 - 19.

Synonyms: Pinnularia borealis var. rectangularis Carlson;
Pinnularia borealis var. rectangulata Hustedt; Pinnularia
dubitabilis Hustedt.

This is one of the more frequently occurring species of Pinnularia in South Africa. Cholnoky (1962B: 101) regards this species as acidophilic. On account of the generally alkaline conditions in the catchment area P.eburnea occurred in small numbers in a few samples.

Fig. - 265.

(320).

P.gibba Ehrenberg.

1930 - Hustedt: Bacillariophyta. P.327, F.600.

Synonyms: Pinnularia stauroptera Grunow.

It appears that a thorough revision of this species is necessary. Cholnoky (1955C: 33; 1962A: 63; 1962B: 101; 1964: 78; 1966A: 62; 1966B: 210,) claimed that intermediate stages between the typical species, its forms and varieties were so numerous that it was impossible to distinguish between them. However as so few specimens of this species have been observed in the catchment area the different forms and varieties have been retained, since the presence of intermediate forms were not detected.

According to Cholnoky (1962B: 101) this species finds its optimum development at pH 6. Its slight occurrence in a few samples from the catchment area may be due to the lack of suitable conditions.

Samples - 345, 347, 350, 353, 370, 479, 485.

P.gibba f. subundulata Mayer.

1930 - Hustedt: Bacillariophyta. P.327, F.601.

This form of the species was recorded from Station 1 on the Vaal River, from a small stream near Ermelo, and from Station 8 on the Klip River.

Samples - 370, 454, 456, 478.

(321).

P.gibba var. linearis Hustedt.

1930 - Hustedt: Bacillariophyta. P.327, F.604.

This variety was recorded in one sample from the acid waters of Station 1 on the Vaal River.

Sample - 370.

P.gibba var. parva (Ehrenberg) Grunow.

1930 - Hustedt: Bacillariophyta. P.327, F.603.

This variety was also recorded only from Station 1 near Breyten.

P.gibba var. sancta Hustedt.

1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch.

Hydrobiol. Suppl. 15: 395, T.20, F.35.

According to Hustedt (l.c.) this variety is an acid water form, particularly common at pH 6.5. Cholnoky (1960B: 263) has recorded it from waters containing high concentrations of organic nitrogen, and stated that it is autochthonous in the drainage channels of the Pretoria Sewage Works. In the catchment area it was recorded in small numbers from Lake Chrissie, Station 21 on the Kleinvaal River, and Station 24 on the Klip River.

Samples - 353, 437, 485.

P. graciloides Hustedt.

- Hustedt: in A.S. Atl. T.392, F. 2, 3. (as P.gracilis: see Hustedt 1949A: 103).
- Hustedt: Foss. Diat. d. Tobasees. P.159, T.2, F.13.
- 1937 - 1939 - Hustedt: Java, Bali und Sumatra. Arch. Hydrobiol. Suppl. 15: 293, T.22, F. 9, 10.

Synonyms: Pinnularia gracilis Hustedt.

Cholnoky (1954B: 103; 1957B: 356; 1957C: 80; 1950B: 135) has recorded this species many times from South Africa, and has found many variations from the original material which are all linked to the original by transitional forms.

The distribution of this species is limited to those rivers in which acid conditions are obtained. It is therefore not particularly common in the catchment area.

Samples - 301, 306, 307, 370, 554.

P.interrupta W. Smith.

- 1853 - W.Smith: British Diat. Vol. 1. P.59, T.19, F.184.
- 1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 76.
- 1930 - Hustedt: Bacillariophyta. P.317, F.573.

Synonyms: Pinnularia interrupta f. minutissima Hustedt;
Pinnularia biceps Gregory; Pinnularia termes Ehrenberg.

According to Cholnoky (1960A: 110) this species is apparently very variable in shape and particularly in the development of the central area, which can be completely different on the two valves of the same diatom cell.

In the alkaline waters found in the catchment area, this species whose pH optimum lies a little under pH 7 (Cholnoky 1962B: 102) was rare, being found in only three samples.

Samples - 301, 330, 449.

P.mesolepta (Ehrenberg) W.Smith.

1853 - W. Smith: British Diat. Vol. 1. P.58, T.19, F.182.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.

27: 76.

1930 - Hustedt: Bacillariophyta. P.319, F.575a.

Synonyms: Navicula mesolepta Ehrenberg; Navicula mesolepta var. - genuina Grunow; Navicula mesolepta var. africana Fritsch et Rich.

P.mesolepta was found almost exclusively in the Vaal River, where it is probably not autochthonous, except in the samples from the headwaters of the Vaal River (Vaal 301, 370, 479) where it might be autochthonous in the acid conditions of the river at this point. Cholnoky (1962B: 102) claimed that this species has a pH optimum of pH 6, and therefore cannot be classed as "indifferent" (cf. Hustedt 1957: 307).

Samples - 301, 307, 345, 356, 370, 409, 464, 477, 479, 485.

P.microstauron (Ehrenberg) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.

27: 77.

1930 - Hustedt: Bacillariophyta. P.320, F.582.

Synonyms: Stauroptera microstauron Ehrenberg; Stauroneis microstauron Kützing; Navicula divergens f. minor; Navicula Brebissonii var. subproducta van Heurck; Navicula bicapitata var. hybrida; Pinnularia Rabenhorstiana Hilse; Navicula divergens var. prolongata Brun.

This Pinnularia species occurred a little more frequently in the catchment area since its pH optimum lies around pH 7 (Cholnoky 1962B: 102). It was, however, not as common as the var. Brebissonii (Kützing) Hustedt.

P.microstauron f. biundulata O. Müller.

1930 - Hustedt: Bacillariophyta. P.320, F.583.

This very rare form has seldom been reported from South Africa. It was recorded from only two localities from the catchment area, from the As River just below Bethlehem and from the Waterval River.

Samples - 259, 554.

P.microstauron var. Brebissonii (Kützing) Hustedt.

1930 - Hustedt: Bacillariophyta. P.321, F. 584.

Synonyms: Navicula Brebissonii Kützing; Pinnularia Brebissonii (Kützing) Rabenhorst; Pinnularia Brebissonii var. mormonorum (Grunow) Cleve-Euler; Pinnularia microstauron var. dahomeyensis Zanon; Pinnularia microstauron f. diminuta Grunow.

The variety var. Brebissonii is fairly common in South Africa, and in the catchment area it is the most commonly occurring Pinnularia. It was recorded from a relatively large number of localities and is most abundant at Station 19 on the Kaffirspruit.

P.minuta Zanon.

1941 - Zanon: Diatomea dell'Africa occidentale Francese.

Pont. Acad. Sci. Comm. 5: 51, T.3, F.23.

Synonyms: Pinnularia Claasseniae Cholnoky.

Cholnoky (1960A: 112) has sunk his Pinnularia Claasseniae into P.minuta.

Since the optimum pH of the species lies around pH 6 (Cholnoky 1962B: 102), it was recorded in small numbers from two samples, one from the Waterval River and one from the Wilge River near Frankfort. The pH at neither of these places was low.

Samples - 233, 324.

P.stomatophora (Grunow) Cleve.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
27: 83.

1930 - Hustedt: Bacillariophyta. P.327, F.605.

Synonyms: Navicula stomatophora Grunow; Pinnularia sub-
stomatophora Hustedt.

The "strichartigen Zeichnung" on either side of the central nodule described earlier by Hustedt (1930: 327) was later found to be unreliable as a diagnostic characteristic (Hustedt 1937 - 1939, Suppl. 15: 396), as occasionally it was found on one valve and not on the other of the same diatom cell. The specimen (Fig. 266) with the characteristic long polar fissures did not have this marking. It also agreed with the smaller forms of this species found in the Okavango material by Cholnoky (1966A: 65) which were 35 μ long and 5.5 μ broad.

This species was recorded from Lake Chrissie which is fed by some acid water streams (Cholnoky 1965), and from the headwaters of the Russespruit River.

Fig. - 266.

Samples - 249, 495.

P.subdivergentissima Cholnoky.

1958 - Cholnoky: Diatomeenflora ii - Waterberg-Gebiet.
Port. Acta Biol. 6: 136, F.137.

A single typical specimen (Fig. 267) of the species was recorded from Station 24 on the Klip River near its headwaters.

Fig. - 267.

Sample - 437.

(326).

P.viridis (Nitzsch) Ehrenberg.

1838 - Ehrenberg: Infusionsthierchen als vollkommene Organismen.

P.182.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 27: 91.

1930 - Hustedt: Bacillariophyta. P.334, F.617a.

Synonyms: Bacillaria viridis Nitzsch; Frustulia viridis (Nitzsch) Kützing; Navicula viridis (Nitzsch) Kützing; Pinnularia medio-constricta Rabenhorst; Navicula Gutwinski Pantocsek.

There are many records of P.viridis from South Africa (Cholnoky 1960B: 265; 1962A: 65; 1962B: 103). Cholnoky (l.c.) has found that its pH optimum lies between pH 6 and 7, and that it is also found in oligotrophic waters. On account of the generally alkaline waters in the catchment area this species was found in small numbers in a few samples.

P.viridis var. intermedia Cleve.

1891 - Cleve: Diat. of Finnland. P.22.

1896 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.
Handl. 27: 91.

1930 - Hustedt: Bacillariophyta. P.335.

Synonyms: Navicula maior, Navicula viridis Pantocsek.

A single specimen of this variety was recorded from the acid waters of Station 1 on the Vaal River.

Sample - 301.

P.viridis var. sudetica (Hilse) Hustedt.

1930 - Hustedt: Bacillariophyta. P.335, F.617 b.

Synonyms: Pinnularia viridis W. Smith; Navicula commutata

(327).

Grunow; Pinnularia Heufleri Pedicino; Pinnularia sudetica Hilse;
Navicula decumana Pantocsek.

This variety is rare in South Africa and only two specimens have been recorded from the catchment area from a small stream near Standerton and from the source region of the Russespruit River.

Samples 249, 415.

RHOPALODIA O.Müller 1897.

R.gibba (Ehrenberg) O. Müller.

1930 - Hustedt: Bacillariophyta. P.390, F.740.

Synonyms: Navicula gibba Ehrenberg; Eunotia gibba Ehrenberg;
Epithemia gibba (Ehrenberg) Kützing; Cystopleura gibba
(Ehrenberg) Kunze; Navicula uncinata Ehrenberg; Cymbella
incrassata Brebisson.

This species was quite widely distributed over the whole catchment area, but generally in small numbers. At scattered isolated points on tributaries of the Waterval River and Vaal River it was found in greater abundance in the samples (Vaal 405 - 15.4%; Vaal 411 - 11.9%; Vaal 413 - 16.3%), and in sample Vaal 420 it was the dominant species (55.8%) in the association. Unfortunately little is known of the physical and chemical conditions of these sampling spots, making it impossible to comment on the ecology of this species. Cholnoky (1962B: 103) maintained that the optimum pH of R.gibba was around pH 8. This might account for its wide distribution.

R.gibberula (Ehrenberg) O. Müller.

1930 - Hustedt: Bacillariophyta. P.391, F.742.

Synonyms: Eunotia gibberula Ehrenberg; Epithemia textricula Kützing; Epithemia gibberula (Ehrenberg) Kützing; Cystopleura gibberula (Ehrenberg) Kunze; Rhopalodia gibba var. pseudo-gibberula Cholnoky; Rhopalodia musculus (Kützing) O. Müller.

R.gibberula has apparently a high pH optimum and prefers well buffered water; this species is also able to tolerate fluctuations of the osmotic pressure (Cholnoky 1954D: 130; 1962B: 103; 1966B: 212). In the catchment area R.gibberula had approximately the same distribution pattern as that of R.gibba, but was generally less abundant than R.gibba.

STAURONEIS Ehrenberg 1843.

S.acuta W. Smith.

1853 - W. Smith: Brit. Diat.Vol.1, P.59, T.19, F.187.

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl.
26: 150.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
819, F.1163.

1930 - Hustedt: Bacillariophyta. P.259, F.415.

Synonyms: Pleurostauron acutum Rabenhorst; Stauroneis Kochii Pantocsek; Navicula acuta Schütt; Stauroneis Frickei Heiden.

This large Stauroneis is seldom seen in South Africa and the Vaal Dam catchment area was not different in this respect. Only one specimen was recorded from a headwater tributary of the Kleinvaal River.

Sample - 464.

S.anceps Ehrenberg.

1841 - Ehrenberg: Abh.Akad.Wiss. P.34, T.2, F.1, 18 (1843).

1894 - Cleve: Naviculoid Diatoms. Kongl.Sv.Vet.Akad.Handl. 26: 147.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
771, F.1120a.

1930 - Hustedt: Bacillariophyta. P.256, F.405.

Synonyms: Stauroneis birostris Ehrenberg; Stauroneis amphicephala Kützing; Stauroneis linearis Grunow; Stauroneis gallica Peragallo et Heribaud; Navicula anceps Mann.

For further synonyms see Hustedt in Rabenhorst (l.c.).

Among the normal typical forms of this species one example (Fig. 268) of the small forms which Cholnoky (1957A: 83) felt to be transitional between S.anceps and S.dahomensis Hustedt was observed.

Stauroneis anceps is found in waters, which are relatively acidic (pH optimum, according to Cholnoky (1966B: 213) is about 6.5 - 6.7), and which do not contain high concentrations of nitrogenous material. In the catchment area it was comparatively rarely seen and was never present in large numbers.

Fig. - 268.

Samples - 325, 358, 402, 404, 412, 437, 449, 479, 489.

S.anceps f.gracilis Rabenhorst.

1864 - Rabenhorst: Flor. Eur. Alg. P.247.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
771, F.1120 b.

1930 - Hustedt: Bacillariophyta. P.256, F.406.

Synonyms: Stauroneis anceps var. rhomboidalis A.Mayer;
Stauroneis anceps var. gracilis f. maior Mayer; Stauroneis anceps
var. gracilis (Ehrenberg) Cleve.

This particular form has been listed from numerous localities in South Africa, but no details of its ecology have been proposed.

(330).

It was recorded in small numbers from a few samples in the catchment area mainly from the acid waters of Station 1.

Samples - 239, 301, 370, 479, 480.

S.anceps var. javanicum Hustedt.

- Hustedt: Foss. Diat. d. Tebasees. P.154, T.1, F.10.

1937 - 1939 - Hustedt: Java, Bali und Sumatra.

Arch.Hydrobiol. Suppl. 15:222, T.15, F.4.

A single specimen of this variety was recorded from Station 21A, a tributary of the Kleinvaal River. This is the first record of this variety for South Africa.

Sample - 350.

S.Borrichii (Boye Petersen) Lund.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
803, F.1151 a, b.

1946 - Lund: Observations on Soil Algae. New Phytologist 46:
63, F.3 C - H.

Synonyms: Navicula Borrichii Boye Petersen.

S.Borrichii is very variable, and two examples have been illustrated to show the range of variation found in the catchment area. Fig. 270 shows a typical specimen, while Fig. 269 illustrates a smaller form with slightly denser striation (34 striae in 10 μ . According to Cholnoky (1957A: 83) the species is widespread in acidic waters in South Africa. Although it was one of the more common Stauroneis species in the region, only a few examples were recorded from relatively few samples.

Figs. - 269, 270.

(331).

S.cimbebasiae Cholnoky.

1966 - Cholnoky: Quellen aus S.W.A. Nova Hedwigia Suppl. 21:
213, F. 110, 111.

A single specimen of this recently described species was recorded from the Wilge River at Harrismith. Since the type locality and Harrismith are so distant from each other this small species may be more widespread than is at present known.

Fig. - 271.

Sample - 331.

S.dahomensis Hustedt.

1910 - Hustedt: Bacillariales aus Dahome. Arch. Hydrobiol.
5: 378, T.1, F.11.

Synonyms: Stauroneis pygmaea Krieger; Stauroneis Kriegeri Patrick.

A specimen (Fig. 272) in which the striae towards the poles become invisible has been illustrated. This species was recorded from two localities, Station 9 on the Wilge River and Station 21A, a tributary of the Kleinvaal River.

Fig. - 272.

Samples - 328, 464.

S.merrimacensis (Grunow) Woodhead and Tweed.

1960 - Woodhead et Tweed: Freshwater Algae of Sierra Leone 3.
Rev. Alg. N.S. 5: 143.

Synonyms: Schizostauron crucicula Grunow; Stauroneis crucicula (Grunow) Cleve; Capartogramma crucicula (Grunow) Ross.

S.merrimacensis has been recorded from neutral to slightly alkaline waters in South Africa (Cholnoky 1956: 87; 1957A: 83;

1962B: 104). In the Vaal Dam catchment area the species was found in very small numbers in five samples.

Samples - 306, 307, 331, 356, 477.

S. palustris Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2: 795, F.1140.

1945 - Hustedt: Arch. Hydrobiol. 40: 914, T.42, F.30 - 32.

Only two specimens of S. palustris were recorded from this area. It has previously been recorded in South Africa only from the Okavango River (Cholnoky 1966A: 69).

Samples - 342, 433.

S. phoenicenteron (Nitzsch) Ehrenberg.

1843 - Ehrenberg: Abh. Akad. Wiss. Berlin (1841) T.2, F. V, 1.

1894 - Cleve: Naviculoid Diatoms. Kongl. Sv. Vet. Akad. Handl. 26: 148.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2: 766, F.1113 a.

1930 - Hustedt: Bacillariophyta. P.255, F.404.

Synonyms: Bacillaria phoenicenteron Nitzsch; Cymbella phoenicenteron Agardh; Navicula phoenicenteron Ehrenberg; Stauroneis amphilepta Ehrenberg; Stauroneis Baileyi Ehrenberg; Stauroneis pterodea Ehrenberg; Stauroneis Boryana Pantocsek; Stauroneis crumenifera Mayer.

For further synonyms see Hustedt in Rabenhorsts Kryptogamenflora (l.c.).

According to Cholnoky (1962B: 104) this very large and easily recognised species is nitrogen autotrophic and inhabits waters which are neutral (pH optimum about 7) and whose pH value

fluctuates towards the acid side. This statement is in almost direct conflict with Hustedt's observations in the Sunda Islands (Hustedt 1937 - 1939, Suppl. 15: 220), where he describes the species as "Indifferente Litoralform, besonders in eutrophen Gewässern verbreitet". It was recorded from a few samples from the area under survey, and mainly from localities where there was evidence of acidic conditions.

Samples - 249, 301, 330, 370, 438, 478, 479, 485.

S.thermicola (Petersen) Lund.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora.

Teil 2: 800, F. 1148, a, b.

1930 - Hustedt: Bacillariophyta. P.259, F.418. (Under S.montana Krasske).

1946 - Lund: Observations on Soil Algae. New Phytologist 45: 61, F.3 K-AA.

Synonyms: Navicula thermicola Petersen; Navicula contempta Krasske; Stauroneis montana Krasske.

A few specimens of this small Stauroneis species were in full agreement with description given by Hustedt (1927 - 1964, Teil 2: 800). These specimens were found mainly in the Wilge River in the vicinities of the headwaters (Vaal 328), Swinburne (Vaal 330) and Harrismith (Vaal 331). It was recorded also from the upper reaches of the Vaal River (Vaal 307). Although Cholnoky has recorded the species frequently he has been unable to clarify its autecology.

Samples - 307, 328, 330, 331.

(334).

S. Wislouchii Poretzky et Anisimowa.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
792, F. 1137.

1933 - Poretzky et Anisimowa: Expl. d. lacs de l'U.R.S.S.
1933 Fasc. 2: 51, T. 9, F. 3 - 5.

Synonyms: Stauroneis Wislouchii f. parva Poretzky et Anisimowa;
Stauroneis salina var. Wislouchii Cleve-Euler.

Since this species appears to be a brackish water form (Hustedt 1927 - 1964, Teil 2: 792; Cholnoky 1966A: 71; 1966B: 214) the identification of this species from the catchment area is doubtful, as the water is generally free of large concentrations of salts. The species was rare, and was always found in small numbers in the samples.

Samples - 251, 330, 340, 421, 422, 432, 441, 455.

STENOPTEROBIA Brebisson 1867.

S. intermedia Lewis.

1863 - Lewis: Intermediate Forms. Proc. Acad. Nat. Sci. Phila.
Philadelphia.

1930 - Hustedt: Bacillariophyta. P. 428, F. 830.

There appears to be some considerable confusion over the author of the species. In the Bacillariophyta Hustedt (l.c.) merely quoted Lewis in parentheses. As a result Cholnoky (1958B: 138) wrote S. intermedia (Lewis) Hustedt. Later Hustedt (1937 - 1939, Suppl. 15: 492) quoted S. intermedia (Lewis) Fricke. Once again this was altered and Cholnoky (1960B: 266; 1960C: 362) showed that Van Heurck was the author of the species. Then finally Cholnoky (1966A: 71) quoted only Lewis as the author. In the Sylloge Algarum, De Toni (1891: 567) transferred the genus in its entirety to what he called Suriraya (Surirella) with this

(335).

note to his synonyms of the generic name:- "Stenopterobia sp. omnes Breb., Lewis, Grunow." Lewis here is cited as the sole author of Suriraya intermedia. The author's conjecture is that Lewis described the species in the genus Stenopterobia, which De Toni then transferred to Suriraya. More recently Stenopterobia has again been accepted as a valid species; therefore Lewis is the only valid author of S.intermedia.

The species was found only in the acidic headwaters of the Vaal River (Vaal 301, 370); this supported the observations of Cholnoky (1958B: 138; 1960B: 266).

Samples - 301, 370.

STEPHANODISCUS Ehrenberg 1845.

S.astraea (Ehrenberg) Grunow var. minutula (Kützing) Grunow.

1881 - Grunow: in V.H.Syn. T.95, F.7, 8.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1: 369, F.193, d, e.

1930 - Hustedt: Bacillariophyta. P.110, F.86.

Synonyms: Cyclotella minutula Kützing; Discoplea oregonica Ehrenberg; Cyclotella oregonica Ralfs; Stephanodiscus bala-tonis Pantocsek.

Very few specimens of this planktonic form were seen in this survey. It was found in only three localities, the Kalk River, the Waterval River and a small tributary near Standerton. Samples - 401, 412, 414.

(336).

SURIRELLA Turpin 1828.

S.angusta Kützing.

1844 - Kützing: Bacill. P.61, T.30, F.52.

1930 - Hustedt: Bacillariophyta. P.435, F.844, 845.

S.angusta is found in water with a high oxygen content, preferring alkaline water as it has a pH optimum of about pH 8 (Cholnoky 1960B: 266; 1962A: 72; 1962B: 105). Cholnoky also claimed that it was nitrogen autotrophic, thus inhabiting water with low concentrations of organic nitrogen. This probably accounts for its widespread distribution in the catchment area, where it sometimes occurred in high numbers in the samples.

S.delicatissima Lewis var. africana Cholnoky.

1959 - Cholnoky: Seltene iv - Kaap-Provinz. Österr.Bot.

Zeitschr. 106: 65, F.345.

Cholnoky (1960B: 266; 1962B: 105) maintained that this species was found in oligotrophic acid water with pH values around 6.0 - 6.2. The presence of var. africana in the acid waters (ave. pH value 6.3) of Station 1 confirmed Cholnoky's evidence.

Samples - 301, 370, 479.

S.fimbriata Hustedt.

1942 - Hustedt: Indomalayischen Archipels. Int.Rev.d.ges.

Hydrob. u. Hydrog. 42: 164, F.409, 410.

Surirella fimbriata is rare in South Africa, previously being reported only from Natal (Cholnoky 1957A: 85; 1960A: 118). Typical forms of S.fimbriata were recorded from the upper reaches

(337).

of the Klip River near Müller's Pass. (Vaal 437, 438). However, a specimen (Fig. 274) showing distinct striation of the valve surface and relatively narrower valves (cf. Cholnoky 1957A: 85) was observed in a sample from Station 21A. It has been assigned to this species on account of the similarities between the two species. This atypical specimen is also similar to S.Chasei Cholnoky (1954B: 225, F. 118, 119), but differs from this species by the coarser striation of the valve surface and the absence of the thorn-like projections in the central area. This may possibly be a new species, but further specimens must be examined before describing it.

Fig. - 274.

Samples - 437, 438, 464.

S.linearis W. Smith.

1853 - W.Smith; Brit.Diat. Vol. 1. P.31, T.8, F.58 a.

1930 - Hustedt: Bacillariophyta. P.434, F.837, 838.

Synonyms: Surirella linearis f. constricta (Ehrenberg) Hustedt.

This species having a pH optimum around neutral point (Cholnoky 1962B: 105) was recorded in one sample from the acid waters of Station 1 on the Vaal River.

Sample - 479.

S.ostentata Cholnoky.

1962 - Cholnoky: Diatomeenflora iii - Kaap Provins.

Rev. de Biol. 3: 73.

1962 - Cholnoky: Ost Transvaal. Hydrobiologia 19: 106.

Synonyms: Surirella ovata var. africana Cholnoky.

This small hyaline Surirella species was described

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originally by Cholnoky (1955A: 28, F.46) as a variety, var. africana, of S.ovata Kützing, on the basis of its very much smaller dimensions, and hyaline valves. Later Cholnoky thought these characters warranted specific separation. Accordingly in 1962 in two papers he proposed that the variety should be raised in rank to species and gave it a new name S.ostentata. It is difficult to tell which is the original description for this new combination as Cholnoky quoted first one paper and then the other in different citations.

The species was one of the more commonly occurring Surirella species in the catchment area. It is apparently found in neutral to weakly alkaline water (Cholnoky 1955A: 46 1956: 90; 1962B: 106).

S.ovalis Brebisson.

1930 - Hustedt: Bacillariophyta. P.441, F.860, 861.

Hustedt (l.c.) claimed that S.ovalis is a marine or brackish water form, normally found in coastal waters or brackish inland waters. This makes the distribution of the species in South Africa surprising as the localities from which it has been recorded are certainly not all brackish (Cholnoky 1958A: 261; 1960A: 119; 1960B: 266; 1962B: 73; 1965: 76). In the Vaal Dam catchment area this species is very wide spread and found in a large number of localities, although never composing a large proportion of the association. The water in the catchment area, however, has generally a relatively low dissolved salt content.

S.ovata Kützing.

1844 - Kützing: Bacill. P.62, T.7, F. 1 - 4.

1930 - Hustedt: Bacillariophyta. P.442, F.863, 864.

S.ovata, although a common species in Europe (Cholnoky 1960B: 266), was seldom seen in this survey. In two samples, however, it occurred in relatively large numbers (Vaal 253 - 5.0% and Vaal 417 - 2.4%). In both these samples the species was associated with large numbers of nitrogen heterotrophic Nitzschiae.

Samples - 253, 333, 336, 360, 401, 417, 431, 445.

S.striatula Turpin.

1828 - Turpin: Mem.d. Museum d'Hist. Nat. 16: 362.

1930 - Hustedt: Bacillariophyta. P.445, F.869.

This is a very rare Surirella species in South Africa. Previously a few of the earlier workers on South African material had recorded it from South Africa (cf. Cholnoky l.c.). Since then Cholnoky has recorded it once (Cholnoky 1962A: 73), and Giffen (1963: 254) once. In the catchment area one specimen was observed in sample Vaal 343.
Sample - 343.

S.tenera Gregory.

1856 - Gregory: New species British Freshwater Diatomaceae.

Q.J.M.S. 4: 10, T.1, F.38.

1930 - Hustedt: Bacillariophyta. P.438, F.853.

Since this species has a pH optimum of 8 (Cholnoky 1962B: 106), it was one of the more widespread and common species in the catchment area, being particularly common in the Vaal River and its tributaries.

SYNEDRA Ehrenberg 1830.

S. acus Kützing f. radians (Kützing) Hustedt.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
202, F. 693 b.

1930 - Hustedt: Bacillariophyta. P.155, F.171

Synonyms: Exilaria tenuissima Brebisson; Frustulia tenuissima
Kützing; Synedra tenuissima Kützing; Synedra radians Kützing;
Synedra acula Kützing; Synedra delicatissima W. Smith; Synedra
amphicephala H.L. Smith; Synedra paludosa Meister.

This form has been recorded commonly in South Africa. In
the catchment area, however, it is scarce, and was recorded mainly
from the Vaal River and its tributaries.

S. acus var. angustissima Grunow.

1881 - Grunow: in V.H. Syn. T.39, F.10.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
202, F. 693 c.

1930 - Hustedt: Bacillariophyta. P.155, F.172.

Synonyms: Synedra delicatissima var. angustissima Grunow;
Synedra Lemmermannii W. & G.S. West; Synedra Schröteri
Meister.

As far as is known this is the first record of the variety
for South Africa. It was found in one sample from Station 5A on
the Vaal River.

Sample - 323.

S. Allansonii Cholnoky.

1958 - Cholnoky: Jukskei - Crocodile System. Hydrobiologia 11:
262, F. 33, 34.

Cholnoky's type material (Cholnoky l.c.) showed differences
of valve shape and construction of the pseudoraphe which

distinguished this species from S.nana Meister or S.tenera W.Smith. Later on he (Cholnoky 1962C: 338) found other examples of this species which differed from the other two only in the construction of the pseudoraphe. The two specimens observed here were more like Cholnoky's original type material.

Samples - 410, 485.

S.mystica n.sp.

This new species, of which a relatively large number of valves were seen in this survey, is similar in outline to S.minuscula Grunow (cf. Hustedt 1927 - 1964, Teil 2: 210, F.700) but differs from it in a better development of the central area and the transapical striae which are finer in their arrangement. The longer examples are also similar to S.tenera but the well developed central area of S.mystica excludes it from this species.

The valves of S.mystica are linear in the middle portion, sometimes slightly concave at the centre in the smaller specimens, with longer or shorter cuneate and acutely rounded poles; 21 - 36 μ long, and 2 - 3 μ wide. The pseudoraphe is narrow and linear, sometimes very slightly lanceolate towards the centre. A well developed central area is present. The transapical striae are fine, but easily seen and number between 24 and 28 in 10 μ . Figs. 275, 276.

S.mystica was recorded from Stations 21 and 21A on the Kleinvaal River, Station 24 on the Klip River, and from the headwaters region of the Elands River in the Witzieshoek area. Figs. - 275, 276.

Samples - 204, 350, 353, 437.

S.nana Meister.

1912 - Meister: Kieselalg. Schweiz. P.76, T.8, F.9.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
212, F. 704.

1930 - Hustedt: Bacillariophyta. P.158, F.183.

According to Cholnoky (1954D: 130; 1966A: 74) this species is an acidophilic planktonic form. The lack of suitable conditions might explain the small number of specimens observed in the catchment area. It was recorded in small numbers from a few samples mainly in the upper reaches of the Vaal River and in the Wilge River system.

S.rumpens Kützing.

1844 - Kützing: Bacill. P.69, T.16, F.VI.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
207, F. 697 a, b.

1930 - Hustedt: Bacillariophyta. P.156, F. 175.

Synonyms: Desmogonium Kützingii Rabenhorst; Synedra campyla Hilse; Fragilaria rumpens Carlson; Synedra scotica Mayer; Synedra scotica var. genuina and var. undulata Mayer.

Cholnoky recorded this species from neutral to alkaline water (Cholnoky 1960B: 267; 1962C: 339), and has stated that its pH optimum lies above pH 8 (Cholnoky 1962B: 107). It was recorded in the Vaal Dam catchment area from four samples.
Samples - 331, 332, 403, 410.

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S.tabulata (Agardh) Kützing.

1844 - Kützing: Bacill. P.68, T.15, F.X, 1 - 3.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:

218, F. 710 a - d.

1930 - Hustedt: Bacillariophyta. P.159, F.184.

(Under S.affinis Kützing).

Synonyms: Diatoma tabulatum Agardh; Exilaria fasciculata minor Agardh; Frustulia subtilis Kützing; Navicula acus Ehrenberg; Synedra subtilis Kützing; Synedra tenuis Kützing e.p.; Synedra affinis Kützing; Synedra gracilis Kützing; For further synonyms see Hustedt in Rabenhorst (l.c.).

Cholnoky (1960B: 267) maintained that this species required a high salt concentration for its optimal growth. A single specimen of this species was recorded from the Grootvlei Dam (Station 16) where the concentration of total dissolved solids was the highest in the catchment area.

Sample - 401.

S.tenera W. Smith.

1856 - W. Smith: Syn. Brit. Diat. Vol. 2. P.98.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:

211, F. 703.

1930 - Hustedt: Bacillariophyta. P.158, F.182.

S.tenera is found in the neutral to acidic waters (cf.

Cholnoky 1956: 161; 1960B: 267; 1962B: 106) of South Africa.

In the Vaal Dam catchment area only two specimens of this species were recorded.

Samples - 321, 364.

S.ulna (Nitzsch) Ehrenberg.

1838 - Ehrenberg: Infusoria. P.211, T.17, F.1.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
195, F. 691A a - c.

1930 - Hustedt: Bacillariophyta. P.151, F.158, 159.

Synonyms: Bacillaria ulna Nitzsch; Echinella vitrea Bory;
Bacillaria vitrea Bory; Bacillaria paxillum Bory; Bacillaria
Lyngbyei Bory; Frustulia splendens Kützing; Synedra
lanceolata Kützing; Synedra splendens Kützing; Synedra vitrea
Kützing; Synedra mesolepta Kützing; Synedra aequalis Kützing;
Synedra mesocampa Brebisson; Synedra radians W. Smith; Synedra
salina W. Smith; Synedra interrupta Auerswald; Synedra
bicurvata Biene. For further synonyms see Hustedt in Rabenhorst
(l.c.).

S.ulna was one of the most common and one of the most
variable diatom species of the Vaal Dam catchment area. Following
Cholnoky (1962A: 74; 1962B: 106; 1963C: 195) no distinction
between the different varieties has been made.

It has been recorded by Cholnoky (1962A: 74; 1962B: 106;
1962C: 339) in weakly alkaline to relatively alkaline water. For
this reason the waters of the Vaal Dam catchment area rivers were
probably suitable for good growth of this species. In some
samples it occurred with a relatively high percentage frequency.

TABELLARIA Ehrenberg 1839.

T.flocculosa (Roth) Kützing.

1844 - Kützing: Bacill. P.127, T.17, 21.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 2:
29, F. 558.

1930 - Hustedt: Bacillariophyta. P.123, F.101.

Synonyms: Conferva flocculosa Roth; Diatoma flocculosum
Lyngbye; Bacillaria tabellaris Ehrenberg; Tabellaria amphicephala
Ehrenberg; Tabellaria gastrum Ehrenberg; Tabellaria trinodis

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Ehrenberg; Tabellaria flocculosa var. ventricosa Grunow;
Tabellaria flocculosa var. amphicephala Grunow; Tabellaria
flocculosa var. genuina Kirchner.

Cholnoky (1955B: 184; 1957A: 87; 1960B: 268; 1962B: 107)
has found that T.flocculosa grows best in acid waters, since its
pH optimum lies around pH 6; it also requires a high oxygen
content of the water. In the catchment area the species was
recorded from a sample from Lake Chrissie (Vaal 485) and in a
sample from the Kleinvaal River.
Samples - 353, 485.

THALASSIOSIRA Cleve 1873.

T.decipiens (Grunow) Joergensen.

1905 - Joergensen: Hydrogr. Biol. Invest. Norw. Fjords P.96.

1927 - 1964 - Hustedt: Rabenhorsts Kryptogamenflora Teil 1:
322, F. 158.

Synonyms: Coscinodiscus excentricus A.Schmidt; Coscinodiscus
excentricus var? decipiens Grunow; Coscinodiscus decipiens Grunow;
Thalassiosira gelatinosa Hensen; Coscinodiscus excentricus var.
gelatinosa Cleve; Coscinodiscus excentricus var. catenata Gran;
Coscinodiscus gelatinosus Lemmermann.

The single record of this species from the catchment area
is the second time it has been reported from South Africa. Cholnoky
(1962A: 75) has previously recorded it from the Cape Province.
Sample - 344.

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SOME NEW AND RARE
DIATOMS
FROM SOUTH AFRICA

BY
R. E. M. ARCHIBALD

WITH 64 FIGURES

Sonderabdruck aus

BEIHEFTE ZUR NOVA HEDWIGIA, 21



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(R. W. A. Dennis in Kew Bulletin 1952: 98-100)

Die Gattung *Cosmarium*

von Dr. WILLI KRIEGER † u. Dr. JOHANNES GERLOFF (Kustos am Bot. Museum, Berlin-Dahlem).

Lieferung 1: 1962. Groß-Oktav. Seite III-XVIII, 1-112. Tafel 1-23. Eine Abbildung im Text.

Broschiert.

DM 35.- (\$ 8.75)

Dieses Werk war ursprünglich als Teil von KRIEGER's Desmidiaceenbearbeitung im Rabenhorst geplant. Die Grundkonzeption dieses Werkes wurde auch für die Bearbeitung der Gattung *Cosmarium* beibehalten. Aus diesem Grunde wurden auf den beigegebenen Tafeln auch alle infraspezifischen Taxa abgebildet. Der Beschreibung der Arten, die etwa 4-5 Lieferungen ausfüllen wird, folgt ein allgemeiner Teil mit ökologischen Angaben etc. Die Bestellung der ersten Lieferung verpflichtet zum Bezug des gesamten Werkes.

SOME NEW AND RARE
DIATOMS
FROM SOUTH AFRICA

BY
R. E. M. ARCHIBALD

WITH 64 FIGURES

Some new and rare Diatoms from South Africa

By

R. È. M. ARCHIBALD

(Council for Scientific and Industrial Research; National Institute for
Water Research, Grahamstown, South Africa)

With 2 plates

The material which has been investigated in this study was collected from the Vaal River Catchment Area in the districts of Villiers and Standerton, both from the Vaal River itself and from some small tributaries. It was collected in August, 1960, by Dr. B. J. CHOLNOKY and F. M. CHUTTER, both of the Hydrobiological Research Group of the National Institute for Water Research in Grahamstown. The following are brief descriptions of the sampling points from which the material was collected: —

- Vaal 401. Grootvlei — a colliery dam situated on the road between Balfour and Villiers. pH 8.5.
- Vaal 402. Stream from the Grootvlei colliery dam, sample taken from under the bridge at the point where the road from Balfour to Villiers crosses the stream. pH 8.7.
- Vaal 403. The Vaal River below the bridge on the north side of Villiers on the main national road to Johannesburg, pH 8.6.
- Vaal 404. A small stream east of Villiers, about 5—7 Km from the town on the road to Standerton. The stream was drying up, and the water was not flowing. pH 8.6.
- Vaal 405. Another stream 1.5 Km further east from Vaal 404. Large pools in a dry stream bed. pH 8.7.
- Vaal 406. The Vaal River where it is crossed by the Villiers-Standerton road. There were growths of a *Cladophora* sp. on the stones. pH 8.7.
- Vaal 407. The same locality; slowly moving water on a wall. pH 8.7.
- Vaal 408. A small stream about 3 Km east of Vaal 406. The stream had a rocky bed, and the water was not flowing. pH 8.6.
- Vaal 409. A small swampy stream between Vaal 407 and Standerton. There was a large amount of algal growth on the surface of the water.

Vaal 485. A swamp between Lake Chrissie and the road to the village of Chrissie. It was entirely covered with reeds and other partly submerged plants. pH 7.0.

The diatom species found in this material are very interesting, and a number of new species, which are described in this paper, were discovered. There were also a few species whose systematic position was unclear and I have commented on these in an attempt to clarify their systematic position. The material includes new diatom records for South Africa. These are discussed.

I wish to acknowledge my thanks and indebtedness to the following people: —

Dr. G. J. STANDER, Director of the National Institute for Water Research, by whom this study was made possible; Professor E. S. TWYMAN, Head of the Department of Botany, Rhodes University, Grahamstown, through whose kind permission the facilities of his Department were made available to me; and in particular to Dr. B. J. CHOLNOKY, for his help and advice.

The interesting species found in the material investigated are enumerated below, with comments. Descriptions of the new species are also given in this section.

CYMBELLA AGARDH 1830

Cymbella aequaloides n. sp.

This diatom bears a superficial resemblance to *C. aequalis* W. SMITH (cf. HUSTEDT, 1955:52), but differs from it in having dorsally turned polar fissures, and a one-sided central area on the dorsal side. In fact, it is more closely related to *C. amphicephala* NAEGELI (cf. HUSTEDT, A. S. Atl. T. 377, F. 31—41; CHOLNOKY, 1960:31). However, on account of the more lanceolate shape of the valve, and since the central area is unilateral and extends to the margin of the valve, I am obliged to describe these specimens as a new species. This species is also slightly more finely striated, having 18 striae in 10 μ . The valves are naviculoid, almost symmetrical, lanceolate, with short protracted ends, the ends being bent slightly ventrally. The valves are about 23 μ long, and about 5 μ wide, but the complete range of variation cannot be given as too few specimens were seen. The raphe is almost straight and only slightly excentric, with small dorsally bent polar fissures. The axial area is narrow and linear, the central area is unilateral and extends to the valve edge on the dorsal side, and on the ventral side the striae are only slightly shortened in the middle. The transapical striae are radial throughout, 18 in 10 μ , becoming gradually closer together towards the poles. — Fig. 1. — Vaal 408.

Valvae naviculiformes, paene symmetricae, apicibus breviter protractis, in sensu ventrale levissime declinatis, circiter 23 μ longae, 5 μ lataeque.

Rhaphe fere directa et haud excentrica fissuris terminalibus brevibus, in directione dorsale declinatis. Area axialis anguste linearis, area centralis vitta una unilateralis marginem dorsalem valvae attingens, in latere ventrale abbreviatione leve striarum medianarum nonnullarum significata. Striae transapicales in tota longitudine valvae radiantes, in media parte lateris dorsalis 18 in 10 μ , ad polos versus densior positae.

Habitat in rivulo uno circiter 3 Km ad orientem versus ab ponte super fluvio Vaal inter pagos Villiers et Standerton Africae Meridionalis.

Typus: praeparatum No. Vaal 408 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 1.

FRUSTULIA GRUNOW 1865

Frustulia subvulgaris CHOLNOKY (1959:27, F. 160.)

Two specimens of this species have been illustrated in the plates, which, although generally agreeing with the original diagnosis of CHOLNOKY, show slight differences which necessitate minor alterations of the original description. In the original description CHOLNOKY gave the dimensions as 27–33 μ long, about 6 μ wide, and having about 30 striae in 10 μ . Later CHOLNOKY (1962a:74) altered his diagnosis to widen the range of variation. His new dimensions were 20–33 μ long, 5–6 μ wide, and 30–36 striae in 10 μ . The specimen from Lake Chrissie (Vaal 485) is small and has over 40 striae in 10 μ , which are so fine that they are invisible with the ordinary light microscope. The second specimen, from sample Vaal 406 (Fig. 3) is broader than previously described specimens, being 7.5 μ wide. The original diagnosis must therefore be amended to 20–33 μ long, 5–7.5 μ wide, and 30 – over 40 striae in 10 μ . — Fig. 2, 3. — Vaal 485, 406.

GOMPHONEMA AGARDH 1824

Gomphonema dichotomum KÜTZING emend. ARCHIBALD

From a study of the drawings in A. SCHMIDT's Atlas (Pl. 234, F. 47–50, 56–57, 58; Pl. 235, F. 15–17, 34–39; Pl. 236, F. 1–8) and GRUNOW's drawings in VAN HEURCK (1880–1881: Pl. 24, F. 28–29, 35–36) it is clear that there is only a superficial similarity between *G. intricatum* KÜTZING and its variety var. *pumila* GRUNOW. This is supported by CHOLNOKY (1962a:75) who says „Ich halte es für sehr wahrscheinlich, daß diese kleinen Formen nur auf Grund einer recht oberflächlichen morphologischen Ähnlichkeit zu *G. intricatum* gestellt wurden.“ *G. intricatum* var. *pumila* is a small diatom and occurs very much more frequently than the typical form, which is much larger. I feel therefore that the variety should be raised to the rank of a true species. Having done this the position of the variety *G. intricatum* var. *dichotoma* (KÜTZING) GRUNOW must also be discussed. HUSTEDT 1937–39,

Suppl. 15:436) states that „die kleinen Formen var. *pumila* und var. *dichotoma* sind kaum voneinander zu trennen. Sie kommen im Material meistens nebeneinander vor; . . .“. In fact the only difference between the two varieties is the number of striae (cf A. S. Atl. Pl. 234, F. 51–55; Pl. 235, F. 30–33). Var. *pumila* has 8–11 striae and var. *dichotoma* has 11–13 striae in 10 μ . In CHOLNOKY's experience var. *pumila* in fact has up to 16 striae in 10 μ . It seems clear, therefore, that these two varieties intergrade and should be united. The oldest valid name which can be applied to this new combination is *Gomphonema dichotomum* KÜTZING. I propose, therefore, that the name for this variety which has been raised in status to species shall be *Gomphonema dichotomum* KÜTZING emend. ARCHIBALD because the var. *pumila* has been incorporated. — Fig. 4. — Vaal 406.

NAVICULA BORY 1824

Navicula adamantiformis n. sp.

This species falls into the group Naviculae minusculae CLEVE emend. HUSTEDT, and in general appearance resembles *N. perpusilla* GRUNOW (cf. HUSTEDT, 1962: 213, F. 1330). It differs from *N. perpusilla* in the more widely arranged striae and the very widely separated central pores. Those valves seen, are rhombic-lanceolate to rhombic-ovate, with very broad and rounded ends, which are not protracted, 6–8.5 μ long, 4.5 μ wide. As few examples were seen the full range of variation is not known. The raphe is straight and filiform with central pores relatively widely separated. The axial area and central area combine to form a very wide lanceolate or elliptical area. The transapical striae are very short, radial at the poles, becoming less so towards the middle of the valve, where the striae are parallel, 23–28 striae in 10 μ . Longitudinal striae are not visible. — Fig. 5, 6. — Vaal 401, and 403.

Valvae rhomboideo-lanceolatae sive rhomboideo-ellipticae apicibus late, regulariterque rotundatis, non protractis, 6–8.5 μ longae, circiter 4.5 μ latae. Rraphe directa, filiformis, poris centralibus in relatione valde distantibus. Area axialis late lanceolata sive elliptica, area centralis nulla. Striae transapicales brevissimae, in media parte valvae modice, ad polos versus valde radiantes, 23–28 in 10 μ . Costae longitudinales invisibiles.

Habitat in lacu artificiale Grootvlei-Dam dicto et in emissario ei putei carbonis uni inter pagos Balfour et Villiers Africae Meridionalis.

Typus : praeparatum No. Vaal 401 in collectione C. S. I. R., Grahamstown.

Iconotypus : figurae nostrae No. 5 et 6.

Navicula aquosa n. sp.

This species belongs to the Naviculae bacillares CLEVE emend. HUSTEDT, since it has an axial rib running down the centre of the valve, although in

this species the rib is not very well developed. It shows a very close affinity to *N. omissa* HUSTEDT (1961: 160, F. 1295) but is separated from this species by parallel striation at the poles, which are not produced. The valves are elliptical to linear-elliptical with blunt and broadly rounded ends, 12–13 μ long, 4–5 μ wide. The full range of variation is not known since only 3 specimens were seen. The raphe is filiform, with slightly bent branches. The axial area is narrow and linear and does not widen, or widens very slightly into a central area round the central nodule. The transapical striae are radial in the middle and parallel or less radial in the vicinity of the poles, 24 in 10 μ . Longitudinal costae are present but not very prominent. — Fig. 7,8. — Vaal 408.

Valvae ellipticae sive lineari ellipticae, apicibus late regulariterque rotundatis, non protractis, 12–13 μ longae, 4–5 μ latae. Fissurae raphae leviter arcuatae, filiformes. Area axialis anguste linearis, area centralis nulla sive dilatatione solum modica areae axialis apud nodulum centralem indicata. Striae transapicales radiantes in parte mediana valvae, sed parallelae sive minor radiantes ad polos versus, circiter 24 in 10 μ . Costae longitudinales indistinctae vix visibiles.

Habitat in rivulo uno circiter 3 Km ad orientem versus ab ponte viae publicae super flumine Vaal inter pagos Villiers et Standerton Africae Meridionalis.

Typus: praeparatum No. Vaal 408 in collectione C. S. I. R., Grahams-town.

Iconotypus: figurae nostrae No. 7 et 8.

Navicula barbarica HUSTEDT (1949: 97, T. 4, F. 14–17)

This small diatom has not been previously recorded from South Africa. It was originally described from the Belgian Congo by HUSTEDT, and HUSTEDT's record was reported again by WOODHEAD and TWEED (1958: 350), and also by VAN MEEL (1954: 372). This specimen agrees in every detail with the original diagnosis of HUSTEDT and there is therefore no doubt that this is *N. barbarica* HUSTEDT. — Fig. 9. — Vaal 404.

Navicula chrissiana CHOLNOKY (1965: 69, F. 13, 14).

This species was originally recorded from Lake Chrissie in the Eastern Transvaal by Cholnoky. — Fig. 30, 31. — Vaal 485.

Navicula chordata n. sp.

This small and finely structured species is similar to *N. perpusilla* GRUNOW (cf. HUSTEDT, 1962: 213, F. 1330) but differs from it in the shape of the valve and the arrangement of the striae, the valve being linear and the striae radial in the middle and parallel or less radial at the poles. The valve is linear-elliptic with broadly rounded ends which are not produced, 14 μ long, and 3 μ wide. The raphe is straight and filiform with distant central pores.

The axial area suddenly widens into a relatively wide but linear area, which widens again around the central nodule to form an elliptical central area. The transapical striae are fine in structure, 30 in 20 μ , radial in the middle and becoming less radial at the poles. — Fig. 10. — Vaal 485.

Valvae lineari-ellipticae, apicibus late, regulariterque rotundatis, non protractis, circiter 14 μ longae, 3 μ latae. Rhaphe directa filiformis, poris centralibus distantibus. Area axialis apud polos subito dilatata et in partibus reliquis late linearis. Area centralis abbreviacione striarum apud nodulum centalem formata, elliptica. Striae transapicales subtiles, circiter 30 in 10 μ , in partibus medianis valvae radiantes, ad polos versus minor inclinatae sed radiantes.

Habitat in palude inter lacum Chrissie et viam publicam in coloniam Chrissie dictam ferentem in vicinitate pagi transvaalensis Ermelo Africae Meridionalis.

Typus: praeparatum No. Vaal 485 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 10.

Navicula confervacea (KÜTZING) GRUNOW (cf. HUSTEDT, 1962: 205, F. 1324a–d).

Morphologically the specimen figured is without doubt *N. confervacea* (KÜTZING) GRUNOW. The valve is elliptical-lanceolate, with broadly rounded ends. The axial area and central area form an ill-defined lanceolate space. The transapical striae are fine but clearly punctate. This particular specimen has, however, dimensions very much larger than those given by HUSTEDT (l. c.). The valve is 35 μ long, 10 μ wide, and has 16 striae in 10 μ . — Fig. 12. — Vaal 409.

Navicula digitulus HUSTEDT (1962:252, F. 1378)

There is no doubt that these specimens (Fig. 14, 15) are *N. digitulus* HUSTEDT. This is a new record for South Africa. This species has previously been found only in northern European mountainous regions. — Fig. 14, 15. — Vaal 485.

Navicula diuturna CHOLNOKY (1962a:83, F. 8, 9)

This small species has until now only been recorded from a small tributary of the Crocodile River near Nelspruit, in the Eastern Transvaal. The present specimen was found in the Heidelberg district, in a stream flowing from a colliery dam. — Fig. 16. — Vaal 402.

Navicula diuturnoides n. sp.

This small but common diatom looks very like *N. diuturna* CHOLNOKY (1962a:83, F. 8, 9), but has fewer striae and is never protracted at the poles. It also bears a similarity to *N. tenellaeformis* HUSTEDT (1937–39: Suppl. 15, 269, T. 19, F. 14, 15) but differs from it in that the valve is more, elliptical,

has no central area and the striae are parallel at the poles and of greater number than in *N. tenellaeformis* HUSTEDT. The valves are linear to linear-elliptical with broadly rounded ends, 8–11 μ long, and 3.0–3.5 μ wide. The raphe is straight and filiform, with small fairly closely situated central pores. The axial area is narrow and linear and does not widen into a central area in the region of the central nodule. The transapical striae are delicate but easily seen, radial in the middle and parallel or slightly convergent at the ends, 24 in 10 μ . — Fig. 17–23. — Vaal 405, 409 and 485.

Valvae lineares, sive lineari-ellipticae, apicibus late regulariterque rotundatis, non protractis, neque acutis, 8–11 μ longae, 3–3.5 μ latae. Rhaphe directa, filiformis, poris centralibus parvis, modice approximatis. Area axialis angustissime linearis, area centralis nulla, neque abbreviatione striarum medianarum indicata. Striae transapicales subtiles sed distinctae, in media parte valvae radiantes, ad polos versus parallelae, sive leviter convergentes, circiter 24 in 10 μ .

Habitat in rivulis parvis in vicinitate pagorum transvaalensium Standerton et Ermelo Africae Meridionalis.

Typus: praeparatum No. Vaal 409 in collectione C. S. I. R., Grahamstown.

Iconotypus: figurae nostrae No. 17–23.

Navicula Grimmei KRASSKE (cf. HUSTEDT, 1930:274, F. 448)

The shape of the valve is very variable in this species. HUSTEDT depicts a very elliptical form with capitate ends. CHOLNOKY (1963: 34, F. 13, 14) shows the other extreme in the range, a rhombic-lanceolate valve with non-protracted ends. The specimen seen here has a linear valve with fairly large protracted and capitate ends. Fig. 24 — Vaal 485.

Navicula helensoides n. sp.

Since it has a very prominent axial rib, this new species belongs to the group *Naviculae bacillares* CLEVE emend. HUSTEDT. It differs from *N. helensis* SCHULZ (cf. HUSTEDT, 1962: 179, F. 1314) in that it does not have a lateral area which runs parallel to the axial costae, and since the striae in the middle are radial and not parallel as in *N. helensis* SCHULZ. The valves are linear with very broadly rounded and blunt ends, 18.5 μ long, and 6 μ wide. The raphe is straight and filiform, the central pores are fairly close together, and the polar fissures bend slightly towards the same side. The axial area is linear and narrow, widening into a central area owing to the irregular shortening of the central striae. The axial rib running down the centre of the valve is prominent. The transapical striae, 22 in 10 μ , are radial throughout and slightly arcuate towards the centre of the valve. — Fig. 25. — Vaal 485.

Valvae lineares, apicibus late, leviter obtuse rotundatis, non protractis, 18.5 μ longae, 6 μ latae. Rhaphe directa, filiformis, poris centralibus

approximatis, fissuris terminalibus unilateraliter leviter declinatis. Area axialis anguste linearis, area centralis abbreviatione irregulare striarum medianarum nonnullarum formata. Costa axialis raphen ferens distinctissima et distinctissime definita. Striae transapicales in tota longitudine valvae radiantes, in vicinitate noduli centralis leviter arcuatae, circiter 22 in 10 μ , neque ad polos versus densior positae.

Habitat in palude uno inter lacum Chrissie et viam publicam in coloniam Chrissie dictam ferentem in vicinitate pagi Transvaalensis Ermelo Africae Meridionalis.

Typus: praeparatum No. Vaal 485 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 25.

Navicula longicephala HUSTEDT (1943: 277, T. 8, F. 17)

The specimen illustrated here is undoubtedly *N. longicephala* HUSTEDT according to its general morphological characteristics. However it shows one small difference in that its valves have very slightly undulate margins, instead of the straight and parallel walls described by HUSTEDT (l. c.). — Fig. 28. — Vaal 485.

Navicula manubialis n. sp.

This species falls into the group *Naviculae bacillares* CLEVE emend. HUSTEDT on account of the well developed axial rib. The general appearance of the valve is similar to *N. fluvialis* HUSTEDT (1961: 158, F. 1291). It differs from this species in not having the constricted middle section of the axial area. The valve is linear-elliptical with fairly broadly rounded ends, about 12 μ long, and 4.5 μ wide. The raphe is straight and filiform, and it lies in a better developed axial rib. The axial area is narrow and linear and does not widen around the central nodule to form a central area. The transapical striae are radial throughout, 21–24 in 10 μ , wider apart in the middle than at the poles. — Fig. 29. — Vaal 406.

Valvae lineari-ellipticae, apicibus late, regulariterque rotundatis, non protractis, circiter 12 μ longae, 4.5 μ latae. Rraphe directa, filiformis, in costa axiale bene evoluta, distinctissima, in media parte non contracta inclusa. Area axialis angustissime linearis, superficiem costae axialis solum occupans, neque apud nodulum centrale dilatata, itaque area centralis nulla. Striae transapicales in tota longitudine valvae radiantes, in vicinitate noduli centralis 21–24 in 10 μ , ad polos versus notabiliter densior positae.

Habitat in aquis celeriter fluentibus fluvii Vaal sub ponte viae publicae inter pagos Villiers et Standerton Africae Meridionalis.

Typus: praeparatum No. Vaal 406 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 29.

Navicula molesta KRASSKE (cf. HUSTEDT, 1962: 252, F. 1379)

This species has until now been reported only as an arctic freshwater form, being found in Spitzbergen. The specimens found in Lake Chrissie fit HUSTEDT's description very well and leave little doubt that they are *N. molesta* KRASSKE. Some specimens are, however, a little larger, being up to 21 μ long, and some have protracted but not capitate ends (Fig. 32). HUSTEDT remarks that *N. submolesta* HUSTEDT (1962: 253, F. 1380) is very similar and is found only in tropical Africa; but the Lake Chrissie examples are much larger than *N. submolesta* HUSTEDT and have a greater number of striae. These specimens are undoubtedly *N. molesta* KRASSKE. — Fig. 32, 33. — Vaal 485.

Navicula parsura HUSTEDT (1962: 183, F. 1365)

This small species has not previously been found in South Africa. In the specimen figured here, the central striae are more definitely radial than those shown by HUSTEDT (l. c.) — Fig. 35. — Vaal 485.

Navicula pascuorum CHOLNOKY (1965: 72, F. 5, 6)

This diatom is found in the Lake Chrissie area. — Fig. 26. — Vaal 485.

Navicula scabellum HUSTEDT (1962: 275, F. 1405)

This is a very small form from the Lake Chrissie area. Only a few specimens were seen. — Fig. 36. — Vaal 485.

Navicula Schubarti HUSTEDT nov. var. *africana*

As HUSTEDT (1952: 396, F. 104) gives the length of *N. Schubarti* HUSTEDT as 40 μ , without mentioning any range of length, it would appear that he saw only one or, at the most, very few specimens. This length may, therefore, not be sufficient to define the whole range of variation for the species. The specimens seen in this sample cannot be morphologically differentiated from the description given by HUSTEDT; they differ only in their dimensions. These specimens are 30–34 μ long, and about 7 μ wide, and have 12–14 striae in 10 μ . These African examples should therefore be made a new variety, var. *africana*, with the reservation that should specimens be found which are intermediate, this new variety should be contracted to *N. Schubarti* HUSTEDT. *N. Schubarti* HUSTEDT has until now only been found in Brazil. — Fig. 13. — Vaal 406, 408.

Differt a typo valvis minoribus, 30–34 μ longis, circiter 7 μ latis, et striis densioribus, 12–14 in 10 μ .

Habitat in aquis celeriter fluentibus fluvii Vaal sub ponte viae publicae inter pagos Villiers et Standerton Africae Meridionalis.

Typus: praeparatum No. Vaal 406 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 13.

Navicula Standeriella n. sp.

This species shows a very close similarity to *N. insociabilis* (cf. HUSTEDT, 1962: 183, F. 1317, under the name *N. monoculata* HUSTEDT; CHOLNOKY, 1960: 66, F. 209), and thus falls into the group *Naviculae bacillares* CLEVE emend. HUSTEDT. It differs from *N. insociabilis* KRASSKE in the shape of the valve, the central area and the number of striae. This species has a linear valve with blunt and broadly rounded ends, 11–19 μ long, and 4–5 μ wide. The raphe branches are slightly bent and the small polar fissures bend towards the same side. The raphe lies in a fairly well thickened axial costa. The axial area is narrow and linear and due to a shortening of the middle transapical striae, a more or less rectangular shaped central area is formed. The transapical striae are delicate and radial throughout, 20–22 striae in 10 μ . Between the axial costa and the valve edge, a hyaline line, probably a thickened longitudinal rib, cuts across the striae; this line bulges out towards the valve edge in the region of the central area. Closer to the axial costa on either side of the central area a further short hyaline line cuts across the first two or three transapical striae. This species was named in honour of Dr. G. J. STANDER, Director of the National Institute for Water Research, through whom this study was made possible. — Fig. 37, 38. — Vaal 402.

Valvae lineares, sive lineari-ellipticae, apicibus late obtuseque rotundatis, 11–19 μ longae, 4–5 μ lataeque. Fissurae raphae in costa axiale una distinctissima inclusae, levissime arcuatae, fissuris terminalibus unilateraliter declinatis. Area axialis anguste linearis, superficiem costae axialis solum occupans, area centralis abbreviatione striarum medianarum nonnullarum formata, irregulariter rectangularis. Striae transapicales subtiles et in tota longitudine valvae radiantes, 20–22 in 10 μ . Inter costam axialem et marginem valvae linea una longitudinalis hyalina, costa longitudinalis incrassata forsan, strias transapicales decussat, quae in vicinitate noduli centralis ad marginem valvae versus convexae semicirculariter decurrit. In vicinitate areae centralis, area axialis approximata, linea longitudinalis brevis una secunda striis transapicalibus transversaria visibilis est.

Habitat in aquis rivuli uni ex lacu artificiali Grootvlei-Dam orientis, sub ponte viae publicae inter pagos Balfour et Villiers Africae Meridionalis.

Typus: praeparatum No. Vaal 402 collectionis C. S. I. R., Grahams-town.

Iconotypus: figurae nostrae No. 37 et 38.

Navicula subarvensoides n. sp.

Because of the invisible structure of the valve at the poles, this small diatom, of which only one specimen was found, falls into the group *Naviculae subtilissimae* HUSTEDT. It resembles *N. subarvensis* HUSTEDT (1961: 87,

F. 1230) from which it differs in the shape of the valve, the invisibility of the striae at the poles, and the straight raphe. The valve is lanceolate with slightly produced, but not capitate, ends about $11\ \mu$ long and $3\ \mu$ wide. The raphe is straight and filiform. The axial area is narrow and linear and does not widen in the middle to form a central area. The structure is delicate and the transapical striae are slightly radial throughout the middle third part of the valve, about 30 striae in $10\ \mu$, becoming invisible towards the poles. — Fig. 39 — Vaal 408.

Valvae lanceolatae, apicibus leviter protractis, non capitatis, regulariter rotundatis, circiter $11\ \mu$ longae, $3\ \mu$ latae. Rraphe directa, filiformis. Area axialis angustissime linearis, apud nodulum centralem non dilatata, itaque area centralis nulla. Striae transapicales in media parte valvae solum visibiles, subtiles, apud nodulum centralem circiter 30 in $10\ \mu$, ad polos versus densior positae, plus quam 40 in $10\ \mu$, itaque invisibiles.

Habitat in rivulo uno circiter 3 Km ad orientem versus ab ponte viae publicae super fluvio Vaal inter pagos Standerton et Villiers Africae Meridionalis.

Typus: praeparatum No. Vaal 408 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 39.

Navicula subcoccus CHOLNOKY (1960: 80, F. 247, 248)

This species was recorded by CHOLNOKY from the Oribi Gorge area near Port Shepstone in Natal, where the species was common. This specimen was found in Lake Chrissie, in the Eastern Transvaal. — Fig. 40 — Vaal 485.

Navicula submolesta HUSTEDT (1962: 253, F. 1380) emend. ARCHIBALD.

In the sample Vaal 404 a series of valves were seen, in which the shape of the valve and its size is very constant. They are linear-lanceolate to elliptical-lanceolate, with a length of $21-21.5\ \mu$ and a width of $6.0-6.5\ \mu$. These features and the widely spaced central pores, constant in all of the them, make it evident that they all belong to the same species. However, in the arrangement of their transapical striae the series shows a range extending from a typical *N. submolesta* HUSTEDT having in the middle about 18 striae in $10\ \mu$ and at the poles 21 striae in $10\ \mu$ (Fig. 65a), through an intermediate form having 21 striae in the middle and 30 striae at the poles in $10\ \mu$ (Fig. 65b), to a typical *N. molestiformis* HUSTEDT (1962: 256, F. 1383) which has 27 striae in $10\ \mu$ in the middle and about 34 striae in $10\ \mu$ at the poles (Fig. 65c). HUSTEDT saw only a few specimens of both *N. molestiformis* HUSTEDT and *N. submolesta* HUSTEDT and would therefore not have been able to determine the full range of variation of the species concerned. Thus although the specimens found here are larger and broader, morphologically they represent a series linking HUSTEDT's two species. Since *N. submolesta* was

the first species described in the original paper (HUSTEDT, 1949: 86) and since it occurs more frequently than *N. molestiformis*, the two species have been contracted into one with the name *N. submolesta* HUSTEDT emend. ARCHIBALD. The following will then be the new diagnosis. The valves are thin-walled, linear, linear-lanceolate to elliptical-lanceolate, with short protracted ends, 14–21 μ long, 3.5–6.5 μ wide. The raphe is straight and filiform, sometimes with central pores widely separated. The axial area is narrow and linear, the central area is absent. The transapical striae are parallel throughout, in the middle 17–30 in 10 μ , at the poles closer together, 21 to 35 in 10 μ . Fig. 34 and in the text 65 a, b, and c. — Vaal 404 and 408.

Navicula temeraria CHOLNOKY (1965: 73, F. 28, 29)

The specimen figured (Fig. 11), although undoubtedly *N. temeraria* CHOLNOKY, shows some differences. The specimen seen has very thick raphe branches which end at the poles in much thinner polar fissures, which are slightly bent in the same direction. This specimen is also slightly longer than CHOLNOKY's specimen, being 16 μ long. — Fig. 11 — Vaal 485.

Navicula Twymaniana n. sp.

The affinities of this new species are difficult to determine, as it is not easy to relate it to any species known to me. In appearance it is similar to *N. subarvensoides* n. sp. but in size and structure of the transapical striae it is quite different. The valves of this species are lanceolate and sometimes slightly produced at the poles, 12–18 μ long, and 3.5–5.0 μ wide. The raphe is straight and filiform. The axial area is narrow and linear and does not widen in the region of the central nodule to form a central area. The structure is delicate, and the transapical striae in the middle third part of the valve are visible and parallel, about 27 in 10 μ . In the remaining parts of the valve towards the poles the striae are invisible, probably over 40 striae in 10 μ . This species is dedicated to Professor E. S. TWYMAN, Head of the Department of Botany, Rhodes University, Grahamstown, through whose kind permission the facilities of his Department have been made available to me. Fig. 41–43. — Vaal 405, 408.

Valvae lanceolatae, apicibus non, sive nonnumquam leviter, 12–18 μ longae, 3.5–5 μ latae. Rhaphe directa, filiformis. Area axialis anguste linearis, neque apud nodulum centralem dilatata, itaque area centralis nulla. Striae transapicales subtiles, parallelae, in parte tertia mediana valvarum solum visibiles, apud nodulum centralem circiter 27 in 10 μ , ad polos versus densior positae, usque ad plus quam 40 in 10 μ , itaque invisibiles.

Habitat in rivulo uno circiter 8 Km ad orientem versus ab pago Villiers sub ponte viae publicae ad pagum Standerton Africae Meridionalis ferentem.

Typus: praeparatum No. Vaal 405 in collectione C. S. I. R., Grahamtown.

Iconotypus: figurae nostrae No. 41–43.

NITZSCHIA HASSALL 1845

Nitzschia Agnewii CHOLNOKY (1962 a: 94, F. 18, 19)

This specimen of *N. Agnewii* CHOLNOKY is larger than the dimensions given by CHOLNOKY, being 25 μ long, and 2.5 μ wide, and it has only 13 carinal pores in 10 μ . Due to its smaller measurements and since it is very weakly silicified it is not considered to be *N. agnita* HUSTEDT (1957: 347, F. 51) — Fig. 44 — Vaal 408.

Nitzschia bacata HUSTEDT (1937—1939: Suppl. 15, 485, T. 41, F. 30—33)

This diatom is fairly common in South African rivers. — Fig. 45, 46. — Vaal 406.

Nitzschia Chutteri n. sp.

This species has longitudinal folds of the valve wall and therefore falls into the group *Nitzschiae tryblionellae* GRUNOW. It is very similar to *N. punctata* (W. SMITH) GRUNOW (cf. HUSTEDT, 1930: 401, F. 762) but differs primarily in the number of transapical striae and carinal pores, and in the number of folds of the valve surface. This species also closely resembles *N. subpunctata* CHOLNOKY (1960: 104, F. 314), but differs from that species in having longitudinal folds of the valve surface, which are not present in *N. subpunctata*. The valve is linear-elliptical to elliptical-lanceolate with very shortly protracted poles, 15–19 μ long, and about 6.5 μ wide. The keel is excentric and not prominent, the carinal pores are not distinct and may be the same number as the transapical striae. The transapical striae are parallel in the middle, slightly arcuate nearer the poles, 16–18 (generally 18) in 10 μ . The striae are very clearly punctate. There are two longitudinal folds of the valve surface, the larger and more prominent fold lying near the keel, and the smaller one very close to the margin of the valve opposite the keel. This species was named after F. M. CHUTTER, who very kindly collected most of the samples. Fig. 47, 48. — Vaal 401, 402 and 404.

Valvae lineari-ellipticae, sive lanceolato-ellipticae, apicibus brevissime protractis, non capitatis, 15–19 μ longae, circiter 6.5 μ latae. Carina excentrica, moderate evoluta, pori carinales indistinctae, probabiliter numerus eorum numero striarum aequabilis. Striae transapicales in parte mediana valvae parallelae, ad apices versus leviter arcuatae, 16–18 (fere 18) in 10 μ , distincte punctatae. Superficies valvae cum rugis duobus munita, quarum una carina approximata est, altera minor evoluta, apud marginem valvae carina remotum decurret.

Habitat in lacu artificiali putei uni carbonis Grootvlei dicto inter pagos Balfour et Villiers Africae Meridionalis.

Typus: praeparatum No. Vaal 401 in collectione C. S. I. R., Grahams-town.

Iconotypus: figurae nostrae No. 47 et 48.

Nitzschia confinis HUSTEDT (1949: 145, T. 11, F. 49—54; T. 13, F. 84—90)

This species is fairly common in South Africa. The specimen seen here is slightly different from HUSTEDT's material, having only 27 transapical striae in 10 μ . The specimen agrees with the rest of the description, being 30 μ long, 2.5 μ wide and having 14 carinal pores in 10 μ . — Fig. 53 — Vaal 409.

Nitzschia crassepunctata n. sp.

This fairly large species falls into the group *Nitzschia dubiae* GRUNOW, and shows some similarity to *N. thermalis* KÜTZING (cf. HUSTEDT, 1930: 403, F. 771), but differs from this species in its greater number of striae and very large carinal pores. The valve is linear, with protracted, almost capitate ends, in some positions („Kiellage“) bending slightly towards the side away from the keel, 48.5 μ long, and 4.5 μ wide. The keel is prominent and excentric and has very large prominent carinal pores elongated in the direction of the apical axis, 10 in 10 μ . The keel is constricted in the middle and the two central carinal pores are slightly more distant than the others. The transapical striae are very fine and delicate, about 40 in 10 μ . — Fig. 49. — Vaal 403.

Valvae lineares, apicibus conice attenuatis, protractis, paene subcapitatis, in situ „Kiellage“ dicto ad marginem carina carentem valvae declinatis, 48.5 μ longae, 4.5 μ latae. Carina valde excentrica, bene evoluta, poris carinalibus magnis, apicaliter elongatis, circiter 10 in 10 μ , medianis duobus distantioribus. Carinae parte mediana constricta et emarginata. Striae transapicales subtiles et modice distinctae, circiter 40 in 10 μ .

Habitat in fluvio Vaal sub ponte viae publice ad oppidum Johannesburg ferentem in limitibus borealibus pagi Villiers in Africa Meridionale.

Typus: praeparatum No. Vaal 403 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 49.

Nitzschia diluta n. sp.

This species, of which only a few specimens were seen, falls into the group *Nitzschia lanceolatae* GRUNOW and has a likeness to *N. palea* (KÜTZING) W. SMITH (cf. HUSTEDT, 1930: 414, F. 801). It differs from *N. palea* in having fewer striae. It also shows a similarity to *N. accomodata* HUSTEDT (1949: 139, T. 12, F. 27—31, 34, 35), but differs from this species in its size. *N. accomodata* is shorter and relatively broader than the new species. The valve is linear with short cuneate and more or less capitate poles; length 48 μ , and width 3 μ . The keel is strongly excentric, not depressed in the middle, with about 14 carinal pores in 10 μ , of which the middle two are not wider apart than the others. The transapical striae fine, 33 in 10 μ . — Fig. 50. — Vaal 405.

Valvae lineares, apicibus breviter cuneato-attenuatis, capitatis, sive subcapitatis, 48 μ longae, 3 μ latae. Carina valde excentrica, bene evoluta, in

media parte non impressa, neque emarginata, poris carinalibus circiter 14 in 10 μ , quorum mediani duo non distantior positi. Striae transapicales subtiles sed distinctae, circiter 33 in 10 μ .

Habitat in rivulo uno circiter 8 Km ad orientem versus ab pago Villiers sub ponte viae publicae ad pagum Standerton Africae Meridionalis ferentem.

Typus: praeparatum No. Vaal 405 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 50.

Nitzschia intermissa HUSTEDT (1949: 136, T. 12, F. 11–14)

This species has not been frequently recorded, but since CHOLNOKY (1960: 96, F. 283–285) found it quite often in Natal rivers, it may be more widespread in South Africa than is at present known. It has also been found in the Eastern Transvaal (CHOLNOKY, 1962 a: 97). — Fig. 51. — Vaal 403.

Nitzschia proxima HUSTEDT (1955: T. 16, F. 13)

This is not a very common diatom in South Africa, where CHOLNOKY has found it only in the Western Cape Province (CHOLNOKY, 1959: 58, F. 311, 312; 1962 b: 59, F. 94, 95). My specimen agrees with the smaller measurements given by CHOLNOKY. — Fig. 54. — Vaal 405.

Nitzschia romana GRUNOW (cf. HUSTEDT, 1930: 415, F. 799)

In the sample Vaal 409 many examples of this species are to be seen, and a series of drawings has been made to illustrate the very wide range of variation of the form of the valve. The valve ranges from linear to lanceolate in shape. The ends are produced and sometimes capitate, sometimes cone-like, or in other cases may be beak-like or only very slightly produced. The dimensions of the valve range from 15–46 μ long, 2.5–5 μ wide, there being 12–14 carinal pores in 10 μ , and 24 transapical striae in 10 μ . — Fig. 55–61. — Vaal 405 and 409.

Nitzschia siliqua n. sp.

This species belongs to the group of Nitzschiae which are similar to *N. amphibia* GRUNOW (cf. HUSTEDT, 1930: 414, F. 793). I have, however, been unable to associate it with *N. amphibia* or any other species of the group known to me. The valve is linear with parallel sides and cuneate poles which are protracted into slightly capitate ends, 22–23 μ long, and about 3 μ wide. The keel is not easily distinguishable from the rest of the structure and the carinal pores are either not visible or are of the same number as the transapical striae. The transapical striae are coarse and easily seen, 16–18 in 10 μ . Longitudinal costae are visible and straight, about 27 in 10 μ . — Fig. 62. — Vaal 402.

Valvae lineares, marginibus parallelis, apicibus cuneato-attenuatis, protractis, levissime capitatis, 22–23 μ longae, circiter 3 μ latae. Carina non

bene visibilis, pori carinales indistinctae, probabiliter striis aequidistantes. Striae transapicales crassae, distinctissimae, 16–18 in 10 μ . Costae longitudinales distinctae, directae, circiter 27 in 10 μ , itaque striae ex punctis distinctis compositae esse conspiciuntur.

Habitat in decurso lacus artificiali putei uni carbonis Grootvlei dicti inter pagos Balfour et Villiers in Africa Meridionale.

Typus: praeparatum No. Vaal 402 in collectione C. S. I. R., Grahams-town.

Iconotypus: figura nostra No. 62.

Nitzschia subacicularis HUSTEDT (1937–1939, Suppl. 15: 490, T. 41, F. 12).

The original description of *N. subacicularis* HUSTEDT gives 14–16 carinal pores in 10 μ , and about 33 striae in 10 μ , but in a drawing in his Congo paper (HUSTEDT, 1949: 150, T. 11, F. 61), HUSTEDT shows carinal pores and striae which are further apart than those dimensions. The specimens in this collection fit the description of *N. subacicularis* except that they have only 12 carinal pores in 10 μ , and 27 transapical striae in 10 μ . In view of HUSTEDT's Congo material I consider that the specimens in this collection can be assigned to this species. — Fig. 52. — Vaal 485.

PINNULARIA EHRENBURG 1840

Pinnularia acoricola HUSTEDT (1937–1939, Suppl. 15: 293, T. 21, F. 11–16)

This is a common species in suitable South African waters. The specimen here is more linear than the typical form illustrated in A. SCHMIDT's Atlas (T. 390, F. 13–16) and by CHOLNOKY (1959: 61, F. 327; 1964: 76, F. 93). — Fig. 52. — Vaal 485.

Pinnularia stomatophora GRUNOW (cf. HUSTEDT, 1930: 327, F. 605; 1937 to 1939, Suppl. 15: 396, T. 22, F. 7)

The specimen has the very long polar fissures which are characteristic of *P. stomatophora* GRUNOW. The length of this specimen is only 35 μ long, and its width 5.5 μ . — Fig. 64. — Vaal 485.

Summary

1. 15 new species of diatoms and 1 new variety from the Vaal River Catchment Area are described and figured.
2. A number of other species are commented on, and in a few cases their systematic position is discussed.
3. The details are to be found in the text.

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Plate 1.

1. *Cymbella aequaloides* n. sp. — 2, 3. *Frustulia subvulgaris* CHOLNOKY. — 4. *Gomphonema dichotomum* comb. nov. — 5, 6. *Navicula adamantiformis* n. sp. — 7, 8. *Navicula aquosa* n. sp. — 9. *Navicula barbarica* HUSTEDT. — 10. *Navicula chordata* n. sp. — 11. *Navicula temeraria* CHOLNOKY. — 12. *Navicula confervacea* (KÜTZING) GRUNOW. — 13. *Navicula Schubarti* HUSTEDT nov. var. *africana*. — 14, 15. *Navicula digitulus* HUSTEDT. — 16. *Navicula diuturna* CHOLNOKY. — 17—23. *Navicula diuturnoides* n. sp. — 24. *Navicula Grimmei* KRASSKE. — 15. *Navicula helenoides* n. sp. — 26. *Navicula pascuorum* CHOLNOKY. — 27. *Achnanthes lanceolata* var. *rostrata* (Oestr.) HUSTEDT. — 28. *Navicula letulenta* n. sp. — 29. *Navicula manubialis* n. sp. — 30, 31. *Navicula chrissiana* CHOLNOKY. — 32, 33. *Navicula molesta* HUSTEDT. — 34. *Navicula submolesta* HUSTEDT. — 35. *Navicula parsura* HUSTEDT. — 36. *Navicula scabellum* HUSTEDT. — 37, 38. *Navicula Standeriella* n. sp. — 39. *Navicula subarvensoides* n. sp. — 40. *Navicula subcoccus* CHOLNOKY. — 41—43. *Navicula Twymaniana* n. sp. — 44. *Nitzschia Agnewii* CHOLNOKY. — 45, 46. *Nitzschia bacata* HUSTEDT. — 47, 48. *Nitzschia Chuteri* n. sp. — 49. *Nitzschia crassepunctata* n. sp. — 50. *Nitzschia diluta* n. sp.

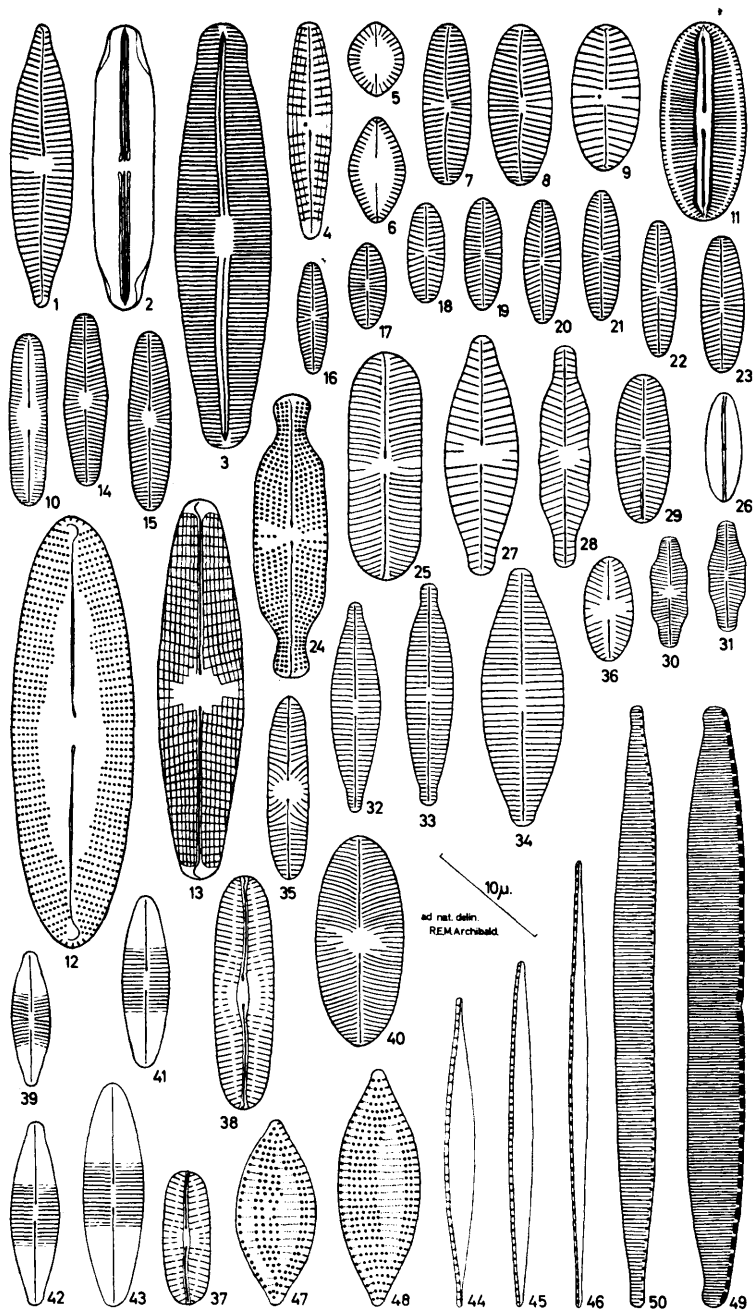
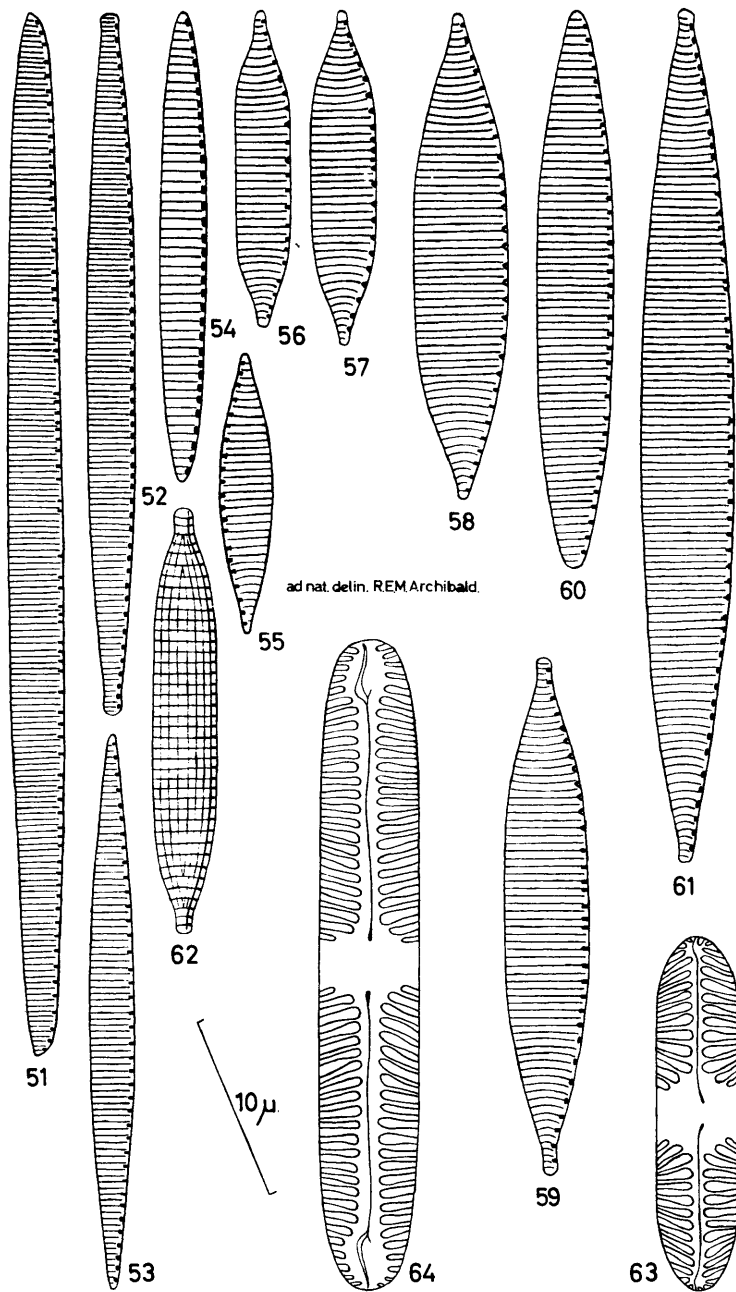


Plate 2.

51. *Nitzschia intermissa* HUSTEDT. — 52. *Nitzschia subacicularis* HUSTEDT. — 53. *Nitzschia confinis* HUSTEDT. — 54. *Nitzschia proxima* HUSTEDT. — 55–61. *Nitzschia romana* GRUNOW. — 62. *Nitzschia siliqua* n. sp. — 63. *Pinnularia acoricola* HUSTEDT. — 64. *Pinnularia stomatophora* GRUNOW.



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SOME NEW AND RARE NITZSCHIAE
(DIATOMACEAE) FROM THE VAAL DAM
CATCHMENT AREA (SOUTH AFRICA)

BY

R. E. M. ARCHIBALD

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SOME NEW AND RARE NITZSCHIAE (DIATOMACEAE) FROM THE VAAL'DAM CATCHMENT AREA (SOUTH AFRICA).

BY

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In studies of the ecology of diatoms, particularly in the case of studies concerned in any way with organic pollution, one of the most important genera of diatoms concerned is the genus *Nitzschia* Hassall. This is, moreover, a genus of which the systematics is not well known, and, in consequence, the identification of some species is difficult. In any ecological study, however, the correct identification of all the species concerned is of prime importance, since misidentification of any of the species (and particularly of the ecologically important species) inevitably leads to misleading results and wrong conclusions.

In this paper some apparently new species of *Nitzschia* are described, and other species are commented upon or discussed in order to make available further facts about their distribution. Certain of the latter species have not previously been recorded from South Africa, and are thus new records for this country.

The samples on which these observations are based were collected during a survey carried out for the National Institute for Water Research by two of its officers, Dr. B. J. Cholnoky and Mr. F. M. Chutter, during the year 1960. The survey covered the catchment area of the Vaal Dam in the Transvaal. I am very grateful to these two gentlemen for making the material collected available to me, and in particular to Dr. Cholnoky for his unfailing help and guidance.

The collecting stations from which the samples investigated were taken are listed below. The pH values given were taken by Mr. Chutter, using a Colour pH meter.

Vaal 401. Grootvlei — a colliery dam, situated on the road between Balfour and Villiers. pH 8.5.

- Vaal 409. A small swampy stream between the Vaal River, where it is crossed by the Villiers-Standerton road, and Standerton. There was a large quantity of filamentous algae floating on the water surface.
- Vaal 410. The Waterval River between Standerton and the Vaal River where it is crossed by the Villiers-Standerton road. pH 8.5.
- Vaal 411. The Grootspuit stream near its confluence with the Waterval River alongside the road to Standerton. pH 8.7.
- Vaal 412. Waterval River below the bridge on the road to Greylingstad from Standerton. pH 8.7.
- Vaal 413. Small stream between station Vaal 412 and Standerton; flowing very slowly. pH 8.8.
- Vaal 498. The Waterval River at Roodebank between Standerton and Leslie, above the waterfalls; very fast flowing water. pH 9.4.

In the samples collected from the above stations, the species of *Nitzschia* described or discussed below were found. In each account the number or numbers quoted at the end are those of the station(s) at which the specimens were collected.

***Nitzschia* Hassall 1845.**

Nitzschia acicularis (Kützing) W. Smith. (cf. Hustedt 1930:423, F. 821).

The specimen figured here is only 32μ long and 2μ wide, and is one of the smaller examples of this species. Such smaller specimens were also found by O. Müller, (1905:137-205), who described them as a new form of the type, namely forma **angustior** O. Müller. Müller's forma *angustior* is now regarded by Cholnoky (personal communication) as being more typical of the species than the specimens originally described. In these small specimens the valve shape is more lanceolate than in the forma *typica*, and thus the ends, though produced, are relatively short. Fig. 1—Vaal 410.

Nitzschia acicularioides n. sp.

These specimens fall into the group Nitzschiellae (Rabenhorst) Grunow on account of the structure of the valves. They show a strong resemblance to **Nitzschia acicularis** (Kützing) W. Smith (cf. Hustedt 1930:423, F. 821), from which they differ only in that the two central carinal pores are more widely separated than the rest. This wider separation was a constant feature in all the specimens seen; they can therefore not be assigned to the species **Nitzschia acicularis**. This characteristic feature, namely the greater separation of the two central carinal pores, is reminiscent of **N. spiculum** Hustedt (1949:150, T 13, F. 1-4.), in which the same separation is seen; the valve of **N. spiculum**, however, differs in shape from that of the new species, being linear and not produced at the poles, and also being relatively narrower than that of **N. acicularioides**. The valves of **N. acicularioides** are spindle-shaped in the middle, and vary somewhat in shape in different individuals, the central part is sometimes linear with parallel sides, sometimes more lanceolate; the ends are long and narrowly produced, in some cases consisting of little more than the keel. Length 51-59 μ , width 2-2.5 μ . The keel is excentric, and has 16-18 (usually 18) small carinal pores in 10 μ , of which the two central pores are more widely separated than the rest; there the keel is sometimes visibly impressed. The transapical striae are too fine to be seen under the light microscope. The cell walls are weakly silicified. Fig. 2-4 — Vaal 410 and 411.

Valvae in parte mediana filiformes, angustissime lineares sive lanceolatae, apicibus angustis, carinam solum contingentibus, 51-59 μ longae, 2-2,5 μ latae. Carina valde excentrica, poris carinalibus parvis, 16-18 (fere 18) in 10 μ , centralibus duobus distantioribus. In positione opportuna impressio levis carinae super canale mediano visibilis. Striae invisibiles. Membranae cellularum levissime silificatae.

Habitat: in lacu artificiale putei uni Grootvlei dicto ad viam publicam inter pagos Balfour et Villiers Africae Meridionalis.

Typus: praeparatum n:o Vaal 401 in collectione C. S. I. R., Grahamstown.

Iconotypus: figurae nostrae n:o 2-4.

Nitzschia amphioxoides Hustedt (1949:140, T. 13, F. 65-72).

The valve of **N. amphioxoides** is typically linear, and generally has slightly concave sides and cuneate ends with more or less capitate poles. The specimen illustrated here does not entirely conform to the typical shape, but nevertheless conforms to the rest of the diagnosis, having a length of 39μ , a width of 4μ , 13 carinal pores in 10μ , and 24 transapical striae in 10μ . The shape of the valve of this specimen is more lanceolate than that of the type, with only a very slight concavity on the keel side of the valve; the ends are, however, cuneate and the poles are capitate. The keel is slightly sunken in the middle, and the two central carinal pores are farther apart than the others. Such a slight difference in the shape of the valve is insufficient ground on which to differentiate this specimen from the typical **N. amphioxoides**, and I am therefore referring it to that species. Fig. 5 — Vaal 401.

Nitzschia capitellata Hustedt (1930:414, F. 792).

The specimen illustrated is of a shape which is abnormally short compared with the type. In the Belgian Congo Hustedt (1949:139, T. 12, F. 36-38) found small examples of this species which had a length of 35μ . In South Africa Cholnoky (1957:73, F. 205-208) has also found similar small forms. This specimen is, however, only 25μ long, but it nevertheless conforms to the rest of Hustedt's description, which he has modified slightly in his Congo paper (l. c.). It can therefore be assigned to the species **N. capitellata** Hustedt. Fig. 6 — Vaal 498.

Nitzschia exilis n. sp.

The affinity of this new species is difficult to determine, as I have only seen one specimen. I have not been able to associate this specimen with any species known to me, and I am therefore obliged to describe it as a new species. When more material becomes available it may prove possible to associate this species with **N. gracilis** Hantzsch (cf. Hustedt 1930:416, F. 794); **N. gracilis** is, however, broader has capitate ends and is weakly silici-

fied. The new species is long and narrowly linear with gradually tapering ends, the poles are regularly and sharply rounded and are not capitate, 86μ long and 1.5μ wide. The keel is excentric and has 12 carinal pores in 10μ , of which the central two are not more widely separated than the rest. The transapical striae are too fine to be seen under the light microscope. The valve walls are fairly well silicified. Fig. 7 — Vaal 410.

Valvae anguste lineares, apicibus longe protractis, angustis, polis regulariter sed anguste rotundatis, non capitatis, circiter 86μ longae. 1.5μ lataeque. Carina excentrica, poris carinalibus 12 in 10μ , medianibus non distantioribus. Striae transapicales subtilissimae, invisibiles. Cellulae bene silificatae, non hyalinae.

Habitat: in rivo Waterval River inter pagum Standerton et pontem viae ad Villiers super fluvio Vaal in Africa Meridionale.

Typus: praeparatum n:o Vaal 410 in collectione C. S. I. R., Grahamstown.

Iconotypus: figura nostra n:o 7.

Nitzschia fonticola Grunow (cf. Hustedt 1930: 415, F. 800).

In the sample Vaal 498 a series of specimens was found in which some very small examples of *N. fonticola* and the typical forms were linked. Drawings have been made to illustrate this linkage. The smallest specimen found in this series is 5μ long and 2.5μ wide. In some of the smaller examples a resemblance to *N. epiphytica* O. Müller (cf. Hustedt 1949: 143, T. 13, F. 53-65) is shown. This is due to the irregular spacing of the carinal pores, which sometimes causes the two central pores to be more widely separated than the rest. This is, however, not a constant feature. This is well illustrated in Figs. 10 and 11. The original diagnosis of the species should be altered to accommodate these small forms, and corrected so that the range of length is $5-30\mu$ long. Fig. 8 — Vaal 498.

Nitzschia immunda n. sp.

The specimens of this new species show a strong similarity to *N. tropica* Hustedt (1949; 147, T. 11, F. 34-38), from which they differ in that the valve is narrower and has a greater number

of transapical striae in 10μ than *N. tropica*. The valves are lanceolate with slightly produced and capitate ends; about 27μ long and 2μ wide. Few specimens were seen and thus the full range of variation could not be determined. The keel is excentric and has 14 carinal pores in 10μ , of which the central two are wider apart than the rest; the keel is visibly impressed. The transapical striae are easily visible under Phase Contrast and are 27-30 in 10μ . Fig. 14 — Vaal 410.

Valvae lanceolatae, apicibus leviter protractis et levissime capitatis, circiter 27μ longae, 2μ lataeque, sed numerus speciminum observatorum pro determinatione variationis non satis esse opinatur. Carina excentrica in parte mediana impressa, poris carinalibus circiter 14 in 10μ , medianibus duobus modice distantibus. Striae transapicales distinctae, 27-30 in 10μ .

Habitat: in rivo Waterval River inter pagum Standerton et pontem viae publicae ad Villiers super fluvio Vaal in Africa Meridionale.

Typus: praeparatum n:o Vaal 410 in collectione C. S. I. R., Grahamstown.

Iconotypus: figura nostra n:o 14.

Nitzschia Kützingiana Hilse (cf. Hustedt 1930:416, F. 802).

This species, very common in South African rivers, is very variable in shape. I have included in this paper some drawings to illustrate this variability. In all the specimens illustrated the transapical striae are too fine to be seen under the light microscope. Fig. 16 shows an extremely narrow form, which is only 1.5μ wide. Fig. 15-18 — Vaal 410, 411 and 413.

Nitzschia lauenburgiana Hustedt (1945:402, T. 40, F. 6, 7, 9-11).

Apart from the length of the valve, this specimen conforms to the description of *N. lauenburgiana* and I am therefore assigning it to that species. Hustedt found specimens reaching a length of 150μ , while this specimen is 190μ long. *N. lauenburgiana* has not previously been recorded from South Africa and further large specimens may well be found here. Hustedt's orig-

inal specimens were found in some North German Lakes (l. c.), and the species was again found at a later date by Chohnoky (1963:189, F. 89) in Dutch New Guinea. This is a new record for South Africa. Fig. 19—Vaal 411.

***Nitzschia obligata* n. sp.**

This species, which was rare in the sample, cannot be associated with *N. Kützingiana* Hilse (cf. Hustedt 1930:416, F. 802) which it resembles, because of its greater length and because it has more widely spaced carinal pores. Neither can it be associated with *N. palea* (Kützing) W. Smith (cf. Hustedt 1930:416, F. 801) on account of the shape of the valve. I am obliged, therefore, to describe this diatom as a new species. The valve is lanceolate, gradually tapering to the poles which are sharply rounded and very slightly capitate. The valves are 45μ long and 2.5μ wide; the full range of variation cannot, however, be given, as few specimens were seen. The keel is excentric and has 14 carinal pores in 10μ . The two central pores are not farther apart than the rest. The transapical striae are very fine and are not visible using the light microscope. Fig. 20—Vaal 412.

Valvae anguste lanceolatae, apicibus gradatim attenuatis, anguste sed regulariter rotundatis, non sive levissime protractis, non capitatis, circiter 45μ longae, circiter $2,5\mu$ latae, sed variatio tota ignota. Carina excentrica, poris carinalibus circiter 14 in 10μ . Striae transapicales invisibiles.

Habitat: in rivo Waterval River sub ponte viae publicae inter pagos Standerton et Greylingstad Africae Meridionalis.

Typus: praeparatum n:o Vaal 412 in collectione C. S. I. R., Grahamstown.

Iconotypus: figura nostra n:o 20.

***Nitzschia perspicua* Chohnoky (1960:262, F. 36).**

Chohnoky described this species from the Swartkops River near Port Elizabeth in the eastern Cape Province. The specimen illustrated here conforms to Chohnoky's description. In this specimen the keel and carinal pores are very well silicified and prom-

inent, but the margin of the valve opposite the keel is very weakly silicified and barely visible. Fig. 21 — Vaal 413.

Nitzschia silica n. sp.

These weakly silicified valves show a strong resemblance to *N. bacata* Hustedt (1937-39:485, T. 41, F. 30-33), but differ in the shape and size of the valve, and the number of carinal pores. The valves are linear to lanceolate in shape. The larger forms have a linear central portion with parallel walls, the ends are relatively long and cuneate, with sharply rounded poles. The smaller forms are more lanceolate and in consequence the ends are less cuneate. The valves are 20-29.5 μ long and 2 μ wide. The keel is excentric and scarcely visible, there are 16-18 (usually 16) carinal pores in 10 μ , of which the central two are more widely separated than the rest. The transapical striae are too fine to be seen under the light microscope. The structure of the valves is very delicate and the whole diatom is weakly silicified. Fig. 22-24 — Vaal 401.

Valvae maiores in media parte lineares, apicibus longe cuneato-attenuatis, minores longe et anguste lanceolatae, 20-29.5 μ longae, circiter 2 μ latae. Carina excentrica indistincta, poris carinalibus 16-18 (fere 16) in 10 μ , medianis duobus distantiores, sed carina super canalem centralem non impressa. Striae transapicales subtilissimae, invisibiles. Membrana cellularum levissime silificata.

Habitat: in lacu artificiali putei uni Grootvlei dicto ad viam publicam inter pagos Balfour et Villiers Africae Meridionalis

Typus: praeparatum n: o Vaal 401 in collectione C. S. I. R., Grahamstown.

Iconotypus: figurae nostrae n: o 22-24.

Nitzschia spiculoides Hustedt (1949: 151, T. 13, F. 5-6).

According to the original diagnosis of this species given by Hustedt (l. c.) the striae are too fine to be seen with the light microscope. The specimen found here conforms to the description of *N. spiculoides* with exception that the striae are visible.

Although difficult to see there are about 40 striae in 10μ . Considering that the striae are difficult to see, and that the specimen conforms to the rest of the description I am assigning it to **N. spiculoides**. This then necessitates the alteration of the diagnosis by inserting the observation that **N. spiculoides** has 40 or more striae in 10μ . Fig. 25 — Vaal 498.

Nitzschia subacicularis Hustedt (1937-39:490, T. 41, F. 12).

Hustedt seems to have been uncertain about this species since a drawing given in his Congo paper (Hustedt 1949:150, T. 11, F. 61) differs from his original description (l. c.). The original description gives 14-16 carinal pores and 33 transapical striae in 10μ , while the Congo specimen had about 9 carinal pores and 23 transapical striae in 10μ . This would suggest either that the Congo specimen is a mis-identification, or else that Hustedt had insufficient material to enable him to give the full range of variation in his original description. The specimen illustrated here has dimensions very much larger than those given by Hustedt, being 62.5μ long and 3μ wide. In its other characteristics this specimen conforms to Hustedt's original description, and I am therefore referring it to this species. Fig. 26 — Vaal 410.

Nitzschia subvitrea Hustedt (1872-1960:T. 347, F. 18-19).

The typical valve of **N. subvitrea** is linear with parallel sides; this can be seen in Hustedt's drawings in Schmidt's Atlas (l. c.) and in his paper on the Sunda Islands (Hustedt 1937-39:471, T. 40, F. 12). The valve in the present specimen is, however, slightly concave on the keel side of the valve and slightly convex on the side away from the keel. Fig. 27 — Vaal 410.

Nitzschia vitrea Norman var. **salinarum** Grunow (cf. Hustedt 1930:411, F. 787).

This variety is uncommon in South African rivers and it is thus of interest to note its presence in this sample. Fig. 28 — Vaal 498.

SUMMARY

1. 5 new species of *Nitzschia* from the Vaal Dam Catchment Area are described and figured. These are *Nitzschia acicularoides*, *N. exilis*, *N. immunda*, *N. obligata* and *N. silica*.
2. A number of other *Nitzschia* species are commented on, in some cases making new records for South Africa. The new record for South Africa is *Nitzschia lauenburgiana* Hustedt.
3. The details are to be found in the text.

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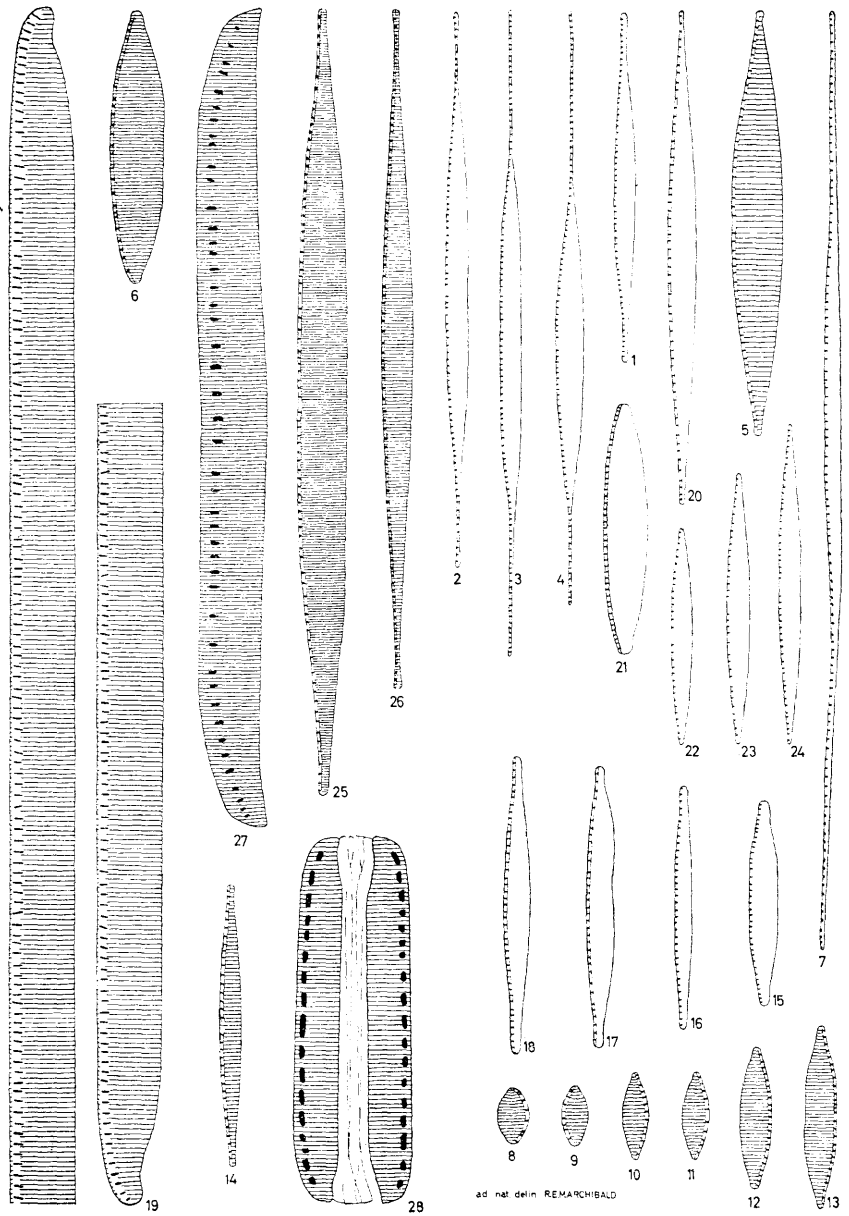
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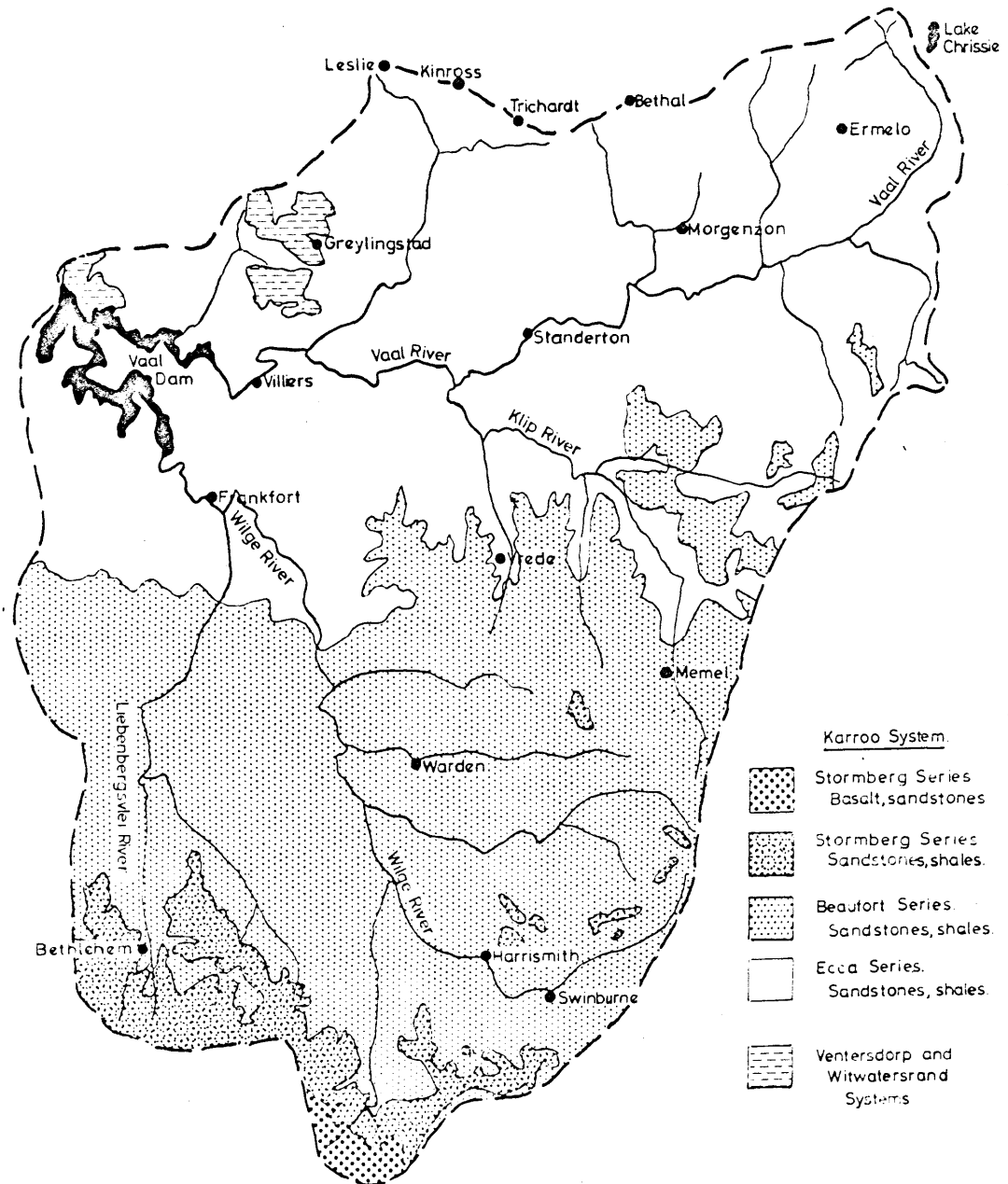
EXPLANATION OF THE PLATES

1. *Nitzschia acicularis* (Kützing) W. Smith.
- 2-4. *N. acicularoides* n. sp.
5. *N. amphioxoides* Hustedt.
6. *N. capitellata* Hustedt.
7. *N. exilis* n. sp.
- 8-13. *N. fonticola* Grunow.
14. *N. immunda* n. sp.
- 15-18. *N. Kützingiana* Hilse.
19. *N. lauenburgiana* Hustedt.
20. *N. obligata* n. sp.
21. *N. perspicua* Cholnoky.
- 22-24. *N. silica* n. sp.
25. *N. spiculoides* Hustedt.
26. *N. subacicularis* Hustedt.
27. *N. subvitrea* Hustedt.
28. *N. vitrea* Norman var. *salinarum* Grunow.

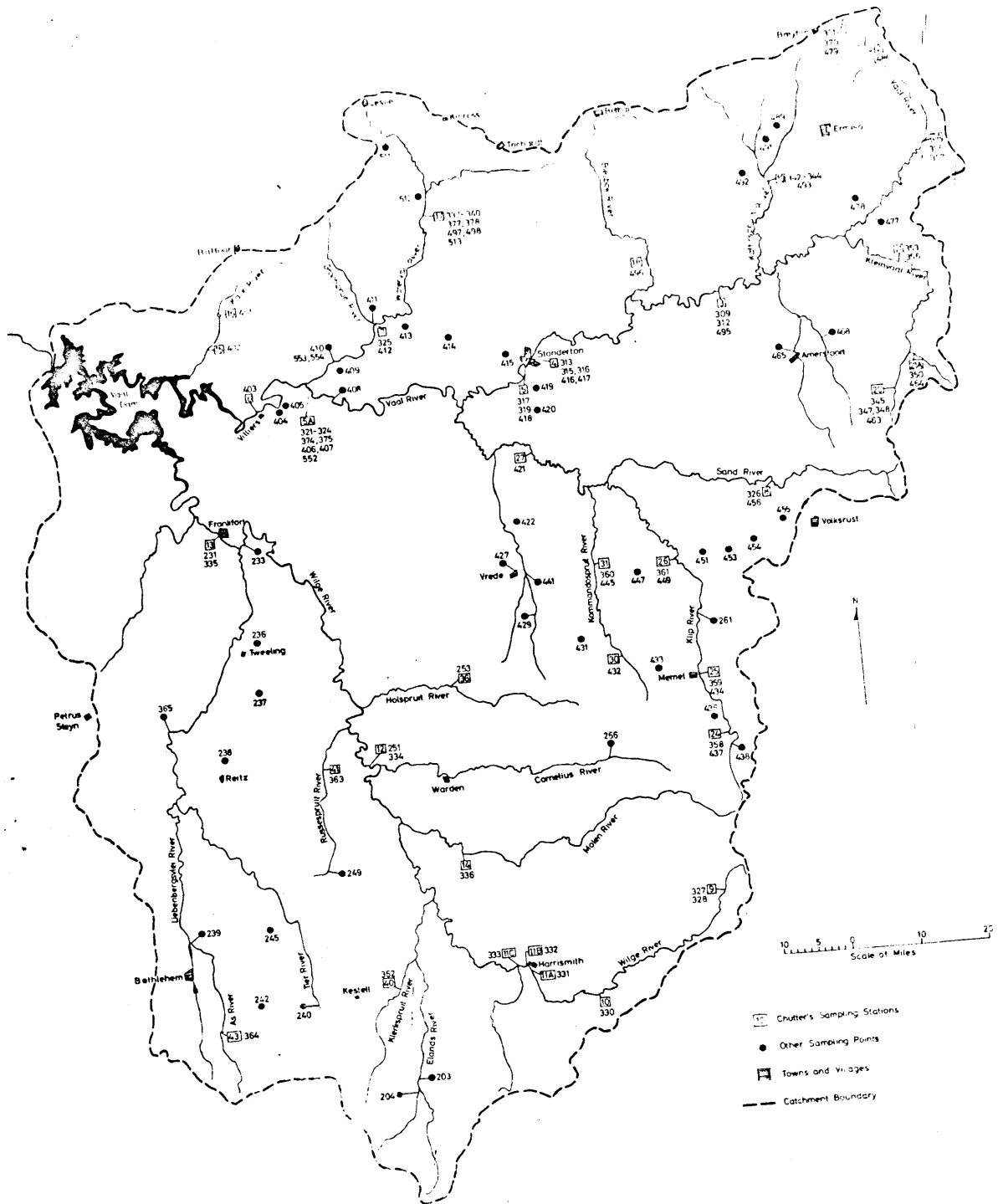


The Geology of the Vaal Dam Catchment Area.

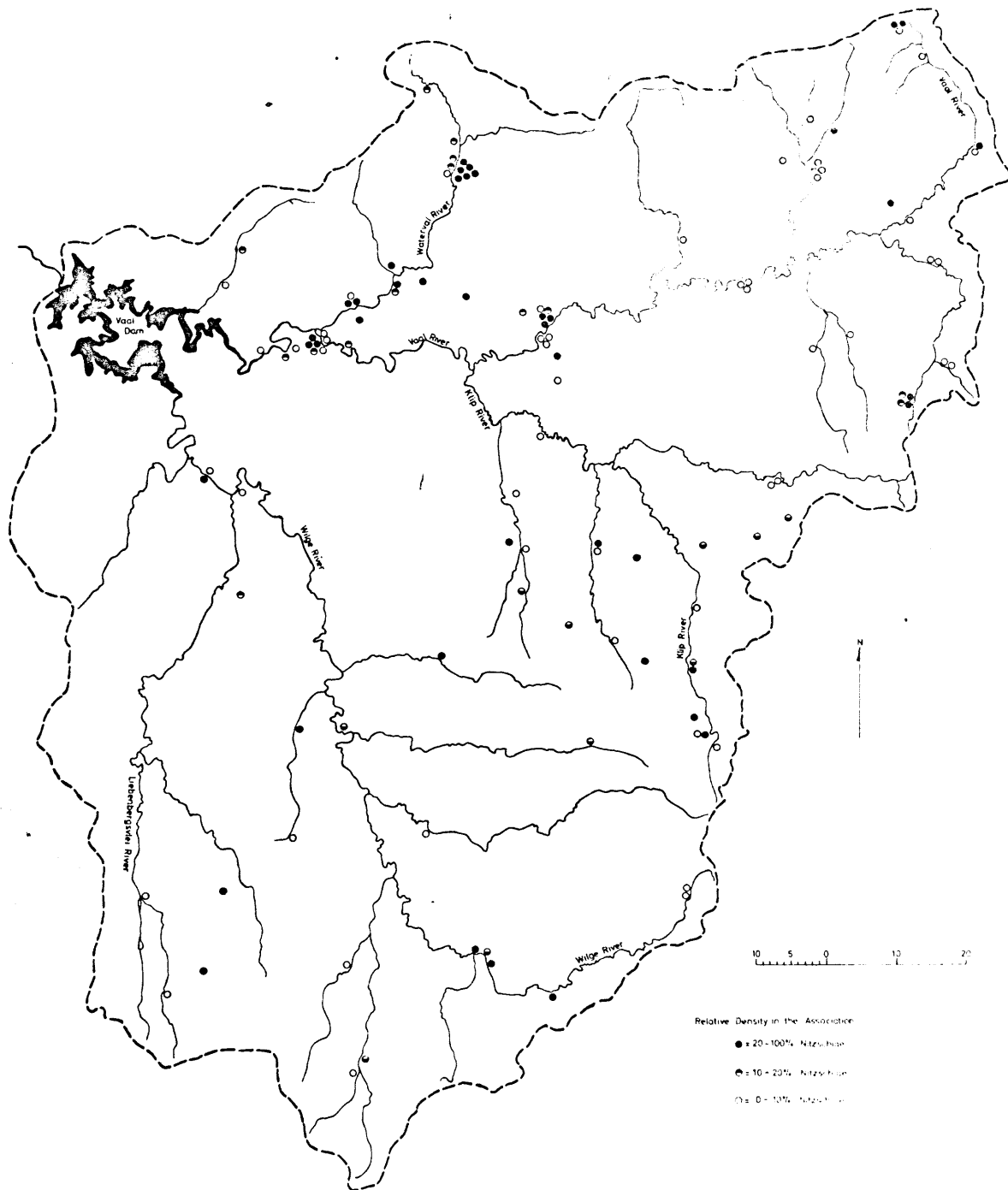
(From a 1:1,000,000 geological survey map printed by the Government Printer, Pretoria, 1955).



Map 2.



The Sampling Points and Stations of the Vaal Dam Catchment Area.



The Distribution of the Nitrogen heterotrophic Nitzschiae
in the Vaal Dam Catchment Area.

Table 8.

Short Descriptions of the Sampling Points of the Vaal Dam
Catchment Area.

- Vaal 203 - A large river near the Witziesshoek Reserve on the road from Kestell to Witziesshoek. 24.7.57.
- Vaal 204 - A swiftly flowing river nearer to the Witziesshoek Reserve. 24.7.57
- Vaal 231 - The Wilge River at Frankfort. Station No. 13 of Chutter. 11.7.58.
- Vaal 233 - The Wilge River south of Frankfort, above the bridge on the Frankfort - Reitz road. 11.7.58.
- Vaal 236 - A small stream near the village of Tweeling on the Frankfort - Reitz road. 11.7.58.
- Vaal 237 - Another small river south of Tweeling on the Tweeling - Reitz road. 11.7.58.
- Vaal 238 - A large river three miles north of Reitz on the Tweeling - Reitz road. 11.7.58.
- Vaal 239 - The Liebenbergsvlei River between Bethlehem and Reitz. 11.7.58.
- Vaal 240 - A marshy river about 10 miles from Kestell on the Kestell - Bethlehem road. This is probably the Tier River. Ice was present on the water surface. 12.7.58.
- Vaal 242 - A large tributary of the As River, about 15 miles east of Bethlehem on the Kestell - Bethlehem road. 12.7.58.
- Vaal 245 - A small tributary of the Tier River on the Bethlehem - Warden road, near the Sherbrooke Station. 12.7.58.
- Vaal 249 - A small spring on the side of the road about 20 miles west of Warden on the Bethlehem - Warden road. Probably the Russespruit stream. 12.7.58.

- Vaal 253 - The Holspruit, swiftly flowing, where it is crossed by the Vrede - Warden road. 12.7.58.
- Vaal 261 - The Seekoeivlei near Memel. 13.7.58.
- Vaal 266 - The Cornelis River, 18 miles south of Memel on the Memel - Harrismith road. 13.7.58.
- Vaal 301 - The headwaters of the Vaal River between Breyten and Lake Chrissie. Station No. 1 of Chutter. 16.9.58.
- Vaal 306 - The Vaal River where it is crossed by the Ermelo - Amsterdam road. Marginal mud. Station No. 2A of Chutter. 22.7.59.
- Vaal 307 - The same locality as Vaal 306. Stones in Current. 19.1.60.
- Vaal 309 - The Vaal River where it is crossed by the Morgenzon - Amersfoort road. Station No. 3 of Chutter. 15.9.58.
- Vaal 312 - The same locality as Vaal 309. Stones in Current. 23.9.59.
- Vaal 313 - The Vaal River at Standerton. Below the creamery effluent. Station No. 4 of Chutter. 15.9.58.
- Vaal 315 - The same locality as Vaal 313. Stones in current. 22.9.59.
- Vaal 316 - The same locality as Vaal 313. Stones in current. 19.1.60.
- Vaal 317 - The Vaal River below Station No. 4, below the Sewage Works at Standerton. Station No. 5 of Chutter. 15.9.58.
- Vaal 319 - The same locality as Vaal 317. Stones in Current. 22.9.59.
- Vaal 321 - The Vaal River where it is crossed by the Standerton - Villiers road. Station No. 5A of Chutter. Stones in current. 20.7.59.

- Vaal 322 - The same locality as Vaal 321. Algae trailing in the current. 18.8.59.
- Vaal 323 - The same locality as Vaal 321. Algae trailing in the current. 22.9.59.
- Vaal 324 - The same locality as Vaal 321. Stones in current. 19.1.60.
- Vaal 325 - The Waterval River where it is crossed by the Balfour - Standerton road. Station No. 7 of Chutter. 10.9.59.
- Vaal 326 - The Sandspruit stream at Sandspruit on the national road from Standerton to Volksrust. Station No. 8 of Chutter. 16.9.58.
- Vaal 327 - The headwaters of the Wilge River, where it is crossed by the Harrismith - Colling's Pass road. Station No. 9 of Chutter. 15.10.58.
- Vaal 328 - The same locality as Vaal 327. Stones in current. 9.12.58.
- Vaal 330 - The Wilge River at Swinburne. Station No. 10 of Chutter. 17.9.58.
- Vaal 331 - The Wilge River at the bridge at its entrance to Harrismith. Station No. 11A of Chutter. 17.9.58.
- Vaal 332 - The Wilge River where it leaves Harrismith. Station No. 11B of Chutter. 17.9.58.
- Vaal 333 - The Wilge River a little below Harrismith. Station No. 11C of Chutter. 14.10.58.
- Vaal 334 - The Wilge River where it is crossed by the road from Warden to Harrismith. Station No. 12 of Chutter. 15.9.58.
- Vaal 335 - The Wilge River at Frankfort. Station No. 13 of Chutter. 18.9.58.

- Vaal 336 - The Molen River where it is crossed by the Warden -
Harrismith road. Station No. 14 of Chutter. 17.9.58.
- Vaal 337 - The Waterval River where it is crossed by the Standerton
- Leslie Road at Roodebank. Stones in current. Station
No. 17 of Chutter. 20.7.59.
- Vaal 338 - The same locality as Vaal 337. 22.9.59.
- Vaal 339 - The same locality as Vaal 337. Stones in Current.
19.1.60
- Vaal 340 - The same locality as Vaal 337. Marginal vegetation.
19.1.60.
- Vaal 342 - The Kaffirspruit stream where it is crossed by the
Morgenzon - Ermelo road. Station No. 19 of Chutter.
15.9.58.
- Vaal 343 - The same locality as Vaal 342. Stones in current.
22.7.59.
- Vaal 344 - The same locality as Vaal 342. 20.1.60.
- Vaal 345 - From a seepage on a bank of a headwaters tributary of
the Kleinvaal River. 10.12.58.
- Vaal 347 - A headwaters tributary of the Kleinvaal River. Stones
in current. Station No. 20 of Chutter. 23.9.59.
- Vaal 348 - The same locality as Vaal 347. 20.1.60.
- Vaal 350 - The Kleinvaal River near Station No. 20. Station No.
21A of Chutter. 23.9.59.
- Vaal 353 - The Kleinvaal River near its confluence with the Vaal
River. Station No. 21 of Chutter. Muddy margin.
23.9.59.
- Vaal 356 - The same locality as Vaal 353. Stones in current.
20.1.60.
- Vaal 358 - The Klip River on the road up Müllers Pass between Memel
and Newcastle. Station No. 24 of Chutter. Stones in
current. 13.1.59.

- Vaal 359 - The Klip River at Memel. Station No. 25 of Chutter.
Stones in current. 14.1.59.
- Vaal 360 - The Kommandospruit stream where it is crossed by the
Vrede - Volksrust road. Station No. 31 of Chutter.
14.1.59.
- Vaal 361 - The Klip River where it is crossed by the Vrede - Volks-
rust road. Station No. 26 of Chutter. 14.1.59.
- Vaal 362 - The Klerkspruit Stream where it is crossed by the
Harrismith - Kestell road. Station No. 40 of Chutter.
14.10.58.
- Vaal 363 - The Russespruit Stream where it is crossed by the Warden -
Reitz road. Station No. 41 of Chutter. 9.2.59
- Vaal 364 - Headwaters of the As River, south of Bethlehem. Station
No. 43 of Chutter. 18.11.58.
- Vaal 365 - The Liebenbergsvlei River where it is crossed by the
Reitz - Petrus Steyn road. Station No. 44 of Chutter.
17.11.58.
- Vaal 370 - The headwaters of the Vaal River, between Breyten and
Lake Chrissie. Station No. 1 of Chutter. 21.3.60.
- Vaal 374 - The Vaal River where it is crossed by the Standerton -
Villiers road. Station No. 5A of Chutter. 3.6.60.
- Vaal 375 - The same locality as Vaal 374. Algae trailing in the
water. 3.6.60.
- Vaal 377 - The Waterval River where it is crossed by the Leslie -
Standerton road. Station No. 17 of Chutter. 6.5.60.
- Vaal 378 - The same locality as Vaal 377. 3.6.60.
- Vaal 401 - Grootvlei, the Springfield Colliery dam on the Kalk
River. Station No. 16 of Chutter. pH 8.5 8.8.60.
- Vaal 402 - The Kalk River below Grootvlei, where it is crossed by
the Heidelberg - Villiers road. Station No. 15 of
Chutter. pH 8.7. 8.8.60.

- Vaal 403 - The Vaal River below the national road bridge at Villiers. pH 8.6. 8.8.60.
- Vaal 404 - A small stream east of Villiers, about 3-4 miles on the road to Standerton. The stream was in the process of drying up and was not flowing. pH 8.6. 8.8.60.
- Vaal 405 - Another small tributary 1 mile further along this road. Large pools in a dry river bed. pH 8.7. 8.8.60.
- Vaal 406 - The Vaal River where it is crossed by the Standerton - Villiers road. Station No. 5A of Chutter. Stones in current. pH 8.7. 8.8.60.
- Vaal 407 - The same locality as Vaal 406. Slowly flowing water on the banks of the river. pH 8.7. 8.8.60.
- Vaal 408 - A small stream about 2 miles east of Vaal 406. Rocky bottom and there was no flowing water. pH 8.6. 8.8.60.
- Vaal 409 - A small marshy stream between Vaal 406 and Standerton. Large quantities of algae were present on the water surface. 8.8.60.
- Vaal 410 - The Waterval River between Vaal 406 and Standerton. Sample taken from below the road bridge. pH 8.5. 8.8.60.
- Vaal 411 - The Grootspuit stream near the Balfour-Standerton road, just before its confluence with the Waterval River. pH 8.7. 8.8.60.
- Vaal 412 - The Waterval River where it is crossed by the Balfour - Standerton road. Station No. 7 of Chutter. pH 8.7. 8.8.60.
- Vaal 413 - A small stream between Vaal 412 and Standerton. The water was flowing very slowly. pH 8.8. 8.8.60.

- Vaal 414 - Another small stream nearer Standerton. Large masses of Oedogonium were present. pH 9.6. 8.8.60.
- Vaal 415 - A small stream 5 miles west of Standerton on the Balfour - Standerton road. pH 8.5. 8.8.60.
- Vaal 416 - The Vaal River at Standerton, below the old railway bridge and below the milk processing factory. Station No. 4 of Chutter. pH 8.2. 8.8.60.
- Vaal 417 - A small stream near Vaal 416; probably drains the area around the milk processing factory. pH 8.2. 8.8.60.
- Vaal 418 - The Vaal River below the Standerton Sewage Works. Station No. 5 of Chutter. The river bed is granite rock. pH 8.5. 8.8.60.
- Vaal 419 - The first small stream outside Standerton on the road to Vrede. pH 8.7. 9.8.60.
- Vaal 420 - The second small stream on the same road. 9.8.60.
- Vaal 421 - The Klip River at de Lange's Drift near the bridge on the Standerton - Vrede road. pH 8.3. 9.8.60.
- Vaal 422 - A small stream between de Lange's Drift and Vrede. pH 8.5. 9.8.60.
- Vaal 427 - A small stream on the northern boundary of Vrede. pH 9.0. 9.8.60.
- Vaal 429 - The Klipspruit Stream between Vrede and Memel. pH 8.7. 9.8.60.
- Vaal 431 - The Maddenspruit Stream between Vrede and Memel. pH 8.5. 9.8.60.
- Vaal 432 - The Kommandospruit Stream between Vrede and Memel. pH 8.6. 9.8.60.
- Vaal 433 - A small spring at the side of the road between the Kommandospruit stream and Memel. pH 7.0. 9.8.60.

- Vaal 434 - The Klip River just above Memel. pH 8.4. 9.8.60.
- Vaal 436 - The Dwarsspruit between Memel and Müller's Pass.
pH 7.4. 9.8.60.
- Vaal 437 - The Klip River between Memel and Müller's Pass.
pH 8.1. 9.8.60.
- Vaal 438 - A marsh alongside the road about 2 miles from Müller's
Pass. pH 7.4. 9.8.60.
- Vaal 441 - The River flowing from Vrede Dam. pH 8.5. 10.8.60.
- Vaal 445 - The Kommandospruit Stream where it is crossed by the
Vrede - Volksrust road. pH 8.4. 10.8.60.
- Vaal 447 - A very small stream between Vaal 445 and Vaal 449.
pH 8.6. 10.8.60.
- Vaal 449 - The Klip River where it is crossed by the Vrede -
Volksrust road. Station No. 26 of Chutter.
pH 8.3. 10.8.60.
- Vaal 451 - A small stream between Vaal 449 and Volksrust. pH 8.2.
10.8.60.
- Vaal 453 - A very small stream near Volksrust. The stream was in
the process of drying up. pH 8.5. 10.8.60.
- Vaal 454 - An unnamed river where it is crossed by the Vrede -
Volksrust road. pH 8.5. 10.8.60.
- Vaal 455 - A small stream west of Volksrust on the road to Vrede.
pH 8.2. 10.8.60.
- Vaal 456 - The Sandspruit River where it is crossed by the Volksrust
- Amersfoort road. Station No. 8 of Chutter. pH 8.3.
10.8.60.
- Vaal 463 - A small headwaters tributary of the Kleinvaal River.
Station No. 20 of Chutter. pH 8.5. 10.8.60.
- Vaal 464 - The Kleinvaal River between Amersfoort and Wakkerstroom.
Station No. 21A of Chutter. pH 8.3. 10.8.60.

- Vaal 465 - The Skulpspruit Stream near Amersfoort. pH 8.2.
11.8.60.
- Vaal 468 - The Rietspruit Stream between Amersfoort and Sheepmoore.
pH 8.5. 11.8.60.
- Vaal 477 - The Vaal River just above the confluence of the Vaal and
the Kleinvaal Rivers. pH 7.9. 11.8.60.
- Vaal 478 - A marsh between Vaal 477 and Ermelo, on the Farm Welge-
legen. pH 8.3. 11.8.60.
- Vaal 479 - The headwaters of the Vaal River between Breyten and
Lake Chrissie. Station No. 1 of Chutter. pH 6.8;
6.0; 6.3. 11.8.60.
- Vaal 480 - Lake Chrissie.
- Vaal 486 - The Vaal River between Lake Chrissie and Ermelo. Water
flowing slowly over a rocky river bed. pH 8.0. 11.8.60.
- Vaal 489 - The Kleinkaffirspruit Stream near Ermelo. pH 9.2.
12.8.60.
- Vaal 491 - The Kaffirspruit between Ermelo and Bethal. Shallow
water on a rocky bed. pH 8.6. 12.8.60.
- Vaal 492 - A small tributary of the Kaffirspruit stream between
Ermelo and Standerton, on the property Nelspan 4.
pH 8.4. 12.8.60.
- Vaal 493 - The Kaffirspruit Stream between Ermelo and Standerton.
Station No. 19 of Chutter. Sandstone rocks. pH 8.1.
12.8.60.
- Vaal 495 - The Vaal River where it is crossed by the Morgenzon -
Amersfoort road. Station No. 3 of Chutter. pH 8.5.
12.8.60.
- Vaal 496 - The Blesbok River between Morgenzon and Standerton.
Station No. 18 of Chutter. Sandstone bed. pH 8.5.
12.8.60.

- Vaal 497 - The Waterval River where it is crossed by the Standerton -
- Leslie road at Roodebank. Station No. 17 of Chutter.
A waterfall on a sandstone base. pH 9.4. 12.8.60.
- Vaal 498 - The same locality as Vaal 497, but the sample was
collected from above the waterfall, where the water was
flowing very swiftly.
- Vaal 511 - The Waterval River, 7 miles from Leslie on the Leslie -
Standerton road. Cattle drink here. pH 8.0. 15.3.65.
- Vaal 512 - The Kaffirspruit stream where it is crossed by the Leslie -
Standerton road. About 17 miles from Leslie. 15.3.65.
- Vaal 513 - The Waterval River where it is crossed by the Leslie -
Standerton road at Roodebank. Station No. 17 of
Chutter. pH 8.4. 15.3.60.
- Vaal 552 - The Waterval River where it is crossed by the Villiers -
Standerton road at Gladdedrift. pH 8.2. 19.3.65.
Station No. 5A.
- Vaal 553 - The Waterval River where it is crossed by the Villiers -
Greylingstad road. 19.3.65.
- Vaal 554 - The Waterval River where it is crossed by the Villiers -
Greylingstad road. A seepage from the river bank.
19.3.65.

Table 9.

A Summary of Malan's (1960) analyses of water from some streams and rivers in the Vaal Dam Catchment Area. Sampling points are numbered according to the station numbers on the Map. (Map). All results are in ppm. and are based on daily water samples. (From Chutter 1967).

River	Sampling point		Total Dissolved solids	Total Alkalinity (as CaCO_3)	Total Hardness (as CaCO_3)	Chlorides (as Cl)	Sulphates (as SO_4)	Sodium (as Na)
Vaal	2	maximum	99	52	48	16	13	14
		mean	<u>67</u>	<u>31</u>	<u>27</u>	<u>11</u>	<u>5.4</u>	<u>9</u>
		minimum	53	19	15	6	1	5.2
	6	maximum	185	152	140	18	10	19
		mean	<u>133</u>	<u>93</u>	<u>86</u>	<u>9</u>	<u>6</u>	<u>15</u>
		minimum	78	40	44	4	3	8
Kafferspruit	19	maximum	292	255	228	20	14	28
		mean	<u>230</u>	<u>185</u>	<u>167</u>	<u>15</u>	<u>9.2</u>	<u>22</u>
		minimum	175	124	112	8	6.2	14.5
Waterval	17	maximum	431	238	188	102	25	94
		mean	<u>106</u>	<u>110</u>	<u>93</u>	<u>25</u>	<u>10.1</u>	<u>29</u>
		minimum	60	24	29	8	4.5	6.0
Klip River	27	maximum	285	220	170	24	24	48
		mean	<u>135</u>	<u>92</u>	<u>80</u>	<u>10</u>	<u>6.5</u>	<u>16</u>
		minimum	65	25	30	5	2.5	4
Wilge River	11a	maximum	81	42	36	12	7	11.5
		mean	<u>57</u>	<u>27</u>	<u>23</u>	<u>7</u>	<u>3.6</u>	<u>7.0</u>
		minimum	27	14	13	3	1.3	3.5
	13	maximum	212	170	150	15	20	13.5
		mean	<u>124</u>	<u>86</u>	<u>75</u>	<u>9</u>	<u>14</u>	<u>5.4</u>
		minimum	65	35	35	4	8	2.3
Cornelis	35	maximum	219	182	157	23	12	27
		mean	<u>128</u>	<u>88</u>	<u>76</u>	<u>9</u>	<u>5.4</u>	<u>15</u>
		minimum	65	25	30	3	2.8	6
Lieberbergsvlei	42	maximum	289	250	212	20	13	34
		mean	<u>167</u>	<u>124</u>	<u>103</u>	<u>10</u>	<u>7.7</u>	<u>20</u>
		minimum	75	34	29	6	4.5	9

The mean values are underlined.

Table 10.

A Summary of Chutter's Chemical analyses of regularly sampled stations, in the Vaal, Kleinvaal and the Waterval and the Kaffirspruit. (Chutter 1967: Table 15).

Station number		1	2A	3	4	5	5A	17	19	20	21	21A
pH (field measurements)	max	6.8	8.1	8.4	8.4	8.5	8.7	9.4	8.4	8.5	9.0	8.3
	mean	6.3(9)	7.2(7)	7.9(8)	7.8(7)	7.8(9)	7.8(9)	8.2(5)	7.9(8)	7.8(9)	7.7(7)	7.7(5)
	min	5.8	6.4	7.2	7.1	7.2	7.2	7.6	7.1	6.7	7.2	7.3
pH (Laboratory measurements)	max	7.6	8.1	8.3	8.4	8.5	8.4	9.5	8.4	7.9	8.1	7.8
	mean	6.6(9)	7.8(8)	7.8(7)	7.9(7)	7.9(6)	8.0(7)	8.2(8)	8.1(9)	7.8(7)	7.7(8)	7.5(4)
	min	5.8	6.6	7.2	7.5	7.4	7.0	7.6	7.3	7.4	7.0	7.2
Free and saline Ammonia (ppm N)	max	0.67	0.50	0.80	0.40	0.20	0.42	0.84	0.60	0.42	0.42	0.84
	mean	0.40(8)	0.15(8)	0.39(5)	0.21(9)	0.34(12)	0.27(6)	0.24(10)	0.15(10)	0.17(5)	0.19(6)	0.57(2)
	min	0.01	N.D.	N.D.	N.D.	N.D.	0.20	N.D.	N.D.	N.D.	N.D.	0.30
Nitrites (ppm N)	max	0.03	0.015	0.01	trace	0.3	trace	0.164	0.050	0.1	N.D.	N.D.
	mean	0.004(10)	trace (11)	trace (7)	trace(13)	0.01(12)	trace(8)	0.068(13)	0.010(12)	trace(8)	N.D.(8)	N.D.(2)
	min	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.010	N.D.	N.D.	N.D.	N.D.
Nitrates (ppm N)	max	0.18	0.60	0.47	0.50	1.87	0.70	4.0	0.82	0.40	0.18	0.20
	mean	0.11(9)	0.14(11)	0.19(7)	0.11(13)	0.42(12)	0.14(8)	1.2(13)	0.33(12)	0.21(8)	0.07(8)	0.18(2)
	min	0.03	N.D.	0.04	N.D.	N.D.	N.D.	0.25	0.05	0.01	N.D.	0.16
Kjeldahl Nitrogen (ppm N)	max	21.0	1.1	1.1	0.5	13.3	0.88	1.3	4.20	2.10	2.30	
	mean	4.7(7)	0.4(7)	0.9(4)	0.11(13)	2.51(8)	0.70(5)	0.7(8)	1.24(7)	1.12(4)	0.98(3)	0.07(1)
	min	0.8	N.D.	0.5	N.D.	0.20	0.5	N.D.	N.D.	0.30	0.25	
Oxygen absorbed in 4 hours from KMnO_4 (ppm O_2)	max	17.7	8.6	3.3	5.6	6.0	4.0	16.8	8.0	4.0	3.6	4.6
	mean	7.9(10)	3.3(11)	2.4(7)	2.9(13)	3.1(11)	2.1(8)	5.1(13)	3.1	1.8(8)	2.3(8)	2.3(8)
	min	1.3	1.2	1.3	1.0	1.1	1.2	1.6	1.3	0.50	1.2	1.2

Table 11.

Water analyses for sampling points in the southern part of the Catchment of the Vaal Dam. All results are derived from single snap samples collected in August, 1961. (Chutter 1967 : Table 16).

Station number	9	10	11A	11B	11X	13	24	25	26	30	41	42	44
pH (Field measurements)..	8.3	8.4	6.8	7.1	7.4	8.6	8.3	8.3	8.2	8.4	8.5	7.8	8.4
pH (Lab. measurements) .	7.7	7.9	7.6	7.6	8.2	8.7	7.6	7.7	7.4	8.0	8.6	8.3	8.6
Total dissolved solids at 105°C ppm.	83	59	99	9.0	107	113	83	53	104	112	190	179	132
Total Nitrogen in ppm N (A)	3.4	3.4	3.2	4.0	8.6	3.5	2.6	3.1	2.7	2.6	3.8	3.1	2.2
Kjeldahl nitrogen ppm N (B)	2.4	1.7	1.2	3.4	6.9	1.7	1.6	1.2	1.5	1.8	2.8	2.7	1.6
Nitrates + Nitrites (A - B) ppm N.	1.0	1.7	2.0	0.6	1.7	1.8	1.0	1.9	1.2	0.8	1.0	0.4	0.6
Total Alkalinity ppm CaCO ₃	26	26	2.6	31	38	116	36	28	51	89	164	91	161
Total Hardness ppm CaCO ₃	28	30	36	37	40	90	46	39	62	94	13	104	150
Calcium Hardness ppm CaCO ₃	13	12	11	17	25	67	16	15	32	54	10	62	104
Magnesium Hardness ppm CaCO ₃	15	18	15	20	15	23	30	24	30	40	3	42	46
Chlorides ppm Cl.	25.8	25.8	36.1	41.5	62.0	46.7	28.4	25.9	36.1	25.8	72.4	108.9	64.5
Sulphates ppm SO ₄	12.5	13.5	13.5	8.0	10.5	5.0	7.5	2.0	4.0	2.0	11.5	26.0	15.0
Sodium ppm Na	10.0	10.0	11.6	12.8	19.0	21.8	9.4	10.0	12.2	15.4	48.4	30.0	32.0
Turbidity ppm SiO ₂	12	33	64	62	58	2.0	2.8	16	28	9	30	50	43
Oxygen absorbed in 4 hours from KMNO ₄ ppm O ₂ .	2.8	6.6	9.4	8.6	9.4	3.9	6.6	2.6	4.7	0.8	7.8	12.7	8.4

Table 12.

THE VAAL RIVER.STATION 1.

	301	370	479
	16.9.58	21.3.60	11.8.60
<i>Achnanthes microcephala</i> Kützing		4.9	
<i>Achnanthes minutissima</i> Kützing	14.3		11.8
<i>Caloneis Chasei</i> Cholnoky	5.1	2.4	1.5
<i>Cymbella gracilis</i> (Rabenhorst) Cleve	8.6	+	1.3
<i>Cymbella naviculiformis</i> Auerswald	3.0	0.5	2.1
<i>Cymbella ventricosa</i> Kützing	4.6	4.4	4.4
<i>Eunotia diodon</i> Ehrenberg			2.8
<i>Eunotia pectinalis</i> (Kützing) Rabenhorst	+	2.1	
<i>Eunotia rhomboidea</i> Hustedt	1.0		
<i>Frustulia rhomboides</i> (Ehrenberg)			
De Toni var. <i>saxonica</i> (Rabenhorst)			
De Toni	1.9	25.3	7.7
<i>Gomphonema gracile</i> Ehrenberg	0.3	2.9	0.3
<i>Gomphonema parvulum</i> (Kützing) Grunow	11.0	7.0	11.3
<i>Navicula cryptocephala</i> Kützing	5.7	11.6	3.6
<i>Navicula diuturnoides</i> Archibald	4.6	0.5	4.6
<i>Navicula esamangensis</i> Foged	0.3	1.1	0.5
<i>Navicula molesta</i> Krasske	0.5		1.3
<i>Navicula muralis</i> Grunow	1.0		0.5
<i>Navicula promota</i> n.sp.	1.3	+	1.3
<i>Navicula submolesta</i> Hustedt	2.4	3.4	4.1
<i>Navicula subtilissima</i> Cleve			3.6
<i>Navicula tenella</i> Brebisson	2.2	1.8	0.5
<i>Navicula tenuissima</i> n.sp.	1.3	0.3	
<i>Navicula Twymaniana</i> Archibald			1.0
<i>Neidium affine</i> (Ehrenberg) Cleve var.			
<i>amphirhynchus</i> (Ehrenberg) Cleve	0.3	0.5	1.8
<i>Nitzschia gracilis</i> Hantzsch	1.3	0.8	
<i>Nitzschia Kützingiana</i> Hilse	1.0	1.8	3.1
<i>Nitzschia palea</i> (Kützing) W. Smith	6.5	6.2	9.2
<i>Nitzschia perminuta</i> Grunow	13.3		9.7
<i>Nitzschia stricta</i> Hustedt			1.0

Table 12 (cont.).

- 2 -

The Vaal River

Station 1.

	301	370	479
	16.9.58	21.3.60	11.8.60
Pinnularia acoricola Hustedt	2.4	0.8	1.5
Pinnularia mesolepta (Ehrenberg)			
W. Smith	+	0.3	1.0
Stauroneis anceps Ehrenberg f.			
gracilis (Ehrenberg) Cleve	+	1.1	+
Surirella delicatissima Lewis var.			
africana Cholnoky	1.0	13.4	2.3
Surirella linearis W. Smith			1.3
Surirella tenera Gregory	0.5	1.6	
Other species	4.6	5.3	4.9
Nitrogen heterotrophic Nitzschiae			
combined	22.4	8.3	24.2
Eunotia species combined	1.6	3.2	3.5

Table 13.

THE VAAL RIVER.

STATION 2.

486

11.8.60

Achnanthes minutissima Kützing.	45.9
Cocconeis microscopica Cholnoky.	1.6
Cymbella ventricosa Kützing.	2.7
Fragilaria familiaris (Grunow) Hustedt.	4.2
Fragilaria pinnata Ehrenberg.	28.9
Fragilaria Vaucheriae (Kützing) Petersen	3.5
Gomphonema parvulum (Kützing) Grunow.	1.8
Navicula Zanonii Hustedt	1.0
Nitzschia obsoleta Hustedt	1.5
Nitzschia palea (Kützing) W. Smith	1.0
Nitzschia perminuta Grunow	1.8
Synedra ulna (Nitzsch) Ehrenberg	4.4
Other species	1.5
 Nitrogen heterotrophic Nitzschiae combined	 4.5

Table 14.

THE VAAL RIVER.STATION 2A.

	306	307
	23.9.59	19.1.60
<i>Achnanthes minutissima</i> Kützing	90.5	37.9
<i>Cymbella Kappii</i> Cholnoky	1.4	+
<i>Fragilaria construens</i> (Ehrenberg) Grunow	+	1.1
<i>Fragilaria familiaris</i> (Kützing) Hustedt	4.3	5.8
<i>Fragilaria Vaucheriae</i> (Kützing) Petersen	+	2.2
<i>Gomphonema parvulum</i> (Kützing) Grunow	0.5	2.0
<i>Navicula cryptocephala</i> Kützing	+	6.5
<i>Navicula diuturnoides</i> Archibald		1.8
<i>Navicula pascuorum</i> Cholnoky		1.8
<i>Navicula rostellata</i> Kützing	+	3.1
<i>Nitzschia acicularis</i> W. Smith		1.5
<i>Nitzschia Kützingiana</i> Hilse	0.5	5.6
<i>Nitzschia obligata</i> Archibald		8.3
<i>Nitzschia palea</i> (Kützing) W. Smith	0.5	5.6
<i>Nitzschia perminuta</i> Grunow.	+	2.7
<i>Nitzschia spiculum</i> Hustedt	+	2.2
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	0.9	1.3
Other species	1.4	10.6
Nitrogen heterotrophic <i>Nitzschiae</i> combined	1.0	23.1

Table 15.

THE VAAL RIVER

SAMPLE 477.

	477
	11.8.60
Achnanthes minutissima Kützing	85.9
Cymbella Kappii Cholnoky	1.4
Cymbella ventricosa Kützing	2.7
Fragilaria Vaucheriae (Kützing) Petersen	4.7
Other species	5.3
Nitrogen heterotrophic Nitzschiae combined	1.3

Table 16.

THE VAAL RIVER.

STATION 3.

	309	312	495
	15.9.58	23.9.59	10.8.60
Achnanthes minutissima Kützing	13.6	5.9	12.5
Amphora coffaeiformis Agardh	+	+	2.6
Cymbella amphicephala Naegeli	22.5	6.3	35.7
Cymbella microcephala Grunow	43.0	56.5	27.4
Navicula cryptocephala Kützing	0.5	2.2	1.7
Navicula rhynchocephala Kützing	1.4		0.9
Navicula rostellata Kützing	+	1.2	1.2
Navicula tenella Brebisson	0.5	1.9	0.9
Navicula Zanonii Hustedt	1.4	0.5	+
Nitzschia adapta Hustedt	3.1	1.2	0.5
Nitzschia fonticola Grunow	+	1.4	0.9
Nitzschia interrupta (Reichel) Hustedt	5.1	12.9	6.9
Nitzschia Kützingiana Hilse	1.4	0.7	0.5
Nitzschia linearis W. Smith	+	+	3.1
Nitzschia palea (Kützing) W. Smith	1.4	0.2	0.2
Nitzschia permiruta Grunow.	+	2.4	+
Nitzschia spiculum Hustedt	1.4	1.4	
Other species	4.7	5.3	5.0
Nitrogen heterotrophic Nitzschiae combined	7.8	8.6	2.1

Table 17.

THE VAAL RIVER. STATION 4.

	313	315	316	416	417
	15.9.58	22.9.59	19.1.60	8.8.60	8.8.60
<i>Achnanthes adamantiformis</i>					
Archibald			2.7		
<i>Achnanthes minutissima</i>					
Kützing	19.7	9.0	2.1	27.5	
<i>Caloneis fasciata</i>					
(Lagerstedt) Cleve	+		2.4	+	+
<i>Cyclotella comensis</i> Grunow	+		2.9	+	+
<i>Cymatopleura solea</i>					
Brebisson	1.5			+	
<i>Cymbella cistula</i> (Hemprich)					
Grunow	+	0.2		1.2	
<i>Cymbella Kappii</i> Cholnoky	1.5	6.3	+	48.2	+
<i>Cymbella microcephala</i>					
Grunow	23.0	1.2	0.8	6.0	
<i>Cymbella ventricosa</i>					
Kützing	0.5	2.8	2.7	1.2	
<i>Fragilaria familiaris</i>					
(Kützing) Hustedt		0.2	0.3	1.9	
<i>Fragilaria Vaucheriae</i>					
(Kützing) Petersen	0.5	+	13.2	1.7	+
<i>Frustulia vulgaris</i>					
(Thwaites) De Toni var.					
angusta Cholmoky	1.3			+	+
<i>Gomphonema parvulum</i>					
(Kützing) Grunow	0.3	1.2	8.0	+	1.1
<i>Melosira granulata</i>					
(Ehrenberg) Ralfs var.					
angustissima O. Müller.	+		0.8	1.0	+
<i>Navicula atomus</i> (Kützing)					
Grunow	1.5	0.5	0.3		
<i>Navicula cinctaeformis</i>					
Hustedt.	0.5	+	1.3		+

Table 17 (cont.).

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The Vaal RiverStation 4.

	313	315	316	416	417
	15.9.58	22.9.59	19.1.60	8.8.60	8.8.60
<i>Navicula cryptocephala</i>					
Kützing	5.6	2.0			0.3
<i>Navicula minima</i> Grunow			1.3		
<i>Navicula muralis</i> Grunow			2.4		0.3
<i>Navicula rhynchocephala</i>					
Kützing	12.8	0.8	0.5	+	+
<i>Navicula Schroeteri</i> Meister	+	0.2	1.6		0.5
<i>Navicula tenella</i> Brebisson	3.3	0.2	0.5	0.7	+
<i>Navicula Twymaniana</i>					
Archibald	0.3		1.3		
<i>Navicula Zanonii</i> Hustedt	0.5	0.8		1.0	
<i>Nitzschia acicularis</i>					
W. Smith		1.8			
<i>Nitzschia adapta</i> Hustedt	1.3	4.0		0.7	
<i>Nitzschia capitellata</i>					
Hustedt		3.8	1.6		
<i>Nitzschia confinis</i> Hustedt		3.3			
<i>Nitzschia diserta</i>	+				1.1
<i>Nitzschia exilis</i> Archibald		1.0			
<i>Nitzschia fonticola</i> Grunow	6.6	10.8	1.1		
<i>Nitzschia hungarica</i> Grunow	+	1.3		+	1.1
<i>Nitzschia interrupta</i>					
(Reichelt) Hustedt	1.0	0.5		0.5	+
<i>Nitzschia Kützingiana</i> Hilse	+	9.5	7.6		3.2
<i>Nitzschia linearis</i> W. Smith	1.8	1.5		1.4	+
<i>Nitzschia palea</i> (Kützing)					
W. Smith	5.4	13.3	10.8	2.7	82.2
<i>Nitzschia perminuta</i> Grunow	1.5	13.0		1.0	
<i>Nitzschia romana</i> Grunow	+	3.3	0.8	+	5.0
<i>Nitzschia spiculum</i> Hustedt		1.2			
<i>Nitzschia tarda</i> Hustedt	0.5	1.3			
<i>Surirella angusta</i> Kützing	0.8	0.8		+	1.1
<i>Surirella ovata</i> Kützing					2.4

Table 17 (cont.).

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The Vaal River.

Station 4.

	313	315	316	416	417
	15.9.58	22.9.59	19.1.60	8.8.60	8.8.60
Synedra nana Meister	4.1	+			
Synedra ulna (Nitzsch)					
Ehrenberg.		0.8	30.8	2.4	0.5
Other species	4.2	3.4	2.2	0.9	1.2
Nitrogen heterotrophic					
Nitzschiae combined	15.8	66.8	22.4	4.4	91.8

Table 18.

THE VAAL RIVER.STATION 5.

	317	319	418
	15.9.58	22.9.59	8.8.60
Achnanthes minutissima Kützing	27.9	23.2	34.8
Cymbella amphicephala Naegeli	10.7	0.5	+
Cymbella Kappii Cholnoky	0.5	23.0	19.8
Cymbella microcephala Grunow	32.0	34.8	30.6
Cymbella ventricosa Kützing	1.4	0.5	2.3
Gomphonema Clevei Fricke	+	0.3	1.3
Gomphonema longiceps Ehrenberg			
var. subclavatum Grunow	+	1.0	0.3
Gomphonema parvulum (Kützing)			
Grunow	0.5	12.7	0.5
Navicula cryptocephala Kützing	6.1	0.3	0.5
Navicula rhynchocephala Kützing	3.0	+	0.3
Navicula tenella Brebisson	1.4	0.8	2.9
Nitzschia hungarica Grunow	1.3		+
Nitzschia linearis W. Smith	1.7	+	0.5
Nitzschia palea (Kützing) W. Smith	5.6	0.3	2.6
Nitzschia perminuta Grunow	1.7	1.0	+
Synedra nana Meister	1.4		
Other species	4.8	1.6	3.6
Nitrogen heterotrophic			
Nitzschiae combined	8.7	1.3	3.1

Table 19.

THE VAAL RIVER

STATION 5A.

	321	322	323	324	375	406	552
	20.7.59	18.8.59	22.9.59	19.1.60	3.6.60	8.8.60	19.3.65
Achnanthes adamantiformis Archibald				1.5			
Achnanthes lanceolata (Brebisson) Grunow var. rostrata Östrup	0.4	0.5	1.0	1.5	+	0.5	
Achnanthes minutissima Kützing	1.8	14.6	20.2	0.5	+	38.1	
Amphipleura pellucida Kützing		0.3	1.2				
Amphora veneta Kützing	+	2.9	3.5		0.5	0.3	1.6
Caloneis fasciata (Lagerstedt) Cleve	2.3	0.3	0.3		+		1.0
Cocconeis placentula Ehrenberg				+		1.0	
Cocconeis placentula var. euglypta (Ehrenberg) Cleve	0.5	5.9	1.8	1.5	0.8	10.5	
Cyclotella comensis Grunow	10.6	18.0	17.7	20.3	1.6	2.3	6.7
Cyclotella Meneghiniana Kützing				3.0			0.5
Cymbella microcephala Grunow	0.9	0.5	1.0	+	+	+	
Cymbella perpusilla Cleve				2.5		+	
Fragilaria familiaris (Kützing) Hustedt					41.6		
Fragilaria Vaucheriae (Kützing) Boye Petersen	0.5	31.1	4.0	0.3	2.7	35.3	
Gomphonema parvulum (Kützing) Grunow	1.4	1.3	1.0	1.3	37.6	1.0	3.1
Gyrosigma scalproides (Rabenhorst) Cleve	1.4	0.3	0.3	0.2	+	0.5	10.8
Navicula agrestis Hustedt							1.6
Navicula atomus (Kützing) Grunow		1.6		0.3			
Navicula bryophila Boye Petersen		+	+	13.5	+	+	
Navicula cintaeformis Hustedt	0.9	0.5	1.0	0.2	+		6.2
Navicula cryptocephala Kützing	25.2	0.8	3.5	1.0		0.8	9.3
Navicula diuturna Cholnoky	0.4						2.6
Navicula diurnoides Archibald	+			1.3		0.3	1.6
Navicula Fritschii Lund							1.0
Navicula minima Grunow		0.3	0.8	2.0			+
Navicula mutalis Grunow	0.9	0.3	2.8	+	0.3	0.3	3.6
Navicula permitis Hustedt	0.5	0.8	2.3			+	
Navicula perparva Hustedt				1.0			1.0
Navicula rostellata Kützing	5.5	0.3	+		0.8	+	2.6
Navicula Schroeteri Meister	4.1	0.3	0.5	1.5	1.8	+	4.1
Navicula tenella Brebisson	12.8	4.0	6.0	12.4	10.9	1.0	2.1
Navicula tenelloides Hustedt	2.3	0.5	0.8	+	+	+	1.6
Navicula Twymaniana Archibald	0.9			1.0	0.3		6.7
Nitzschia acicularis W. Smith			1.5	1.3		+	
Nitzschia Agnewii Cholnoky		+		2.0			1.0
Nitzschia bacata Hustedt			5.0			2.0	
Nitzschia Clausii Hantzsch	1.5						

Table 19 (cont.).

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The Vaal River Station 5A.

	321	322	323	324	375	406	552
	20.7.59	18.8.59	22.9.59	19.1.60	3.3.60	8.8.60	19.3.65
Nitzschia dissipata (Kützing) Grunow		0.8	1.0				
Nitzschia fonticola Grunow	4.1	0.5		1.3		+	0.5
Nitzschia intermissa Hustedt	0.9	1.3	3.5			0.3	
Nitzschia Kützingiana Hilse	9.6	5.3	7.3	14.0		0.8	19.1
Nitzschia levidensis W. Smith. var. victoriae Grunow							2.1
Nitzschia linearis W. Smith	4.6	+	1.5		0.3	0.3	
Nitzschia palea (Kützing) W. Smith	+		+	3.8		+	4.6
Nitzschia perminuta Grunow	+	+	2.8	4.8		+	1.0
Nitzschia perpusilla (Rabenhorst) Grunow	+	1.1	0.3	0.3			
Nitzschia romana Grunow	+			1.0	+		0.5
Rhopalodia gibba (Ehrenberg) O. Müller	0.5	1.3	1.8	+	+		
Synedra ulna (Nitzsch) Ehrenberg		+	1.0		0.3	1.0	
Other species	5.5	4.6	4.6	4.7	0.5	3.7	3.5
Nitrogen heterotrophic Nitzschiae combined	15.1	9.0	21.7	29.0	0.0	3.1	27.2

Table 20.

THE VAAL RIVER.STATION 6.

	403
	8.8.60
<i>Achnanthes lanceolata</i> (Brebisson)	
Grunow var. <i>rostrata</i> Östrup.	1.2
<i>Achnanthes minutissima</i> Kützing	5.1
<i>Cyclotella comensis</i> Grunow	4.0
<i>Cyclotella Kützingiana</i> Thwaites	1.2
<i>Cymbella amphicephala</i> Naegeli	3.4
<i>Cymbella microcephala</i> Grunow	1.7
<i>Cymbella perpusilla</i> Cleve	1.2
<i>Cymbella ventricosa</i> Kützing	1.7
<i>Gyrosigma scalproides</i> (Rabenhorst) Cleve	17.7
<i>Hantzschia amphioxys</i> (Ehrenberg) Grunow	1.7
<i>Navicula cinctaeformis</i> Hustedt	6.8
<i>Navicula cryptocephala</i> Kützing	18.2
<i>Navicula microcephala</i> Grunow	1.2
<i>Navicula rostellata</i> Kützing	8.6
<i>Navicula Schroeteri</i> Meister	1.1
<i>Navicula tenella</i> Brebisson	4.0
<i>Navicula Zanonii</i> Hustedt	1.7
<i>Nitzschia intermissa</i> Hustedt	4.6
<i>Nitzschia palea</i> (Kützing) W. Smith	1.1
Other species	13.8
 Nitrogen heterotrophic <i>Nitzschia</i> combined	 8.7

Table 21.

TRIBUTARIES OF THE UPPER VAAL RIVER

THE KAFFIRSPRUIT STREAM.

	Station 19.						
	342	343	344	493	489	491	492
	15.9.58	22.7.59	20.1.60	12.8.60	12.8.60	12.8.60	12.8.60
<i>Actinanthus minutissima</i> Kützing	5.7	3.1	14.8	0.5	13.9	0.5	20.7
<i>Caloneis Clevei</i> (Lagerstedt) Cleve	5.5	2.1	2.8	+		0.7	+
<i>Caloneis Schumanniana</i> (Grunow) Cleve		1.0	+	+	2.8		
<i>Cymatopleura solea</i> Brebisson	1.1	+	0.5	+	+	+	
<i>Cymbella aequalis</i> W. Smith	+		+			+	18.3
<i>Cymbella amphicephala</i> Naegeli	23.2	34.9	3.1	62.8	+	8.7	23.8
<i>Cymbella Kappii</i> Cholnoky	0.8	0.3		+		5.6	3.3
<i>Cymbella microcephala</i> Grunow	4.4	28.1	1.0	5.4		64.8	0.5
<i>Diploneis subovalis</i> Cleve	+	+	1.0	+	0.3	+	
<i>Gyrosigma Kützingii</i> (Grunow) Cleve	4.9	1.3	+	0.8			
<i>Navicula cinctaeformis</i> Hustedt	1.4	+	2.3	0.3	+	+	
<i>Navicula cryptocephala</i> Kützing	5.7	1.8	8.5	7.4	13.7	1.8	
<i>Navicula esamangensis</i> Foged	1.1		+				
<i>Navicula pygmaea</i> Kützing	0.5	+		1.2	0.3	+	
<i>Navicula rhynchocephala</i> Kützing	9.3		+	0.3	5.3	+	
<i>Navicula rostellata</i> Kützing	1.1	2.9	+		+		
<i>Navicula Schroeteri</i> Meister	0.5	+	1.0				
<i>Navicula tenella</i> Brebisson	9.0	0.8	0.8	2.2	0.5	2.9	+
<i>Navicula Zanonii</i> Hustedt	2.5	1.8	+	2.0		8.5	+
<i>Nitzschia acicularis</i> W. Smith			2.1				+
<i>Nitzschia adapta</i> Hustedt	0.5	0.5	3.6	1.2	+		0.2
<i>Nitzschia dissipata</i> (Kützing) Grunow		1.8	0.5	0.3		+	
<i>Nitzschia elliptica</i> Hustedt var. <i>alexandrina</i> Cholnoky					1.6		
<i>Nitzschia fonticola</i> Grunow			1.0	+	1.6		
<i>Nitzschia gracilis</i> Hantzsch			2.1			+	
<i>Nitzschia hungarica</i> Grunow	+		0.8	+	6.6		
<i>Nitzschia interrupta</i> (Reichel) Hustedt	5.2	+	3.9	0.5		4.9	29.0
<i>Nitzschia Kützingiana</i> Hilse	+	+	18.4	0.5	5.0	+	+
<i>Nitzschia linearis</i> W. Smith	5.5	14.0	+	8.4	0.3	0.2	1.4
<i>Nitzschia palea</i> (Kützing) W. Smith	0.3	+	17.1	0.5	13.4	0.5	0.2
<i>Nitzschia perminuta</i> Grunow		+	3.9	+	1.6	+	0.5

Table 21 (cont.).

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Tributaries of the Upper Vaal River - The Kaffirpoort Stream.

	Station 19.						
	342	343	344	493	489	491	492
	15.9.58	22.7.59	20.1.60	12.8.60	12.8.60	12.8.60	12.8.60
Nitzschia romana Grunow	+		1.0	+	25.0	0.2	
Pinnularia microstauron (Ehrenberg) Cleve var. Brebissonii (Kützing) Hustedt	3.5	2.3	0.5	3.8		+	+
Surirella angusta Kützing	0.5	+	0.3	0.3	2.3	+	+
Surirella ovalis Brebisson	1.4	0.8	+	+	+	+	+
Other species	6.4	2.5	9.0	1.6	5.8	0.7	2.1
Nitrogen heterotrophic Nitzschiae combined	1.3	2.3	50.6	2.5	48.4	0.7	0.9

Table 22.

TRIBUTARIES OF THE UPPER VAAL RIVER.

THE BLESBOK RIVER - STATION 18.

	496
	12.8.60
Achnanthes minutissima Kützing.	59.3
Cymbella Kappii Cholnoky	1.6
Cymbella microcephala Grunow	16.6
Cymbella ventricosa Kützing	1.6
Fragilaria Vaucheriae (Kützing)	
Boye Petersen.	1.6
Gomphonema parvulum (Kützing) Grunow	1.3
Navicula tenella Brebisson	1.3
Nitzschia interrupta (Reichelt) Hustedt	12.6
Synedra nana Meister	2.2
Other species	1.9
 Nitrogen heterotrophic Nitzschiae combined	 0.0

Table 23.

TRIBUTARIES OF THE UPPER VAAL RIVER.

THE KLEINVAAL RIVER - STATION 20.

	345	347	348	463
	10.12.58	23.9.59	20.1.60	10.8.60
<i>Achnanthes minutissima</i> Kützing	24.6	15.5	35.2	5.7
<i>Cymbella Kappii</i> Cholnoky	+	0.5	1.0	31.9
<i>Cymbella microcephala</i> Grunow	1.0	+	0.3	+
<i>Cymbella ventricosa</i> Kützing	11.5	0.7	9.7	21.6
<i>Fragilaria familiaris</i> (Kützing) Hustedt	7.9		0.8	
<i>Frustulia vulgaris</i> (Thwaites) De Toni var. <i>angusta</i> Cholnoky	3.3	2.2		+
<i>Gomphonema parvulum</i> (Kützing) Grunow	5.9	+	1.6	0.3
<i>Navicula cryptocephala</i> Kützing	5.2	3.6	5.0	11.1
<i>Navicula diuturna</i> Cholnoky		1.2	1.6	
<i>Navicula microcephala</i> Grunow	1.6			+
<i>Navicula pascuorum</i> Cholnoky				1.3
<i>Navicula rhynchocephala</i> Kützing	0.5	2.8	2.5	6.0
<i>Navicula Schroeteri</i> Meister		0.2	1.3	+
<i>Navicula subhamulata</i> Grunow		5.4	+	+
<i>Navicula Twymaniana</i> Archibald			1.3	
<i>Nitzschia acicularis</i> W. Smith		2.0	2.3	1.6
<i>Nitzschia adapta</i> Hustedt	0.2	+	1.3	0.3
<i>Nitzschia fonticola</i> Grunow		1.2	0.5	+
<i>Nitzschia Kützingiana</i> Hilse	2.8	2.8	10.2	1.6
<i>Nitzschia linearis</i> W. Smith	4.4	0.7	1.8	6.0
<i>Nitzschia palea</i> (Kützing) W. Smith	5.9	1.2	7.6	+
<i>Nitzschia perminuta</i> Grunow	9.6	1.5	1.8	1.3
<i>Nitzschia spiculum</i> Hustedt		54.6	1.6	4.2
<i>Pinnularia acoricola</i> Hustedt	3.2			
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	7.6	+	8.4	0.3
Other species	4.8	3.9	6.0	6.8
Nitrogen heterotrophic <i>Nitzschiae</i> combined	18.7	63.8	25.8	10.4

Table 24.TRIBUTARIES OF THE UPPER VAAL RIVER.THE KLEINVAAL RIVER - STATION 21A.

	350	464
	23.9.59	10.8.60
<i>Achnanthes minutissima</i> Kützing	73.0	75.2
<i>Cymbella microcephala</i> Grunow	3.6	0.5
<i>Cymbella ventricosa</i> Kützing	1.3	8.0
<i>Fragiliaria Vaucheriae</i> (Kützing) Petersen	8.2	1.3
<i>Navicula indifferens</i> Hustedt		6.7
<i>Navicula promota</i> n.sp.	1.1	+
<i>Nitzschia adapta</i> Hustedt	1.8	+
<i>Nitzschia interrupta</i> (Reichel) Hustedt	2.0	+
<i>Nitzschia palea</i> (Kützing) W. Smith	0.9	1.0
<i>Nitzschia perminuta</i> Grunow	0.2	1.3
<i>Nitzschia spiculum</i> Hustedt	2.0	2.1
<i>Synedra nana</i> Meister	1.1	
Other species	4.8	3.9
 Nitrogen heterotrophic <i>Nitzschiae</i> combined	 5.5	 4.9

Table 25.

TRIBUTARIES OF THE UPPER VAAL RIVER.

THE KLEINVAAL RIVER - STATION 21.

	353	356
	23.9.59	20.1.60
<i>Achnanthes lanceolata</i> (Brebisson)		
Grunow var. <i>elliptica</i> Cleve		1.0
<i>Achnanthes lanceolata</i> var. <i>rostrata</i>		
Östrup	+	1.0
<i>Achnanthes minutissima</i> Kützing	50.1	31.3
<i>Cymbella Kappii</i> Cholnoky	1.9	0.5
<i>Cymbella microcephala</i> Grunow	5.3	1.0
<i>Cymbella ventricosa</i> Kützing	2.8	1.0
<i>Fragilaria familiaris</i> (Kützing)		
Hustedt	2.3	55.9
<i>Fragilaria Vaucheriae</i> (Kützing)		
Petersen	5.0	+
<i>Gomphonema Clevei</i> Fricke	+	4.0
<i>Gyrosigma Kützingii</i> (Grunow) Cleve	1.3	
<i>Navicula cryptocephala</i> Kützing	5.0	1.0
<i>Navicula rhynchocephala</i> Kützing	2.0	+
<i>Navicula rostellata</i> Kützing	2.5	0.5
<i>Navicula Zanonii</i> Hustedt	6.5	0.7
<i>Nitzschia interrupta</i> (Reichelt)		
Hustedt	1.0	0.7
<i>Nitzschia Kützingiana</i> Hilse	4.3	0.2
<i>Nitzschia linearis</i> W. Smith	1.9	
<i>Nitzschia palea</i> (Kützing) W. Smith	1.3	+
<i>Nitzschia spiculum</i> Hustedt	1.0	
<i>Surirella angusta</i> Kützing	1.0	
Other species	4.8	0.2
Nitrogen heterotrophic <i>Nitzschiae</i>		
combined	7.6	0.7

Table 26.

THE TRIBUTARIES OF THE UPPER VAAL RIVER.THE SKULPSPRUIT RIVER AND RIETSPRUIT RIVER

	465	468
	11.8.60	11.8.60
Achnanthes minutissima Kützing	20.2	11.6
Amphora veneta Kützing		1.0
Cymbella amphicephala Naegeli	12.8	0.8
Cymbella Kappii Cholnoky	0.5	1.0
Cymbella microcephala Grunow	43.6	64.0
Cymbella ventricosa Kützing	4.0	2.8
Navicula cryptocephala Kützing	1.3	2.0
Navicula muralis Grunow		1.0
Navicula tenella Prebisson	0.5	1.8
Navicula Zanonii Hustedt	1.0	1.3
Nitzschia adapta Hustedt	0.5	1.0
Nitzschia interrupta (Reichelt)		
Hustedt	12.4	6.2
Nitzschia Kützingiana Hilse	+	1.0
Nitzschia perminuta Grunow	1.0	+
Rhopalodia gibba (Ehrenberg)		
O. Müller		1.0
Other species	2.2	3.5
Nitrogen heterotrophic Nitzschiae		
combined	2.0	2.3

Table 27.

THE KLIP RIVER - STATION 24.

		Station 24.	
		438	358 437
		9.8.60	13.1.59 9.8.60
Achnanthes linearis W. Smith			0.8 7.8
Achnanthes minutissima Kützing	29.2	4.2	64.6
Amphora coffaceaformis Agardh		+	1.3
Cymbella aspera (Ehrenberg)			
Cleve	4.3	+	+
Cymbella naviculiformis			
Auerswald	15.6		
Cymbella ventricosa Kützing	17.3	4.4	3.2
Fragilaria Vaucheriae (Kützing)			
Petersen		+	11.4
Gomphonema Clevei Fricke		+	1.3
Gomphonema parvulum (Kützing)			
Cleve	3.4	1.8	1.3
Navicula cryptocephala			
Kützing	10.1	3.4	+
Navicula microcephala Grunow	0.7	1.6	+
Navicula muralis Grunow		7.6	
Navicula rostellata Kützing		12.1	1.3
Navicula Schroeteri Meister		1.0	+
Navicula Twymaniana Archibald		1.3	
Nitzschia accomodata Hustedt		1.0	+
Nitzschia amphioxoides Hustedt		1.0	
Nitzschia Clausii Hantzsch		4.4	+
Nitzschia dissipata (Kützing)			
Grunow	0.5	+	1.3
Nitzschia Kützingiana Hilse		38.3	1.8
Nitzschia linearis W. Smith	15.6	+	+
Nitzschia palea (Kützing)			
W. Smith		7.4	0.2
		2/	

Table 27 (cont.).

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The Klip River - Station 24.

		Station 24	
	438	358	437
	9.8.60	13.1.59	9.8.60
Nitzschia perminuta Grunow	1.0	2.4	1.0
Surirella ostentata Cholnoky		2.6	1.0
Other species	2.3	4.7	2.5
Nitrogen heterotrophic			
Nitzschiae combined	1.5	50.9	4.3

Table 28.

THE KLIP RIVER - STATION 25.

	359	434
	14.1.59	8.8.60
<i>Achnanthes linearis</i> W. Smith	1.8	5.3
<i>Achnanthes minutissima</i> Kützing	4.4	16.6
<i>Amphora coffaeiformis</i> Agardh		1.0
<i>Cymbella ventricosa</i> Kützing	2.6	0.2
<i>Fragilaria Vaucheriae</i> (Kützing) Petersen	1.6	26.0
<i>Gomphonema parvulum</i> (Kützing) Grunow	3.0	1.7
<i>Navicula atomus</i> (Kützing) Grunow	1.0	2.9
<i>Navicula cryptocephala</i> Kützing	2.6	11.3
<i>Navicula microcephala</i> Grunow	1.0	12.3
<i>Navicula rostellata</i> Kützing	2.6	1.0
<i>Nitzschia acicularis</i> W. Smith	1.0	3.9
<i>Nitzschia Kützingiana</i> Hilse	54.8	4.1
<i>Nitzschia linearis</i> W. Smith	1.0	2.9
<i>Nitzschia palea</i> (Kützing) W. Smith	11.2	+
<i>Nitzschia perminuta</i> Grunow	5.9	1.7
<i>Surirella ostentata</i> Cholnoky	+	1.0
Other species	5.5	8.1
Nitrogen heterotrophic <i>Nitzschiae</i> combined	74.2	12.1

Table 29.

THE KLIP RIVER - STATION 26.

	261	449
	13.7.58	10.8.60
<i>Achnanthes linearis</i> W. Smith		28.3
<i>Achnanthes minutissima</i> Kützing	3.6	21.0
<i>Cocconeis placentula</i> Ehrenberg		
var. <i>euglypta</i> (Ehrenberg) Cleve.		10.9
<i>Cymbella ventricosa</i> Kützing.	6.2	0.2
<i>Fragilaria Vaucheriae</i> (Kützing)		
Petersen	7.9	5.0
<i>Frustulia vulgaris</i> (Thwaites) De		
Toni var. <i>angusta</i> Cholnoky.	1.8	0.2
<i>Gomphonema Clevei</i> Fricke	0.5	2.5
<i>Gomphonema javanicum</i> Hustedt.		1.8
<i>Gomphonema parvulum</i> (Kützing) Grunow	1.5	0.5
<i>Cyrosigma Kützingii</i> (Grunow) Cleve.	1.0	+
<i>Melosira varians</i> Agardh.	2.4	7.9
<i>Navicula atomus</i> (Kützing) Grunow	1.2	4.5
<i>Navicula cryptocephala</i> Kützing	20.1	1.0
<i>Navicula rostellata</i> Kützing	2.0	0.2
<i>Navicula Schroeteri</i> Meister	0.2	1.3
<i>Navicula Twymaniana</i> Archibald	0.5	3.0
<i>Nitzschia accomodata</i> Hustedt.	1.0	+
<i>Nitzschia acicularis</i> W. Smith	3.6	0.5
<i>Nitzschia Kützingiana</i> Hilse	1.8	0.7
<i>Nitzschia linearis</i> W. Smith	35.0	+
<i>Nitzschia perminuta</i> Grunow	2.0	1.3
<i>Pinnularia acoricola</i> Hustedt	1.0	
<i>Surirella angusta</i> Kützing	2.2	+
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	+	5.9
Other species	4.5	3.3
Nitrogen heterotrophic <i>Nitzschiae</i>		
combined	8.6	3.2

Table 30.

THE KLIP RIVER - STATION 27.

	421
	9.8.60
<i>Achnanthes minutissima</i> Kützing	9.8
<i>Amphora coffaeiformis</i> Agardh	2.6
<i>Amphora submontana</i> Hustedt	1.5
<i>Cyclotella comensis</i> Grunow.	1.7
<i>Cymbella microcephala</i> Grunow	1.7
<i>Cymbella ventricosa</i> Kützing	1.7
<i>Fragilaria Vaucheriae</i> (Kützing) Petersen	2.6
<i>Frustulia vulgaris</i> (Thwaites) De Toni	
var. <i>angusta</i> Cholnoky	2.8
<i>Gomphonema Clevei</i> Fricke	1.5
<i>Gyrosigma Kützingii</i> (Grunow) Cleve	2.1
<i>Gyrosigma scalproides</i> (Rabenhorst) Cleve	9.5
<i>Navicula cryptocephala</i> Kützing	16.5
<i>Navicula muralis</i> Grunow	1.0
<i>Navicula rostellata</i> Kützing	2.8
<i>Navicula tenella</i> Brebisson	2.6
<i>Navicula Twymaniana</i> Archibald	1.0
<i>Nitzschia adapta</i> Hustedt	2.1
<i>Nitzschia dissipata</i> (Kützing) Grunow	1.0
<i>Nitzschia Kützingiana</i> Hilse	2.6
<i>Nitzschia linearis</i> W. Smith	19.6
<i>Nitzschia sigma</i> (Kützing) W. Smith	
var. <i>fonticola</i> Hustedt.	1.0
<i>Rhopalodia gibberula</i> (Ehrenberg)	
O. Müller	1.3
Other species	3.2
Nitrogen heterotrophic <i>Nitzschiae</i>	
combined	7.8

Table 31.

SMALL TRIBUTARIES OF THE KLIP RIVER.

	436	433	447	451	453
	9.8.60	9.8.60	10.8.60	10.8.60	10.8.60
<i>Achnanthes lanceolata</i>					
(Brebisson) Grunow var.					
<i>rostrata</i> Östrup	1.3	29.6		3.6	1.0
<i>Achnanthes linearis</i> W.					
Smith				2.4	1.5
<i>Achnanthes minutissima</i>					
Kützing	2.9	7.2	37.1	23.7	13.7
<i>Amphora submontana</i> Hustedt		3.3		1.2	0.5
<i>Cymbella amphicephala</i>					
Naegeli	+	3.3	5.6	12.6	0.7
<i>Cymbella Kappii</i> Cholnoky	0.5	0.8	6.6	9.0	2.7
<i>Cymbella microcephala</i> Grunow	+		11.0	0.5	4.7
<i>Cymbella ventricosa</i> Kützing	2.9	0.2	1.5	0.7	1.0
<i>Diploneis subovalis</i> Cleve		1.9		+	
<i>Fragilaria Vaucheriae</i>					
(Kützing) Petersen	18.9			0.2	
<i>Frustulia vulgaris</i>					
(Thwaites) De Toni var.					
<i>angusta</i> Cholnoky	0.5	0.4		1.2	0.2
<i>Gomphonema dichotomum</i>					
(Kützing) Archibald	0.3			3.1	
<i>Gomphonema parvulum</i>					
(Kützing) Grunow	0.8	3.3	1.2	2.1	
<i>Gyrosigma Kützingii</i>					
(Grunow) Cleve	+		+	1.2	+
<i>Navicula atomus</i> (Kützing)					
Grunow.		1.2			
<i>Navicula avenacea</i> Brebisson				1.2	
<i>Navicula cryptocephala</i>					
Kützing	10.5	0.4	2.0	2.4	12.0
<i>Navicula indifferens</i>					
Hustedt					3.4
<i>Navicula microcephala</i>					
Grunow	+	1.5			

Table 31 (cont.).

- 2 -

Small tributaries of the Klip River.

	436	433	447	451	453
	9.8.60	9.8.60	10.8.60	10.8.60	10.8.60
Navicula muralis Grunow	5.6	0.8		2.6	1.2
Navicula pupula Kützing			+		1.0
Navicula rhynchocephala Kützing		+		1.7	1.0
Navicula rostellata Kützing	1.3				+
Navicula submolesta Hustedt		2.1			1.0
Navicula tantula Hustedt	0.5	1.9			+
Navicula tenella Brebisson	+	0.6	2.0	6.8	2.0
Navicula Twymaniana Archibald	1.1	0.8			0.5
Nitzschia acicularis W. Smith	5.4				1.0
Nitzschia adapta Hustedt	0.3		0.7	3.8	0.5
Nitzschia dissipata (Kützing) Grunow	1.6		+	+	
Nitzschia fonticola Grunow		1.1	0.7	0.7	4.9
Nitzschia interrupta (Reichel) Hustedt			4.9		29.9
Nitzschia Kützingiana Hilse	29.1	21.4	1.2	9.0	1.5
Nitzschia linearis W. Smith	1.6	12.3	0.5	6.2	1.0
Nitzschia palea (Kützing) W. Smith	1.6	0.4	0.5		0.7
Nitzschia perminuta Grunow	7.0	0.6	14.1	0.2	8.6
Nitzschia Rautenbachiae Cholnoky			7.8		
Nitzschia romana Grunow			1.5	+	2.2
Surirella angusta Kützing	0.5	1.7	+	1.2	+
Surirella ovalis Brebisson			+	1.4	
Other species	5.8	3.2	1.1	1.3	1.6
Nitrogen heterotrophic Nitzschiae combined	46.3	24.3	26.7	14.1	19.4

Table 32.

THE SAND RIVER - STATION 8.

	Station 8		
	326	456	455
	16.9.58	10.8.60	10.8.60
<i>Achnanthes linearis</i> W. Smith	2.8	43.1	
<i>Achnanthes microcephala</i> Kützing		1.9	
<i>Achnanthes minutissima</i> Kützing	50.6	10.1	14.8
<i>Cocconeis placentula</i> Ehrenberg var. <i>euglypta</i> (Ehrenberg) Cleve	1.6		
<i>Cyclotella comensis</i> Grunow	+	12.7	
<i>Cymbella amphicephala</i> Naegeli			6.7
<i>Cymbella cistula</i> (Hemprich) Grunow			9.3
<i>Cymbella Kappii</i> Cholnoky	1.2	+	13.6
<i>Cymbella microcephala</i> Grunow		1.3	14.8
<i>Cymbella ventricosa</i> Kützing	+	1.1	1.0
<i>Gomphonema parvulum</i> (Kützing) Grunow	4.2	0.4	+
<i>Melosira varians</i> Agardh	7.3		
<i>Navicula cryptocephala</i> Kützing	0.2	1.3	5.9
<i>Navicula permitis</i> Hustedt		3.8	+
<i>Navicula rhynchocephala</i> Kützing	+	0.9	1.0
<i>Navicula tenella</i> Brebisson	+	+	5.9
<i>Navicula tenelloides</i> Hustedt	0.5	6.7	+
<i>Navicula Twymaniana</i> Archibald		3.8	0.3
<i>Navicula Zanonii</i> Hustedt	0.2	1.7	2.3
<i>Nitzschia acicularis</i> W. Smith			1.0
<i>Nitzschia fonticola</i> Grunow	0.7	0.6	4.6
<i>Nitzschia interrupta</i> (Reichel) Hustedt		0.2	1.5
<i>Nitzschia Kützingiana</i> Hilse	0.2	1.5	1.5
<i>Nitzschia linearis</i> W. Smith	+		1.5
<i>Nitzschia palea</i> (Kützing) W. Smith	0.5	0.4	1.0
<i>Nitzschia perminuta</i> Grunow	2.3	2.4	+

Table 32 (cont.).

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The Sand River - Station 8.

	Station 8		
	326	456	455
	16.9.58	10.8.60	10.8.60
Nitzschia romana Grunow		+	2.1
Nitzschia silica Archibald	24.6		
Rhopalodia gibba (Ehrenberg)			
O. Müller	+	2.4	1.3
Rhopalodia gibberula			
(Ehrenberg) O. Müller	+		1.0
Other species	3.1	3.7	9.8
Nitrogen hetrotrophic			
Nitzschiae combined	3.7	5.3	12.3

Table 33.

THE KOMMANDOSPRUIT STREAM - STATION 30.

	432
	9.8.60
Achnanthes linearis W. Smith	2.1
Achnanthes minutissima Kützing	4.2
Cymbella Kappii Cholnoky	5.6
Cymbella microcephala Grunow	64.4
Navicula cryptocephala Kützing	5.2
Navicula tenella Brebisson	4.4
Navicula Zenonii Hustedt	2.3
Nitzschia dissipata (Kützing) Grunow	1.2
Other species	10.6
Nitrogen heterotrophic Nitzschiae	
combined	3.3

Table 34.

THE KOMMANDOSPRUIT STREAM - STATION 31.

	Station 31.		
	431	360	445
	9.8.60	14.1.59	10.8.60
<i>Achnanthes minutissima</i> Kützing	+	+	16.5
<i>Cocconeis placentula</i> Ehrenberg			
var <i>euglypta</i> (Ehrenberg) Cleve			8.0
<i>Cymbella amphicephala</i> Naegeli	+	0.5	1.2
<i>Cymbella Kappii</i> Cholnoky	4.3	0.5	4.6
<i>Cymbella microcephala</i> Grunow		0.2	2.2
<i>Fragilaria Vaucheriae</i> (Kützing)			
Petersen	0.4		24.2
<i>Gomphonema javanicum</i> Hustedt	+		3.1
<i>Gomphonema longiceps</i> Ehrenberg			
var <i>subclavatum</i> Grunow.	+		2.2
<i>Gomphonema parvulum</i> (Kützing)			
Grunow	+	0.9	14.5
<i>Navicula atomus</i> (Kützing) Grunow	0.9	1.6	0.5
<i>Navicula cinctaeformis</i> Hustedt		7.0	+
<i>Navicula cryptocephala</i> Kützing	13.3	2.6	1.2
<i>Navicula perparva</i> Hustedt	+	+	1.9
<i>Navicula rhynchocephala</i> Kützing	0.4	2.3	1.0
<i>Navicula rostellata</i> Kützing	2.4	3.0	+
<i>Navicula Schroeteri</i> Meister	+	5.3	3.9
<i>Navicula tenella</i> Brebisson	0.2	0.5	3.4
<i>Navicula Twymaniana</i> Archibald		4.2	0.2
<i>Nitzschia accomodata</i> Hustedt		1.9	+
<i>Nitzschia acicularis</i> W. Smith	7.0	0.9	+
<i>Nitzschia capitellata</i> Hustedt		1.9	
<i>Nitzschia fonticola</i> Grunow		1.2	0.5
<i>Nitzschia Kützingiana</i> Hilse	0.9	49.9	0.5
<i>Nitzschia linearis</i> W. Smith	63.9	0.9	0.5
<i>Nitzschia palea</i> (Kützing)			
W. Smith	1.1	10.4	+
<i>Nitzschia perminuta</i> Grunow	1.1		0.2
<i>Nitzschia spiculum</i> Hustedt	0.4		1.0

Table 34 (cont.).

- 2 -

The Kommandospruit Stream - Station 31.

	Station 31.	
	431	360 445
	9.8.60	14.1.59 10.8.60
Synedra ulna (Nitzsch)	0.2	1.9
Ehrenberg		
Other species	3.5	4.3 6.8
Nitrogen heterotrophic		
Nitzschiae combined	12.3	66.9 3.4

Table 35.

THE VREDE STREAM.

	429	441	427	422
	9.8.60	10.8.60	9.8.60	9.8.60
<i>Achnanthes linearis</i> W. Smith		0.8	1.0	1.5
<i>Achnanthes minutissima</i> Kützing	1.5	2.6	10.1	3.0
<i>Cymbella aequalis</i> W. Smith		+	0.5	1.1
<i>Cymbella amphicephala</i> Naegeli	66.4	12.8	3.8	62.5
<i>Cymbella Kappii</i> Cholnoky	+	7.8	1.8	2.2
<i>Cymbella microcephala</i> Grunow	1.5	62.3	22.2	6.4
<i>Cymbella ventricosa</i> Kützing	1.0	+	1.2	+
<i>Navicula cryptocephala</i> Kützing	4.2	0.6	1.2	5.4
<i>Navicula exiguiformis</i> Hustedt				1.1
<i>Navicula tenella</i> Brebisson	+	1.5	+	4.3
<i>Navicula Zanonii</i> Hustedt	0.4	1.0	0.5	0.9
<i>Nitzschia adapta</i> Hustedt	0.4	0.2	1.0	2.2
<i>Nitzschia amphioxoides</i> Hustedt	1.3			
<i>Nitzschia fonticola</i> Grunow	5.5		2.0	0.2
<i>Nitzschia gracilis</i> Hantzsch	4.0	+	1.2	
<i>Nitzschia interrupta</i> (Reichelt) Hustedt	5.9	6.6	29.9	0.9
<i>Nitzschia Kützingiana</i> Hilse	0.2	1.0		+
<i>Nitzschia linearis</i> W. Smith	0.2	0.2	+	1.1
<i>Nitzschia palea</i> (Kützing) W. Smith	0.2	+	12.6	0.4
<i>Nitzschia Rautenbachiae</i> Cholnoky	1.1	+	+	
<i>Nitzschia romana</i> Grunow	0.2		9.1	
<i>Surirella angusta</i> Kützing	1.0	+	+	
Other species	5.0	2.6	1.9	6.8
Nitrogen heterotrophic Nitzschiae combined	14.1	1.4	26.4	3.0

Table 36.

THE WATERVAL RIVER - UPPER REGIONS.

	511	512
	15.3.65	15.3.65
<i>Achnanthes Engelbrechtii</i> Cholnoky		2.3
<i>Amphora submontana</i> Hustedt	1.0	
<i>Amphora veneta</i> Kützing		3.3
<i>Caloneis fasciata</i> (Lagerstedt) Cleve	1.0	+
<i>Caloneis silicula</i> (Ehrenberg) Cleve	1.0	
<i>Diploneis Smithii</i> (Brebisson) Cleve		
var. <i>pumila</i> (Grunow) Hustedt	0.5	3.3
<i>Diploneis subovalis</i> Cleve		2.8
<i>Navicula cinctaeformis</i> Hustedt	37.5	+
<i>Navicula cryptocephala</i> Kützing	19.9	2.8
<i>Navicula elginensis</i> Gregory	1.0	+
<i>Navicula minima</i> Grunow	1.0	+
<i>Navicula muralis</i> Grunow	6.2	2.8
<i>Navicula pascuorum</i> Cholnoky		3.3
<i>Navicula perparva</i> Hustedt	1.0	
<i>Navicula pupula</i> Kützing	2.1	
<i>Navicula rostellata</i> Kützing	4.1	1.4
<i>Navicula tenella</i> Brebisson	2.6	15.4
<i>Navicula tenelloides</i> Hustedt	+	32.8
<i>Navicula Twymaniana</i> Archibald	3.6	2.8
<i>Nitzschia accomodata</i> Hustedt	+	2.8
<i>Nitzschia adapta</i> Hustedt	2.1	+
<i>Nitzschia dissipata</i> (Kützing) Grunow	0.5	1.4
<i>Nitzschia fonticola</i> Grunow	1.0	+
<i>Nitzschia Kützingiana</i> Hilse	3.1	8.4
<i>Nitzschia levidensis</i> W. Smith		1.9
<i>Nitzschia levidensis</i> var. <i>victoriae</i>		
Grunow	1.0	
<i>Nitzschia romana</i> Grunow	1.6	+
<i>Nitzschia siliqua</i> Archibald	2.6	
<i>Nitzschia stricta</i> Hustedt	1.0	
<i>Rhopalodia gibberula</i> (Ehrenberg)		
O. Müller	+	1.4
Other species	4.5	11.1
Nitrogen heterotrophic <i>Nitzschiae</i>		
combined	12.4	14.9

Table 37.

THE WATERVAL RIVER - STATION 17.

	337	338	339	340	377	378	497	498	513
	20.7.59	22.9.59	19.1.60	19.1.60	6.5.60	3.6.60	12.8.60	12.8.60	15.3.65
<i>Achnanthes minutissima</i> Kützing	37.9	8.9	9.5	+	+	1.8	0.9	2.5	+
<i>Amphora ovalis</i> Kützing var. <i>pediculus</i> Kützing	7.4	0.3	1.2	0.8		+	+		
<i>Amphora veneta</i> Kützing	0.3	11.8	0.7	1.6	+	26.4	2.9	25.3	0.5
<i>Galoneis fasciata</i> (Lagerstedt) Cleve			0.2	0.8	+	1.0	+	+	0.5
<i>Cyclotella comensis</i> Grunow	0.3	0.3	+	+	+	1.0	0.2	+	
<i>Cymbella Kappii</i> Cholnoky	15.4	0.3	+	+	+		+		
<i>Cymbella ventricosa</i> Kützing	+	+	0.7	1.3	+	+	0.2	+	+
<i>Fragilaria familiaris</i> (Kützing) Hustedt	1.3								
<i>Fragilaria fonticola</i> Hustedt			4.5		+	+			
<i>Fragilaria Vaucheriae</i> (Kützing) Boye Petersen	9.8	+	4.2	+	+	6.3	+	+	+
<i>Frustulia vulgaris</i> (Thwaites) De Toni	+		1.0			+		+	
<i>Gomphonema longiceps</i> Ehrenberg var. <i>subolavata</i> Grunow	+	+		2.7	+			+	
<i>Gomphonema parvulum</i> (Kützing) Grunow	9.8	4.2	4.5	26.9	+	29.1	0.2	0.2	3.7
<i>Navicula adsidua</i> n.sp.		11.8	+		+	+			
<i>Navicula atomus</i> (Kützing) Grunow						2.1			
<i>Navicula cinctaeformis</i> Hustedt		+	2.0	1.6	+		+	+	6.0
<i>Navicula confervacea</i> (Kützing) Grunow									8.9
<i>Navicula cryptocephala</i> Kützing	0.3	1.8	0.7	1.3	0.5	0.3	0.2	+	+
<i>Navicula diuturnoides</i> Archibald	0.3		0.5	1.1					0.3
<i>Navicula indifferens</i> Hustedt								8.8	
<i>Navicula minima</i> Grunow	+		1.5	2.4					0.7
<i>Navicula muralis</i> Grunow	+		0.3	0.3			+	12.4	0.5
<i>Navicula permitis</i> Hustedt		0.5			88.7	14.4			
<i>Navicula perparva</i> Hustedt	+		4.2	2.4	+	1.0	+		5.2
<i>Navicula pseudohalophila</i> Cholnoky	5.6	+	0.2	+			1.3	+	
<i>Navicula rostellata</i> Kützing	+		0.5	+	+	+			15.4
<i>Navicula Schroeteri</i> Meister	0.8	+	18.3	4.6	+	+		+	22.8
<i>Navicula seminuloides</i> Hustedt							0.4	2.0	+
<i>Navicula submolesta</i> Hustedt			0.7	+				+	3.2
<i>Navicula tenella</i> Brebisson	0.8	0.3	3.8	0.5	+	0.5	+	0.5	2.0
<i>Navicula Twymaniana</i> Archibald	0.3		1.5	4.3	0.8	2.4		0.5	3.5
<i>Nitzschia amphibia</i> Grunow	+	2.1	0.2	1.9		1.0	+	0.5	7.4
<i>Nitzschia apiculata</i> (Gregory) Grunow	1.8	1.2	1.2	0.3	+	1.6	4.2	0.2	+
<i>Nitzschia capitellata</i> Hustedt				+	+	+		1.3	+
<i>Nitzschia fonticola</i> Grunow	+	2.1	7.1	2.4	0.3	0.5	3.3	31.6	4.7

Table 37 (cont.).

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The Waterval River - Station 17.

	337	338	339	340	377	378	497	498	513
	20.7.59	22.9.59	19.1.60	19.1.60	6.5.60	3.6.60	12.8.60	12.8.60	15.3.65
Nitzschia interrupta (Reichel) Hustedt	2.0	1.0	1.5	+		+	1.8	+	
Nitzschia Kützingiana Hilse	1.8	6.3	5.9	10.2	1.4	1.8		4.3	5.5
Nitzschia levidensis W. Smith			1.0	0.3					
Nitzschia palea (Kützing) W. Smith	0.3	0.5	3.3	13.7	5.4	0.5	83.5	7.8	1.5
Nitzschia perminuta Grunow	1.1	12.8	9.5	6.5	0.5	5.6		0.8	1.0
Nitzschia perpusilla (Rabenhorst) Grunow	+	32.2	+	+		+	+	+	
Synedra ulna (Nitzsch) Ehrenberg	0.3		4.6	9.4	+	1.3		+	3.2
Other species	2.3	1.1	4.8	2.7	2.4	1.4	0.9	1.3	3.5
Nitrogen heterotrophic Nitzschiae combined	4.0	56.3	27.9	34.7	10.0	10.5	87.0	46.3	20.8

Table 38.

THE WATERVAL RIVER - STATION 7.

	Station 7.		Groot-spruit	
	325	412	411	413
	10.9.59	8.8.60	8.8.60	8.8.60
<i>Achnanthes lanceolata</i> (Brebisson)				
Grunow var. <i>rostrata</i> Östrup		0.7	1.1	
<i>Achnanthes minutissima</i> Kützing	2.7	21.5	2.7	22.1
<i>Amphora veneta</i> Kützing		7.0	+	1.5
<i>Caloneis Schumanniana</i> (Grunow)				
Cleve	3.9			
<i>Caloneis silicula</i> (Ehrenberg)				
Cleve		0.2	1.1	+
<i>Cocconeis placentula</i> Ehrenberg var.				
<i>euglypta</i> (Ehrenberg) Cleve		1.6		
<i>Cyclotella comensis</i> Grunow		4.9		
<i>Cymatopleura solea</i> Brebisson	10.5	+	+	
<i>Cymbella Kappii</i> Cholnoky	0.2	1.4	0.3	1.0
<i>Cymbella ventricosa</i> Kützing	0.2	4.1	2.2	
<i>Diploneis ovalis</i> (Hilse) Cleve	+	1.8	1.1	
<i>Diploneis subovalis</i> Cleve		0.2	1.1	
<i>Epithemia sorex</i> Kützing		+	4.6	0.5
<i>Epithemia zebra</i> (Ehrenberg) Kützing				
var. <i>saxonica</i> (Kützing) Grunow			4.1	
<i>Fragilaria fonticola</i> Hustedt		5.7		
<i>Fragilaria Vaucheriae</i> (Kützing)				
Petersen		2.8		
<i>Frustulia vulgaris</i> (Thwaites)				
De Toni	0.2		+	1.0
<i>Gomphonema parvulum</i> (Kützing)				
Grunow	1.2	4.5		1.5
<i>Gyrosigma Kützingii</i> (Grunow) Cleve	2.5			
<i>Gyrosigma Specerii</i> (W.Smith) Cleve				1.0
<i>Navicula atomus</i> (Kützing) Grunow				1.0
<i>Navicula cinctaeformis</i> Hustedt	1.0	1.4	+	1.0
<i>Navicula cryptocephala</i> Kützing	9.1	1.2	7.0	11.6

Table 38 (cont.).

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The Waterval River - Station 7.

	Station 7		Groot-spruit	
	325	412	411	413
	10.9.59	8.8.60	8.8.60	8.8.60
Navicula diuturna Cholnoky	1.5		0.3	
Navicula diurnoides Archibald			1.1	
Navicula muralis Grunow		0.7	2.4	
Navicula permitis Hustedt			4.2	
Navicula rhynchocephala Kützing	36.0		0.8	
Navicula rostellata Kützing	2.9	1.6	+	
Navicula Schroeteri Meister		+	1.4	
Navicula tenella Brebisson	2.0	0.5	5.1	7.2
Navicula tenelloides Hustedt		0.7	11.9	+
Navicula Zanonii Hustedt	0.2	+	2.4	3.4
Nitzschia bacata Hustedt		2.1	1.1	
Nitzschia communis Rabenhorst				1.8
Nitzschia confinis Hustedt		3.7		
Nitzschia epiphytica O. Müller		1.0		
Nitzschia epiphyticoides Hustedt			1.4	
Nitzschia fonticola Grunow		5.4	0.5	0.8
Nitzschia intermissa Hustedt		1.2	2.2	
Nitzschia Kützingiana Hilse	2.7	0.2	10.3	13.7
Nitzschia linearis W. Smith	1.7	1.6		0.8
Nitzschia microcephala Grunow		1.2	0.3	0.8
Nitzschia palea (Kützing) W. Smith		1.2	3.5	3.9
Nitzschia perminuta Grunow	8.1	7.3	1.4	+
Nitzschia perspicua Cholnoky				1.3
Nitzschia recta Hantzsch			2.4	
Nitzschia sigma (Kützing) W. Smith	6.6			
Rhopalodia gibba (Ehrenberg) O. Müller		+	11.9	16.5
Stephanodiscus astraea (Ehrenberg)				
Grunow var. minutula (Kützing)				
Grunow.		1.8		
Surirella ovalis Brebisson		0.2		4.1
Synedra ulna (Nitzsch) Ehrenberg		2.5	0.5	
Other species	6.8	8.1	9.6	3.5
Nitrogen heterotrophic				
Nitzschiae combined	12.6	23.5	25.2	22.3

Table 39.

THE WATERVAL RIVER - LOWER REGIONS.

	410	553	554	409
	8.8.60	19.3.65	19.3.65	8.8.60
<i>Achnanthes lanceolata</i> (Brebisson)				
Grunow var. <i>rostrata</i> Östrup	+	3.2	0.2	
<i>Achnanthes minutissima</i> Kützing	3.0		+	4.2
<i>Amphora veneta</i> Kützing	0.9	6.9	0.2	1.6
<i>Caloneis bacillum</i> (Grunow) Cleve				2.1
<i>Caloneis Clevei</i> (Lagerstedt) Cleve	+	0.3	2.0	2.1
<i>Caloneis fasciata</i> (Lagerstedt)				
Cleve	0.3	+	1.3	
<i>Caloneis silicula</i> (Ehrenberg)				
Cleve			+	1.6
<i>Cyclotella comensis</i> Grunow	47.0	+		
<i>Cymatopleura solea</i> Brebisson				1.1
<i>Cymbella Kappii</i> Cholnoky	1.1			
<i>Cymbella microcephala</i> Grunow	0.3			1.6
<i>Cymbella ventricosa</i> Kützing	3.8	3.6	1.8	3.7
<i>Diploneis subovalis</i> Cleve	0.3	23.8	4.3	
<i>Fragilaria fonticola</i> Hustedt	1.4			
<i>Fragilaria Vaucheriae</i> (Kützing)				
Boye Petersen	5.7			
<i>Gomphonema parvulum</i> (Kützing)				
Grunow	1.1	7.2	0.8	1.6
<i>Gyrosigma Kützingii</i> (Grunow) Cleve		0.3		1.1
<i>Gyrosigma scalproides</i> (Rabenhorst)				
Cleve	+	0.5	2.0	
<i>Navicula aquosa</i> Archibald		1.6		
<i>Navicula cinctaeformis</i> Hustedt	+	4.5	22.7	2.1
<i>Navicula cryptocephala</i> Kützing	1.4	1.3	6.6	2.6
<i>Navicula diuturnoides</i> Archibald			1.6	6.3
<i>Navicula Grimmei</i> Krasske	+	0.8	1.0	
<i>Navicula microcephala</i> Grunow	1.1			
<i>Navicula muralis</i> Grunow		16.7	2.3	
<i>Navicula pupula</i> Kützing	+	0.3	2.0	19.1
<i>Navicula rostellata</i> Kützing	0.8	0.3	+	1.1
<i>Navicula Schroeteri</i> Meister	1.6	1.9	0.2	+

Table 39 (cont.).

- 2 -

The Waterval River - Lower Regions

	410	553	554	409
	8.8.60	19.3.65	19.3.65	8.8.60
Navicula submolesta Hustedt	+	1.3	1.0	
Navicula tenella Brebisson	0.9		2.3	
Navicula tenelloides Hustedt	0.3	6.4	3.5	
Navicula Twymaniana Archibald	+	6.0	1.8	
Nitzschia acicularis W. Smith	1.9			
Nitzschia amphibia Grunow	+	0.3		3.2
Nitzschia capitellata Hustedt	1.1	+	3.3	
Nitzschia Clausii Hantzsch	+	1.1	1.6	
Nitzschia confinis Hustedt			0.2	1.1
Nitzschia epiphyticoides Hustedt	1.9			
Nitzschia fonticola Grunow	+	+	1.3	1.1
Nitzschia gracilis Hantzsch	1.1			
Nitzschia intermissa Hustedt	3.3			
Nitzschia Kützingiana Hilse	3.0	2.4	6.1	
Nitzschia linearis W. Smith	+		4.5	1.1
Nitzschia palea (Kützing) W. Smith	5.1	1.3	7.1	4.2
Nitzschia perminuta Grunow	+	1.6	1.5	
Nitzschia Rautenbachiae Cholnoky				3.2
Nitzschia romana Grunow	0.3		0.8	17.5
Nitzschiae sigma (Kützing) W. Smith			1.0	
Nitzschia spiculum Hustedt	3.8			
Nitzschia tropica Hustedt	1.1			
Nitzschia umbilicata Hustedt		1.6	3.5	
Nitzschia vitrea Norman var. salinarum Grunow				1.1
Pinnularia mesolepta (Ehrenberg) W. Smith				2.1
Rhopalodia gibberula (Ehrenberg) O. Müller	+		0.8	4.2
Surirella angusta Kützing	+		6.8	1.1
Synedra ulna (Nitzsch) Ehrenberg	1.1		+	4.2
Other species	5.3	4.8	3.9	4.0
Nitrogen heterotrophic Nitzschiae combined	23.5	5.9	20.8	30.3

Table 40.

Tributaries of the Lower Regions of the Vasil River.

	404	405	408	414	415	419	420
	8.8.60	8.8.60	8.8.60	8.8.60	8.8.60	9.8.60	9.8.60
<i>Achnanthes minutissima</i> Kützing			66.2	3.0	4.2	10.8	2.9
<i>Amphora ovalis</i> Kützing var. <i>libyca</i> (Ehrenberg) Cleve					1.0		
<i>Amphora veneta</i> Kützing		0.6	0.3	54.6		0.3	2.4
<i>Caloneis Clevei</i> (Lagerstedt) Cleve			0.3		1.5	0.8	0.3
<i>Caloneis fasciata</i> (Lagerstedt) Cleve		1.4			0.5	1.2	0.5
<i>Caloneis silicula</i> (Ehrenberg) Cleve					1.3	0.3	
<i>Cymbella ventricosa</i> Kützing		0.6				1.9	3.2
<i>Epithemia sorex</i> Kützing		9.9					
<i>Epithemia zebra</i> (Ehrenberg) Kützing var. <i>saxonica</i> (Kützing) Grunow		1.7					
<i>Fragilaria Vaucheriae</i> (Kützing) Boye Petersen					2.1		
<i>Gomphonema parvulum</i> (Kützing) Grunow	0.3			2.4	0.5	1.2	0.5
<i>Gyrosigma acuminatum</i> (Kützing) Rabenhorst		19.3					
<i>Navicula atomus</i> (Kützing) Grunow	43.1						
<i>Navicula cinctaeformis</i> Hustedt	1.0	0.2	0.3			1.2	0.5
<i>Navicula confervacea</i> (Kützing) Grunow		0.2		1.9	0.3		
<i>Navicula cryptocephala</i> Kützing	11.2	9.9	3.2		2.7	33.3	2.9
<i>Navicula diuturnoides</i> Archibald		1.9			0.3		
<i>Navicula muralis</i> Grunow	0.3	0.2			0.5	0.8	1.1
<i>Navicula permitis</i> Hustedt	12.3						
<i>Navicula pupula</i> Kützing					1.5	0.3	
<i>Navicula rhynchocephala</i> Kützing					2.6	0.3	
<i>Navicula rostellata</i> Kützing					1.3	0.3	
<i>Navicula submolesta</i> Hustedt	3.7			0.8		0.3	
<i>Navicula tenella</i> Brebisson		20.6	1.7		9.9	5.3	1.8
<i>Navicula Zanonii</i> Hustedt		3.6	1.2		39.6	1.2	0.5
<i>Nitzschia adapta</i> Hustedt					6.5	1.1	0.3
<i>Nitzschia amphibia</i> Grunow	1.3	0.6		24.9	0.3	0.3	
<i>Nitzschia apiculata</i> (Gregory) Grunow	1.6					1.1	
<i>Nitzschia bacata</i> Hustedt						1.9	0.3
<i>Nitzschia dissipata</i> (Kützing) Grunow					3.4		
<i>Nitzschia fenticola</i> Grunow	5.0		1.7		0.3	1.1	
<i>Nitzschia gracilis</i> Mantzsch					1.7		
<i>Nitzschia hungarica</i> Grunow	0.5		1.0		0.3	0.8	
<i>Nitzschia intermissa</i> Hustedt		2.2	1.7				
<i>Nitzschia interrupta</i> (Reichel) Hustedt			7.1			0.8	0.8

Table 40 (cont.).

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Tributaries of the Lower Regions of the Vaal River.

	404	405	408	414	415	419	420
	8.8.60	8.8.60	8.8.60	8.8.60	8.8.60	9.8.60	9.8.60
Nitzschia Kützingiana Hilse	2.9	1.9			1.7	1.9	0.5
Nitzschia linearis W. Smith		2.5			6.5		
Nitzschia microcephala Grunow			0.3			3.7	2.0
Nitzschia palea (Kützing) W. Smith	5.7		5.4	1.6	1.0	1.5	2.6
Nitzschia perminuta Grunow					0.3	3.2	2.6
Nitzschia Rautenbachiae Cholnoky			1.7		0.3	17.2	
Nitzschia romana Grunow	1.6	0.8	3.9			0.5	
Nitzschia sigma (Kützing) W. Smith		1.9			1.6		
Nitzschia tryblionella Hantzsch							
Pinnularia microstauron (Ehrenberg) Cleve var. Brebissonii (Kützing) Hustedt	3.0						
Rhopalodia gibba (Ehrenberg) O. Müller		15.4			0.5	0.8	55.8
Rhopalodia gibberula (Ehrenberg) O. Müller							15.3
Surirella angusta Kützing	2.0				0.5		
Synedra ulna (Nitzsch) Ehrenberg		0.8		8.6	0.3		
Other species	4.5	3.8	4.0	2.2	5.0	4.6	3.2
Nitrogen heterotrophic Nitzschiae combined	17.3	6.5	15.2	26.5	17.1	33.2	8.6

Table 41.

THE KALK RIVER - STATIONS 15 AND 16.

	Station 16	Station 15
	401	402
	8.8.60	8.8.60
<i>Cyclotella comensis</i> Grunow	20.5	
<i>Diploneis ovalis</i> (Hilse) Cleve		1.5
<i>Navicula cinctaeformis</i> Hustedt		2.3
<i>Navicula cryptocephala</i> Kützing	9.5	44.3
<i>Navicula hungarica</i> Grunow var. <i>capitata</i> (Ehrenberg) Cleve	1.1	0.5
<i>Navicula rostellata</i> Kützing	1.1	
<i>Navicula tenella</i> Brebisson		3.5
<i>Navicula tenelloides</i> Hustedt		7.3
<i>Nitzschia amphibia</i> Grunow	1.5	
<i>Nitzschia apiculata</i> (Gregory) Grunow	36.7	4.5
<i>Nitzschia capitellata</i> Hustedt	2.2	
<i>Nitzschia Chutteri</i> Archibald	0.2	8.0
<i>Nitzschia elliptica</i> Hustedt var. <i>alexandrina</i> Cholnoky		1.0
<i>Nitzschia epiphyticoides</i> Hustedt	2.4	
<i>Nitzschia fonticola</i> Grunow	2.2	
<i>Nitzschia microcephala</i> Grunow		3.5
<i>Nitzschia palea</i> (Kützing) W. Smith	7.0	0.5
<i>Nitzschia perpusilla</i> (Rabenhorst) Grunow		2.8
<i>Nitzschia sigma</i> (Kützing) W. Smith	5.4	
<i>Nitzschia silica</i> Archibald	2.4	
<i>Nitzschia tropica</i> Hustedt	1.4	
<i>Nitzschia tryblionella</i> Hantzsch	2.9	
<i>Rhopalodia gibberula</i> (Ehrenberg) O. Müller		13.0
Other Species	3.5	7.3
Nitrogen heterotrophic <i>Nitzschiae</i> combined	18.0	9.8

Table 42.

THE WILGE RIVER - STATION 9.

	327	328
	15.10.58	9.12.58
<i>Achnanthes minutissima</i> Kützing	18.0	33.6
<i>Cocconeis placentula</i> Ehrenberg		
var. <i>euglypta</i> (Ehrenberg) Cleve	1.3	
<i>Cyclotella comensis</i> Grunow	3.3	
<i>Cymbella ventricosa</i> Kützing	2.3	1.4
<i>Fragilaria familiaris</i> (Kützing) Hustedt	7.0	4.1
<i>Fragilaria Vaucheriae</i> (Kützing)		
Boye Petersen	28.9	7.2
<i>Gomphonema parvulum</i> (Kützing) Grunow	4.3	27.2
<i>Gyrosigma Kützingii</i> (Grunow) Cleve	0.5	1.2
<i>Navicula cryptocephala</i> Kützing	15.0	12.8
<i>Navicula rostellata</i> Kützing	0.8	1.4
<i>Navicula Schroeteri</i> Meister	1.5	
<i>Navicula tenelloides</i> Hustedt	1.3	0.2
<i>Nitzschia Clausii</i> Hantzsch	3.3	+
<i>Nitzschia Kützingiana</i> Hilse	2.8	2.9
<i>Nitzschia palea</i> (Kützing) W. Smith	1.5	2.7
<i>Nitzschia perminuta</i> Grunow	1.0	+
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	0.5	1.0
Other species	6.7	4.3
Nitrogen heterotrophic <i>Nitzschiae</i>		
combined	9.8	6.6

Table 43.

THE WILGE RIVER - STATION 10.

	330
	17.9.58
<i>Achnanthes linearis</i> W. Smith	3.2
<i>Achnanthes minutissima</i> Kützing	18.0
<i>Caloneis Chasei</i> Cholnoky	1.0
<i>Cymbella ventricosa</i> Kützing	1.6
<i>Fragilaria Vaucheriae</i> (Kützing)	
Boye Petersen	2.1
<i>Frustulia Weinholdii</i> Hustedt	2.5
<i>Gomphonema parvulum</i> (Kützing) Grunow	3.5
<i>Gyrosigma scalproides</i> (Rabenhorst) Cleve	1.0
<i>Navicula cryptocephala</i> Kützing	13.9
<i>Navicula muralis</i> Grunow	1.8
<i>Navicula rostellata</i> Kützing	2.3
<i>Navicula tenelloides</i> Hustedt	16.4
<i>Nitzschia accomodata</i> Hustedt	2.1
<i>Nitzschia amphioxoides</i> Hustedt	2.7
<i>Nitzschia Clausii</i> Hantzsch	9.0
<i>Nitzschia confinis</i> Hustedt	1.8
<i>Nitzschia Kützingiana</i> Hilse	2.7
<i>Surirella ostentata</i> Cholnoky	4.3
Other species	10.1
Nitrogen heterotrophic <i>Nitzschiae</i>	
combined	20.7

Table 44.

THE WILGE RIVER - STATIONS 11A, 11B, 11C.

	A	B	C
	331	332	333
	17.9.58	17.9.58	14.10.58
<i>Achnanthes linearis</i> W. Smith	0.8	4.8	0.2
<i>Achnanthes minutissima</i> Kützing	13.4	34.0	2.1
<i>Cyclotella comensis</i> Grunow			6.7
<i>Cymbella Kappii</i> Cholnoky	0.3	12.2	0.5
<i>Cymbella microcephala</i> Grunow		4.1	0.5
<i>Cymbella ventricosa</i> Kützing	4.5	1.4	4.3
<i>Fragilaria familiaris</i> (Kützing) Hustedt	1.0	1.6	1.5
<i>Fragilaria Vaucheriae</i> (Kützing) Boye Petersen	9.8	7.3	45.0
<i>Frustulia vulgaris</i> (Thwaites) De Toni var. <i>angusta</i> Cholnoky	3.4	0.2	0.2
<i>Gomphonema parvulum</i> (Kützing) Grunow	2.4	1.8	3.3
<i>Navicula cryptocephala</i> Kützing	8.6	3.9	4.5
<i>Navicula indifferens</i> Hustedt	0.3	1.6	0.2
<i>Navicula pupula</i> Kützing	1.5	+	
<i>Navicula rhynchocephala</i> Kützing	+	+	1.5
<i>Navicula rostellata</i> Kützing	2.4	0.2	0.7
<i>Navicula Schroeteri</i> Meister	1.8	1.6	0.5
<i>Navicula tantula</i> Hustedt		7.5	0.2
<i>Navicula tenelloides</i> Hustedt	4.2	+	+
<i>Navicula Zanonii</i> Hustedt	1.8		0.2
<i>Nitzschia accomodata</i> Hustedt	1.3		0.2
<i>Nitzschia Clausii</i> Hantzsch	9.4	4.1	1.8
<i>Nitzschia confinis</i> Hustedt	0.8	1.1	2.6
<i>Nitzschia fonticola</i> Grunow			1.0
<i>Nitzschia Kützingiana</i> Hilse	8.6	1.8	6.4
<i>Nitzschia linearis</i> W. Smith	4.5	+	0.2
<i>Nitzschia microcephala</i> Grunow	1.5		
<i>Nitzschia palea</i> (Kützing) W. Smith	1.5	0.5	3.8
<i>Nitzschia perminuta</i> Grunow	0.3	1.1	2.4
<i>Nitzschia romana</i> Grunow		1.4	+
<i>Nitzschia spiculum</i> Hustedt		1.1	1.3

Table 44 (cont.).

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Stations 11A, 11B, 11C.

The Wilge River.

	A	B	C
	331	332	333
	17.9.58	17.9.58	14.10.58
Surirella angusta Kützing	0.5	2.1	1.8
Surirella ostentata Cholnoky	2.1		+
Synedra nana Meister	2.6	1.8	0.2
Synedra ulna (Nitzsch) Ehrenberg	0.8	0.7	2.0
Other species	9.9	2.1	4.2
Nitrogen heterotrophic Nitzschiae combined	25.0	11.1	21.8

Table 45.

THE WILGE RIVER - STATION 12.

	334
	15.9.58
Achnanthes linearis W. Smith	1.7
Achnanthes minutissima (Kützing)	22.6
Cyclotella comensis Grunow	2.0
Cymbella amphicephala Naegeli	1.0
Cymbella microcephala Grunow	36.9
Cymbella turgida (Gregory) Cleve	2.9
Cymbella ventricosa Kützing	8.0
Navicula cinctaeformis Hustedt	1.0
Navicula cryptocephala Kützing	4.8
Navicula muralis Grunow	1.0
Navicula rostellata Kützing	2.5
Nitzschia adapta Hustedt	3.8
Nitzschia Kützingiana Hilse	1.5
Nitzschia palea (Kützing) W. Smith	1.0
Nitzschia spiculum Hustedt	1.5
Other species	7.4
Nitrogen heterotrophic Nitzschiae combined	10.2

Table 46.

THE WILGE RIVER
BEFORE THE CONFLUENCE OF THE LIEBENBERGSVLEI RIVER.

	233
	11.7.58
Achnanthes linearis W. Smith	14.5
Achnanthes minutissima Kützing	60.3
Fragilaria familiaris (Kützing) Hustedt	6.0
Fragilaria Vaucheriae (Kützing) Petersen	4.8
Gomphonema longiceps Ehrenberg var.	
subclavata Grunow	1.8
Gomphonema parvulum (Kützing) Grunow	1.5
Nitzschia acicularis W. Smith	1.5
Nitzschia palea (Kützing) W. Smith	1.0
Nitzschia perminuta Grunow	1.0
Nitzschia spiculum Hustedt	1.8
Other species	5.8
Nitrogen heterotrophic Nitzschiae	
combined	6.0

Table 47.

THE WILGE RIVER - STATION 13.

	231	335
	11.7.58	18.9.58
<i>Achnanthes linearis</i> W. Smith	+	3.5
<i>Achnanthes minutissima</i> Kützing	21.6	48.3
<i>Amphora coffaeiformis</i> Agardh	1.5	0.7
<i>Caloneis fasciata</i> (Lagerstedt) Cleve		1.2
<i>Cyclotella comensis</i> Grunow	1.3	0.5
<i>Cymbella Kappii</i> Cholnoky	0.4	2.3
<i>Cymbella microcephala</i> Grunow	15.4	22.5
<i>Cymbella ventricosa</i> Kützing	3.4	0.7
<i>Fragilaria Vaucheriae</i> (Kützing) Petersen	0.6	2.9
<i>Gomphonema parvulum</i> (Kützing) Grunow	+	1.6
<i>Navicula cryptocephala</i> Kützing	6.0	1.4
<i>Navicula rhynchocephala</i> Kützing	1.9	0.2
<i>Navicula rostellata</i> Kützing	1.5	+
<i>Navicula tenella</i> Brebisson	1.5	1.4
<i>Navicula Zanonii</i> Hustedt	2.6	1.2
<i>Nitzschia accomodata</i> Hustedt	2.6	
<i>Nitzschia adapta</i> Hustedt	5.1	0.5
<i>Nitzschia Kützingiana</i> Hilse	3.4	0.2
<i>Nitzschia linearis</i> W. Smith	2.1	0.5
<i>Nitzschia palea</i> (Kützing) W. Smith	14.1	0.5
<i>Nitzschia spiculum</i> Hustedt	8.3	0.5
<i>Nitzschia stricta</i> Hustedt	1.5	
<i>Synedra nana</i> Meister	+	5.7
Other species	4.2	3.7
Nitrogen heterotrophic <i>Nitzschiae</i> combined	37.2	1.7

Table 48.

TRIBUTARIES OF THE WILGE RIVER - THE ELANDS RIVER.

	203	204
	24.7.57	24.7.57
<i>Achnanthes linearis</i> W. Smith		2.0
<i>Achnanthes minutissima</i> Kützing	3.8	4.2
<i>Amphora coffaeiformis</i> Agardh	2.0	
<i>Amphora submontana</i> Hustedt	1.0	+
<i>Cymbella amphicephala</i> Naegeli	19.9	8.6
<i>Cymbella cistula</i> (Hemprich) Grunow		1.0
<i>Cymbella Kappii</i> Cholnoky	2.4	33.9
<i>Cymbella microcephala</i> Grunow	31.2	0.5
<i>Cymbella ventricosa</i> Kützing	2.4	23.2
<i>Gomphonema parvulum</i> (Kützing) Grunow	0.2	2.7
<i>Navicula cryptocephala</i> Kützing	14.6	13.5
<i>Navicula microcephala</i> Grunow	2.0	0.2
<i>Navicula rostellata</i> Kützing	0.4	1.0
<i>Navicula tenelloides</i> Hustedt	1.3	
<i>Nitzschia adapta</i> Hustedt	0.4	1.5
<i>Nitzschia fonticola</i> Grunow	3.3	1.2
<i>Nitzschia Kützingiana</i> Hilse	5.3	+
<i>Nitzschia linearis</i> W. Smith	2.8	2.7
<i>Nitzschia palea</i> (Kützing) W. Smith	1.0	0.7
<i>Surirella angusta</i> Kützing	1.0	0.5
<i>Synedra ulna</i> (Nitzsch) Ehrenberg		1.0
Other species	5.0	1.6
Nitrogen heterotrophic <i>Nitzschiae</i> combined	11.3	3.9

Table 49.

TRIBUTARIES OF THE WILGE RIVER - THE KLERKSPRUIT RIVER: STATION 40.

	362
	14.10.58
Achnanthes minutissima Kützing	32.5
Achnanthes pseudohungarica	
Cholnoky-Pfannkuche	3.2
Amphora submontana Hustedt	1.2
Caloneis Clevei (Lagerstedt) Cleve	1.4
Cymbella amphicephala Naegeli	14.7
Cymbella microcephala Grunow	32.5
Navicula cryptocephala Kützing	1.2
Navicula exiguiformis Hustedt	1.7
Nitzschia amphibia Grunow	1.4
Nitzschia fonticola Grunow	1.0
Nitzschia microcephala Grunow	1.2
Nitzschia perminuta Grunow	2.2
Rhopalodia gibberula (Ehrenberg)	
O. Müller	3.2
Other species	2.6
Nitrogen heterotrophic Nitzschiae	
combined	6.3

Table 50.

THE TRIBUTARIES OF THE WILGE RIVER - THE RUSSESPRUIT RIVER.

		Station 41.
	249	363
	12.7.58	9.2.59
<i>Achnanthes minutissima</i> Kützing	11.8	
<i>Amphora veneta</i> Kützing	1.7	+
<i>Cymbella naviculiformis</i> Auerswald	2.2	
<i>Cymbella turgida</i> (Gregory) Grunow	1.4	
<i>Cymbella ventricosa</i> Kützing	8.2	0.7
<i>Diploneis subovalis</i> Cleve		2.4
<i>Frustulia vulgaris</i> (Thwaites) De Toni var. <i>angusta</i> Cholnoky	1.7	
<i>Gomphonema parvulum</i> (Kützing) Grunow	21.0	0.7
<i>Navicula cinctaeformis</i> Hustedt		6.3
<i>Navicula cryptocephala</i> Kützing	8.6	13.3
<i>Navicula microcephala</i> Grunow	1.0	
<i>Navicula permitis</i> Hustedt	1.7	
<i>Navicula rhynchocephala</i> Kützing		1.5
<i>Navicula rostellata</i> Kützing	2.4	0.9
<i>Navicula Schroeteri</i> Meister	+	9.8
<i>Navicula seminulum</i> Grunow	2.2	
<i>Navicula tenella</i> Brebisson	+	2.0
<i>Navicula tenelloides</i> Hustedt	4.8	12.0
<i>Navicula Twymaniana</i> Archibald	1.9	1.3
<i>Nitzschia adapta</i> Hustedt		2.8
<i>Nitzschia dissipata</i> (Kützing) Grunow	1.9	0.9
<i>Nitzschia fonticola</i> Grunow	+	1.5
<i>Nitzschia Kützingiana</i> Hilse	3.4	10.3
<i>Nitzschia linearis</i> W. Smith	7.0	
<i>Nitzschia palea</i> (Kützing) W. Smith	1.9	21.9
<i>Nitzschia perminuta</i> Grunow	2.6	3.9
<i>Nitzschia romana</i> Grunow		1.3
<i>Rhopalodia gibba</i> (Ehrenberg) O. Müller	0.7	1.1
<i>Surirella angusta</i> Kützing	1.4	+
<i>Synedra ulna</i> (Nitzsch) Ehrenberg	6.7	+
Other species	3.8	5.4
Nitrogen heterotrophic <i>Nitzschiae</i> combined	10.3	43.7

Table 51.

THE TRIBUTARIES OF THE WILGE RIVER -
THE MOLEN, CORNELIUS AND HOLSPRUIT RIVERS.

	MOLEN	CORNELIUS	HOLSPRUIT
	St. 14		St. 36.
	336	266	253
	17.9.58	13.7.58	12.7.58
<i>Achnanthes linearis</i> W. Smith	1.0		0.5
<i>Achnanthes minutissima</i> Kützing	12.2	1.0	
<i>Amphipleura pellucida</i> Kützing			1.3
<i>Amphora coffaeiformis</i> Agardh	1.0	0.8	1.1
<i>Caloneis fasciata</i> (Lagerstedt) Cleve	1.5		0.3
<i>Cyclotella comensis</i> Grunow	25.3	0.2	
<i>Cymbella Kappii</i> Cholnoky	7.7		12.0
<i>Cymbella microcephala</i> Grunow	4.8		0.5
<i>Fragilaria Vaucheriae</i> (Kützing) Boye Petersen	3.8		0.3
<i>Gophonema parvulum</i> (Kützing) Grunow	1.8	1.0	+
<i>Gyrosigma Kützingii</i> (Grunow) Cleve	0.3	5.1	+
<i>Gyrosigma scalproides</i> (Rabenhorst) Cleve	0.3	1.8	0.3
<i>Melosira varians</i> Agardh	1.3		
<i>Navicula atomus</i> (Kützing) Grunow	1.8		1.9
<i>Navicula cinctaeformis</i> Hustedt	1.3	+	0.5
<i>Navicula cryptocephala</i> Kützing	8.5	50.9	5.8
<i>Navicula exigua</i> (Gregory) O.Müller		1.3	+
<i>Navicula perparva</i> Hustedt	2.0	+	+
<i>Navicula rostellata</i> Kützing	2.5	6.6	0.5
<i>Navicula Schroeteri</i> Meister	4.5	0.8	5.3
<i>Navicula tenella</i> Brebisson	+		2.1
<i>Navicula tenelloides</i> Hustedt	1.5	0.8	
<i>Nitzschia accommodata</i> Hustedt	+	1.5	0.3
<i>Nitzschia acicularis</i> W. Smith		+	1.9
<i>Nitzschia adapta</i> Hustedt	1.8		1.9
<i>Nitzschia Clausii</i> Hantzsch	+	1.0	

Table 51 (cont.).

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The Tributaries of the Wilge River -

The Molen, Cornelius and Holspruit Rivers.

	MOLEN	CORNELIUS	HOLSPRUIT
	St. 14		St. 36.
	336	266	253
	17.9.58	13.7.58	12.7.58
Nitzschia dissipata (Kützing) Grunow	0.5	1.5	0.5
Nitzschia exilis Archibald	0.5	4.8	
Nitzschia fonticola Grunow	0.5	1.0	1.1
Nitzschia Kützingiana Hilse	1.8		3.7
Nitzschia linearis W. Smith	3.3	8.1	22.9
Nitzschia mediocris Hustedt			1.1
Nitzschia palea (Kützing) W. Smith	1.5	3.3	3.5
Nitzschia perminuta Grunow	1.8	1.3	14.7
Nitzschia spiculum Hustedt	0.5		2.9
Pinnularia viridis Ehrenberg		2.0	
Surirella angusta Kützing	+		2.4
Surirella ovata Kützing	+		5.0
Synedra ulna (Nitzsch) Ehrenberg	1.0		0.5
Other species	3.7	5.2	5.2
Nitrogen heterotrophic Nitzschiae combined	8.4	13.9	32.6

Table 52 (cont.).

The Liebenbergsvlei River System.

		St. 43			
	236	239	364	242	245
	11.7.58	11.7.58	18.11.58	12.7.58	12.7.58
Navicula Zanonii Hustedt	1.8		+		
Nitzschia acicularis W. Smith	1.8			0.7	
Nitzschia adapta Hustedt	0.4		0.4	1.2	0.4
Nitzschia amphibia Grunow	+		1.5		
Nitzschia Chasei Cholnoky	+		2.8		
Nitzschia dissipata (Kützing)					
Grunow	0.4		1.5		
Nitzschia fonticola Grunow	0.9	0.9	0.4	1.8	2.7
Nitzschia hungarica Grunow					3.5
Nitzschia Kützingiana Hilse	2.7	1.5	+	2.2	16.0
Nitzschia linearis W. Smith	+	64.2	0.4	44.8	0.4
Nitzschia mediocris Hustedt					1.1
Nitzschia palea (Kützing)					
Grunow	0.7	0.4	0.6	0.2	11.2
Nitzschia perminuta Grunow	2.5		1.3	0.4	1.3
Nitzschia romana Grunow	0.2		+		6.4
Nitzschia spiculum Hustedt	0.8			33.2	
Pinnularia microstauron					
(Ehrenberg) Cleve var.					
Brebissonii (Kützing) Hustedt.		2.8			
Surirella angusta Kützing	0.4	0.4	+	1.2	0.9
Synedra ulna (Nitzsch) Ehrenberg	3.3		+		
Other species	2.7	1.7	5.3	1.7	1.8
Nitrogen heterotrophic Nitzschiae					
combined	11.2	3.2	5.7	39.7	39.9

THE WINTER AND SUMMER DIATOM ASSOCIATIONS FROM CERTAIN SAMPLING STATIONS.

	Station 1		Station 24		Station 19		Station 21		Station 24		Station 25		Station 31	
	21.3.60	11.8.60	19.1.60	23.9.59	20.1.60	12.8.60	20.1.60	23.9.59	13.1.59	9.8.60	14.1.59	9.8.60	14.1.59	10.8.60
	370	479	307	306	344	493	356	353	358	437	359	434	360	445
Achnanthes lanceolata var. elliptica							1.0	.						
Achnanthes lanceolata var. rostrata	4.9						1.0	+						
Achnanthes linearis									0.8	7.8	1.8	5.3		
Achnanthes microcephala														
Achnanthes minutissima		11.8	37.9	90.5	14.8	0.5	31.3	50.1	4.2	64.6	4.4	16.6	+	16.5
Amphora coffeaeformis									+	1.3		1.0		
Caloneis Chasei	2.4	1.5					.	.						
Caloneis Clevei					2.8	+								
Cocconeis placentula var. euglypta														8.0
Cymbella amphicephala					3.1	62.8							0.5	1.2
Cymbella gracilis	+	1.3												
Cymbella Kappii			+	1.4	.	+	0.5	1.9					0.5	4.6
Cymbella microcephala					1.0	5.4	1.0	5.3					0.2	2.2
Cymbella naviculiformis	0.5	2.1					.	.						
Cymbella ventricosa	4.4	4.4					1.0	2.8	4.4	3.2	2.6	0.2		
Diploneis subovalis					1.0	+								
Eunotia diodon		2.8					.							
Eunotia pectinalis	2.1													
Fragilaria construens			1.1	+		.								
Fragilaria familiaris			5.8	4.3	.	.	55.9	2.3						
Fragilaria Vaucheriae			2.2	+		.	+	5.0	+	11.4	1.6	26.0		24.2
Frustulia rhomboides var. saxonica	25.3	7.7					.	.						
Gomphonema Clevei							4.0	+	+	1.3				
Gomphonema gracile	2.9	0.3					.	.						
Gomphonema javanicum														3.1
Gomphonema longiceps var. subclavatum														2.2
Gomphonema parvulum	7.0	11.3	2.0	0.5	.	.			1.8	1.3	3.0	1.7	0.9	14.5
Gyrosigma Kützingii					+	0.8		1.3						
Navicula atomus											1.0	2.9	1.6	0.5
Navicula cinctaeformis					2.3	0.3							7.0	+
Navicula cryptocephala	11.6	3.6	6.5	+	8.5	7.4	1.0	5.0	3.4	+	2.6	11.3	2.6	1.2

Table 53 (cont.).

- 2 -

The Winter and Summer Diatom Associations from certain Sampling Stations.

	Station 1		Station 2A		Station 19		Station 21		Station 24		Station 25		Station 31	
	21.3.60	11.8.60	19.1.60	23.9.59	20.1.60	12.8.60	20.1.60	23.9.59	13.1.59	9.8.60	14.1.59	9.8.60	14.1.59	10.8.60
	370	479	307	306	344	493	356	353	358	437	359	434	360	445
<i>Navicula diurnoides</i>	0.5	4.6	1.8											
<i>Navicula esamangensis</i>	1.1	0.5			+									
<i>Navicula microcephala</i>									1.6	+	1.0	12.3		
<i>Navicula molesta</i>		1.3												
<i>Navicula muralis</i>		0.5							7.6					
<i>Navicula pascuorum</i>			1.8											
<i>Navicula perparva</i>													+	1.9
<i>Navicula promota</i>	+	1.3												
<i>Navicula pygmaea</i>						1.2								
<i>Navicula rhynchocephala</i>					+	0.3	+	2.0					2.3	1.0
<i>Navicula rostellata</i>			3.1	+	+		0.5	2.5	12.1	1.3	2.6	1.0	3.0	+
<i>Navicula Schroeteri</i>					1.0				1.0	+			5.3	3.9
<i>Navicula submolesta</i>	3.4	4.1												
<i>Navicula subtilissima</i>		3.6												
<i>Navicula tenella</i>	1.8	0.5			0.8	2.2							0.5	3.4
<i>Navicula Twymaniana</i>		1.0											4.2	0.2
<i>Navicula Zanonii</i>					+	2.0	0.7	6.5	1.3					
<i>Neidium affine</i> var. <i>amphirhynchus</i>														
<i>Nitzschia accomodata</i>									1.0				1.9	+
<i>Nitzschia acicularis</i>			1.5		2.1						1.0	3.9	0.9	+
<i>Nitzschia adapta</i>					3.6	1.2								
<i>Nitzschia amphioxoides</i>									1.0					
<i>Nitzschia capitellata</i>													1.9	
<i>Nitzschia Clausii</i>									4.4	+				
<i>Nitzschia dissipata</i>					0.5	0.3			+	1.3				
<i>Nitzschia fonticola</i>					1.0	+							1.2	0.5
<i>Nitzschia gracilis</i>	0.8				2.1									
<i>Nitzschia interrupta</i>					3.9	0.5	0.7	1.0						
<i>Nitzschia Kützingiana</i>	1.8	3.1	5.6	0.5	18.4	0.5	0.2	4.3	38.3	1.8	54.8	4.1	49.9	0.5
<i>Nitzschia linearis</i>					+	8.4		1.9	+	+	1.0	2.9	0.9	0.5
<i>Nitzschia obligata</i>			8.3											
<i>Nitzschia palea</i>	6.2	9.2	5.6	0.5	17.1	0.5	+	1.3	7.4	0.2	11.2	+	10.4	+

Table 53 (cont.).

The Winter and Summer Diatom Associations from certain Sampling Stations.

	Station 1		Station 21		Station 19		Station 21		Station 24		Station 25		Station 31	
	21.3.60	11.8.60	19.1.60	23.9.59	20.1.60	12.8.60	20.1.60	23.9.59	13.1.59	9.8.60	14.1.59	9.8.60	14.1.59	10.8.60
	370	479	307	306	344	423	356	353	358	437	359	434	360	445
Nitzschia perminuta		9.7	2.7	+	3.9	+	.		2.4	1.0	5.9	1.7		
Nitzschia romana					1.0	+								0.2
Nitzschia spiculum			2.2	+				1.0						1.0
Nitzschia stricta		1.0					.							
Pinnularia acoricola	0.6	1.5					.	.						
Pinnularia mesolepta	0.3	1.0					.	.						
Pinnularia microstauron var. Brebissonii					0.5	3.8								
Stauroneis anceps f. gracilis	1.1	+												
Surirella angusta					0.3	0.3		1.0						
Surirella delicatissima var. africana	13.4	2.3					.	.						
Surirella linearis		1.3					.							
Surirella ostentata									2.6	1.0	+	1.0		
Surirella tenera	1.6						.							
Synedra ulna			1.3	0.9	.	.								1.9
Nitrogen heterotrophic Nitzschiae combined	8.3	24.2	23.1	1.0	50.6	2.5	0.7	7.6	50.9	4.3	74.2	12.1	66.9	3.4
Eunotia combined	3.2	3.5					.	.						

Table 54.

THE COMPOSITION OF THE CYMBELLA DOMINANT ASSOCIATIONS FROM THE VAAI DAM
CATCHMENT AREA.

	15.9.58	23.9.59	12.8.60	15.9.58	22.9.59	8.8.60	15.9.58	22.7.59	12.8.60	12.8.60	12.8.60	10.8.60	11.8.60	11.8.60	9.8.60	10.8.60	9.8.60	9.8.60	10.8.60	15.9.58	24.7.57	24.7.57	14.10.58							
	St.3			St.4		St.5			St.19					St.20						St.30						St.12				
	309	312	495	313	413	317	319	413	342	343	493	491	492	463	465	468	438	455	432	422	429	441	334	203	204	362				
Achnanthes linearis																			2.1	1.5	0.8	1.7		2.0						
Achnanthes minutissima	13.6	5.9	12.5	19.7	27.5	27.9	23.2	34.8	5.7	3.1	0.5	0.5	20.7	5.7	20.2	11.6	29.2	14.8	4.2	3.0	1.5	2.6	22.6	3.8	4.2	32.5				
Achnanthes pseudohungarica																									3.2					
Amphora coffaeiformis	0.7	0.5	2.6	0.5		0.8		0.3						0.5	0.3								0.7	2.0						
Caloneis Clevei		0.2				0.8			5.5	2.1		0.7			0.3				0.2	0.9						1.4				
Cyclotella comensis																							2.0							
Cymbella aequalis		0.5	0.2			0.3		0.3				18.3								1.1				0.2						
Cymbella amphicephala	22.5	6.3	35.7	0.8		10.7	0.5		23.2	34.9	62.3	8.7	23.8		12.8	0.8		6.7	0.2	62.5	66.4	12.8	1.0	19.9	8.6	14.7				
Cymbella aspera																4.3														
Cymbella cistula					1.2			0.3						0.5				9.3	0.2						1.0					
Cymbella Kappii	0.9	0.2	0.8	1.5	48.2	0.5	23.0	19.3	0.8	0.3		5.6	3.3	31.8	0.5	1.0		13.6	5.6	2.2		7.8		2.4	33.9					
Cymbella microcephala	43.0	56.5	27.4	23.0	6.0	32.0	34.8	30.6	4.4	28.1	5.4	4.8	0.5		43.6	64.0		14.8	64.4	6.4	1.5	62.3	36.9	31.2	0.5	32.5				
Cymbella naviculiformis																15.6														
Cymbella ventricosa	0.5		0.8	0.5	1.2	1.4	0.5	2.3	0.3		0.5	0.2		21.6	4.0	2.8	17.3	1.0	0.9		1.0		8.0	2.4	23.2					
Fragilaria familiaris			0.5		1.9			0.3													0.4									
Fragilaria Vaucheriae					1.7		0.3																0.7		0.7					
Frustulia vulgaris var. angusta		0.2	0.2	1.3					0.3										0.2		0.4									
Gomphonema parvulum	0.5	0.5				0.5	12.7	0.5	0.5					0.3			0.4			0.2	0.4									
Gyrosigma Kützingii			0.5						4.9	1.3	0.8				0.3			0.5		0.4										
Navicula cryptocephala	0.5	2.2	1.7	5.6		6.1	0.3	0.5	5.7	1.8	7.4	1.8		11.1	1.3	2.0	10.1	5.9	5.2	5.4	4.2	0.6	4.8	14.6	13.5	1.2				
Navicula microcephala																	0.7	0.5		0.2			0.3	2.0	0.2					
Navicula muralis														0.3		1.0							1.0							
Navicula rhynchocephala	1.4		0.9	12.8		3.0		0.3	9.3		0.3			6.0	0.5			1.0	0.2	0.4	0.4		0.7	0.2	0.2					
Navicula rostellata		1.2	1.2	0.8		0.3			1.1	2.9				0.5					0.2			0.2	2.5	0.4	1.0					
Navicula tenella	0.5	1.9	0.9	3.3	0.7	1.4	0.8	2.9	9.6	0.8	2.3	2.9			0.5	1.8		5.9	4.4	4.3		1.5	0.3	0.4		0.2				
Navicula Zanonii	1.4	0.5		0.5	1.0			0.5	2.5	1.8	2.0	8.5			1.0	1.3		2.3	2.3	0.9	0.4	1.0		0.4						
Nitzschia adapta	3.1	1.2	0.5	1.3	0.7	0.3		0.5	0.5	0.5	1.2		0.2	0.3	0.5	1.0		0.8		2.2	0.4	0.2	3.8	0.4	1.5					
Nitzschia fonticola		1.4	0.9	6.6		0.8												4.6	0.9	0.2	5.5		0.7	3.3	1.2	1.0				
Nitzschia gracilis																0.3					4.0									
Nitzschia interrupta	5.1	12.9	6.9	1.0	0.5		0.5	0.3	5.2		0.5	4.9	29.0		12.4	6.2		1.5	0.8	0.9	5.9	6.6								
Nitzschia Kützingiana	1.4	0.7	0.5								0.5			1.6		1.0		1.5	0.5		0.2	1.0	1.5	5.3		0.5				
Nitzschia linearis	0.2	0.2	3.1	1.8	1.4	1.7		0.5	5.5	14.0	8.4	0.2	1.4	6.0		0.3	15.6	1.5	0.2	1.1	0.2	0.2	0.7	2.8	2.7					
Nitzschia palea	1.4	0.2	0.4	5.4	2.7	5.6	0.3		0.3		0.5	0.5	0.2					1.0		0.4	0.2		1.0	1.0	0.7					

Table 54 (cont.).

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The Composition of the *Cymbella* dominant associations from the Vaal Dam

Catchment Area.

	15.9.58	23.9.59	12.8.60	15.9.58	8.8.60	15.9.58	22.9.59	8.8.60	15.9.58	22.7.59	12.8.60	12.8.60	12.8.60	10.8.60	11.8.60	11.8.60	9.8.60	10.8.60	9.8.60	9.8.60	9.8.60	10.8.60	15.9.58	24.7.57	24.7.57	14.10.58
	St.3			St.4		St.5			St.19			St.20						St.30				St.12				
	309	312	495	313	416	317	319	418	342	343	493	491	492	463	465	468	438	455	432	422	429	441	334	203	204	362
Nitzschia perminuta		2.4		1.5	1.0	1.7	1.0	2.6	.	.	.	.	0.5	1.3	1.0		1.0		0.2			0.2	0.5	0.7		2.2
Nitzschia Rautenbachiae		0.2													.			0.5			1.1					
Nitzschia romana						0.3						0.2						2.1	0.5		0.2					
Nitzschia spiculum	1.4	1.4											0.7	4.2	.	.		0.5			0.8	1.5				
Pinnularia microstauron var. Brebissonii		0.2	0.2						3.5	2.3	3.0			.	.			0.3		0.2						
Rhopalodia gibberula			0.2											.				1.0	0.2	0.2		0.3	0.4		3.2	
Surirella angusta		0.2		0.8		0.3												0.8			1.0	0.3	1.0	0.5		
Synedra nana				4.1		1.4																				
Synedra ulna					2.4									0.3			0.2								1.0	
Other species	1.9	2.4	1.4	7.1	1.9	2.2	2.1	2.7	11.3	6.1	2.9	0.5	1.4	7.9	1.1	4.6	2.5	7.6	6.4	5.4	3.9	2.3	6.5	5.2	3.4	7.4
Nitrogen heterotrophic																										
Nitzschiae combined	7.8	8.6	3.0	15.8	4.4	8.7	1.3	3.1	1.3	2.3	2.5	0.7	0.9	10.4	2.0	2.3	1.5	12.3	3.3	3.0	14.1	1.4	10.2	11.3	3.9	6.3
Cymbella spp. combined	66.9	63.5	63.9	25.8	56.6	44.9	58.8	53.3	28.7	63.3	68.7	79.3	45.9	54.0	60.9	68.6	37.2	45.4	71.3	72.2	68.9	82.9	45.9	54.1	67.2	47.2

Table 55.

The Detailed Results of the Chemical Analysis of the Bloukrans River.

Total Nitrogen

April	1	2	3	4	August	1	2	3	4
3.4.67	32.44	44.55	16.99	8.52	3.8.67	56.32	52.26	-	25.73
5.4.67	26.90	40.92	12.69	7.15	7.8.67	20.75	27.16	22.72	20.02
11.4.67	9.89	18.05	11.72	9.45	9.8.67	14.78	33.82	21.56	14.69
13.4.67	14.27	31.85	13.97	-	14.8.67	21.22	30.10	16.79	13.77
17.4.67	14.24	19.06	14.37	6.38	16.8.67	16.91	28.64	19.39	12.67
19.4.67	41.65	31.68	12.55	5.77	21.8.67	29.78	30.46	21.66	17.91
24.4.67	23.19	33.27	9.33	7.17	23.8.67	22.03	32.74	12.67	21.40
26.4.67	10.79	30.76	10.91	7.22	25.8.67	-	-	-	-

Ammonia Nitrogen.

April	1	2	3	4	August	1	2	3	4
3.4.67	20.81	29.18	4.81	0.19	3.8.67	31.60	32.00	12.50	4.20
5.4.67	19.11	27.23	4.49	0.18	7.8.67	3.55	10.64	5.88	4.20
11.4.67	4.90	10.31	5.32	2.24	9.8.67	2.38	13.11	3.36	0.09
13.4.67	8.07	21.61	7.56	0.65	14.8.67	3.74	11.25	1.49	0.19
17.4.67	8.40	11.29	5.37	0.28	16.8.67	3.27	10.46	2.24	0.00
19.4.67	33.14	20.44	3.59	0.09	21.8.67	7.75	8.40	3.55	3.17
24.4.67	11.01	20.90	0.00	0.00	23.8.67	8.77	12.23	0.37	1.77
26.4.67	2.61	15.22	0.00	0.00	25.8.67	-	-	-	-

Table 56.

The Detailed Results of the Chemical Analysis of the Bloukrans River.

Organic Nitrogen.

April	1	2	3	4	August	1	2	3	4
3.4.67	7.00	8.07	5.27	3.37	3.8.67	6.00	3.11	3.02	2.51
5.4.67	6.53	7.53	4.92	3.15	7.8.67	1.68	2.57	2.24	2.10
11.4.67	3.59	4.29	4.20	4.02	9.8.67	1.68	2.94	2.01	1.77
13.4.67	3.92	5.56	3.64	-	14.8.67	1.68	2.05	1.96	1.63
17.4.67	3.31	3.78	3.87	2.85	16.8.67	1.40	2.66	2.05	1.77
19.4.67	4.06	5.69	3.55	2.43	21.8.67	7.75	5.97	6.58	1.59
24.4.67	3.27	4.67	3.50	2.71	23.8.67	1.40	2.24	1.45	1.96
26.4.67	4.29	5.46	2.89	2.94	25.8.67	-	-	-	-

Nitrite Nitrogen.

April	1	2	3	4	August	1	2	3	4
3.4.67	0.49	1.15	0.36	0.10	3.8.67	6.00	3.11	3.02	2.51
5.4.67	0.04	1.20	0.34	0.05	7.8.67	4.84	3.75	3.60	0.72
11.4.67	0.20	0.49	0.10	0.39	9.8.67	3.07	4.37	3.49	0.43
13.4.67	0.28	0.80	0.29	0.34	14.8.67	3.80	4.05	2.84	0.15
17.4.67	0.21	0.49	0.43	0.05	16.8.67	6.04	4.27	3.25	0.05
19.4.67	1.55	0.75	0.49	0.05	21.8.67	4.18	3.39	1.53	1.35
24.4.67	0.69	0.80	0.13	0.02	23.8.67	5.86	5.12	1.70	1.27
26.4.67	0.29	2.18	0.08	0.02	25.8.67	5.58	4.56	2.37	0.14

Table 57.

The Detailed Results of the Chemical Analysis of the Bloukrans River.

Nitrate Nitrogen.

April	1	2	3	4	August	1	2	3	4
3.4.67	4.14	6.15	6.55	4.86	3.8.67	7.38	8.95	12.28	14.40
5.4.67	1.22	4.96	4.93	3.36	7.8.67	10.68	10.20	11.00	13.00
11.4.67	1.20	2.96	2.10	2.80	9.8.67	7.65	13.40	12.70	12.40
13.4.67	2.00	3.88	2.48	2.20	14.8.67	12.50	12.75	10.50	11.80
17.4.67	2.32	3.50	4.70	3.20	16.8.67	6.20	11.25	11.85	10.85
19.4.67	2.90	4.80	4.92	3.20	21.8.67	10.10	12.70	10.00	11.80
24.4.67	8.22	6.90	5.70	4.44	23.8.67	11.60	13.15	9.15	16.40
26.4.67	3.60	7.90	7.94	4.26	25.8.67	7.50	9.00	6.30	5.60

Percentage Saturation of Dissolved Oxygen.

April	1	2	3	4	August	1	2	3	4
3.4.67	-	-	-	-	3.8.67	37.10	71.03	66.77	80.56
5.4.67	-	-	-	-	7.8.67	76.85	81.62	57.24	85.33
11.4.67	71.55	71.03	73.13	78.03	9.8.67	62.76	106.00	59.88	90.10
13.4.67	28.32	71.55	58.30	76.32	14.8.67	56.18	118.70	51.40	94.34
17.4.67	55.65	79.50	77.38	81.62	16.8.67	63.60	83.73	57.24	91.16
19.4.67	45.58	71.55	54.06	82.68	21.8.67	76.85	81.62	43.46	68.37
24.4.67	46.55	79.50	54.06	84.80	23.8.67	72.07	105.40	41.34	68.84
26.4.67	58.30	91.16	59.36	84.80	25.8.67	64.41	92.67	52.93	82.04

Explanation of Figures.

1-5. *Achnanthes adamantiformis* Archibald n.comb. - 6,7. *Achnanthes cogitata* n.sp. - 8. *Achnanthes Engelbrechtii* Cholnoky. - 9-11. *Achnanthes lanceolata* (Brebisson) Grunow var. *rostrata* Östrup. - 12,13. *Achnanthes pseudohungarica* Cholnoky-Pfannkuche. - 14. *Amphora fontinalis* Hustedt. - 15. *Amphora veneta* Kützing. - 16. *Caloneis bacillum* (Grunow) Cleve. - 17. *Caloneis bacillum* var. *minima* Cholnoky. - 18. *Caloneis Chasei* Cholnoky. - 19. *Caloneis Clevei* (Lagerstedt) Cleve. - 20-23. *Caloneis fasciata* (Lagerstedt) Cleve. - 24. *Caloneis hyalina* Hustedt. - 25. *Caloneis incognita* Hustedt. - 26. *Cyclotella comensis* Grunow. - 27, 28 *pseudostelligera* Hustedt. - 29, 30. *Cyclotella stelligeroides* Hustedt. - 31. *Cymbella Oliffii* Cholnoky. - 32. *Cymbella pusilla* A. Cleve-Euler. - 33. *Diploneis marginestriata* Hustedt. - 34. *Eunotia exigua* (Brebisson) Rabenhorst. - 35. *Eunotia polydentula* Brun. - 36. *Eunotia rhomboidea* Hustedt. - 37. *Eunotia similis* Hustedt. - 38, 39. *Fragilaria Vaucheriae* (Kützing) Boye Petersen. - 40. *Frustulia subvulgaris* Cholnoky. - 41-43. *Frustulia tugelae* Cholnoky. - 44. *Frustulia Weinholdii* Hustedt. - 45. *Gomphonema dichotomum* Kützing emend. Archibald. - 46. *Gomphonema gracile* Ehrenberg. - 47. 48. *Gomphonema javanicum* Hustedt. - 49-51. *Navicula adsidua* n.sp. - 52, 53. *Navicula agrestis* Hustedt. - 54-57. *Navicula aquosa* Archibald.

58,59. *Navicula bacilloides* Hustedt. - 60. *Navicula barbarica* Hustedt. - 61. *Navicula belliatula* n.sp. - 62, 63. *Navicula bryophila* Boye Petersen. - 64. *Navicula bushmanorum* Cholnoky. - 65,66. *Navicula chrissiana* Cholnoky. - 67,68. *Navicula cinctaeformis* Hustedt. - 69. *Navicula citrus* Krasske. - 70. *Navicula confervacea* (Kützing) Grunow. - 71. *Navicula contenta* Grunow f. *parallela* Boye Petersen. - 72,73. *Navicula cryptocephala* Kützing. - 74. *Navicula difficillima* Hustedt. - 75,76. *Navicula digitulus* Hustedt. - 77. *Navicula diuturna* Cholnoky. - 78-90. *Navicula diuturnoides* Archibald. - 91-93. *Navicula esamangensis* Foged. - 94,95. *Navicula fluens* Hustedt. - 96. *Navicula Fritschii* Lund var. *dissipatoides* Hustedt. - 97.98. *Navicula gilva* n.sp. - 99. *Navicula Grimmei* Krasske. - 100. *Navicula halophila* (Grunow) Cleve. - 101. *Navicula halophila* f. *robusta* Hustedt. - 102. *Navicula halophila* f. *tenuirostris* Hustedt. - 103. *Navicula Hambergii* Hustedt. - 104. *Navicula insociabilis* Krasske. - 105. *Navicula Geitleri* Hustedt.

106,107. *Navicula letulenta* n.sp. - 108. *Navicula longicephala* Hustedt. 109,110. *Navicula manubialis* Archibald. - 111-114. *Navicula microcephala* Grunow. - 115. *Navicula minuscula* Grunow. - 116-118. *Navicula molesta* Krasske. - 119. *Navicula montisatrae* Cholnoky 120,121. *Navicula pascuorum* Cholnoky. - 122-124. *Navicula permitis* Hustedt. - 125. *Navicula promota* n.sp. - 126,127. *Navicula pseudoventralis* Hustedt. - 128,129. *Navicula pupula* Kützing f. *rostrata* Hustedt. - 130. *Navicula Scottiae* Cholnoky. - 131,132. *Navicula seminulum* Grunow.- 133,134. *Navicula söhrensii* Krasske f. *musciicola* (Boye Petersen) Krasske. - 135. *Navicula simplex* Krasske var. *minor* Cholnoky. - 136-138. *Navicula Ständeriella* Archibald. - 139. *Navicula microcephala* Grunow - 140. *Navicula subcoccus* Cholnoky. - 141. *Navicula subcostulata* Hustedt. var. *avittata* Cholnoky. - 142-150. *Navicula submolesta* Hustedt. - 151. *Navicula mutica* Kützing var. *nivalis* (Ehrenberg) Hustedt. 152,153. *Navicula subrotundata* Hustedt. - 154-156. *Navicula tantula* Hustedt. - 157,158. *Navicula temeraria* Cholnoky. - 159-161. *Navicula tenella* Brebisson. - 162-164. *Navicula tenellaeformis* Hustedt. - 165,166. *Navicula tenuissima* n.sp.

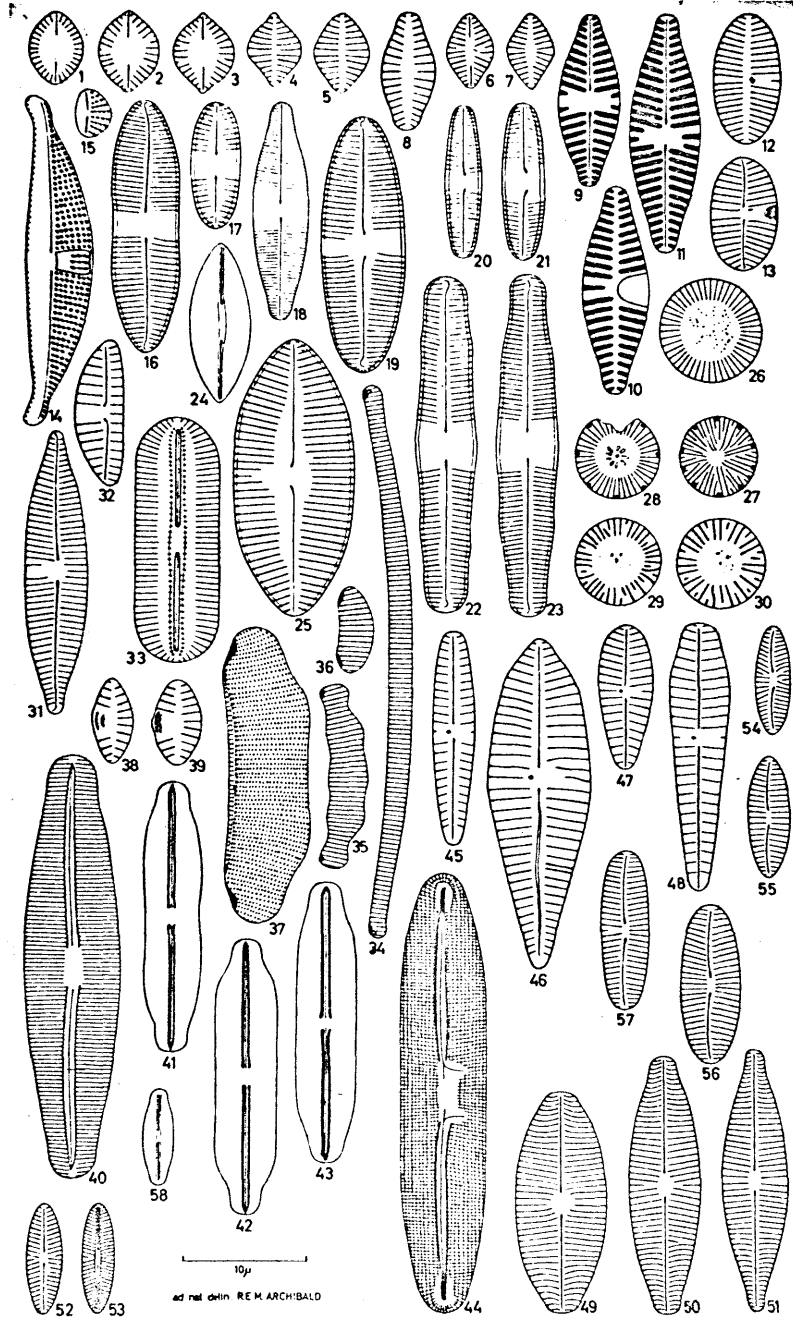
167-175. *Navicula Twymaniana* Archibald. - 176-178. *Navicula venezuelenoides* n.sp. - 179-181. *Navicula ventosa* Hustedt. - 182,183. *Navicula ventosoides* n.sp. - 184. *Neidium inconspicuum* Hustedt. - 185. *Nitzschia acicularis* (Kützing) W. Smith. - 186. *Nitzschia Agnewii* Cholnoky. - 187. *Nitzschia capitellata* Hustedt. - 188-192. *Nitzschia Chasei* Cholnoky. - 193.194. *Nitzschia Chutteri* Archibald. - 195. *Nitzschia Clausii* Hantzsch. - 196. *Nitzschia angustecarinata* Hustedt. -197,198. *Nitzschia diluta* Archibald. - 199,200. *Nitzschia diserta* Hustedt. - 201, 202. *Nitzschia exilis* Archibald.-203-208. *Nitzschia fonticola* Grunow.

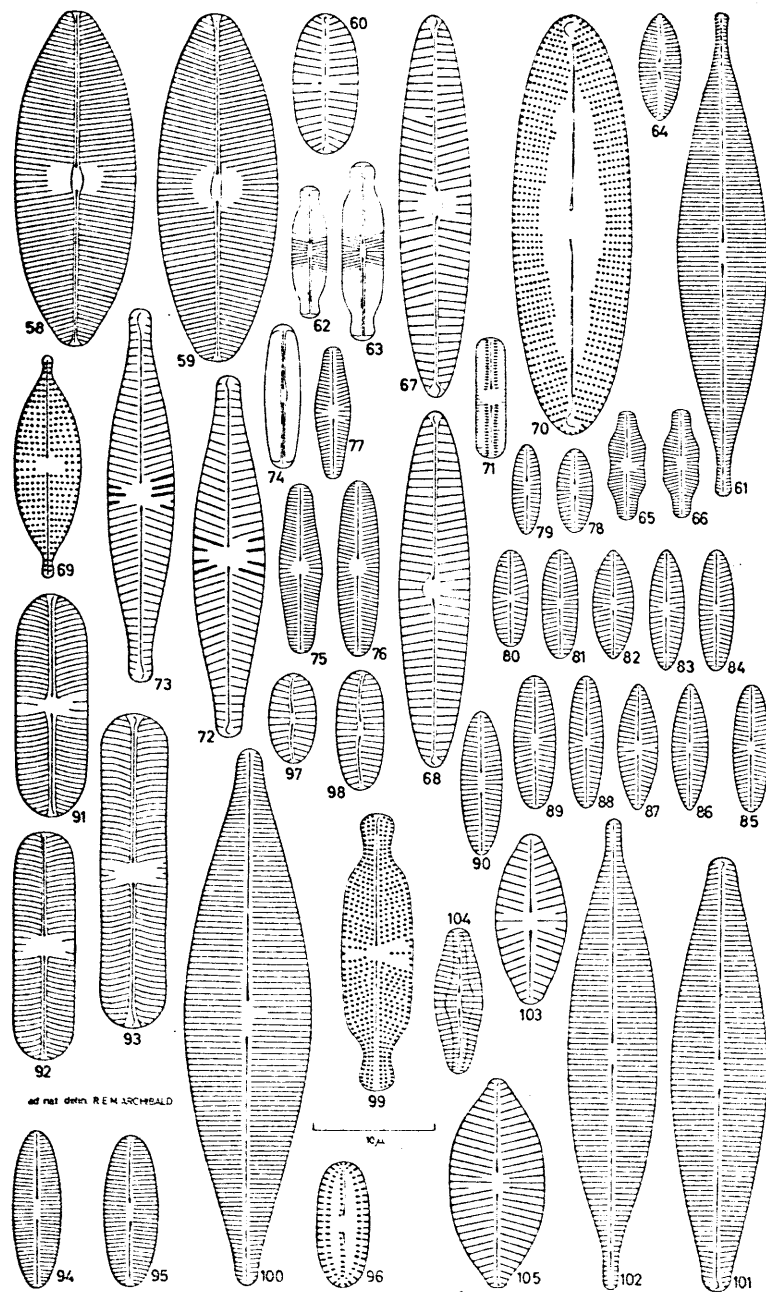
209. *Nitzschia gracilis* Hantzsch. - 210-213. *Nitzschia Kützingiana* Hilse. - 214. *Nitzschia lauenbergiana* Hustedt. - 215. *Nitzschia linearis* (Agardh) W. Smith. - 216. *Nitzschia mediocris* Hustedt. - 217, 218 *Nitzschia obligata* Archibald. - 219. *Nitzschia obsidialis* Hustedt. - 220-222. *Nitzschia palea* (Kützing) W.Smith - 223-225. *Nitzschia perminuta* Grunow. - 226,227. *Nitzschia perpusilla* Rabenhorst. - 228. *Nitzschia perspicua* Cholnoky. - 229. *Nitzschia proxima* Hustedt.- 230-236. *Nitzschia romana* Grunow.

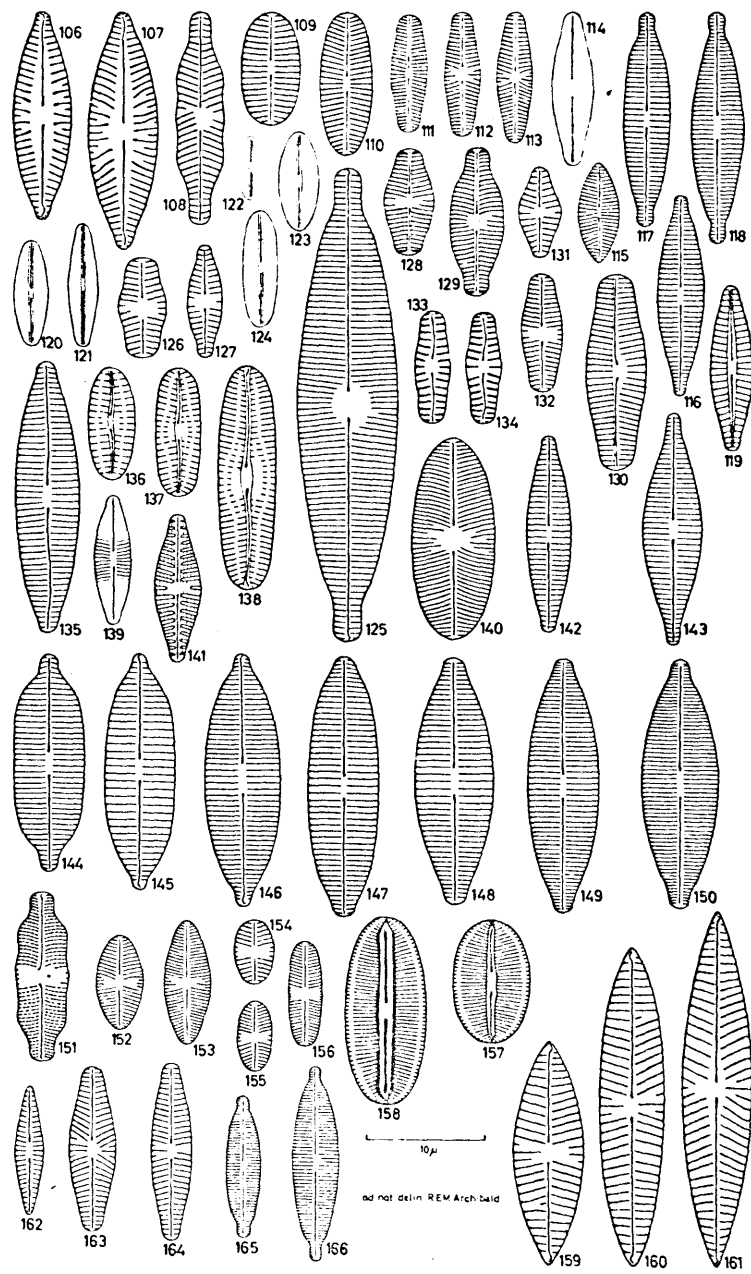
237. *Nitzschia rufitorrentis* Cholnoky. - 238-243. *Nitzschia silica* Archibald. - 244,245. *Nitzschia siliqua* Archibald. - 246. *Nitzschia spiculoides* Hustedt. - 247-254. *Nitzschia spiculum* Hustedt. - 255. *Nitzschia stricta* Hustedt. - 256. *Nitzschia subacicularis* Hustedt.

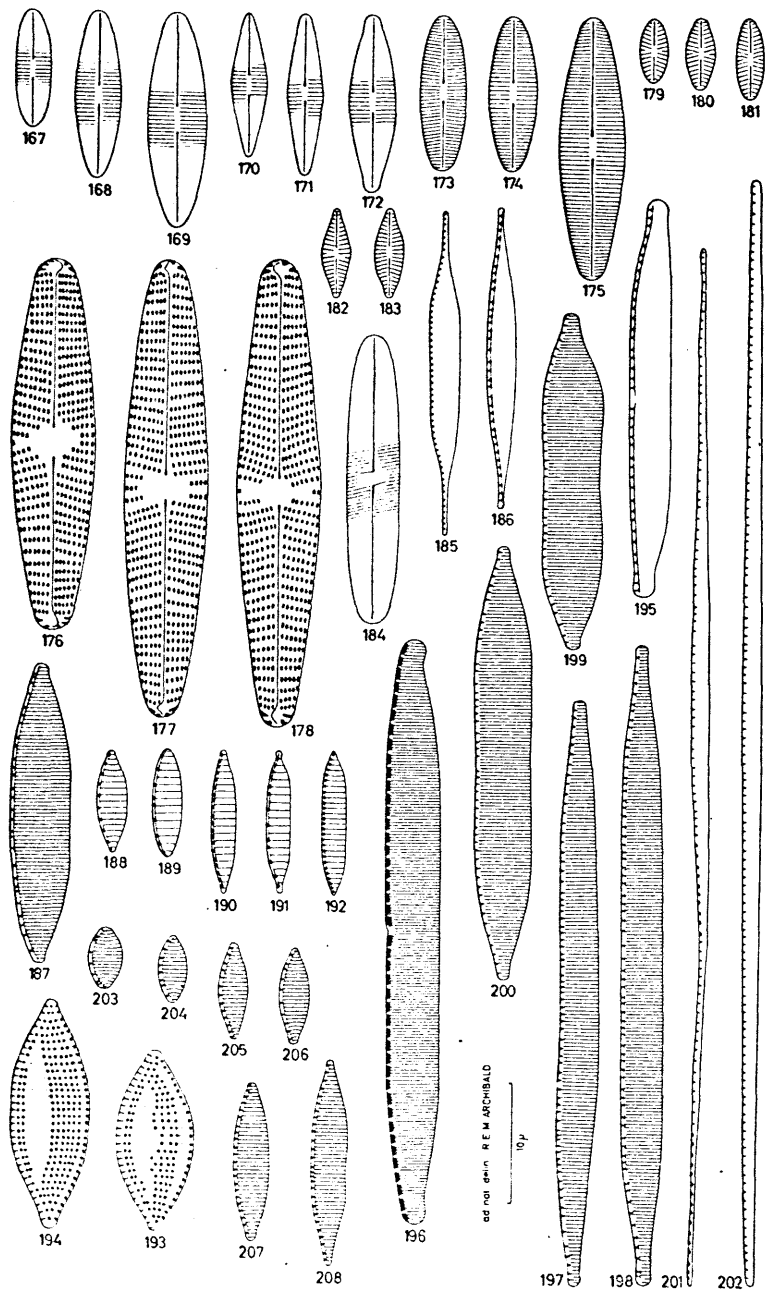
257,258. *Nitzschia subvitrea* Hustedt. - 259. *Nitzschia tropica* Hustedt. - 260,261. *Nitzschia umbilicata* Hustedt. - 262. *Nitzschia vandermerwei* Cholnoky. - 263. *Nitzschia vitrea* Norman var. *salinarum* Grunow. - 264. *Pinnularia brevicostata* Cleve var. *sumatrana* Hustedt. - 265. *Pinnularia eburnea* (Carlson) Zanon.

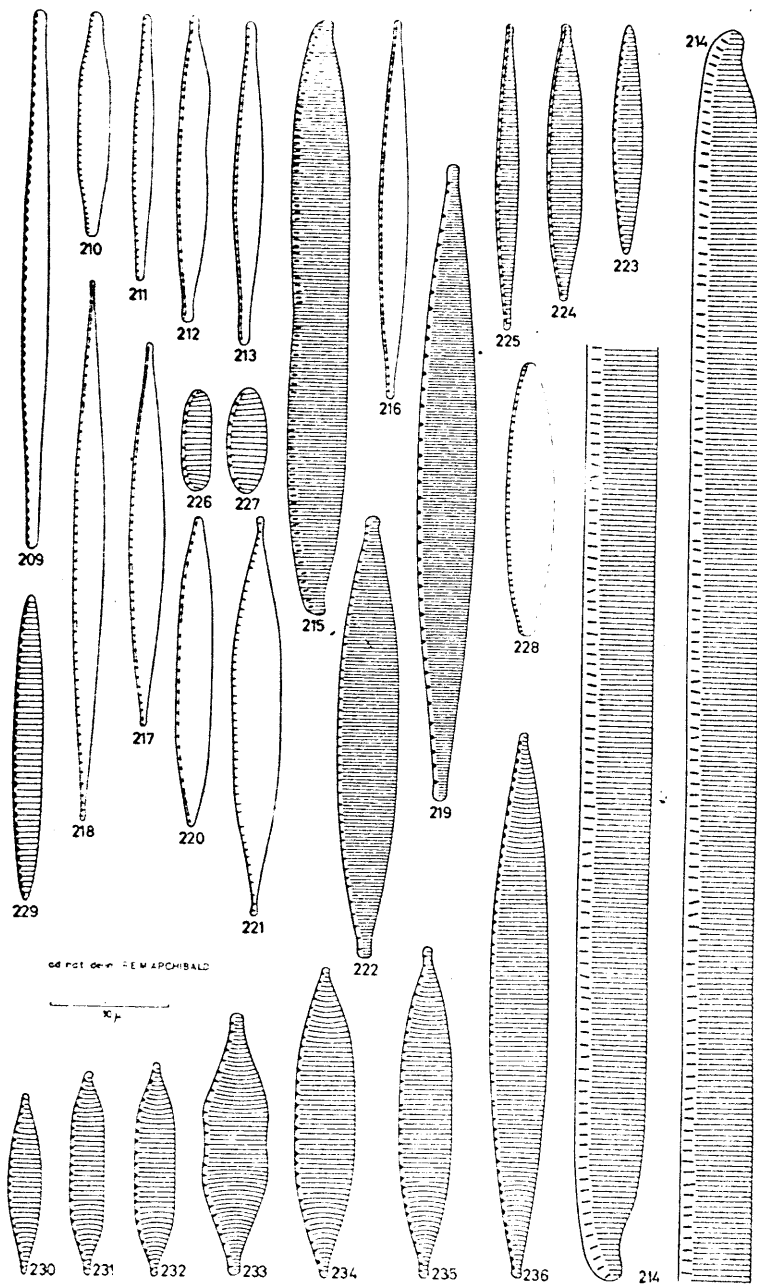
266. *Pinnularia stomatophora* (Grunow) Cleve. - 267. *Pinnularia subdivergentissima* Cholnoky. - 268. *Stauroneis anceps* Ehrenberg. - 269, 270. *Stauroneis Borrichii* (Petersen) Lund. - 271. *Stauroneis cimbebasiae* Cholnoky - 272. *Stauroneis dahomensis* Hustedt. - 273. *Navicula Mengeae* Cholnoky. - 274. *Surirella fimbriata* Hustedt. - 275,276. *Synedra mystica* n.sp.

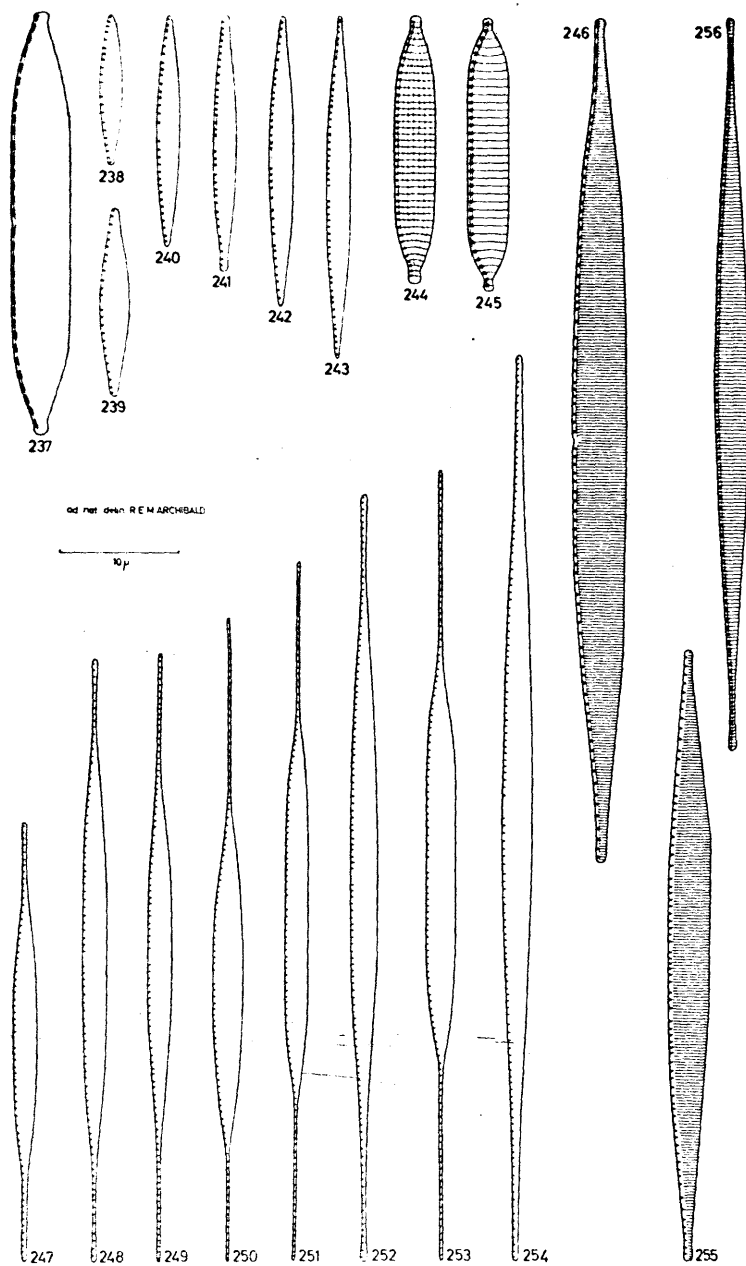


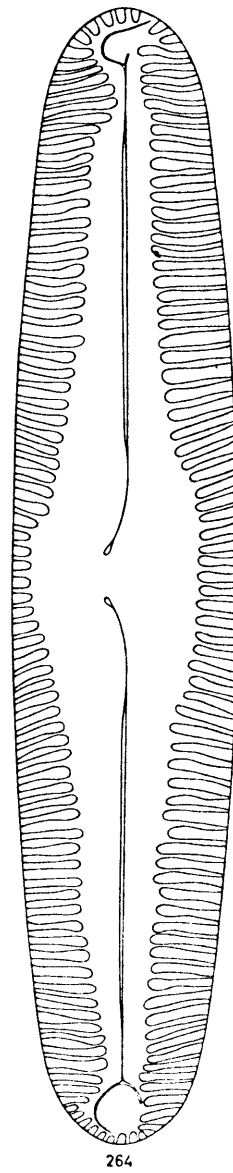
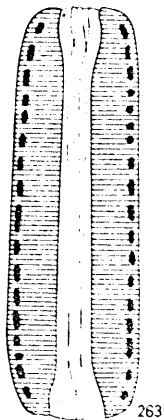




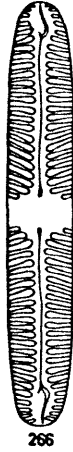




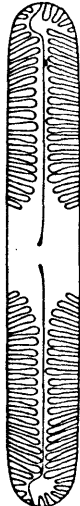




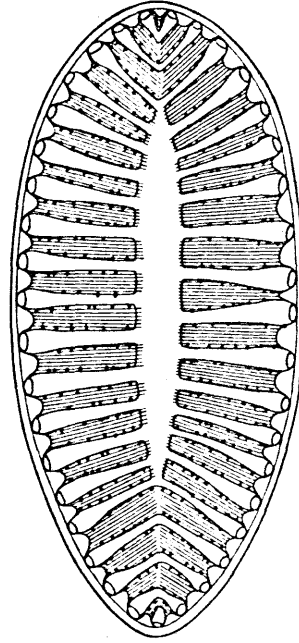
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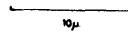


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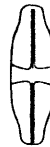


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see also section R.E.M. ARCHERD



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