THE INFLUENCE OF ANTS ON THE INSECT FAUNA OF BROAD - LEAVED, SAVANNA TREES.

by

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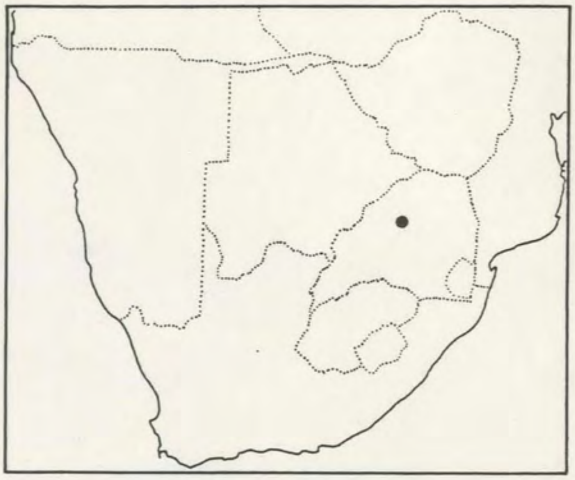
TO MY PARENTS AND SISTER, ROSEMARY



FRONTISPIECE

TOP RIGHT - A map of Southern Africa indicating the position of the Nylsvley Provincial Nature Reserve.

TOP LEFT - One of the dominant ant species, Crematogaster constructor, housed in a carton nest in a Terminalia sericea tree.

BOTTOM RIGHT - A sticky band of Formex[R] which was applied to the trunk of trees to exclude ants.

BOTTOM LEFT - Populations of the scale insect Ceroplastes rusci on the leaves of an unbanded Ochna pulchra shrub.

CONTENTS

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ABSTRACT

The influence of foraging ants on the insect fauna within the canopy of the tree species Terminalia sericea, Burkea africana and Ochna pulchra was studied in an area of typical South African savanna, over a two-year period. The number of individual insects and their species composition was compared on unbanded, ant-infested plants and on banded plants where ants had been excluded. Differences in the level of herbivory recorded on banded and unbanded trees were related to the guild composition of insects within the canopy, and the results are discussed in terms of plant protection as a consequence of ant - insect interactions.

Twenty-six ant species were recorded on the study trees at Nylsvley, with individuals belonging to the genus Crematogaster being numerically abundant and dominant within the canopy of each species of tree. These dominant ant species influenced the insect fauna by their strong dependence on honeydew, encouraging a build up in numbers of Homoptera on the branches and leaves of foraged trees, and supporting homopterous populations within the confines of their nest compartments. The exclusion of ants from trees led to fewer "mobile" homopterans (Aphididae, Membracidae, Psyllidae and Cicadellidae) and "sessile" homopterans (mainly Coccidae but also Pseudococcidae). Pyrethrum spraying showed that the guild composition of non-homopterous insects was similar on banded and unbanded trees.

Differences in the level of herbivory on banded and unbanded trees suggested that, although slight, foraged trees were protected from some damage by the presence of ant species within the canopy. A trend did exist towards a greater number of insect individuals and species on unbanded trees, and it is postulated that during the period 1982 - 1984 when drought conditions prevailed over Nylsvley, ants do not reduce insect numbers through predation or disturbance but simply deter phyllophagous feeding. A separate experiment showed that Crematogaster constructor would feed on the eggs and early instar larvae of the

saturnid moth, *Cirina forda*, but low numbers of lepidopterous larvae on the trees may have forced ants to seek honeydew. The negative impact of large homopterous populations on foraged trees was only seen in an isolated field observation where *Polyrachis schistacea* was found to associate with the lac insect *Tachardina* sp.. In conclusion it can be said that where homopterans are not the dominant phyllophages, plants do benefit from foraging populations of ants in that damage to the leaves is reduced.

2. INTRODUCTION

This study of the influence of ants upon insect fauna within the canopy of trees at Nylsvley centres around observations on trees supporting ant populations and on trees where ants have been excluded.

Ants have been described as the dominant social insects, both numerically and with regard to their wide distribution (Wilson, 1971). Individuals vary greatly in their food preferences (Carroll and Janzen, 1973; Petal, 1978): some obtain all or a large part of their food by predation, some subsist on seeds, while others rely on mutualistic relationships with plants (Janzen, 1966; Bentley, 1977a,b) and sap-sucking insects (Way, 1963).

Considering ant-insect interactions only, workers have shown that predation by individual ant species or ant communities is important in controlling populations of insect pests. For example, the red imported fire ant is used to suppress numbers of the boll weevil (Sterling, 1978) and Tilman (1978) reports on the ability of *Formica obscuripes* Forel to reduce the eastern tent caterpillar, *Malacosoma americanum* Fabricius, on the North American black cherry. Leston (1970, 1973) and Majer (1972, 1976 a,b,c) working on cocoa, and Greenslade (1971) on coconut plantations, showed that the most numerous or dominant ants form a three-dimensional mosaic, and are associated with a distinctive fauna resulting from negative associations with group of insects which they prey upon and positive associations encouraging homopterans.

Mutualism between ants and plant-feeding Homoptera is common. The ants obtain honeydew, a complex mixture of nutrients including free amino acids, amides, protein, minerals and B-vitamins, and are known to harvest the homopterans themselves for protein and lipids (Way, 1963). Following the removal of this honeydew and other contaminants and as a result of ant protection against natural enemies, homopterous populations multiply more rapidly in the presence of ants

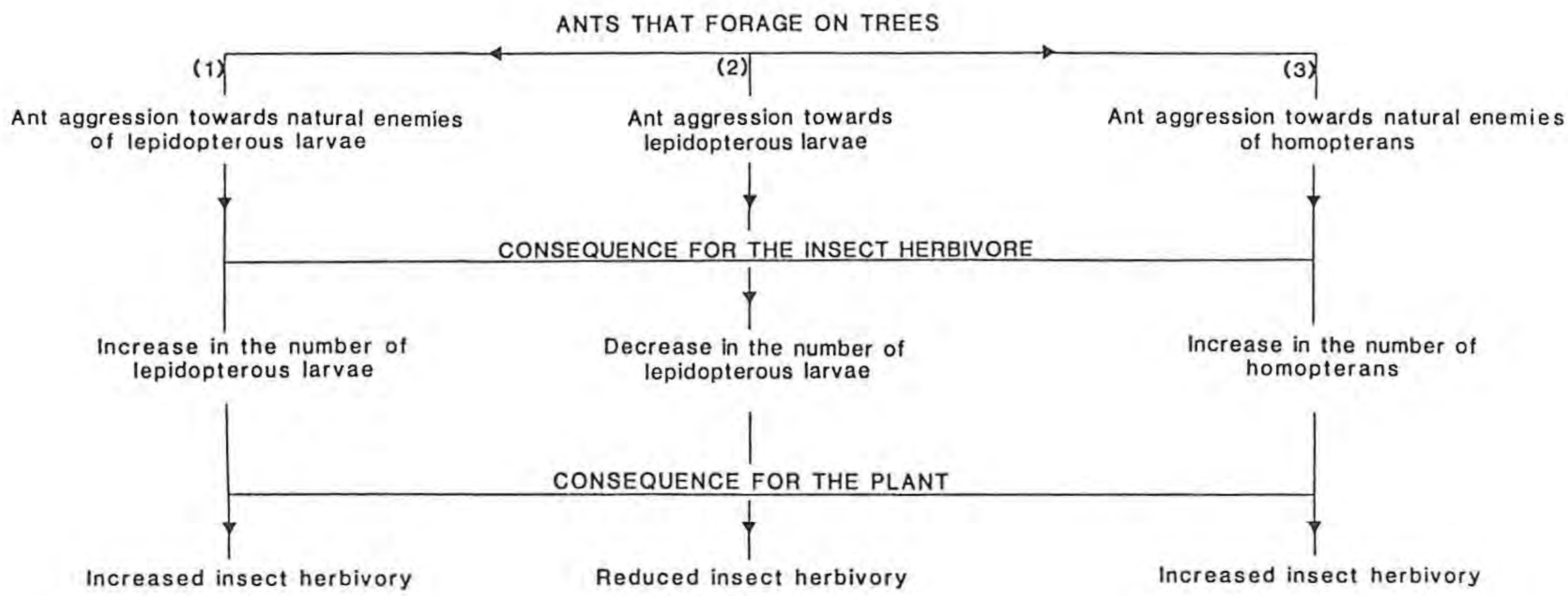


Fig. 1.1. The consequence of an ant - insect - plant association.

than when unattended (Muller, 1958). Other interactions may however complicate the simple mutualistic ant - homopteran association. Ants might show a general aggressive response to phyllophages for example lepidopterous larvae, and whenever the ant-tended Homoptera are not the dominant herbivores there may be a reduction in overall herbivory to the plant (Messina, 1981; Fritz, 1982). Extending the interaction to include the third trophic level and using the above example, Fritz (1983) suggests a further consequence of an ant-homopteran-plant association; ant aggression may be directed towards parasitoids and predators of lepidopterous larvae thereby increasing herbivore survival and leading to higher levels of herbivory. The effect to the host plant will depend on the influence of predators and parasitoids relative to the influence of ant disturbance in reducing lepidopterous larval numbers (Fig. 1.1).

To date little is known about ant communities within savanna-type ecosystems in South Africa. The present report forms part of a multi-disciplinary study, The South African Savanna Ecosystem Project (SASEP), and describes the influence of ants on the canopy insects of trees at the SASEP study area. The research objectives are three fold. Firstly, to describe the ant community associated with the woody plant species, *Terminalia sericea* Burch.ex.DC., *Burkea africana* Hook and *Ochna pulchra* Hook. Secondly, to carry out ant-exclusion experiments to compare the canopy fauna on ant-infested and ant-free trees and finally, to demonstrate whether changes in the composition of canopy herbivores through the manipulation of ant populations is advantageous or detrimental to the plant in terms of levels of herbivory.

The use of sticky bands to prevent entry of ants into the canopy of trees is described in Chapter 4. Any effects on plant phenology following the banding operation is reported in Chapter 5 together with data on the guild composition of insects caught in the sticky bands.

In Chapter 6 information is given on the ant community at Nylsvley, with descriptions of individual ant species appearing as an appendix to help with ant identification in the field. The influence ants have upon the insect fauna was monitored by direct observations and pyrethrum spraying of the canopy of banded and unbanded trees (Chapter 7). Finally, any effect ants have on the guild composition of insects within the canopy of the unbanded trees will be seen in the level of herbivory, and comparisons of damage assessments on banded and unbanded trees are given in Chapter 8.

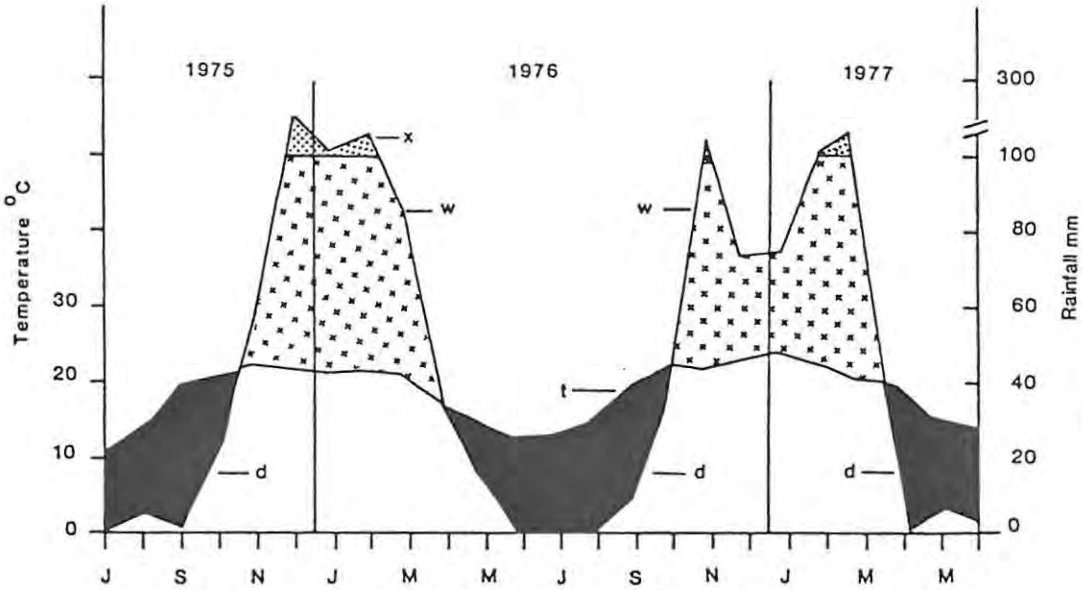


Fig. 3.1. A clamadiagram of the study site, Nylsvley, July 1975 to June 1977: d = arid period (black area); w = humid period (crossed area); x = rainfall above 100 mm (dotted area); t = monthly means of temperature.

3. STUDY AREA

The study area forms part of the Nylsvley Provincial Nature Reserve in the northern Transvaal, situated at 24°29'S and 28°42'E and at an altitude of between 1080 and 1140 m ASL (Frontispiece). The Nyl River borders the study area and flows south west to north east across the Reserve.

Within the study area a 2,5 ha plot was selected for intensive study which was located in the *Eragrostis pallens* Hack. - *Dombeya rotundifolia* (Hochst.) Planchon. vegetation-type over the Hutton soil form of the Portsmouth series (Harmse, 1975; Coetzee *et al.*, 1977).

3.1 Abiotic components

Climate

According to the South African Weather Bureau (Schulze, 1965) Nylsvley is included in the climatic region NT (Northern Transvaal) which corresponds to the international koppen climatic type BShw (Strahler, 1975). Three distinctive seasons prevail; hot and wet (November to April), cool and dry (April to August) and hot and dry (August to October) (Hirst, 1975). The general macro-climate of the area is summarised in Fig. 3.1 and Appendix I shows precipitation and temperature records for 1981 to 1984. These data indicate that the study period was dry compared with a 40 year mean of 630 mm falling at Mosdene, 10 km north east of the study area.

Geology and soils

The topography of the area is essentially flat, rising gently from north to south east. The uplands are mainly well drained, and comprise shallow to deep, non-calcareous litholitic soils overlying sandstones, conglomerates and grits of the Waterberg System. Harmse (1975) summarises the main characteristics of the A (to ca. 300mm) and

B (300 - 600mm) soil horizons within the Burkea africana area. The clay content and pH of the soil governs the availability of the soil nutrients and accounts for their low nutritional status. Jeanne (1979) related ant density with soil type when he observed that sandy soils supported a sparse and depauperate flora which in turn accounted for the relative sparsity of ant colonies. For further details on geology and soils see Harmse (1975) and Huntley and Morris (1978).

3.2 Biotic components

Producers

The vegetation type of the study area is a broad-leaved savanna, defined as Burkea veld by Acocks (1970). However, Coetzee et al. (1977) termed the area Eragrostis pallens - Burkea africana woodland and recognised three major variations and four sub-variations. The density of the woody plants at the study site was similar to figures presented for transect C in Lubke et al. (1975) and shown in Appendix II. The area is dominated by the shrubs Ochna pulchra Hook and Grewia flavesens Juss. and the tree species Terminalia sericea and Burkea africana (Fig. 3.2)

Following the work on social Hymenoptera by Kirsten (1978) who noted that Terminalia sericea, Burkea africana and Ochna pulchra supported greater foraging populations of Formicidae compared to the other dominant woody trees, it was decided to limit the present study to the above three mentioned tree species. Their phenology was noted from 1982 to 1984 at Nylsvley and is shown in Fig. 3.3.

Consumers

Annotated checklists for the Reserve have been published on birds (Tarboton, 1977), for amphibians, reptiles and mammals (Jacobsen, 1977) and a number of short-term monitoring programmes to sample the aboveground insect groups have been undertaken by various workers (Holm et al., 1976; Levey, 1977 and Nunn, 1976). Branch beating of the dominant tree species shows Terminalia sericea to carry the greatest diversity of insect herbivores with Ochna pulchna and Burkea africana sharing a similarity in species composition (Holm et al., 1976). Prinsloo (1978) suggests that a comprehensive study would reveal 1000 or more species of parasitoids acting upon insects within the major groups.

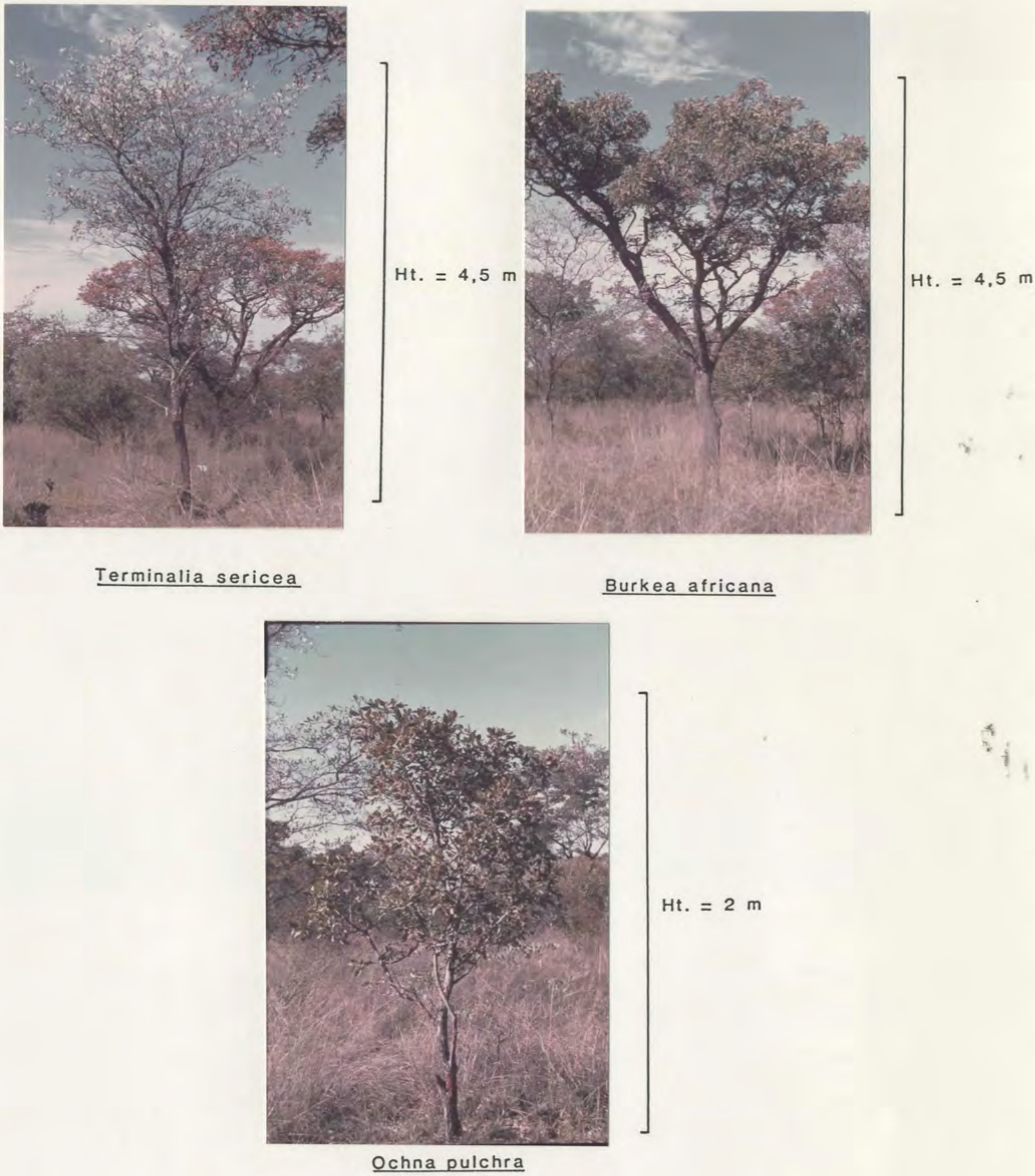


Fig. 3.2. The study trees Terminalia sericea, Burkea africana and Ochna pulchra at Nylsvley.

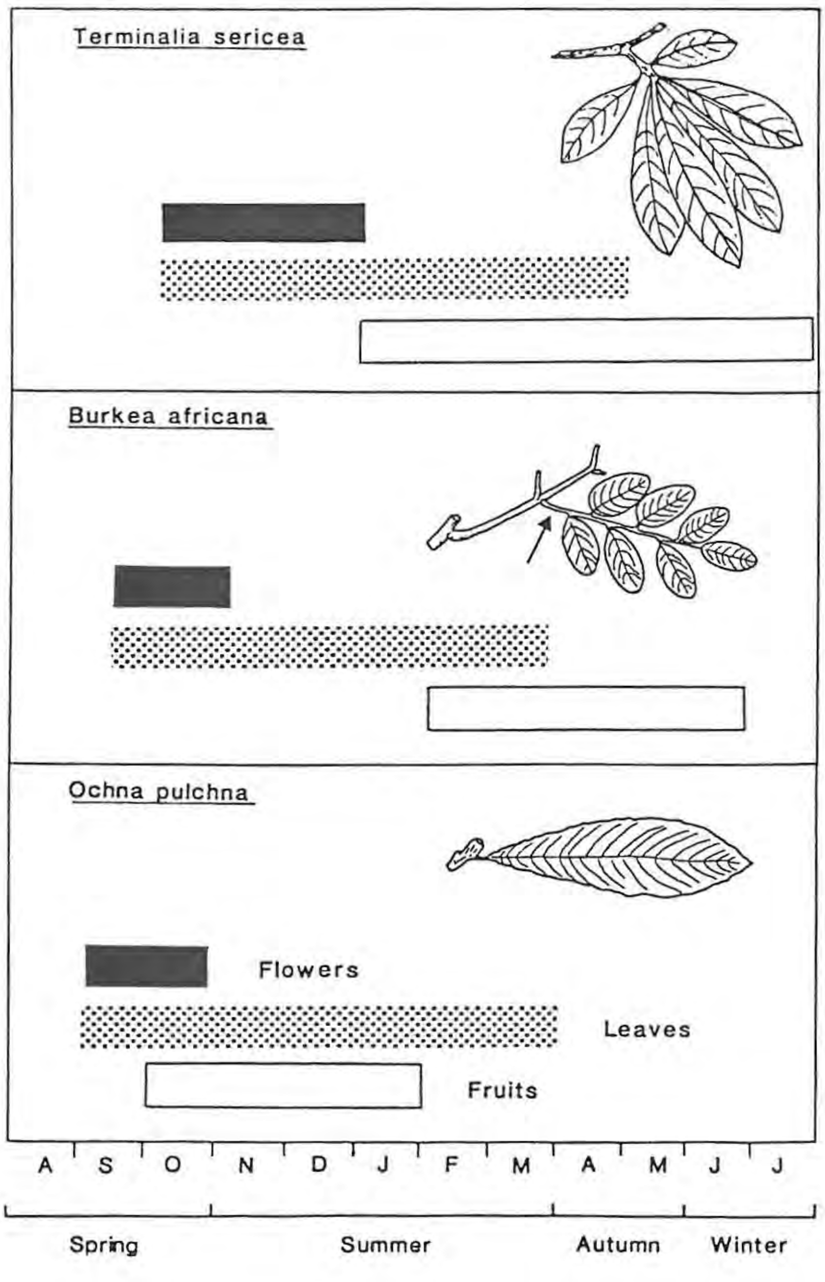


Fig. 3.3. The phenology of the study trees Terminalia sericea, Burkea africana and Ochna pulchra at Nylsvley. Inset indicates the leaf form of the tree species.

4. GENERAL MATERIALS AND METHODS

4.1 Ant exclusion by banding

Trees were paired on the basis of height and proximity and designated banded and unbanded. Ants were prevented from entering the canopy of the banded trees by banding (Frontispiece) the trunk, halfway between ground level and first branch, and all the main branches, with Formex^{R}. This polybutene material was diluted with paraffin to allow penetration into the crevices of the bark. To exclude ants which were resident within trees as was the case with ants on *Burkea africana*, Formex was used to block off all nest entrances. Care was taken to remove vegetation which formed bridges between the plant and ground or adjacent vegetation on both banded and unbanded trees (Samways *et al.*, 1981). This method of ant exclusion was repeated for each tree species.

More specific methods used in this study are described in context.

4.2 The effect of banding

Heeding the comments by Samways (1982b) on the dangers of sticky bands, an experiment was set up to test whether Formex affected plant phenology and altered the composition of the insect populations within the canopy of the banded trees.

The affect of Formex on plant phenology was tested by observing the timing of leaf emergence, and the number and size of the leaves produced from buds on banded and unbanded trees. The coincidence of leaf emergence and phyllophage appearance has been shown by many workers (Elton, 1966 referring to Satchell, 1962; Varley and Gradwell, 1962) to be important in explaining insect attack. If banding was to influence leaf emergence then the level of herbivory on banded trees could not be explained solely by ant exclusion but would be affected by the banding operation.

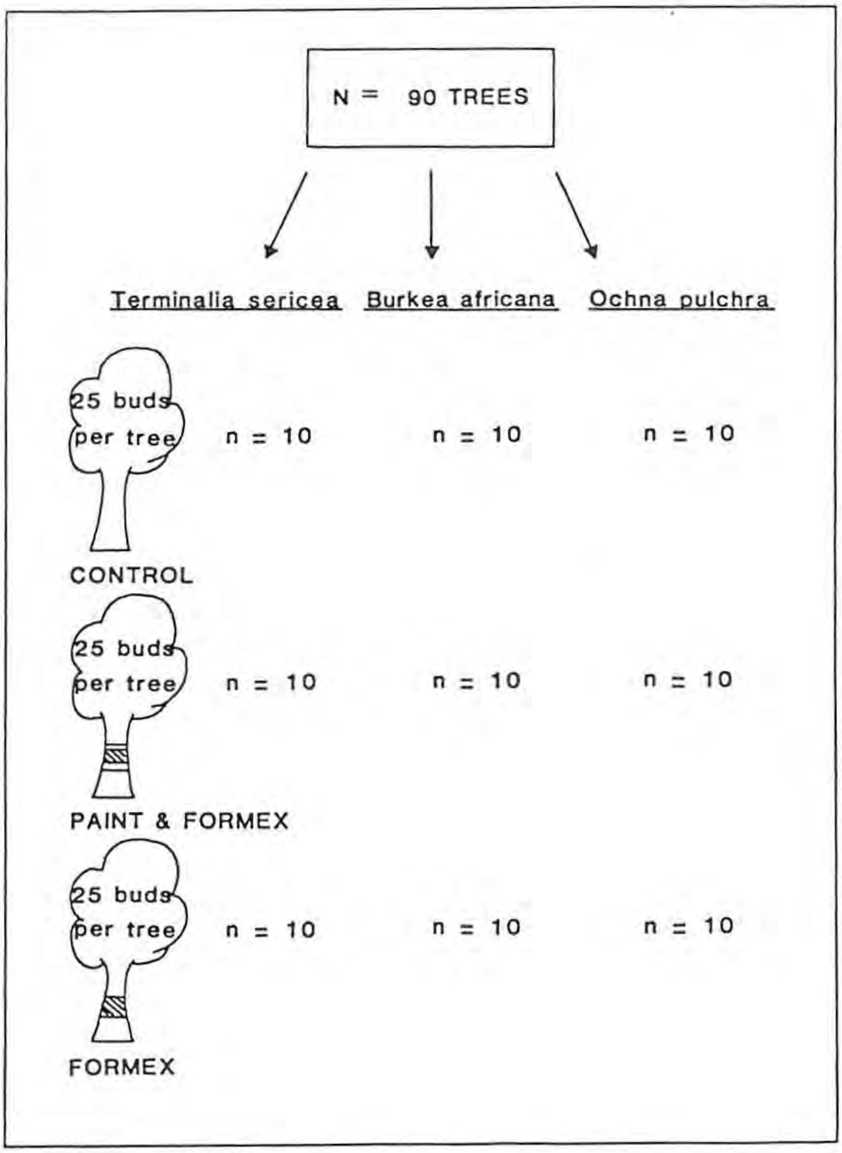


Fig. 4.1. Diagram outlining the procedure followed in obtaining data to show the effect of Formex ^{R} on the study trees at Nylsvley.

During the growing season of 1982, ninety trees, ten sets of three individual plants per tree species were chosen. One individual plant was banded in the usual way with a direct application of the Formex/paraffin mixture to the trunk and main branches. To the second plant, a layer of fast drying water-based grey paint was placed under the banding material to prevent it's seepage through the bark. The third individual plant in each set was designated the control. Twenty five buds on each plant were randomly chosen and marked (Fig. 4.1) and bud-burst patterns observed during the following Spring. On Terminalia sericea and Ochna pulchra trees, the number of leaves produced per bud and the area of individual leaves was calculated in December when leaf expansion had been halted (Rutherford, M.C., pers. comm.; Botanical Research Institute, Pretoria). Since Burkea africana has a compound leaf unlike the above tree species, the numbers of rhacides bearing the leaflets were noted from the selected buds (Inset to Fig. 3.3).

In the field, an indirect method was used to assess leaf area (Cilliers, 1982). One hundred and fifty undamaged leaves from Terminalia sericea and Ochna pulchra trees and the same number of leaflets from Burkea africana trees were collected, and the length and breadth of individual leaves measured with calipers and leaf area assessed with a Paton planimeter. In all cases there was a positive linear correlation between length and breadth and leaf area. It was found that for Burkea africana, leaf width gave a better estimate of area whereas length was a better estimate for Terminalia sericea and Ochna pulchra (Appendix III).

Sticky bands prevent insects other than ants from entering the canopy of trees, and as a consequence produces differences in the composition of the insect fauna on banded and unbanded trees. If the bands are dominated by visiting insects, which are not permanently associated with the tree and assumed not to be important damage agents, then differences in the level of herbivory on banded and unbanded trees could be explained solely by ant removal. However, if the bands consist of large numbers of phyllophages then there would be a reduction in herbivory on banded plants which would be due to the banding operation and not from the exclusion of ants. Insects trapped in the bands were removed, placed in vials of paraffin to dissolve away the Formex and sorted into guilds (Table 4.1). The grouping of insects which are not taxonomically related but ecologically similar in terms of their feeding habits into guilds, has been used by many workers in community studies (Root, 1967, 1973; Moran and Southwood, 1982).

Table 4.1. The guild composition of the insect fauna on trees at Nylsvley.

Phyllophages	- Chewers
Phyllophages	- Sap-suckers
Parasitoids	
Predators	
Visitors	- With no permanent or lasting association with the tree.
(Spiders)	- Although not insects, they were found within the canopy of trees and are considered as general predators.

5. THE RESULTS OF BANDING

The influence of sticky bands on plant phenology is given in section 5.1, and the guild composition of insects caught in the bands described in section 5.2. Conclusions are drawn as to whether banding could alter the level of herbivore damage to the leaves through its affect on the insect fauna of banded trees.

5.1 The effect on plant phenology

Irrespective of treatment, all the chosen buds on Terminalia sericea and Ochna pulchra showed a short pattern of bud-burst which overlapped in the two plant species. For Ochna pulchra the first leaves broke on 18.10.83 and buds continued opening until 25.10.83, with similar dates for Terminalia sericea being 20.10.83 until 25.10.83. Bud-burst was extended on Burkea africana trees, and the number of days for it's completion on treated trees was compared with length of time observed on the control trees and found not to differ ($F = 2{,}9$ for 2df, $p = >0{,}05$). These results showed that the timing of leaf emergence from marked buds on all the three species of trees was similar on trees treated with Formex or with an application of paint underneath the band compared with the control trees.

Comparisons were made of the number of leaves produced from buds on treated Terminalia sericea and Ochna pulchra trees and the area of these leaves, with similar figures obtained from the control trees. These data are summarised in Table 5.1 together with a comparison of the number of rhacides produced on Burkea africana trees. The ANOVA of the number of leaves produced from buds on treated Ochna pulchra trees revealed a significant difference between the three treatments. A separate pairwise analysis was used to locate differences between the treatments and revealed a significant difference between paint/Formex X Formex trees of Ochna pulchra. This interaction is not understood, however as no significant differences between paint/Formex X Formex trees occurred on either Terminalia sericea or Burkea africana and because no differences were found in the number of leaves produced on the control and treated trees of any of the three tree species, it is assumed that the above mentioned interaction will not affect the overall findings. Therefore in summary, the data suggests that the timing of leaf emergence, leaf production and the size of leaves does not differ on banded and unbanded trees.

Table 5.1. Comparison of leaf production on trees treated with Formex, paint / Formex and control trees at Nylsvley, using Analysis of Variance.
The number of trees observed per tree species, n = 30. N.S. = Not significant

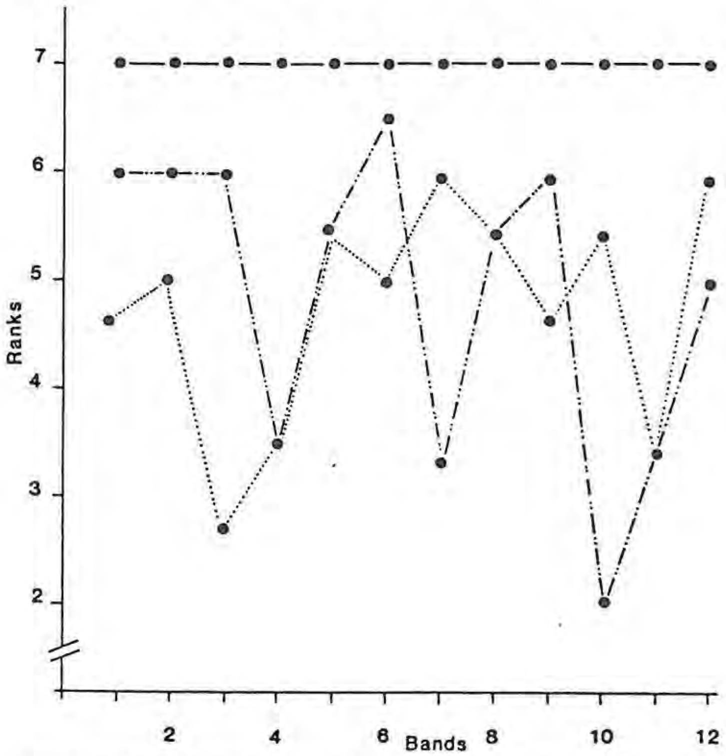
TREE SPECIES	VARIABLES	F-VALUE	p (2df)
Terminalia sericea	No. of leaves produced	0,3	N.S.
Terminalia sericea	Area of leaves produced	3,4	N.S.
Burkea africana	No. of rhacides produced	0,1	N.S.
Ochna pulchra	No. of leaves produced	5,0	<0,025*
Ochna pulchra	Area of leaves produced	0,2	N.S.

* = a separate comparison revealed a significant paint/Formex X Formex interaction. F = 8,00 for 1 df, p = <0,025

5.2 The effect on the insect fauna

Insects were removed from the sticky bands around the trunk and branches of the trees, sorted into guilds and ranked; the greatest number of individuals in a guild obtaining the highest rank. The results showed that the ranks of insect guilds remained the same in bands around the trunk and upper branches, and ranks did not vary with tree species. An example of this rank sequence is shown in Fig. 5.1 when the bands around the trunk of 12 Burkea africana trees were examined. Insects designated as visitors were consistently the dominant guild caught in the bands, followed by the homopterans and the phyllophagous chewing insects, mainly Coleoptera of which the Chrysomelidae, Elateridae and Bruchidae predominated. The remaining insect guilds were poorly represented in the bands.

The banding operation could be characterised by its effect on the visiting populations of insects to the study trees. Visitors do not remain within the canopy of trees for long periods of time and are thus considered unimportant contributors to herbivory on the study trees. For this reason, differences in the level of insect damage on banded and unbanded trees will reflect the exclusion of ants from the trees and not be the result of the banding operation.



Het.	2	1,5	3	3,5	2	2	3	2,5	2	2	3,5	1,5
Par.	2	1,5	3	3,5	2	2	3	2,5	4,5	5,5	3,5	3,5
Pred.	2	4	3	3,5	2	2	3	2,5	2	2	3,5	1,5
Spi.	4,5	3	3	3,5	4	4	3,5	4	2	2	3	3,5

Fig. 5.1. Insects removed from sticky bands applied around the trunks of Burkea africana trees (n = 12 trees), sorted into guilds and ranked to show the relative size of each guild represented in the band. (●—●—● visitors; ●-··●-··● Homoptera; ●···●···● chewers. Ranks of Heteroptera (Het.), parasitoids (Par.), predators (Pred.) and spiders (Spi.) appear below the axis.

Table 6.1. Check-list of the Formicidae (Workers) foraging within the canopy of the study trees at Nylsvley.
(* = race unknown; B.A. = Burkea africana; T.S. = Terminalia sericea; O.P. = Ochna pulchra)
Unknown ant species appear with an accession no. SG. A reference collection of the specimens is housed in The National Collection of Insects, Pretoria.

FAMILY Tribe	SPECIES	OCCURRENCE
FORMICIDAE Camponotini	Camponotus eugeniae, Forel	B.A., T.S., O.P.
	Camponotus fulvopilosus*, De Geer	B.A., T.S., O.P.
	Camponotus mayri, Forel	B.A., T.S.
	Camponotus robecchii, Emery race Rhodesiana, Forel	T.S.
	Camponotus rufoglaucus*, Jerdon	T.S.
	Polyrachis schistacea, Gerstaecker	B.A., T.S., O.P.
	Camponotus sp. SG. 89	B.A., O.P.
	Polyrachis sp. SG. 85	B.A.
FORMICIDAE Plagiolepidini	Acantholepis capensis, Mayr	B.A., T.S., O.P.
	Acantholepis custodiens, Smith	T.S., O.P.
	Plagiolepis pygmaea, Latreille	B.A., T.S., O.P.
DOLICHODERINAE Tapinomini	Tapinoma arnoldi, Forel	B.A., T.S.
	Technomyrmex albipes*, Smith	B.A., T.S., O.P.
MYRMICINAE Crematogastrini	Crematogaster amita, Forel	B.A., T.S., O.P.
	Crematogaster castanea, Smith	B.A., T.S.
	Crematogaster constructor, Emery	B.A., T.S., O.P.
	Crematogaster gerstaeckeri, Della Torre.	B.A., T.S., O.P.
	Crematogaster nigronitens, Santschi	B.A., T.S., O.P.
	Crematogaster transvaalensis, Forel	B.A.
	Crematogaster sp. SG. 116	B.A.
MYRMICINAE Meranoplini	Meranoplus simoni, Emery	O.P.
MYRMICINAE Pheidolini	Pheidole megacephala, Fabricius	B.A., T.S., O.P.
MYRMICINAE Solenopsidini	Monomorium sp. SG. 88	T.S.
MYRMICINAE Tetramorini	Tetramorium sp. SG. 101	T.S.
PSEUDOMYRMICINAE Pseudomyrmini	Tetraponera penzigi, Mayr	B.A.
	Tetraponera sp. SG. 81	T.S.

6. THE ANT COMMUNITY

Observations throughout the study period provided background information on the ant community at Nylsvley. A monthly survey, from June 1982 to February 1983 was carried out to determine the frequency of occurrence of the ant species present. The study site was divided randomly into 100 x 100m sub-plots within which 25 individual plants of each species were selected. From a 3 metre-high ladder, trees were systematically searched, and individual ants within reach collected using an aspirator and transferred to vials containing 80% ethyl alchol. To minimise the effect of within-habitat differences, each sampling per month was standardised as far as possible: sampling was carried out only by the author, and during the early morning and mid-afternoon only when general ant activity was at a peak (Kirsten, 1978).

6.1 The ant species

Twenty- six species of ants were collected during the study period of which the majority occurred in the tribes Camponotini and Crematogastrini (Table 6.1). A guide to the field identification of these species, describing the external anatomy of the individual workers is given in Appendix IV. The ants are divided into three size categories, small <3mm, medium 3 - 6mm and large >6mm. Many closely-allied forms occur in the genus *Crematogaster*, and to help distinguish between species an illustrated key of the differences in the thorax, epinotal spines and petiole is included in Appendix IV.

Investigations have shown that on all three tree species ants within the genus *Crematogaster* were always more abundant than individuals in other genera, and thus termed dominant. An indication of the order of magnitude in the number of individuals classed as dominants compared to those which were less numerous and deemed non-dominants is given further in the text. No two dominants were found foraging on the same tree, and they appeared to be associated with specific sub-dominants and non-dominants. The ant species Camponotus eugeniae, Pheidole megacephala and Polyrachis schistacea were classed as sub-dominants for in the absence of any dominant Crematogaster species, they would become numerically abundant (Table 6.2). The most common non-dominant ant species were Plagiolepis pygmaea and Acantholepis capensis (Table 6.2).

Table 6.2. Ants functioning as dominants, sub-dominants and non-dominants at Nylsvley.
S-Dom. = Sub-dominant. N-Dom. = Non-dominant.

DOMINANT	SUB-DOMINANTS AND NON-DOMINANTS	
Crematogaster amita	Polyrachis schistacea	S-Dom.
	Acantholepis capensis	N-Dom.
	Acantholepis custodiens	N-Dom.
	Camponotus fulvopilosus	N-Dom.
	Plagiolepsis pygmaea	N-Dom.
	Meranoplus simoni	N-Dom.
Crematogaster castanea	Polyrachis schistacea	S-Dom.
	Camponotus eugeniae	S-Dom.
	Camponotus rufoglaucus	N-Dom.
	Technomrymex sp. SG. 98	N-Dom.
Crematogaster constructor	Polyrachis schistacea	S-Dom.
	Camponotus eugeniae	S-Dom.
	Acantholepis capensis	N-Dom.
	Plagiolepsis pygmaea	N-Dom.
Crematogaster gerstaeckeri	Polyrachis schistacea	S-Dom.
	Camponotus eugeniae	S-Dom.
	Tetraponera penzigi	N-Dom.
	Tetramorium sp. SG. 101	N-Dom.
	Plagiolepsis pygmaea	N-Dom.
Crematogaster nigronitens	Polyrachis schistacea	S-Dom.
	Pheidole megacephala	S-Dom.
	Tetraponera sp. SG. 81	N-Dom.
	Camponotus fulvopilosus	N-Dom.
Crematogaster transvaalensis	Plagiolepis pygmaea	N-Dom.
	Camponotus fulvopilosus	N-Dom.

6.2 Distribution and nesting sites

The study trees shared a similarity in ant species : eleven ant species were common to all three tree species (Table 6.1). Four species of ants were limited to Burkea africana, five species to Terminalia sericea and one ant species, Meranoplus simonsi restricted to Ochna pulchra (Table 6.1). The frequency with which individual ant species occurred on the plants each month were ranked and summarised in Table 6.3. Using the Mann-Whitney "U" statistic it was found that the change in rank of individual ant species from one sampling to another was insignificant ($U = 49$; $p = >0,05$) thus suggesting a consistency in the frequencies throughout the growing season.

Table 6.3. Ordinal ranks of frequency of occurrence of named ant species on the study trees at Nylsvley, from July 1982 to February 1983.

	CENSUS DATES					
SPECIES	JULY	AUG.	SEPT.	OCT.	JAN.	FEB.
			Terminalia sericea			
P. schistacea	8	3	3,5	8	8	8
C. eugeniae	3,5	3	3,5	6	2,5	7
P. pygmaea	3,5	3	3,5	1,5	6	4
P. megacephala	7	3	3,5	4	2,5	5
A. capensis	3,5	7,5	8	7	7	6
A. custodiens	3,5	3	3,5	4	2,5	2,5
C. amita	3,5	7,5	3,5	1,5	2,5	1
C. nigronitens	3,5	6	7	4	5	2,5
			Burkea africana			
P. schistacea	2,5	2,5	5	9	7,5	6,5
P. pygmaea	9	9,5	8,5	8	7,5	10
P. megacephala	2,5	7	7	2	3,5	2,5
A. capensis	2,5	5,5	5	5	5	9
C. amita	6,5	2,5	5	5	3,5	2,5
C. nigronitens	5	7	8,5	5	6	8
C. gerstaeckeri	10	9,5	10	10	10	9
C. castanea	8	5,5	2,5	1	1	2,5
C. transvaalensis	2,5	7	2,5	5	3,5	5
T. penzigi	6,5	2,5	2,5	5	3,5	6,5
			Ochna pulchra			
P. schistacea	2,5	2	4,5	7	8	7
C. eugeniae	2,5	2	1,5	6	6	4
P. pygmaea	8	8	8	8	7	8
P. megacephala	7	7	4,5	7	8	7
A. capensis	2,5	5	6	5	4,5	6
A. custodiens	2,5	2	1,5	1,5	3	2,5
C. amita	6	5	7	1,5	4,5	2,5
C. nigronitens	5	5	3	3,5	1,5	1

A number of features of the nesting habits of the individual ant species were noted (Table 6.4). With the exception of Crematogaster amita, all dominants and the non-dominant Tetraponera penzigi formed arboreal nests whereas the remaining non-dominants and sub-dominants nested in the ground. A further distinction could be made between the sub and non-dominant ants and Crematogaster constructor which formed centralised nests and those which were polydomous, living in decentralised nest compartments within the canopy layer and trunk of trees. Individual nest compartments housing small colonies of Tetraponera penzigi, Crematogaster nigronitens, Crematogaster gerstaeckeri and Crematogaster transvaalensis within branches of Burkea africana were examined and found to contain scale insects which were mixed with the ant host's brood and tended in the normal way (Tables 6.5 - 6.8).

Table 6.4. The nesting sites and nest material of ants within the study site at Nylsvley.

ANT SPECIES	NEST SITE AND NESTING MATERIAL
Crematogaster amita	Subterranean, entrance covered with chewed vegetable matter and leaf litter.
Crematogaster castanea	Arboreal, occurring in hollow twigs and crevices in the bark.
Crematogaster constructor	Arboreal, forming conspicuous carton nests made of chewed vegetable matter.
Crematogaster gerstaeckeri	Arboreal, occurring in hollow twigs and crevices in the bark.
Crematogaster nigronitens	Arboreal, occurring in hollow twigs and crevices in the bark.
Crematogaster transvaalensis	Arboreal, occurring in hollow twigs and crevices in the bark.
Acantholepis capensis	Subterranean, small nest entrance holes covered with leaf litter.
Acantholepis custodiens	Subterranean, with a single entrance hole.
Camponotus eugeniae	Subterranean, large entrance hole surrounded by a mound of excavated soil.
Camponotus fulvopilosus	Subterranean, entrance surrounded by a horse-shoe of excavated soil.
Polyrachis schistacea	Subterranean, entrance of contructed turrets of grass.

Table 6.5. The contents of Tetraponera penzigi nests in branches of Burkea africana. (n = 12 branches)

COLONY NO.	LARVAE	PUPAE	WORKERS	MALES	QUEENS	COCCIDS
1	22	1	34	-	5	12
2	17	3	10	-	-	33
3	17	1	12	-	-	5
4	18	8	25	-	1	8
5	23	5	43	-	-	8
6	13	-	18	-	-	-
7	46	10	54	-	-	13
8	28	11	33	-	-	20
9	10	1	15	-	-	2
10	5	1	18	-	-	4
11	6	1	17	-	-	2
12	4	1	13	-	-	22

Table 6.6. The contents of Crematogaster nigronitens nests in branches of Burkea africana. (n = 12 branches)

COLONY NO.	LARVAE	PUPAE	WORKERS	MALES	QUEENS	COCCIDS
1	-	-	19	-	-	7
2	49	38	183	-	-	34
3	21	20	58	-	-	44
4	-	-	30	1	-	11
5	17	7	40	-	-	15
6	-	1	124	-	-	8
7	31	13	78	-	-	40
8	-	-	20	-	-	7
9	8	8	124	9	-	32
10	4	7	15	-	-	7
11	3	-	12	-	-	6
12	35	6	28	-	1	5

Table 6.7. The contents of Crematogaster gerstaeckeri nests in branches of Burkea africana. (n = 12 branches)

COLONY NO.	LARVAE	PUPAE	WORKERS	MALES	QUEENS	COCCIDS
1	44	12	33	-	-	13
2	169	13	80	-	-	12
3	-	-	63	-	-	7
4	70	34	107	-	-	37
5	1	2	20	-	-	1
6	80	145	-	-	-	3
7	4	2	58	-	-	2
8	-	-	32	-	-	3
9	3	2	149	-	-	5
10	1	5	50	-	-	11
11	-	-	30	1	1	11
12	8	8	124	9	-	32

Table 6.8. The contents of Crematogaster transvaalensis nests in branches of Burkea africana. (n = 10 branches)

COLONY NO.	LARVAE	PUPAE	WORKERS	MALES	QUEENS	COCCIDS
1	33	11	78	-	-	27
2	2	-	138	-	-	14
3	131	14	178	-	-	60
4	11	3	42	-	-	3
5	5	-	60	1	-	11
6	14	2	26	-	-	3
7	9	-	119	-	-	6
8	34	6	140	-	-	4
9	-	-	10	-	-	3
10	159	42	161	-	-	13

6.3 Field observations

Individual ant species are involved in numerous interactions: with other ant species, and with individual insects which are preyed upon or are tendered for honeydew as seen by ant-Homoptera mutualism. Reported below are three unrelated observations describing (i) an ant-ant interaction, (ii) an ant - homopteran interaction and finally, (iii) an ant- lepidopterous larva interaction.

(i) Plagiolepis pygmaea / Crematogaster sp. interaction

Plagiolepis pygmaea was frequently encountered foraging within the canopy of all the tree species (Table 6.3), and formed distinctive trunk trails. Where these trails occurred on trees dominated by Crematogaster species there was clear avoidance behaviour of the non-dominant, and trails between the two ant species never met.

(ii) Polyrachis schistacea / Tachardina sp. interaction

In the absence of any dominant ant species, the sub-dominant Polyrachis schistacea was found to associate with the lac insect Tachardina sp. (Homoptera: Lacciferidae) on Ochna pulchra. Populations of these homopterans built up and exceeded 2000 individuals per branch and the production of copious quantities of honeydew as a result, encouraged sooty mould to form on the upper surface of the leaves. It was noted that differences existed in the size of leaves on branches dominated by scales and in the size of leaves from branches which were homopteran-free. A mean length of 51,24 mm (n = 100 leaves) for leaves collected from branches with Tachardina sp. was tested against a mean length of 67,99 mm (n = 5000 leaves) for leaves from branches without lac insects and found to be significantly smaller ($t = 6{,}56$; $p = \leqslant 0{,}001$). Clearly nutrients from the plant are being tapped by the large populations of Homoptera, and this is reflected by a considerable reduction in the size of the leaves on branches dominated by Tachardina sp. when compared with the size of leaves from leaves without the lac insect.

Ants are known to disturb the natural enemies of homopterous insects and a measure of the extent of this disturbance was gained through the dissection of mature lac insects from the branches. A low figure of 14% parasitism was obtained (n = 1915 insects).

(iii) Crematogaster constructor / Cirina forda interaction

Thirdly, this study served to emphasize the influence of Crematogaster constructor as an important controller of Cirina forda Westwood (Saturniidae: Saturninae) either through egg predation or the removal of the first and second larval instars.

During the period of late September and early October 1983, numbers of adult Cirina forda collected in three Robinson light traps situated near to the study site indicated that eggs would be present on Burkea africana trees (Appendix V). Eggs of Cirina forda are laid in batches of approximately 550 ($\bar{x}$ = 554,2: n = 5, SE = 14,5) cemented together with a colourless adhesive. Individual eggs measure between 1,6 - 2,0 mm in length, and when freshly laid are white in colour changing to a light grey as development proceeds.

Branches of Burkea africana supporting egg batches were cut down and 10 egg batches were relocated to trees (Fig. 6.3) of each treatment combination as follows: (i) egg batches were placed on unbanded trees frequented by all predator groups but dominated by Crematogaster constructor. (ii) By placement of muslin sleeves around a further 10 egg batches on ant-infested trees the efficiency of predation by ants could be tested. (iii) Batches were transferred to trees treated with Formex where no ants were present, (iv) and finally batches were placed in the laboratory free from any predatory groups. The number of Cirina forda larvae were recorded from the time of egg hatch until the 8th day when individuals had reached the end of the 2nd instar.

Fig. 6.3 Egg batches of Cirina forda were relocated to banded and unbanded branches of Burkea africana trees within the study site at Nylsvley.

Treatment	No. of egg batches removed	No. of egg batches unhatched
Laboratory	–	1
Banded	2	2
Unbanded	1	2
Unbanded(sleeved)	1	3

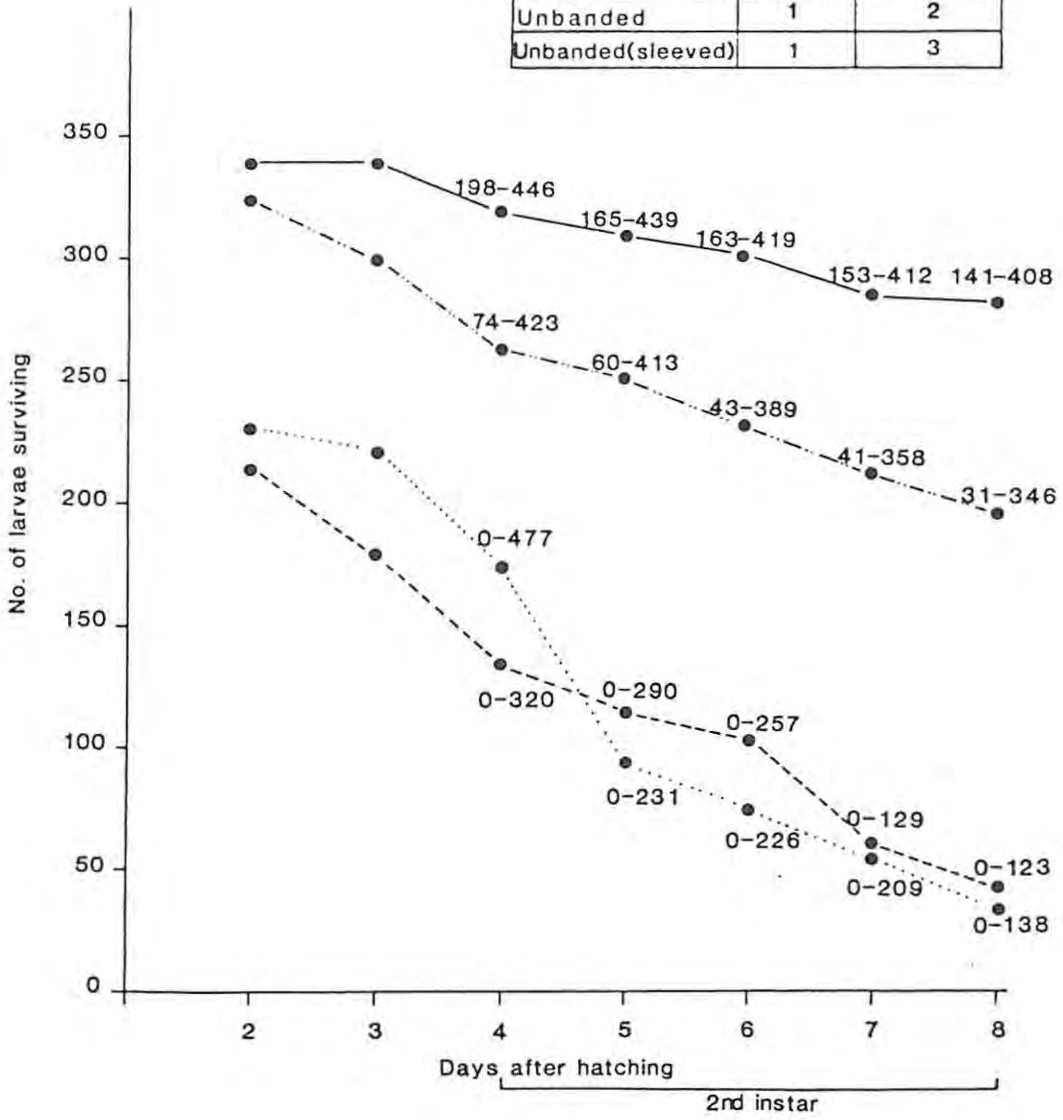


Fig. 6.4. Mean number of first and second instar Cirina forda larvae surviving from egg batches placed in the laboratory (●—●—●), on banded Burkea africana branches (●-·●-·●), on unbanded branches dominated by Crematogaster constructor (●--●--●) and on unbanded branches around which were placed muslin sleeves(●···●···●).
The number of egg batches relocated per treatment, n = 10; the inset shows the number of egg batches which were removed from the branches before egg hatch, and the number of egg batches which remained unhatched after 50 days in the field. Maximum and minimum numbers of larvae surviving after the 2nd instar are indicated above each data point.

The actual number of eggs removed following placement in the field could not be obtained because of the dense arrangement of eggs which were bound firmly together. Assuming an egg batch size of 550 eggs, the counts of the number of larvae which hatched (Fig. 6.4) showed that 62% of all eggs laid hatched in the laboratory with a slightly reduced figure of 59% occurring on the banded trees, and indicated that the controlling factors of predation by animals other than the Formicidae and adverse weather conditions in the field were minimal upon Cirina forda eggs during the period of observation. The affect of ant predation is shown by a further 20% reduction in egg hatch on trees dominated by Crematogaster constructor with only 41% of the total number of eggs hatching (Fig. 6.4). Student t-tests were used to compare the number of second instar larvae (from the 4th to the 8th day after egg hatch) present on trees dominated by ants and from banded trees where ants have been excluded, and the results are summarised in Table 6.9. The counts of larvae on the banded trees did not vary significantly from the number recorded in the laboratory , however numbers of larvae on both sets of unbanded trees, with and without muslin sleeves, were significantly lower than the number of 2nd instar larvae reared in the laboratory. Larval survival was greater on banded than on unbanded trees with significant differences appearing after the 6th day of egg hatch. The counts of larvae on unbanded trees with and without muslin sleeves appeared statistically similar and it can be concluded that the effect of predatory groups other than the Formicidae appears minimal on ant-infested trees. Of the number of Cirina forda larvae emerging, 83,1% remained on the 8th day after egg hatch on branches within the confines of the laboratory and 59,9% of the larvae which hatched remained on banded trees. Percentage figures for the number of larvae remaining on unbanded trees were considerably lower, 18,3% on the larvae which emerged survived to the end of the 2nd instar on ant-foraged trees where all predatory groups were present, and on trees where muslin sleeves covered the egg batches only 16,2% survived.

Table 6.9. Comparison of the number of second instar Cirina forda larvae surviving on banded and unbanded branches of Burkea africana at Nylsvley, 4 - 8 days after egg hatch, using Student t-tests. Degrees of freedom, df. are given in parenthesis. Significance levels are from 2-tailed tests.

TREATMENT	DAYS AFTER HATCHING 4	5	6	7	8
Laboratory X Banded (df = 13)	t = 1,04 N.S.	t = 1,05 N.S.	t = 1,19 N.S.	t = 1,25 N.S.	t = 1,73 N.S.
Laboratory X Unbanded (df = 14)	t = 3,77 p =<0,005	t = 4,09 p =<0,002	t = 4,77 p =<0,001	t = 6,15 p =<0,001	t = 6,77 p =<0,001
Laboratory X Unbanded(sleeved)(df = 13)	t = 2,05 N.S.	t = 4,62 p =<0,001	t = 4,88 p =<0,001	t = 5,23 p =<0,001	t = 6,31 p =<0,001
Banded X Unbanded (df = 11)	t = 1,84 N.S.	t = 1,81 N.S.	t = 1,85 p =<0,02	t = 2,74 p =<0,02	t = 2,98 p =<0,02
Banded X Unbanded(sleeved)(df = 10)	t = 0,93 N.S.	t = 2,04 N.S.	t = 2,13 N.S.	t = 2,38 p =<0,05	t = 2,70 p =<0,02
Unbanded X Unbanded(sleeved)(df = 11)	t = 0,47 N.S.	t = 0,25 N.S.	t = 0,42 N.S.	t = 0,01 N.S.	t = 0,10 N.S.

On encountering a Cirina forda caterpillar Crematogaster constructor would first raise its abdomen above its head and emit a whitish fluid from the anal gland. This was followed by rapid palpitation with the antennae over the body of the larvae before attacking the head region with their mandibles.

The results showed that ants appeared the major predatory group in controlling the egg and early stages of Cirina forda with a four-fold reduction in the number of larvae surviving at the end of the 2nd instar on branches dominated by Crematogaster constructor when compared with a situation where ant have been excluded (Fig. 6.4). The dominant ants can therefore be characterised by their ability to feed on a protein source, lepidopterous larvae, and also a liquid carbohydrate source of food, honeydew. The patchiness and low densities of prey populations of lepidopterous larvae are obviously important factors influencing the feeding habits of the dominant ant species, and this is discussed in Chapter 9.

7. SAMPLING OF BANDED AND UNBANDED TREES

The abundance of insects on *Terminalia sericea*, *Burkea africana* and *Ochna pulchra* was assessed to estimate any ant interference with other insects. The insect fauna on banded and unbanded trees was monitored by (i) a non-destructive method of continuous observations of branches and (ii) destructively, sampling the entire tree canopy with a pyrethrum knockdown spray.

7.1 Non-destructive sampling

(i) Non-destructive sampling was chosen as a particularly suitable method of monitoring large conspicuous insects and sessile individuals which could not be collected by pyrethrum knockdown, and has the advantage over the destructive method in that sampling could be carried out at frequent intervals. Care was taken not to dislodge any insects from the branches or overlook any small insect species. Before the onset of the 1982 growing season branches on banded and unbanded trees were randomly chosen and tagged, and from October onwards the numbers of insects and their species composition were noted on these branches.

From observations on banded and unbanded branches over the growing season it was clear that the sap-sucking Homoptera predominated within the canopies of all the three tree species (Insets to Figures 7.1-7.3). Over 90% of all insects observed on the unbanded branches of *Terminalia sericea*, *Burkea africana* and *Ochnha pulchra* were homopterans with comparable figures on banded trees being 54,9% on *Burkea africana*, 45,6% on *Ochna pulchra* and 23,2% on *Terminalia sericea*. In the field, individual homopterans were classed as follows: "mobile" (Membracidae, Cicadellidae, Psyllidae and Aphididae) and "sessile" (predominantly Coccidae although some Pseudococcidae were observed). A third group, immature aleyrodid nymphs were found on the underside of leaves of *Ochna pulchra* and *Burkea africana*. However, *Terminalia sericea* seemed an unsuitable host for aleyrodids as no nymphs were encountered on the leaves of

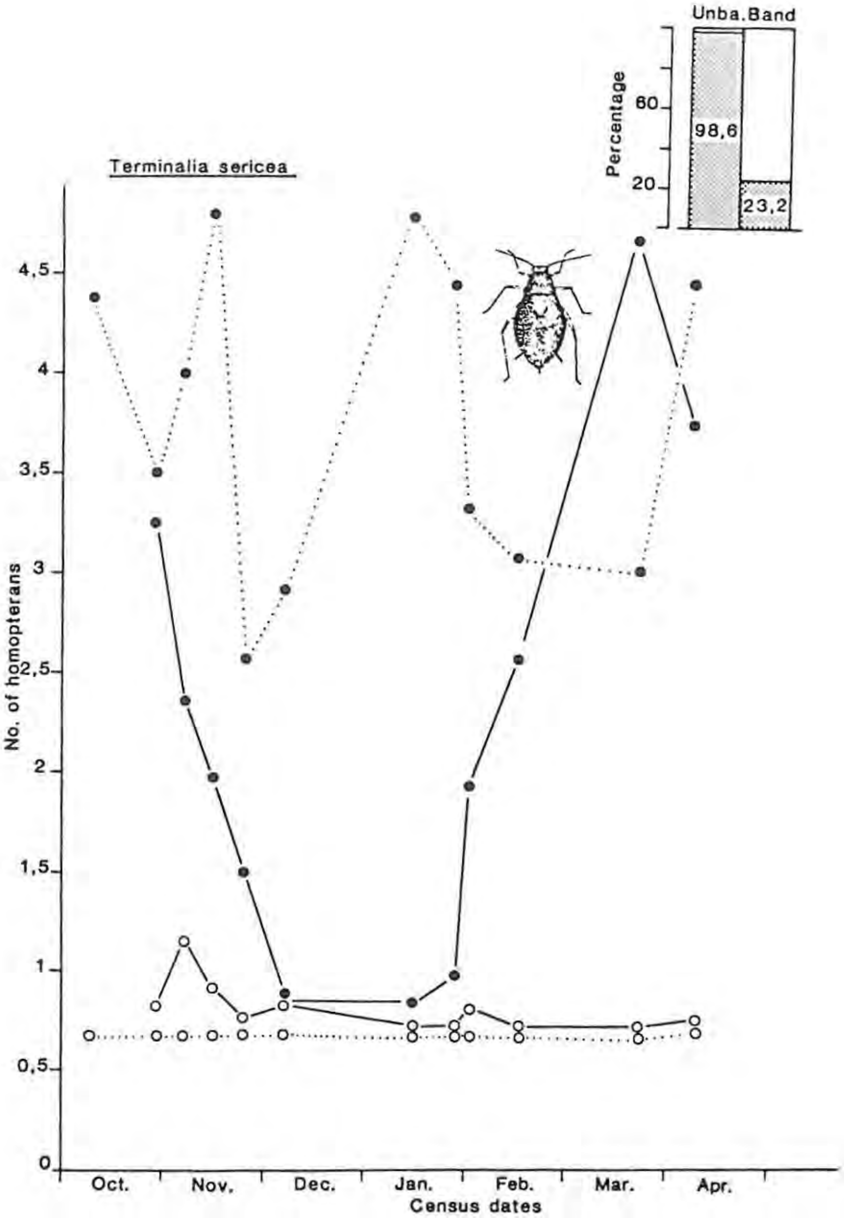


Fig. 7.1 Population data for the number of "mobile" (unbroken line between symbols) and "sessile" Homoptera (dotted line between symbols) on banded (open symbols) and unbanded branches (closed symbols) of <u>Terminalia sericea</u>. Plotted are the transformed mean number of individuals per branch ($\sqrt{x + 0,5}$; where x = the number of insects). n = 20 for each data point.

Inset indicates the percentage of the total number of insects observed on the banded and unbanded branches which were homopterans (stippled), over the 12 census dates.

The peak in the number of "mobile" individuals on unbanded branches, from January onwards, is due to the appearance of <u>Aphis gossypii</u> on the leaves (diagram).

either banded or unbanded trees. To compensate for the skewness in the frequency distribution of the insect populations from clumping, and to satisfy the assumptions of a t-test (Sokal and Rohlf, 1969), the actual counts of insects were transformed using the equation below:

(1) $X = \sqrt{X + 0,5}$ (Sokal and Rohlf, 1969)

X = Number of individuals

Following transformation Figures 7.1 - 7.3 show the mean number of mobile (unbroken line between symbols) and sessile homopterans (dotted line between symbols) on banded branches (open symbols) and unbanded branches (closed symbols) over the season. The differences in these counts on banded and unbanded trees were tested using a Student t-test and summarised in Tables 7.1 - 7.3 with the resultant probability levels shown in Fig. 7.4.

Considering each tree species separately, the greatest number of sap-sucking insects was recorded on unbanded branches of Terminalia sericea (Fig. 7.1 closed symbols), and exceeded homopterous populations on unbanded Burkea africana (Fig. 7.2 closed symbols) and on unbanded Ochna pulchra branches (Fig. 7.3 closed symbols). The number of sessile individuals (Fig. 7.1 ····●···●···●····) peaked in December and January and again in April when a maximum of 1138 soft brown scales Parasaissetia nigra (Nietner) were recorded on a single branch; mobile individuals (Fig. 7.1-●-●-●-) peaked early season when the membracid nymphs of the Oxyrachis sp. were found on the new leaves, and again in January onwards when populations of Aphis gossypii Glover built up. At each census date the differences in sessile and mobile populations with treatment were significant at the 0,05 probability level and above (Table 7.1 and Fig. 7.4).

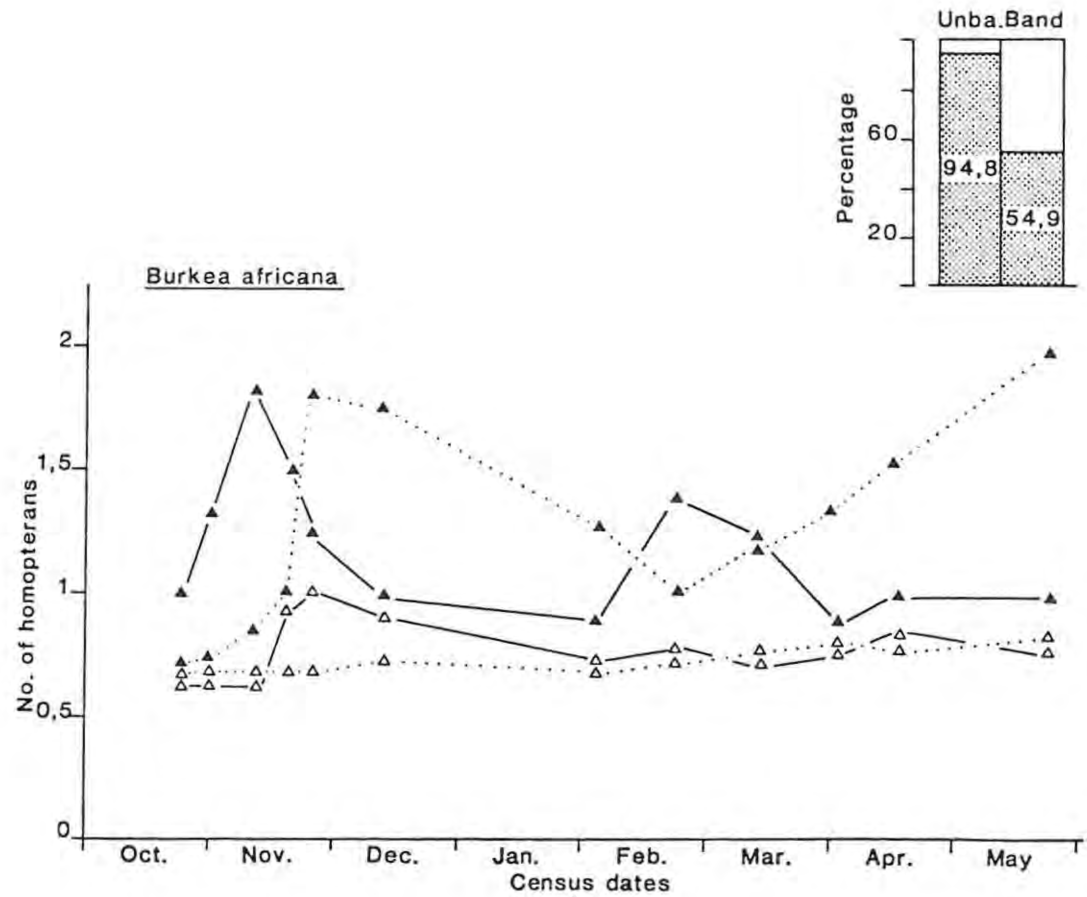


Fig. 7.2 Population data for the number of "mobile" (unbroken line between symbols) and "sessile" Homoptera (dotted line between symbols) on banded (open symbols) and unbanded branches (closed symbols) of Burkea africana. Plotted are the transformed mean number of individuals per branch ($\sqrt{x + 0,5}$; where x = the number of insects). n = 45 for each data point.

Inset indicates the percentage of the total number of insects observed on the banded and unbanded branches which were homopterans (stippled), over the 12 census dates.

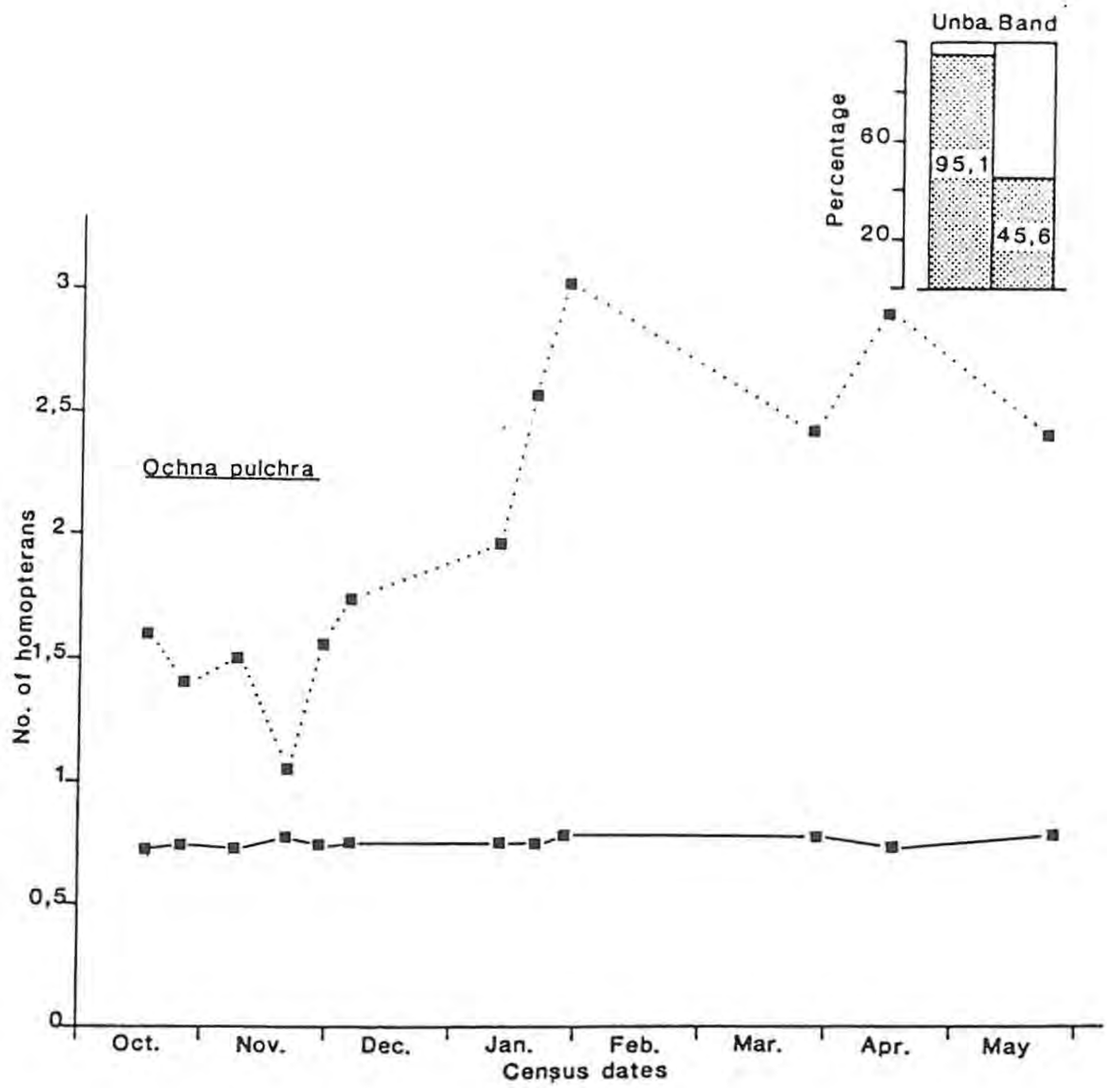


Fig. 7.3 Population data for the number of "mobile" (unbroken line between symbols) and "sessile" Homoptera (dotted line between symbols) on unbanded branches of Ochna pulchra. Plotted are the transformed mean number of individuals per branch ($\sqrt{x + 0,5}$; where x = the number of insects). n = 45 for each data point.
Inset indicates the percentage of the total number of insects observed on the banded and unbanded branches which were homopterans (stippled), over the 12 census dates.

All significant t-values (Table 7.2) indicated that more sap-suckers occurred on unbanded branches of Burkea africana when compared with the number found on banded branches. However, these differences in homopterous populations were not consistent over the growing season and on several census dates there was no difference in counts of mobile and sessile homopterans on banded and unbanded trees.

The counts of mobile and sessile homopterans were very low within the canopy of banded Ochna pulchra trees and although not represented in Fig. 7.3, the densities reached on the branches were similar to figures quoted for mobile homopterans on unbanded trees (Fig. 7.3). Where significant differences did occur in mobile populations, on the 28.11.82 and 19.01.83, more individuals appeared on the banded branches. A similar trend as on Terminalia sericea could be seen with a build up mid-season in Coccidae (Ceroplastes rusci L., see frontispiece) on the unbanded branches, with densities increasing as the season progressed.

The number of aleyrodid nymphs on the leaves of Burkea africana and Ochna pulchra trees did not differ with banding and as no foraging ants were observed tending these nymphs for honeydew, it would seem that these immature forms are not involved in any ant association.

Table 7.1. Comparison of populations of Homoptera on banded and unbanded branches of Terminalia sericea, using Student t-tests. Number of branches observed per treatment, n = 20. Significance levels are from 2-tailed tests.

DATES	"SESSILE" HOMOPTERA	"MOBILE" HOMOPTERA	ALEYRODID NYMPHS
08.10.82	t = 6,31;p = <0,001	-	-
28.10.82	t = 3,11;p = <0,005	t = 4,75;p = <0,001	-
08.11.82	t = 2,22;p = <0,05	t = 3,42;p = <0,002	-
15.11.82	t = 3,06;p = <0,005	t = 3,46;p = <0,001	-
22.11.82	t = 1,82;N.S.	t = 4,01;p = <0,001	-
06.12.82	t = 3,22;p = <0,005	t = 2,22;p = <0,05	-
17.01.83	t = 3,20;p = <0,005	t = 1,50;N.S.	-
26.01.83	t = 3,45;p = <0,002	t = 2,07;p = <0,05	-
02.02.83	t = 3,27;p = <0,005	t = 2,66;p = <0,02	-
15.02.83	t = 3,29;p = <0,005	t = 2,44;p = <0,02	-
23.03.83	t = 2,00;N.S.	t = 2,11;p = <0,05	-
11.04.83	t = 2,18;p = <0.05	t = 2,83;p = <0,01	-

Table 7.2. Comparison of populations of Homoptera on banded and unbanded branches of <u>Burkea africana</u>, using Student t-tests. Number of branches observed per treatment, n = 45. Significance levels are from 2-tailed tests.

DATES	"SESSILE" HOMOPTERA	"MOBILE" HOMOPTERA	ALEYRODID NYMPHS
22.10.82	-	t = 2,97;p = <0,005	-
29.10.82	t = 0,75;N.S.	t = 2,28;p = <0,05	-
09.11.82	t = 3,20;p = <0,005	t = 3,55;p = <0,001	-
16.11.82	t = 1,87;N.S.	t = 2,71;p = <0,01	-
25.11.82	t = 2,18;p = <0,05	t = 1,72;N.S.	-
09.12.82	t = 2,15;p = <0,05	t = 1,02;N.S.	-
02.02.83	t = 2,01;p = <0,05	t = 2,37;p = <0,02	t = 0,38;N.S.
21.02.83	t = 1,90;N.S.	t = 2,17;p = <0,05	t = 0,69;N.S.
11.03.83	t = 1,73;N.S.	t = 2,82;p = <0,01	t = 0,26;N.S.
28.03.83	t = 2,13;p = <0,05	t = 1,78;N.S.	t = 0,01;N.S.
14.04.83	t = 1,94;N.S.	t = 1,18;N.S.	t = 0,88;N.S.
23.05.83	t = 2,05;p = <0,05	t = 1,99;N.S.	t = 0,60;N.S.

Table 7.3. Comparison of populations of Homoptera on banded and unbanded branches of <u>Ochna pulchra</u>, using Student t-tests. Number of branches observed per treatment, n = 45. Significance levels are from 2-tailed tests.

DATES	"SESSILE" HOMOPTERA	"MOBILE" HOMOPTERA	ALEYRODID NYMPHS
17.10.82	t = 3,49;p = <0,001	-	-
26.10.82	t = 3,01;p = <0,005	-	-
10.11.82	t = 3,10;p = <0,005	-	-
21.11.82	t = 2,15;p = <0,05	t = 0,58;N.S.	-
28.11.82	t = 3,26;p = <0,002	t = 2,31;p = <0,05	-
08.12.82	t = 3,21;p = <0,002	t = 0,46;N.S.	-
14.01.83	t = 3,07;p = <0,005	-	-
19.01.83	t = 2,96;p = <0,005	t = 2,07;p = <0,05	t = 2,01;p = <0,05
27.01.83	t = 3,73;p = <0,001	t = 0,84;N.S.	t = 0,01;N.S.
29.03.83	t = 4,27;p = <0,001	t = 0,46;N.S.	t = 0,62;N.S.
12.04.83	t = 3,98;p = <0,001	t = 0,58;N.S.	t = 1,22;N.S.
24.05.83	t = 4,39;p = <0,001	t = 0,48;N.S.	t = 0,83;N.S.

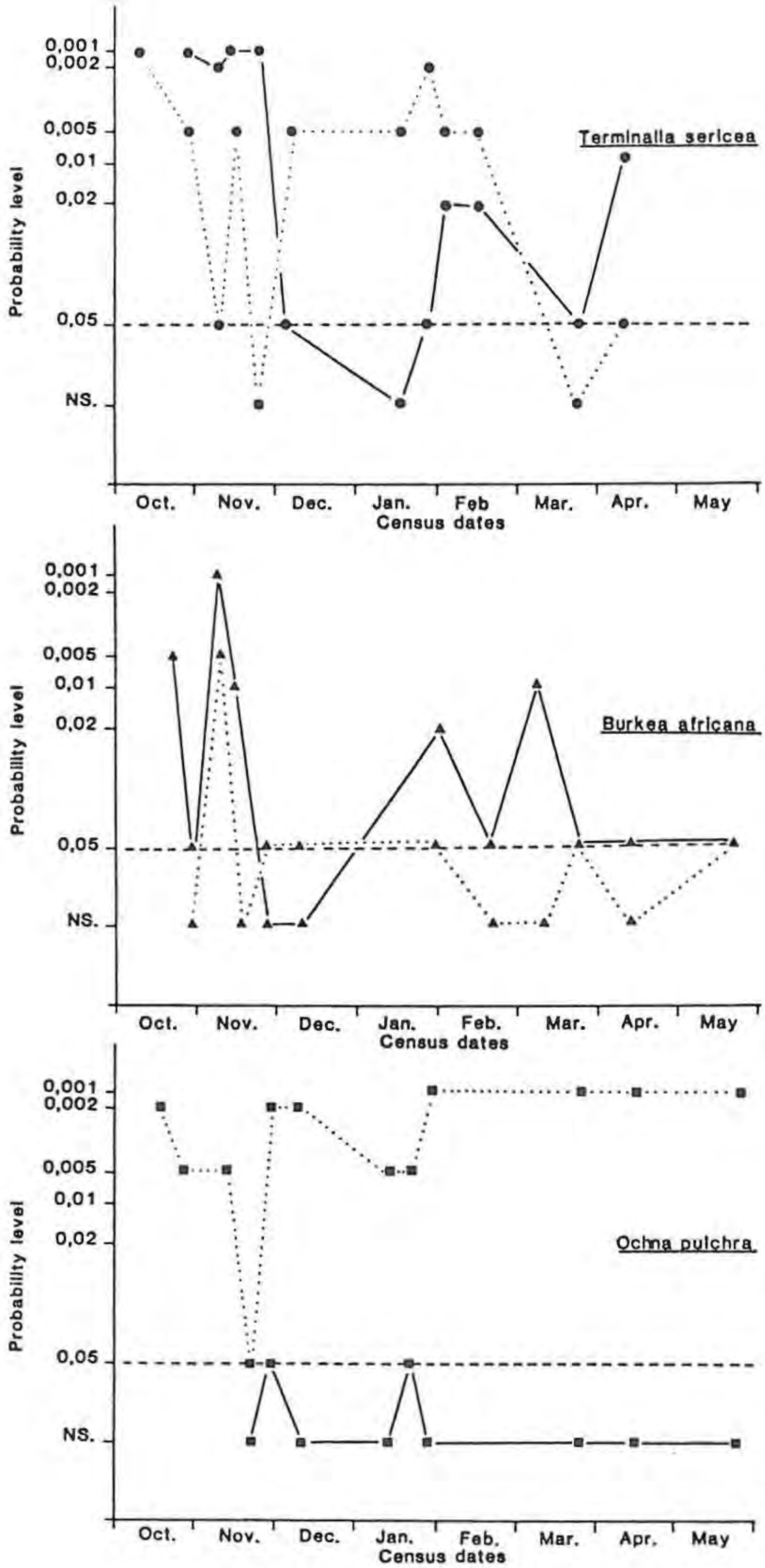


Fig. 7.4 The probability levels from the Student t-tests (Tables 7.1 - 7.3) to compare the number of "mobile" (———) and "sessile" homopterous populations (········) on banded and unbanded branches of <u>Terminalia sericea</u>, <u>Burkea africana</u> and <u>Ochna pulchra</u> trees.

Insects other than the homopterans appeared on both banded and unbanded trees in extremely low numbers throughout the growing season (12 observations per tree species), and so it was impossible from direct observations to draw conclusions as to the effect ants have on insect groups other than the sap-sucking Homoptera. Of all the species of trees, Terminalia sericea supported a greater number of non-homopterous individuals over the growing season ($\bar{x}$ = 0,69 individuals on banded branches, number of branches = 20; $\bar{x}$ = 0,40 individuals on unbanded branches, number of branches = 20). On Burkea africana the mean number of insects recorded on banded and unbanded branches were 0,38 and 0,35 respectively (45 banded and 45 unbanded branches were observed), with banded branches of Ochna pulchra supporting 0,35 individuals and unbanded branches 0,26 (45 banded and 45 unbanded branches were observed).

In conclusion it can be said that direct observations of branches on banded and unbanded study trees showed that foraging populations of ants encouraged a build up in numbers of both mobile and sessile homopterous populations within the canopy of unbanded trees. This positive association was more pronounced on Terminalia sericea (Fig. 7.1) where significant differences occurred in mobile and sessile populations throughout the growing season. Patterns on Ochna pulchra and Burkea africana were less marked but indicates that the dominant ants on the trees are heavily dependant on honeydew and this strong preference is seen by their influence on the sap-sucking group. Trends in insects other than the homopterans were difficult to detect because of low insect numbers.

7.2 Destructive sampling

(ii) Destructive sampling of the entire tree was carried out by placing one-m^2 sampling sheets under banded and unbanded trees, from the trunk to the edge of the canopy (Southwood, 1978). Using a knapsack sprayer a synthetic pyrethrum was applied, and insects falling onto the sheets during 1 hour were collected and placed in vials containing

80% ethyl alcohol. (Avigrain Protectant AI, 5% m/v pyrethrins, 50% m/v piperonyl butoxide in a 1 : 11,5 mixture of pyrethrum and water).

The faunal composition of insects on banded and unbanded trees was sampled in greater detail by pyrethrum knockdown. The numbers of individuals and species in the major guilds are described and a measure of the extent to which individual groups are represented within the canopy is reflected by Berger-Parker dominance indices (Southwood, 1978).

Of the three tree species, Terminalia sericea supported a greater number of insect individuals and species with Ochna pulchra and Burkea africana sharing a similarity in faunal composition (Table 7.4). Excluding the Formicidae there was a greater number of individuals and species on unbanded Terminalia sericea than on banded, ant-free trees ($t = 2,53$ for 108df; $p = < 0,05$ for the number of individuals: $t = 2,97$ for 108 df; $p = < 0,01$ for the number of species). Similarly, the number of species on the unbanded Ochna pulchra trees differed significantly ($t = 2,18$ for 78 df; $p = < 0,05$). The relationship between the log number of individuals found in the samples for each tree type (Table 7.4; Columns "A" and "B") and the number of insect species was positive and highly significant ($y = 0,036 + 0,462 \log x$; $r^2 = 0,98$).

From the calculated Berger-Parker dominance indices -d- (Tables 7.5 - 7.7) it may be concluded that the dominant group were the Formicidae on the unbanded trees. Of the total number of insects caught on Burkea africana, 95,4% were ants with a reduction in their dominance on Ochna pulchra (66%) and Terminalia sericea (32%); the higher d-indices for the Coleoptera and sap-sucking Heteroptera may be explained by a lessening in ant dominance or alternatively because this tree species may be the preferred host. Other foliage-feeding insects, the lepidopterous larvae and individuals primarily within the order Orthoptera, were poorly represented along with the parasitoids and predators. Excluding the Formicidae from the calculation of the Berger-Parker indices gave separate indices for the unbanded trees and these are graphically shown in the pie charts (Fig. 7.5).

Table 7.4. The number of insect individuals(A) and the number of species(B) found on banded and unbanded trees following pyrethrum knockdown. Means ($\bar{x}$) and standard errors (SE) of insect numbers and species per sample sheet is given. The faunal composition of the Formicidae is shown for the unbanded trees. An indication of the order of magnitude of the number of dominant and sub-dominant ant individuals to non-dominant ants is shown with the counts of non-dominant ants appearing in parenthesis.

TREE SPECIES	TREATMENT	NO. OF SAMPLE SHEETS	A	B	NO. OF INDIVIDUAL ANTS	NO. OF ANT SPECIES
T. sericea	Banded	50	475 $\bar{x}$ = 8,80 SE = 0,75	346 $\bar{x}$ = 6,41 SE = 0,44	-	-
T. sericea	Unbanded	60	767 $\bar{x}$ =12,78 SE = 1,35	551 $\bar{x}$ = 9,18 SE = 0,80	325 (13) $\bar{x}$ = 5,42 SE = 2,33	17 $\bar{x}$= 0,28 SE= 0,08
B. africana	Banded	45	346 $\bar{x}$ = 7,64 SE = 0,94	272 $\bar{x}$ = 6,04 SE = 0,53	-	-
B. africana	Unbanded	40	383 $\bar{x}$ = 9,57 SE = 1,43	273 $\bar{x}$ = 6,88 SE = 0,74	8033 (13) $\bar{x}$ =200,82 SE= 42,83	65 $\bar{x}$ = 1,62 SE= 0,14
O. pulchra	Banded	40	309 $\bar{x}$ = 7,73 SE= 0,91	237 $\bar{x}$= 5,93 SE= 0,68	-	-
O. pulchra	Unbanded	40	416 $\bar{x}$ =10,40 SE= 1,32	338 $\bar{x}$ =08,45 SE= 0,93	802 (6) $\bar{x}$ =20,05 SE= 6,95	58 $\bar{x}$ = 1,45 SE= 0,16

Table 7.5. Berger-Parker dominance indices for the different insect groups collected from banded and unbanded Terminalia sericea trees by pyrethrum knockdown.

TREATMENT	GROUP		d-INDEX
Banded	Chewers	- Coleoptera	0,324
Unbanded	Formicidae		0,294
Banded	Sap-suckers	- Heteroptera	0,274
Unbanded	Chewers	- Coleoptera	0,239
Unbanded	Sap-suckers	- Heteroptera	0,160
Banded	Sap-suckers	- Homoptera	0,135
Banded	Visitors		0,103
Unbanded	Sap-suckers	- Homoptera	0,097
Unbanded	Visitors		0,085
Banded	Predators	- Spiders	0,071
Unbanded	Predators	- Spiders	0,062
Banded	Parasitoids		0,040
Unbanded	Chewers	- Lepidoptera	0,029
Banded	Chewers	- Lepidoptera	0,027
Unbanded	Parasitoids		0,026
Banded	Predators	- excluding Spiders	0,021
Unbanded	Predators	- excluding Spiders	0,008
Banded	Chewers	- excluding Coleoptera and Lepidoptera	0,004

Table 7.6. Berger-Parker dominance indices for the different insect groups collected from banded and unbanded Burkea africana trees by pyrethrum knockdown.

TREATMENT	GROUP		d-INDEX
Unbanded	Formicidae		0,954
Banded	Chewers	- Coleoptera	0,215
Banded	Sap-suckers	- Heteroptera	0,142
Banded	Visitors		0,139
Banded	Predators	- excluding Spiders	0,133
Banded	Chewers	- Lepidoptera	0,124
Banded	Predators	- Spiders	0,092
Banded	Sap-suckers	- Homoptera	0,080
Banded	Parasitoids		0,038
Banded	Chewers	- excluding Coleoptera and Lepidoptera	0,037
Unbanded	Chewers	- Coleoptera	0,012
Unbanded	Sap-suckers	- Homoptera	0,008
Unbanded	Visitors		0,006
Unbanded	Sap-suckers	- Heteroptera	0,005
Unbanded	Chewers	- Lepidoptera	0,004
Unbanded	Predators	- Spiders	0,004
Unbanded	Predators	- excluding Spiders	0,002
Unbanded	Chewers	- excluding Coleoptera and Lepidoptera	0,002
Unbanded	Parasitoids		0,002

Table 7.7. Berger-Parker dominance indices for the different insect groups collected from banded and unbanded Ochna pulchra trees by pyrethrum knockdown.

TREATMENT	GROUP		d-INDEX
Unbanded	Formicidae		0,658
Banded	Visitors		0,321
Banded	Chewers	- Coleoptera	0,208
Banded	Chewers	- excluding Coleoptera and Lepidoptera	0,132
Unbanded	Visitors		0,126
Banded	Predators	- Spiders	0,111
Banded	Chewers	- Lepidoptera	0,093
Unbanded	Chewers	- Coleoptera	0,078
Banded	Sap-suckers	- Homoptera	0,075
Unbanded	Sap-suckers	- Homoptera	0,038
Banded	Sap-suckers	- Heteroptera	0,029
Unbanded	Predators	- Spiders	0,027
Unbanded	Chewers	- Lepidoptera	0,023
Banded	Chewers	- excluding Coleoptera and Lepidoptera	0,021
Banded	Parasitoids		0,019
Unbanded	Sap-suckers	- Heteroptera	0,016
Banded	Predators	- excluding Spiders	0,012
Unbanded	Parasitoids		0,007
Unbanded	Predators	- excluding Spiders	0,005

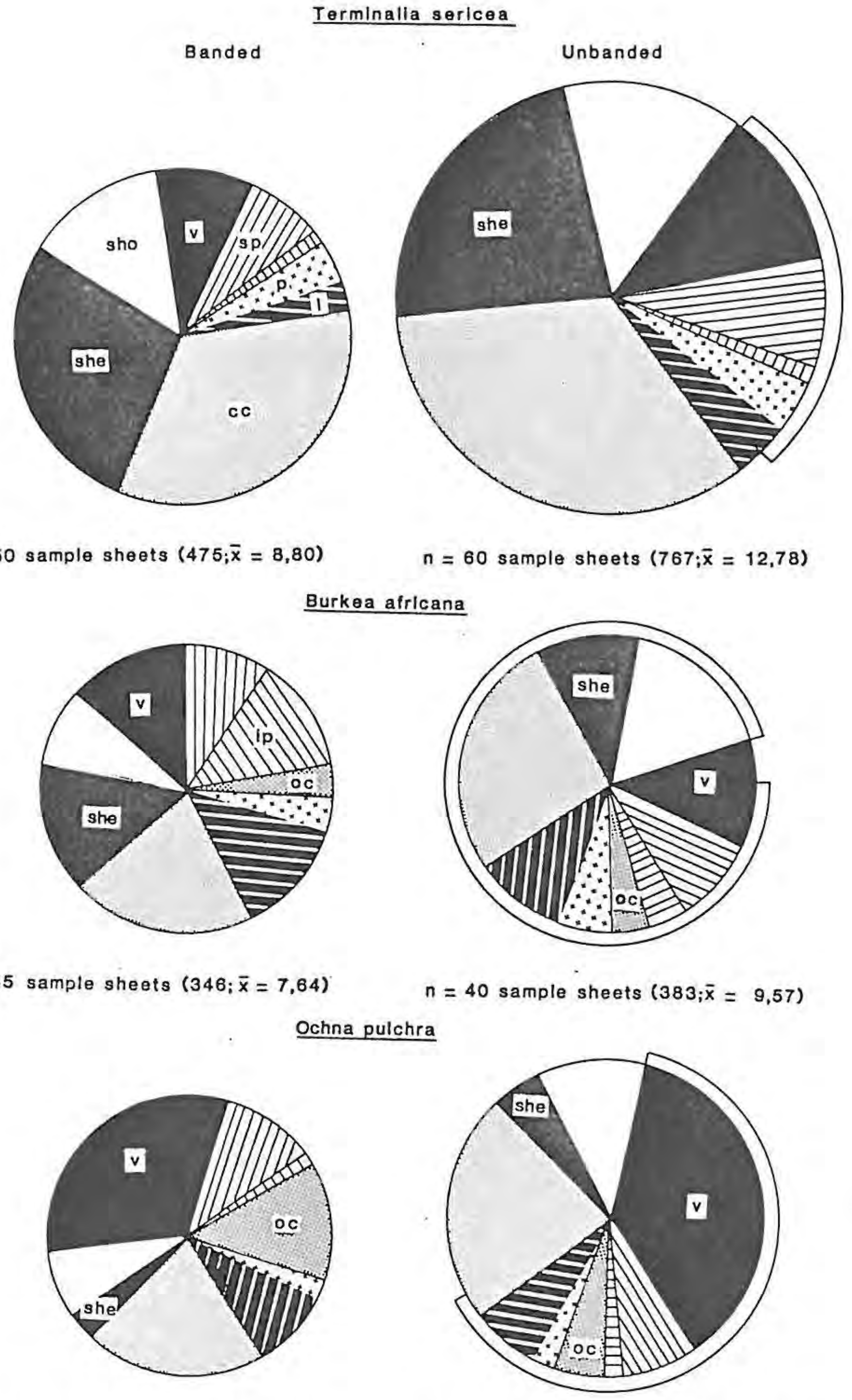


Fig. 7.5 The guild structure of the insect fauna on banded and unbanded Terminalia sericea, Burkea africana and Ochna pulchra trees following pyrethrum knockdown at Nylsvley. The area of the graph is representative of the total number of insects caught, and total counts appear in parenthesis together with the mean number of insects per sample sheet; the number of sample sheets used is given. The white outlined peripheral segments on the unbanded trees indicates the proportion of the total canopy fauna which are members of the Formicidae. cc, Coleoptera - chewers; l, Lepidoptera; oc, chewers other than Coleoptera and Lepidoptera; sho, Homoptera - sap-suckers; she, Heteroptera - sap-suckers; p, parasitoids; sp, spiders; ip, insect predators; v, visitors.

The results from pyrethrum spraying can be summarised as follows: (i) the Formicidae dominated the knockdown samples within the canopy of the unbanded trees, and were numerically abundant on *Burkea africana*, decreasing in dominance on *Ochna pulchra* and *Terminalia sericea* respectively. (ii) excluding the ants from any guild comparison of the insect fauna on banded and unbanded trees, it would appear that each insect guild monitored shared a similar dominance on both banded and unbanded trees although a trend did exist of the unbanded trees having a greater number of insect individuals and species within the canopy.

Patterns in the associated fauna on unbanded, ant-infested trees may have been simply the result of ant interference acting upon certain-sized insect individuals, and not be reflected in any guild comparison between banded and unbanded trees. The lengths of insects collected from pyrethrum knockdown were recorded, and it was found that individuals on unbanded *Burkea africana* trees were smaller than individuals on banded trees ($\bar{x}$ = 27 mm on banded *Burkea africana* trees, $\bar{x}$ = 33 mm on unbanded trees; t = 2,60 for 727 df, P = <0,01). No differences occurred on *Ochna pulchra* and *Terminalia sericea*, and thus it is postulated that where high densities of foraging ants occur within the canopy of trees as was seen on *Burkea africana*, ants may disturb the larger-sized individuals.

8. ASSESSMENT OF HERBIVORY

The potential of ants to reduce herbivore pressure on unbanded, ant-infested trees through ant predation of insect phyllophages within the canopy of trees and / or through disturbance of potential phyllophages, thereby reducing phyllophagous feeding, could be shown by monitoring the level of herbivory on banded and unbanded trees.

An experiment was set up to study the impact phyllophages had on the study trees by examining the leaves on banded and unbanded branches which had been used for direct observations on the insect fauna (Section 7.1). There was a similar number of leaf-producing buds on both banded and unbanded branches of *Terminalia sericea*, *Burkea africana* and *Ochna pulchra* (Table 8.1) which indicated that the area under leaf was similar for each treatment. This enabled a direct comparison of phyllophage attack between banded and unbanded branches. After bud-burst at the start of the 1982 growing season the fate of the leaves was monitored mid-season (December) and late season (April - May). A plastic grid in mm^2 divisions was placed over each leaf and the attack marks identified according to the categories listed in Table 8.2, and their areas recorded. For leaves where phyllophages had removed a large area of photosynthetic area, an approximation of the size and the shape of the original leaf was made by tracing the leaf outline onto paper (Heinrich, 1978). Total leaf area of branches was calculated in the field according to the method previously stated (Appendix III).

Table 8.1. The mean number ($\pm$ 1 SE) of leaf-producing buds on banded and unbanded branches of trees used in the monitoring of herbivory at Nylsvley.

TREE SPECIES	BRANCH TYPE		
	Banded	Unbanded	p**
Terminalia sericea (20 banded, 20 unbanded branches)	35,00 ± 4,43	38,15 ± 3,63	N.S.
Burkea africana * (45 banded, 45 unbanded branches)	66,13 ± 5,08	66,02 ± 4,20	N.S.
Ochna pulchra (45 banded, 45 unbanded branches)	30,47 ± 1,75	32,87 ± 2,14	N.S

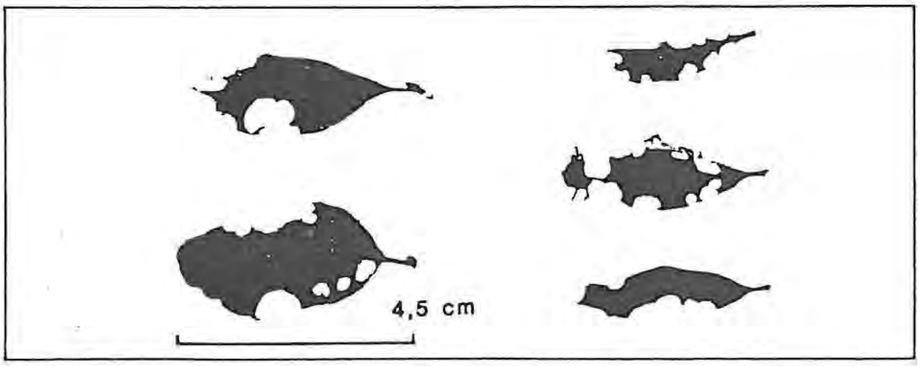
* = For *Burkea africana* the mean numbers of rhacides are given.
** = Two-tailed Student t-test.

Table 8.2. Categories of leaf damage observed on the trees at Nylsvley.

DAMAGE AGENT	DESCRIPTION
Chewers	Phyllophagous insects initiating attack from the margin of the leaf inwards; Laminar feeders sometimes removing the main vein.
Chewers	Phyllophagous insects causing holes in leaf laminae.
Thamnobius sp. (Coleoptera; Curculionidae)	Removal of small circular areas from the superficial layers of either the upper or lower surface of the leaf. Opposite the site of initial attack the tissue breaks down and a circular hole appears.
Damage "E" agents	Removal of surface layers of the leaf together with the leaf veins.
Lepidopterous larvae	Phyllophages causing window skeletonisation removing the surface layers and leaving the veins of the leaf intact.
Dipterous larvae	Larvae produce spherical blister mines, 1cm in diameter. Only found on Terminalia sericea.
Eriophyid mites	Mites produce red and green plant galls. Only found on Terminalia sericea. See below.

Table 8.3. Lepidopterous and Coleopterous macrophages found on the banded and unbanded trees at Nylsvley. The inset below shows the laminar feeding patterns of the lepidopterous larvae on Terminalia sericea leaves.

HOST TREE SPECIES	GROUP	MACROPHAGE	DAMAGE
Terminalia sericea	Lepidoptera	Euproctis fasciata Walker (Lymantriidae)	Laminar feeder
Terminalia sericea	Lepidoptera	Maurilia arcuata Walker (Noctuidae)	Laminar feeder
Terminalia sericea	Lepidoptera	Craspia ignectincta Aurivillius (Lasciocampidae)	Laminar feeder
Terminalia sericea	Lepidoptera	Polelassothys plumitarsus Janse (Notodontidae)	Laminar feeder
Terminalia sericea	Lepidoptera	T4: (Gelechiidae) see Scholtz, 1978	Window feeder
Ochna pulchra & Burkea africana	Lepidoptera	Phylloxiphia punctum Rothchild (Sphingidae)	Laminar feeder
Burkea africana	Lepidoptera	Rohaniella pygmaea Massen & Weymer (Sphingidae)	Laminar feeder
Ochna pulchra	Coleoptera	Trochalius sp. (Scarabidae)	Laminar feeder
Burkea africana	Coleoptera	Syagrus (Eumolpinae)	Laminar feeder



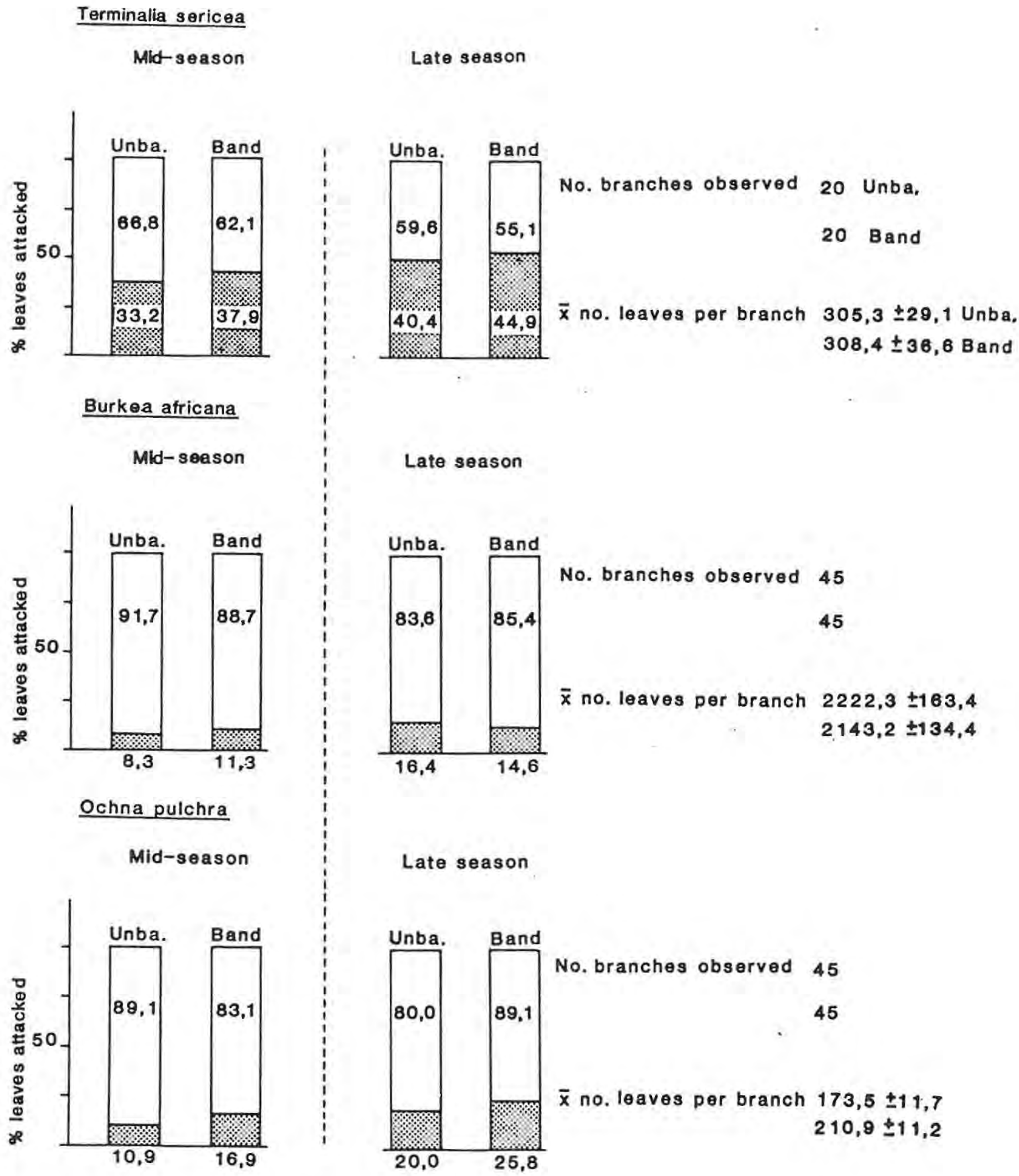


Fig. 8.1. The percentage of leaves attacked by insect phyllophages (stippled area) on banded and unbanded branches of Terminalia sericea, Burkea africana and Ochna pulchra mid-season and late season at Nylsvley. Given are the mean ($\bar{x}$) and standard error (SE) of the number of leaves per branch for each tree species.

8.1 Phyllophage attack on banded and unbanded trees

Observations mid-season and late season showed that more of the leaves were attacked on trees which had been treated with sticky bands in comparison with the leaves on the unbanded trees (Fig. 8.1) . Terminalia sericea trees had the highest attack level of all the three species of trees, between 33 - 38% of all leaves on the branches were attacked at the mid-season census. On Ochna pulchra 10 - 17% of all the leaves were attacked with branches of Burkea africana having the lowest attack level, between 8 - 12% attacked leaves.

The number of attack marks per specific damage category (Table 8.2) was recorded separately for each leaf on the banded and unbanded branches, and the amount of damage attributable to each damage agent of attack measured in mm^2 using the plastic grid. More leaves were attacked by chewing insects than by any other phyllophage, and although the feeding marks of individual chewing insects could not be identified, much of the damage could be accounted for by foliage-feeding lepidopterous larvae and Coleoptera (Table 8.3). Patterns of leaf damage are indicated below the table. Leaves categorised as badly chewed with between 75 - 99% of their photosynthetic tissue removed were more numerous on banded branches of Ochna pulchra mid-season, comprising 7,81% of the total number of leaves attacked. On unbanded branches 2,73% were badly damaged and this difference between treatments was found to be significant (F-value = 4,44, p = 0,038). Tables 8.4 - 8.7 give the number of attack marks caused by individual phyllophages and the area of attack on leaves from banded and unbanded branches at the two census dates. The F-statistic for "between treatment" comparisons is included in the above tables.

The following points can be noted, (i) from Table 8.4 it can be seen that leaf damage from phyllophages causing holes in the leaves was greater on banded branches than unbanded branches of Terminalia sericea at the mid-season census. (ii) the area of tissue affected by dipterous larvae causing blister mining was greater on unbanded trees at the end of the season: a mean area of 97,85 mm^2 per branch on unbanded trees was tested against a mean of 54,55 mm^2 per branch on banded trees and found to be significant. Dissection of several mines revealed one small agromyzid larva but rearing out the adult flies proved unsuccessful. (iii) from Table 8.5, trees void of ants were more heavily attacked by the weevil Thamnobius sp. as at both the mid-season and the late season census more circular attack marks were found on leaves from banded Terminalia sericea branches. (iv) monitoring the leaf damage on banded and unbanded branches of Burkea africana (Table 8.6) showed that differences in intensity of attack by individual phyllophages on banded and unbanded branches could be seen at the mid-season census only. The area under attack by phyllophagous insects causing holes in the leaves and from insects producing damage categorised as Damage "E" was significantly greater on banded branches when compared with area measurements obtained from unbanded trees.

(v) Brown necrotic patches appeared on the Burkea trees soon after bud-burst and at the mid-season census the area of photosynthetic tissue affected was greater on banded branches when compared with the unbanded branches (Table 8.6): no difference was observed on the branches at the end of the season. Burkea africana was more affected by pathogens than the other species of trees. At the end of the growing season 34,26% and 36,52% of the total number of leaves attacked were damaged by pathogens on banded and unbanded branches respectively. Comparable figures for Terminalia sericea and Ochna pulchra are as follows:- 1,21% and 0,99% of the total number of leaves attacked on banded and unbanded branches of Terminalia sericea were affected by pathogens with 0,62% and 1,18% of the leaves affected on banded and unbanded branches of Ochna pulchra.

The overall impact of phyllophages on the banded and unbanded trees at Nylsvley was calculated by pooling the actual areas of the different types of damage (Tables 8.4 - 8.7) recorded on the branches, and expressing this figure as a proportion of the total leaf area. Leaf consumption by phyllophages was exceedingly low on all species of trees

Table 8.4. Mean areas of damage ($mm^2 \pm 1$ SE) caused by phyllophages, mid-season and at the end of the growing season on banded and unbanded branches of <u>Terminalia sericea</u> at Nylsvley.
Number of branches observed, 20 on banded and 20 on unbanded trees.
Calculated F-values for between treatment comparisons are given.

DAMAGE AGENT	SEASON	TREATMENT	AREA	F-VALUE
Phyllophages -causing holes in laminae.	Mid-season	Banded Unbanded	188,9 ± 24,2 121,1 ± 24,8	F = 3,83 p = 0,058
Phyllophages -margin feeders of laminae.	Mid-season	Banded Unbanded	1166,8 ± 232,4 1147,0 ± 163,5	F = 0,005 N.S.
Phyllophages -causing skeletonisation.	Mid-season	Banded Unbanded	35,1 ± 22,5 37,3 ± 15,5	F = 0,006 N.S.
Phyllophages -causing blister mining.	Mid-season	Banded Unbanded	37,6 ± 10,5 63,2 ± 10,6	F = 1,39 N.S.
Pathogenic attack	Mid-season	Banded Unbanded	128,7 ± 43,8 84,9 ± 42,8	F = 0,51 N.S.
Phyllophages -causing holes in laminae.	End of season	Banded Unbanded	148,2 ± 21,6 100,1 ± 20,7	F = 2,60 N.S.
Phyllophages -margin feeders of laminae.	End of season	Banded Unbanded	664,3 ± 102,3 764,0 ± 143,4	F = 0,32 N.S.
Phyllophages -causing skeletonisation.	End of season	Banded Unbanded	38,2 ± 22,1 12,3 ± 5,5	F = 1,91 N.S.
Phyllophages -causing damage"E".	End of season	Banded Unbanded	28,6 ± 7,8 28,2 ± 6,9	F = 0,32 N.S.
Phyllophages -causing blister mining.	End of season	Banded Unbanded	54,6 ± 8,7 97,9 ± 14,2	F = 6,79 p = 0,013
Pathogenic attack	End of season	Banded Unbanded	101,6 ± 39,1 59,3 ± 26,7	F = 0,80 N.S.

studied. The highest apparent damage occurred on Ochna pulchra, with end of season figures of 1,34% of the total leaf area removed recorded on banded branches and 1,20% removed on unbanded branches: the area affected by chewing insects on Burkea africana and Terminalia sericea ranged from 0,50 - 0,88% of the total area under leaf.

In conclusion it can be said that more leaves were attacked on banded trees free from foraging populations of ants when compared with leaves from unbanded branches. Certain phyllophagous groups did concentrate their attack on banded rather than unbanded trees (Tables 8.4 - 8.7) and the overall percentage consumption on Ochna pulchra trees was higher on banded branches, free from ants. However it would seem that the cumulative level of herbivory on plants of all the tree species studied at the end of the season is slight and that plant protection as a consequence of ant - insect interactions appears minimal in the savanna ecosystem at Nylsvley.

Table 8.5. Mean number of attack marks (± 1 SE) caused by phyllophages, mid-season and at the end of the growing season on banded and unbanded branches of *Terminalia sericea* at Nylsvley.
Number of branches observed, 20 on banded and 20 on unbanded trees.
Calculated F-values for between treatment comparisons are given.

DAMAGE AGENT	SEASON	TREATMENT	NUMBER	F-VALUE
Eriophyid galls	Mid-season	Banded	39,8 ± 14,4	F = 1,67
		Unbanded	117,0 ± 57,9	N.S.
Holes caused by	Mid-season	Banded	25,1 ± 9,0	F = 6,07
Thamnobius sp.		Unbanded	2,6 ± 1,3	P = 0,018
Eriophyid galls	End of season	Banded	58,6 ± 25,7	F = 1,28
		Unbanded	166,8 ± 92,0	N.S.
Holes caused by	End of season	Banded	35,7 ± 9,9	F = 4,35
Thamnobius sp.		Unbanded	11,6 ± 5,8	p = 0,044

Table 8.6. Mean areas of damage ($mm^2 \pm$ 1 SE) caused by phyllophages, mid-season and at the end of the growing season on banded and unbanded branches of <u>Burkea africana</u> at Nylsvley.
Number of branches observed, 45 on banded and 45 on unbanded trees.
Calculated F-values for between treatment comparisons are given.

DAMAGE AGENT	SEASON	TREATMENT	AREA	F-VALUE
Phyllophages	Mid-season	Banded	24,5 ± 5,5	F = 4,32
-causing holes in laminae.		Unbanded	12,1 ± 2,4	P = 0,04
Phyllophages	Mid-season	Banded	4680,3 ± 895,4	F = 3,73
-margin feeders of laminae.		Unbanded	2840,2 ± 327,1	N.S.
Phyllophages	Mid-season	Banded	19,2 ± 8,3	F = 0,23
-causing skeletonisation.		Unbanded	26,0 ± 11,6	N.S.
Phyllophages	Mid-season	Banded	15,5 ± 4,2	F = 6,15
-causing "damage E".		Unbanded	4,5 ± 1,4	p = 0,015
Pathogenic attack	Mid-season	Banded	653,5 ± 66,9	F = 15,02
		Unbanded	313,1 ± 56,9	P = 0,001
Phyllophages	End of season	Banded	31,8 ± 5,1	F = 3,79
-causing holes in laminae.		Unbanded	18,9 ± 4,2	N.S.
Phyllophages	End of season	Banded	4221,5 ± 568,3	F = 1,22
-margin feeders of laminae.		Unbanded	6396,9 ± 1886,0	N.S.
Phyllophages	End of season	Banded	79,6 ± 21,5	F = 0,47
-causing skeletonisation.		Unbanded	100,7 ± 22,1	N.S.
Phyllophages	End of season	Banded	4,2 ± 1,8	F = 1,00
-causing "damage E".		Unbanded	7,9 ± 3,2	N.S.
Pathogenic attack	End of season	Banded	1340,9 ± 142,7	F = 0,95
		Unbanded	1566,9 ± 183,4	N.S.

Table 8.7. Mean areas of damage (mm^2 $\pm$ 1 SE) caused by phyllophages, mid-season and at the end of the growing season on banded and unbanded branches of Ochna pulchra at Nylsvley.
Number of branches observed, 45 on banded and 45 on unbanded trees.
Calculated F-values for between treatment comparisons are given.

DAMAGE AGENT	SEASON	TREATMENT	AREA	F-VALUE
Phyllophages -causing holes in laminae.	Mid-season	Banded	31,6 ± 6,8	F = 5,55
		Unbanded	13,7 ± 3,4	p = 0,021
Phyllophages - margin feeders of laminae.	Mid-season	Banded	3418,8 ± 568,3	F = 9,30
		Unbanded	1373,7 ± 355,6	P = 0,003
Pathogenic attack	Mid-season	Banded	4,9 ± 1,8	F = 0,43
		Unbanded	6,7 ± 2,0	N.S.
Phyllophages -causing holes in laminae.	End of season	Banded	55,4 ± 9,9	F = 2,27
		Unbanded	36,3 ± 7,9	N.S.
Phyllophages - margin feeders of laminae.	End of season	Banded	4345,0 ± 559,1	F = 1,99
		Unbanded	3205,0 ± 583,2	N.S.
Pathogenic attack	End of season	Banded	81,0 ± 16,1	F = 0,28
		Unbanded	70,3 ± 12,3	N.S.

9. DISCUSSION

The aim of this specific project was to assess the influence that ants have upon phyllophagous insects on the dominant tree species, Terminalia sericea, Burkea africana and Ochna pulchra within the broad-leaved savanna at Nylsvley in the northern Transvaal. Key questions that were researched in the study are (i) what is the insect number and species composition of the insect fauna on banded trees where ants have been excluded and on unbanded trees, which are ant-infested ?; (ii) does the guild composition of the insect fauna on unbanded trees differ from the guild composition on banded trees where ants have been excluded ?; (iii) if changes do occur in the insect fauna in the presence of the ants, what is the effect on the unbanded trees in terms of levels of herbivory ?.

The main conclusions to the study are as follows:

Pyrethrum spraying the canopy of both banded and unbanded Terminalia sericea, Burkea africana and Ochna pulchra trees indicated that, irrespective of tree species, the Formicidae were overwhelmingly dominant on the unbanded trees. Ants in the genus Crematogaster occurred on the trees in greater numbers than members of other ant genera, and were thus termed dominant; it was these dominant ants which mainly influenced the guild composition of insects on unbanded, ant-infested trees.

Populations of sessile and mobile homopteran populations increased greatly from ant attendance on the stems and leaves of unbanded branches on all the tree species as seen from Figures 7.1 - 7.3. In this study the greatest number of homopterans were recorded on unbanded Terminalia sericea trees of which membracid nymphs of Oxyrachis sp. were observed during the early part of the growing season, and Aphis gossypii appeared on the leaves from January onwards. The dominant ant species housed within the trunk and branches of Burkea africana trees encouraged coccids into their nests, which were mixed with the ant host's brood and tended in the normal way (Tables 6.5 - 6.8).

The numbers of insects other than the Homoptera were low on both banded and unbanded trees (Tables 7.5 - 7.7), and excluding the ants from the Berger-Parker dominance indices as seen in Fig. 7.5, showed the guild composition of insects to be similar on both banded and unbanded Terminalia sericea, Burkea africana and Ochna pulchra trees. While no differences in lepidopterous larval densities occurred on banded and unbanded trees, there is evidence from a separate experiment (Section 6.3) that the ant species Crematogaster constructor would remove eggs and early larval instars of the saturnid moth, Cirina forda. Pyrethrum spraying indicated a trend towards a greater number of insect individuals and species on unbanded, ant-infested trees. Finally, from the damage assessments given in Chapter 8, there appear to be some benefits to the plant from the presence of ants within the canopy of trees, and leaf damage is higher on banded trees where ants have been excluded.

In studying the feeding preferences of ants it has been shown that certain ant species become mutualistically associated with honeydew-producing Homoptera. Way (1963) defines this "mutualism" as an association between ants and other insects which is mutually beneficial without necessarily implying obligate dependence or interdependence, and workers (Way, 1963; Carroll and Janzen, 1973; Strong et al., 1984) have listed the benefits derived by the ants and homopterans from such associations. The homopterans have an increased rate of development and fecundity when attended by ants because of protection from natural enemies (Flanders, 1958; Nixon, 1951) and from improved hygiene through the removal of contaminating honeydew which is fed upon by the ants. Wheeler (1910) and Nixon (1951) showed that protection of homopterans from natural enemies was enhanced if sap-suckers occurred within ant nests. Steyn (1954a,b; 1955) and Samways (1982a) who studied ant communities suggests that ant populations consisting of one dominant ant species together with one or more non-dominants, are not simply the cause of honeydew-producing Homoptera but the result of them; the ant-homopteran mutualism raising the population level of both allowing extreme dominance of honeydew-seeking ants and a build up in numbers of sap-suckers. Studies on ant communities within tropical agroecosystems have indicated that ants influence the development of pest insects and weed species (Leston, 1970, 1973; Majer, 1972, 1976a,b,c; Room, 1971, 1975; Taylor, 1977 on cocoa; Brown, 1959; Greenslade, 1971 on coconut plantations). The dominant ant species in these crop situations were found to be patchily distributed having discrete non-overlapping territories, a pattern called a mosaic. Each dominant is associated with a distinctive fauna resulting from positive association with some species, especially ant-attended Homoptera, and negative associations with insects which are preyed upon. It follows that where ant predation or ant disturbance predominates, there should be a reduction in species diversity and abundance of insects and this has been seen within the Hawaiian Islands (Zimmermann, 1970) and on the Galapagos Islands following the invasion of the little fire ant, Wasmannia auropunctata (Lubin, 1984).

Plant protection from insect herbivores resulting from ant - Homoptera mutualism has been suggested or demonstrated several times (Room, 1972; Finnegan, 1974; Nickerson et al., 1977; Tilman, 1978; Laine and Niemela, 1980; Jutsum et al., 1981; Skinner and Whittaker, 1981). There is a point however, when the negative impact of an increase in homopteran density and feeding rates from an ant - homopteran interaction outweighs the protection gained by the plant from potential herbivores as shown by previous workers (Mitler, 1958; Dixon, 1971).

In essence the findings in this study have shown that a broad-leaved savanna ecosystem, which may be characterised by its stability and which has not been significantly modified by man, still conforms to the findings recorded on ant community studies in agroecosystems or from individual ant species interactions with insects. A mosaic of the dominant ant species within the genus Crematogaster with their associated sub and non-dominants was found on all the three species of trees, and this can be likened to the crop situations of cocoa and coconut in that it is this ant mosaic which influences the composition of insect fauna on ant-infested trees. This study therefore is in agreement with previous reports on ant - Homoptera mutualism where homopteran populations increase through the benefits of ant attendance. The tree species selected, Terminalia sericea, Burkea africana and Ochna pulchra were not modified in any way to attract or feed ants through structures such as foliar and extra-floral nectaries and Beltian bodies (Berg, 1975; Bentley, 1977b), and it would seem that these trees do not need to be structurally adapted to encourage foraging populations of ants to enter the trees. The trend towards an increase in the number of individual insects and species on unbanded trees is in opposition to the findings of previous workers who observed that ant predation and / or ant disturbance of canopy insects led to a reduction in insect numbers and diversity. If ants do not exclude the phyllophages why do the damage assessments indicate that when the homopterans are not the dominant herbivores, there are some benefits to the plant from the presence of the ants ?. At Nylsvley the only negative impact of an increase in homopteran density to the plant was seen by the Polyrachis schistacea / Tachardina sp. interaction on Ochna pulchra. A possible explanation is that the ants at Nylsvley donot disturb the insects within the canopy of trees but deter their feeding, which was also seen from Messina's work on Goldenrod (Messina, 1981). It is apparent that the protection gained from phyllophagous insects at Nylsvley is slight and even on unbanded trees the low levels of herbivory suggests that leaf loss through the insect consumer component was low during the study, and consequently had a minimal effect on the primary productivity of individual plants (Harper, 1977). Scholtz (1976) who worked on Lepidoptera at Nylsvley also quoted low consumption figures and found that the lepidopterous larvae removed on average 2% of the available photosynthetic area from the 8 dominant woody trees within the Burkea africana - Eragrostis pallens area.

Finally, this project has emphasized that the influence of ants on the canopy fauna, encouraging homopterous populations and protecting plants from insect herbivore damage is a general phenomenon. This has been demonstrated in crop situations and where ants form specialised ant-plant relationships as seen between ants of the genus Pseudomyrmex and the plant Acacia cornigera (Janzen, 1967) and now on three dominant broad-leaved trees, Terminalia sericea, Burkea africana and Ochna pulchra within an area of South African savanna, which are neither crops nor modified for obligate relationships with ants.

APPENDIX I

Climatic records for Nylsvley from January 1981 to December 1981.

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
PRECIPITATION (mm).												
Monthly Total.	185	034	041	030	003	005	000	013	013	035	068	045
Mean daily Rainfall.	006	001	001	001	000	000	000	000	000	001	002	001
Maximum Reading.	030	017	017	014	003	004	000	009	013	017	024	019
Minimum Reading.	000	000	000	000	000	000	000	000	000	000	000	000
No. of Rain days.	017	006	009	004	001	002	000	003	001	006	010	010
MONTHLY AIR TEMPERATURE (°C).												
Mean daily.	023	021	021	019	015	012	014	022	022	019	024	023
Max. reading On max. Thermometer.	033	030	030	031	026	024	027	029	035	032	039	035
Min. reading O min. Thermometer.	015	013	011	006	002	-01	003	000	011	007	014	012

APPENDIX I(Cont.)

Climatic records for Nylsvley from January 1982 to December 1982.

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
PRECIPITATION (mm).												
Monthly Total.	154	154	037	049	018	000	005	000	008	045	039	096
Mean daily Rainfall.	005	006	001	002	001	000	000	000	000	001	001	003
Maximum Reading.	055	100	015	034	018	000	004	000	004	031	015	025
Minimum Reading.	000	000	000	000	000	000	000	000	000	000	000	000
No. of Rain days.	018	008	009	006	001	000	002	000	002	011	008	013
MONTHLY AIR TEMPERATURE (°C)												
Mean daily.	023	024	022	018	016	013	013	016	020	021	023	024
Max. reading On max. Thermometer.	034	034	034	031	027	025	028	030	035	035	037	037
Min. reading On min. Thermometer.	015	012	012	003	005	-01	-01	002	006	009	011	014

APPENDIX I(Cont.)

Climatic records for Nylsvley from January 1983 to December 1983.

	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
PRECIPITATION (mm).												
Monthly Total.	084	047	096	053	003	013	000	016	000	029	230	050
Mean daily Rainfall.	003	002	003	002	000	000	000	001	000	001	011	003
Maximum Reading.	054	022	057	049	002	012	000	016	000	011	057	016
Minimum Reading.	000	000	000	000	000	000	000	000	000	000	000	000
No. of Rain days.	010	006	010	004	002	003	001	001	000	008	017	011
MONTHLY AIR TEMPERAURE (^{o}C)												
Mean daily.	024	024	022	020	017	014	014	015	020	021	023	022
Max. reading On a max. Thermometer.	039	038	036	032	030	026	026	029	035	036	034	033
Min. reading On a min. Thermometer.	021	012	010	009	002	-01	003	002	006	010	012	012

APPENDIX II

Densities of the dominant broad-leaved woody plants at Nylsvley.
(after Lubke *et al.*, 1975)

SPECIES AND SIZE CLASS	TRANSECTS A	B	C	D	E
	DENSITY OF INDIVIDUALS PER HECTARE				
SHRUBS					
Ochna pulchra					
<1 m	3 168	928	5 186	3 700	1 695
1 - 3 m	3 256	1 768	499	1 151	3 625
>3 m	11	23	4	3	15
Grewia flavescens					
Individuals	585	1 261	911	719	1 119
Clumps	117	256	163	145	230
TREES					
Burkea africana					
<4 m	494	244	245	790	355
4 - 7 m	37	28	57	40	46
>7 m	11	3	1	4	3
Strychnos pungens					
<1 m	69	334	80	28	82
1 - 3 m	27	100	6	6	59
>3 m	3	4	1	0	1
Terminalia sericea					
3 m	51	46	81	210	77
3 - 5,5m	34	33	16	0	57
>5,5m	7	2	2	31	1
Vitex rhemannii					
All	105	59	168	123	138
Combretum molle					
All	77	24	39	16	67
Dombeya rotundifolia					
All	33	19	0	1	1

APPENDIX III

Table for the determination of leaf area (mm^2), from leaf length measurements in mm (Column = units; rows = tens).

Terminalia sericea

Leaf area (tens)	Leaf length (units) 0	1	2	3	4	5	6	7	8	9
20	26,90	55,82	84,74	113,66	142,58	171,50	200,42	229,34	258,26	287,18
30	316,10	345,02	373,94	402,86	431,78	460,70	489,62	518,54	547,46	576,38
40	605,30	634,22	663,14	692,06	720,98	749,90	778,82	807,74	836,66	865,58
50	894,50	923,42	952,34	981,26	1010,18	1039,10	1068,02	1096,94	1125,86	1154,78
60	1183,70	1212,62	1241,54	1270,46	1299,38	1328,30	1357,22	1386,14	1415,06	1443,98
70	1472,90	1501,82	1530,74	1559,66	1588,58	1617,50	1646,42	1675,34	1704,26	1733,18
80	1762,10	1791,02	1819,94	1848,86	1877,78	1906,70	1935,62	1964,54	1993,46	2022,38
90	2051,30	2080,22	2109,14	2138,06	2166,98	2195,90	2224,82	2253,74	2282,66	2311,58
100	2340,50	2369,42	2398,34	2427,26	2456,18	2485,10	2514,02	2542,94	2571,86	2600,78
110	2629,70	2658,62	2687,54	2716,46	2745,38	2774,30	2803,22	2832,14	2861,06	2889,98
120	2918,90	2947,82	2976,74	3005,66	3034,58	3063,50	3092,42	3121,34	3150,26	3179,18

Linear regression: $Y = -551,50 + 28,92X$; $r^2 = 0,96$

Y = Leaf area; X = Leaf length

APPENDIX III (Cont.)

Table for the determination of leaf area (mm^2), from leaf width measurements in mm (Columns = units; rows = tens).

Burkea africana

Leaf area (tens)	Leaf length (units) 0	1	2	3	4	5	6	7	8	9
30	191,70	208,26	224,82	241,38	257,94	274,50	291,06	307,62	324,18	340,74
40	357,30	373,86	390,42	406,98	423,54	440,10	456,66	473,22	489,78	506,34
50	522,90	539,46	556,02	572,58	589,14	605,70	622,26	638,82	655,38	671,94
60	688,50	705,06	721,62	738,18	754,74	771,30	787,86	804,42	820,98	837,54
70	854,10	870,66	887,22	903,78	920,34	936,90	953,46	970,02	986,58	1003,14
80	1019,70	1036,26	1052,82	1069,38	1085,94	1102,50	1119,06	1135,62	1152,18	1168,74
90	1185,30	1201,86	1218,42	1234,98	1251,54	1268,10	1284,66	1301,22	1317,78	1334,34
100	1350,90									

Linear regression: $Y = -305,10 + 16,56X$; $r^2 = 0,87$

Y = leaf area; X = Leaf length

APPENDIX III (Cont.)

Table for the determination of leaf area (mm^2), from leaf length measurements in mm (Columns = units; rows = tens).

Ochna pulchra

Leaf area (tens)	Leaf breadth (units)									
	0	1	2	3	4	5	6	7	8	9
0	-	-	-	-	-	-	15,42	49,35	83,28	117,21
10	151,14	185,07	219,00	252,93	286,86	320,79	354,72	388,65	422,58	456,51
20	490,44	524,37	558,30	592,23	626,16	660,09	694,02	727,95	761,88	795,81

Linear regression: $Y = -188,16 + 33,93X$; $r^2 = 0,89$

Y = Leaf area; X = Leaf width

APPENDIX IV

Key to the Sub-families of the Formicidae found foraging on the trees at Nylsvley.

(from Borror, Delong and Triplehorn, 1981)

(4) 1. Petiole one-jointed.

(3) 2. Anal aperture transverse (Fig. 6.1A). Petiole not particularly scale-like. Sting very small.

...DOLICHODERINE

(2) 3. Anal aperture circular (Fig. 6.1B) and usually surrounded by a fringe of hairs. Petiole is scale-like. Sting absent. Pupae enclosed in cocoons.

...FORMICINAE

(1) 4. Petiole two-jointed.

(6) 5. The frontal carinae are usually close together and not expanded laterally to cover the bases of the antennae (Fig. 6.1C). The clypeus has an upper rounded margin and is not prolonged upwards between the frontal carinae.

...PSEUDOMYRMICINAE

6. The frontal carinae are nearly always well separated and expanded laterally to cover the bases of the antennae (Fig. 6.1D). The clypeus is usually prolonged upwards between the frontal carinae.

...MYRMICINAE

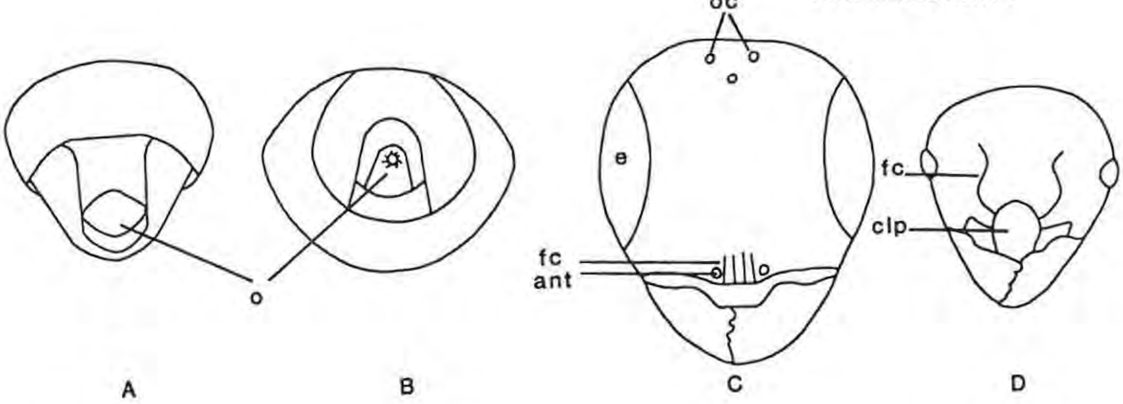


Fig. 6.1. Characteristics of Formicidae. A, apex of the abdomen of Tapinoma sp.(Dolichoderinae), ventro-posterior view; B, apex of abdomen of Formica sp. (Formicinae); C, Pseudomyrmex (Pseudomyrmicinae); D, Myrmica (Myrmicinae). ant, base of the antenna; clp, clypeus; e, compound eye; fc, frontal carinae; o,opening at posterior end of gaster; oc, ocelli.

APPENDIX IV (Cont.)

Key to the Species of the Dolichoderinae at Nylsvley based on observations in the field.

(2) 1. Antennae 11-segmented, terminal segment of the flagellum is enlarged. The scapes are short reaching to two thirds the length of the the head. Minute species 1,5mm in length, yellowish brown in colour. Body covered with fine yellow pubescence and sparse erect hairs on the clypeus. Head 1,5X as long as wide, sides slightly convexed with a straight posterior margin. Thorax narrower than the width of the head; pronotum wider than long, sides convexed. Epinotum unarmed. Petiole one-segmented and small, flattened, longer than wide.

...*Tapinoma arnoldi*

2. Antennae 12-segmented and filiform. The terminal segment is 3X as long as wide; the scapes extend to the posterior margin of the head. Small species, dark brown in colour with a yellowish brown clypeus, antennae and legs. Body finely sculptured with a few sparsely distributed erect white hairs on the clypeus, head, thorax and abdomen. Head slightly longer than wide, tapering anteriorly with a rounded posterior margin. Frontal area well-defined. In profile the pro and mesonotum are curved; the pronotum is the widest thoracic segment, the mesonotum is as wide as long and the epinotum is twice as long as wide. The petiole is oval and one-segmented, hidden by the abdomen which overhangs it.

...*Technomyrmex albipes*

Key to the Species of the Formicinae at Nylsvley.

(5) 1. Antennae 11-segmented and filiform.

(3) 2. Minute species 2mm, dark brown in colour with lighter golden brown antennae and legs. Body covered with fine pubescence and sparsely distributed erect yellow hairs on the clypeus and margins of the abdominal segments. Pronotum narrower in width than the head and the widest thoracic segment; the mesonotum is twice as wide as long. The epinotum widens towards the base and is unarmed.

...*Plagiolepis pygmaea*

APPENDIX IV (Cont.)

(4) 3. Medium sized species, black in colour with dark brown antennae and and tarsi. Body covered with fine pubescence with longer erect brown hairs at the gaster. The pedicel of the antenna is 3X as long as wide, the flagellal segments are longer than wide increasing towards the apex. Eyes large. Pronotum large, 1,5X as wide as long and considerably wider than the meso and metanotal segments but of equal width to the epinotum. The epinotum bears two small triangular teeth. Petiole one-segmented and bi-dentate from above.

...Acantholepis capensis

(3) 4. Medium sized species, golden brown in colour, having a deeper brown petiole and gaster. Body finely sculptured with erect yellow pilosity on the dorsum of the head, thorax, legs and concentrated on the gaster. Noticeable long and slender legs; forelegs bearing a tibial spur. Antennae inserted close to the posterior margin of the clpyeus; the scapes extending beyond the hind margin of the head for half their total length. The frontal carinae are short. Pronotum as wide as long, the epinotum bears two very small backwards pointing teeth. In profile the scale of the petiole is as high as the epinotum, taller than wide and rounded at the apex.

...Acantholepis custodiens

(9) 5. Medium sized ant species. Antennae 12-segmented and filiform.

(7) 6. Medium sized species, reddish brown head and thorax and a black gaster; scapes extend to the posterior margin of the head. Body finely sculptured with long erect hairs sparsely distributed on the clypeus, thorax and abdomen and increasing in density on the declivity of the epinotum and petiole. Head slightly longer than wide, widest anteriorly. Pro and mesothorax clearly wider than long. In profile the petiole is triangular with the anterior face inclined at a more steeper angle than the posterior face.

...Camponotus robecchii
race rhodesiana

(8) 7. Medium sized species, reddish brown head and thorax and a black gaster; scapes extend beyond the posterior margin of the head for half their total length. Pronotum is the widest thoracic segment having convexed sides. The scale of the petiole is forward-pointing and rounded.

...Camponotus rufoglaucus

APPENDIX IV (Cont.)

(7) 8. Medium sized species, dark brown in colour with reddish brown antennae and legs. Eyes large and flat and situated towards the posterior half of the head. The pronotum is twice as wide as long and marginated laterally. Body finely punctured with sparsely distributed white hairs on the head, thorax and abdomen and longer thicker hairs occurring on the declivity of the epinotum and the scale of the petiole; the scale is taller than wide and forward- pointing, rounded at its apex.

...Camponotus sp. SG. 89

(5) 9. Large ant species. Antennae 12-segmented and filiform.

(14) 10. Epinotum unarmed.

(12) 11. Large black species with a few erect yellow hairs occurring on the head, thorax and petiole and increasing on the gaster to give a noticeable pale brown colour. Head is 1,5X as long as wide, widest at its base with a straight posterior margin. Scapes extend a quarter of their total length beyond the posterior margin of the head. Frontal carinae pronounced; long labial palps. Pronotum is the widest thoracic segment with clear rectangular shoulders and is raised above the remaining thoracic segments. The petiole is triangular in profile with the anterior face gradually inclined when compared with a steeper posterior face. Abdomen elongated.

...Camponotus fulvopilosus

(13) 12. Large black species with reddish brown flagellae, body covered with fine and thick white hairs. A large distinctive scale to the petiole, cuboid in profile. Head roughly triangular, widest posteriorly and having convexed sides. The scapes extend beyond the posterior margin of the head for a third of their total length. In profile the pro, meso and metanotum are curved towards a deep meso-epinotal suture; the dorsum of the epinotum is horizontal and is depressed longitudinally. Abdomen globose.

...Camponotus mayri

APPENDIX IV (Cont.)

(12)13. Large black species, and in profile has a triangular-shaped petiole which has an anterior face angled more steeply than the posterior face. Body covered with fine white pubescence and long black erect hairs occurring on the head, thorax, petiole and margin of the abdomen. Head distinctly longer than wide, parallel- sided tapering slightly anteriorly and having well-rounded posterior angles. The scapes are long and extend beyond the posterior margin of the head for half their total length. Frontal carinae are pronounced; clypeus divided by a ridge. The pronotum is the widest thoracic segment, considerably wider at its base. Abdomen oval.

...*Camponotus eugeniae*

(10)14. Epinotum armed.

(16)15. Large black species, the shoulders of the pronotum bear long forward-pointing spines. Body is covered with a whitish grey pubescence and erect grey hairs. Head oval, widest at its base. The scapes extend beyond the posterior margin of the head for two thirds of their total length. Frontal carinae raised. The dorsum of the thoracic segments is strongly emarginate, and in profile the thorax is curved. The epinotum bears two small triangular teeth. The petiole is conical in profile with two long spines directed upwards.

...*Polyrachis schistacea*

16. Large black species, the shoulders of the pronotum are spineless. Body covered with whitish grey pubescence and grey erect hairs. The scapes extend beyond the posterior margin of the head for half their total length. Frontal carinae are well pronounced and raised. The pro, meso and metanotum are strongly convexed forming a raised shield above the epinotum. Epinotum is wider than long and bears two small triangular teeth. The petiole is conical in profile with two upward-pointing spines.

...*Polyrachis* sp. SG. 85

APPENDIX IV (Cont.)

Key to the Species of the Myrmicinae and the Pseudomyrmicinae at Nylsvley.
(excluding the genus Crematogaster)

(2) 1. Antennae 9-segmented with a three-jointed club; the scapes extend to the front of the occipital margin. Medium sized species, reddish brown in colour with a dark brown abdomen. Large convexed compound eyes positioned in the posterior third of the head. Frontal carinae are wide apart. Pronotum distinctly convexed and shield-shaped; the mesonotum has two acute backward-pointing spines. The epinotum is armed with similar sized spines. Pro- mesonotal suture absent. Two-jointed petiole, the node of the first joint is wedge-shaped; the second joint is globose. Abdomen oval.

...Meranoplus simoni

(5) 2. Slender ants of the Sub-family Pseudomyrmicinae. Antennae 12-segmented and filiform; the scapes extend to the front occipital margin, and the flagellal joints thicken towards the apex. Fig. 6.1C indicates the position of the frontal carinae.

(4) 3. Medium sized species, dark brown in colour with paler brown antennae and legs. Body covered fine white pubescence, no pilose hairs. Large rectangular head, twice as long as wide and wider than the thorax. The mandibles are placed ventrally beneath the face of the head. The pronotum is the widest thoracic segment which tapers gradually towards the epinotum. The petiole is two-jointed, the first node is rounded, wider posteriorly; the second joint is oval. Abdomen is elongated.

...Tetraponera penzigi

4. Medium sized species, golden brown in colour. Body finely punctured with sparse yellow hairs over its entirity. Head elongated. Large compound eyes. The mandibles are placed vertically below the head. Pronotum is margined laterally and tapers slightly towards the mesonotum which is as long as wide. The epinotum is unarmed. The petiole is two-jointed, the first node is wedge-shape; the second joint is spherical. Abdomen is elongated.

...Tetraponera sp. SG. 81

APPENDIX IV (Cont.)

(7) 5. Antennae 12-segmented and filiform, the scapes extend beyond the hind margin of the head for a quarter of their total length; the terminal three segments clearly longer than wide forming a club.

(5) 6. Medium sized species, yellowish brown with a deeper brown gaster and paler flagellae and legs. In profile the pro and mesonotum are raised above the epinotum forming a shield. The thoracic sutures are clearly defined. Body covered with pale yellow pilose hairs. Head large, slightly longer than wide having convexed sides. Frontal carinae are distinctive and raised. The epinotum is armed with two small teeth. The first node of the petiole is wedge-shaped, the anterior face is more gently inclined than the steeper, posterior side. The second joint is spherical and distinctly wider and larger than the first joint. Abdomen is oval.

...Pheidole megacephala

(9) 7. Antennae 12-segmented and filiform, the scapes extend to three quarters the length of the head; the terminal segments clearly longer than wide forming a club.

(7) 8. Medium sized species, golden brown in colour. All the thoracic segments are strongly marginate, the pronotum having angular corners. All thoracic sutures are indistinctive on the dorsum of the body. The body is covered with short erect yellow pilose hairs. Eyes relatively large, situated midway along the length of the head. The frontal carinae are close together. The epinotum is widest anteriorly, bearing two small triangular teeth. Petiole is 2-segmented, the first node is trapezoidal, the second is oblong-ovate wider than long. Abdomen is oval.

...Tetramorium sp. S.G. 101

9. Antennae 12-segmented and filiform, the scapes extend to the posterior margin of the head; the terminal segments clearly longer than wide forming a club.

APPENDIX IV (Cont.)

(9) 10. Medium sized species, golden brown with a dark brown gaster. Pro-mesanotal suture is absent but the meso-epinotal suture is deep and well-defined. The body is covered with fine yellow pubescence and yellow pilose hairs occurring sparsely on the clypeus, petiole and gaster. Head rectangular with a straight posterior margin. Eyes small, situated halfway along the length of the head. Frontal area is indistinct. A two-segmented petiole, the first node is wedge-shaped, the anterior face is inclined at a more gentle angle than the posterior face; the second node is spherical. Abdomen globose.

...*Monomorium* sp. SG. 88

Key to the genus Crematogaster found at Nylsvley.

A separate key for individuals within the genus *Crematogaster* was thought useful as in the field all dominant ant species belong to this genus. Individual *Crematogaster* species are difficult to distinguish and so an illustrated key is given here.

(2) 1. Small sized species, dark brown in colour. The first joint of the petiole is twice as long as wide, having parallel or slightly convexed sides; the second joint is globose, as wide as the first joint. Sparse erect white hairs occur on the dorsum of the head, thorax and abdomen. Head longer than wide with convexed sides and well-rounded posterior angles. Antennae 11-segmented, flagellum ending in a distinctive 2-jointed club. The scapes are short, extending just beyond the occipital margin. Frontal area is indistict. The pronotum is the widest thoracic segment, lateral margins well-rounded. The sides of the epinotum are convexed, widest posteriorly bearing 2 small acute teeth. The epinotum merges with the declivity in a gentle curve. The abdomen is 2,5X as long as wide.

...*Crematogaster transvaalensis*

Fig. 6.2 A.

(3) 2. Medium sized species.

(7) 3. The second joint of the petiole is clearly divided into 2 equal discs.

APPENDIX IV (Cont.)

(5) 4. Reddish brown species, base of abdomen a darker brown. The epinotum widens towards its base where it terminates in 2 long diverging spines. Body covered with a fine white pubescence and white pilose hairs. Head as long as wide having convexed sides, and well-rounded posterior margins. Antennae 11-segmented with a distinctive 3 jointed club; the scapes extend to the posterior margin of the head. Frontal area indistinct. Pronotum is the widest thoracic segment. The first joint of the petiole is triangular, as long as wide. The second joint is as wide as long and clearly divided into 2 discs. The abdomen is widest anteriorly 1,5X as long as wide.

...*Crematogaster castanea*
Fig. 6.2 B.

(6) 5. Dark brown species. Head clearly rectangular, longer than wide with a straight posterior margin. The first joint of the petiole is triangular in shape. Antennae 11-segmented with a distinctive 3 jointed club; the scapes are short extending to three quarters the length of the head. The epinotum bears 2 spines, acutely pointed and directed upwards. The second joint of the petiole is as wide as the first, clearly divided into 2 discs by a longitudinal groove. Abdomen 1,5X as long as wide.

...*Crematogaster nigronitens*
Fig. 6.2 C.

(5) 6. Dark brown species. Head with convexed sides. The first joint of the petiole is clearly heart-shaped. Antennae 11-segmented with a distinctive 3 jointed club; the scapes are short extending to three quarters the length of the head. The frontal area is indistinct. The epinotum diverges posteriorly into 2 spines, acutely pointed and directed upwards. The second node of the petiole is as wide as the first, divided into 2 discs by a longitudinal groove.

...*Crematogaster gerstaeckeri*
Fig. 6.2 D.

APPENDIX IV (Cont.)

(8) 7. The second joint of the petiole is not clearly divided into 2 equal discs.

(9) 8. Dark brown species. The dorsum of the epinotum is slightly narrower anteriorly, bearing 2 small triangular teeth. Head is as long as wide, convexed sides and well-rounded posterior angles. Antennae 11-segmented with an indistinctive 3 jointed club; antennae are situated at the posterior margin of the clypeus. Pronotum the widest thoracic segment. The first joint of the petiole is triangular, the second joint is oval, wider than long with a feeble median groove. Abdomen 1,5X as long as wide.

...Crematogaster constructor
Fig. 6.2 E.

(8) 9. Golden brown species, abdomen bark brown; sparse pilose hairs occurring on the clypeus, petiole and abdomen. The epinotum is widest at its base, bearing 2 large sharply-diverging spines. Antennae 11-segmented terminating in a 3 jointed club; the scapes reach the posterior margin of the head. Frontal area distinctive. Pronotum widest thoracic segment divided by a longitudinal depression. The first node of the petiole is slightly wider than long, the second node is globose without a median groove.

...Crematogaster amita
Fig. 6.2 F.

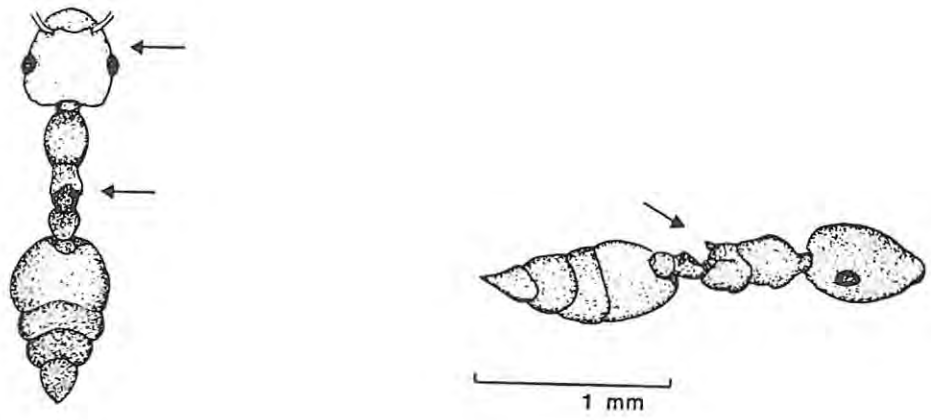


Figure A. Crematogaster transvaalensis

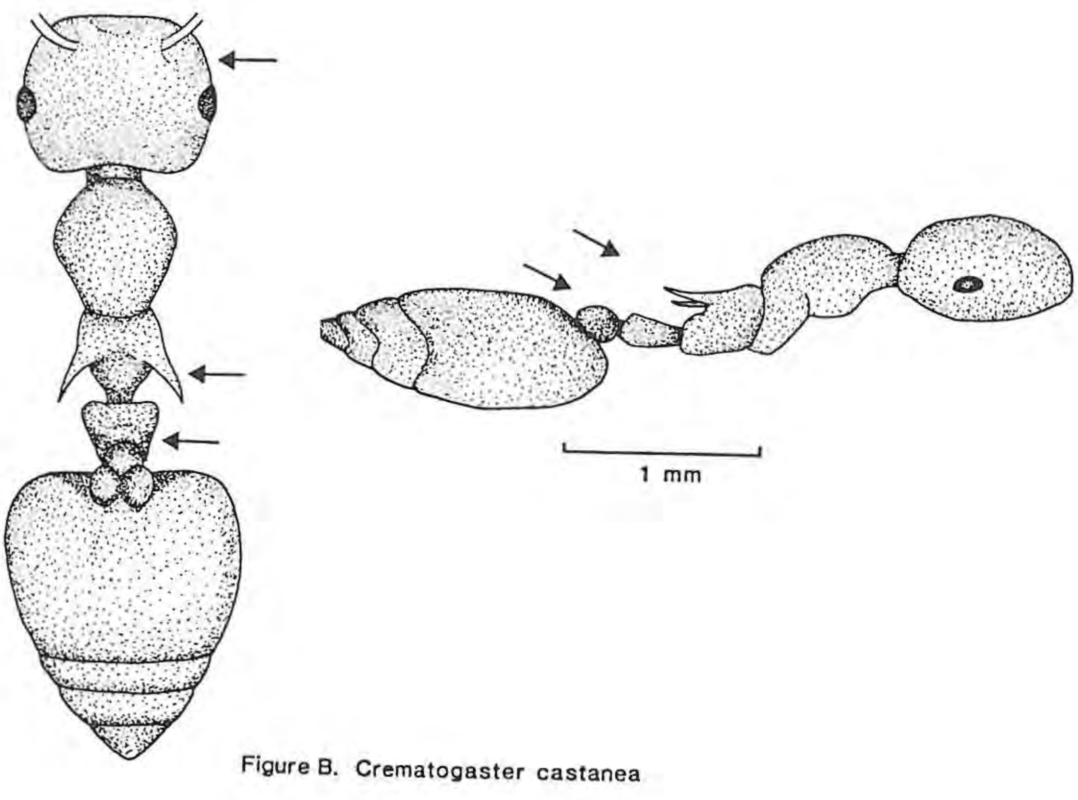
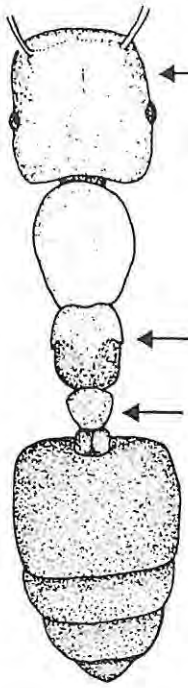


Figure B. Crematogaster castanea

Fig. 6.2. Characteristics of the Crematogaster species found at Nylsvley. A, Crematogaster transvaalensis; B, Crematogaster castanea; C, Crematogaster nigronitens; D, Crematogaster gerstaeckeri; E, Crematogaster constructor; F, Crematogaster amita



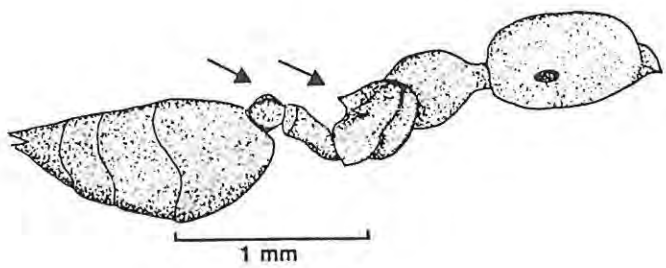
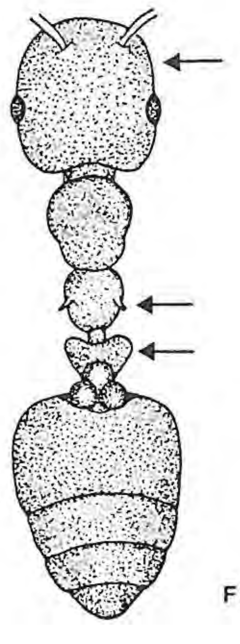


Figure C. Crematogaster nigronitens



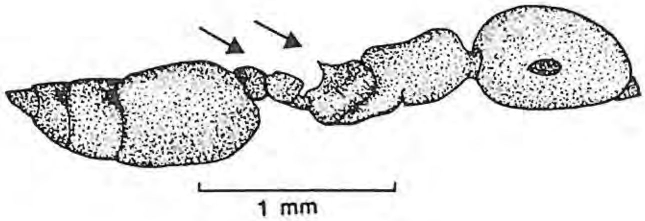


Figure D. Crematogaster gerstaeckeri

Fig. 6.2 (Cont.). Characteristics of the Crematogaster species found at Nylsvley.

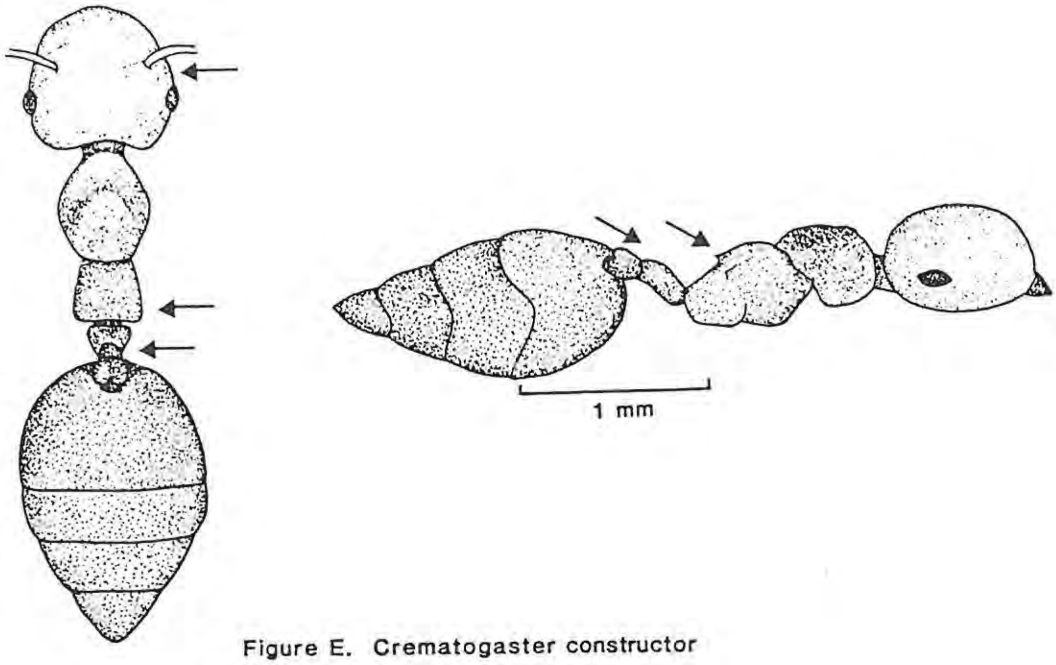


Figure E. Crematogaster constructor

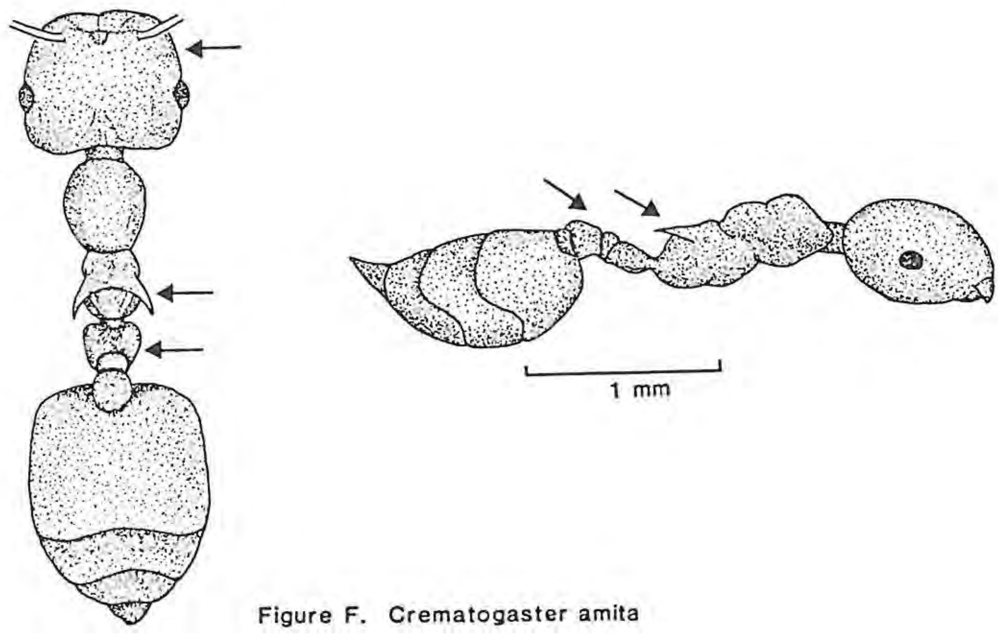


Figure F. Crematogaster amita

Fig. 6.2 (Cont.). Characteristics of the Crematogaster species found at Nylsvley.

APPENDIX V

The number of adult Cirina forda (Saturniidae : Saturninae) caught in Robinson light traps (125 Watts) situated in Burkea veld, from September to October 1983 at Nylsvley.

DATE	TRAP NO.	NO. OF ADULTS
26.09.83	1	6
	2	32
	3	8
28.09.83	1	9
	2	46
	3	20
03.10.83	1	83
	2	128
	3	72
05.10.83	1	13
	2	19
	3	3
11.10.83	1	45
	2	143
	3	37
12.10.83	3	10
18.10.83	1	3
	2	10
	3	5
19.10.83	1	3
	2	8
	3	3
24.10.83	1	1
	2	193
	3	28
26.10.83	2	11
	3	1
31.10.83	1	3
	2	6
	3	1

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