

SOME ADAPTATIONS OF MYRMELEONTID (NEUROPTERA) AND  
RHAGIONID (DIPTERA) LARVAE TO LIFE IN HOT DRY SAND

PART II. FIGURES AND TABLES

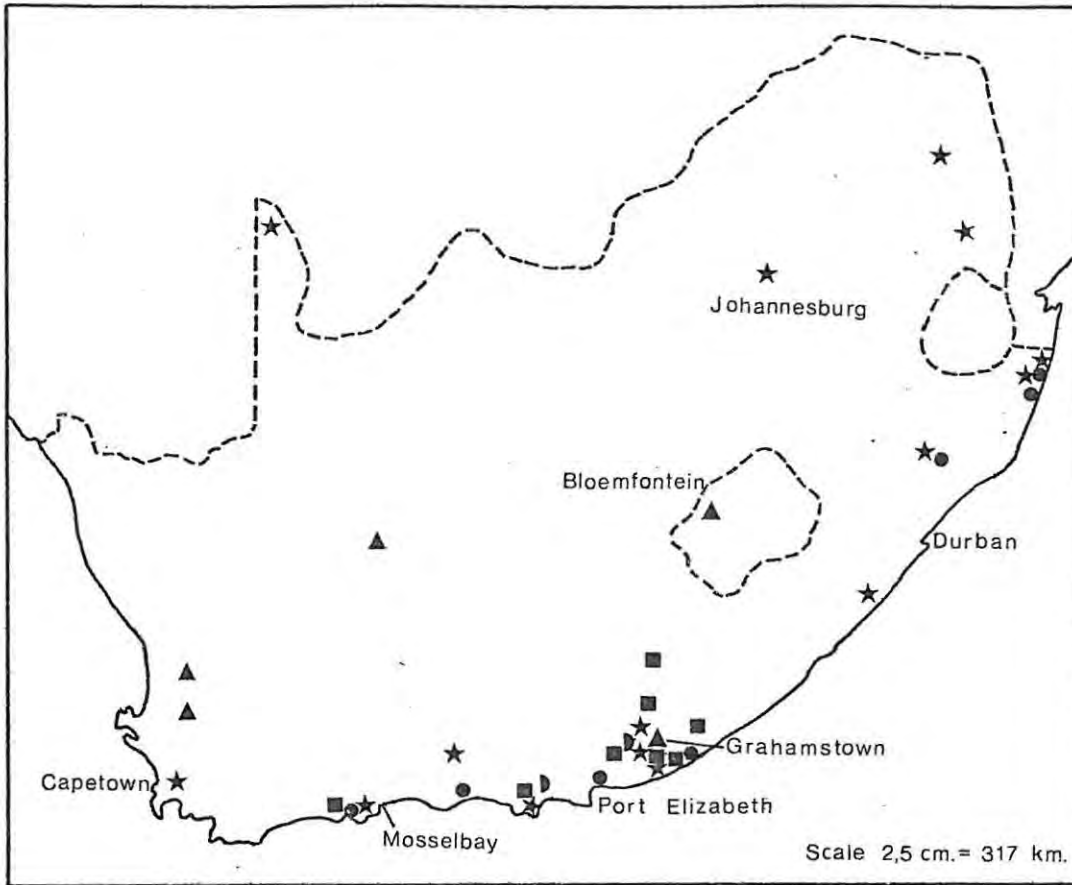
G.J.YOUTHED M.Sc.

1973

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A thesis presented to Rhodes University for the degree  
of Doctor of Philosophy.

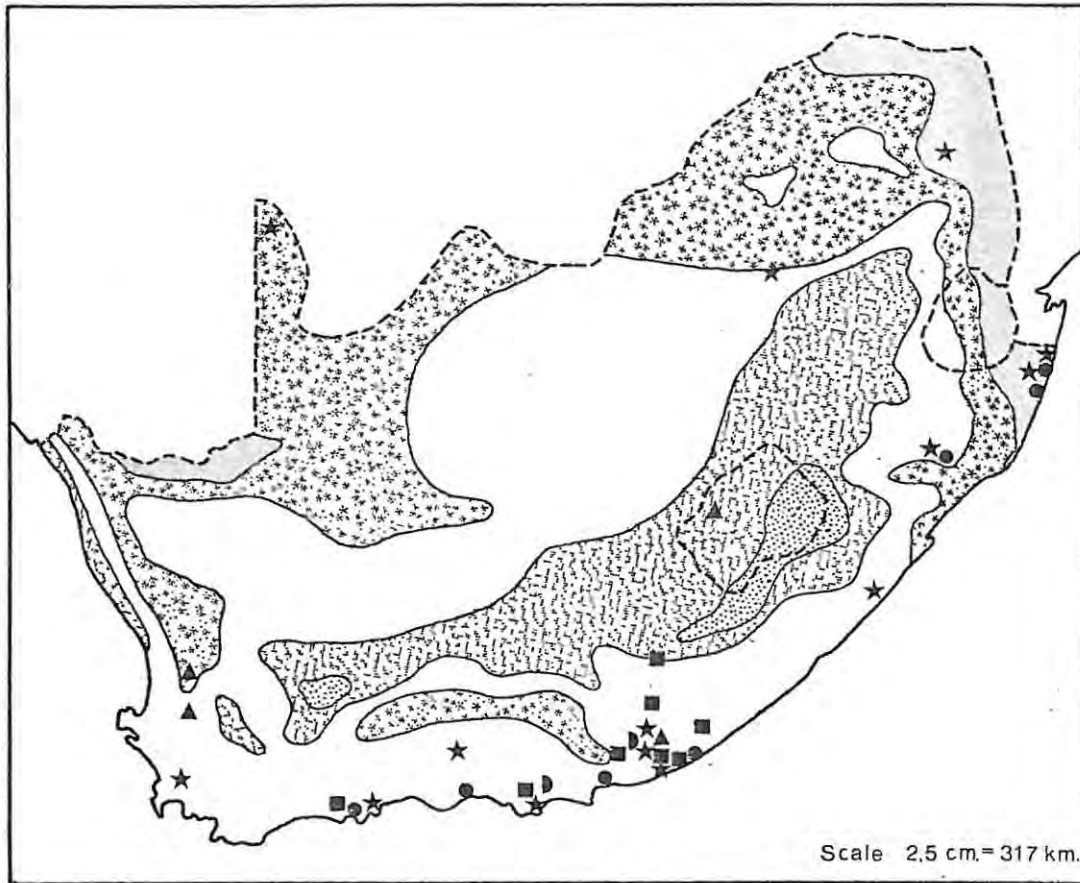
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KEY

- ◐ Lampromyia intermedia
- Myrmeleon medialis
- ★ Myrmeleon obscurus
- Syngenes longicornis
- ▲ Cueta lanceolatus

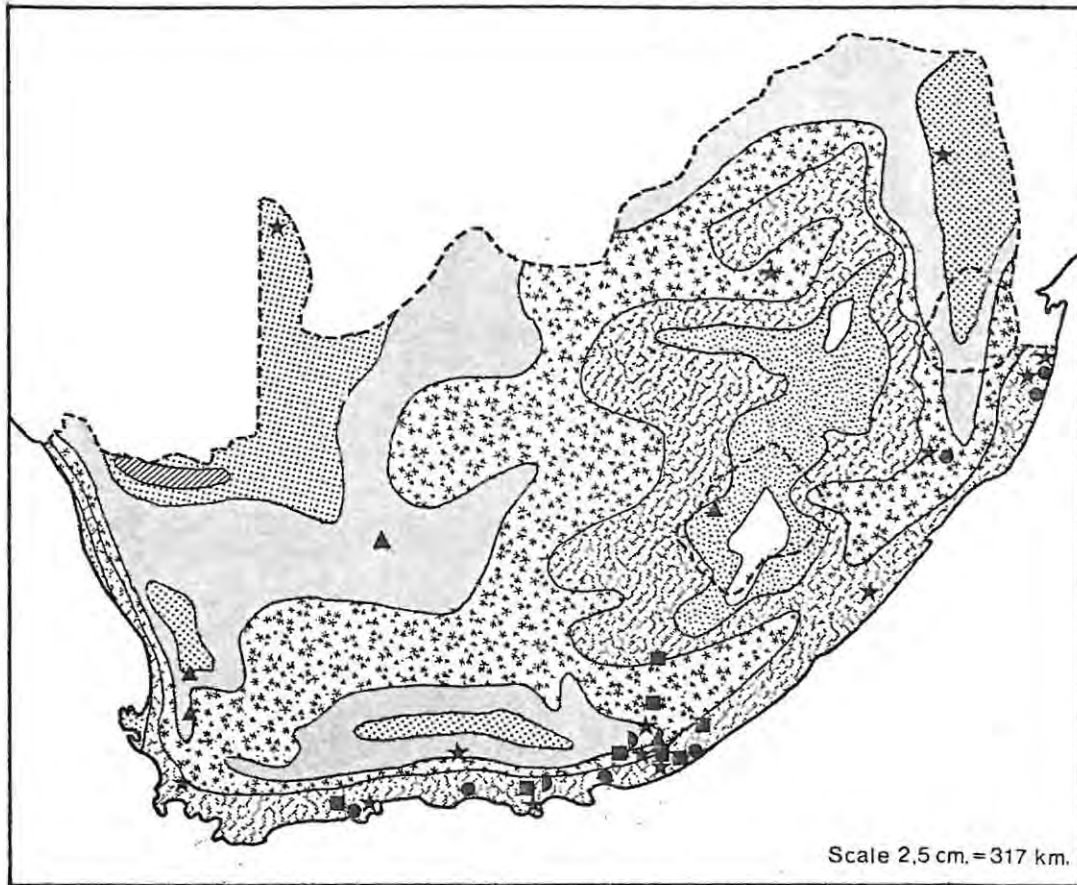
Fig.1. The distribution of four species of Myrmeleontidae and one species of Rhagionidae in the Republic of South Africa.



KEY

●	<u>Lampromyia intermedia</u>	■	less than 55°F (12,7°C)
■	<u>Myrmeleon medialis</u>	▨	55-60°F (12,7 - 15,5°C)
★	<u>Myrmeleon obscurus</u>	□	60-65°F (15,5 - 18,3°C)
●	<u>Syngenes longicornis</u>	▩	65-70°F (18,3 - 20,9°C)
▲	<u>Cueta lanceolatus</u>	□	more than 70°F (20,9°C)

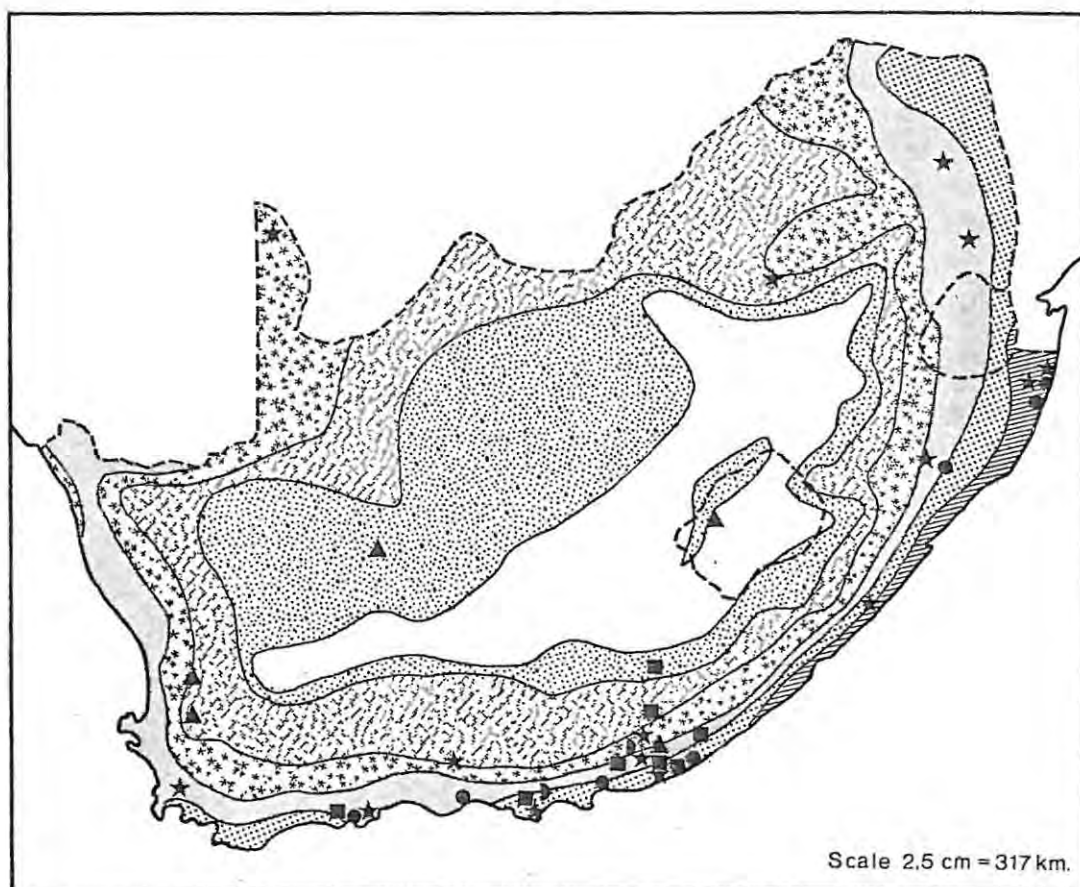
Fig. 2. The mean annual temperature (°F) for the Republic of South Africa and the distribution of four species of Myrmeleontidae and one species of Rhagionidae. Metric isotherms were not available and the temperatures are therefore shown in degrees Fahrenheit. (Climate of South Africa, 1957).



KEY

▷	<u>Lampromyia intermedia</u>	□	less than 85°F (29,2°C)
■	<u>Myrmeleon medialis</u>	▤	85-90°F (29,2 - 31,9°C)
★	<u>Myrmeleon obscurus</u>	▥	90-95°F (31,9 - 34,6°C)
●	<u>Syngenes longicornis</u>	▦	95-100°F (34,6 - 37,4°C)
▲	<u>Cueta lanceolatus</u>	▧	100-105°F (37,4 - 40,2°C)
		▨	105-110°F (40,2 - 42,9°C)
		▩	more than 110°F (42,9°C)

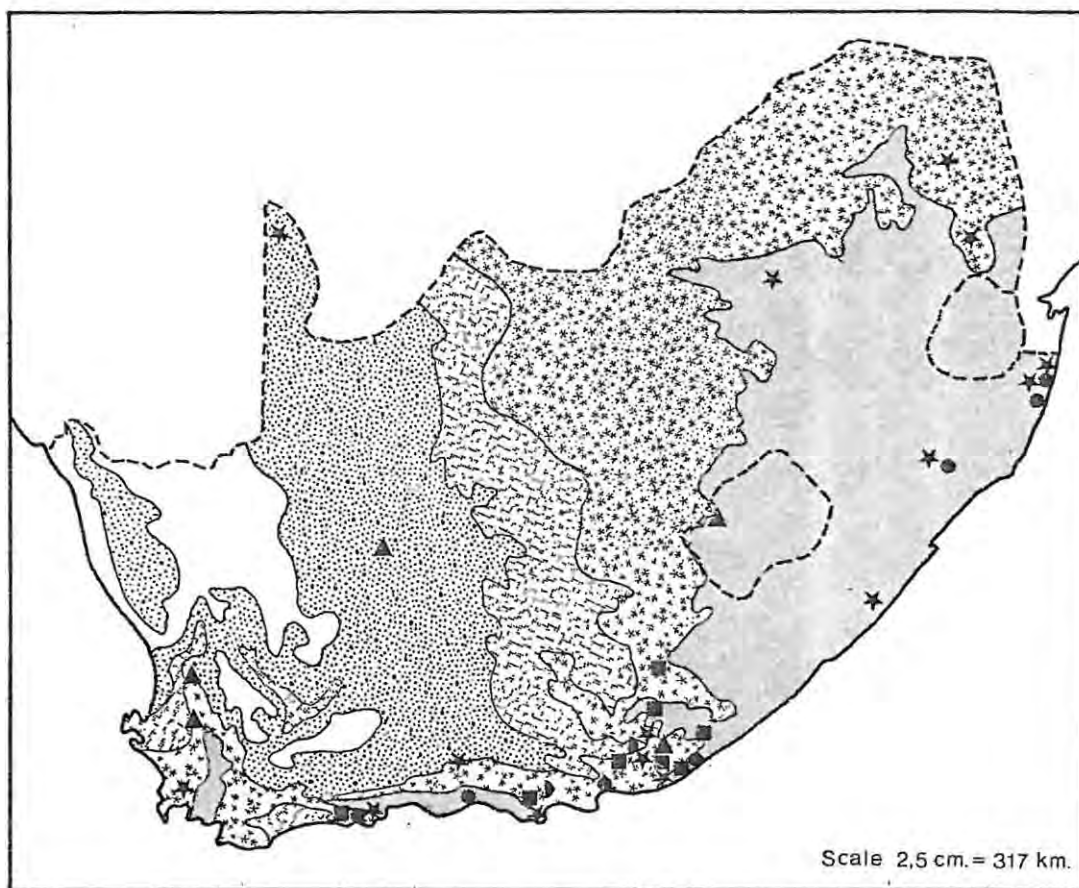
Fig. 3. The mean absolute maximum temperatures (°F) during January in the Republic of South Africa and the distribution of four species of Myrmeleontidae and one species of Rhagionidae. Metric figures were not available and the temperatures are therefore shown in degrees Fahrenheit. (Climate of South Africa, 1957)



KEY

◐	<u>Lampromyia intermedia</u>	□	less than 20°F (-6,6°C)
■	<u>Myrmeleon medialis</u>	▤	20-25°F (-6,6 to -3,9°C)
★	<u>Myrmeleon obscurus</u>	▥	25-30°F (-3,9 to -1,1°C)
●	<u>Syngenes longicornis</u>	▦	30-35°F (-1,1 to 1,6°C)
▲	<u>Cueta lanceolatus</u>	▧	35-40°F (1,6 to 4,4°C)
		▨	40-45°F (4,4 to 7,2°C)
		▩	more than 45°F (7,2°C)

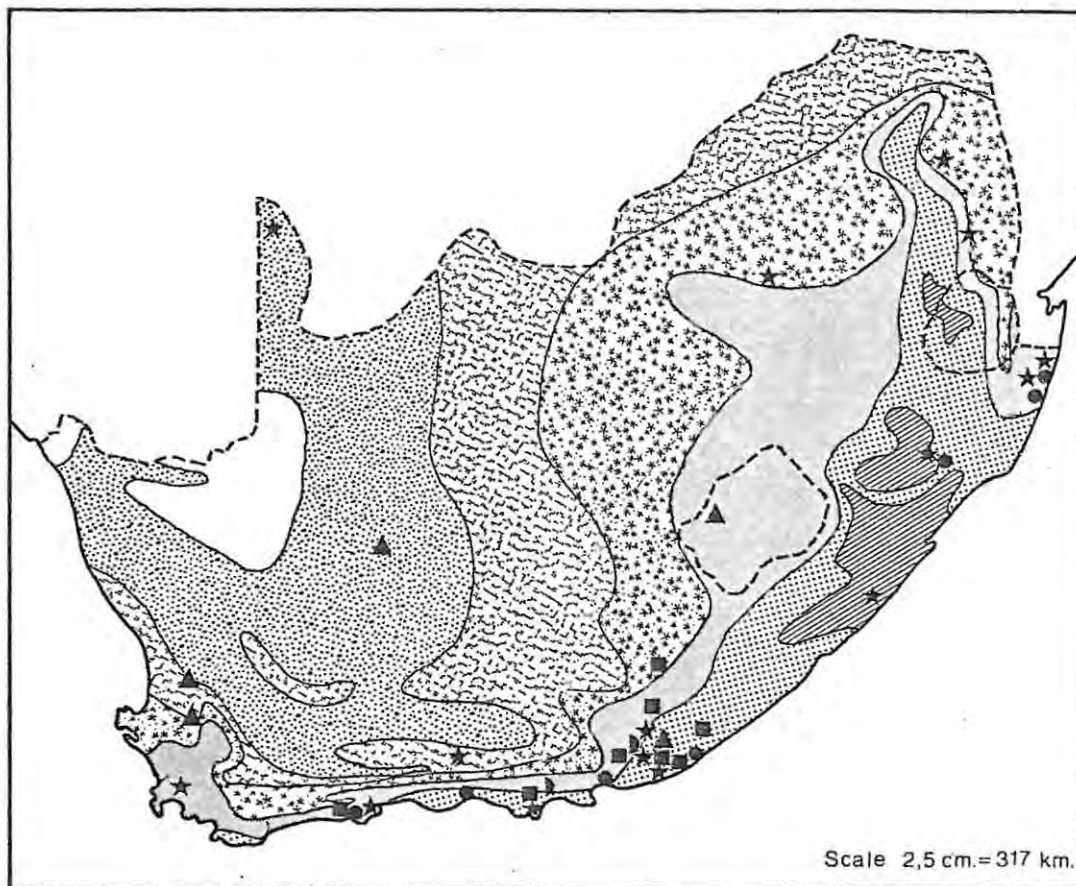
Fig. 4. The mean absolute minimum temperatures (°F) during July in the Republic of South Africa and the distribution of four species of Myrmeleontidae and one species of Rhagionidae. Metric figures were not available and the temperatures are therefore given in degrees Fahrenheit. (Climate of South Africa, 1957)



KEY

◆	<u>Lampromyia intermedia</u>	□	less than 5 ins. (127 mm.)
■	<u>Myrmeleon medialis</u>	▒	5-10 ins. (127-254 mm.)
★	<u>Myrmeleon obscurus</u>	▓	10-15 ins. (254-381 mm.)
●	<u>Syngenes longicornis</u>	⦿	15-25 ins. (381-635 mm.)
▲	<u>Cueta lanceolatus</u>	■	more than 25 ins. (635 mm.)

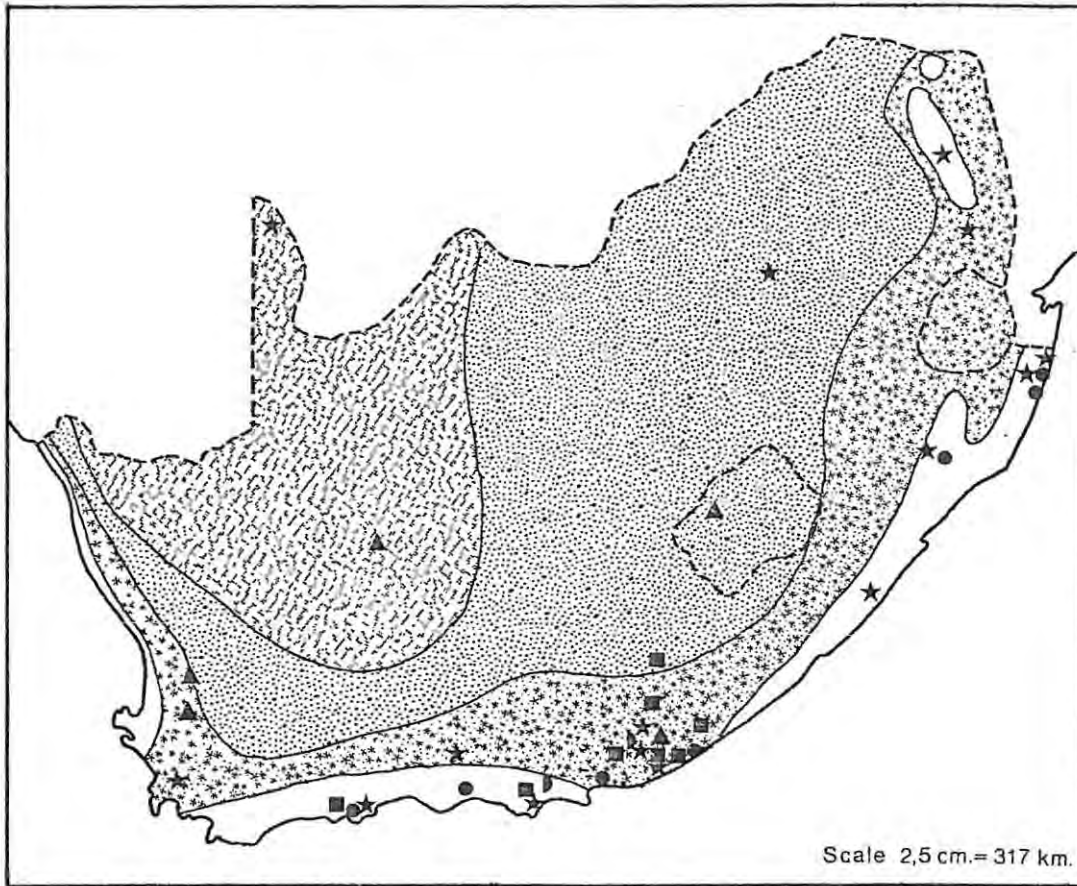
Fig. 5. The mean annual rainfall for the Republic of South Africa and the distribution of four species of Myrmeleontidae and one species of Rhagionidae. Metric rainfall figures were not available and the rainfall is therefore shown in inches. (Talbot and Talbot, 1960)



KEY

●	<u>Lampromyia intermedia</u>	□	less than 20 days
■	<u>Myrmeleon medialis</u>	▤	20-40 days
★	<u>Myrmeleon obscurus</u>	▥	40-60 days
●	<u>Syngenes longicornis</u>	▧	60-80 days
▲	<u>Cueta lanceolatus</u>	▨	80-100 days
		▩	100-120 days
		▪	more than 120 days

Fig. 6. Rainfall frequency (expressed as the number of days per annum with 0,25 mm. or more rain) in the Republic of South Africa and the distribution of four species of Myrmeleontidae and one species of Rhagionidae. (Climate of South Africa, 1957)



KEY

- ◊ Lampromyia intermedia
- Myrmeleon medialis
- ★ Myrmeleon obscurus
- Syngenes longicornis
- ▲ Cueta lanceolatus

- less than 60%
- ▣ 60-70%
- ▤ 70-80%
- ▥ more than 80%

Fig. 7. The average annual duration of sunshine, as a percentage of the possible sunshine, in the Republic of South Africa and the distribution of four species of Myrmeleontidae and one species of Rhagionidae. (Cole, 1961)



Fig. 8. A general view of a typical habitat of the larvae of Lampromyia intermedia. The position of the pits, shown in the detailed view below, is indicated by an arrow.



Fig. 9. A detailed view of the pits of the larvae of Lampromyia intermedia.



Fig. 10. A general view of a typical habitat of the larvae of Myrmeleon medialis. The position of the pits, shown in the detailed view below, is indicated by an arrow.



Fig. 11. A detailed view of the pits of the larvae of Myrmeleon medialis.



Fig. 12. A general view of a typical habitat of the larvae of Myrmeleon obscurus. The position of the pits, shown in the detailed view below, is indicated by an arrow.

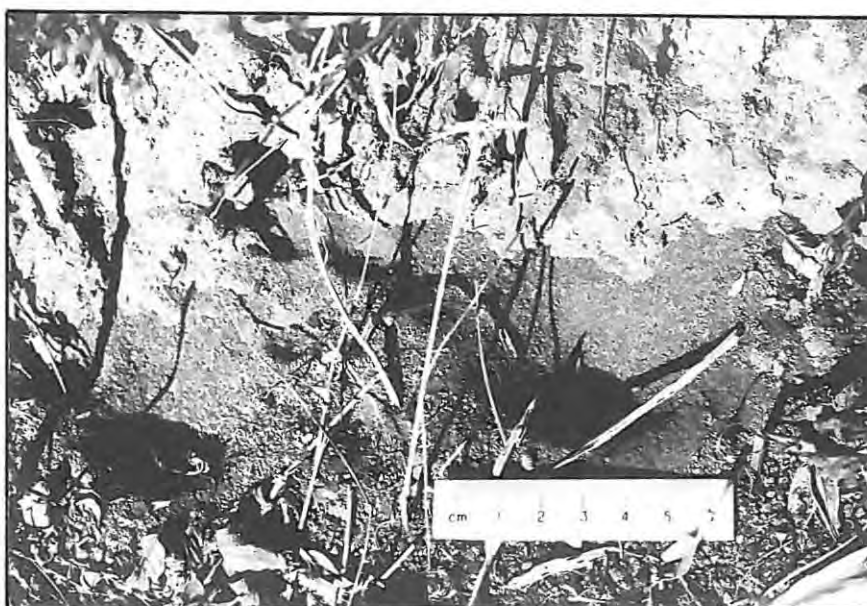


Fig. 13. A detailed view of the pits of the larvae of Myrmeleon obscurus.



Fig. 14. A general view of a typical habitat of the larvae of Syngenes longicornis. The position in which the larva, shown below, was found is indicated by an arrow.

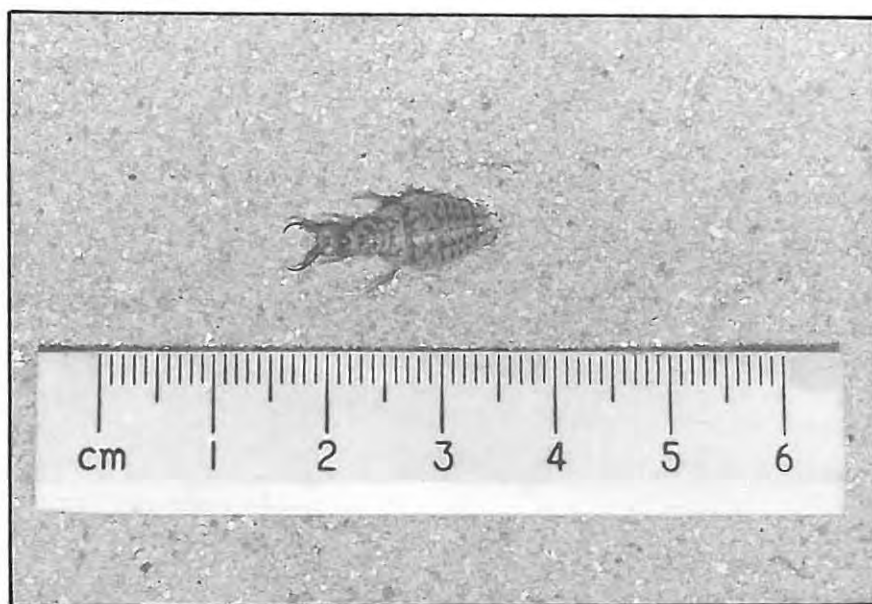


Fig. 15. The larva of Syngenes longicornis.



Fig. 16. A general view of a typical habitat of the larvae of Cueta lanceolatus. The position of the pits, shown in the detailed view below, is indicated by an arrow.



Fig. 17. A detailed view of the pits of the larvae of Cueta lanceolatus.

Table 1. Pit construction, mean pit diameter and the habitat of the larvae of four species of Myrmeleontidae and one species of Rhagionidae. 50 pits of each species were measured.

Species	Pit construction	Mean pit diameter (mm.)	Habitat
<u>L.intermedia</u> (worm-lion)	yes	17 $\pm$ 2,7	Very sheltered areas
<u>M.medialis</u> (ant-lion)	yes	72 $\pm$ 6,3	Moderately sheltered
<u>M.obscurus</u> (ant-lion)	yes	30 $\pm$ 3,4	Moderately sheltered
<u>S.longicornis</u> (ant-lion)	no	-	Sand dunes, partly sheltered
<u>C.lanceolatus</u> (ant-lion)	yes	19 $\pm$ 2,3	Very exposed and rocky

KEY

- C = Cueta lanceolatus
- S = Syngenes longicornis
- O = Myrmeleon obscurus
- M = Myrmeleon medialis
- L = Lampronia  
intermedia

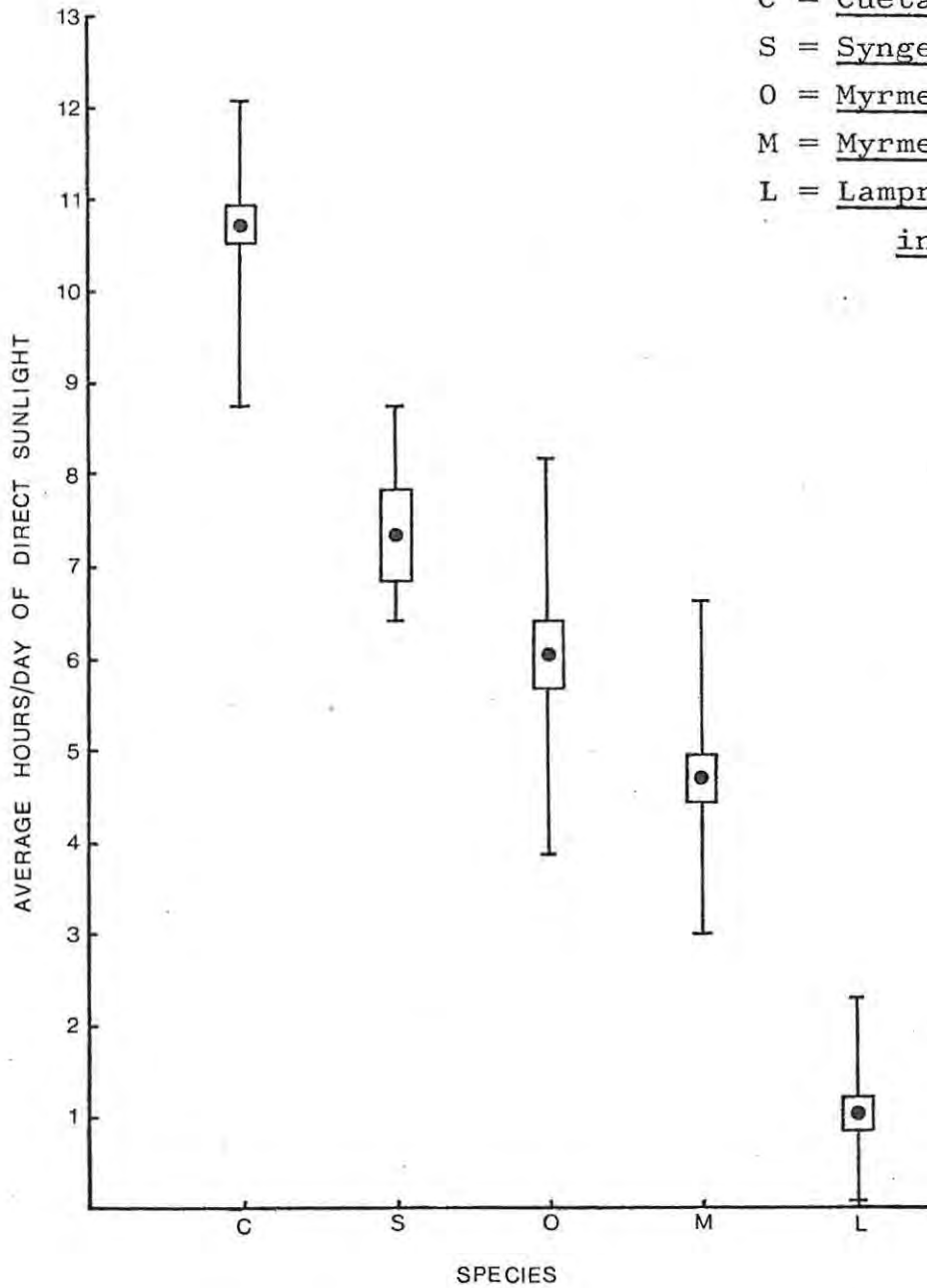
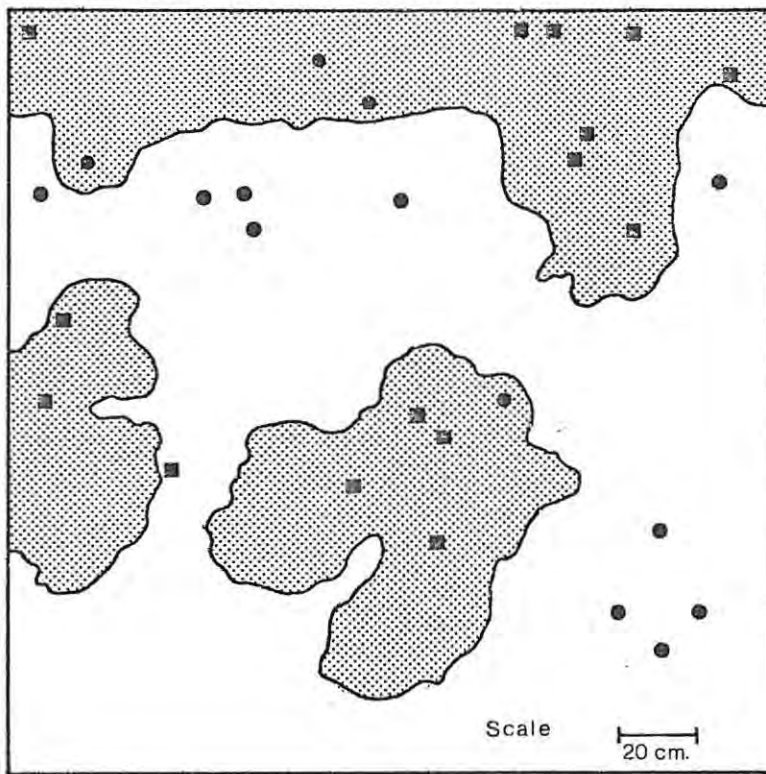


Fig. 18. The mean number of hours exposure to direct sunlight for the larval habitats of four species of Myrmeleontidae and one species of Rhagionidae. The mean values are indicated by circles, twice the standard error by rectangles and the maximum and minimum values are also shown. The mean values were calculated from 60 observations of each habitat, except for the habitat of S.longicornis where only 10 observations were made. All the data were obtained during the period 20th October to 18th November, 1969



KEY

- Pits of Myrmeleon obscurus
- Pits of Myrmeleon medialis
- ▨ Shade

Fig. 19. The positions of the pits of the larvae of Myrmeleon obscurus and Myrmeleon medialis in the field and the pattern of shade cast by overhanging vegetation at 12 noon.

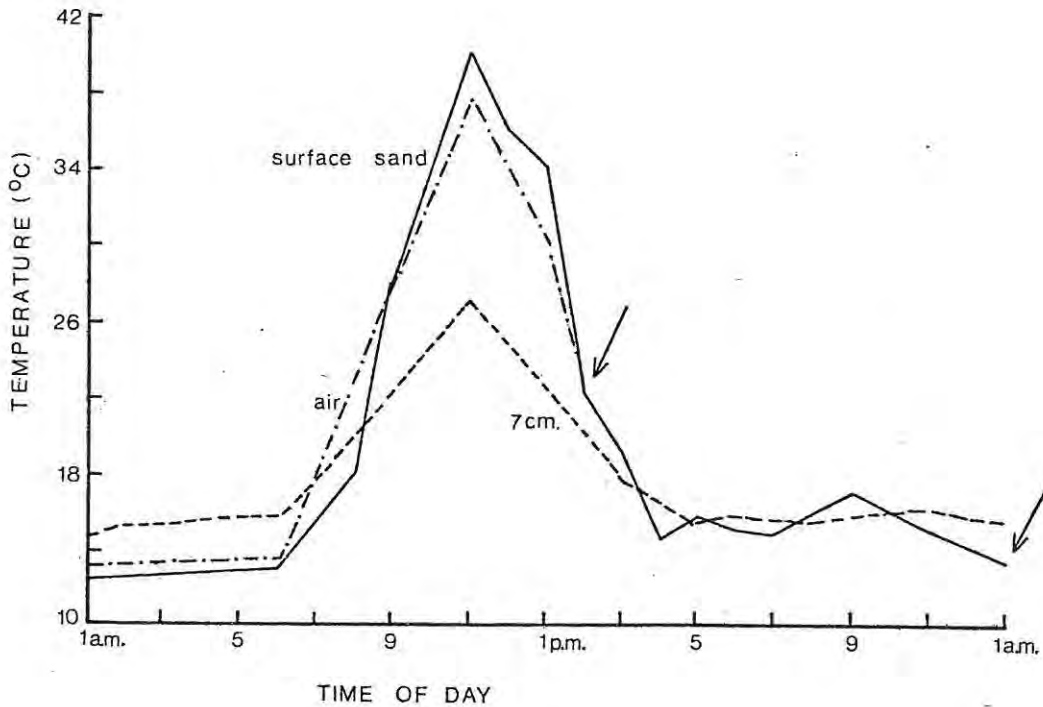
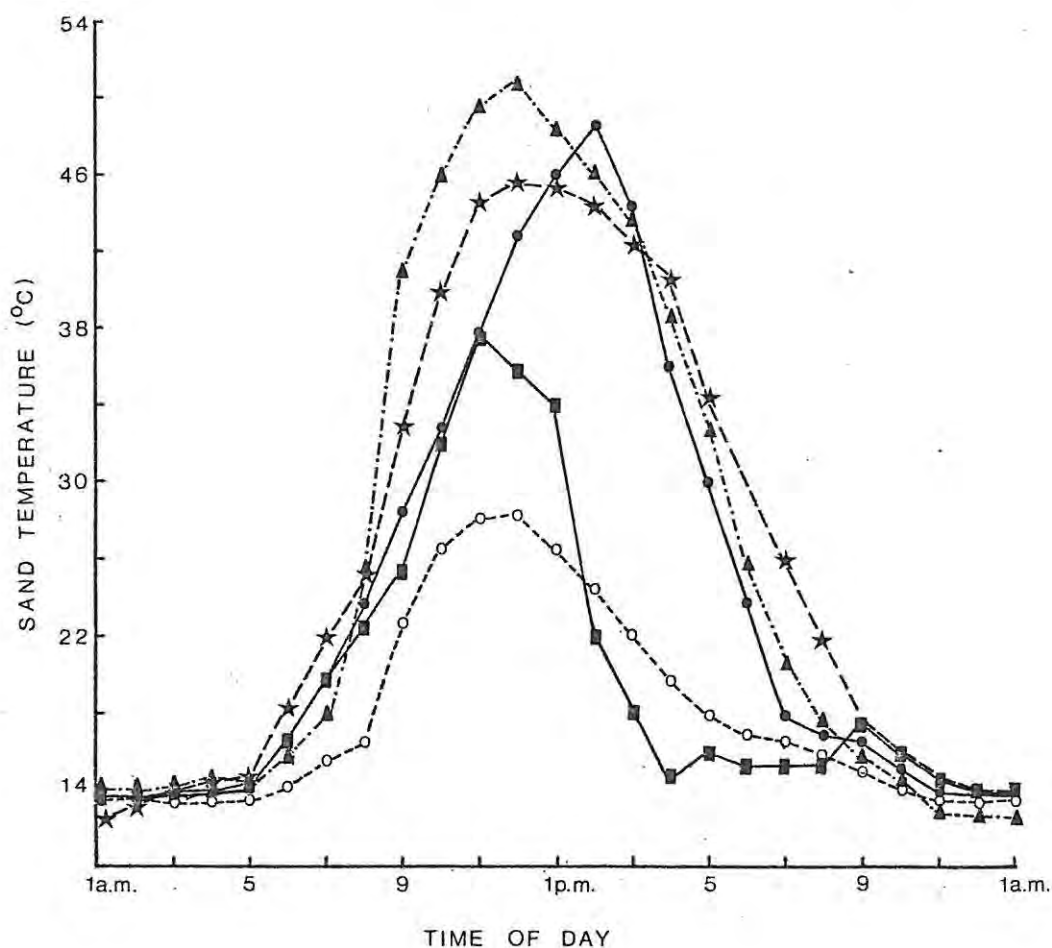


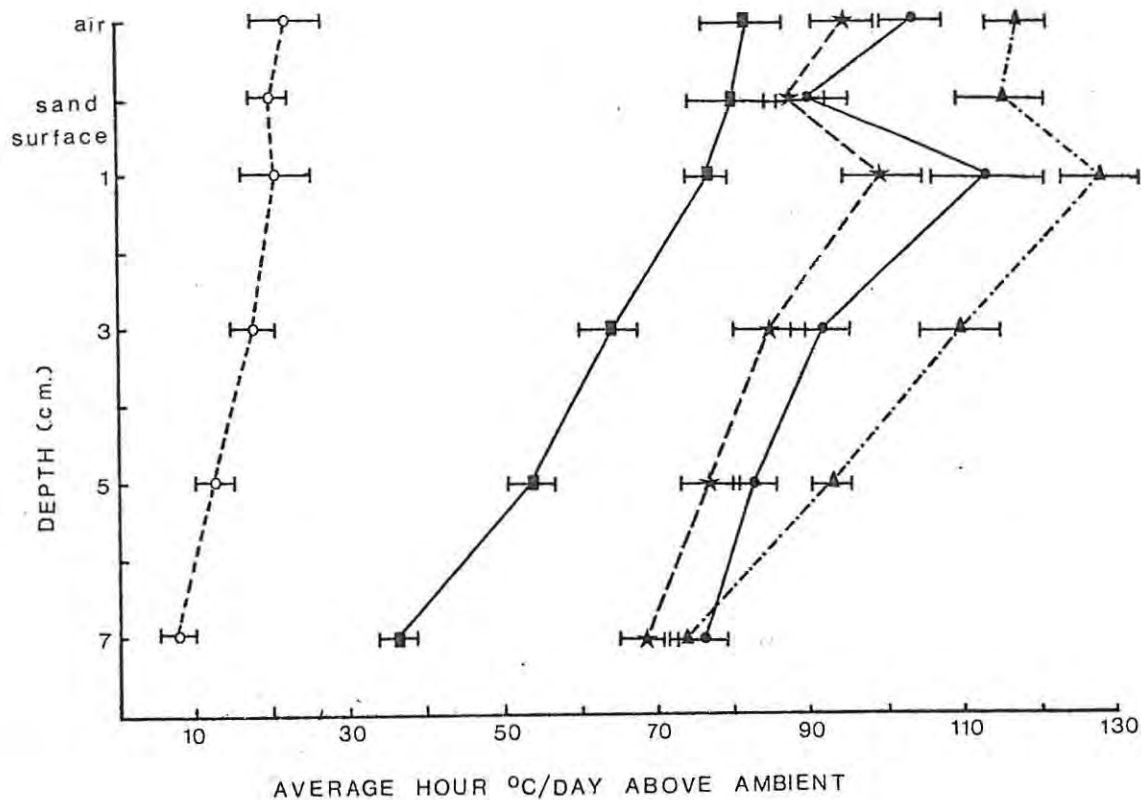
Fig. 20. The daily temperature changes (mean of seven days) of the air, surface sand and sand at a depth of 7 cm. in the habitat of Myrmeleon medialis. During the period 2 p.m. to 1 a.m. (indicated by arrows) the air and the surface sand were at the same temperature and this is indicated by a solid line. At depths of 1 cm., 3 cm. and 5 cm. the temperatures were intermediate between those of the surface sand and sand at a depth of 7 cm. and these data have not been included in the figure.



KEY

- o-----o Lampromyia intermedia
- Myrmeleon medialis
- \*-----\* Myrmeleon obscurus
- Syngenes longicornis
- ▲-----▲ Cueta lanceolatus

Fig. 21. The temperature of the surface sand in various myrmeleontid and rhagionid habitats. All figures represent the mean temperatures recorded over a period of seven days. The recordings were made during October-January, 1969/70.



KEY

- o-----o Lampromyia intermedia
- Myrmeleon medialis
- ★-----★ Myrmeleon obscurus
- Syngenes longicornis
- ▲-----▲ Cueta lanceolatus

Fig. 22. The average number of hour degrees centigrade (above ambient) per day at various depths in myrmeleontid and rhagionid habitats. Each result represents the mean of seven days. Twice the standard errors are indicated. The number of hour degrees was calculated from 6 a.m. to 6 p.m. and the ambient temperature was defined as the temperature at each particular depth at 6 a.m.

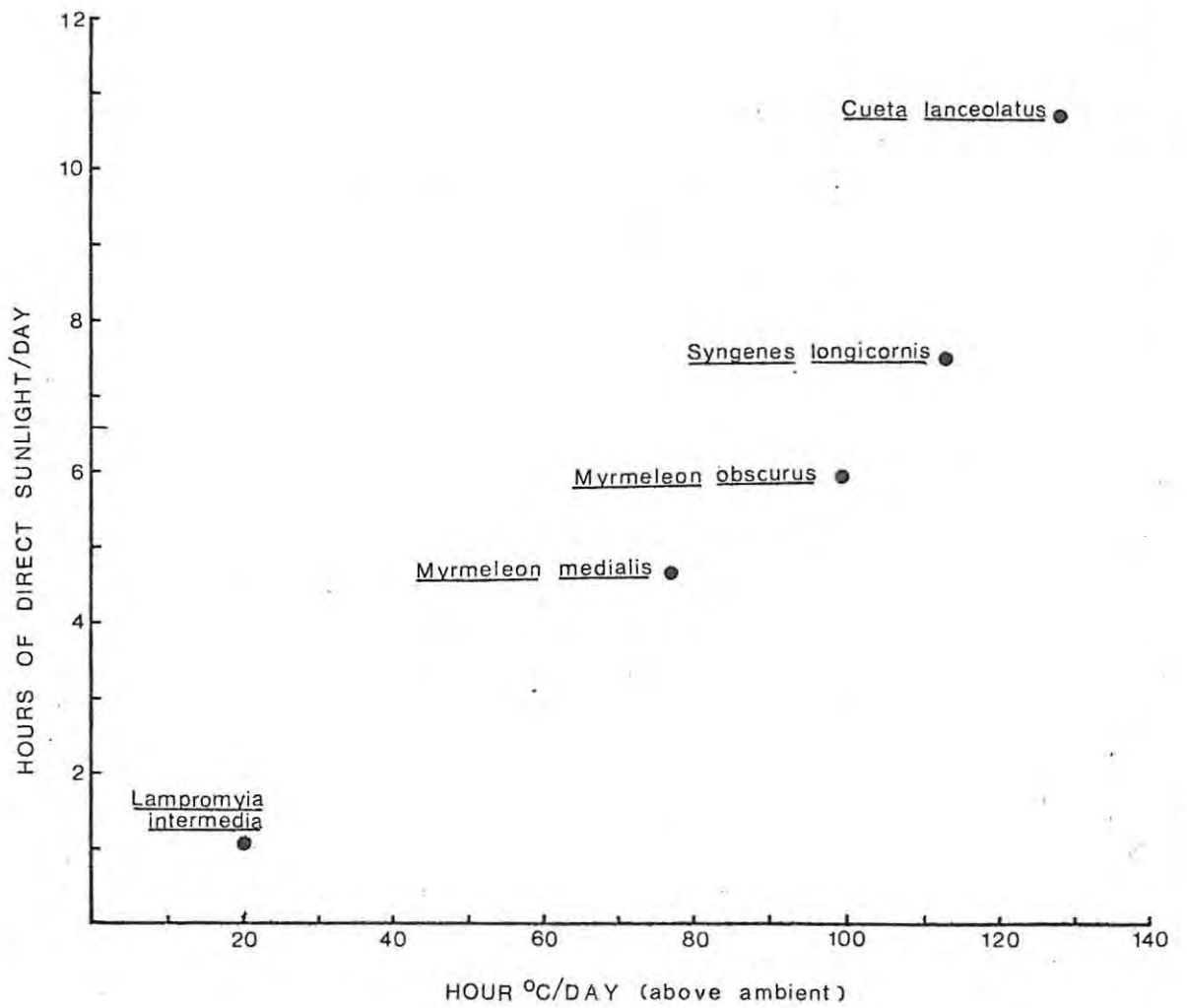


Fig. 23. The number of hours per day for which various myrmeleontid and rhagionid habitats were exposed to direct sunlight and the total daily (6 a.m. to 6 p.m.) rise in temperature of the sand at a depth of 1 cm. The temperature rise is expressed as hour degrees centigrade above the ambient temperature at 6 a.m.

Table 2a. The mean temperature ( $^{\circ}\text{C}$ ) of the air (1 cm. above the sand) and the sand at various depths in four myrmeleontid and one rhagionid habitat from 6 p.m. to 6 a.m. over a period of seven days. These data were obtained during the winter months of June and July, 1969.

Species	air	surface sand	1 cm.	3 cm.	5 cm.	7 cm.
<u>L.intermedia</u>	8,9	9,8	9,8	9,8	10,1	10,9
<u>M.medialis</u>	10,8	10,5	10,1	10,4	11,2	12,4
<u>M.obscurus</u>	11,7	12,0	12,0	12,0	12,4	12,6
<u>S.longicornis</u>	12,5	13,7	13,7	13,9	13,9	14,1
<u>C.lanceolatus</u>	9,6	9,6	10,0	10,5	11,6	12,0

Table 2b. The mean temperature ( $^{\circ}\text{C}$ ) of the air (1 cm. above the sand) and the sand at various depths in four myrmeleontid and one rhagionid habitat from 7 a.m. to 5 p.m. over a period of seven days. These data were obtained during the winter months of June and July, 1969.

Species	air	surface sand	1 cm.	3 cm.	5 cm.	7 cm.
<u>L. intermedia</u>	14,9	14,3	14,3	14,2	13,4	13,1
<u>M. medialis</u>	16,8	17,0	16,6	15,9	15,0	14,5
<u>M. obscurus</u>	20,2	23,1	21,3	20,0	19,7	18,8
<u>S. longicornis</u>	19,2	20,0	23,1	22,6	21,0	19,7
<u>C. lanceolatus</u>	22,3	24,1	23,6	22,2	20,6	18,9

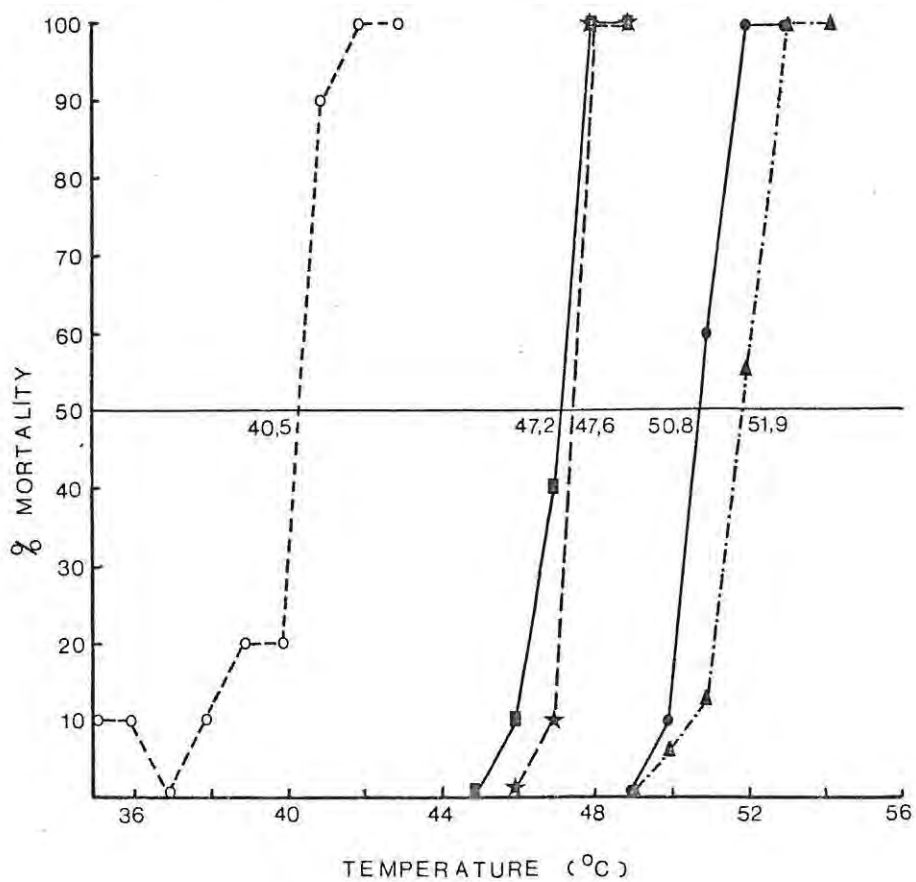
Fig. 24. The temperatures ( $^{\circ}\text{C}$ ) recorded in various parts of myrmeleontid and rhagionid pits at different times of the day. The pits are represented diagrammatically as circles, the inner circles representing the pit base. Each temperature is a mean of 10 readings. The direction of the sun's rays is indicated where applicable, while the sectional view of the pits indicates the angle of incidence of the sun's rays at each time of day. The temperature of the air 1 cm. above the surface and the temperature of the surface sand is also indicated.

TIME OF DAY		<u>Lampromyia intermedia</u>	<u>Myrmeleon medialis</u>	<u>Myrmeleon obscurus (shade)</u>	<u>Myrmeleon obscurus (sun)</u>	<u>Cueta lanceolatus</u>	SECTIONAL VIEW
10 am.	AIR TEMP.	28	26	22	29	33	
	SAND TEMP.	30	28	23	30	37	
	PIT TEMP.						
12 noon	AIR TEMP.	30	33	26	43	43	
	SAND TEMP.	30	34	26	46	49	
	PIT TEMP.						
2 pm.	AIR TEMP.	32	32	24	41	41	
	SAND TEMP.	32	34	23	47	45	
	PIT TEMP.						

Table 3. The average exposure to sunlight (A), the mean maximum sand temperature (B), the mean elevation of sand temperature at a depth of 1 cm. below the surface (C) and the maximum recorded pit temperatures (D) in various myrmeleontid and rhagionid habitats. These data are derived from Figures 18, 21, 22 and 24 respectively. The mean depth of soft surface sand in each habitat is also shown (E).

Species	A (hrs.)	B (°C)	C (hr°C/day)	D (°C)	E (mm.)
<u>L.intermedia</u>	1,13	28	20	32	42
<u>M.medialis</u>	4,65	38	76	35	48
<u>M.obscurus</u>	5,95	45	99	51	37
<u>S.longicornis</u>	7,46	48	113	-*	311
<u>C.lanceolatus</u>	10,75	51	128	51	13

\* S.longicornis is a non-pit-building species.



KEY

- *Lampromyia intermedia*
- *Myrmeleon medialis*
- ★-----★ *Myrmeleon obscurus*
- *Syngenes longicornis*
- ▲-----▲ *Cueta lanceolatus*

Fig. 25. The percentage mortality of various species of myrmeleontid and rhagionid larvae when exposed to high temperatures for a period of 24 hours, at a relative humidity of 90%.

Fig. 26. The mean survival time for groups of 10 individuals of various myrmeleontid and rhagionid species at different temperatures. Twice the standard errors are indicated.

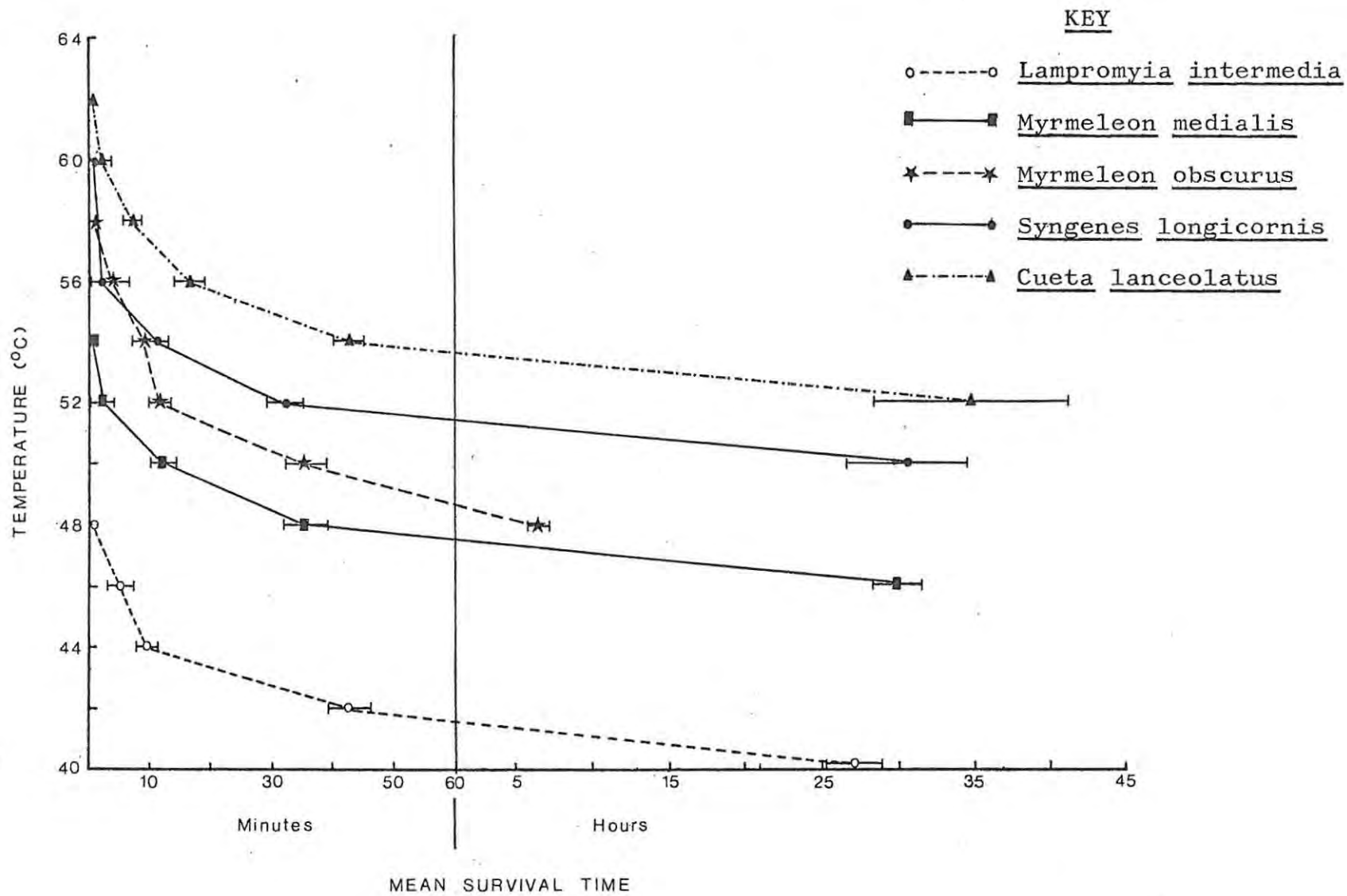


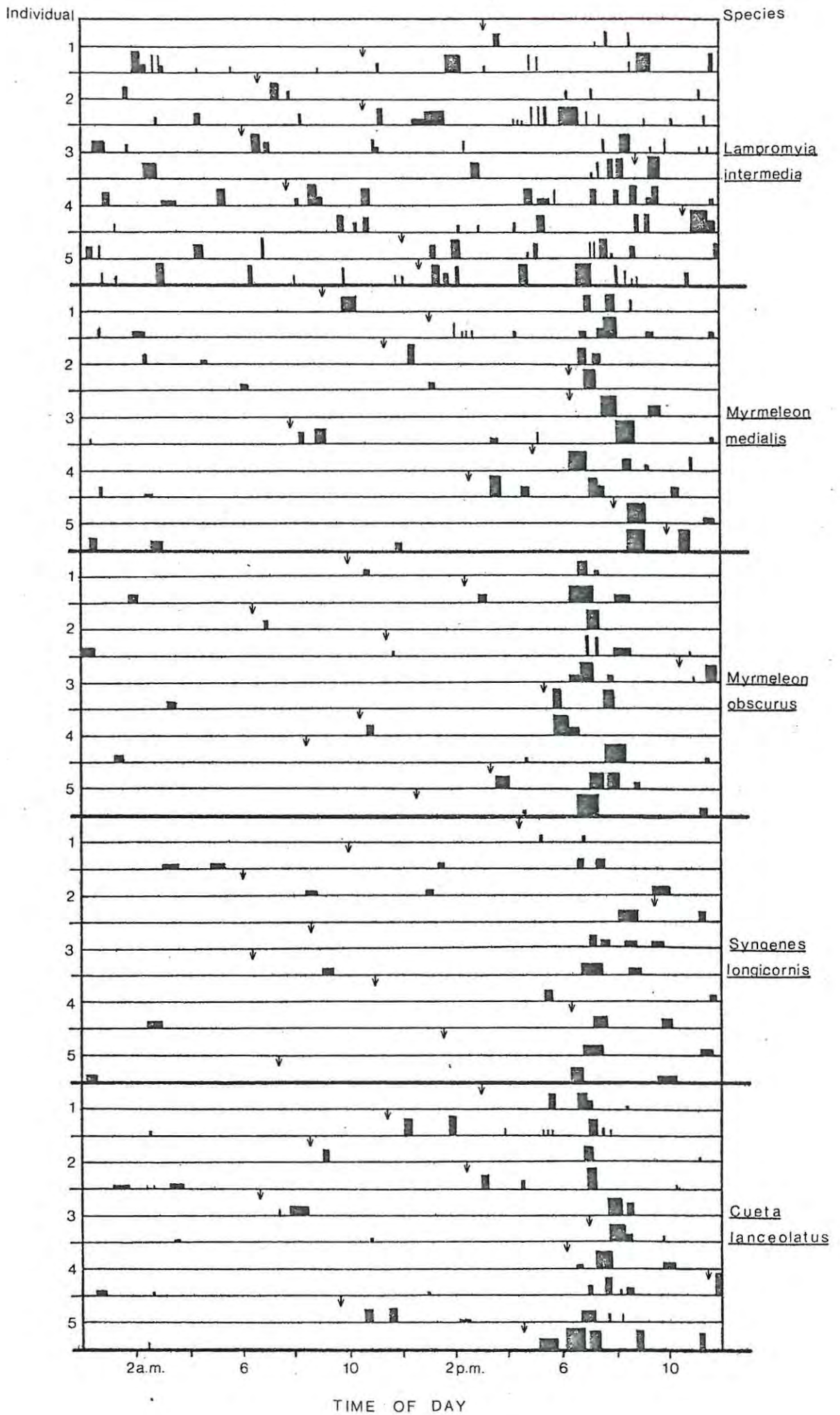
Table 4a. The maximum, minimum and mean survival times of groups of 10 myrmeleontid and rhagionid larvae when exposed to high temperatures at different times of the day. The standard errors are also given.

Species	Temp. (°C)	Time of day	Survival time (mins.)			
			max.	min.	mean	S.E.
<u>L. intermedia</u>	42	9 a.m.	44	36	39,4	± 0,9
		5 p.m.	43	34	38,2	± 0,9
		7 p.m.	40	29	36,2	± 1,0
<u>M. medialis</u>	48	9 a.m.	43	30	36,0	± 1,2
		5 p.m.	34	23	27,2	± 1,2
		7 p.m.	28	19	24,7	± 1,0
<u>M. obscurus</u>	50	9 a.m.	51	18	36,5	± 1,2
		2 p.m.	45	20	33,9	± 2,6
		3 p.m.	37	19	26,7	± 1,8
		4 p.m.	19	8	13,1	± 0,9
		5 p.m.	13	7	10,1	± 0,7
		7 p.m.	13	6	9,2	± 0,7
<u>S. longicornis</u>	52	9 a.m.	38	29	33,8	± 1,0
		5 p.m.	30	17	23,2	± 1,5
		7 p.m.	30	20	24,7	± 1,0
<u>C. lanceolatus</u>	54	9 a.m.	49	34	42,3	± 1,6
		5 p.m.	31	20	26,1	± 1,2
		7 p.m.	30	20	24,7	± 1,0

Table 4b. Results of statistical analysis of the survival times of groups of 10 myrmeleontid and rhagionid larvae when exposed to high temperatures at different times of the day (from Table 4a). For L.intermedia, for example, the survival time at 9.00 a.m. is compared with that at 5.00 p.m. and also the survival time at 5.00 p.m. is compared with that at 7.00 p.m. The values of "t" and the probability "p" are given.

Species	Time of day	t	p
<u>L.intermedia</u>	9 a.m. cf. to 5 p.m.	0,82	>0,1
	5 p.m. cf. to 7 p.m.	1,37	>0,1
<u>M.medialis</u>	9 a.m. cf. to 5 p.m.	4,85	<0,001
	5 p.m. cf. to 7 p.m.	1,66	<0,1 >0,2
<u>M.obscurus</u>	9 a.m. cf. to 2 p.m.	0,52	>0,1
	9 a.m. cf. to 5 p.m.	6,32	<0,001
	2 p.m. cf. to 3 p.m.	2,14	<0,05 >0,02
	3 p.m. cf. to 4 p.m.	6,37	<0,001
	4 p.m. cf. to 5 p.m.	3,38	<0,01 >0,001
	5 p.m. cf. to 7 p.m.	0,90	>0,1
<u>S.longicornis</u>	9 a.m. cf. to 5 p.m.	5,58	<0,001
	5 p.m. cf. to 7 p.m.	0,04	>0,1
<u>C.lanceolatus</u>	9 a.m. cf. to 5 p.m.	7,70	<0,001
	5 p.m. cf. to 7 p.m.	0,84	>0,1

Fig. 27. The daily activity of various myrmeleontid and rhagionid species under normal laboratory daylight-dark conditions. Five individuals of each species were used and the activity of each individual was recorded for two days. Activity is represented as dark blocks. The height of each block is proportional to the deflection recorded on the original trace. The times of feeding and pit destruction are indicated by arrows.



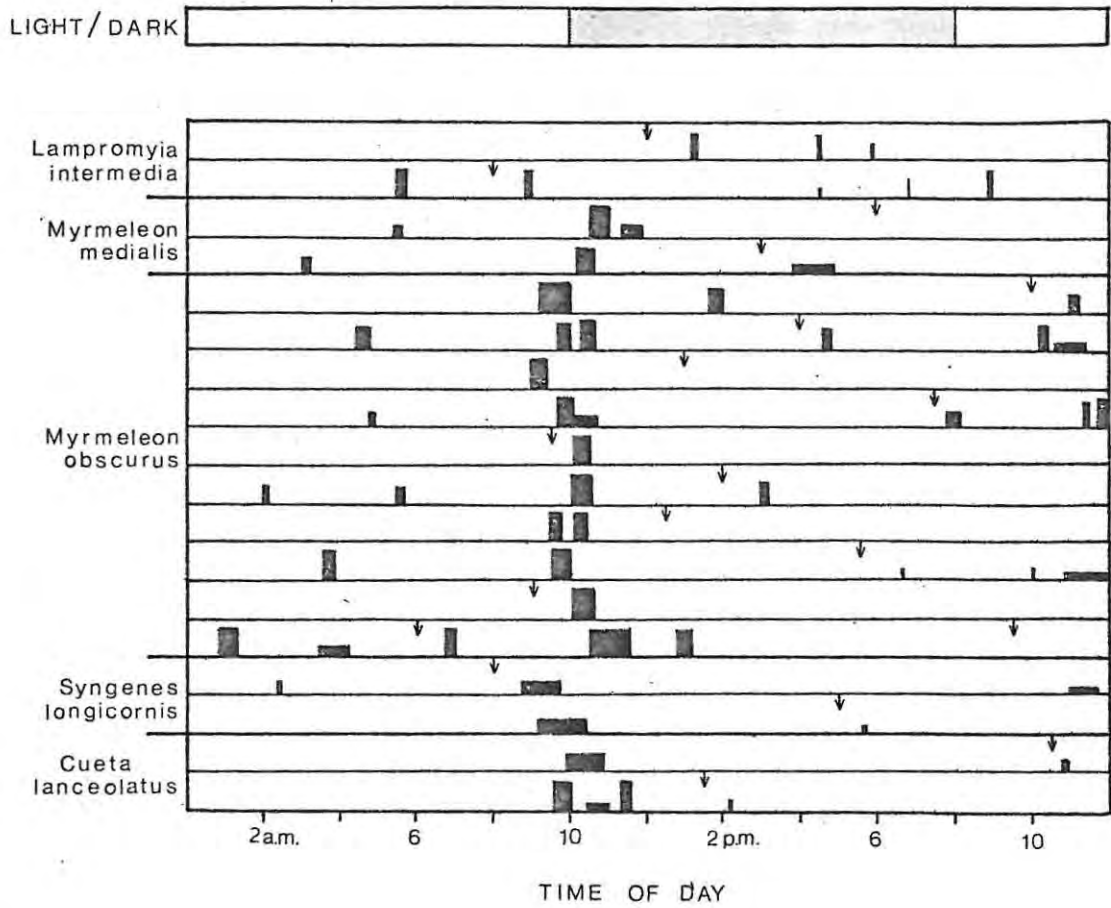


Fig. 28. The daily activity of various myrmeleontid and rhagionid larvae under a reversed light regime. The activity of each individual was recorded for two days. The larvae were each fed one ant a day at times which were randomly determined and which are indicated by arrows.

Table 5. The maximum, minimum and mean survival times of various myrmeleontid and rhagionid larvae at different times of the day when exposed to high temperatures. Results which have been compared by means of "Student's t" are bracketed together and the values of "t" and "p" are given. All the larvae were placed in a reversed light regime for 14 days prior to the experiment and the new "induced" activity peak was at 10 a.m.

Species	No. of larvae	Temp. (°C)	Time of day	Survival time (mins.)				
				max.	min.	mean	t	p
<u>M. obscurus</u>	10	50	10 a.m.	17	12	14,3	-10,92	<0,001
	10		5 p.m.	29	21	25,3		
	10		7 p.m.	27	20	23,6		
<u>L. intermedia</u>	5	42	10 a.m.	44	35	38,2		
	5		5 p.m.	47	29	39,4		
<u>M. medialis</u>	3	48	10 a.m.	29	15	21,7		
	3		5 p.m.	46	28	35,2		
<u>S. longicornis</u>	3	52	10 a.m.	32	13	22,3		
	3		5 p.m.	43	28	36,9		
<u>C. lanceolatus</u>	3	54	10 a.m.	30	12	24,5		
	3		5 p.m.	46	31	38,8		

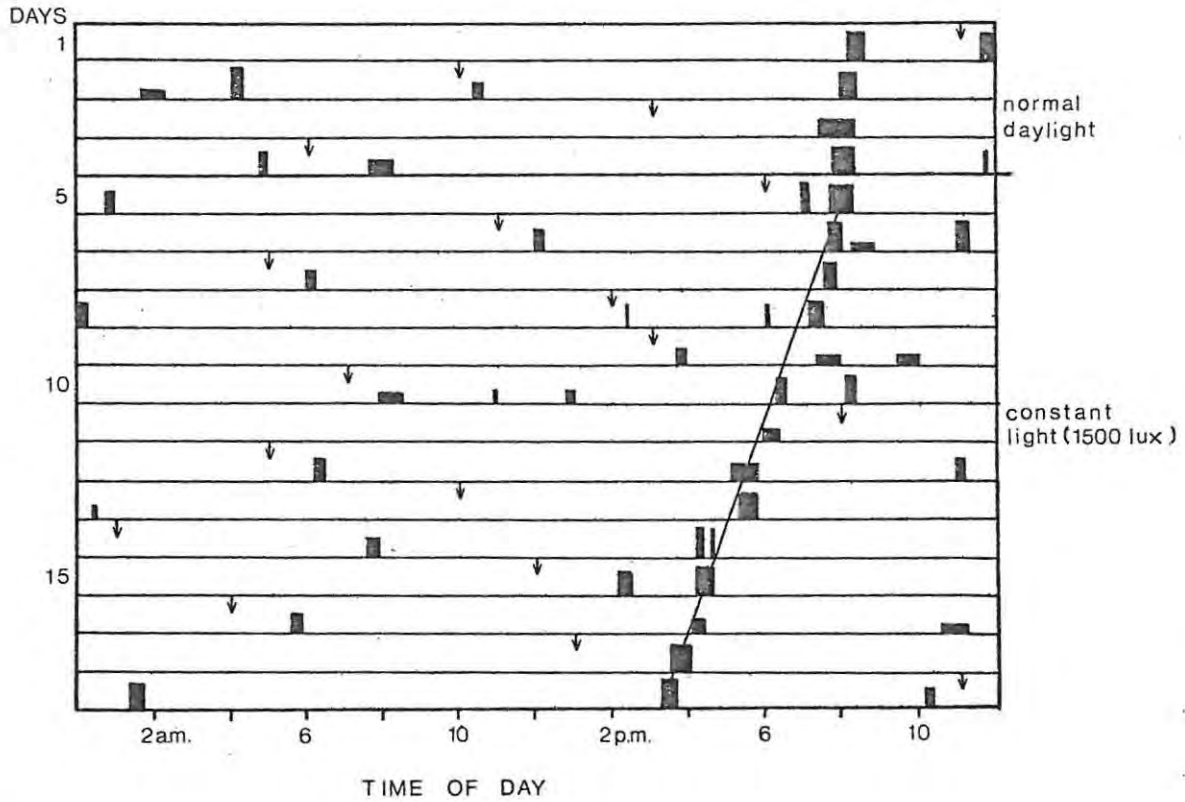


Fig. 29. The daily activity of a Myrmeleon obscurus larva under normal laboratory daylight conditions and in constant light of approximately 1500 lux. The ant-lion was fed one ant a day at times which were randomly determined and which are indicated on the figure by means of arrows.

Table 6. The mean survival time at 50°C of 10 Myrmeleon obscurus larvae at various times of the day. The larvae were maintained in constant light of approximately 1500 lux for a period of two weeks prior to the experiment and the new "induced" activity peak was at 4 p.m. The values of "Student's t" and the probability "p" are given.

Time of day	Mean survival time (mins.)	Statistical analysis		
			t	p
9 a.m.	13,4 $\pm$ 0,99	9 a.m. cf. to 7 p.m.	0,11	>0,1
4 p.m.	9,1 $\pm$ 0,99	9 a.m. cf. to 4 p.m.	2,89	<0,01 >0,001
7 p.m.	13,2 $\pm$ 1,35	4 p.m. cf. to 7 p.m.	2,32	<0,05 >0,02

Table 7. The mean difference ( $^{\circ}\text{C}$ ) between the internal temperature of groups of five myrmeleontid and rhagionid larvae and the ambient temperature at 100% relative humidity. The rate of temperature rise was about  $2^{\circ}\text{C}/10$  minutes. Minus signs indicate that the internal temperature of the larvae was lower than ambient, while plus signs indicate that the internal temperature of the larvae was above ambient.

Temp. ( $^{\circ}\text{C}$ )	<u>L. intermedia</u>	<u>M. medialis</u>	<u>M. obscurus</u>	<u>S. longicornis</u>	<u>C. lanceolatus</u>
22	0,0	-0,1	-0,2	-0,1	0,0
24	-0,2	0,0	-0,1	-0,3	0,0
26	+0,1	-0,1	+0,2	0,0	+0,2
28	0,0	-0,1	+0,1	0,0	+0,1
30	+0,1	0,0	+0,2	+0,3	+0,1
32	+0,2	0,0	+0,1	-0,1	+0,3
34	+0,1	0,0	0,0	+0,2	+0,6
36	0,0	+0,2	+0,2	+0,2	+0,3
38	0,0	+0,1	+0,2	+0,1	+0,2
40	0,0	+0,1	0,0	+0,1	+0,3
42	+0,1	+0,2	+0,2	+0,1	+0,2
44	0,0	-0,1	0,0	+0,4	+0,1
46	0,0	+0,2	+0,2	+0,1	+0,2
48	+0,2	+0,1	+0,1	+0,3	+0,1
50	+0,1	-0,1	0,0	+0,2	+0,3
52	+0,1	0,0	+0,1	+0,2	+0,2
54	+0,1	+0,1	+0,1	+0,1	+0,2
56	-0,1	+0,2	+0,1	+0,2	0,0

Table 8. The mean difference ( $^{\circ}\text{C}$ ) between the internal temperature of groups of five myrmeleontid and rhagionid larvae and the ambient temperature at 0% relative humidity. The rate of temperature rise was about  $2^{\circ}\text{C}/10$  minutes. Minus signs indicate that the internal temperature of the larvae was lower than ambient, while plus signs indicate that the internal temperature of the larvae was above ambient.

Temp. ( $^{\circ}\text{C}$ )	<u>L. intermedia</u>	<u>M. medialis</u>	<u>M. obscurus</u>	<u>S. longicornis</u>	<u>C. lanceolatus</u>
22	-0,2	-0,3	-0,5	-0,5	-0,3
24	-0,2	-0,4	-0,6	-0,4	-0,4
26	0,0	0,0	-0,5	-0,1	-0,4
28	-0,1	-0,5	-0,1	-0,6	-0,4
30	-0,1	-0,8	-0,6	-0,5	-0,4
32	-0,1	-1,2	-0,8	-0,5	-0,3
34	+0,1	-1,9	-1,0	-0,6	-0,6
36	+0,2	-1,8	-0,8	-0,7	-0,3
38	0,0	-0,5	-0,8	-0,7	-0,3
40	+0,3	-1,1	-0,8	-0,8	-0,3
42	+0,1	-1,2	-0,9	-1,2	-0,5
44	0,0	-1,2	-0,9	-1,0	-0,4
46	0,0	-1,2	-0,9	-0,9	-0,3
48	+0,1	-1,0	-0,2	-1,2	-0,3
50	0,0	-0,6	-0,6	-0,8	-0,2
52	0,0	-0,3	-0,6	-0,5	-0,3
54	+0,1	-0,2	-0,3	-0,1	-0,2
56	0,0	-0,2	-0,2	-0,1	-0,1

Table 9. The upper lethal temperature limits of groups of 10 larvae of various myrmeleontid and rhagionid species at 0% and 100% relative humidity. The maximum, minimum and mean values are given together with the standard errors. The results at both humidities for each species were compared statistically by means of "Student's t" and the values of "t" and the probability "p" are given.

Species	Lethal temp. (°C) at 0% RH				Lethal temp. (°C) at 100% RH				t	p
	max.	min.	mean	S.E.	max.	min.	mean	S.E.		
<u>L.intermedia</u>	44,5	41,0	42,5	± 0,37	44,5	40,0	41,9	± 0,45	0,98	>0,1
<u>M.medialis</u>	52,0	49,0	50,4	± 0,32	51,5	47,0	48,6	± 0,33	3,70	<0,01 >0,001
<u>M.obscurus</u>	55,5	51,0	53,2	± 0,45	54,0	50,0	51,8	± 0,40	2,18	<0,05 >0,02
<u>S.longicornis</u>	57,5	54,0	56,0	± 0,35	56,5	53,0	54,9	± 0,36	2,09	<0,1 >0,05
<u>C.lanceolatus</u>	58,0	55,0	56,2	± 0,31	57,0	54,5	55,6	± 0,25	1,42	>0,1

Table 10. The highest average surface sand temperatures (mean of seven days, from Fig. 21) and the maximum observed sand temperatures (mean of 10 readings) in various myrmeleontid and rhagionid habitats. The mean lethal temperature of the various larvae during an exposure period of five hours (from Fig. 26) is also shown.

Species	Surface sand temp. (°C)		Mean lethal temp. (°C)
	mean	max.	
<u>L.intermedia</u>	28,5	35,0	41,4
<u>M.medialis</u>	38,0	50,1	47,3
<u>M.obscurus</u>	45,9	61,5	48,2
<u>S.longicornis</u>	48,0	56,3	51,2
<u>C.lanceolatus</u>	51,1	65,5	53,4

Table 11. The distribution of larvae of four species of Myrmeleontidae and one species of Rhagionidae when placed in evenly lighted (1500 lux) and heated ( $30 \pm 1^{\circ}\text{C}$ ) sand. 60 larvae of each species were used and their positions with respect to six numbered squares of sand determined after a period of two days. The values of  $\chi^2$  and the probability (p) are given for each species.

Square	<u>L. intermedia</u>	<u>M. medialis</u>	<u>M. obscurus</u>	<u>S. longicornis</u>	<u>C. lanceolatus</u>
1	9,5*	10,0	8,0	10,0	11,0
2	8,0	10,0	6,0	11,0	6,5
3	12,0	7,0	14,0	11,0	10,5
4	10,0	11,0	10,0	9,0	11,0
5	13,0	12,0	12,0	10,0	14,0
6	7,5	10,0	10,0	9,0	7,0
$\chi^2$	2,4	1,4	4,0	0,4	3,1
p	<0,80 >0,70	<0,95 >0,90	<0,70 >0,50	>0,99	<0,70 >0,50

\* A non-integer denotes larvae midway between two squares.

Table 12a. The responses of the larvae of Lampromyia intermedia to light of various intensities at three different sand temperatures. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in the light and shade is indicated together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

Sand temperature (°C)	30				35				45			
Light intensity (lux)	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
No. of larvae in light	26,5*	21,5 ↓	19,0 ↓	15,0 ↓	29,0	19,5 ↓	17,5 ↓	14,5 ↓				
No. of larvae in shade	33,5	38,5 ↓	41,0 ↓	45,0 ↓	31,0	40,5 ↓	42,5 ↓	45,5 ↓	100% of larvae dead			
$\chi^2$	0,6	4,3	7,4	14,0	0,02	6,7	9,6	15,0				
p	<0,50 >0,30	<0,05 >0,02	<0,01 >0,001	<0,001	<0,90 >0,80	<0,01 >0,001	<0,01 >0,001	<0,001				

\* A non-integer denotes larvae midway between two squares.

Table 12b. The responses of the larvae of Lampromyia intermedia to sand temperature gradients. The sand was heated from above with infra-red lights suspended at various heights and lighted with lamps of various intensities. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in heated and lighted sand and the number of larvae found in the shade is indicated, together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

	A	B	C	D	E	F	G
Height of infra-red lights (cm.)	60	50	40	50	50	50	50
Light intensity (lux)	dark	dark	dark	200	600	1200	14000
Temp. in "light" (°C)	33	38	53	38	38	38	38
Temp. in shade (°C)	26	29	34	29	29	29	29
No. of larvae in "light"	31,0	20,0 ↓	55% of larvae dead	21,0 ↓	16,0 ↓	20,0 ↓	12,0 ↓
No. of larvae in shade	29,0	40,0 ↓		39,0 ↓	44,0 ↓	40,0 ↓	48,0 ↓
$\chi^2$	0,02	6,0		4,8	12,2	6,0	20,4
p	<0,90 >0,80	<0,02 >0,01		<0,05 >0,02	<0,001	<0,02 >0,01	<0,001

Table 13a. The responses of the larvae of Myrmeleon medialis to light of various intensities at three different sand temperatures. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in the light and shade is indicated together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

Sand temperature (°C)	30				35				45			
	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
Light intensity (lux)	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
No. of larvae in light	27,0	31,5*	26,0	20,0	34,0	24,0	27,0	18,0	27,5	36,0	20,5	21,0
No. of larvae in shade	33,0	28,5	34,0	40,0 ↓	26,0	36,0	33,0	42,0 ↓	32,5	24,0	39,5 ↓	39,0 ↓
$\chi^2$	0,4	0,1	0,8	6,0	0,8	2,0	0,4	8,8	0,3	2,0	5,4	4,8
p	<0,70 >0,50	<0,80 >0,70	<0,50 >0,30	<0,02 >0,01	<0,50 >0,30	<0,20 >0,10	<0,70 >0,50	<0,01 >0,001	<0,70 >0,50	<0,20 >0,10	<0,05 >0,02	<0,05 >0,02

\* A non-integer denotes larvae midway between two squares.

Table 13b. The responses of the larvae of Myrmeleon medialis to sand temperature gradients. The sand was heated from above with infra-red lights suspended at various heights and lighted with lamps of various intensities. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in heated and lighted sand and the number of larvae found in the shade is indicated, together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

	A	B	C	D	E	F	G
Height of infra-red lights (cm.)	60'	50	40	50	50	50	50
Light intensity (lux)	dark	dark	dark	200	600	1200	14000
Temp. in "light" (°C)	33	38	53	38	38	38	38
Temp. in shade (°C)	26	29	34	29	29	29	29
No. of larvae in "light"	28,5*	21,0 ↓	15,0 ↓	19,0 ↓	20,5 ↓	17,5 ↓	17,0 ↓
No. of larvae in shade	31,5	39,0 ↓	45,0 ↓	41,0 ↓	39,5 ↓	42,5 ↓	43,0 ↓
$\chi^2$	0,1	4,8	14,0	7,4	5,4	9,6	10,4
p	<0,80 >0,70	<0,05 >0,02	<0,001	<0,01 >0,001	<0,05 >0,02	<0,01 >0,001	<0,01 >0,001

\* A non-integer denotes larvae midway between two squares.

Table 14a. The responses of the larvae of Myrmeleon obscurus to light of various intensities at three different sand temperatures. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in the light and shade is indicated together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

Sand temperature (°C)	30				35				45			
	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
Light intensity (lux)	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
No. of larvae in light	29,5*	27,0	32,0	34,0	27,5	25,5	32,0	38,5	29,0	27,5	27,5	21,5
No. of larvae in shade	30,5	33,0	28,0	26,0	32,5	34,5	28,0	21,5	31,0	32,5	32,5	38,5
$\chi^2$	0,0	0,4	0,2	0,8	0,3	1,1	0,2	4,3	0,02	0,3	0,3	4,3
p	>0,99	<0,70 >0,50	<0,70 >0,50	<0,50 >0,30	<0,70 >0,50	<0,30 >0,20	<0,70 >0,50	<0,05 >0,02	<0,90 >0,80	<0,70 >0,50	<0,70 >0,50	<0,05 >0,02

\* A non-integer denotes larvae midway between two squares.

Table 14b. The responses of the larvae of Myrmeleon obscurus to sand temperature gradients. The sand was heated from above with infra-red lights suspended at various heights and lighted with lamps of various intensities. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in heated and lighted sand and the number of larvae found in the shade is indicated, together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

	A	B	C	D	E	F	G
Height of infra-red lights (cm.)	60	50	40	50	50	50	50
Light intensity (lux)	dark	dark	dark	200	600	1200	14000
Temp. in "light" (°C)	33	38	53	38	38	38	38
Temp. in shade (°C)	26	29	34	29	29	29	29
No. of larvae in "light"	30,0	27,5*	21,0 ↓	42,5 ↑	39,5 ↑	38,5 ↑	40,0 ↑
No. of larvae in shade	30,0	32,5	39,0 ↓	17,5 ↑	20,5 ↑	21,5 ↑	20,0 ↑
$\chi^2$	0,0	0,3	4,8	9,6	5,4	4,3	6,0
p	>0,99	<0,70 >0,50	<0,05 >0,02	<0,01 >0,001	<0,05 >0,02	<0,05 >0,02	<0,02 >0,01

\* A non-integer denotes larvae midway between two squares.

Table 15a. The responses of the larvae of Syngenes longicornis to light of various intensities at three different sand temperatures. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in the light and shade is indicated together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

Sand temperature (°C)	30				35				45			
	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
Light intensity (lux)	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
No. of larvae in light	32,0	38,0	39,0	42,0	36,0	39,0	42,0	43,0	26,0	33,0	20,0	20,0
No. of larvae in shade	28,0	22,0	21,0	18,0	24,0	21,0	18,0	17,0	34,0	27,0	40,0	40,0
$\chi^2$	0,2	3,8	4,8	8,8	2,0	4,8	8,8	10,4	0,8	0,4	6,0	6,0
p	<0,70 >0,50	<0,10 >0,05	<0,05 >0,02	<0,01 >0,001	<0,20 >0,10	<0,05 >0,02	<0,01 >0,001	<0,01 >0,001	<0,50 >0,30	<0,70 >0,50	<0,02 >0,01	<0,02 >0,01

Table 15b. The responses of the larvae of Syngenes longicornis to sand temperature gradients. The sand was heated from above with infra-red lights suspended at various heights and lighted with lamps of various intensities. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in heated and lighted sand and the number of larvae found in the shade is indicated, together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

	A	B	C	D	E	F	G
Height of infra-red lights (cm.)	60	50	40	50	50	50	50
Light intensity (lux)	dark	dark	dark	200	600	1200	14000
Temp. in "light" (°C)	33	38	53	38	38	38	38
Temp. in shade (°C)	26	29	34	29	29	29	29
No. of larvae in "light"	29,0	44,0	20,0	44,0	48,0	44,0	45,0
No. of larvae in shade	31,0	16,0 ↑	40,0 ↓	16,0 ↑	12,0 ↑	16,0 ↑	15,0 ↑
$\chi^2$	0,02	12,2	6,0	12,2	20,4	12,2	14,0
p	<0,90 >0,80	<0,001	<0,02 >0,01	<0,001	<0,001	<0,001	<0,001

Table 16a. The responses of the larvae of Cueta lanceolatus to light of various intensities at three different sand temperatures. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in the light and shade is indicated together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

Sand temperature (°C)	30				35				45			
Light intensity (lux)	200	600	1200	14000	200	600	1200	14000	200	600	1200	14000
No. of larvae in light	30,0	34,0	29,5*	34,0	32,0	30,5	35,0	39,5	32,5	32,0	27,5	26,0
No. of larvae in shade	30,0	26,0	30,5	26,0	28,0	29,5	25,0	20,5	27,5	28,0	32,5	34,0
$\chi^2$	0,0	0,8	0,0	0,8	0,2	0,0	1,4	5,4	0,3	0,2	0,3	0,8
p	>0,99	<0,50 >0,30	>0,99	<0,50 >0,30	<0,70 >0,50	>0,99	<0,30 >0,20	<0,05 >0,02	<0,70 >0,50	<0,70 >0,50	<0,70 >0,50	<0,50 >0,30

\* A non-integer denotes larvae midway between two squares.

Table 16b. The responses of the larvae of Cueta lanceolatus to sand temperature gradients. The sand was heated from above with infra-red lights suspended at various heights and lighted with lamps of various intensities. 60 larvae were exposed at each set of conditions and their responses noted after a period of two days. The number of larvae found in heated and lighted sand and the number of larvae found in the shade is indicated, together with the values of  $\chi^2$  and the probability (p). Statistically significant results are indicated by arrows; movement from light to shade is indicated by ↓ and movement from shade to light by ↑.

	A	B	C	D	E	F	G
Height of infra-red lights (cm.)	60	50	40	50	50	50	50
Light intensity (lux)	dark	dark	dark	200	600	1200	14000
Temp. in "light" (°C)	33	38	53	38	38	38	38
Temp. in shade (°C)	26	29	34	29	29	29	29
No. of larvae in "light"	32,0	41,5*	33,0	46,0	41,5	48,5	43,5
No. of larvae in shade	28,0	18,5 ↑	27,0	14,0 ↑	18,5 ↑	11,5 ↑	16,5 ↑
$\chi^2$	0,2	8,1	0,4	16,0	8,1	21,6	11,3
p	<0,70 >0,50	<0,01 >0,001	<0,70 >0,50	<0,001	<0,01 >0,001	<0,001	<0,001

\* A non-integer denotes larvae midway between two squares.

Table 17. The percentage of pits in which no myrmeleontid and rhagionid larvae were found at various times of the day. The mean temperatures of the warmest sides of the pits are also given. These data were obtained from an examination of 50 pits of each species at each time of day.

Species	Time of day	Mean temp. (°C)	% pits without larvae
<u>L. intermedia</u>	10 a.m.	31,4	0
	12 noon	29,4	1
	2 p.m.	31,9	0
<u>M. medialis</u>	10 a.m.	29,4	4
	12 noon	35,6	2
	2 p.m.	33,0	2
<u>M. obscurus</u>	10 a.m.	32,6	4
	12 noon	47,4	49
	2 p.m.	46,0	54
<u>C. lanceolatus</u>	10 a.m.	38,0	2
	12 noon	50,3	37
	2 p.m.	49,5	35

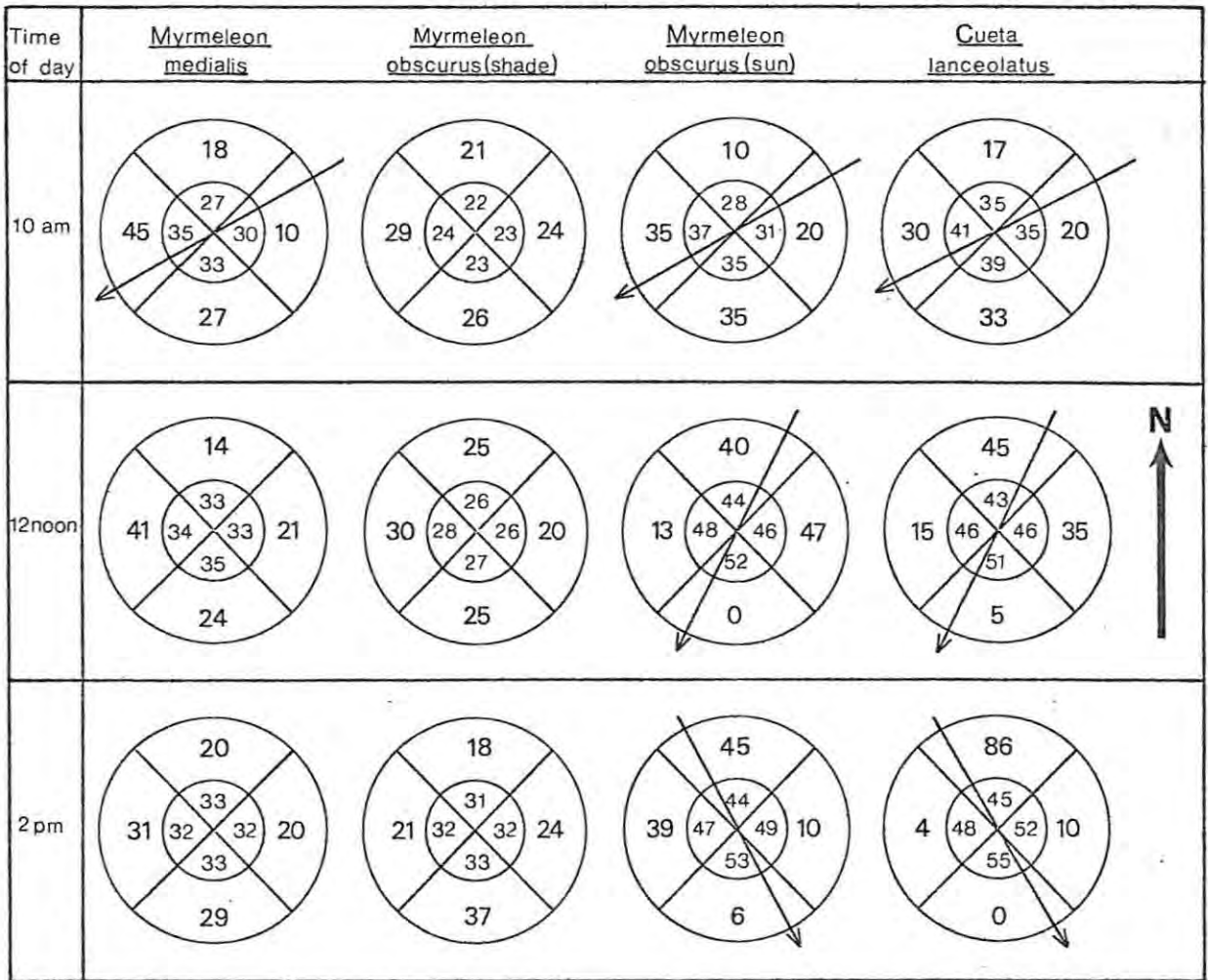


Fig. 30. The percentage of myrmeleontid larvae in various quadrants of their pits at different times of the day (bold figures). The pits are represented diagrammatically as circles and the mean temperature ( $^{\circ}\text{C}$ ) of each quadrant is given in the inner circle. The direction of the sun's rays is indicated by arrows where applicable.

Table 18a. The number of myrmeleontid and rhagionid larvae in the north (N), south (S), east (E) and west (W) quadrants of their pits when heated with infra-red lights placed at a height of 60 cm. and three different angles of incidence (I). The pits were heated from the north side. 20 larvae of each species were used in each replicate. The values of Chi-square ( $\chi^2$ ) and the probability (p) are indicated. Statistically significant movement of the larvae to any particular quadrant is indicated by an arrow.

I	Quadrant	Mean temp. (°C)	<u>L.intermedia</u>	<u>M.medialis</u>	<u>M.obscurus</u>	<u>C.lanceolatus</u>
90°	N	34,2	10*	5	4	3
	S	33,4		4	5	6
	E	33,8	10	5	6	5
	W	33,6		6	5	6
		$\chi^2$	-	0,10	0,10	0,55
	p	-	>0,99	>0,99	<0,95	
60°	N	27,0	4	2	1	0
	S	34,5		16 ←	9	14 ←
	E	31,7	16 ←	1	5	3
	W	31,4		1	5	3
		$\chi^2$	6,00	28,60	4,90	19,40
	p	<0,02	<0,001	<0,02	<0,001	
		>0,01		>0,01		
40°	N	27,4	5	2	1	0
	S	34,4		13 ←	11 ←	17 ←
	E	29,8	15 ←	3	5	2
	W	30,4		2	3	1
		$\chi^2$	4,00	14,20	8,95	34,20
	p	<0,05	<0,01	<0,05	<0,001	
		>0,02	>0,001	>0,02		

\* The larvae of L.intermedia normally lie with their bodies stretched diagonally across the bases of the pits and were therefore recorded as being either in the north-south or east-west quadrants.

Table 18b. The number of myrmeleontid and rhagionid larvae in the north (N), south (S), east (E) and west (W) quadrants of their pits when heated with infra-red lights placed at a height of 40cm. and three different angles of incidence (I). The pits were heated from the north side. 20 larvae of each species were used in each replicate. The number of larvae which had migrated downwards into the sand away from their pits is given (B), while the number of dead larvae is indicated in parentheses. No statistical analysis could be performed on these results due to the large number of fatalities.

I	Quadrant		Mean temp. (°C)	<u>L.intermedia</u>	<u>M.medialis</u>	<u>M.obscurus</u>	<u>C.lanceolatus</u>
90°	N		53,1		0	1	3
	S		53,5	(10)*	0(1)	0	2
	E		54,3		0(2)	0	1
	W		52,8	(10)	0	1	2
		B			0	17	18
60°	N		42,3		5	14	3
	S		55,2	(10)	0(2)	0(1)	0
	E		49,4		0	1	10
	W		50,0	(8)	0	0	7
		B			2	13	4
40°	N		36,9		8	13	4
	S		52,7	1(12)	0	0	1
	E		44,6		2	1	7
	W		46,4	(4)	0	0	8
		B			3	10	6

\* The larvae of L.intermedia normally lie with their bodies stretched diagonally across the bases of the pits and were therefore recorded as being either in the north-south or east-west quadrants.



Table 19a. The number of myrmeleontid larvae in the north (N), south (S), east (E) and west (W) quadrants of their pits when exposed to light of various intensities. The light was at an angle of  $90^{\circ}$  and the sand temperature was maintained at  $18 \pm 3^{\circ}\text{C}$ . 20 individuals were used in each replicate. The values of Chi-square ( $\chi^2$ ) and the probability (p) are given.

Light intensity (lux)	Quadrant		<u>M. medialis</u>	<u>M. obscurus</u>	<u>C. lanceolatus</u>
600	N		4	3	8
	S		3	5	4
	E		6	7	4
	W		7	5	4
		$\chi^2$	1,00	0,80	1,40
		p	0,80	<0,90 >0,80	<0,80 >0,70
1200	N		4	6	5
	S		8	6	3
	E		4	4	7
	W		4	4	5
		$\chi^2$	1,40	0,20	0,90
		p	<0,80 >0,70	<0,98 >0,95	<0,90 >0,80
14000	N		5	3	4
	S		6	7	6
	E		4	5	4
	W		5	5	6
		$\chi^2$	0,10	0,90	0,20
		p	0,80	<0,90 >0,80	<0,98 >0,95

Table 19b. The number of myrmeleontid larvae in the north (N), south (S), east (E) and west (W) quadrants of their pits when exposed to light of various intensities. The light was at an angle of  $90^{\circ}$  and the sand temperature was maintained at  $35 \pm 1^{\circ}\text{C}$ . 20 individuals of each species were used in each replicate. The values of Chi-square ( $\chi^2$ ) and the probability (p) are given.

Light intensity (lux)	Quadrant		<u>M. medialis</u>	<u>M. obscurus</u>	<u>C. lanceolatus</u>
600	N		7	7	3
	S		4	4	5
	E		6	5	7
	W		3	4	5
		$\chi^2$	1,00	0,55	0,90
		p	0,80	<0,95 >0,90	<0,90 >0,80
1200	N		4	4	6
	S		3	4	3
	E		6	6	7
	W		7	6	4
		$\chi^2$	1,00	0,20	1,00
		p	0,80	<0,98 >0,95	0,80
14000	N		4	5	6
	S		4	5	4
	E		5	5	7
	W		7	5	3
		$\chi^2$	0,55	0,00	1,00
		p	<0,95 >0,90	>0,99	0,80

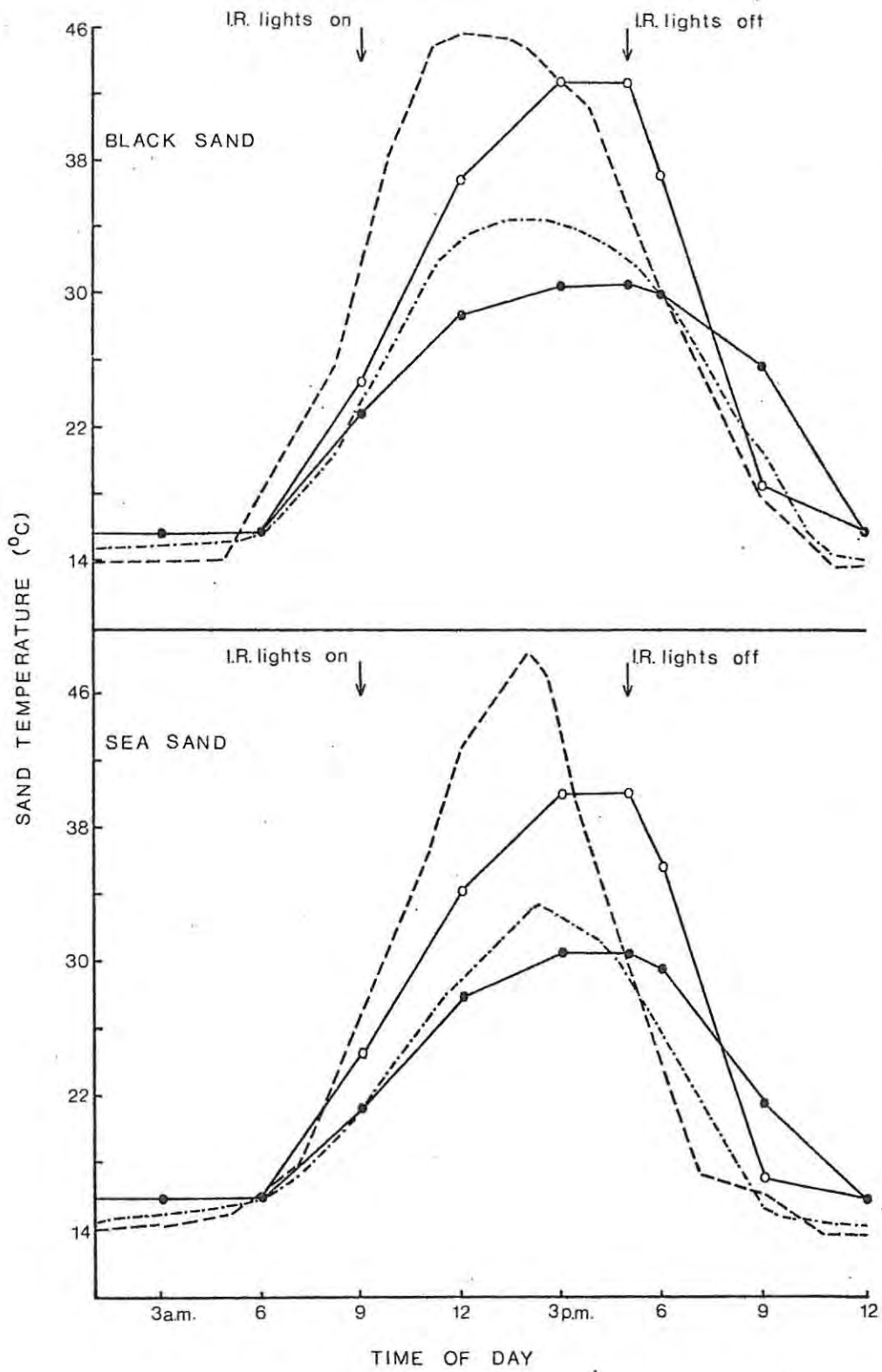
Table 19c. The number of myrmeleontid larvae in the north (N), south (S), east (E) and west (W) quadrants of their pits when exposed to light of various intensities. The light was at an angle of  $40^{\circ}$  and shone from the north. The sand temperature was maintained at  $18 \pm 3^{\circ}\text{C}$ . 20 individuals of each species were used in each replicate. The values of Chi-square ( $\chi^2$ ) and the probability (p) are given. Statistically significant movement of larvae to any particular quadrant is indicated by an arrow.

Light intensity (lux)	Quadrant		<u>M. medialis</u>	<u>M. obscurus</u>	<u>C. lanceolatus</u>
600	N		5	7	8
	S		5	4	3
	E		4	3	5
	W		6	6	4
		$\chi^2$	0,10	1,00	2,15
		p	>0,99	0,80	<0,70 >0,50
1200	N		9	6	3
	S		5	7	8
	E		3	4	5
	W		3	3	4
		$\chi^2$	3,35	1,00	1,75
		p	<0,50 >0,30	0,80	<0,70 >0,50
14000	N		10	3	3
	S		3	12 ←	5
	E		3	2	5
	W		4	3	7
		$\chi^2$	5,00	10,60	0,90
		p	<0,20 >0,10	<0,02 >0,01	<0,90 >0,80

Table 19d. The number of myrmeleontid larvae in the north (N), south (S), east (E) and west (W) quadrants of their pits when exposed to light of various intensities. The light was at an angle of  $40^{\circ}$  and shone from the north. The sand temperature was maintained at  $35 \pm 1^{\circ}\text{C}$ . 20 individuals of each species were used in each replicate. The values of Chi-square ( $X^2$ ) and the probability (p) are given. Statistically significant movement of larvae to any particular quadrant is indicated by an arrow.

Light intensity (lux)	Quadrant		<u>M. medialis</u>	<u>M. obscurus</u>	<u>C. lanceolatus</u>
600	N		6	5	4
	S		3	4	5
	E		7	6	6
	W		4	5	5
		$X^2$	1,00	0,10	0,10
		p	0,80	>0,99	>0,99
1200	N		13 ←	6	5
	S		0	4	7
	E		3	4	3
	W		4	6	5
		$X^2$	15,80	0,30	0,90
		p	<0,01 >0,001	<0,98 >0,95	<0,90 >0,80
14000	N		12 ←	2	4
	S		2	11	5
	E		3	6	4
	W		3	4	7
		$X^2$	10,60	7,40	0,55
		p	<0,02 >0,01	<0,10 >0,05	<0,98 >0,90

Fig. 31. The temperature of the surface sand and sand at a depth of 6,5 cm. when heated with infra-red lights in a constant environment room, and the temperature of the surface sand and sand at a depth of 6,5 cm. in the field. The field results for black sand were obtained from the habitat of Myrmeleon obscurus and those for sea sand from the habitat of Syngenes longicornis. In the laboratory the sand was heated from above with infra-red lights, suspended at a height of 44 cm., which were switched on from 9 a.m. to 5 p.m. each day.



KEY

- Temperature of surface sand in the laboratory
- Temperature of sand at a depth of 6,5 cm. in the laboratory
- Temperature of surface sand in the field
- Temperature of sand at a depth of 6,5 cm. in the field.

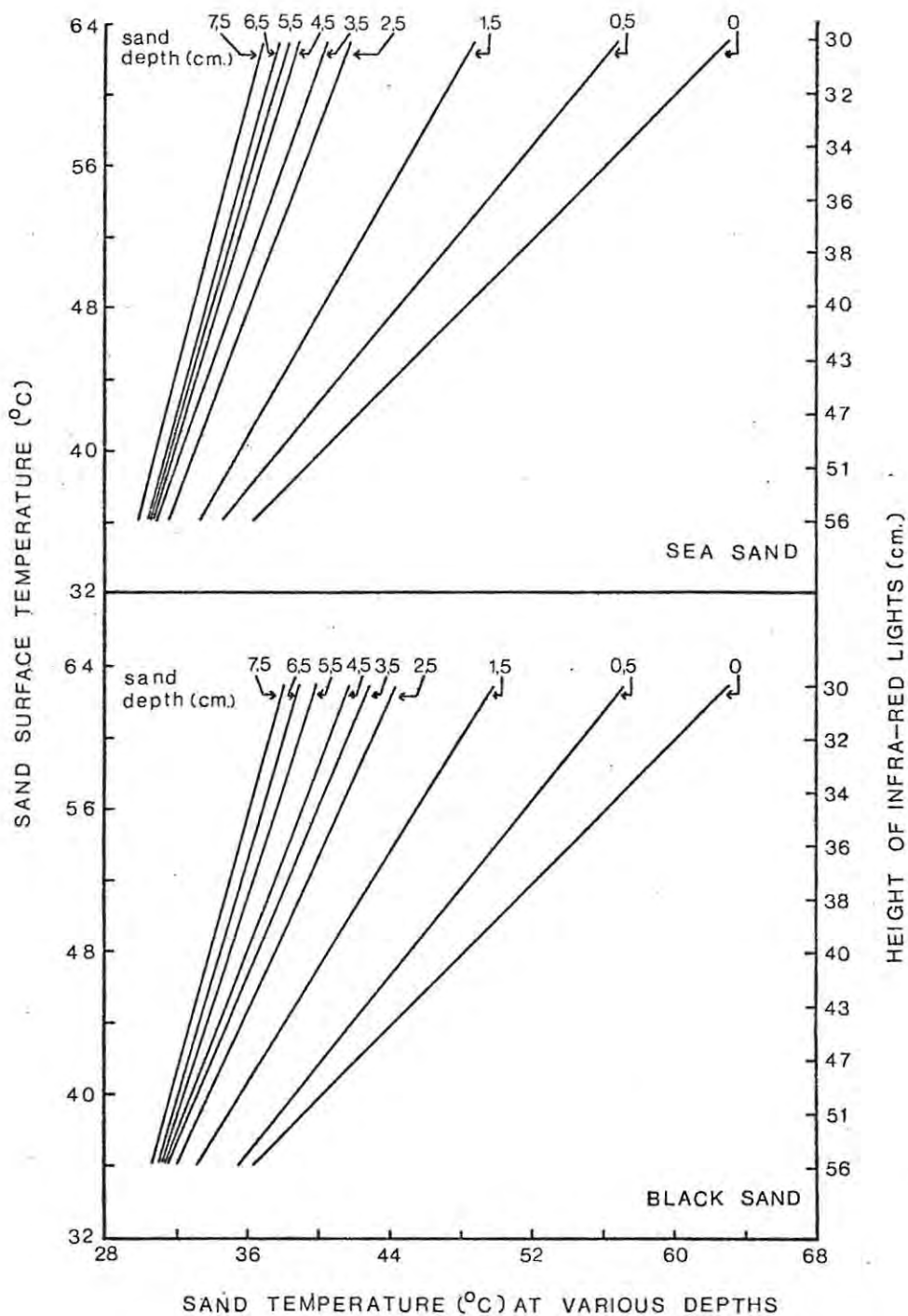


Fig. 32. The temperatures recorded at various depths in sea sand and black sand when the surface temperature was varied from about 36°C to about 63°C by alterations in the height of the infra-red lamps. All temperatures were recorded at noon and the graphs indicate the lines of best fit calculated by the method of least squares regression.

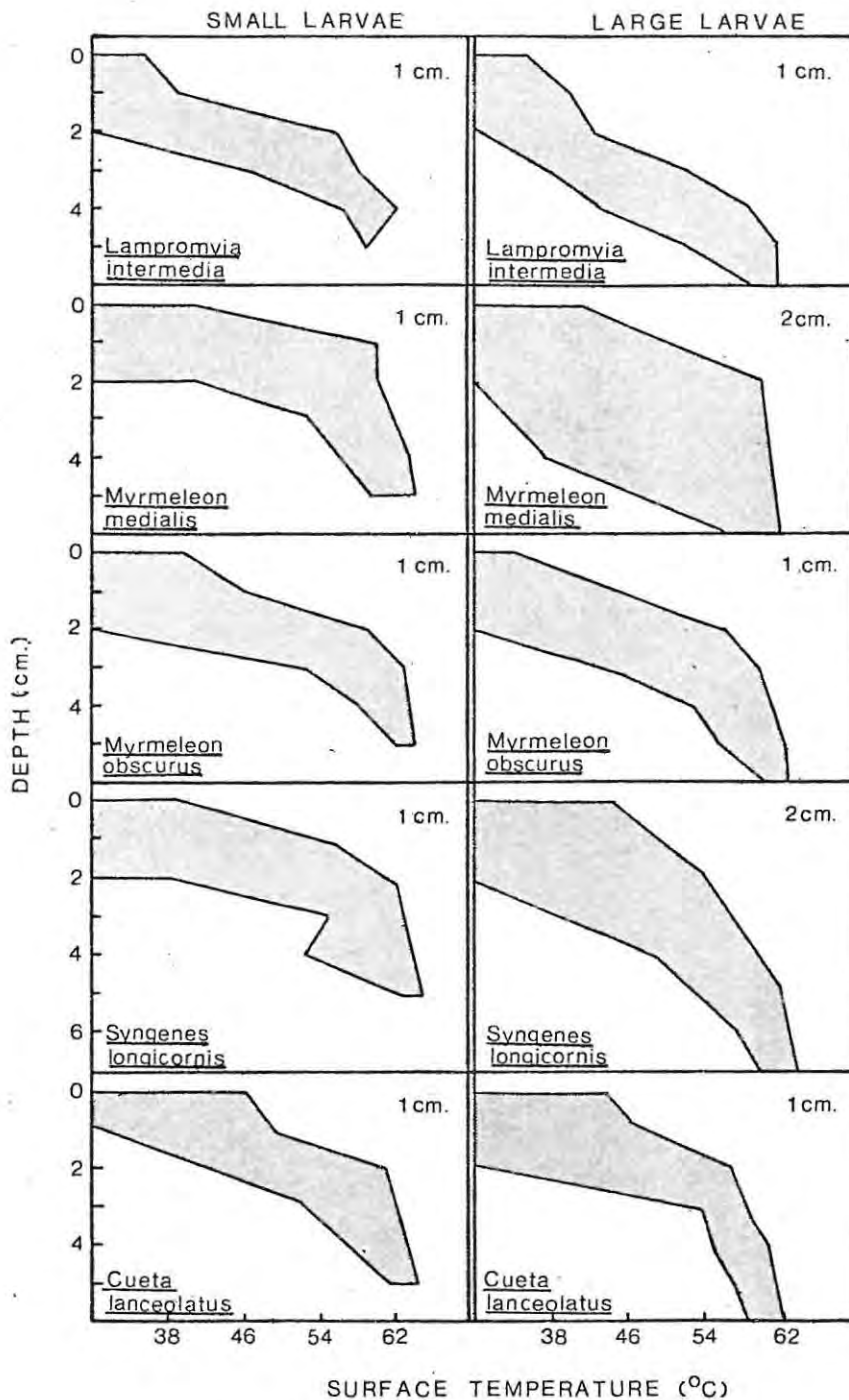


Fig. 33. The depth of myrmeleontid and rhagionid larvae, at noon, in the presence of vertical sand temperature gradients. The surface sand was heated to temperatures varying from about 36°C to about 63°C. 400 observations were made in each experiment and the shaded areas indicate the position of 75% of the larvae in each case. The positions of the larvae were determined to the nearest centimeter, except for very large larvae when two centimeter intervals were used.

Fig. 34a. The mean temperature of the surface sand and the mean depth of large myrmeleontid and rhagionid larvae at various times of the day. Each temperature represents a mean of 10 readings, while each depth represents a mean of 40 readings. The maximum and minimum depths at which larvae were found are also indicated.

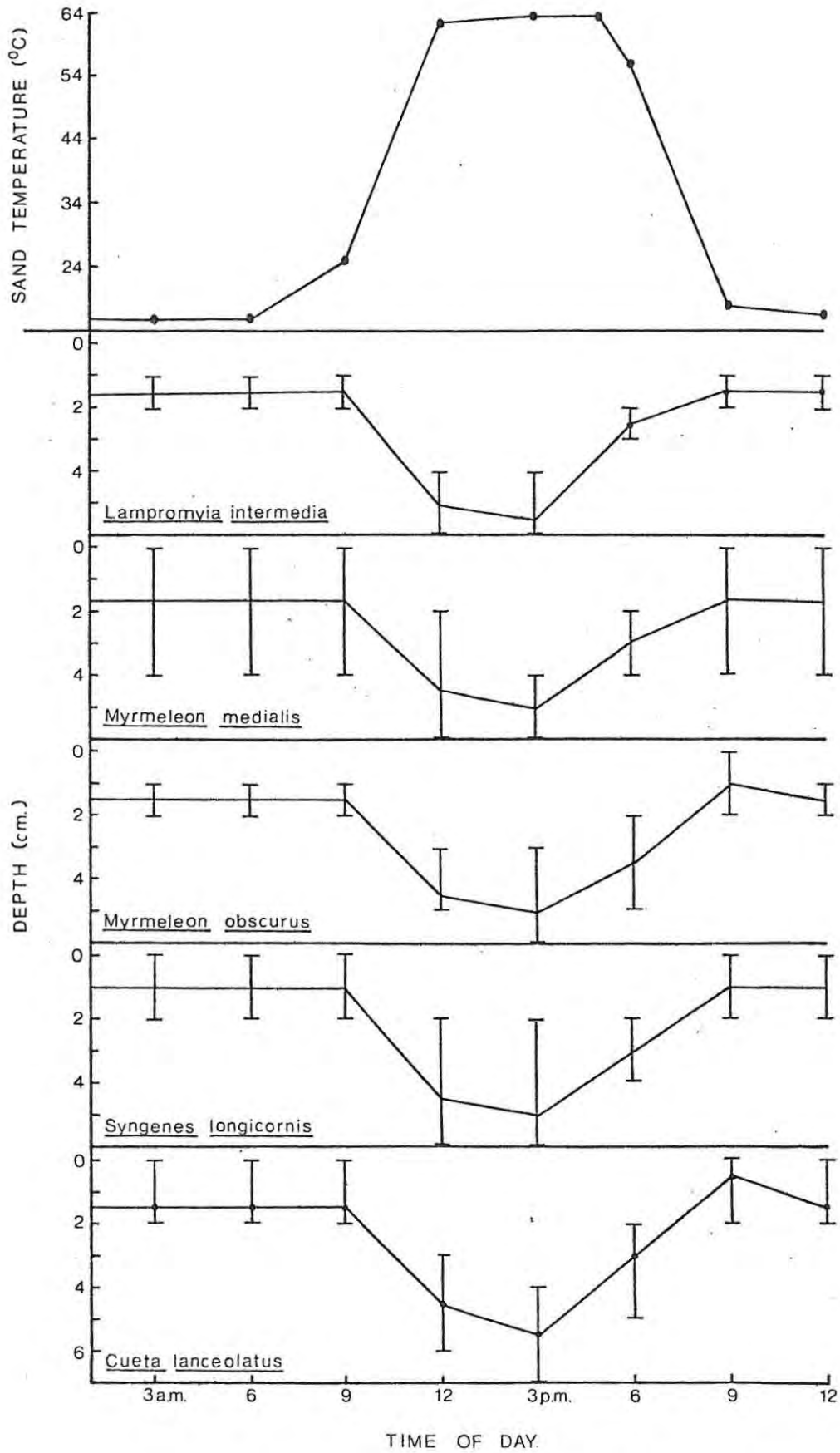


Fig. 34b. The mean temperature of the surface sand and the mean depth of small myrmeleontid and rhagionid larvae at various times of the day. Each temperature represents a mean of 10 readings, while each depth represents a mean of 40 readings. The maximum and minimum depths at which larvae were found are also indicated.

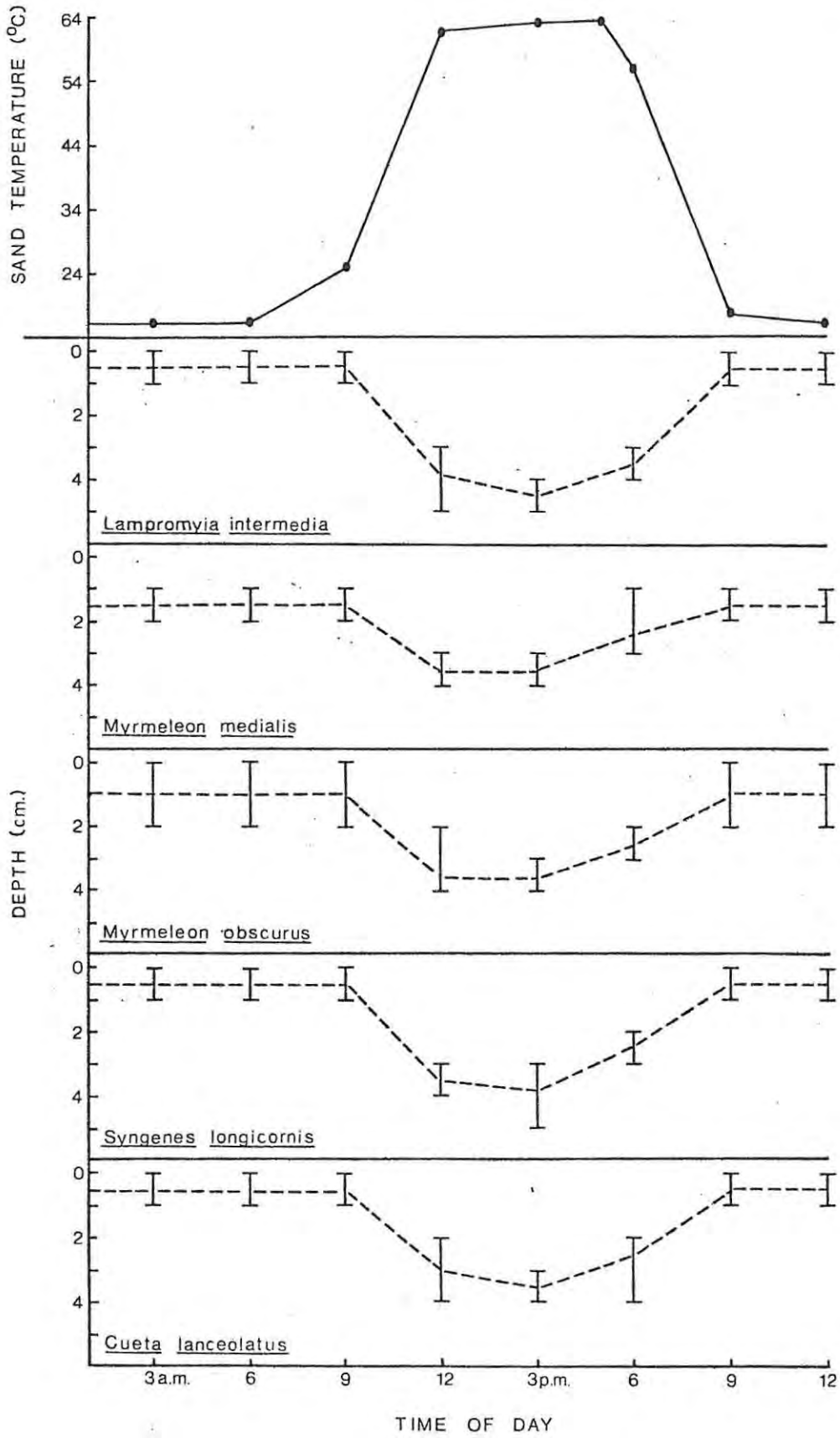
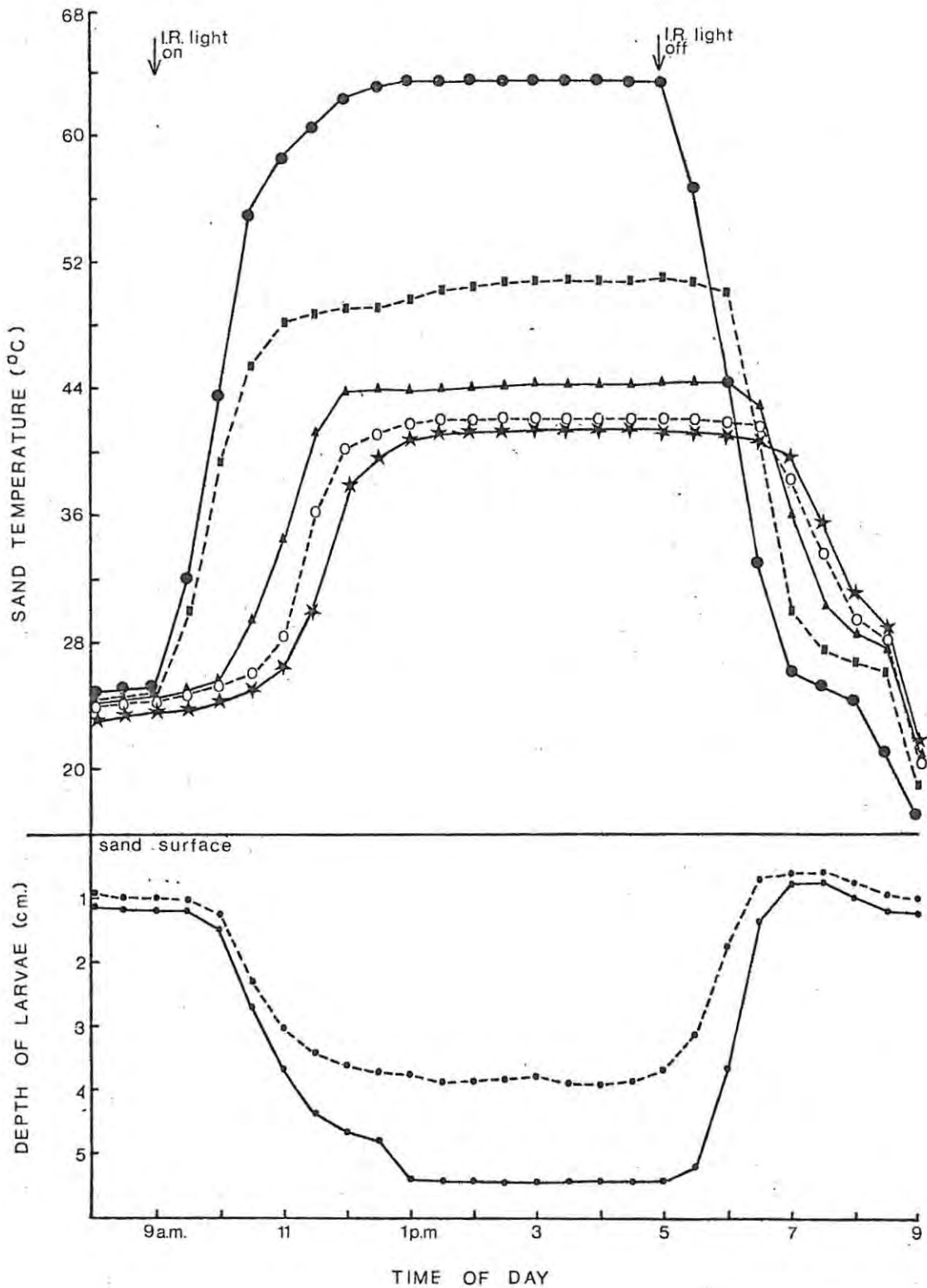


Fig. 35. The temperature of sand at various depths when placed in a constant environment room and heated from above with infra-red lights. Temperatures were taken at half hourly intervals. The mean depths of 40 large (solid lines) and 40 small (dotted lines) Myrmeleon obscurus larvae are shown in the lower figure.



KEY

- Surface sand
- - - ■ Sand at a depth of 1,5 cm.
- ▲—▲ Sand at a depth of 2,5 cm.
- - - ○ Sand at a depth of 3,5 cm.
- ★—★ Sand at a depth of 4,5 cm.

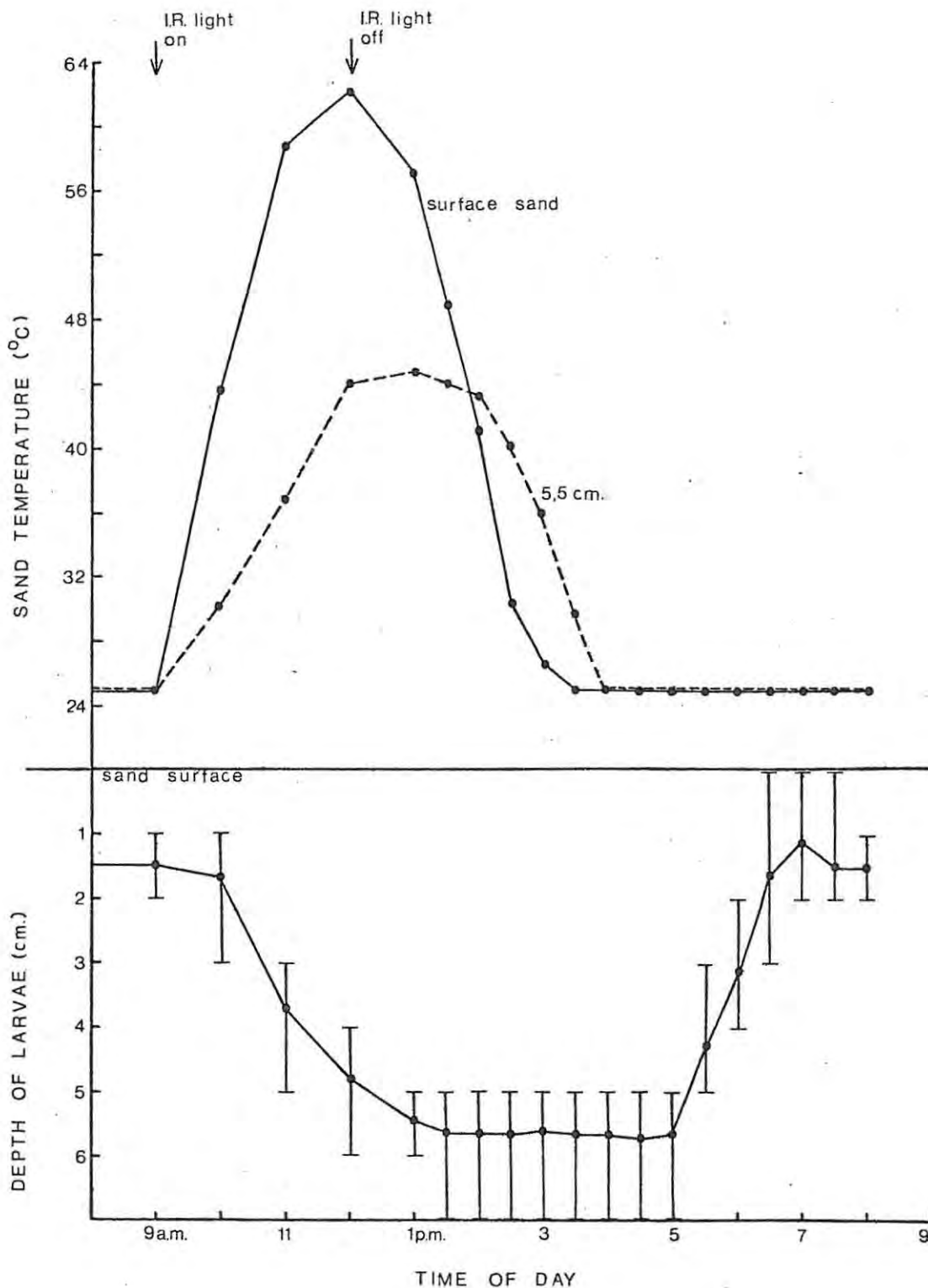


Fig. 36. The maximum, minimum and mean depths of 10 large Myrmeleon obscurus larvae at various times of the day, and the temperature of the surface sand and sand at a depth of 5,5 cm. The sand was heated from above with infra-red lights between 9 a.m. and 12 noon, as indicated by arrows.

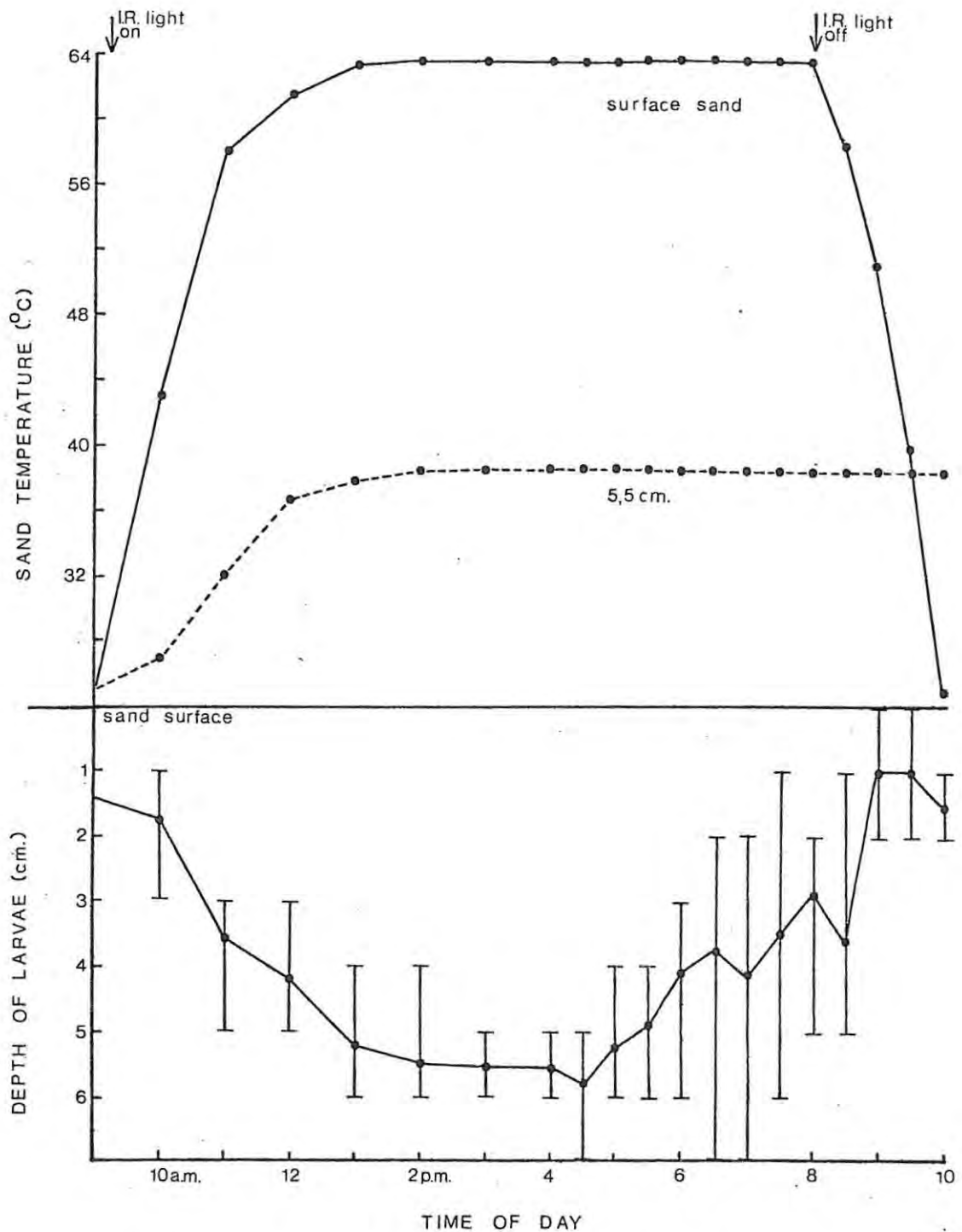


Fig. 37. The maximum, minimum and mean depths of 10 Myrmeleon obscurus larvae at various times of the day when placed in sand which was heated from above between 9 a.m. and 8 p.m. each day. The sand was heated with infra-red lights and the temperature of the surface sand and sand at a depth of 5,5 cm. is indicated.

Fig. 38. The depth of larvae of Myrmeleon obscurus which had been kept in a reversed light regime for a period of two weeks. During this time it was light from 10 p.m. to 2 p.m. each day. The sand was heated with infra-red lights from 9 a.m. to noon, as indicated by the arrows, and the temperature of the surface sand, and sand at a depth of 5,5 cm. is given. Each depth represents a mean of 10 readings and the maximum and minimum depths at which larvae were recorded are given.

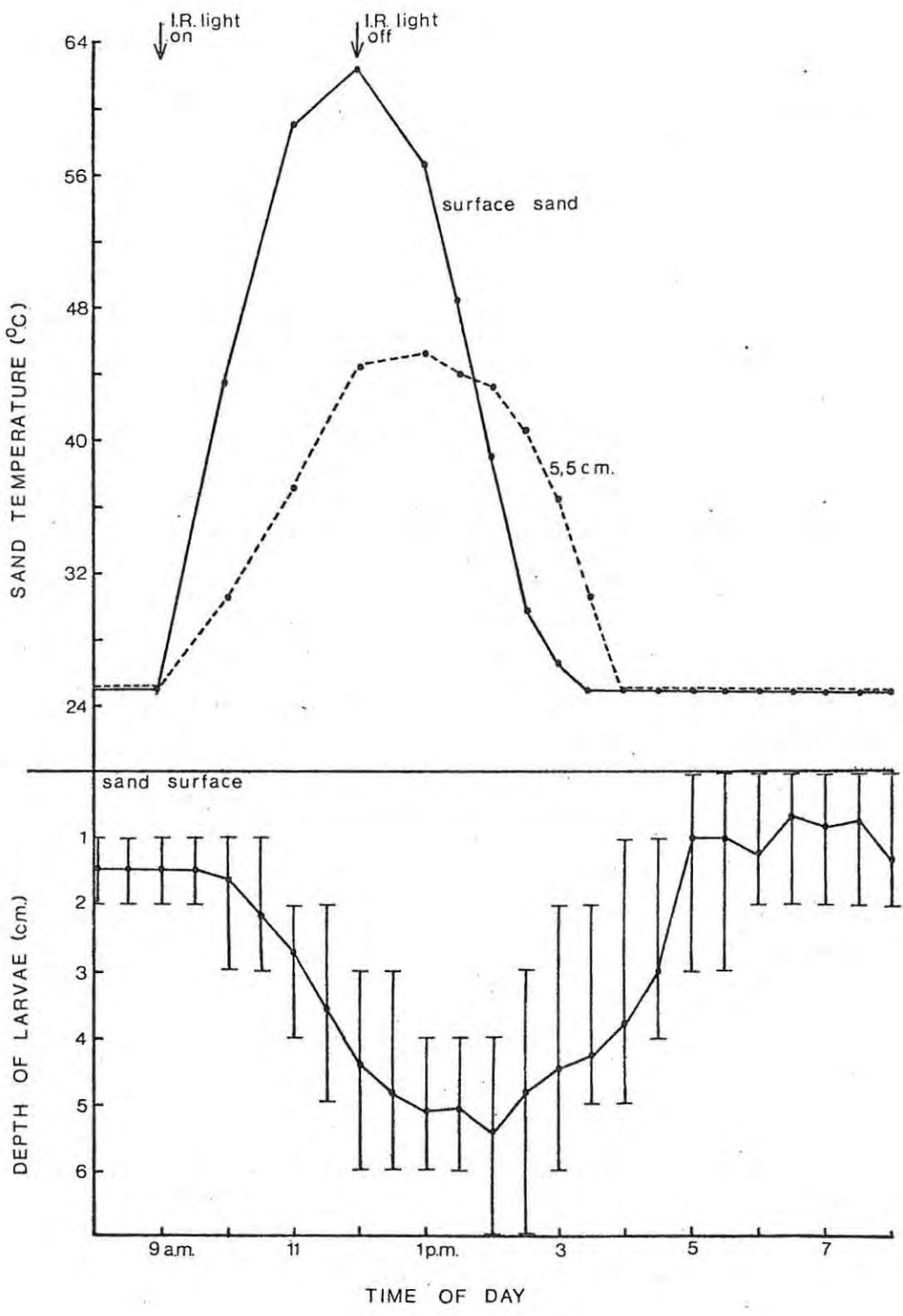


Fig. 39. The upper temperatures tolerated by 480 large (dotted lines) and 480 small (solid lines) larvae of various myrmeleontid and rhagionid species when placed in a vertical temperature gradient. For further details see text.

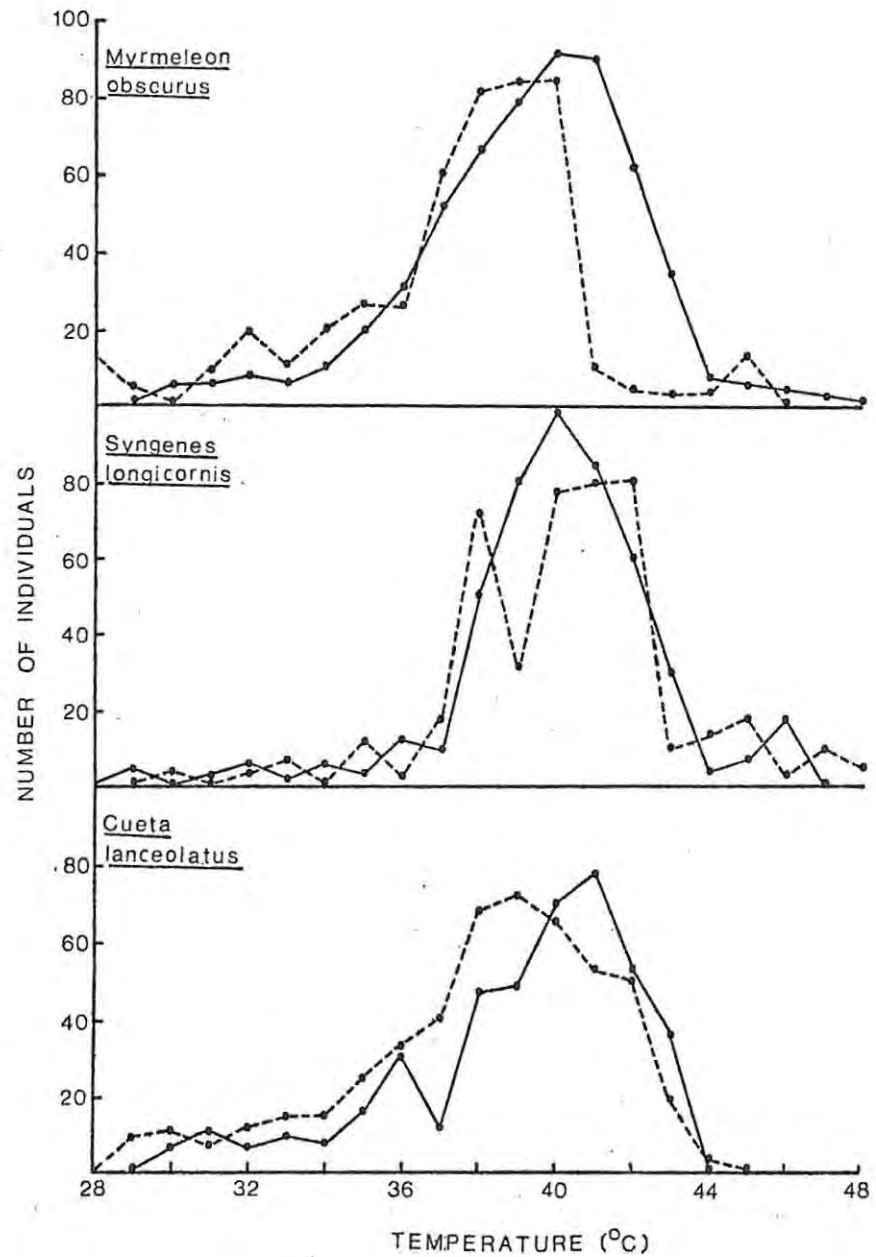
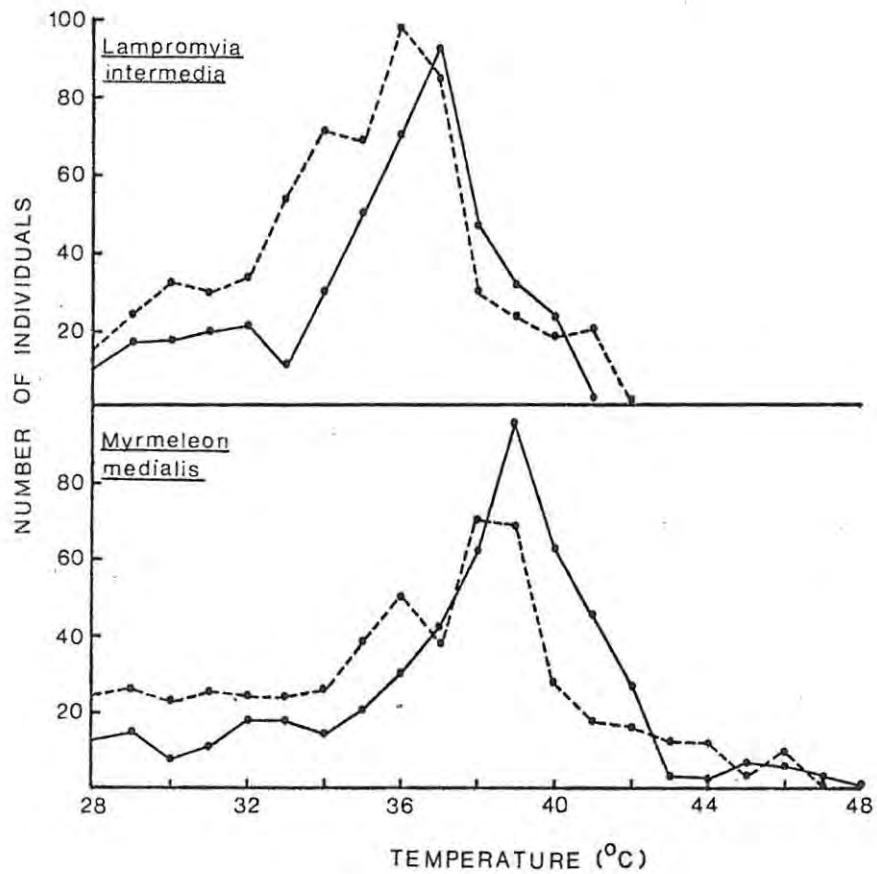


Table 20. The number of myrmeleontid and rhagionid larvae in sand of various depths at  $18 \pm 3^{\circ}\text{C}$  and at  $52 \pm 2^{\circ}\text{C}$ . 12 larvae of each species were used and their positions were determined after a period of four days. The values of Chi-square ( $\chi^2$ ) and the probability (p) are given where appropriate.

Species	Sand temp. ( $^{\circ}\text{C}$ )	Number of larvae		$\chi^2$	p
		depth 1 cm.	depth 20 cm.		
<u>L. intermedia</u>	18	6	6	-	-
	52	3	9	2,04	<0,10 >0,05
<u>M. medialis</u>	18	5	7	0,80	<0,50 >0,30
	52	2	10	4,00	<0,05 >0,02
<u>M. obscurus</u>	18	6	6	-	-
	52	5	7	0,08	<0,80 >0,70
<u>S. longicornis</u>	18	6	6	-	-
	52	4	8	0,74	<0,50 >0,30
<u>C. lanceolatus</u>	18	6	6	-	-
	52	6	6	-	-

Table 21a. The mean survival time and mean weight loss at the time of death of various myrmeleontid and rhagionid larvae when dehydrated over silica gel at a temperature of  $32 \pm 1^{\circ}\text{C}$ . The mean original body weight and the mean total and percentage weight loss for each species are also given. The data were obtained from 30 large individuals of each species.

Species	Survival time (days)			Original body weight (mg.)	Weight loss at death	
	max.	min.	mean		mean total wt. loss/individual	mean % wt. loss/individual
<u>L.intermedia</u>	33	15	24,5 $\pm$ 0,89	22,7 $\pm$ 1,17	4,7 $\pm$ 0,27	21,0 $\pm$ 0,75
<u>M.medialis</u>	35	20	26,1 $\pm$ 0,68	65,6 $\pm$ 4,00	15,0 $\pm$ 0,83	23,3 $\pm$ 0,46
<u>M.obscurus</u>	39	24	31,8 $\pm$ 0,85	37,2 $\pm$ 2,14	12,0 $\pm$ 0,59	33,2 $\pm$ 1,37
<u>S.longicornis</u>	39	17	27,2 $\pm$ 1,52	142,5 $\pm$ 13,11	40,8 $\pm$ 3,26	28,3 $\pm$ 1,01
<u>C.lanceolatus</u>	46	18	33,1 $\pm$ 1,50	33,3 $\pm$ 1,29	10,5 $\pm$ 0,39	31,9 $\pm$ 0,57

Table 21b. The values of "Student's t" and the probability (p) for the survival time and percentage weight loss of various myrmeleontid and rhagionid larvae which were dehydrated over silica gel at a temperature of  $32 \pm 1^{\circ}\text{C}$ . (From data presented in Table 19a.)

Species	Survival time		% weight loss	
	t	p	t	p
<u>L.intermedia</u> cf. to <u>M.medialis</u>	1,40	>0,1	2,57	<0,02 >0,01
<u>L.intermedia</u> cf. to <u>M.obscurus</u>	5,83	<0,001	8,74	<0,001
<u>L.intermedia</u> cf. to <u>S.longicornis</u>	1,51	>0,1	5,71	<0,001
<u>L.intermedia</u> cf. to <u>C.lanceolatus</u>	4,85	<0,001	11,38	<0,001
<u>M.medialis</u> cf. to <u>M.obscurus</u>	5,26	<0,001	6,74	<0,001
<u>M.medialis</u> cf. to <u>S.longicornis</u>	0,65	>0,1	4,43	<0,001
<u>M.medialis</u> cf. to <u>C.lanceolatus</u>	4,18	<0,001	11,54	<0,001
<u>M.obscurus</u> cf. to <u>S.longicornis</u>	2,62	<0,02 >0,01	2,83	<0,01 >0,001
<u>M.obscurus</u> cf. to <u>C.lanceolatus</u>	0,75	>0,1	0,86	>0,1
<u>S.longicornis</u> cf. to <u>C.lanceolatus</u>	2,72	<0,01 >0,001	3,05	<0,01 >0,001

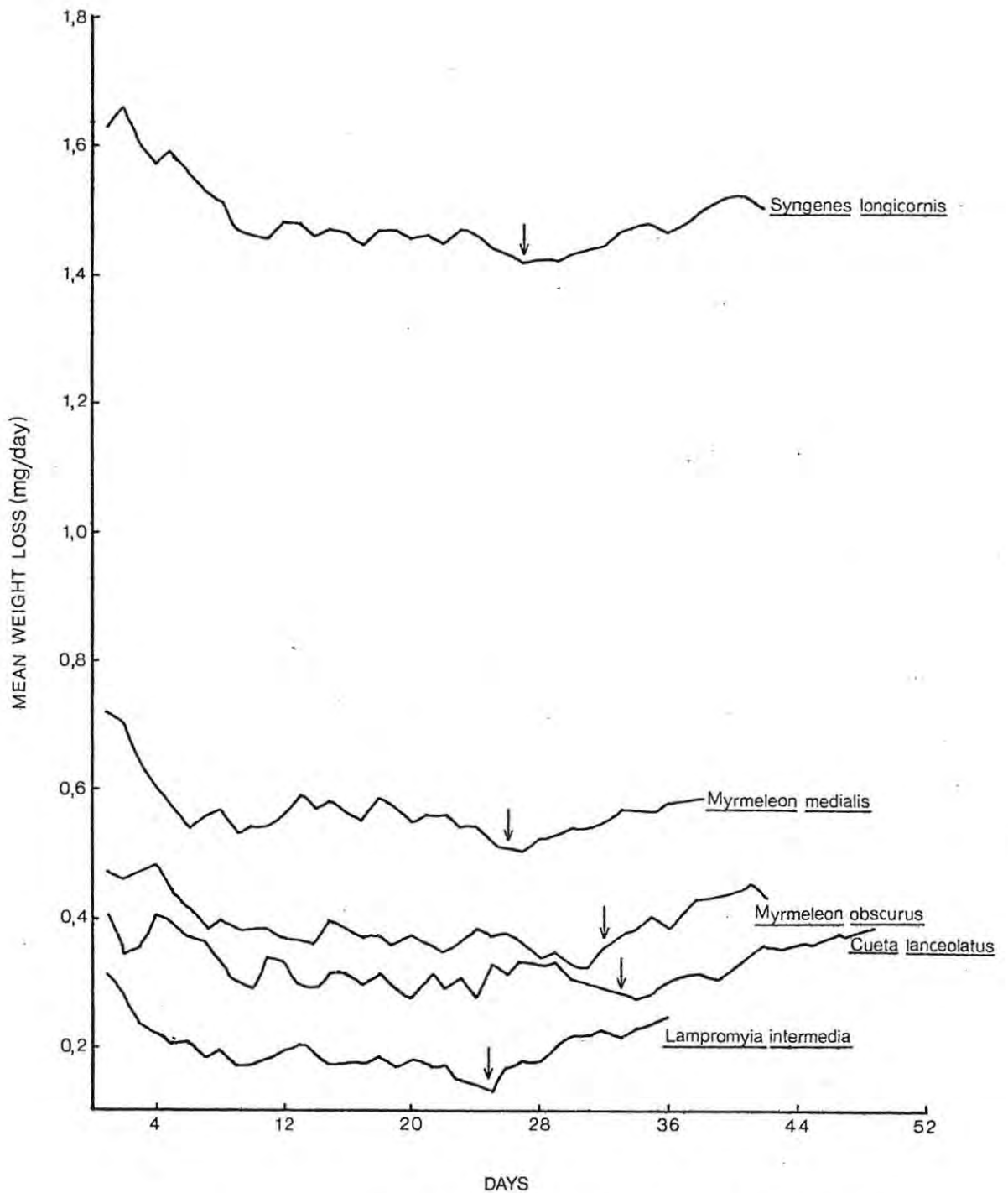


Fig. 40. The mean weight loss per day of various myrmeleontid and rhagionid larvae when dehydrated over silica gel at a temperature of  $32 \pm 1^{\circ}\text{C}$ . 30 large final instar larvae of each species were used and the mean time at which death occurred in each species is indicated by an arrow.

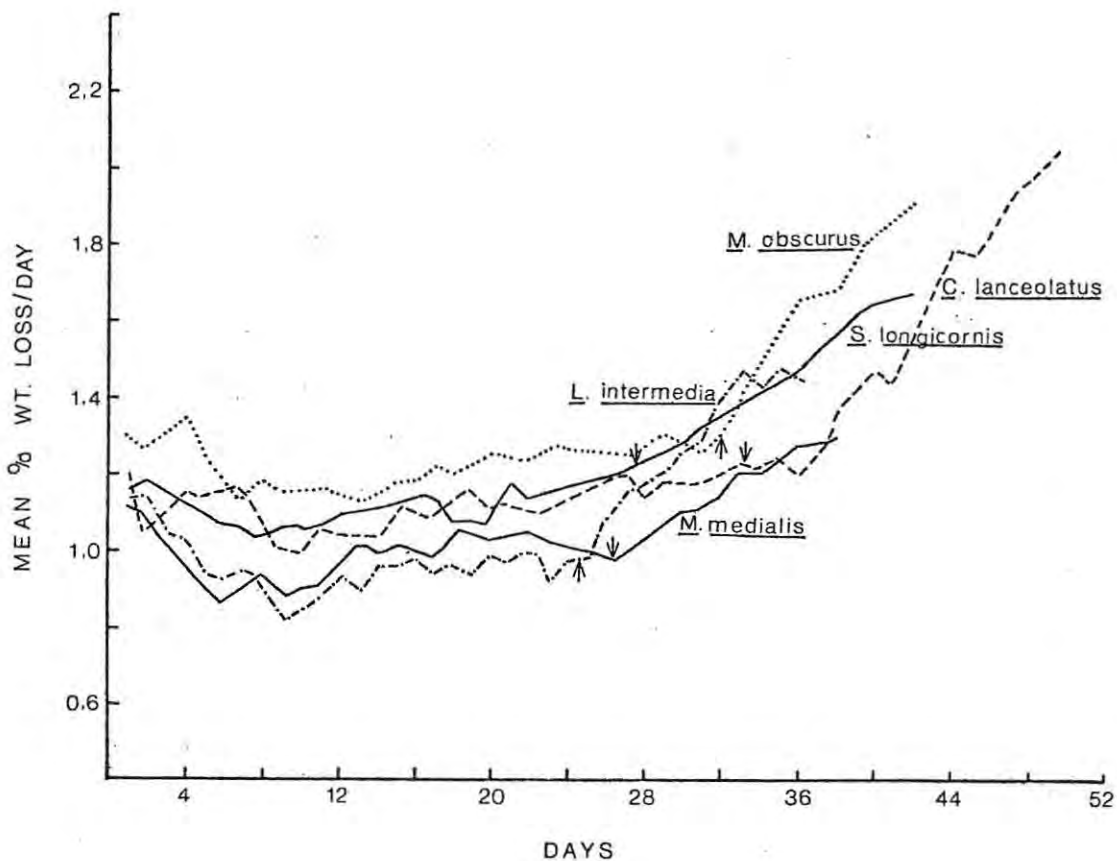


Fig. 41. The mean daily weight loss, expressed as a percentage of the body weight, of various myrmeleontid and rhagionid larvae when dehydrated over silica gel at a temperature of  $32 \pm 1^{\circ}\text{C}$ . 30 large final instar larvae of each species were used and the mean time at which death occurred in each species is indicated by an arrow.

Table 22. The mean weight loss, over a 10 day period, for various myrmeleontid and rhagionid larvae which were dehydrated over silica gel at both low and high temperatures. 30 individuals of each species were used at each temperature. The values of "Student's t" and the probability (p) are given.

Species	Mean weight loss (mg.) at low temperature	Temp. (°C)	Mean weight loss (mg.) at high temperature	Temp. (°C)	t	p
<u>L.intermedia</u>	2,0 $\pm$ 0,08	32	2,2 $\pm$ 0,07	36	1,85	< 0,1 > 0,05
<u>M.medialis</u>	5,9 $\pm$ 0,09	32	5,7 $\pm$ 0,07	42	1,72	< 0,1 > 0,05
<u>M.obscurus</u>	4,0 $\pm$ 0,04	32	4,1 $\pm$ 0,06	42	1,36	> 0,1
<u>S.longicornis</u>	15,1 $\pm$ 0,10	32	15,3 $\pm$ 0,17	46	0,99	> 0,1
<u>C.lanceolatus</u>	3,3 $\pm$ 0,09	32	3,5 $\pm$ 0,12	46	1,31	> 0,1

Table 23. The mean body weight of 20 larvae of various myrmeleontid and rhagionid species before and after a 24 hour period at a relative humidity of 98%. All the larvae were dehydrated over silica gel for a period of seven days before the start of the experiment. The values of "Student's t" and the probability (p) are given.

Species	Initial wt. (mg.)	Final wt. (mg.)	t	p
<u>L.intermedia</u>	27,9 $\pm$ 1,02	28,1 $\pm$ 1,05	0,13	>0,1
<u>M.medialis</u>	60,3 $\pm$ 2,46	60,5 $\pm$ 2,46	0,06	>0,1
<u>M.obscurus</u>	49,8 $\pm$ 2,40	49,6 $\pm$ 2,40	0,03	>0,1
<u>S.longicornis</u>	168,7 $\pm$ 7,91	168,9 $\pm$ 7,91	0,05	>0,1
<u>C.lanceolatus</u>	32,6 $\pm$ 1,57	32,8 $\pm$ 1,56	0,04	>0,1

Table 24.

The mean survival time and the mean percentage loss of original weight at the time of death of various species of desert insects at 0% relative humidity. For comparison, the survival times and weight loss, derived from the present study, are given for the larvae of Rhagionidae and Myrmeleontidae.

Species	Author	Temp. (°C)	50% survival time (days)	Mean % wt. loss
<u>Poecilocerus</u> <u>hieroglyphicus</u> (Orthoptera)	Abushama, 1970	33	18	25,9
<u>Adesmia</u> <u>antiqua</u> (Coleoptera)	El Rayah, 1970b	29	9-24	38,0
<u>Pimelia</u> <u>grandis</u> (Coleoptera)	El Rayah, 1970b	29	15-24	49,4
<u>Lampromyia</u> <u>intermedia</u> (Rhagionidae)		32	24	21,0
<u>Myrmeleon</u> <u>medialis</u> (Myrmeleontidae)		32	26	23,3
<u>Myrmeleon</u> <u>obscurus</u> (Myrmeleontidae)		32	32	33,2
<u>Syngenes</u> <u>longicornis</u> (Myrmeleontidae)		32	27	28,3
<u>Cueta</u> <u>lanceolatus</u> (Myrmeleontidae)		32	33	31,9

Table 25. The rate of water loss per day at 0% relative humidity, expressed as a percentage of original body weight, of four species of Myrmeleontidae, one species of Rhagionidae, and various desert insects.

Species	Author	% wt. loss/day
<u>Eleodes armata</u>	Ahearn and Hadley, 1969	5,0
<u>Cryptoglossa verrucosa</u>	Ahearn and Hadley, 1969	1,4
<u>Poeciloceru hieroglyphicus</u>	Abushama, 1970	1,4
<u>Adesmia antiqua</u>	El Rayah, 1970b	1,6
<u>Pimelia grandis</u>	El Rayah, 1970b	2,0
<u>Onymacris plana</u>	Edney, 1971a	1,1
<u>Onymacris laeviceps</u>	Edney, 1971a	1,8
<u>Onymacris rugatipennis</u>	Edney, 1971a	1,4
<u>Gyrosis moralesi</u>	Edney, 1971a	2,6
<u>Calosis amabilis</u>	Edney, 1971a	1,8
<u>Lepidochora argentogrisea</u>	Edney, 1971a	2,0
<u>Ctenolepisma terebrans</u>	Edney, 1971a	3,0
<u>Lampromyia intermedia</u>		0,9
<u>Myrmeleon medialis</u>		0,9
<u>Myrmeleon obscurus</u>		1,0
<u>Syngenes longicornis</u>		1,0
<u>Cueta lanceolatus</u>		0,9

Table. 26. The upper lethal temperature limit, over a 24 hour period, for various desert arthropods. For comparison, the upper lethal limits of the larvae of one species of Rhagionidae and four species of Myrmeleontidae are given.

Species	Author	RH	Mean lethal temp. (°C)
<u>Pimelia grandis</u> (Coleoptera)	Cloudsley-Thompson 1962a	10	43
<u>Ocnera hispida</u> (Coleoptera)	Cloudsley-Thompson 1962a	10	45
<u>Galeodes granti</u> (Arachnida)	Cloudsley-Thompson 1962a	10	50
<u>Adesmia antiqua</u> (Coleoptera)	El Rayah, 1970a	20	46
<u>Lampromyia intermedia</u> (Rhagionidae)		90	40,5
<u>Myrmeleon medialis</u> (Myrmeleontidae)		90	47,2
<u>Myrmeleon obscurus</u> (Myrmeleontidae)		90	47,6
<u>Syngenes longicornis</u> (Myrmeleontidae)		90	50,8
<u>Cueta lanceolatus</u> (Myrmeleontidae)		90	51,9