Proc. Indian Acad. Sci. (Anim. Sci.), Vol. 98, No. 5, September 1989, pp. 367–372.

Foraging activity and temperature relations in the ponerine ant *Harpegnathos saltator* Jerdon (Formicidae)

T SHIVASHANKAR*, H C SHARATHCHANDRA and G K VEERESH
Department of Entomology, University of Agricultural Sciences, GKVK Campus, Bangalore 560 065, India

MS received 20 April 1989; revised 1 August 1989

Abstract. *Harpegnathos saltator* Jerdon constructs nests in the shade of plants and are strictly individual foragers. The nest entrance is barricaded by seeds, seed stalks and faecal pellets of rodents, the function of which is not clear. The diurnal foraging activity is controlled by a combination of surface temperature and light. High midday surface temperature resulted in the bimodal transit activity in a day.

Keywords. Foraging; temperature; light; transit-activity.

1. Introduction

Factors governing the activity of any species are important, since they determine the foraging time available to that species and more so for central place foragers such as ants. Light is the controlling factor for a number of ant species particularly forest dwellers which experience fairly constant temperatures and humidities (Levieux 1975; Levieux and Louis 1975).

The present study was undertaken to determine the factors governing the activity of *Harpegnathos saltator* Jerdon and to establish the temperature range over which activity of these ants occurs. Observations were also made on the nesting behaviour and dietary specialization of this ant. This is also the first ecological observation of a species of genus *Harpegnathos.*

Ants of the genus *Harpegnathos* have few representatives and have limited distributions in the Old World area (Bingham 1903). *H. saltator* is a large (14–18 mm) predatory ant which forages individually and can be compared to the primitive ants of Australia (Taylor 1978). Studies on this genus are not many due to their specific habitat and inconspicuous foraging methods; except for the taxonomic work by Bingham (1903), little is known about these large, jumping, predatory ants.

2. Materials and methods

The present study was undertaken in the tropical scrub forest with eucalyptus plantations (12°57′ N and 77°35′ E) situated in Gandhi Krishi Vignana Kendra Campus of the University of Agricultural Sciences, Bangalore, where 2·5 ha of forest area was thoroughly searched for 20 days to locate all the nests, during cool hours of the day. The nests were located by following a forager returning to the nest with food, and the nests were marked for further observations. To determine the diurnal activity pattern of this ant, hourly visits were made to all the marked nests ($n = 9$).

*To whom all correspondence should be addressed.

The presence or absence of a worker at the entrance for a period of 5 min near the nest was used as an indication of nest activity. Based on this, the per cent nests active at a given time was calculated by using the following formula:

$$\text{Active nests (\%)} = \frac{\text{Number of active nests at a time}(t)}{\text{Total number of nests in the study area}} \times 100,$$

where t is the time at which the nest activity was recorded.

The surface temperature near the nests was recorded by using a Diel thermotron, at an hourly interval during the day.

A total of 29·25 h of transit activity was recorded for nest 1 which included the entire foraging observations of this nest for 5 different days during March and April 1987. The transit activity of the ants was recorded from the time of the first worker leaving till the last worker returning to the nest. During this transit activity period, surface temperatures at 15 min intervals were recorded.

The success ratio of foraging was calculated by dividing the number of ants returning with food by the total workers in that foraging session. The success rate per hour basis was calculated by the following formula:

$$\text{Success rate/h} = \frac{\text{Number of workers with food}}{\text{Total number of workers participated in foraging} \times \text{duration of foraging (min)}} \times 100.$$

Differences between the number of workers participating, quality of food collected, success rate and the temperature differences during morning and evening sessions of foraging were analysed using the student's t test.

3. Results

The nests were located by following the workers carrying food. All the nests located were below the plants of varying heights (0·5–2·5 m) having a shade of 2·8–5·5 m^2 during mid-day.

The nest entrance was always barricaded by eucalyptus seeds, seed stalks and faecal pellets of rodents. When the materials were removed or disturbed, additional materials were brought back to the nest entrance during subsequent foraging trips spread over several days.

3.1 *Foraging behaviour*

H. saltator was always found to forage individually. Even a slight disturbance to a forager elicited repeated jumps of 1·5–2 cm and the disturbed ants were found to hide below leaf litter. Nine nests observed for foraging activity at hourly intervals showed two distinct peaks. All the nests were found to be active between 0600–0800 h, while only 66–77% of the nests were found to be active between 0600 and 1900 h. No activity was observed during the rest of the day.

3.2 *Transit activity in nest 1*

The transit activity was never observed during night. The diurnal activity was bimodal during the study period (figure 1). Foraging commenced in the morning any time from 0502 to 0540 h, while it was observed to take place between 1633 and 1722 h in the afternoon. The mean temperatures at the beginning and during transit activity were 22·72 ± 1·50 and 31·55 ± 1·86°C respectively. Transit activity terminated between 0914 to 0946 (range) and between 1856 to 1943 h. The mean temperature during the termination of foraging was 30·77 ± 1·37 and 27·4 ± 1·47°C respectively for the two sessions. The commencement of foraging coincided with sunrise while the termination coincided with sunset (table 1).

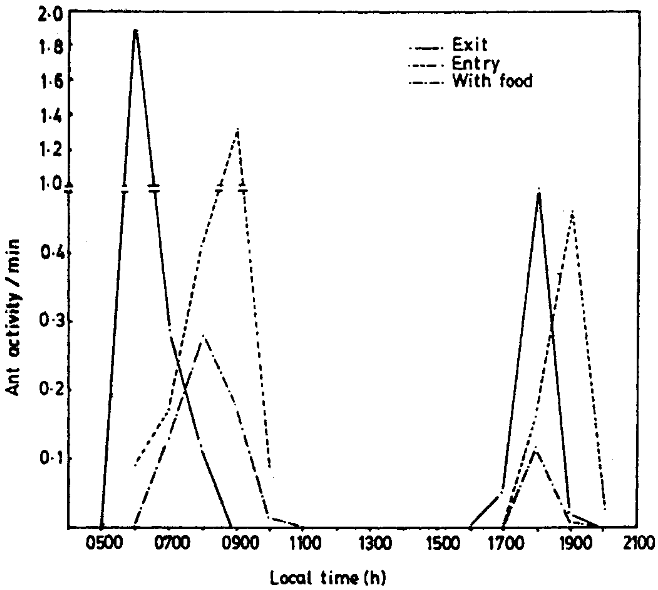

Figure 1. Bimodality in transit activity of *H. saltator* during summer.

Table 1. Transit activity in *H. saltator* during morning and evening foraging.

	Morning $\bar{X} \pm SD$	Evening $\bar{X} \pm SD$	Test statistics
Initiation of foraging	0502–0540 h (range)	1633–1722 h (range)	
Surface temperature (°C)	22·72 ± 1·50	31·55 ± 1·86	
Sunrise	0601–0610 h	—	
Termination of foraging	0914–0946 h (range)	1856–1943 h (range)	
Sunset	—	18·06–18·32 h	
Surface temperature (°C)	30·77 ± 1·37	27·47 ± 1·44	$t = 6·67$ $P < 0·001$ df = 14
Total duration of foraging (min)	219 ± 7·35	117 ± 25·81	$t = 7·6$ $P < 0·001$ df = 8
Number of workers participating in foraging (Av. 5 days)	31·8 ± 3·49	10·4 ± 4·67	$t = 15·76$ $P < 0·001$ df = 8
Success ratio	0·2921	0·1804	
Success rate (%)	7·66	8·66	
Mid-day surface temperature (33·71 ± 3·39°C)			
Morning (24·6 ± 1·21°C)	$t = 6·87$ $P < 0·001$		
Evening (29·3 ± 1·42°C)	$t = 2·88$ $P < 0·025$		

The mean foraging duration in the morning was significantly longer (36·5 ± 0·123 h: $t = 7{\cdot}6$ $P < 0{\cdot}0C$, df = 8), than that in the evening (19·5 ± 0·43) (table 1). Significantly ($t = 6{\cdot}67$ $P < 0{\cdot}001$ df = 8) more number of ants participated in the morning session (3·17 ± 3·49) compared to the evening session (10·4 ± 4·67) (table 1). The mean surface temperature during the morning foraging was significantly low ($t = 6{\cdot}67$ $P < 0{\cdot}001$, df = 8) compared to evening hours. However the mean temperatures in the morning and evening of the day were significantly ($t = 6{\cdot}87$ $P < 0{\cdot}001$ and 2·88 $P < 0{\cdot}025$, df = 14 and 11 respectively) lower than the mean mid-day temperatures (table 1).

The increase in surface temperature during foraging (morning) resulted in the reduction of transit activity (figure 2).

The success ratio was better in the morning (0·2921) compared to the evening foraging (0·1804). However, the success rate per unit time was lower (7·66%) in the morning compared to evening (8·66%), although the differences were not significant.

Foraging workers collected 36·17 (n = 622) and 25·33% (n = 75) food in the morning and evening sessions respectively, during the 37 days of observation at nest 1.

The faecal pellets, mostly of rodents, were collected by the unsuccessful foragers on their way back; such materials were rarely carried into the nest.

4. Discussion

Many ponerine ants are known to occur in the thick tree canopy and are forest dwellers. These ants are often found below the shades of undisturbed forest. The reason for the accumulation of seeds, seed stalks and faecal pellets around the nest is

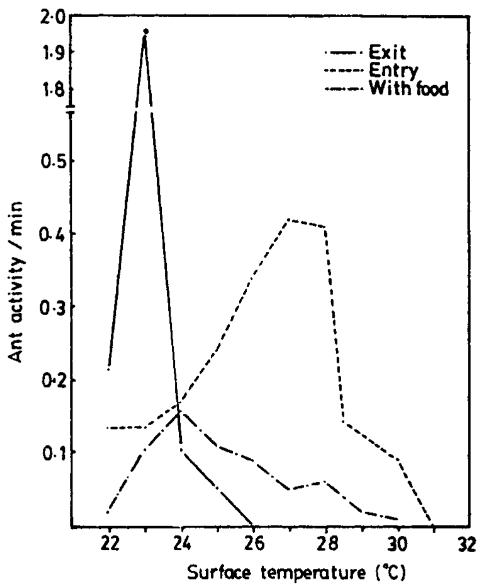

Figure 2. Transit activity in the workers of *H. saltator* decreased with increase in surface temperature.

not clear. *H. saltator* is a strict visual hunter and was never found to use trail pheromones.

Temperature appeared to be a major factor controlling the activity of *H. saltator*. Both the number of nests covered by foraging activity and the transit activity (figure 2) were significantly influenced by this factor. The low rate of increase in the surface temperature and sufficient light available during the morning session were responsible for 100% foraging observed in all the nests while in the evenings, though the temperature was within the foraging range (22–30°C), light restricted the average time for foraging as evidenced by few active nests in the evenings. The mid-day high temperature significantly affected foraging (figure 1) during March and April 1987. Many ant species from different habitats are known to exhibit bimodal pattern of diurnal foraging with mid-day inactivity when surface temperature reaches a certain threshold (DeBruyn and Kruk 1973; Levieux 1975; Whitford *et al* 1976, 1980).

Formica polyctena alternates between bimodal and unimodal activity patterns depending upon surface temperatures (DeBruyn and Kruk 1972). *H. saltator* nests can remain active even during mid-day periods during winter (November–January) and on cloudy days suggesting the existence of a similar phenomenon in this species as in *F. polyctena*. Although the surface temperature was lowest at the beginning of transit activity, it appears that light determined the initiation of foraging as these ants are strict visual hunters. In the evening though the surface temperature was within the foraging range and success rate per unit time was high but the termination of transit activity was observed on account of the non-availability of light due to sunset. Similarly light is the main factor controlling the activity of a number of forest dwelling ants (Levieux 1975; Levieux and Louis 1975). It has been found that in temperate regions low surface temperature results in a total cessation of ants activity (Brian 1965; Sanders 1972), while in *H. saltator* the absence of light has been found to be responsible for total inactivity during night hours.

Food availability and quality can affect the foraging activity (Bernstein 1979; Briese and Macaulay 1980) of ants. *H. saltator* prey was available throughout the day. Adverse microclimatic conditions such as high mid-day surface temperature and lack of light in the evening restricted the available foraging duration in a day. Lack of stored food in the nest was an added evidence of limited foraging duration in this species.

A major proportion of the prey captured were capable of jumping or fast-running, such as crickets and field cockroaches (65%). These ants hunt their prey searching systematically below leaf litter. When they locate the prey, they jump on to it (except for termites) and catch them by their long forceps-like mandibles. The specialization for catching such prey is probably involved in the evolution of jumping behaviour in this species.

References

Bernstein R A 1979 Schedules of foraging activity in species of ants; *J. Anim. Ecol.* **48** 921–930

Bingham 1903 *The Fauna of British India Hymenoptera. Ants and cuckoo-wasps* (London: Taylor and Francis)

Brian M V 1965 *Social insect populations* (London: Academic Press)

Briese D T and Macaulay B J 1980 Temporal structure of an ant community in semi arid Australia; *Aust. J. Ecol.* **5** 121–134

DeBruyn G and Kruk D B M 1972 The diurnal rhythm in a population of *Formica polyctena* Forest; *Ekol. Pol.* **20** 117–127

Levieux J 1975 La Nutrition des fourmis tropicales. I Cycle d'activite et regime alimentaire de *Camponotus solon* (Forel) (Hymenoptera: Formicidae); *Insectes Soc.* **22** 381–390

Levieux J and Louis D 1975 La nutrition des fourmis tropicales II compartment alimentaire et regime de *Camponotus vividus* (Smith); *Insectes Soc.* **22** 391–404

Sanders C J 1972 Seasonal and daily activity patterns of carpenter ants (*Camponotus* spp.) in north-western Ontario (Hymenoptera: Formicidae); *Can. Entomol.* **104** 1681–1987

Taylor R W 1978 *Nothomyrmecia macrops* a living fossil ant rediscovered; *Science* **201** 979–985

Whitford W G, Johnson P and Ramirez J 1976 Comparative ecology of the harvester ants *Pogonomyrmex barbatus* (F Smith) and *P. rugosus* (Emery.); *Insectes Soc.* **23** 117–132

Whitford W G, Depee D J and Johnson P 1980 Foraging ecology of two chinnuahuan desert ant species. *Novomessor cockerelli* and *N. albisetosus*; *Insectes Soc.* **27** 148–156