

**ECOLOGY  
OF  
ANIMAL POPULATION**

**PART 3**

**Zoological Survey of India**

# **ECOLOGY OF ANIMAL POPULATION**

**PART—3**

**PROCEEDINGS OF THE SYMPOSIUM ON  
ECOLOGY OF ANIMAL POPULATION  
From 26th Oct. to 28th Oct., 1978**

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# ZOOLOGICAL SURVEY OF INDIA

## PROCEEDINGS OF THE SYMPOSIUM ON ECOLOGY OF ANIMAL POPULATION

### PART—3

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POPULATION FLUCTUATIONS OF A PREDATORY  
NEMATODE, *PARAHADRONCHUS SHAKILI*  
(JAIRAJPURI, 1969) MULVEY 1978 (MONONCHIDA)

By

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INTRODUCTION

Although considerable work has been done during last few decades on the population dynamics of plant-parasitic nematodes (Hollis and Fielding 1955, Riggs *et al.*, 1956, Wallace 1962, '63; Norton 1963, Zuckerman *et al.*, 1964, Szczygiel 1966, Szczygiel and Hasiór '72a & b; Flegg 1968, Singh and Misra 1968; Khan *et al.*, 1971; Biro 1973 and others), but almost no work has been done on predatory nematodes of Order Mononchida Jairajpuri, 1969 which are known to feed upon plant-parasitic nematodes and may serve as agents for their biological control.

The studies that have been carried out on the feeding behaviour of the predatory nematodes have fully established the role of mononchs in suppressing the population of the phytophagus nematodes. Steiner and Heinley (1922) have observed that *Clarkus papillatus* (Bastian, 1865) Jairajpuri, 1970 could kill about 83 juveniles of root-knot nematodes in one day and a total of about 1332 nematodes in its life span of 12 weeks. Cobb (1920) had shown that *C. papillatus* could bring down the population of sugarbeet nematode to a low level. Thorne (1927) also observed that the population of *Heterodera schachtii* could be controlled by *C. papillatus* if they are present in sufficiently large numbers in the infested fields. Other species of mononchs like *Iotonchus brachylaimus* (Cobb, 1917) Andrassy, 1958, *Iotonchus tridentatus* (de Man, 1876) de Coninck, 1939, have also been observed preying upon other nematodes by Cassidy (1931) and Mulvey (1961) respectively.

The present work was undertaken with a view to study the population fluctuations, seasonal variations, vertical migration, breeding cycle and predator-prey relationship of *Parahadronchus shakili* (Jairajpuri, 1969) Mulvey, 1978 a species of mononch which is widely distributed in Uttar Pradesh, India.

## MATERIAL AND METHOD

The present study was carried out in a plot of about one acre at Company Gardens, Bareilly, Uttar Pradesh on which were planted 25 trees of litchi, *Litchi chinensis* Sonn, in five rows and the soil around these plants harboured the predatory nematode, *P. shakili*, in abundance. From each row one tree was selected for sampling. Soil samples were collected at three depths, viz., 0-10, 10-20, 20-30 cm with the help of a hand spade at intervals of 15 days from July, 1977 to June, 1978 (except in late July when it was impossible to collect the samples at middle and lower depths due to water-logging and it has been shown in the figures by dotted lines). The three depths are mentioned in the following text as upper, middle and lower depths. For taking samples an area of about 10×10 cm was marked and the total soil of each 10 cm successive depths was taken out and kept separately. This bulk of soil from each depth was mixed up thoroughly and 500 gm of soil was taken out of this bulk into a polythene bag. Thus 15 bags (5 rows of tree × 3 depths) was collected and stored, and was brought to the laboratory at Aligarh Muslim University for analysis.

The five soil samples of the same depth obtained from the 5 rows of trees were composited into one grand sample, were thoroughly mixed and out of this bulk 250 gm soil was taken for processing for the isolation of nematodes. The nematodes were extracted from the soil by a combination of sieving and decantation and Baermann's funnel method. The water from the bottom of the funnel was taken exactly after 24 hours. This contained nematodes in clear suspension. The nematode suspension obtained as above was transferred to a graduated flask and the nematodes were allowed to settled down at the bottom. The suspension was concentrated to 100 ml by pipetting out the excess volume of water. This 100 ml of nematode suspension was made homogeneous with the help of a bubbler and 10 ml was taken out of this with the help of a pipette and was transferred to a Syracuse counting dish. The nematodes were counted and the counting was repeated thrice and the mean values of the countings noted down. The different juvenile stages and the adults (males and females) were counted separately. Temperature was noted regularly on the day of sampling at each depth. The soil moisture of each sample was determined in the laboratory.

## RESULTS

Soil temperature at three depths was variable at different intervals of this study. The maximum variation (10 to 26°C) occurred in the upper depth of soil in February and April respectively. The soil temperature between the three layers also varied and a maximum of 4°C difference was

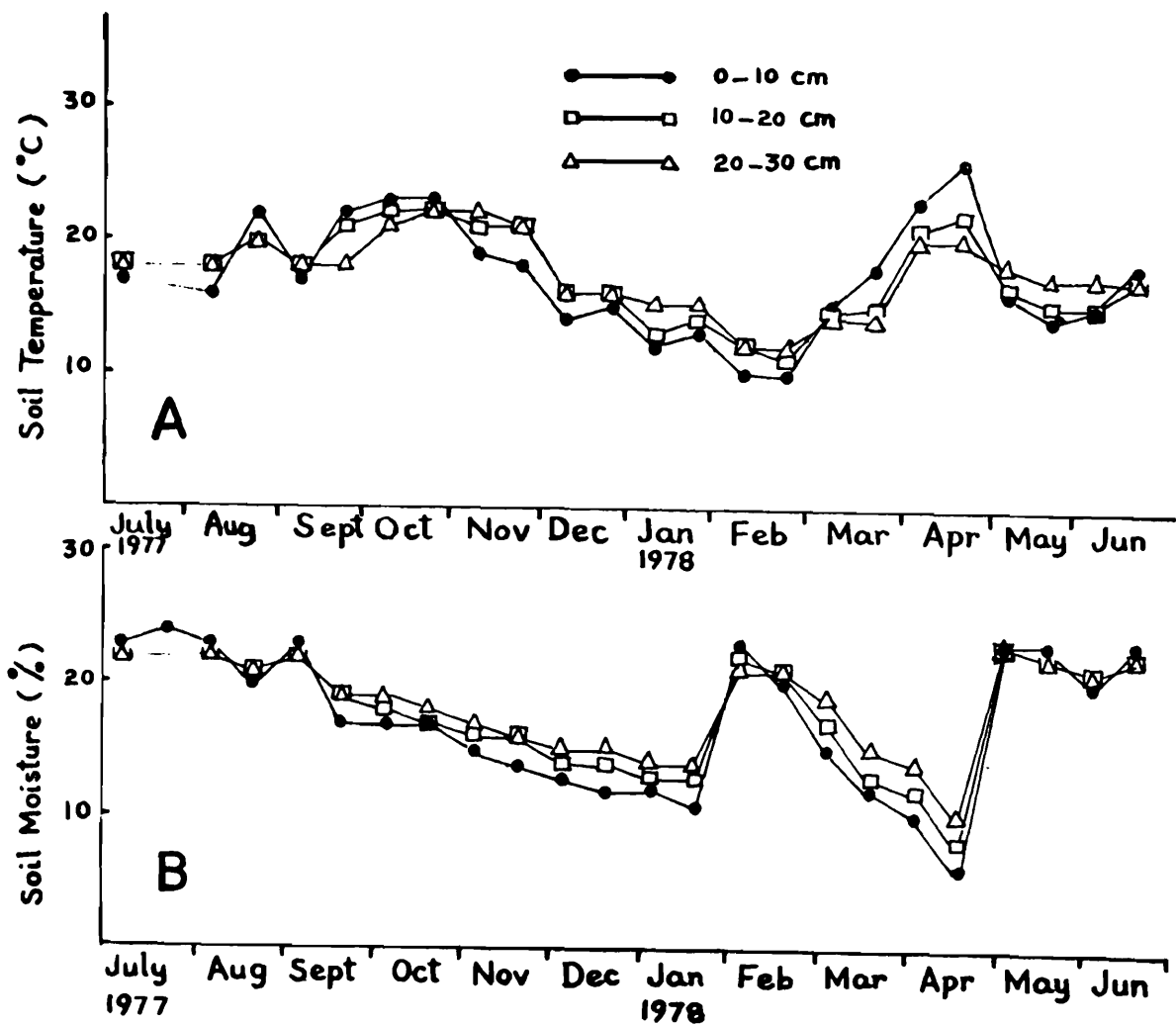


Fig. 1. Seasonal fluctuation in A : Soil temperature,  
B : Soil moisture at Company Garden, Bareilly.

noted between two adjacent layers. During winter (November to February), the temperature was higher at the two lower depths, but in summer (March to May) it was just reverse (fig. 1, A). Soil moisture also varied during different seasons and at different depths. The highest (24%) of soil moisture was recorded in July, 1977 and the lowest (6%) in April, 1978 (fig. 1, B).

The studies on population fluctuations of nematodes from July, 1977 to June, 1978 showed that they were abundant during the monsoon period occurring in maximum number in the month of August. Afterwards the population gradually declined with a corresponding fall in the soil moisture. The lowest of population was reached in April (fig. II) where the temperature was maximum and the soil moisture was minimum (fig. 1 A & B).

The distribution of worms varied greatly throughout the year especially in the upper and middle depths. The largest number of nematodes were recovered in the upper depth soil while the lowest concentration was found at the lower depth (fig. 2). The relative distribution of different juvenile

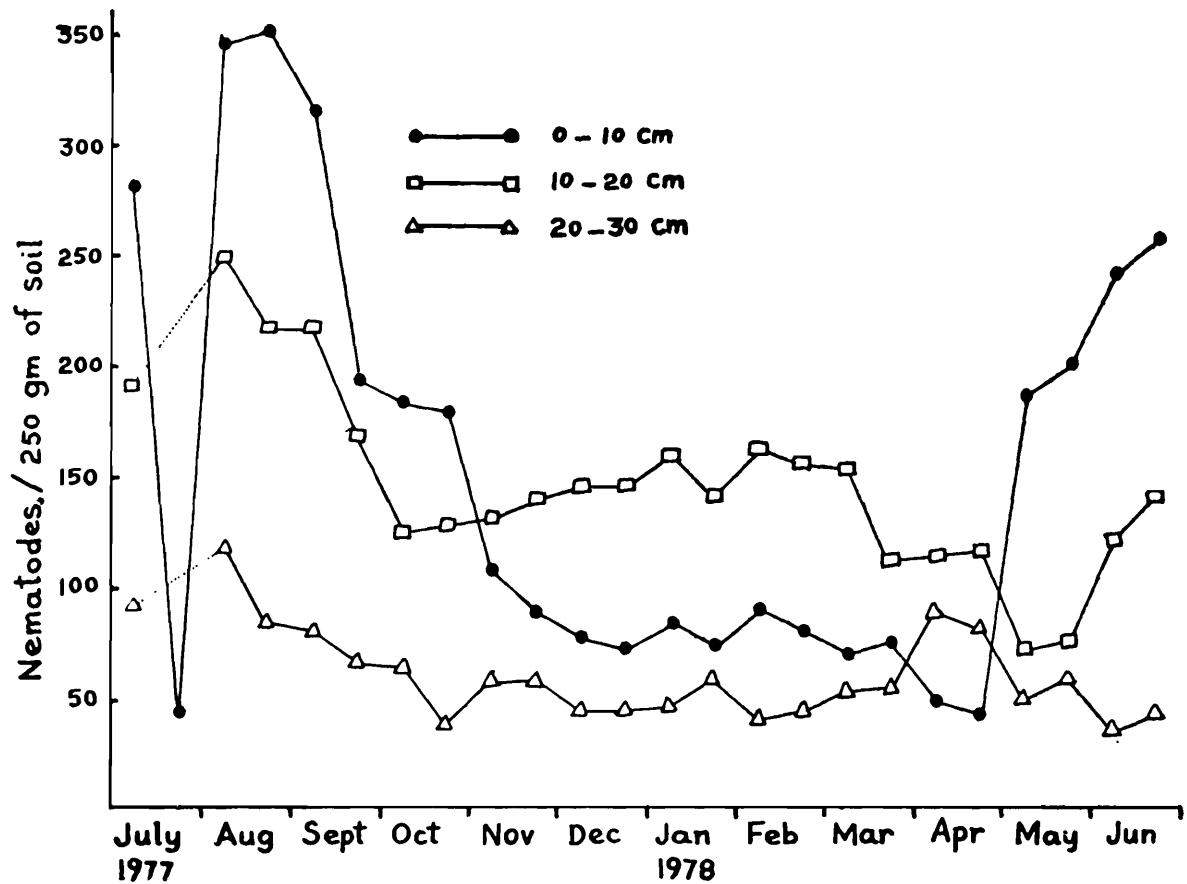


Fig. 2. Seasonal fluctuation in the distribution of *Hadronchus shakili* in soil.

stages and the adults at three depths was found to be almost same (figs. 3 & 4). The maximum concentration of *P. shakili* was noticed at the upper depth from May to October, when the soil moisture and temperature were 17-23% and 16-23°C respectively, except in late July when the entire field was water-logged due to heavy rain (fig. 2). From October onwards they started migrating downwards and concentrated at middle depth until April, with a gradual decline of 6% in moisture (except in February when the moisture was 20-23% due to rain). Again an upward migration took place from May onwards when the plot was irrigated. The least migration was noticed in the lower depth where there was least variation in temperature as well as moisture (fig. 2).

The breeding season of *Parahadronchus shakili* started from the month of March. The maximum number of uterine eggs (0.44 eggs per female) were recorded in early September while the lowest numbers in October (0.04 per female). From late October until late February no eggs were found in the uteri (fig. 5).

The first stage juveniles though present throughout the year increased in number as the breeding season started and reached its peak (46% of the total population of *P. shakili*) in early September. The lowest level (8%) was recorded in February (fig. 6, A). The highest concentration of the

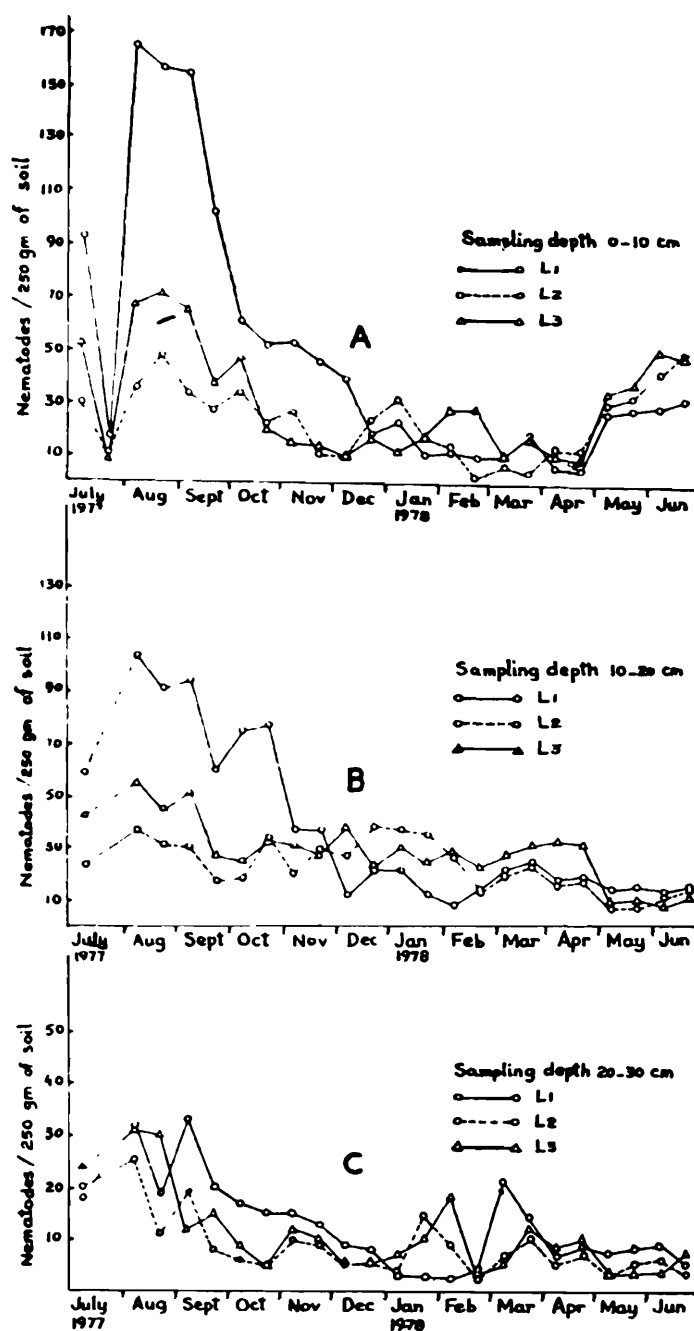


Fig. 3. Seasonal fluctuations in the distribution of L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> of *Hadronchus shakili* in soil. A : 0-10 cm ; B : 10-20 cm ; C : 20-30 cm.

second stage juveniles (27%) was recorded in January, *i.e.*, about five months after the peak period of first stage juveniles, and its lowest count was 12% in May (fig. 6, A). The population of the third stage juveniles varied from 14 to 22% of the total population of *P. shakili* in June and March respectively (fig. 6 A). The population of the fourth stage juveniles was highest (43%) in February and lowest (7%) in August. On the basis of above observations it can be inferred that the population of fourth stage juvenile was highest when the population of the first stage juveniles was lowest and vice versa (fig. 6). The peak in the population of adults (36% of the total population of *P. shakili*) occurred about five

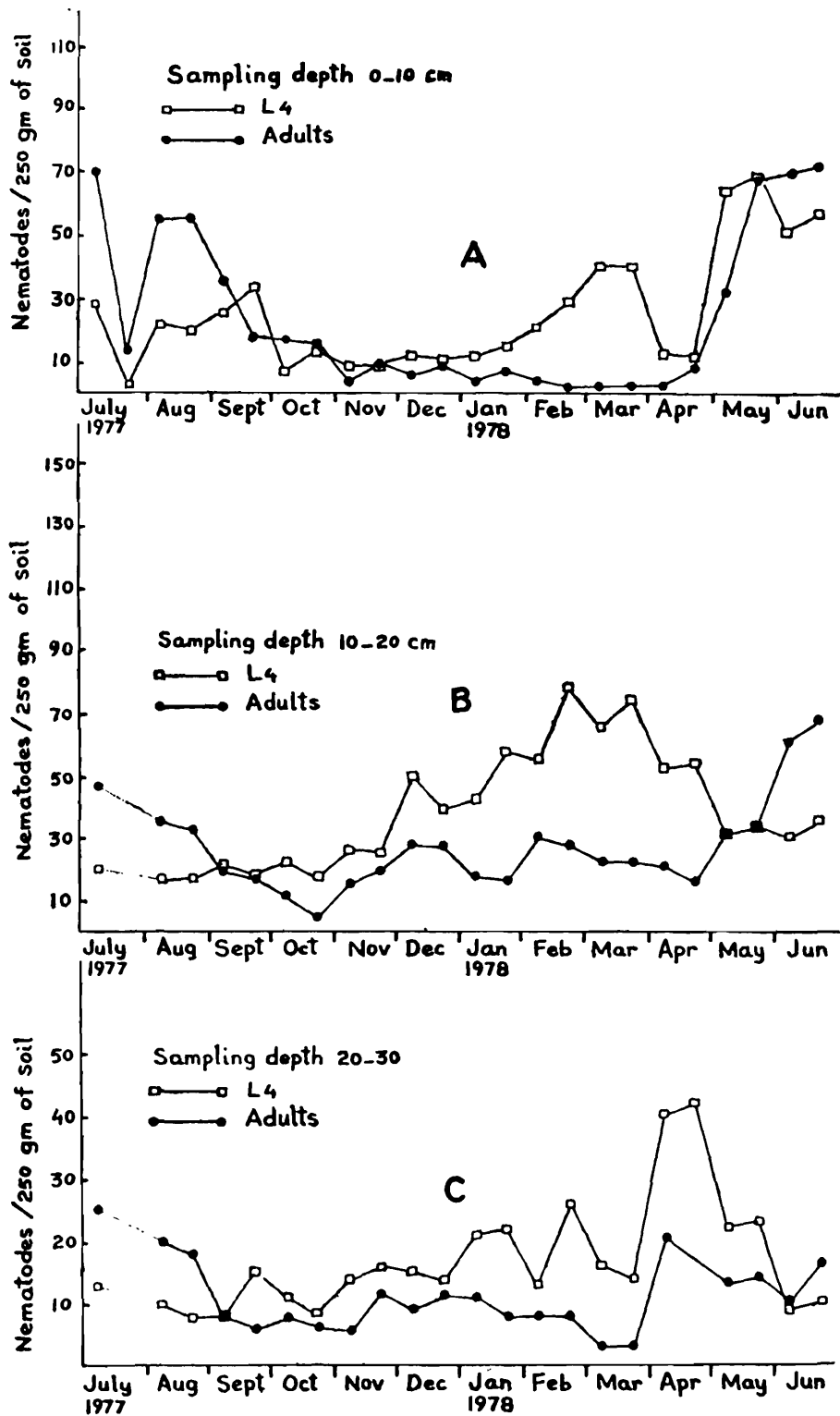


Fig. 4. Seasonal fluctuations in the distribution of L<sub>4</sub> and adults of *Hadronchus shakili*. A : 0-10 cm ; B : 10-20 cm ; C : 20-30 cm.

months later to the peak of fourth stage juveniles, *i.e.*, in June with their lowest count (8%) in October (fig. 6, B). The male female ratio was almost constant (1:1) throughout the seasons.

The observation made on total population of prey (other nematodes) along with the individual populations of *Trichodorus* sp. *Thornenema* sp. and *Hemicriconemoides* sp., to the population of *P. shakili* showed an

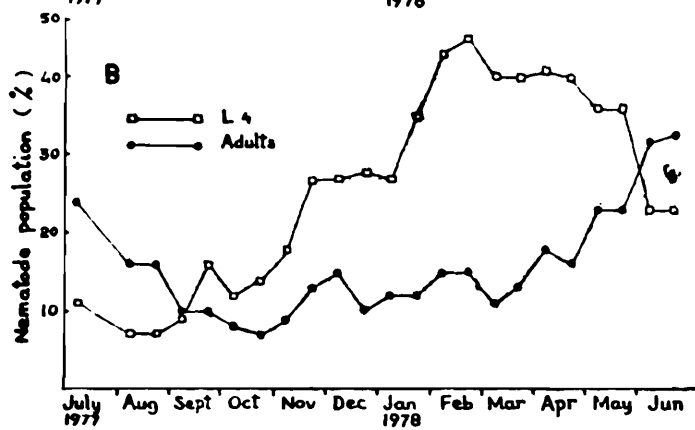
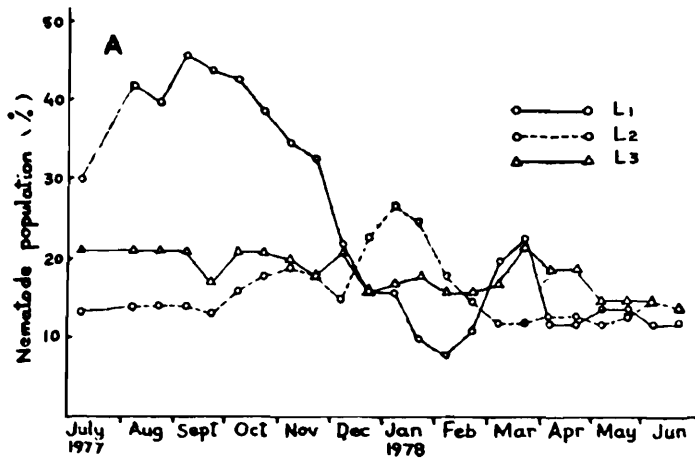
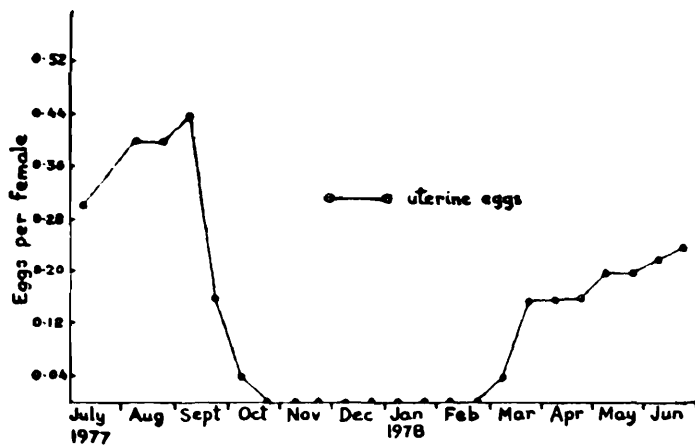


Fig. 5. Seasonal fluctuations in uterine egg count.

Fig. 6. Seasonal fluctuations in the population of A : L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> ; B : L<sub>4</sub> and adults of *Hadronchus shakili*

inverse relationship (fig. 7, A & B). The population of *Trichodorus* sp. increased from August until March as the population of *P. shakili* decreased. In case of *Thornenema* sp. its population increased as the population of *P. shakili* decreased and vice versa. The population of *Hemicriconemoides* sp. (occurring only at middle and lower depths) decreased as the number of *P. shakili* at the respective depths increased and vice versa (fig. A). The trend in the total population of prey was also found almost parallel to the population of *Trichodorus* sp. (fig. B).

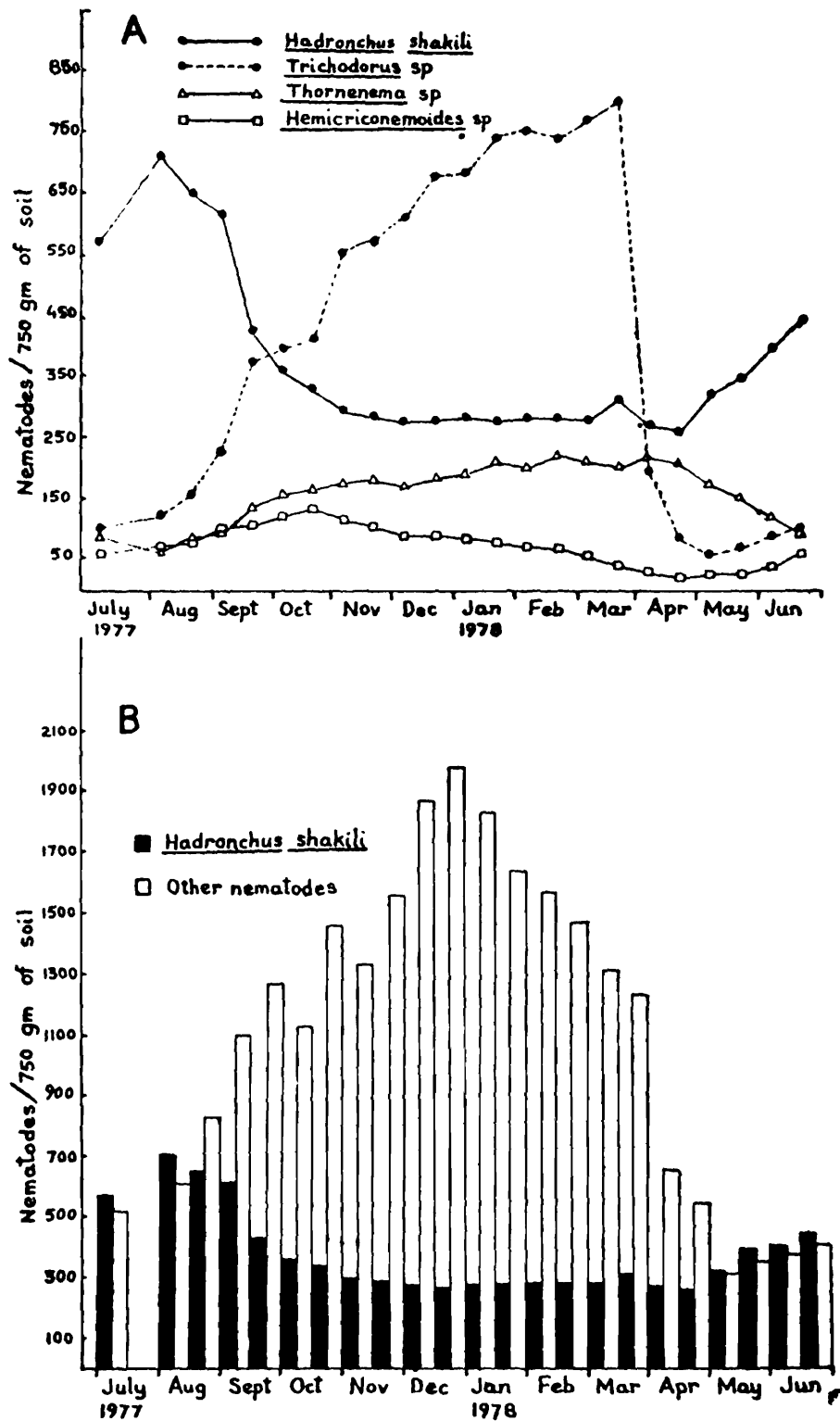


Fig. 7. Relationship between population of A : *Hadronchus shakili* and the populations of *Trichoderus* sp. *Thornenema* sp. and *Hemicriconemoides* sp., ; B : *H. shakili* and the total population of prey (other nematodes).

#### DISCUSSION

The results of the present study on *Parahadronchus shakili* support the findings of Kable and Mai (1968), Wallace (1971), O'Bannon *et al.*, (1972) and others that seasonal fluctuations in the nematode population is

governed mainly by the variations in the soil moisture. The present results also support the findings of Griffin and Darling (1964) that the minimum population of nematodes is found when maximum soil temperature and minimum soil moisture are encountered.

The fluctuation in the nematode population is highest at the upper and middle depths and least at the lower depths is correlated with the variations in soil moisture and temperature at the respective depths. This is in accordance with the observations of Griffin and Darling (1964). The sharp decline in the population of *P. shakili* during late July and its subsequent increase in August at upper depths can be attributed to water-logging. Further, the migration of nematodes from the upper depth to the middle from October to April is due to corresponding decrease in soil moisture in the upper depth. During May, after irrigation, their migration to the upper depth is again due to soil moisture. This observation supports the findings of Wallace (1962), Wallace and Greet (1964). In spite of optimum moisture (20-23%) at upper depth in the month of February, the nematode density was higher at middle depth. Most probably, the upward migration was prevented due to a low temperature (10°C) at upper depth in February. This confirms the observations of Lewis and Mai (1961) that temperature affects nematode migration.

The gradual increase in the population of adults and a corresponding decrease in the population of the fourth stage juveniles preceding the breeding season is due to moulting of the fourth stage juveniles to become adults. The sharp decline in the population of adults in October is perhaps due to the death of spent females. The peak in egg count is followed by an increase in the population of first stage juveniles. This suggests that the eggs have hatched promptly during this period. Further, the peaks in the population of other stages is not followed by the peak of first stage juveniles which suggests that the span of life of each stage is variable, extending for several months. The continuous presence of uterine eggs from March to October with its peak in September along with the total absence of such eggs from late October until late February clearly indicates that *P. shakili* breeds only once in a year.

The sharp decline in the total population of prey along with the individual populations of *Trichodorus* sp. in April is probably due to the dry weather. Their further reduction in May, when the soil moisture is sufficient and the number of predator is relatively high appears to be due to over predation. The slight decline in the population of *Hemicricone-moides* sp. in April when the predator density was highest may be attributed to the interaction between prey and predator. In case of *Thornenema* sp. the results are similar to that of *Trichodorus* sp. except that there is no such sharp decline in the population in April. Thus the

population fluctuations of prey is inversely related to the population of predator under normal conditions and it shows that there is a clear antagonism between the prey and the predator (fig. 7). Further, the results show that the studies on such interactions should be undertaken in relation to the specific species or genera of nematodes instead of the total population of prey which may not give proper results. This might be due to the diversity in the mode of reproduction of different species, especially in case of free-living nematode where the life cycle is usually short and the rate of reproduction is tremendous. However, one thing that becomes quite evident from the present study is that even a slight increase in the population level of the predator, *P. shakili* caused a sharp decline in the population of prey (other nematodes) and vice versa.

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## THE REGULATION OF CESTODE PARASITE POPULATIONS

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Parasitism is the result of a successful inter-specific association, where the parasite becomes physiologically dependent on the host and manifests a higher reproductive capacity than the latter. It is therefore, fundamentally, a qualitative relationship. But, ideally speaking, the parasite should not over-burden or outnumber the host species to the extent that the equilibrium is upset and the host is endangered. For, overinfection, in terms of numbers of parasite individuals or a very high reproductive and or dispersal rate exploiting the nutritional and spatial resources within the host, will eventually jeopardize their survival. Thus, in the process of establishing themselves within the host and subsequent growth and reproduction, a quantitative relationship becomes evident. The density of the parasite and host populations is necessarily determined, for stability of the host-parasite system, by the operation of appropriate negative controls, ecological and physiological.

In the transmission of the parasite, ecological factors such as temperature, humidity etc., and behaviour or habits of the host would govern the survival and dispersal of the free living stages, as well as the accessibility of the host to the infective stages. Regulation of the parasite population within the host is achieved entirely by physiological factors implicit in intra-specific relationships and host response, which constitute the "feed-back control mechanism",

Since cestodes are obligatory intestinal parasites, it is to be expected that their numbers and growth will be influenced by the micro-environment in the host's intestine. "Crowding Effect" is a phenomenon that has been observed by several workers studying cestode infections. Manifestations of this effect, in the case of *Hymenolepis nana*, *H. diminuta*, *H. microstoma*, *Raillietina cesticillus*, and *Dibothriocephalus latus* were revealed by the size of the individual worms being inversely related to the number of worms in the intestine at one time (Read and Simmons, 1963 ; Smyth, 1969). Overcrowding of individuals of the same species and competition

for available and utilizable carbohydrates leads to inhibited establishment of many of them, retarded growth-rate and fertility, and extended generation periods. Some of them even shift the sites of attachment, as an accommodation, and become restricted to those places of preference.

In *H. diminuta*, the crowding effect does not become obvious till about a week after infection (Roberts, 1961), and the size of the tapeworm individuals diminishes in proportion to the wormload. Maturation is, however, not decelerated or prevented, but the number of mature and gravid segments may be fewer (Roberts, 1966). In *Diphyllobothrium dendriticum*, evidence was obtained for the reduction in the number of eggs per individual cestode, under crowded conditions, the overall egg output from the host remaining unaffected (Halvorsen and Andersen, 1974). Thus, crowding effect may be regarded as a negative feed-back control mechanism resulting in a homeostatic state (Kennedy, 1975).

In the micro-habitat of the vertebrate small intestine, cestodes of one species are likely to encounter other species. Inter-specific reactions, with a nutritional basis, are known in concurrent infections. For example, Read and Phifer (1959) showed that, in the hamster, infected with a single *H. diminuta* and *H. citelli*, there was a reduction in the weight of each of the individual worms. When the acanthocephalan *Moniliformis dubius* and *H. diminuta* occurred together, *H. diminuta* individuals were lesser in weight, shorter, had a lower average weight/length ratio, and attached themselves more posteriorly in the intestine than usual. *M. dubius* were also lighter and shorter, but attached themselves more anteriorly (Holmes, 1961, 1962a, 1962b). Competition for carbohydrate resources appears to be involved in these inter-specific influences. Understandably, inter-specific competition effects are determinable only in experimental studies. They are less pronounced than in intra-specific reactions and seldom function as feed-back control. Factors like the sequence in and intervals between infections with different species may be of importance.

Host-mediated immune response may also limit cestode numbers. The majority of cestode larvae in mammals are capable of provoking strong and effective host-immunity, as in *Cysticercus fasciolaris*, in contrast to their adults (Weinmann, 1966, 1970). Hydatid cysts do not however produce total immunity in sheep. In *H. microstoma* infections, antibodies produced in the normal host, the mouse, are ineffective against the adults, while those in the rat prevent their growth and reproduction (Moss, 1971). Only in *H. nana* infections in mice is a true immune response limiting levels of adult numbers evident, which is attributable to the possible development of the strongly antigenic cysticercoid in the same host.

Factors controlling infection levels in cestodes and host-diet and status, stress, and intra-specific competition. The phenomenon of 'Premunition', in which an initial or existing worm-load prevents further establishment of the same species, is known in *H. diminuta* in rats, *Taenia saginata*, and possibly *T. solium* in man.

Multiple infections, involving tens, hundreds or thousands of adult tapeworms, are commonly encountered in the case of *Dipylidium caninum*, *Echinococcus granulosus* etc., in dogs and other carnivores, *Railletina* spp., in poultry, and *Moniezia* spp., in cattle and sheep. But *T. saginata* and *T. solium* occur generally as single worm infections in man, and multiple infections are rare and superimposed infections do not normally occur. Commenting on this aspect in *T. saginata*, Pawlowski (1972) considered that the factors accounting for single worm infections are not known, but "evidently, the crowding effect operates in multiple infections" It is, again, interesting that *T. saginata* could concurrently exist with *T. solium* or *Diphyllobothrium latum*, indicating that inter-specific hostility is weak or non-existent. In the author's experience with over twenty cases, of persons with *T. saginata* and *T. solium* infections studied, all were single worm infections as proved by the recovery of the scolex after Yomesan therapy and subsequent non-expulsion of segments.

It is conceivable that a meat-eater swallows more than one *Cysticercus* (*C. cellulosae* or *C. bovis*) at a time, but where single worm infections result, there operates a factor which generates incompatibility between two or more individuals of the *same* species, but not of *different* species. The mechanism by which the establishment of multiple infections of the same species occurs, whether at one time or on subsequent occasions, is yet unknown. Inhibition of development of individuals of later infections is presumably unrelated to antibody or other immune response (Kennedy, 1975), but what militates against the simultaneous establishment of worms of the same batch is a subject for inquiry. That this feed-back control mechanism is so effective as to limit the infection to one worm, in the case of *T. saginata* and *T. solium*, species exhibiting an extreme degree of host specificity (having only man as their host), and not so in other members of the Taeniidae (*T. hydatigena*, *Multiceps* spp., *Echinococcus* sp., —having a wider host range) is also intriguing, and calls for a deeper understanding of these cestodes in their micro-habitat.

Only experimental infections with the cysticerci could demonstrate the interaction between them, but as no animal host is yet known for *T. saginata* or *T. solium*, such studies will have to wait for the establishment of an animal model.

Whereas ecological factors favouring contact between the parasite and the host will determine *incidence*, intra-specific competition, rather than

host-response, appears to be the principal factor regulating intensity levels of cestode populations.

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## POPULATION AND SOCIAL BIOLOGY OF ROSE-RINGED PARAKEET, *PSITTACULA KRAMERI* IN PUNE, MAHARASHTRA

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### INTRODUCTION

The Rose-ringed Parakeet, *Psittacula krameri* (Scopoli) is a familiar bird in both cities and villages. It is a social bird, found in loose parties during the daytime. In the evening it can be seen flying towards the communal roost in small as well as bigger flocks. The feeding, nesting and breeding biology of this bird have been studied in detail by Ali and Ripley (1972), Lamba (1966) and Simwat and Sidhu (1973, 1974). However, there is practically no information on its population and social activities. We have collected data on the populations of Rose-ringed Parakeets during 1974-1976 in Pune City. Some interesting observations are also made on the roosting behaviour at the communal roost. As these parakeets are said to be serious pest of agricultural crops and orchards, this study will be useful to those who are interested in controlling their population.

### MATERIALS AND METHODS

Studies on the population and social behaviour of major species roosting communally in the Pune city were attempted. As a part of this study, the Brahminy Myna, Indian Myna, House Crow, Jungle Crow, Rosy Pastor, Cattle Egret, Pond Heron, Pariah kite, House Sparrow and Rose-ringed Parakeet at all this communal roosts were located of the two roosts of Rose-ringed Parakeets in the city (fig. 1). A monthly observations were made from May 1974 to September 1976 of each roost. Census records were maintained at five minutes interval on the number of flocks and flock sizes of parakeets arriving at the communal roost in the evening. The flocks follow certain definite directions and hence they are accurately countable from a good distance.

### POPULATION

The life cycle of Rose-ringed Parakeets can be divided into three stages : Pre-breeding (September-December), breeding (January-May) and post-breeding (June-August). Fig. 2 indicates the monthly fluctuations in the population of parakeets during 1974-1976 and also shows that

rhythmic cyclic changes continues from year to year. It was also observed that the average population for these years is constant and maximum population reaches in the month of August.

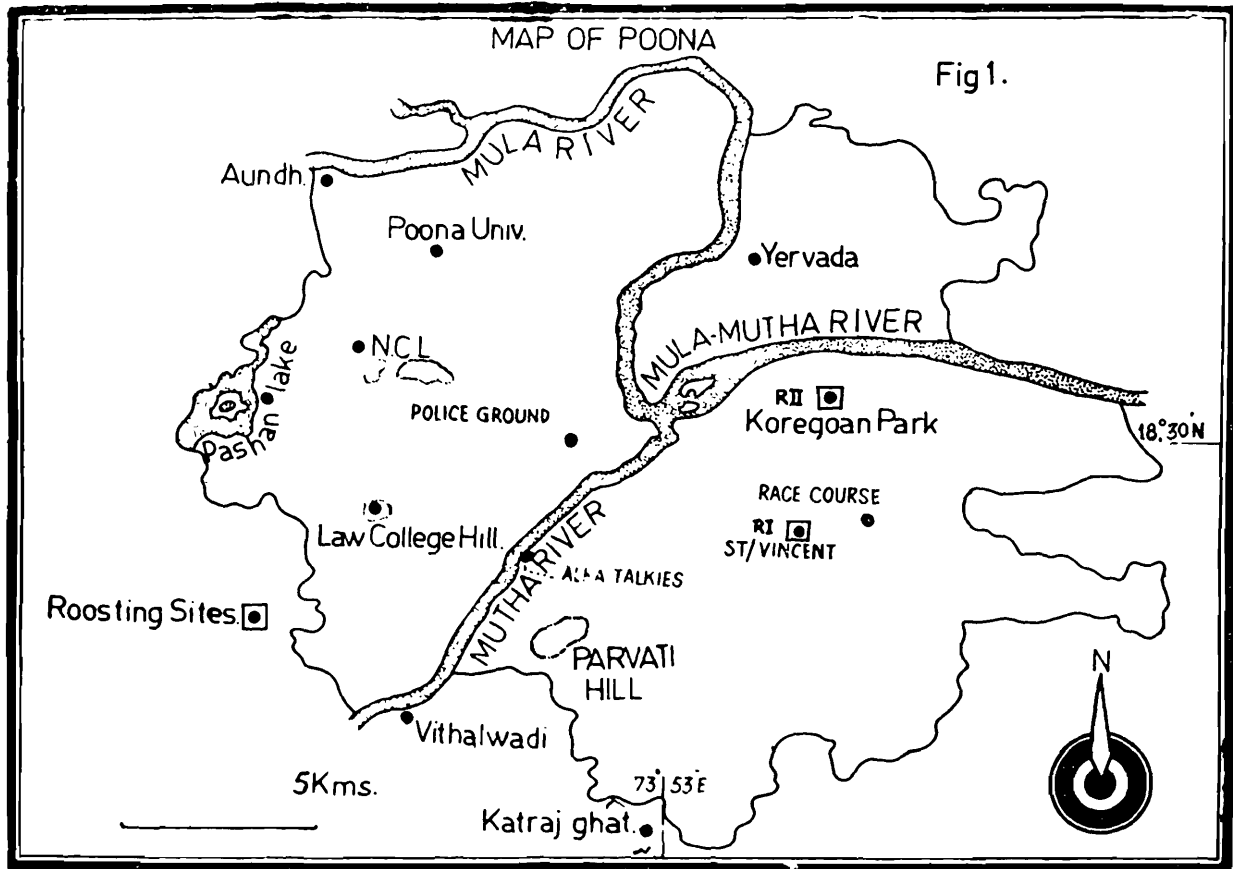


Fig. 1. Map of Pune city showing the location of the two roost of Rose-ringed Parakeet.

In the pre-breeding season, a constant decline was observed in the population, due perhaps to the emigration of the parakeets from the city, possible due to food scarcity and for the finding of the nest holes. On the onset of breeding season, this decline in the population continued and attains its lowest level, in the month of February perhaps due to the fact that female parakeet during this nesting season was known to stay on the nest (Simwat and Sidhu 1973). Hence their number can not be included in the population counts. From the middle of this breeding season, the number of parakeets increased as young ones join the adults which come to the communal roost. This is further confirmed by observation of Lamba (1966) on various nest in Pune that egg hatched during February and March and nestlings leave the nest after 6-7 weeks, *i.e.* during the month of April. Interestingly, this period of nesting coincides with the period of fruiting season in the city and around. Towards the end of the breeding season a decrease in the number of parakeets was observed. Possibly this is because of victimization of the young ones by predators or by diseases.

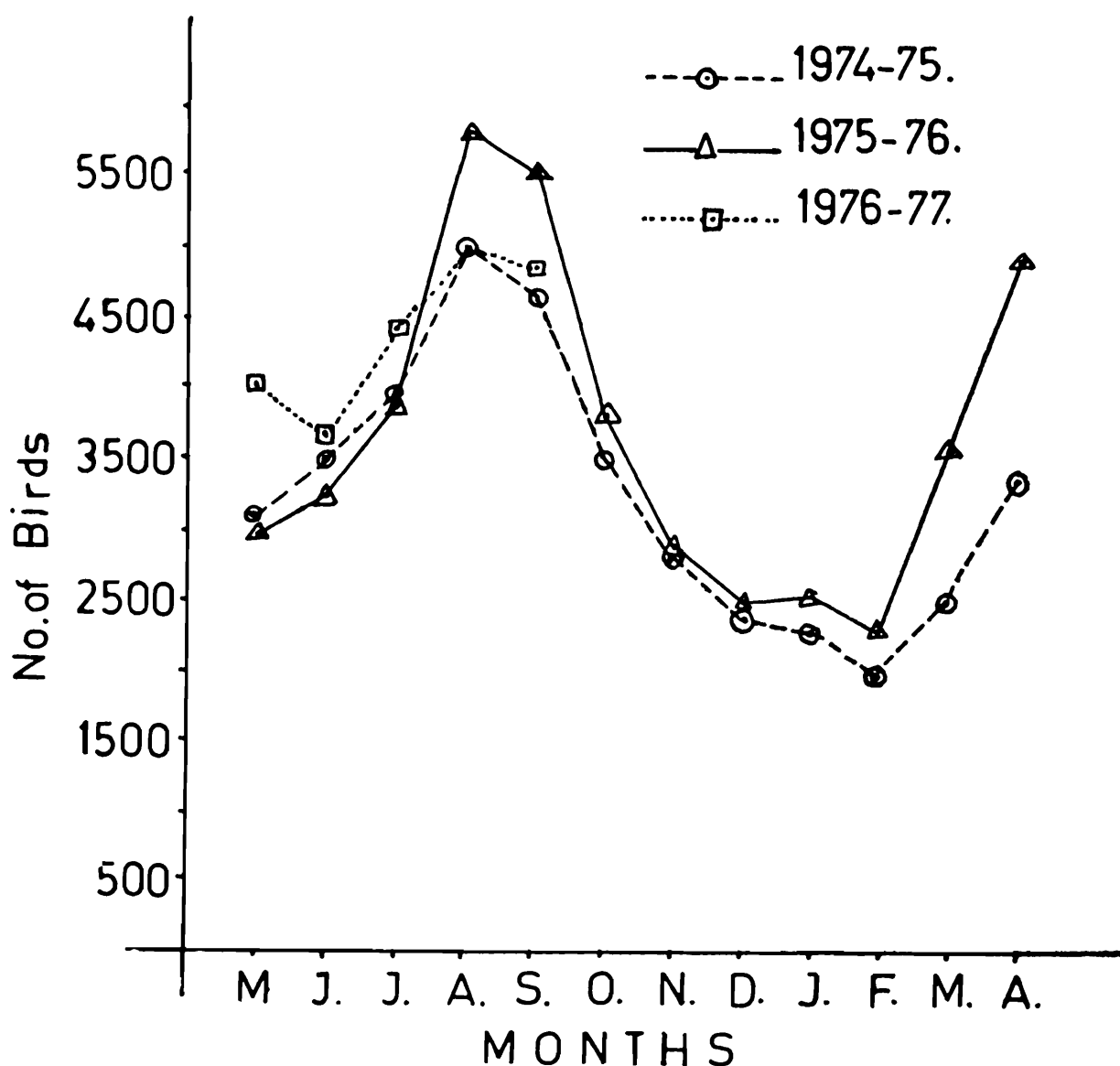


Fig. 2. Population of Rose-ringed Parakeets in Pune city in different months of the year May 1974-September 1976.

With the starting of post-breeding season, a continuous increase in the number was observed till the end of this season during which it reached the maximum population of the year. This appears to be due to the immigration of parakeets to the city. Notably during this season the largest population appears to be concentrated at only one roost-II. It was also noticed that roost-I disappeared during this season. Fig. 3 shows the average population of Rose-ringed Parakeets distributed at two roosts in different seasons from September 1975 to August 1976, clearly indicating that throughout the year concentration of population is observed at roost-II.

#### SOCIAL BIOLOGY

##### *Roosting Sites :*

During the period of these observations, Rose-ringed Parakeets were

noticed to occupy two roosts in the city (Fig. 1). The aerial distance between these two roosts is about 4 kms. At these two sites parakeets have preferred the Banyan trees *Ficus bengalensis* for roosting. At both these roosting sites parakeets invariably form their mixed communal roost in the company of Indian Myna *Acridotheres tristis*, Brahminy Myna, *Sturnus pagodarum* and Rosy Pastor, *Sturnus roseus*. Besides this at roost I, House Crow *Corvus splendens*, Jungle Crow *Corvus macrohynchos*, Pariah kite *Milvus migrans* and House Sparrow *Passer domesticus* were also seen roosting very closely with the parakeet roost.

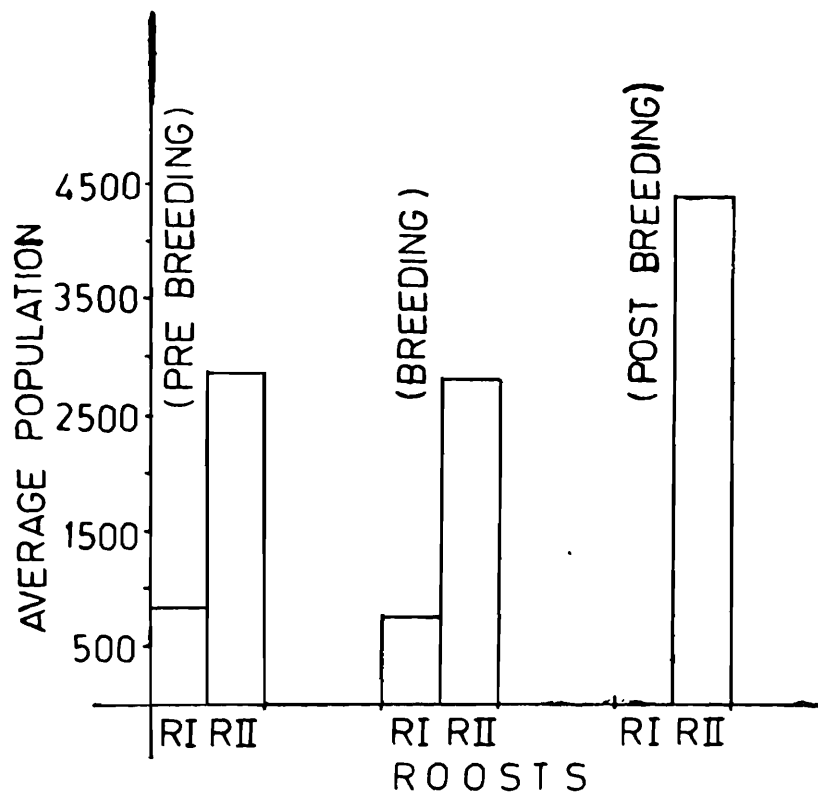


Fig. 3. Average population of Rose-ringed Parakeets at each roost in different seasons.

The shifting and the abandoning of the roosting sites were observed in the parakeets. Roost-I was found to be completely abandoned during June 1975 and from June-August 1976, whereas few new roosts were occupied temporarily during this period at roost-II. Besides this, shifting from one roosting tree to another nearest tree was also noticed at Roost-II.

#### Day time Activities :

Sociable activities of parakeets start early in the morning 30 to 45 minutes before the sunrise. Ultimately 5 to 10 minutes before the sunrise all of them vacate the roost and disperse for feeding. Small parties of 3-8 birds as well as flocks of 10-40 birds dispersed over feeding

arenas preferring the south-west, north-east and eastern part of the city. While moving towards, the feeding arenas solitary, paired birds and small parties fly at low level and take number of halts on the way. On the other hand, after leaving the roost, bigger size flocks go high up in the air and follows a definite direction. Such flocks after crossing the distance of 12-15 kms. at a stretch takes halt for some time and then dispersed for feeding in different directions. The parakeets travel the distance of about 20-40 kms from the roost in search of food.

Many times loose parties of parakeets associate together and attack the orchards or Jowar and Bajra crops. Particularly during the summer (March-May) intraspecific assemblages of birds were observed to be feeding on *Ficus* trees. At such spots parakeets were also seen in company of other birds such as Indian Myna, Brahminy Myna, Rosy Pastor, Redvented Bulbul, Koel and Crimson breasted Barbet.

#### *Pre-roosting Behaviour :*

In the late afternoon, small parties of parakeets slowly start their roostward movements. Such flocks gather together from different directions and halt at certain places called as 'assembly points' At such places as well as on the way develops the bigger strength flocks which ultimately fly in the direction of the communal roost. These flocks follow the same directional routes of the morning and reach the roost in a short period. Various sizes of flocks when come in the vicinity of roost, they fly at low level and congregate at a final halt which is 50-200 mts. away from the actual roost. Finally, while coming to the communal roost, the flocks swoop down, again come up and then spread all over the roosting tree.

Fig. 4 (A-C) shows the number of Rose-ringed Parakeets arriving at the roost at five minutes intervals in different seasons. It is clear that in the breeding season a maximum of 72% of the total birds arrive at the roost after the time of sunset. While in pre-breeding season 68% and in post-breeding 92% of birds arrive before the time of sunset. In post-breeding season the time of arrival of flock shows a greater spread over 60 minutes before and 5 minutes after the sunset, whereas in other seasons it is 25-30 minutes before and 15-20 minutes after the sunset. These seasonal differences in time of roostward movements and time course of assembly of peak numbers at the roost might be due to a combined effect of physical factors such as rainfall, temperature, cloud-cover and light intensity.

Various flock sizes assembling at the communal roost and their distribution in different seasons has been plotted in Fig. 5 (A-C). It indicates that all the distributions are positively skewed and approximately

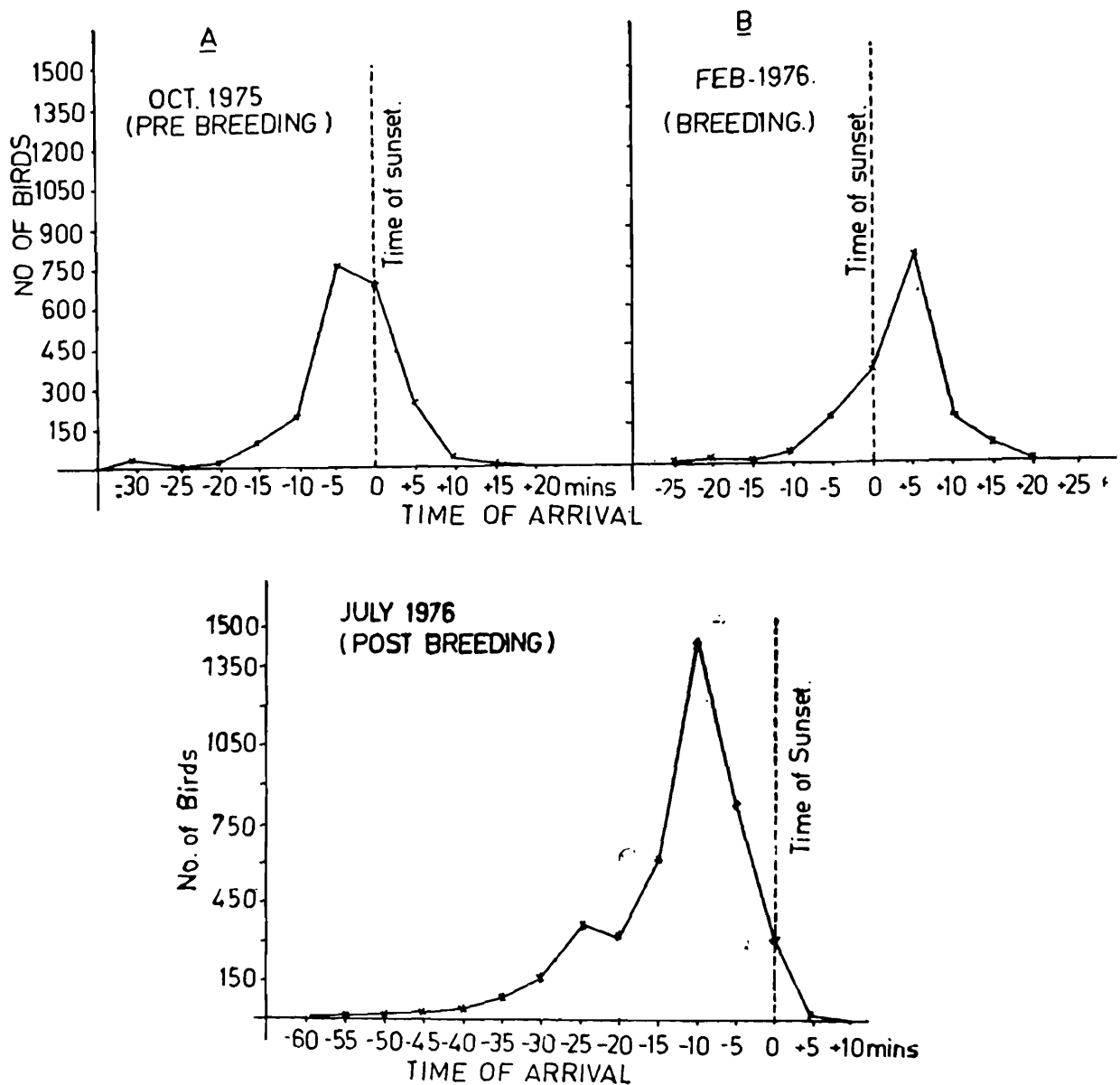


Fig. 4. Time of arrival of Rose-ringed Parakeets at the communal roost R-II in relation to time of sunset. (A) Pre-breeding, (B) Breeding (C) Post-breeding.

the log normal distributions. In pre-breeding and breeding seasons various size of parakeet flocks flying into the communal roost are almost similar. While in the post-breeding season it is noticed that with an increase in the population, number of various size of flocks also increases particularly the solitary, paired and flocks above ten birds.

#### *Pre-roosting Displays :*

With the starting of pre-breeding season the flocks of Rose-ringed Parakeet begin to exhibit synchronised pre-roosting aerial displays. Intensity of these displays slowly increased from October to January and declined thereafter whereas from March to September they did not show any displays, Fig. 6. Flocks comprising of 10-200 birds took part in such displays at the communal roost in the evening. Such flocks suddenly

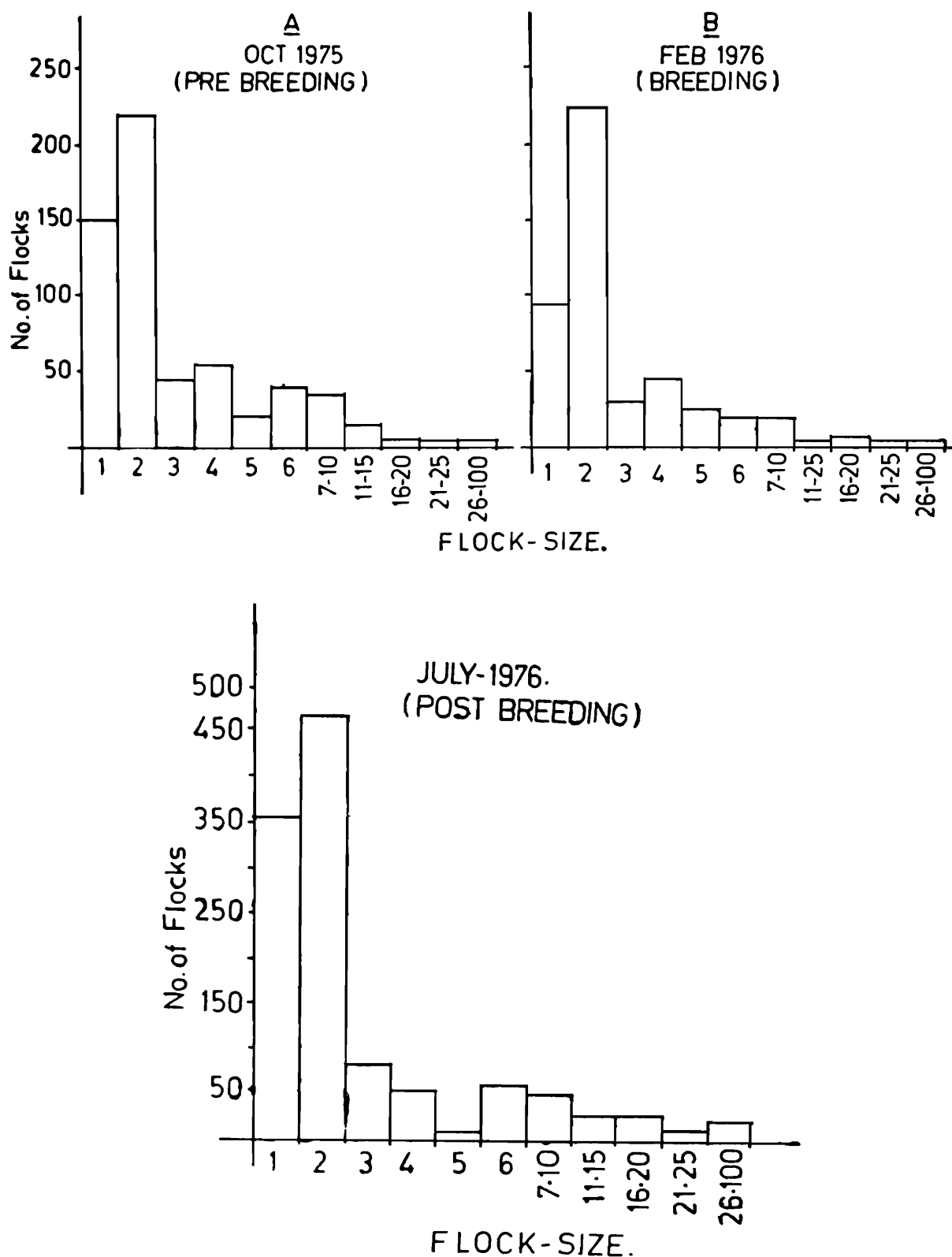


Fig. 5. Flock size of Rose-ringed Parakeets flying into the communal roost R-II (A) Pre-breeding, (B) Breeding, (C) Post-breeding.

take off in the air from the roosting or neighbouring trees making a big noise. The displaying flocks fly for 5-30 seconds performing semicircular, circular or 'S' shaped flights in the air. It was noticed that number of displays performed by flocks of 2-25 are much more than the flocks or other sizes, Fig. 7.

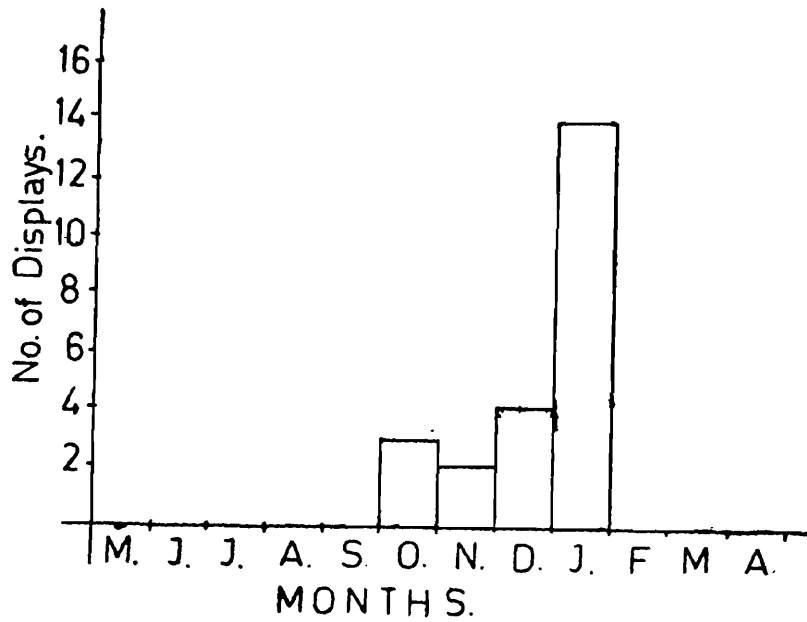


Fig. 6. Number of pre-roosting displays of Rose-ringed Parakeets in different months of the year 1975-76 at the communal roost R-II.

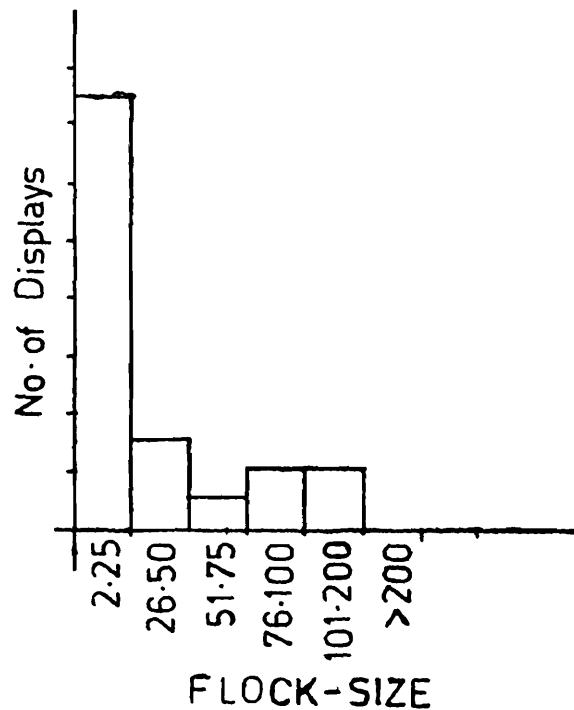


Fig. 7. Number of displays by flocks of various sizes at the communal roost R-II in 1975-76.

One of the major associate of Rose-ringed Parakeet, the Indian Mynas also exhibit such pre-roosting displays during this period. However not only the myna and parakeets perform their displays separately but the time was also relatively different. The number of other communally roosting bird species also behave in the same manner in their pre-breeding season but the exact function of these displays is still unclear.

## CONTROL MEASURES

Many bird species are destructive to the agricultural crops and orchards. Among these, the Rose-ringed Parakeets are said to be the topmost destroying species to the orchards. In controlling this species, the following steps can be followed : (1) Find out the permanent roosting sites of these birds in cities and towns. (2) Census the population at every month, for complete year and find out the average population. (3) Then during their breeding season *i.e.* January onwards and particularly when young ones joins the roost, they can be caught near by the roosting sites with using many mist nets. Because of their habit of flying at very low level near by the roosting site number of adult and young ones are likely to be trapped. (4) The adult and young parakeets can be sold out for experimental purposes or as pet birds. (5) Count the population for next year and repeat the netting till it comes to half of the average population. Ultimately it will affect the total population to reduce in succeeding years.

## ACKNOWLEDGEMENTS

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SEASONAL FLUCTUATION IN THE PERIPHERAL  
PARASITAEMIA OF *RANA LIMNOCHARIS*  
INFECTED WITH *TRYPANOSOMA*  
*ROTATORIUM* COMPLEX.

By

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INTRODUCTION

Observations presented here relate to the effects of seasonal variations on the intensity of trypanosomes in the peripheral blood of *Rana limnocharis* Wiegmann and factors influencing the density of peripheral trypanosome population in this anuran host.

Seasonal fluctuations of trypanosome populations from anuran hosts have been well documented (Vide Bardsley and Harmsen, 1973). However, no attention has been paid to such studies so far from India.

MATERIALS AND METHODS

*Rana limnocharis*, the Indian cricket frog or the paddy field frog, occurring to a greater or lesser extent throughout the year, has been found to harbour a species of trypanosome, herein designated *Trypanosoma rotatorium* Complex, making available sufficient material for study.

Field observations on the prevalence of parasite and intensity of peripheral parasitaemia were made from blood smears sampled from four districts of West Bengal *viz.*, Bankura, Hooghly, Howrah and 24-Parganas. Blood smears were taken by clipping fingers, stained with Leishman or Giemsa's stain and examined until a count of 10,000 erythrocytes or satisfactions before declaring any specimen negative for the infection. The intensity of peripheral parasitaemia was determined counting parasites per 10,000 erythrocytes in a linear fashion.

The intensity of peripheral trypanosomes was also studied in the naturally infected laboratory maintained frogs. Three frogs infected with *T. rotatorium* collected earlier (in Oct.-Dec. 1975) were used for the purpose. After a few month's acclimitization, routine examination of blood smears were carried on once a month from each frog, *i.e.*, on every 10th day from three infected frogs kept in the laboratory at room temperature.

OBSERVATIONS

A total of 307 frogs were examined for a period of two years, January 1976-December, 1977, of which only 46 frogs (14.9%) were

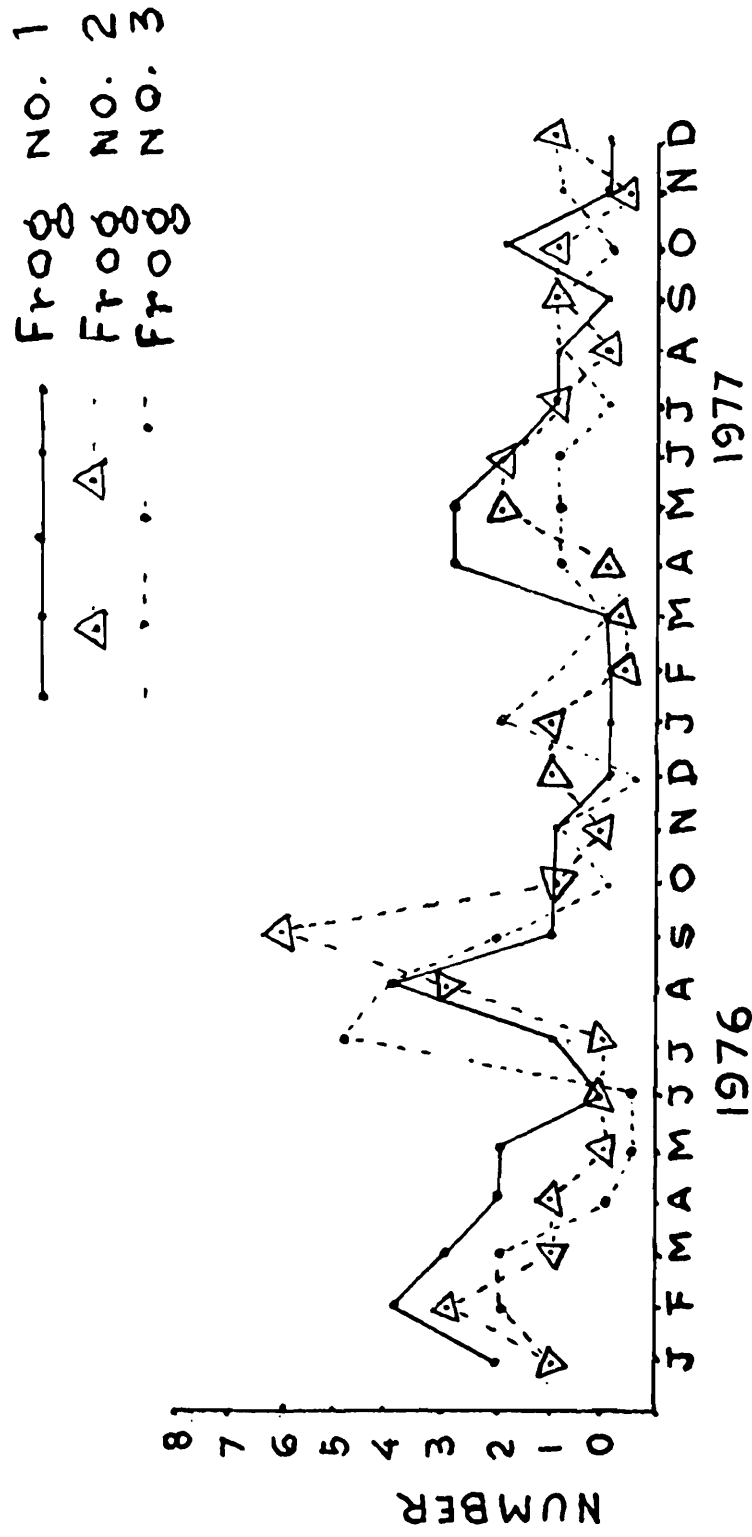


Fig. 1. Intensity (no. of tryps / 10,000 erythrocytes) of peripheral parasitaemia in three laboratory maintained frogs.

found to be infected with this parasites. The results are shown in histograms (figs. 1-4) which indicate that the overall prevalence of parasitaemia was relatively high (22.2-28.9%) during July-September period and low (0-5.8%) during winter (figs. 2 and 3).

The intensity of trypanosome infection per 10,000 erythrocytes was recorded from all the 46 infected frogs. An average (N=5) as high as 10 parasites per 10,000 erythrocytes was observed in the month of August 1977). The overall intensity of parasites was also observed to be high

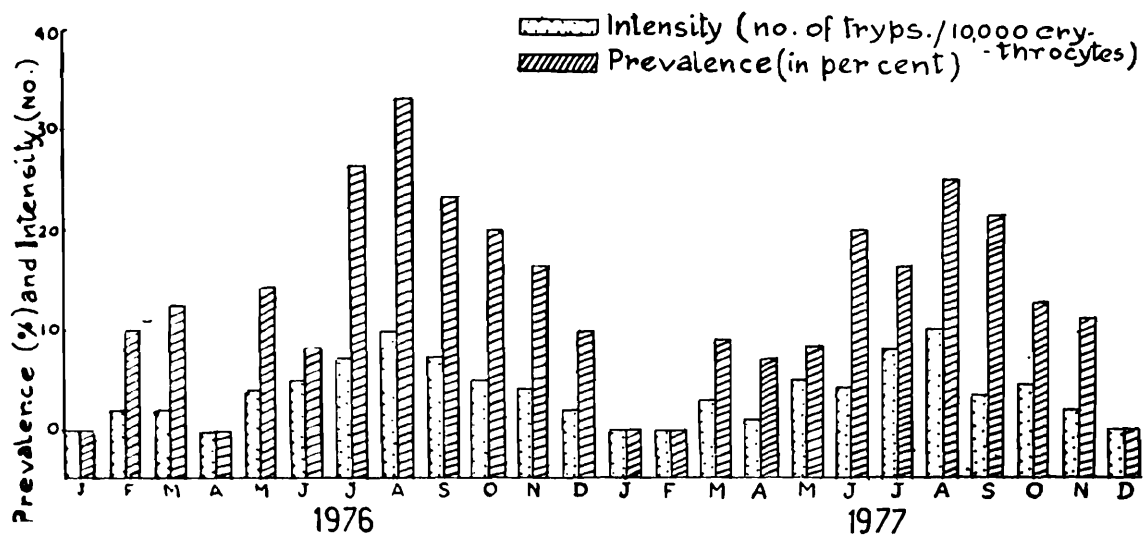


Fig. 2. Seasonal prevalence and intensity of peripheral trypanosomes (*T. rotatorium*) from *Rana limnocharis*.

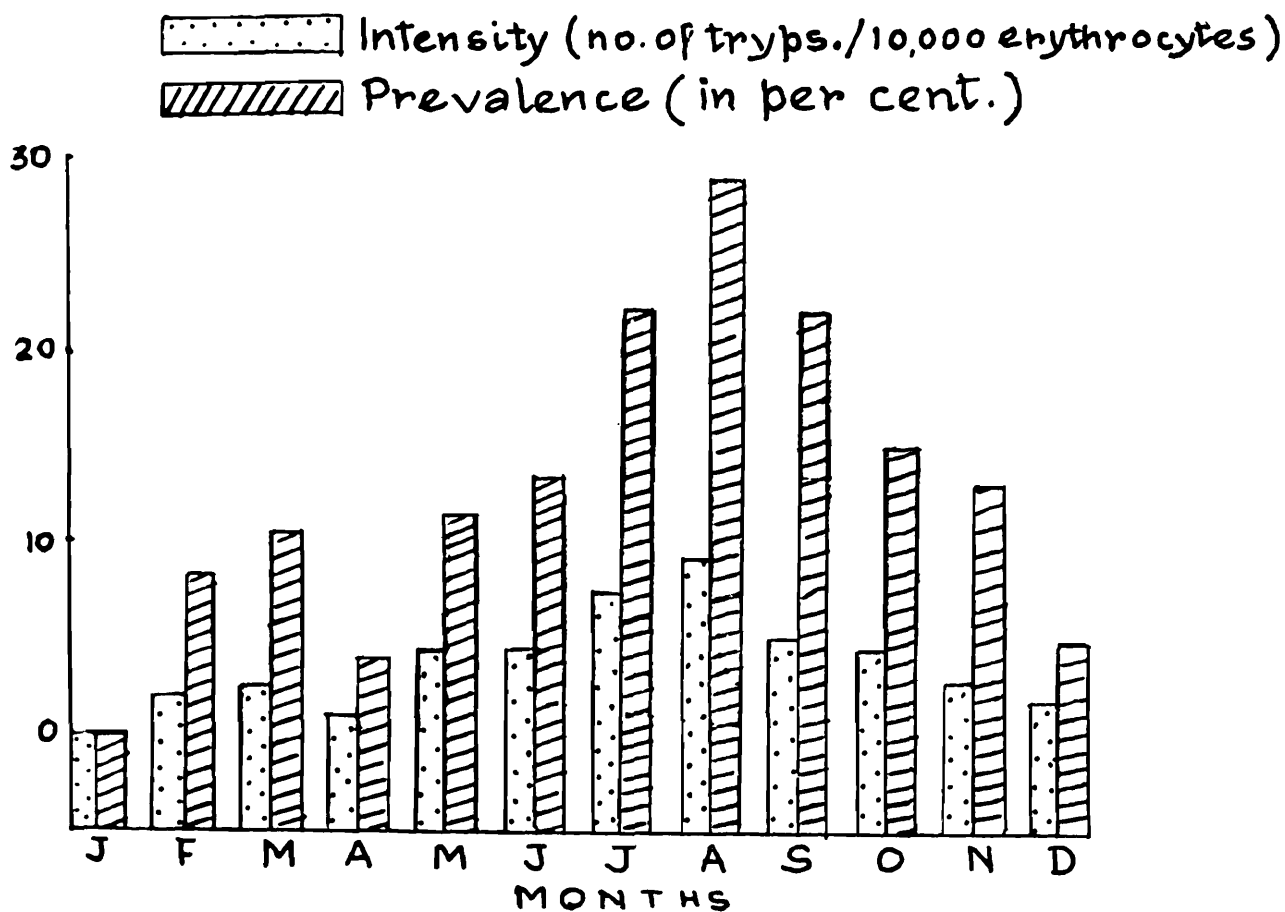


Fig. 3. Overall prevalence and intensity of *T. rotatorium* in *Rana limnocharis*.

(9.8 tryps./10,000 erythrocytes ; average of 11 frogs) during this month for the years 1976 and 1977 (fig. 3). A low level of parasitaemia (0-2 tryps/10,000 erythrocytes) was observed during winter (December-February).

Monthly observations of the intensity of peripheral trypanosome populations were observed on the three frogs kept in the controlled laboratory conditions at room temperature. The intensity of infection is shown in fig. 1 which showed a peak in July-September period with a maximum of 6 tryps/10,000 erythrocytes in September, 1976 exhibited by the frog No. 2. The intensity of trypanosome infection in the second year was more or less irregular and on the whole the intensity of the laboratory maintained frogs showed a gradual decline as compared to that recorded from the field (fig. 4).

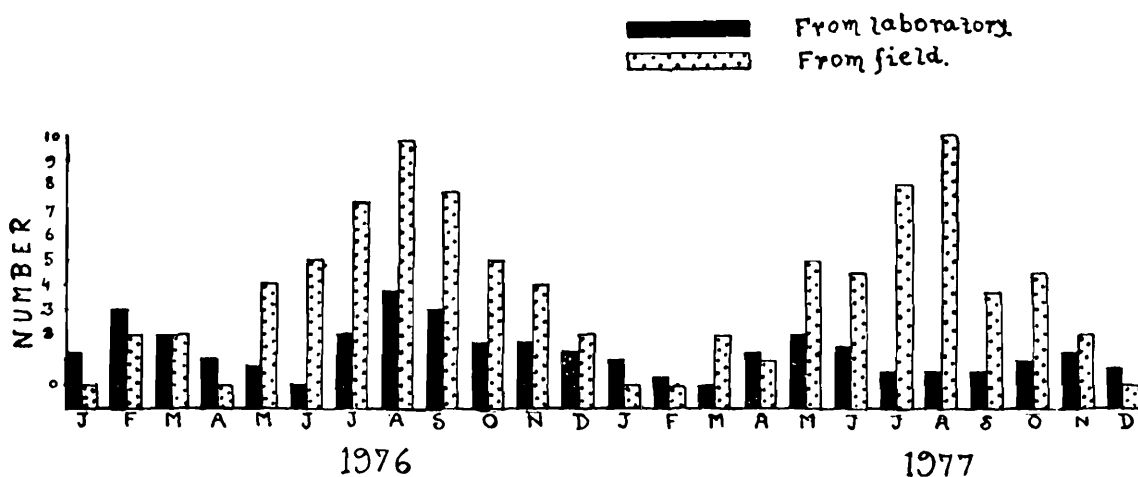


Fig. 4. Comparative intensity (No. of tryps./10,000 erythrocytes) of peripheral parasitaemia in the field and Laboratory maintained frogs.

#### DISCUSSION

*Trypanosoma rotatorium* is a pleomorphic species occurring in a wide range of frogs throughout the globe, and considerable confusion exists as to the specific diagnosis of this species. Because of this confusion in frog trypanosome taxonomy, the authors herein have chosen to name the trypanosomes encountered in the paddy field frogs, *R. limnocharis*, as *Trypanosoma rotatorium* Complex.

That the intensity of the peripheral parasitaemia varies on a seasonal basis is an observation as old as the discovery of frog trypanosome itself. Gruby (1843) noticed that trypanosomes could be found in the peripheral blood of frogs only during spring and summer. A perusal of the literature revealed that spring is the usual time of peak parasitaemia (Bardsley, 1972; Bardsley and Harmsen, 1969; Bollinger *et al.*, 1969; Nigrelli, 1929; Perez-Reyes *et al.*, 1960). The present study, on the contrary, indicates its peak during the rainy season (July-September). It is interesting to note that inspite of this contradiction, one common aspect exists *i.e.*, it coincides with the breeding time of the hosts which is

in spring in colder countries, but monsoon in India. This suggests that the host's physiology might also have some role to play in the fluctuation of peripheral parasitaemia.

The literature on amphibian physiology reveals that various endocrine glands namely pituitary, thyroid, etc., are seasonally active with peak values at the breeding time (Carter, 1933 ; Smith, 1954 ; Wurster and Miller, 1960) resulting hyperglycaemia in the blood. This hyperglycaemia is mediated through catecholamine during excitement at the breeding time and would potentiate the hyperglycaemic effects of catecholamines in a fashion synchronous with endocrine activity cycles (Bardsley and Harmsen, 1973). A comparison of these cycles with those of the peripheral trypanosome parasitaemia cited above may possibly show a positive correlation.

Such factors like host's immune responses is also important as they may induce sufficient impact on the internal regulation mechanism. The vector's activity *i.e.*, leech-feeding may produce short-term effect through excitation. This may stimulate the CNS via adrenergic system and may help releasing trypanosomes from storage sites (liver, kidney) into the peripheral circulation. The environmental conditions such as temperature and rainfall may indirectly held altering amphibian physiology and in turn, possibly influence the seasonal oscillation of peripheral trypanosome population.

From the foregoing account it appears that the distribution and density of populations of trypanosomes in their anuran hosts are seasonally influenced and presumably internally regulated through the change in hormonal balance. The seasonally active pituitary, thyroid, and pancreatic gland might have influenced the amphibian physiology in such a way leading to increasing motility and release of trypanosome from storage sites into the circulating blood during July-September period. The reverse is being true for the low parasitaemia in December-February *i.e.*, in winter. The effects of excitation (*e.g.* leech-feeding), thermoperiod and rainfalls are indirect inducers of internal dispersal regulation system. Thus the seasonal fluctuation of trypanosome population is, indeed, a complex phenomenon of natural regulatory mechanism.

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## MICROCLIMATE AND THE NIVAL INSECT COMMUNITIES OF N. W HIMALAYA

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### INTRODUCTION

The insects inhabiting the higher altitudes, between the timber-line and the permanent snow-line, representing the nival zone (fig. 1), are generally referred to as nival insects. The nival zone is seasonally covered with winter snow when the snow-line descends much below the timber-line. The snow cover acts as a blanket for all the micro and macro-organisms inhabiting that belt. The rise of temperature with the advance of summer initiates the melting of the snow-cover at its lower margin which gradually recedes and ascends till it reaches the permanent snow-line. Thus within twelve months the nival zone is alternately covered and uncovered by snow. This single factor exerts a profound influence on the behaviour, life histories, distribution, community structure, population density etc. of the insect life.

The pioneering and monumental works of Mani (1962-1974) and Mani & Singh (1955-1963) have enriched our knowledge of the various aspects of high altitude insect ecology and biogeography, wherein a great deal of emphasis has been laid on the importance and significance of microclimatic conditions. They have repeatedly drawn attention to the overcrowding and discontinuity of distribution of insect populations. An attempt is made here to discuss some of the factors which have led to the formation of isolated and overcrowded units of insect populations in the higher reaches of the Northwest Himalaya.

### CHARACTERISTICS OF HIGH ALTITUDE ECOLOGY

The high altitude insect ecology with particular reference to the microclimatic conditions outlined here, merely attempts at presenting the general average most likely to be observed in the biome of the treeless montane tundras above an elevation of 3,000 metres above mean sea level. This average should indicate the broad central tendencies of the more or less cyclic fluctuations and oscillations of the special environmental factors, the insect communities, their structure, composition, activities, etc. The environmental factors and insect communities are

constantly changing and yet a certain seemingly unchanging pattern of factors and communities continues to exist over long periods. This is made possible by the existence of numerous complex, self-regulating, community stabilizing mechanisms, continually operating within the ecosystems themselves. This dynamic ecologic equilibrium, is however by no means permanent, but is merely a way of describing our observations in the field.

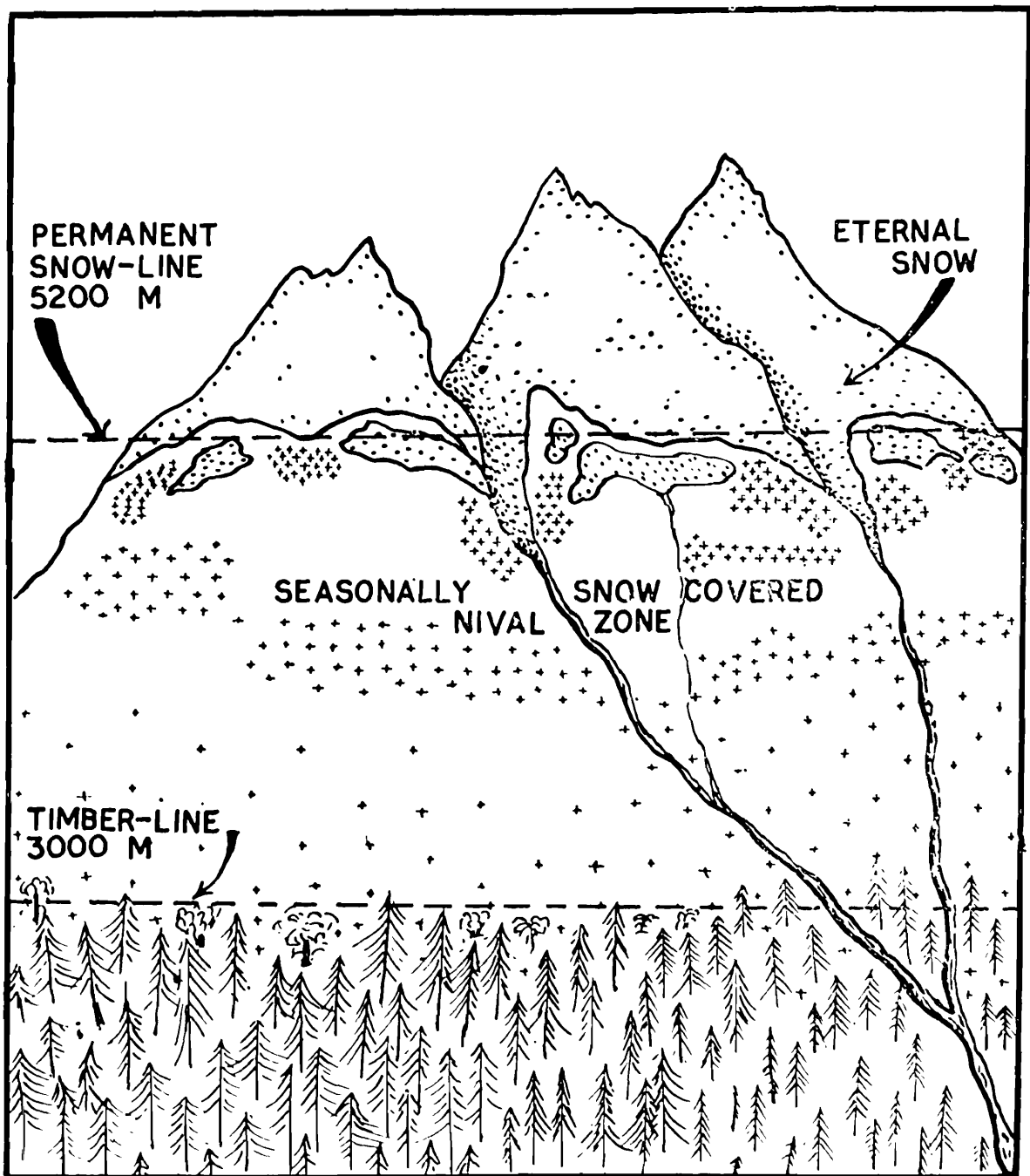


Fig. 1. A schematic diagram showing the Nival zone of a mountain, with the distributional pattern of soil insects (+) at different altitudes.

During winter the insects undergo hibernation under the snow-cover. Higher the altitude longer the duration of hibernating period. Of the

various factors which influence the high altitude life (i) atmospheric cold, (ii) atmospheric aridity, and (iii) the local conditions play a very decisive role. In this triangle of dominant factors the atmospheric cold and aridity effectively contribute to greatly exaggerate the importance of microclimate due to differences in local conditions. *The agencies which actually influence the high altitude insects are to be found in the climate of square and cubic centimetres and still smaller spaces under stones, in soil, rock crevices, etc.* Here we actually deal with micro-microclimate, of which the usual meteorological data totally fail to give us any adequate idea. Irrespective of the atmospheric conditions, a wide range of micro-microclimate niches, each with optimal conditions for various specific groups of insect communities, occur as small irregularly distributed islets in vast stretches of extremely adverse conditions. In spite of these extreme conditions, the microclimatic niches harbour a bewildering variety of insect life.

i. *Micro-Microclimatic Conditions*—The records of atmospheric temperature and humidities are in no sense correct indices of the conditions on the barren rock surface, in rock crevices, and in soil, under snow, in underground cavities, in spaces under snow covered stones, in hollows under more or less deeply buried boulders, in the glacial torrents, springs, lakes, alpine meadows, crests of the mountain ranges and on the different slopes and spurs. The measurements of the general atmospheric conditions thus rarely coincide with the conditions to which the insects are actually exposed in their habitats.

Random observation of the temperatures on barren and exposed boulder surfaces, under stones and the corresponding atmospheric temperatures, during the hours of bright sunshine between 3,000 and 4,500 metres on the southern slopes of the Pir Panjal Range during June are summarized in Table 1. The mean air temperature is 18.4 °C, but the surface of the boulder exposed to the direct sun registers 28.9 °C. At the same time the temperature under some of the comparatively smaller stones is 21.4 °C. The mean difference between air temperature and that of the rock surface is 10.5 °C and that between the atmosphere and the temperature under stones 7.5 °C. During the hours of sunshine the temperatures rise rapidly on exposure to the direct sun rays. Very often the rock surface temperatures at these times range from 30 °C to 35 °C, while the atmospheric temperature may read anything between 2 °C and 18 °C. Nocturnal radiation however greatly reduces their temperatures to as low as that of the atmosphere. Bähler (1910) reports similar differences between atmospheric and rock surface temperatures in the Alps. He found that when the maximum atmospheric temperature in August was 13 °C the rock surface showed a temperature of 31 °C. Although the

atmospheric temperature fluctuation in the North-West Himalaya may be between  $-10^{\circ}\text{C}$  and  $14^{\circ}\text{C}$  in June, the underground insect shelters under more or less deeply buried boulders and larger stones, even at the edge of the melting snow, at an elevation between 4,000 and 4,400 metres, show temperatures of  $5^{\circ}\text{C}$  to  $7^{\circ}\text{C}$  only.

Table I. Random observations of atmospheric and microclimatic temperatures on the south slopes of Pir Panjal Range during May-June between 3000 and 4500 metres above m.s.l.

No. of observations	Temperature in $^{\circ}\text{C}$		
	Atmospheric	Understone	Stone surface
1.	16.5	19.8	28.2
2.	16.5	21.5	28.0
3.	17.8	23.0	29.4
4.	17.5	13.0	29.4
5.	19.0	21.2	28.2
6.	18.8	22.0	29.5
7.	19.2	22.2	29.5
8.	19.0	21.8	29.8
9.	17.0	19.2	27.0
10.	17.0	18.5	28.0
11.	17.5	23.5	27.2
12.	17.5	20.5	17.5
13.	17.5	20.5	27.0
14.	20.9	26.5	31.2
15.	19.5	25.5	31.0
16.	20.2	22.0	29.2
17.	19.0	21.5	29.9
18.	20.0	21.5	29.5
19.	19.5	22.0	30.0
20.	19.5	22.5	30.0
Average	18.4	21.4	28.9

Very pronounced differences are also observed between the atmospheric and soil temperatures. When the atmospheric temperature ranges, for example, from a maximum of  $14^{\circ}\text{C}$  to a minimum of  $4^{\circ}\text{C}$  in summer at an elevation of 4,000 metres on the southern slopes, the soil temperature at a depth of 154 mm remains at about  $15^{\circ}\text{C}$ . At 4,500 metres, with the atmospheric temperature maximum not above  $2.2^{\circ}\text{C}$  and minimum near  $10^{\circ}\text{C}$ , the soil temperature ranges only from  $5^{\circ}\text{C}$  to  $7^{\circ}\text{C}$ . Bähler (1910) found that at an altitude of 3,647 metres on the south slope of Mte. Rosa in the Alps, with the atmospheric temperature during August  $-2^{\circ}\text{C}$ , the soil temperature was  $37^{\circ}\text{C}$ .

The soil temperature is governed by altitude, aspect, gradient of the hill slope, the depth and moisture content of the soil and other factors. The soil temperatures differ at different depths; the surface soil temperatures show greater fluctuations than the deeper soil temperatures. It was found, for example, that the surface soil temperature varied from a minimum of 20°C during the day to a minimum almost equal to that of the air at night. Yet below a depth of about 15 cm the temperatures remained nearly constant. The great importance of soil temperature to the high altitude insect life has been known for some time (Franz, 1950). The soil temperature influences the germination and growth of the plants of the alpine meadows. The rate of absorption by and radiation of heat from the soil affects the temperature of the layer of air immediately above ground, the penetration and evaporation of water from the melting snow, the depth of penetration underground by the hibernating insects, etc. It also largely governs the nature and composition of the insect communities in the underground refuges.

The maximum temperature of the air 10-15 cm above the surface of a snow field or glacier at 4,500 metres in mid summer is often as low as 1.0°C and the minimum drops to -10.0°C. The torrential streams from the melt water present fairly uniform conditions of temperature. Between 5,500 and 3,000 metres the temperature of water in these torrential streams during summer remains between 0.5°C and 4.5°C, while the air temperature may often fall below -4°C. It is only when the torrents have reached below 3,000 metres that their temperature rises appreciably and rapidly attains the level of about 10°C. According to Bähler (1910), the water temperature in the torrents in the Alps lies between 0.5°C and 1.5°C. The high altitude lakes, also fed by melt water, on the other hand show relatively greater temperature fluctuations. Some of the lakes like the frozen Sarkund Lake at 4,408 metres recorded in the course of the last 10 days of June a temperature ranging from 0°C to 1.4°C during the day. The temperatures of the hot and sulphur springs occurring at altitudes of about 5,400 metres are found to be between 24-27°C and 43-49°C, though the prevailing atmospheric temperatures are very much lower than zero.

It is, therefore, found that high altitude, atmospheric cold and heavy snow cover do not necessarily rule out the existence of pockets of warmer conditions. Irrespective of the altitude, slope, atmospheric temperatures, etc., we find relatively wide range of microclimatic temperatures (Table II), optimal for a great many variety of high altitude insects.

ii. *Soil Moisture*.—In spite of the low atmospheric moisture, lack of rain and high rate of evaporation from exposed surface, the soil moisture is however surprisingly high at the edge of the melting snow

and in the neighbourhood of torrents and lakes. This moist belt follows the edge of the receding snow and leaves the soil behind relatively dry. As the melting commences from lower elevations and progresses upward with the advance of summer, the narrow belt of moist soil gradually ascends higher and higher with the advance of summer. *The maximum soil moisture is therefore met with at higher elevations in late rather than in early summer.* The soil moisture at about 3,500 metres is lower than at 5,000 metres in August.

Table II. Mean temperatures in °C during the hours of bright sunshine in June on the south slope of the Pir Panjal between 3,500 and 4,000 metres.

Atmos. shade temp.	Air temp. above snow.	Torrent	Lake	Rock Surface	Under stone	Under stone cavity	Soil
18.4	-1.0	4.5	1.5	28.9	21.4	15	15

Relatively high moist conditions are found on moss-covered stones and boulders and under vegetation mats of the alpine meadows. Fairly high moist conditions obtain in spaces under stones and deeply buried boulders. The humidity conditions of these refuges are comparable to the deep soil moisture. Though the surface layers of soil become rapidly dry in summer when the edge of the receding snow has moved up far, the deeper layers are still sufficiently moist. Although the evaporating power of the atmosphere is high, the humidity level of the insect refuges is maintained high from the melting of winter snow.

iii. *Soil.*—Besides the temperature, soil humidity and the snow-cover, the soil conditions play a dominant role in the composition and population of high altitude insect communities. The availability of soil depends on numerous factors like the colonisation of higher altitudes by the pioneering plants like lichens and mosses, nature of the rock, gradient and snow retaining capacity of the rock, exposure to sunshine, etc. The altitudinal stratification and succession of plant communities are fairly well understood. Near and above the timber-line (3,000 m) adequate forest floor litter and alpine meadows with a variety of plant life provide vast and continuous stretches of soil cover on the mountain slopes where the insect populations are fairly distributed. But with the rise in elevation the continuity of the stretches of soil becomes interrupted due to local conditions like the precipitous nature of rock, exposure of the rock to high winds and lack of colonisation by the pioneering plants. In other words the absence of pioneering plant communities renders the soil forming agencies absolutely ineffective which results in

the discontinuity of stretches of soil. This discontinuity becomes correspondingly more pronounced with the increase in altitude, till at the extreme altitudes soil is available only in small and isolated patches nearer the permanent snow-line where from melt-water provides optimum soil moisture. Thus as pointed out earlier the maximum soil moisture is met with at higher elevations in late rather than in early summer.

iv. *Pleistocene glaciation*.—It would be improper to discuss the present day general high altitude ecology without any reference to the past climates of the region. The existing climatic conditions are actually the result of Pleistocene glaciations which the North-West Himalaya experienced. Many workers like Holdhaus (1932-1933), Franz (1950) and Rand (1948) have investigated the influence of glaciations on the ecology and the high altitude insect life. Holdhaus (1933) believes, for instance, that the absence of torrenticole Coleoptera on the mountains of Fennoscandinavia is the result of glaciations which are supposed to have annihilated the entire populations. Though numerous Pleistocene relict species have survived on the marginal areas, which were not covered by ice during the Pleistocene. These marginal areas, which the botanists termed as the “massifs de refuge” have a remarkable mountain relict fauna belonging to apterous and blind Coleoptera.

v. “*Massifs de refuge*” or *Nunataks*.—A number of workers like Bähler (1910), Steinböck (1931), Franz (1950) and Mani & Singh (1961-63) have shown that *nunatak* rocks which are still projecting above the snow-line harbour insects even under the most inhospitable conditions at the present time. A number of hypsobiont species of Collembola, Thysanura and Coleoptera, for example, flourish on the *nunatak* rocks far above the glaciers and the permanent snow-line. These *nunataks* provide micro-climatic niches for the insect inhabitants and being isolated from other similar niches, their insect populations naturally tend to reach a point of over-crowding—a characteristic feature of all the nival zone insects.

#### INSECT COMMUNITIES AND THEIR POPULATION STRUCTURES

The insect life of nival zone can easily be categorised into various communities like torrential stream communities, alpine meadow communities, soil communities, rock communities, snow communities, etc. A reference may be made to the works of Mani (1962-1974) and Mani & Singh (1955-1963) and Singh (1958, 1967) for detailed information on the structure of various insect communities of the nival zone of the Northwest Himalaya. These communities are able to thrive due to the existence of microclimatic conditions. The structure of these communities exhibit very interesting trends towards higher density of population

leading to heavy concentration of individuals with the rise in the elevation. Another significant aspect of the heavy concentration is the discontinuity in the distribution leading to more or less pronounced isolation.

The scope of the paper would not permit a detailed discussion on the population structure and behaviour of all the communities listed above. The discussion is, therefore, confined to the soil insect communities only. No attempt is made here to present any taxonomic analysis of the soil insect communities, the effort merely aims at discussing the population structure of the soil insects as a whole, in the nival zone. The dominant constituents of the soil insect fauna are represented by Collembola, Thysanura, Dermaptera, Coleoptera and Hymenoptera. Since all these groups of insects have to spend major part of their life-cycles, if not all, in the soil which must be moist and soft enough to permit burrowing or tunnel making. As discussed earlier such soil conditions are abundantly available in the lower altitude of the nival zone near the timber-line, in the alpine meadows, along the glacial torrential streams and high altitude lakes besides the not too steep mountain slopes. At these elevations soil insect fauna is thus almost uniformly distributed, unless disrupted by local conditions of precipitous rocks, permanent absence of sunshine, rapid evaporation of soil moisture due to thinness of the soil layers, etc. A reference to the figure 1, will show that soil insects (+) are evenly though sparsely distributed at the lower elevation of the nival zone. Consequent to the increase in altitude the continuity of the soil stretches is disrupted resulting in discontinuity of the insect population distribution. But correspondingly, number of individuals tend to accumulate in the discontinuous patches of soil. This phenomenon of the discontinuity and over-crowding becomes further accentuated as the permanent snow-line is reached. As shown in the figure 1, nearer the snow-line, the soil patches become smaller and smaller wherein larger number of individuals thrive under conditions of overcrowding. This tendency of over-crowding in smaller and isolated pockets lends certain advantages to the individuals. As is well known (Long, 1953), over-population helps to increase the temperature and humidity of the habitat, thus providing optimal conditions of life, in otherwise ecologically most inhospitable region of the nival zone.

From the above description one is likely to draw erroneous conclusions regarding the number of species involved in crowding the small and isolated patches of soil. Mani & Singh (1957) has drawn attention to the fact that though with the rise in altitude number of individuals increase causing crowded conditions, the actual number of species exhibits marked decline. Thus at the extreme altitudes the number of species are relatively much smaller than near the timber-line. Mani & Singh (1957) while discussing the faunistics of Coleoptera of the nival zone in

North-west Himalaya, for instance, have reported that with the replacement of forests by exposed and wind-blown alpine meadows, forest species give place mostly to endogenous localised concentrations of scavengers and carnivorous forms. With the increase in altitude there is not only marked fall in number of families, genera and species, but an extremely interesting succession of types — a succession characterised by more or less pronounced replacement of forms characteristic of lower elevations. Out of the twenty three families of the Coleoptera known so far from the N.W Himalaya, an extremely small number of families, viz. Carabidae, Hydrophilidae, Staphylinidae, Coccinellidae, Scarabaeidae and Curculionidae, have successfully extended their range into the extreme elevations. Carabidae and Staphylinidae have in particular colonised much higher elevations than others and are also numerically far superior, both as species and as individuals. The genera above the timber-line approximately constitute about one-twentieth that occurring below 3,000m. Of the dozen genera so far collected from the nival region, *Bembidion Calosoma*, *Amara*, *Atheta*, *Onthophagus* and *Scepticus* may perhaps be mentioned as the more important and commonly met with. *Bembidion* outnumbers all others in the number of species and has also been taken at great elevations. *Bembidion nivicola* has been found to be occurring nearly upto 5,500 m. Two species of Staphylinidae, viz. *Atheta (Bessobia) submetallica* and *A. (Microdota) ladakiana* have been collected at about 5,000 m.

In conclusion it may be said that the nival zone endogenous insect populations exhibit pronounced concentrations of individuals of fewer species in smaller units of area with marked discontinuity and isolation.

#### ACKNOWLEDGEMENTS

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## NESTING BIOLOGY OF *MEGACHILE NANA* BINGH. AS INFLUENCED BY SOME ECOLOGICAL FACTORS

By

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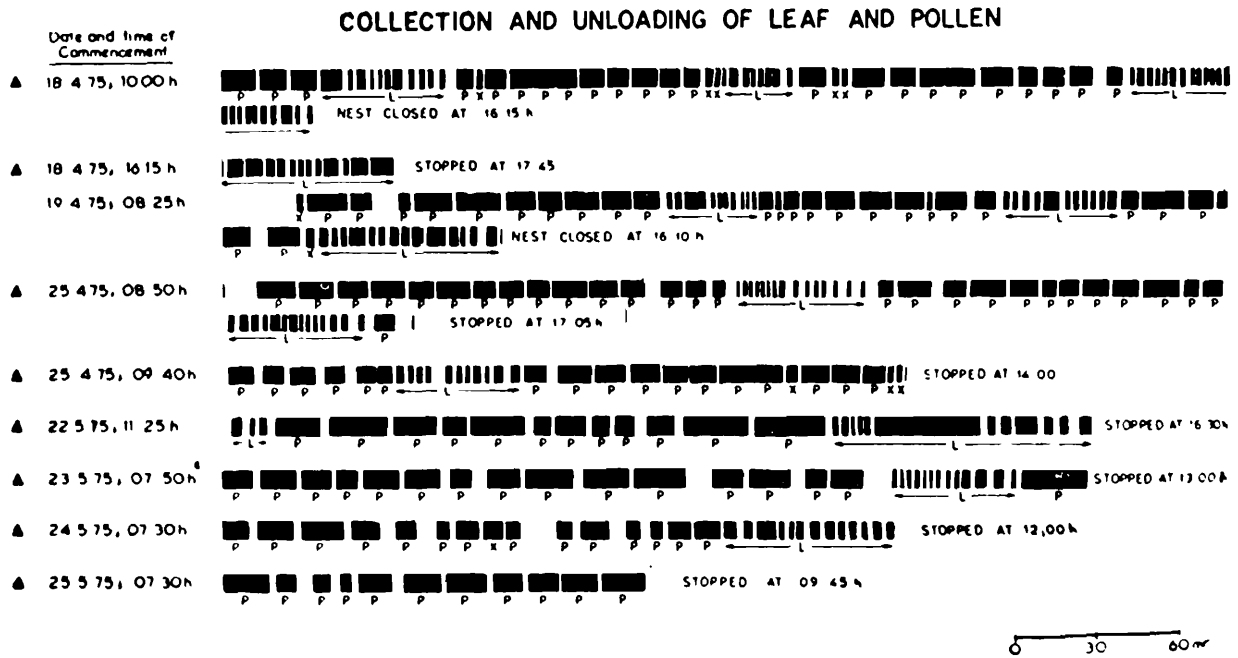
### INTRODUCTION

The nesting activity of social as well as the solitary bees including *Megachile nana* Bingh. is a product of the foraging activity which is essentially comprised of two main activities—(i) connected with the collection of leaf-cuttings to construct a cell and (ii) pollen collection to provision it. This suggest a keen relationship of bees with host plants. Since the solitary bees are generally oligolectic, hence, associated with a particular category of plants. Being associated with each other within a narrow range, the plants and the bees seem to have similar ecological requirements. Such a synchrony of the bee's activity with the flowering of the plants is the obvious reason of their coevolution and of similar ecological requirements. *M. nana* presents an analogous condition being essentially associated with alfalfa and another xerophytic wild plant, *Parkinsonia aculeata* L. Both plants are leguminous and flower almost at the same time or in succession with time gap too little to distinguish. The kind of synchrony so developed between the bee and the host plants and the influence of some ecological factors which may control the activity have been discussed in this paper.

### RESULTS AND DISCUSSION

*Nesting activity* : *M. nana* is a leaf-cutting bee. It has three life cycles with several generations intercepted by either aestivation hibernation or the adults are active mainly in April-May and September-November (Kapil *et al.*, 1977b). The nesting activity regardless of the generations follow a definite pattern which has been presented in figure 1. The study is based on 15 individual female bees drawn from the overwintered brood, yielding adults in summer when alfalfa and *Parkinsonia* blossom. This period has been selected for the study of this activity because it is the normal activity period for both the bee and the plant. The case history of 15 bees presented in figure 1 indicate that the first activity at the start of the day commenced in general with collection of pollen. The last

activity at the end of the day was generally inconsistent, it ended either with carrying in of a last leaf indicating completion of the cell construction or if the cell had already been constructed the remaining time was utilized to provision it. In such cases, the provisioning was obviously incomplete.



The commencement and cessation of activities of *M. nana* have already been reported as highly consistent within a certain range of temperature, relative humidity and light intensity (Szabo and Smith, 1972; Kapil *et al.*, 1977a). The data shown in table 1 indicate that time taken to construct each cell was consistent within the particular season of activity. During summer of 1975 and 1976, the bees took an average of 2.78 h/cell and 2.44 h/cell, respectively. By comparison more time was taken to complete a cell (3.55 h) during autumn. Besides the number of cells constructed per unit time during the seasons also varied. The variation in the number of cells was influenced by the number of flowers present. Obviously, the number of flowers and the general activity of bees are possibly effected by primary energy parameters like temperature and light intensity in association with relative humidity.

#### FACTORIAL ANALYSIS OF NESTING BEHAVIOUR

As already argued, the nesting is a product of the foraging activity primarily concerned with leaf and pollen collection activities to construct a cell. The stage of a cell attained, time taken for the activities to construct and provision it are obviously the results of interaction between

the two activities and is ultimately a factor in the build up of the bee population. The seasonal changes indicated in the nesting activity are reflections of dependence of the nesting activity and its components on the environmental factors. Therefore, an analysis of interactions between the components of the nesting activity and the primary energy factors is likely to yield more information.

Table 1. Number of trips to collect leaf and pollen loads for each cell during different seasons and the ecological conditions prevailing at the time of observations

Parameters recorded	Oct.-Nov., 1973	Apr.-May, 1975	Apr.-May 1976
No. of leaf cuttings/cell	17 (12-18)	10 (8-15)	12.3 (9-15)
No. of pollen loads/cell	15 (10-18)	12 (10-17)	10.5 (9-13)
Total time taken/cell (h)	3.55 (2.7-6.5)	2.78 (2.0-5.4)	2.44 (2.2-3.4)
Average cells/day	1.0 (0.5-1.5)	3.0 (1.5-3.5)	3.5 (2.0-4.0)
Temperature(°C)	32.0	40.3	39.0
Relative humidity (%)	45	35	27
No. flowers open/h (million)	5.1	39.8	61.2
Bright hours/day	9.6	6.5	10.9
Wind velocity (km/h)	3.4	4.8	9.6

*Leaf collection activity*: The leaf collection activity was found quicker as one single trip was completed in a shorter time. So also the time taken to unload and set the leaf was accomplished in a considerable less time (Table 2). The activities were generally consistent and seemed relatively independent of the seasonal variations as the correlation coefficients among them are non-significant. The data shown in figure 2 indicated the maximum frequency dispersion of time duration in time classification scale was concentrated between 0.5 to 2.0 minutes. The deviations during April-May, 1976 remain unexplained, however.

The diurnal rhythmic leaf collection and unloading activities are shown in figure 3. It was observed that the higher frequency dispersion in time interval of the two activities was mainly distributed between 1.0 and 2.0 minutes of the time classification scale. The average time consumed for the activities remained independent of the diurnal rhythm. The minimum time was however taken between 1200-1400 h.

Table 2. Mean duration for collection and unloading of a leaf and a pollen load and relation of the prevailing ecological conditions

Parameters recorded	Period of observations (h)				
	0800-1000	1000-1200	1200-1400	1400-1600	1600-1800
Collection of a leaf cutting (min.)	1.8	1.6	1.2	1.9	1.7
Unloading of a leaf cutting (min.)	2.3	2.0	1.3	1.8	2.1
Collection of a pollen load (min.)	10.7	9.2	10.2	10.8	10.2
Unloading of a pollen load (min.)	1.4	1.6	2.0	2.1	2.5
Temperature (°C)	29.1	33.0	35.1	36.8	36.5
Relative humidity (%)	47	37	32	27	29
Light intensity (lux)	1760	2800	3225	3067	1763
No. of flowers open/h	66.9	82.1	70.1	67.7	56.5

*Correlation of coefficient between :*

Leaf collection	×	Temperature	-0.10
		RH	0.08
		Light intensity	-0.45
Leaf unloading	×	Temperature	-0.52
		RH	0.53
		Light intensity	-0.84*
Pollen collection	×	Temperature	0.03
		RH	-0.04
		Light intensity	-0.18
		No. flowers	-0.64
Pollen unloading	×	Temperature	0.89*
		RH	-0.87*
		Light intensity	0.02
		No. flowers	-0.66
Temperature	×	Relative humidity	-1.00*
		Light intensity	0.43
		No. flowers	-0.31
Relative humidity	×	Light intensity	-0.46
		No. flowers	0.28

\*Significant (P&lt;0.05)

*Pollen collection activity* : The principal association of the solitary bees and the resulting evolution which they may have undergone seem to be primarily associated with pollen which serves as food for the bees themselves and the youngones. The pollen food for youngones since stored in the cells in quantity enough to complete the development of an individual indicates that the association of bees with a particular species of plants perhaps depends upon its nutritive quality. The size of the pollen ball may also be dependent upon the nutritive quality. All these factors are obviously determined by the female bee herself, therefore, the biologi-

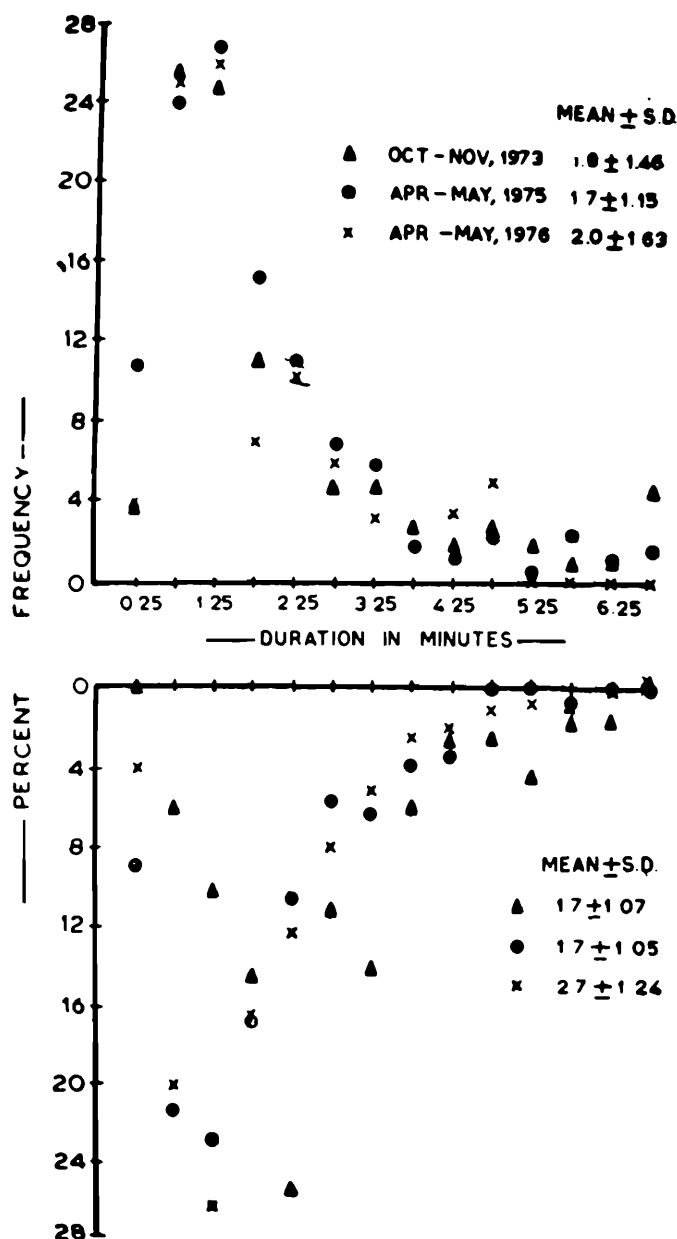


Fig. 2. Seasonal frequency distribution of leaf collection and unloading activities of *M. nana*.

cal energy requirements per individual also becomes a pre-determined factor. This varies, however, from one season to another (Table 1) as the number of trips during autumn were generally more than during summer season. The difference in the number of trips and the time taken per trip were clearly dependent upon the number of flowers available (Tables 1,2). Since, the difference in the number of flowers available during summer and autumn were highly variable, the flowers being 8-12 times more during summer over autumn season, a definite relationship is the clear possibility ( $r = -0.64$ ). In support of the statement given at the initial stage of this discussion, the evidence is also provided by a certain amount of consistency in time range utilized to collect pollen during a particular trip (Table 2). The class interval frequency concentrated

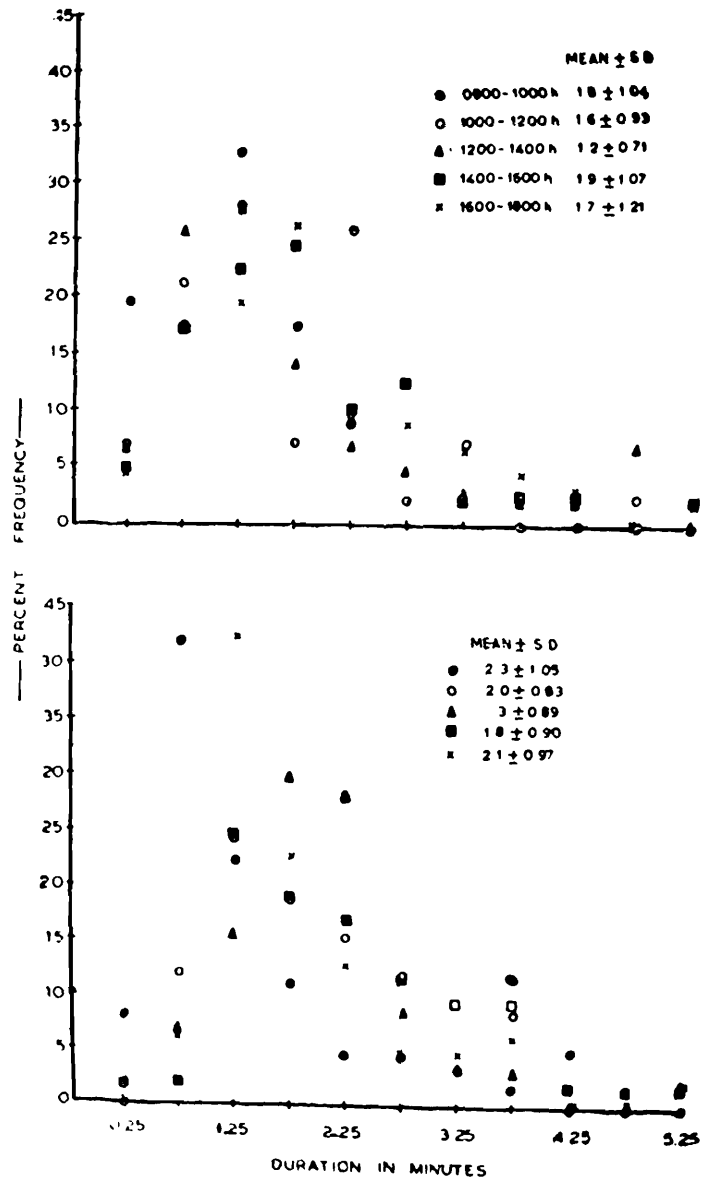


Fig. 3. Frequency distribution of diurnal rhythmicity of leaf collection and unloading activities of *M. nana*.

between 6 to 12 minutes, no matter what season it was. However, there were slight shifts during different seasons. The shifts in the class interval were pronounced during autumn (October-November) than during summer (Fig. 4). This is also shown by the higher value of standard deviation.

The class interval of duration for pollen unloading was also highly consistent between 15 seconds to 4 minutes indicating that the unloading time economy of the bee was as well independent of environmental factors around. The guiding factor seems to be an intrinsic urge for collection of more pollen within a specified time.

The diurnal pollen collection activity was generally stable, but the minimum time was taken by the bees during 1000 to 1200 h (Fig. 5). Probably this was the time when the frequency of dehiscence of flower anthers was also at its peak. This fact was supported by the availability

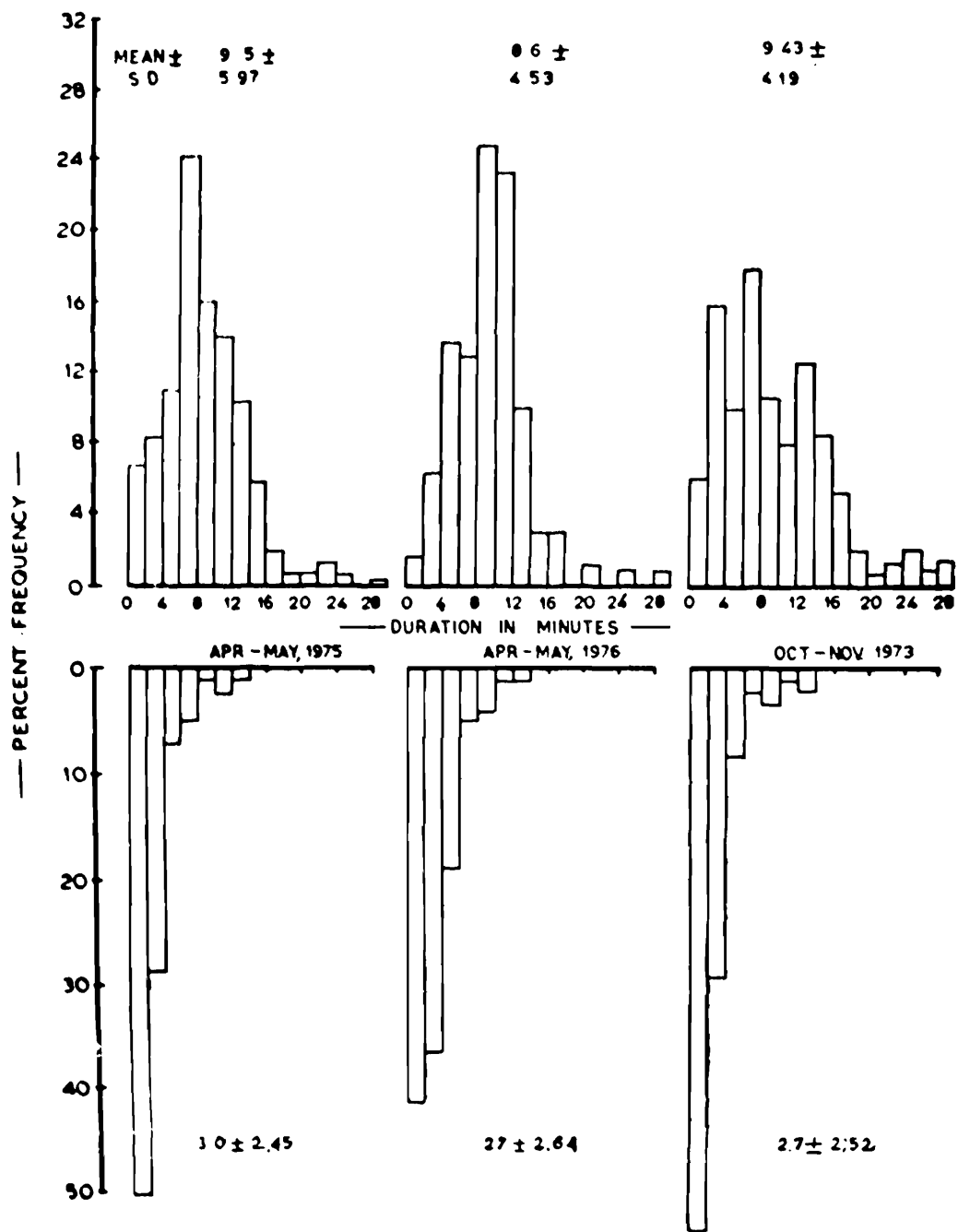


Fig. 4. Seasonal frequency distribution of pollen collection and unloading activities of *M. nana*.

of a large number of open flowers during the same period (Table 2). It is possible that the opening of flowers and their dehiscence are related with one another. The dispersion as indicated by standard deviation is not too large to suggest much variation in the pollen collection activity. The coefficients of correlations are not significant with any of the ecological factors like temperature, relative humidity and light intensity with the diurnal activity of pollen collection. But the percentage of bees collecting pollen seem to be related with light intensity ( $r=0.90$ , Table 3). Szabo and Smith (1972) found that foraging activity of females *M. rotundata* was positively correlated with light intensity and temperature combined.

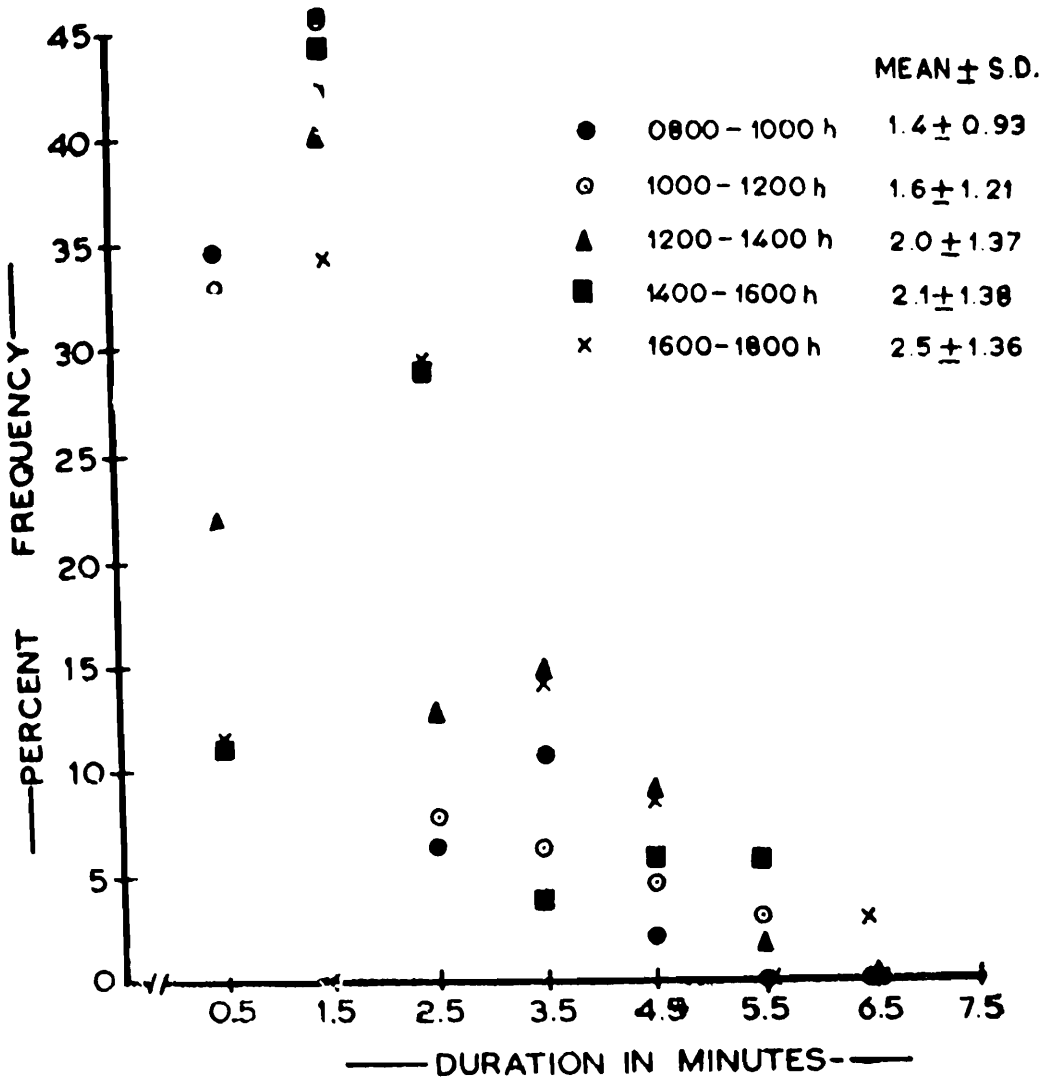
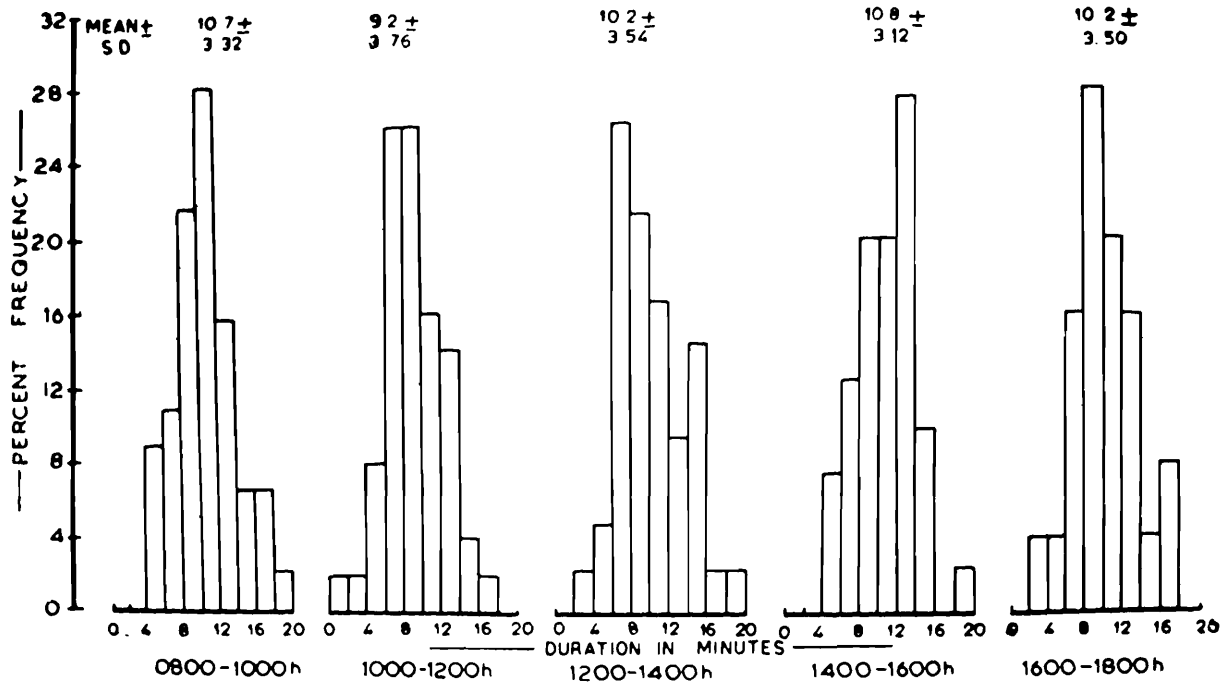


Fig. 5. Frequency distribution of diurnal rhythmicity of pollen collection and unloading activities of *M. nana*.

Table 3. Diurnal rhythmicity of percentage pollen carrying bees in relation to prevailing ecological conditions

Time of observation	Bees collecting pollen	Temperature	Relative humidity	Light intensity
(h)	(%)	(°C)	(%)	(lux)
0800	35	27.8	44	2000
0900	92	30.0	40	2733
1000	64	32.4	35	2900
1100	71	34.5	32	3233
1200	78	35.5	28	3250
1300	65	37.0	26	3566
1400	62	37.1	26	3225
1500	60	38.3	22	2833
1600	44	37.9	22	2250
1700	30	37.2	24	1566
1800	17	36.2	25	507
1900	0	34.0	23	40

*Coefficient of correlation between :*

Percent pollen carrying bees	×	Temperature	-0.10
		Relative humidity	0.36
		Light intensity	0.90*
Temperature	×	Relative humidity	-0.22
		Light intensity	0.08
Relative humidity	×	Light intensity	0.22

\*Significant

( $P < 0.05$ )

#### ACKNOWLEDGEMENT

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## ECOLOGY OF NATURAL ENEMY COMPLEX OF APHIDOIDEA (HOMOPTERA) IN SOME AREAS OF EASTERN INDIA

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### INTRODUCTION

In India a few observation on the ecology of natural enemies of aphids appear to have been made except for a noteworthy contribution by Rao (1969) on the biology and other aspects of natural enemies of six aphid species. This study was carried out in different parts of India including Khasi Hills in Meghalaya and Kalimpong in West Bengal.

The subject matter of this paper is in respect of the information gathered on the predators and parasites of aphids occurring in two different areas *viz.* Sikkim-Kalimpong and Khasi Hills, both being temperate hilly regions of northeast India and having a low temperature gradient 0°C—30°C coupled with high average annual rainfall 400 cm—500 cm (it may be even upto 1550 cm at Cherrapunji in Khasi Hills). As a result these two areas present a rich floral assemblage. These factors together with short day length have proved conducive to the aphids to thrive successfully through generations. As a consequence a congenial environ has also been found by the natural enemy complex of aphids for successful maintenance of life. In Sikkim-Kalimpong area observations were made during 1975-1978 and in Khasi Hills during 1972-1977.

It may be stated here that the aphids have a rather wide range of natural enemies. Here however, discussion has been restricted to the members of Coccinellidae (Coleoptera) in respect of the predators and to the members of Aphidiidae (Hymenoptera) for the parasites.

### ECOLOGY OF APHIDIID (HYMENOPTERA) PARASITES OF APHIDS (HOMOPTERA) IN KHASI HILL, MEGHALAYA

Aphidiid parasites of aphid are usually solitary in habit and endophagous in nature. Usually second and third nymphal stages of host are preferred for egg-laying and larval development of parasitoids is completed within 8-10 days in normal circumstances but may last for several weeks in adverse condition. Usually a mature larva pupates under the hardened

skin of the host-aphid but members of the genus *Praon* form separate cocoons under-neath the host-skin. The females upon emergence from the host, starts egg-laying after a short period. In cases where mating does not occur before egg-laying, unfertilized haploid eggs develop into males ; usually mating takes place within 48 hours and fertilized eggs develop into female. Rate of fecundity varies among different species and some species of the genera *Aphidius* and *Trioxys* may lay as many as 1800 and 850 eggs respectively. Adults depends on honey dew and extrafloral nectaries for food and hardly have a life-span of more than 14 days depending on climatic conditions (Mackauer, 1968).

Environmental influences are known to determine the assemblage of flora and consequently the present day distribution of phytophagous insects like the aphids and also their parasites. Stary (1970) has summarized the peculiarities of parasite-foci in (i) Temperate Zone (ii) Subtropical and (iii) Tropical zones. The parasite fauna has been reported to be richest in the temperate zone and species occurring in various foci are numerous and natural communities of host and parasites usually exhibit somewhat stable characters. The aphid hosts usually exhibit obligatory host alteration, hibernation and many other peculiarities in temperate areas. Parasites in subtropical zone show less habitat dependance since the host aphid species may breed parthenogenetically all through the year, on a wide variety of host plants. In the tropics, however occurrence of both aphids and parasites becomes perennial as a result of influence of dry and wet season on different floristic association.

Parasite foci in a natural ecosystem exhibits more stable characteristic pattern in contrast to the agricultural crop land and irrigated plains. A general biological observation on aphidiid wasps shows that (with which the present paper deals) these are mainly parasitic on nymphs and adults of vivi-oviparous insects and strictly oviparous hosts of Adelgidae and Phylloxeridae are not attacked perhaps due to certain antibiosis or resistant factors.

Review of literature indicates that no systematic work has been done on survey of natural enemies of aphids in India, except for a project by C.I.B.C. to study natural enemy complex of six major aphid pests (Rao, 1969). The present study was undertaken to survey the aphidiid parasites of aphids in Shillong and adjacent localities of Khasi Hills in Meghalaya. The area, incidentally, is one of the richest one for members of Aphidoidea and offers wide assemblage of flora. Temperate climatic condition (Max. 25°C—min. 5°C), heavy monsoon rain with high humidity, short average day length, are certain characteristic features of the area of present study. The results of observation of six year survey has been summarized and presented in this paper.

The method for collecting the parasites was to rear live colonies of aphids along with a part of their host plants in glass jars covered with a piece of cloth on top cover. Three weeks time was allowed for the parasites to emerge.

The rearing was carried out from 1972 to 1977 and a total of about 520 collections of aphid-colonies (mostly from Shillong, Mawphlang and Barapani) of 78 species were cultured for parasites. About 140 samples comprising 50 aphid species yielded 16 aphidiid parasites. Results of the rearing experiments have been published earlier (Stary and Ghosh, 1975, 1977 ; Ghosh and Vasanth, 1975).

#### HOST-GROUP PREFERENCE

The aphidiid parasites appear to prefer the aphids belonging to sub-family Aphidinae which largely feed on dicot plants ; a total of 50 aphid-species were reared and out of these aphidiid parasites emerged from 33 species ; if those aphid species, which were reared once only, be excluded then it indicates that about 50% of the host-species are prone to parasitisation in natural ecosystem. Some species like *Cavariella salicicola* (Matsumura) on *Salix* on *Micromyzus kalimpongensis* Basu on *Hedichyum* when reared even for more than 7 times for parasite emergence never yielded any parasite.

Next preferred group of host appeared to be Lachninae. Six species of this group were reared on plants of Rosaceae and Coniferae and from three of these, parasites emerged. Five species of aphids belonging to Drepanosiphinae were reared on plants of Fagaceae and Rosaceae when two of these showed parasite infection Mackauer (1968) has listed 5 other species of Drepanosiphinae from the world as hosts of aphidiid parasites.

It is interesting to note that out of 11 aphid species under Greenideinae, a group feeding on Fagaceae, Moraceae, Euphorbiaceae, Myrtaceae, Lythraceae etc. and restricted to Southeast Asia, only one species showed infection by aphidiid parasite. According to Mackauer (1968) only two other species of this group are known to be the hosts of aphidiids.

There species of Hormaphidinae were reared on *Quercus* and Orchids and two species of Pemphiginae on Bamboo and *Michelia* but none was found to be infected by parasites.

Host group preference, could be influenced by several factor *viz.* lack of host in suitable habitat may lead to infestation on less suitable host degree of host density (may influence on position) as also the host-habitats (plant), host-size, host-instar and physical factors, like temperature etc.

## HOST-SPECIFICITY

Host-specificity of aphidiid parasites was noted in some cases during the present study viz.

i) *Pauesia laricis* (Haliday) was noted to be the only species parasitising pine-feeding *Cinara atrotibialis* David and Narayanan during October-February. *P. laricis* was not noted from any other host species.

ii) *Trioxys (Betulaxys) assamensis* Stary, was the only species collected from *Betacallis querciphaga* Basu, Ghosh, Raychaudhuri, reared on *Quercus*. Both males and females could be obtained from this endemic host-species.

iii) *Trioxys (Binodoxys) eutrichosiphi* Stary, appear to be specific to *Eutrichosiphum makii* Raychoudhuri and Chatterjee infesting *Litsaea* and *Castanopsis* during September-October. One more species of *Eutsichosiphum dubium* (v.d.G.) was reared thrice but no parasite ever emerged.

iv) *Trioxys (Binodoxys) shillongensis* Stary, was seen to parasitise only one endemic species, *Sinomegoura pyri* Ghosh and Raychaudhuri infesting an unidentified host during September.

It is interesting to note that all the 4 aphid-host species and last three species of parasites are endemic *Pauesia laricis*, a Palearctic species is known to parasitise 6 other species of aphids elsewhere, all of them belonging to the genus *Cinara*. The aspect of close host parasite relationship resulting in host specificity, according to Stary (1970), should be regarded as a regressive feature when viewed from the angle of whole group. Host specificity has been looked upon as the result of complex interaction of physical factors, floristic zones and also that of host and parasite.

## PARASITES, HOST and HABITAT

Out of all the aphidiid parasites reared during the present study, at least two species appear to be restricted to hosts which are known to be specific for plant groups (Habitat) viz.

i) *Diaerctiella rapae* (M'Int) was seen to parasitise only two species of aphid hosts, *Brevicoryne brassicae* (Linn.) and *Lipaphis erysimi* (Kltb.) both infesting Cruciferae during February-April. Sethumadhavan and Dharmadhikari (1969) also mentioned that this species appear to be the only major parasite of above mentioned aphids in India. However, they have listed three other aphid species which were found to be parasitised by *D. rapae* at Jullander and Gauhati.

ii) *Ephedrus niger* Gautier, Bonnamour and Gaumont, was reared only from two host species viz. *Macrosiphoniella sanborni* Gillette and *Uroleucon tanaceti indica* Ghosh, both feeding on *Chrysanthemum* during November.

## HOST-RANGE

Host-range of most of aphidiid parasites appears to be narrow and in general these parasites appears to be restricted to closely related aphids. An attempt may be made to draw relation between host-habitat and parasitoid specificity from the fact that non-migratory, monoecious hosts like members of Lachninae which feed on coniferae or Greenideinae which feed on Fagaceae have specific parasites.

On the otherhand, analysis of data on parasites affecting aphid-species feeding on a wide range of host plants reveals that such species may be infected by more than one species of parasite. *Aphis citricola* v.d.Goot is known to feed on 170 different host plants and it was reared in 50 different cultures ; 24 of these cultures yielded 7 species of parasites. Host plants of this aphids include *Bidens*, *Clerodendron*, *Eupatorium*, *Glochidion*, *Hibiscus*, *Rubus*, *Spiraea*, *Symplocos*. Three species of aphidid have been listed by Mackuer (1968) from this aphid and these include only *L. scutellaris* from among those recorded. About 205 different host-plants are known for *Aphis gossypii* Glover, but five species of parasites emerged for 16 out of 32 cultures when the same was reared on plants like *Cosmos*, *Eupatorium*, *Eurya*, *Glycine*, *Vitis*. Eight species of aphidiids were so far known from *Aphis gossypii* (Mackuer, 1968) and again only *L. scutellaris* appears to be in common with those in the present list. However, another polyphagous aphid, *Toxoptera aurantii* (Boyer) appears to deviate from the previous postulation since only one parasite is known from this aphid. It is interesting to note that population of polyphagous aphid species infesting certian plants appear to escape parasite infection as a number of cultures of polyphagous species never yielded any parasites.

It has been already observed that some aphidiid parasites are restricted with regard to host species. Beside, following Stary (1970) other parasite species may be grouped as follows :

- i) Host-range restricted to two or more host-species of same genus, e.g. *Diacretus leucopterus* (Haliday) : *Eulachnus* spp.
- ii) Host-range restricted to two or more genera of same host-groups ; other groups are rarely parasitised : *Trioxys indicus* Subba Rao and Sharma on *Aphis* spp., *Toxoptera* spp. and *Sinomegoura* spp. alternative hosts : *Brachycaudus* and *Myzus* spp ; *Lipolexis scutellaris* Mack : *Aphis* spp., *Toxoptera* spp.
- (iii) Host-range includes several host-genera of same host group : *Aphidius matricariae* Haliday : Macrosiphini group ; *Toxares deltiger* (Haliday) : Aphidini and Macrosiphini group.

(iv) Host-range includes several host genera of various host group : *Ephedrus plagiator* (Nees) : *Aphis*, *Brachycaudus*, *Myzus* spp. (Aphidinae) also *Prociphilus* (Chaitophorinae) and *Schizoneura* (Pemphiginae) elsewhere.

#### INTERSPECIFIC RELATIONS

A number of aphidiid species have been reared from the same host-species. This indicates that several parasites may parasitise one host-species. The following is the list of such parasites :

Parasites	Host-species
<i>Aphidius</i> sp.	<i>Aphis citricola</i> v.d.Goot
<i>Ephedrus plagiator</i> (Nees)	
<i>Lipolexis scutellaris</i> Mack.	
<i>Toxares deltiger</i> (Haliday)	
<i>Trioxys indicus</i> Subba Rao and Sharma	
<i>Trioxys nepalensis</i> Takada	
<i>Aphidius colemani</i> Viereck	
<i>Ephedrus plagiator</i> (Nees)	
<i>Lipolexis scutellaris</i> Mack.	<i>Aphis gossypii</i> Glov.
<i>Trioxys indicus</i> Subba Rao and Sharma	
<i>Trioxys nepalensis</i> Takada	
<i>Aphidius matricariae</i> Haliday	
<i>Ephedrus plagiator</i> (Nees)	<i>Myzus persicae</i> Sulzer
<i>Toanes deltiger</i> (Haliday)	
<i>Trioxys indicus</i> Subba Rao and Sharma	

Relation between the parasite species may be considered as that of competition, usually the endemic species being more successful than the exotic ones. Out of the species parasitising *A. citricola* v.d. Goot, *Trioxys nepalensis* Takada seems to parasitise the host more often than others. In case of *A. gossypii* Glover *Trioxys indicus* Subba Rao and Sharma is by far the most successful parasite than others. In both the cases *Lipolexis scutellaris* Mackauer, a species originally described from Hong Kong and now known from China, Taiwan and India, appears to compete most closely with *T. indicus*, Subba Rao and Sharma. Among the parasite complex of *Myzus persicae* (Sulzer), however, a palaeartic species *Aphidius matricariae* Haliday, seems to be most well established in this region.

In case of multiple parasites of the same host-species, a seasonal succession of more established species has been observed viz. *Trioxys nepalensis* Takada has mostly been seen to parasitise *Aphis citricola* v.d. Goot during August-September just after monsoon period whereas *Lipolexis scutellaris* Mack., has been recorded mostly during June-July, i.e. during monsoon. Similarly, *Trioxys indicus* Subba Rao and Sharma

could mostly be reared during winter, *i.e.* November – January, whereas *Lipolexis scutellaris* Mack., was reared during autumn months, *i.e.* July – October, from *Aphis gossypii* Glover. The seasonal succession may also be interpreted as co-operation between parasitoid species, while competing for the same host species at different time. However, in case of *Myzus persicae*, Sulzer no seasonal succession as stated above could be observed, all the species being active during the period of November – March and here concept of competition remains the only significant factor.

#### NATURAL ENEMIES

The aphidiid parasites may help the aphid population to maintain a natural equilibrium, Similarly, as over-exploitation of aphid-hosts due to population growth of primary parasites may lead to danger, a number of hyper-parasites are associated with parasite fauna of aphids. These are all obligatory hyper parasites of aphidiids during their development, their adults being free living insects like the adults of aphidiids. Three main groups of Hymenoptera are known *viz.* Chalcids (Pteromalidae), Proctatrupids (Ceraphronidae) – both being ectoparasites of aphidiid larvae and pupae and cynipids (Charipinae) which are endoparasites of aphidiid larvae (Stary, *op. cit.*) In the region under study, out of 140 aphid cultures which yielded aphidiid parasitoids, Chalcids hyper-parasites were obtained in 15 samples and cynipid ones were noted in 12 samples. Chalcid hyperparasites were noted for *Aphidius colemani* Viereck (3-1), *Aphidius matricariae* Haliday (10-2), *Diaeretrella rapae* (M.Int) (6-1), *Lipolexis scutellaris* Mackauer (10-1), *Toxares deltiger* (Haliday) (11-2), *Trioxys indicus* Subba Rao and Sharma (14-1), *Trioxys nepalensis* Takada (5-1); Cynipid hyperparasites were observed for *Aphidius matricariae* Haliday (10-1), *Ephedrus plagitator* (Nees) (5-1), *Lipolexis scutellaris* Mack, (10-1), *Toxares deltiger* (Haliday) (11-1), *Trioxys indicus* Subba Rao and Sharma (14-2) the figures within parenthesis denoting total number of primary parasites cultures followed by the number of time the hyperparasite were obtained. The data thus indicate low percentage of hyperparasite in the aphidiid fauna in the region.

#### PREDOMINANCE

The rearing experiments indicate that out of all aphidiid parasites the following 8 species show higher incidence than others (emergence above 10-40 in a culture) these may be grouped into three categories :

1) *Trioxys indicus* Subba Rao and Sharma : Appears to be most common and effective in ovipositing on a number of aphid-hosts *viz.* *Aphis citricola* v.d. Goot (May-June), *Aphis gossypii* Glov., (November January), *Aphis craccivora* Koch (November), *Aphis favae solanella* Theo.

(November) *Toxoptera aurantii* Boyer, (August) *Sinomegoura citricola* (v.d. Goot) (September).

2) *Lipolexis scutellaris* Mack., is the next common species parasitising *Aphis citricola*, v.d. Goot, *Aphis gossypii* Glov, and *Toxoptera citricidus* (Kirk.) mostly during August-September. This is followed by the four species of parasites, e.g. *Aphidius matricariae* Haliday, on *Myzus persicae* Sulz and *Lipaphis erysimi* (Kltb.) (February), *Ephedrus plagiator* (Nees) on *Aphis fabae solanella* Theo. and *Myzus persicae* Sulz. (January-February), *Toxares deltiger* on *Aphis fabae solanella* Theo. *Myzus ornatus* (Laing) and *Myzus persicae* (Sulzer) (January-April) and *Trioxys nepalensis* Takada on *Aphis citricola* v.d. Goot (August).

In case of all other parasites very few adults emerged out of the cultured aphid-hosts and on many occasions this was also noticed even for the above named species.

The study of aphids and parasites when considered in totalities reveals that about 27% of aphid species in nature are prone to parasite infection ; as the sampling was done all through the year the above figure may be taken as a general index of percentage of parasitism in terms of total aphid population irrespective of host-specificity and habitat-dependance factors.

#### ANTS, APHIDS AND PARASITES

Stary (1966) has opined that generally there is no influence of ants on aphid parasites. He has, however, grouped the parasites into two major groups, (1) parasites of aphids not visited by ants, (2) parasites of ant-attended aphids — this group has further been subdivided into (i) non-specialized parasites where ants remain indifferent to parasites and protect both healthy aphids and parasitised mummies and (ii) specialized parasites — where a mutualism exist between ants attending the aphids and the parasites. In the present study only in 7 out of 140 cultures from which aphidiid parasites emerged, ants were observed. These ants belong to genera *Camponotas*, *Crematogaster* and *Pheidole*, the last named one being most common. The parasites species include *Ephedrus plagiator* (Nees), *Lipolexis scutellaris* Mack., *Pauesia laricis* (Haliday), *Toxares deltiger* (Haliday) and *Trioxys* sp. while the host-aphids include *Aphis citricola* v.d. Goot, *Aphis gossypii* Glover, *Brachycaudus helichrysi* (Kltb.) *Cinara atrotibialis* David and Narayanan, *Eulachnus thunbergii* (Wilson), *Mollitrichosiphum (M) tenuicarpus* (Okajima) and *Toxoptera citricidus* (Kirk). In all the above cases, parasitoids have been observed to belong to non-specialized group.

## II. ECOLOGY OF APHIDOPHAGOUS COCCINELLIDAE (COLEOPTERA) IN KALIMPONG-SIKKIM REGION

Aphidophagous coccinellid beetles form one of the major groups of natural enemies of aphids. These insects are known to exhibit a very wide range in food preference (Hodek, 1966). The rate of fecundity of these beetles depends largely on the suitability of accepted food (nutritionally adequate) and the amount of available food in terms of the number of prey species in a colony. Effect of food-quality and quantity on size, weight and water content has been studied by Dixon (1959). Okamoto (1966) has shown the relationship between suitability of aphids as food and the taxonomic position of their host plants.

It is known that in Coccinellids' site of feeding coincides with site of oviposition at later stage. Iperti (1966) has indicated that the females while ovipositing move away from the ground (negative geotaxis) are attracted to lighted areas where surface is rough and humidity is more. However response to the 4 major stimuli, e.g. geotropism, phototropism, hygrotropism and thigmotactism vary in different species, e.g. *Coccinella septempunctata* (L.) may be more strongly phototropic and thigmotactic than others.

On hatching, larvae usually move aimlessly on the leaves and search for prey using thigmotactic stimulus. Once prey is found, search in the region becomes intensive. Usually larvae first move on leaves and then on stems (Bansch, 1966).

Distribution of these insects, like other entomophagous insect, is governed by macro—and microecological factors. During 1975-1978 a study was undertaken on the aphids and their natural enemies in Sikkim and Darjeeling district of West Bengal. A list of natural enemies has already been published (Raychoudhuri *et al.*, 1978). This paper gives an account of the observations on the ecology of aphidophagous coccinellids recorded in these areas.

### PREY-GROUP PREFERENCE

The prey-range for the aphidophagous coccinellids population extends over 17 aphid species and of these Aphidinae comprises 66%. The rest of the species are almost equally distributed over Lachninae (—), Greenideinae (+), Pemphiginae (+) and Drepanosiphinae(+). It may be noted that a large percentage of aphidine species is widely distributed in diverse habitats and usually exhibit higher rate of fecundity in general and as such these offer greater quantity of food to the developing larvae of predatory coccinellidae.

### PREY-SPECIFICITY

In Sikkim-Kalimpong region, *Coccinella septempunctata* (Linn.) could

be identified as the only polyphagous species predated on 10 different prey-species of diverse taxonomic groups which are found on a wide range of plant habitat, e.g. Betulaceae, Compositae, Fagaceae, Leguminosae, Rosaceae, Rutaceae etc. Most of the species are predated upon in May. Blackmann (1966) has stated that this concinellid species may accept and feed on a wide range of prey in the field but in terms of food, suitable for larval development and for reproduction, it exhibits far more restriction. *Aphis gossypii* Glover, an extremely polyphagous aphid seems to be most preferred food, specially when it colonizes *Ageratum conyzoides*.

*Oenopia sauzeti* Muls., is the only other species noted to feed on three different prey-species, all belonging to same taxonomic group. Three other species *Ailocaria dodecaspilota* (Hope), *Oenopia kirbyi* Muls., and *Hemosepilachna* sp., show prey-range of two species each. The first of these predatory species appears to be restricted to the same habitat as the prey-species, e.g. *Hordeum vulgare*. Rest of the species exhibit a curious prey-specificity.

The polyphagous species of predators may show a different prey preference at different season even if the aphid inhabit the same plant community, e.g. *Hemosepilachna* sp. predated on *Rhopalosiphum maidis* (Fitch) during December and on *Macrosiphum (S) miscanthi* (Tak.) during May, when both feed on *Hordeum vulgare*. Sometimes preference for prey may vary according to the seasonal factors and also habitat e.g. *Oenopia sauzeti* Muls., predated on *Aphis fabae solanella* Theo. in November and on *Capitophorus hippophaeus javanicus* Eastop and *Macrosiphoniella sanbornii* (Gill) during May-July, all the three species inhabiting three very different plant groups viz. Solanaceae, Polygonaceae and Compositae, respectively.

#### HOST-PLANTS, PREY AND PREDATORS

The prey-species complex of the coccinelids exhibit diverse feeding habit. Some may be restricted to a specific plant-species, e.g. *Lachnus tropicalis* (v. d. G.) on *Quercus* sp., *Taoia indica* Ghosh and Raychaudhuri on *Alnus nepalensis*, *Greenidea (T) formosana heeri* Raychadhuri et al. on *Psidium guajava*, some others may feed on host plants belonging to same plant family and some on plants belonging to distantly related plant families. Most of the prey-species in the present study have been observed to be specific to a particular host for host-plant family. But some like *Aphis citricola* v.d. Goot, *Aphis gossypii* Glover, *Brachycaudus helichrysis* (Kltb.) and *Texoptero aurantii* (Boyer) were noticed to be highly polyphagous.

Consideration of the prey-predator relationship and habitat of the prey-species reveals some interesting features :

Table 1. Aphidophagous Coccinellidae of Kalimpong (Ca 1248 m)

Predator species	Prey-species	Host plants	Period
1. <i>Aiolocaria dodecaspilota</i> (Hope)	<i>Taoia indica</i> Gh & Rch	<i>Alnus</i>	December
2. <i>Altica</i> sp.	<i>Macrosiphum miscanthi</i> Tak	<i>Hordeum vulgare</i>	May
3. <i>Chilochorus rubidius</i> Hope	<i>Nippolachnus piri</i> Mats	<i>Pyrus communis</i>	December
4. <i>Coccinella septumpunctata</i> Linn.	<i>Aphis gossypii</i> Glov. <i>G. (T.) formosana heeri</i> Rch. et al., <i>Taoia indica</i> Gh. & Rch	<i>Ageratum conyzoides</i> <i>Psidium guajava</i> <i>Alnus nepalensis</i>	December June December
5. <i>Coleoptera sexareata</i> Mls	<i>Taoia indica</i> Gh. & Rch	<i>Alnus nepulus</i>	May
6. <i>Hemosepilachna</i> sp.	<i>Macrosiphum (S) miscanthi</i> (Tak)	<i>Hordeum vulgare</i>	May
7. <i>Menochilus sexmaculata</i> (F)	<i>G. (T.) formosana heeri</i> Rch. et al.,	<i>Psidium guajava</i>	April
8. <i>Monolepta signata</i> (Oliv.)	<i>Macrosiphum rosae</i> (L)	<i>Rosa</i> spp.	Janunary
9. <i>Oenopia kirbyi</i> Mls	<i>Macrosiphum rosae</i> (L)	<i>Rosa</i> spp.	December
10. <i>Oenopia sauzeti</i> Mls	<i>Macrosiphoniella sanborni</i> Gill.	<i>Chrysanthemum</i>	July
11. <i>Oenopia luteopustulata</i> Mls	<i>Macrosiphum (S) rosaeiformis</i> Das	<i>Rosa cania</i>	May
12. <i>Pagria kanaraensis</i> (Jac)	<i>Aphis craccivoro</i> Koch	<i>Vicia faba</i>	Nov
13. <i>Synonycha grandis</i> (Th)	<i>Pseudoregma alexandri</i> (Jak.)	Bamboo	July

Table 2. Aphidophagous Coccinellidae of Sikkim (ca 1248 m)

Predator-species (Coccinellids)	Prey-species (Aphids)	Host Plant	Period	Altitude	
1. <i>Aiolocaria</i> nr. <i>dodecaspilota</i> (Hope)	<i>Rhopalosiphum maidis</i> (Fitch)	<i>Hordeum vulgare</i>	December	1666 m	
2. <i>Coccinelia septumpunctata</i> (Linn.)	<i>Acyrtosiphon pisum</i> (Harris)	<i>Pisum sativum</i>	May	1666 m	
	<i>Aphis citricola</i> v.d.G.	<i>Capsicum frutescens</i>	May	1666 m	
	<i>Aphis craccivora</i> Koch	<i>Vicia faba</i>	May	1666 m	
	<i>Aphis gossypii</i> Glover	<i>Ageratum conyzoides</i>	December	1666 m	
		<i>Bidens pilosa</i>	May	1666 m	
		<i>Brachycaudus helichrysi</i> (Kltb)	<i>Artemisia</i> sp.	May	1500 m
		<i>Greenidea</i> (T) <i>formosana heeri</i> Rch. et. al.	<i>Psidium guajava</i>	February	1675 m
		<i>Lachnus tropicalis</i> v.d.G.	<i>Quercus</i> sp.	May	2080 m
		<i>Macrosiphum rosae</i> (L)	<i>Rosa cania</i>	May	1500 m
		<i>Toxoptera aurantii</i> (Boyer)	<i>Citrus</i> sp.	May	1500 m
3. <i>Coleophora bisellata</i> Muls.	<i>Aphis craccivora</i> Koch	<i>Vicia faba</i>	May	1675 m	
4. <i>Coleophora</i> sp.	<i>Aphis gossypii</i> Glover	<i>Galinsuga parviflora</i>	December	1666 m	
5. <i>Henosepilachna</i> sp.	<i>Rhopalosiphum maidis</i> (Fitch)	<i>Hordeum vulgare</i>	December	1666 m	
6. <i>Oenopia kirbyi</i> Muls	<i>Rhopalosiphum maidis</i> (Fitch)	<i>Hordeum vulgare</i>	May	1666 m	
7. <i>Oenopia</i> nr. <i>quadripunctata</i> Kapur	<i>Aphis fabae</i> group	Unidentified host	May	1500 m	
8. <i>Oenopia sauzeti</i> Muls	<i>Aphis fabae</i> group	Unidentified host	November	1675 m	

### A. *Monophagous and Oligophagous prey and their predators*

- (1) Two rose-infesting *Macrosiphum* species have been found to be predated upon by a complex of 4 species. Two of these are active in May and other two become active in December-January (Tables 1 and 2).
- (2) *Rhopalosiphum maidis* (Fitch), a well known pest of Gramineae, has three predator species, one being active in May and other two in December. Similarly *Taoia indica* Ghosh and Raychaudhuri, an endemic prey-species feeding on *Alnus* has a complex of 3 predator-species, one predated during May and other two during December (Tables 1 and 2).
- (3) Each of *Greenidea (T) formosana heeri* Raychaudhuri *et al.*, infesting *Psidium guajava* and *Macrosiphum (S) miscanthi* (Tak) infesting *Hordeum vulgare* is predated upon by two species during February-June.
- (4) Each of *Nippolachnus piri* Mats. infesting *Pyrus* and *Pseudoregma alexanderi* (Tak.) infesting Bamboo and *Macrosiphoniella sanborni* (Gill.) infesting *Chrysanthemum* is predated upon by only one predator.

From the foregone account it appears that in case of monophagous or oligophagous aphid prey, at least 50% of predatory species are polyphagous as may be evidenced from their prey-range (Table 1, 2).

### B. *Polyphagous prey and their predators*

- (1) *Aphis citricola* v.d. Goot feeding on a very diverse host plant-groups has only one predator, *C. septumpunctata* (L) which is highly polyphagous.
- (2) *Aphis gossypii* Glover, another polyphagous species has two predator species. One of these is polyphagous and the other is monophagous.
- (3) *Toxoptera aurantii* (Boyer), another prey-species noted for polyphagism was seen to be predated upon by one polyphagous predator-species, *viz. C. septumpunctata* (L.).

It seems that polyphagous prey species are more prone to be attacked by polyphagous predators than what has been observed earlier.

### FREQUENCY OF PREDATION

Frequency of predation appears to be highly variable in different species. The polyphagous prey-species like *A. gossypii* Glover may have 5% of population, predated upon whereas in other polyphagous species it may go up to 14%-20%. But Monophagous and oligophagous aphid species may show much higher rate, *e.g.* about 75% in case of *Taoia*

*indica* Ghosh and Raychaudhuri or about 80% in case of *Rhopalosiphum maidis* (Fitch). The total number of observations per species was however variable, the highest number being that for *A. gossypii* which shows lowest frequency rate for predation. Irrespective of the habitat, of the pre species and the number of observations, it may be stated that 15%-25% of the aphid colonies in natural ecosystem in the area of study area are frequented by predators.

#### RELATIONSHIP WITH HABITAT

The area under present study offers an opportunity to compare the effect of different habitat on occurrence of aphidophagous coccinellids. The activity rhythm clearly indicates two cycles *viz.* spring-summer and Autumn-winter. More than 60% of the predatory species show a high activity rhythm during spring-summer cycle coinciding obviously with the peak of population build up on the prey-species. In the first cycle large number of aphid species may infest young plants after winter specially in areas lying in subtemperate climatic condition till the summer temperature rises. The strata having continuous plant growth offers favourable microclimate *i.e.* good feeding condition to the predators to complete their life cycle. The end of monsoon rain leads to another peak of aphid population during autumn-winter season in hilly region and predatory activity consequently becomes prominent. The concept that in coccinellids moisture acts as a limiting factor for distribution is well known. Analysis of present data reveals that areas having low temperature, diverse floral assemblage, high moisture, exhibit a much richer assemblage of predatory fauna. Consideration of vertical distribution of predator-and pre-complex shows that maximum concentration of species occurs in areas lying between *ca* 1100-1700 m. (Tables 1-2).

#### SUMMARY

Natural enemies of aphids includes hymenopteran parasites and coccinellid predators, besides some dipteran, neuropteran insects and spiders. Observation on the population trend, host-parasite relation, host-specificity, predator-prey relation, seasonal fluctuation for aphidiid parasites in Khasi hills, Meghalaya and Coccinellid predators in Kalimpong-Sikkim region are reported. Both the areas have temperate climate, high rainfall and rich floral assemblage, offering thereby excellent habtiat for the population build up of aphid hosts or prey.

The aphidiid parasites exhibit less habitat dependance in this zone when the host-aphid species may breed parthenogenitically all through the year. The study on aphidiid parasites of aphids in Khasi Hill area clearly indicates host-group-preference to the subfamily Aphidinae and 50% of host-species reared for parasite emergence show susceptability to

infection in natural ecosystem. Out of a total of 16 species studied host specificity was noted for 4 aphidiid species and host-habitat dependence was observed in two species. Non-migratory species of aphids appeared to have specific parasites, whereas polyphagous species showed a wide spectrum of parasite complex. Relation between the parasites in case of multiple parasites, for single aphid host, seems to be one of competition. However, in some cases, succession of parasite species seems to be that of mutualism. Very low percentage of hyperparasites could be noted in the present study. Preponderance of some parasite species, relation between ants attending aphid colonies and parasites etc. have also been discussed.

Studies on coccinellid population complex preying on aphids in Kalimpong-Sikkim region show that most species occur above *ca* 1000 m although study area included localities between *ca* 540-3000 m. Aphidophagous species remain active in April-June and in November-December. Most of the coccinellid species showed prey specificity, irrespective of habitat factor, except for *C. septumpuncta* (L) which exhibits wide-prey range. Some predator species, *e.g.* *A. dodecaspilota* (Hope) however shows different prey-preference at different localities and habitats. Present data indicate that strata having continuous plant growth offers a microclimate favourable for completion of the life cycle of the predators and low temperature, coupled with high moisture lead to large faunal diversity and population assemblage.

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ECOLOGICAL SPECIFICITY OF A NEW  
OOTHECAL PARASITE OF *NEOSTYLOPYGA*  
*RHOMBIFOLIA* (STOLL)

by

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INTRODUCTION

The harlequin cockroach, *Neostylopyga rhombifolia* (Stoll) (Orthoptera : Blattidae), has been reported from the Indo-Malaysian region, Hawaii, the Philippine Islands and the New World Tropics (Roth and Willis, 1960) but its habits are poorly known. During a survey for domiciliary cockroaches and their parasites in parts of south India, this species was found to be abundant in thatched huts in and near Bangalore and in some villages in Tumkur district (Karnataka) and Chittoor district (Andhra Pradesh). Nymphs and adults were found resting between the palm leaves of the roof. This species was very rarely encountered in buildings constructed of bricks and stones.

Three species of oothecal parasites were reared from *N. rhombifolia* : *Evania appendigaster* (L.), *Evania* sp. near *antennalis* Westw. (Evaniidae) and *Anastatus umae* Boucek (Eupelmidae). The last was the most important parasite, with 43.5% parasitism of 1,349 oothecae collected, while the two *Evania* spp. accounted for only 2.6%. Laboratory studies on the life-history and biology of *A. umae* showed that it oviposited and completed its development in the oothecae of *Periplaneta americana* (L.), *P. australasiae* (F.) and *P. brunnea* Burmeister. Since it was not reared from the oothecae of *Periplaneta* spp. collected in brick and stone buildings, an attempt was made to introduce it into such buildings—some houses and a canteen—near the CIBC laboratory and see if it would become established. An account of the observations made on this parasite during 1977-78 is given in this paper.

MATERIAL AND METHODS

In the laboratory the parasite was bred on oothecae of *P. americana*. Three pre-release samples of cockroach oothecae from the houses and 2 samples from the canteen were collected to record the pest and parasite species in these buildings. They were identified to species and those that

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\* *Anastatus umae* is a new species being described by Z. Boucek (in press)

Table 1. Pre-release parasitism

Site	Date of collection	No. of oothecae	% parasitism	Host species	Parasite species
B-type—13 houses other than B <sub>14</sub>	5, 6 & 7 July, 1977	400	31	<i>P. americana</i> , <i>P. australasiae</i> , <i>P. brunnea</i> <i>Supella longipalpa</i> (F.)	<i>Tetrastichus hagenowii</i> , <i>T. asthenogmus</i> , <i>Tetrastichus</i> sp. ( <i>miser</i> group) <i>Comperia merceti</i> Comp.
	3 & 4 Oct., 1977	230	22.6	Do	Do
	6 & 7 Jan., 1978	168	40.0	Do	Do
B <sub>14</sub>	6 July, 1977	103	45.6	<i>P. americana</i> , <i>P. australasiae</i> , <i>P. brunnea</i>	<i>T. asthenogmus</i> <i>Tetrastichus</i> sp. ( <i>miser</i> group)
	3 Oct., 1977	26	19.3	Do	Do
	6 Jan., 1978	27	30.0	Do	Do
Canteen	4 Mar., 1978	179	7.6	<i>P. americana</i> , <i>P. australasiae</i> , <i>P. brunnea</i> <i>S. longipalpa</i>	<i>T. asthenogmus</i> , <i>Tetrastichus</i> sp. ( <i>miser</i> group) <i>C. merceti</i>
	3 Apr. 1978	184	15.2	Do	Do

were apparently healthy were individually held in glass vials (8×1 cm), plugged with cotton. Emergence of parasites was recorded. Oothecae from which there was no emergence were dissected after 2 months to check the contents.

#### PARASITE RELEASES AND SURVEYS

The pest species and the pre-release parasitism of oothecae in the sites where the parasite was released are given in Table 1. *N. rhombifolia* and its oothecal parasites were absent in these sites.

The releases made are shown in Table 2. In the laboratory culture adults of *A. umae* emerged from host oothecae only during a short period of the year, the larvae undergoing a long diapause within the host oothecae. Field releases were therefore limited to a short period synchronising with adult activity.

Table 2. Parasite releases

Site	Date	Mated females	Males
B <sub>11</sub>	25 March-15 April, 1978	75	24
B <sub>14</sub>	3 to 8 June, 1978	70	29
Canteen	4 to 12 June, 1978	150	57

The post-release parasitism is given in Table 3, which shows the absence of the eupelmid from the parasite complex. Although releases were made only in one house several other houses in close proximity were also covered in the post-release surveys to see if the parasite had dispersed to them in search of hosts.

#### LABORATORY AND FIELD OBSERVATIONS

To investigate the possible causes for the failure of *A. umae* to become established in the release sites some observations on the habits of the parasite were made in the laboratory and in the field. These are detailed below.

1 *Host species* : In the huts *Periplaneta* spp. were generally rare. A collection of 1,393 oothecae included 1,349 of *N. rhombifolia*, 24 of *P. americana*, 3 of *P. australasiae*, 1 of *P. brunnea* and 16 of *Supella longipalpa* (F.). Of these, 585 *N. rhombifolia*, 3 *P. americana* and none of the rest were parasitised by *A. umae*.

An experiment to study the host preference of *A. umae* was set up by exposing an ootheca each of the three species of *Periplaneta*, along with one of *N. rhombifolia* for 12 hours, to a 4-day-old mated honey-fed female. The oothecae were dissected after 10 days to check for parasite larvae. In 10 replicates all the oothecae of *N. rhombifolia* but only 2 of

Table 3. Post-release parasitism

Site	Date of collection	No. of oothecae	% parasitism	Host species	Parasite species
B type houses	12 May, 1978	26	7.7	<i>P. americana</i> , <i>P. australasiae</i> .	<i>T. asthenogmus</i> , <i>Tetrastichus</i>
B <sub>13</sub> & B <sub>14</sub>		55	16.3	<i>P. brunnea</i>	sp. ( <i>miser</i> group)
B type—12 houses other than B <sub>13</sub> & B <sub>14</sub>	2 & 3 July, 1978	387	26.5	<i>P. americana</i> , <i>P. australasiae</i> , <i>P. brunnea</i> <i>S. longipalpa</i>	<i>T. hagenowii</i> , <i>T. asthenogmus</i> , <i>Tetrastichus</i> sp. ( <i>miser</i> group) <i>C. merceti</i>
B <sub>14</sub>	5 July, 1978	89	29.7	<i>P. americana</i> , <i>P. australasiae</i> , <i>P. brunnea</i>	<i>T. asthenogmus</i> , <i>Tetrastichus</i> sp. ( <i>miser</i> group)
Canteen	1 July, 1978	174	11.5	<i>P. americana</i> , <i>P. australasiae</i> , <i>P. brunnea</i>	<i>T. asthenogmus</i> , <i>Tetrastichus</i> sp. ( <i>miser</i> group)
	3 Aug., 1978	58	12.2	<i>S. longipalpa</i>	<i>C. merceti</i>

*P. americana* and 1 each of *P. australasiae* and *P. brunnea* were found parasitised. This shows a definite preference for oothecae of *N. rhombifolia*, which were absent in the release sites.

2. *Light* : One of the important ecological features in huts was the scarce penetration of daylight. The oviposition behaviour of the parasite in light and darkness was compared using a glass cylinder measuring 22 x 6.5 cm, covered for half its length with black paper. The opening on the dark side was covered with a thick black cloth and at the opposite end by a white muslin cloth. An ootheca of *P. americana* was placed in each half of the cylinder and a single 4-day-old, honey-fed female was released into it. The cylinder was placed in a room illuminated by a 60-W electric bulb for 12 hours. Observations on 10 replicates showed that in 7 the ootheca in the dark side was parasitised, in 2 the oothecae on both sides were parasitised and only in 1 the ootheca in the illuminated side was parasitised.

Light was also found to influence the fecundity of the parasite. In the normal daylight schedule, females parasitised only 1 ootheca each in their lifetime although exposed to 3 oothecae each day whereas they parasitised 2.6 oothecae on average when kept in continuous darkness, the maximum being 5.

From these experiments it would appear that darkness is an important factor inducing oviposition by the female.

3. *Distribution of oothecae* : Field observations in the huts showed that all oothecae of *N. rhombifolia* were laid on the inner side of the palm leaves of the roof. In other types of buildings, the distribution of the oothecae by the other species of cockroaches is different. In a survey in which 270 oothecae of *Periplaneta* spp. were collected, 47.2% were found on door and window frames, 28.5% below cooking platforms and sinks, 18.8% on storage racks and cabinets, 3.6% on furniture and 1.9% in other places like gunny bags, steel trunks etc. The difference in the location of the oothecae could be one of the factors accounting for the failure of *A. umae* to establish in brick and stone buildings since several species of parasites are known to be highly restricted to the ecological niches in which the susceptible host stages occur.

4. *Effect of multiple parasitism* : *Tetrastichus* spp. were not reared from oothecae of *N. rhombifolia* though 2 of *P. americana* collected from huts were parasitised by *T. hagenowii* (Ratz.). When *T. hagenowii* and *T. asthenogmus* (Wtst.) were exposed to oothecae of *N. rhombifolia*, they did not oviposit in them. Hence in the huts, *A. umae* and *Tetrastichus* spp. co-existed on different hosts, with no inter-action between them. In the release sites the absence of *N. rhombifolia* might have led to multiple

parasitism of *Periplaneta* oothecae by *Tetrastichus* and the introduced *A. umae*, if the latter parasite had also oviposited in them. The result of such interaction between these parasites was studied in the laboratory. Ten *P. americana* oothecae parasitised by *A. umae* were individually exposed to females of either of the two *Tetrastichus* spp. Similarly, ten oothecae parasitised by each of the *Tetrastichus* spp. were exposed to females of *A. umae*. In all cases the second oviposition followed within 24 hours of the first. The progeny was allowed to complete its development and emerge. From all these oothecae, either *T. hagenowii* or *T. asthenogmus* emerged. Moreover, one ootheca in which *T. hagenowii* had oviposited first contained a larva of *A. umae* and two oothecae in which *A. umae* oviposited first contained one and 2 larvae of it, respectively. These larvae failed to complete the development.

The hyperparasite *Tetrastichus* sp. *miser* group did not oviposit when exposed to oothecae containing mature larvae of *A. umae*. This eliminates loss of oothecae parasitised by *A. umae* due to hyperparasitism.

#### DISCUSSION

Parasites are known to be attracted first to the habitat of the host (Salt, 1935). This is particularly so when they are removed from the host habitat. When *A. umae* was released in brick and stone buildings, which are not the habitat of *N. rhombifolia*, it might have dispersed away from the release area. The abundance of *N. rhombifolia* in huts but not in other types of buildings is possibly due to the adaptation of this cockroach to its peculiar microhabitat. Little information is available on the biology of this species.

Availability of the preferred host is another important factor governing the efficiency of a parasite. Though capable of ovipositing in oothecae of *Periplaneta*, the female *A. umae* appears to be able to restrain from ovipositing in them and be in constant search for the preferred host. Limited oviposition in *Periplaneta* in the laboratory was possibly due to confinement within a small area.

Light, though not of critical importance, influences the fecundity of this eupelmid.

The success of *Tetrastichus* spp. in cases of multiple parasitism further decreases the chances of development of *A. umae* even if it had oviposited in the oothecae in the release sites.

Once a wall-lizard, *Hemidactylus ? brooki* Gray, was found to prey on a female *A. umae* in a house where the releases were made. Since the eupelmid does not take to flight, its mode of locomotion being walking or hopping, it is easily vulnerable to predation.

## ACKNOWLEDGEMENTS

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## STUDY ON POPULATION DENSITY OF LIGHT-ATTRACTED INSECTS FROM CALCUTTA AIR-PORT

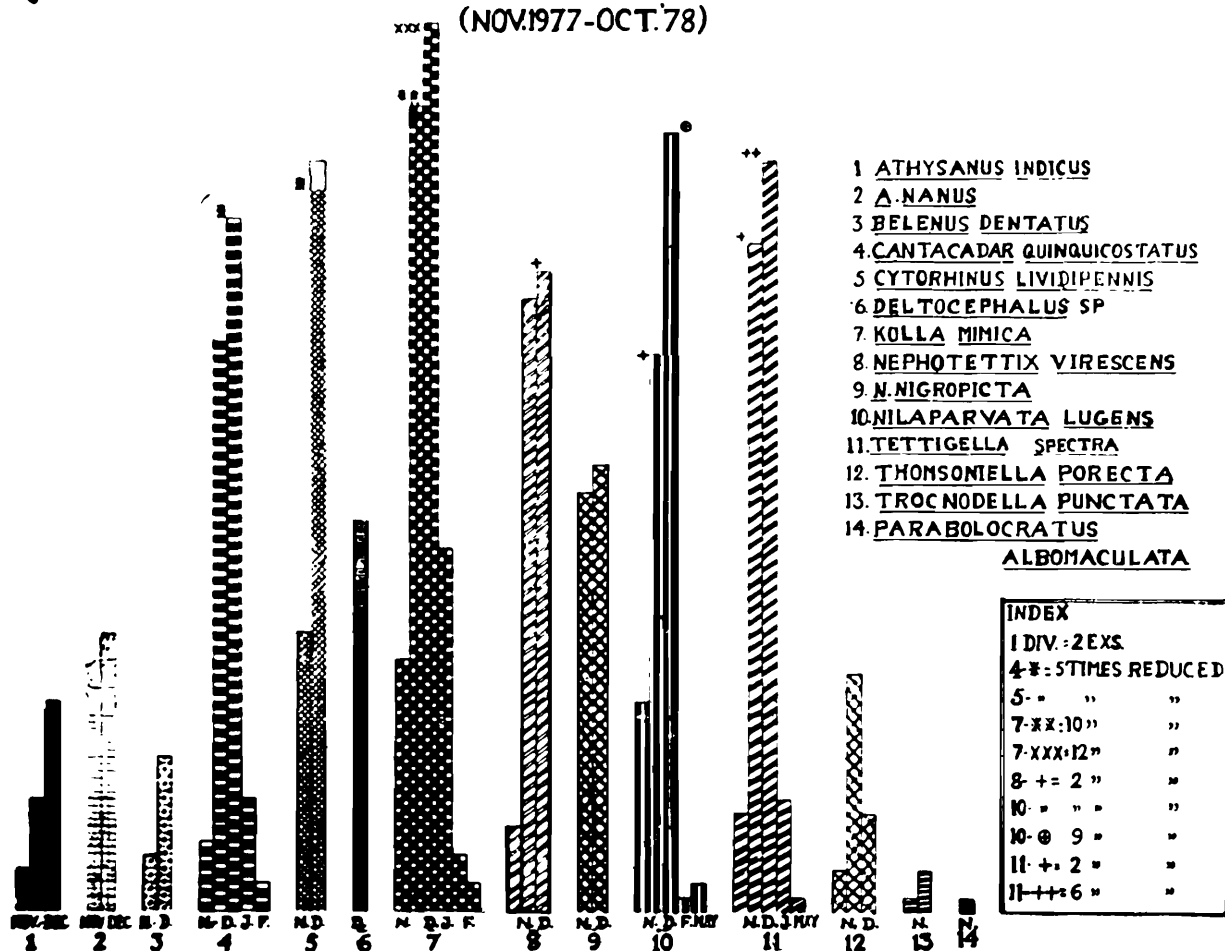
By

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The study on the bimonthly collections of the light-attracted diverse insect groups from the Calcutta Air Port was initiated since November 1977 and continued till October 1978. The prime objective of such an investigation was to delve into the seasonal fluctuation of hemipterous insects of economic bearing specifically and to record on the abundance of other insect groups in general. The 40,000 insect individuals which were attracted by lights at varied points at the Calcutta Air Port, consisted of 42 families appertaining to 5 major Orders. The diversity in the fluctuation of each family was characterized in Graph No. III and comparative abundance of species pertaining to two Suborders under Hemiptera had been represented in Graph Nos. I and II.

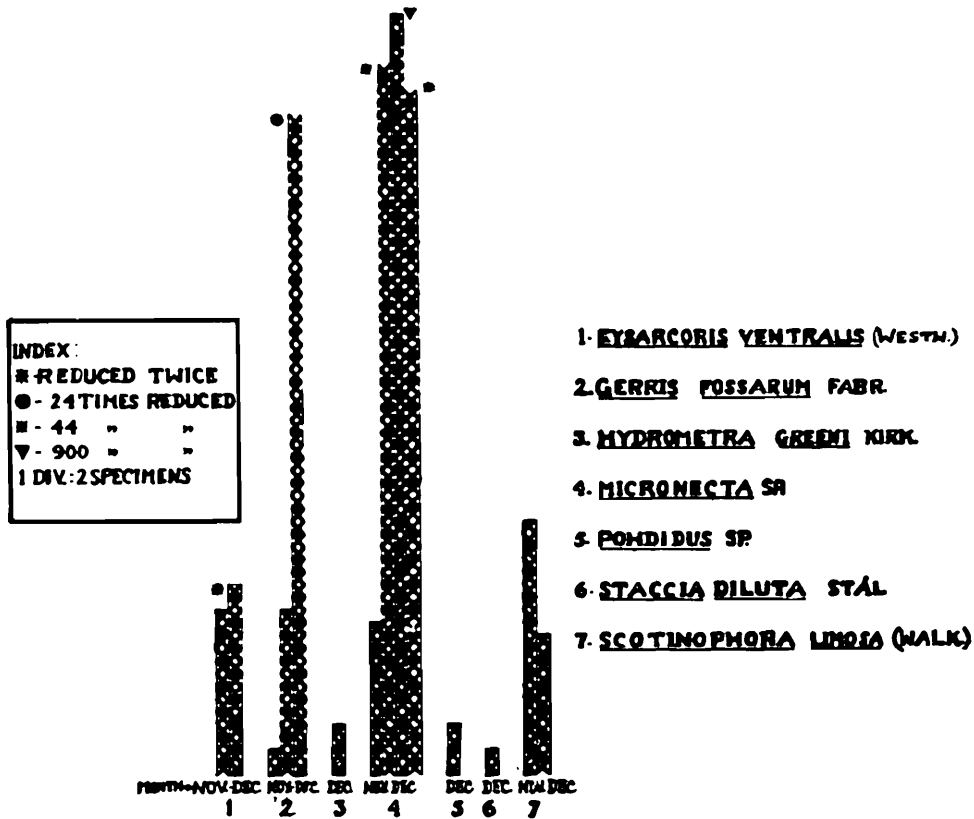
### RECORDS OF LIGHT-ATTRACTED INSECTS TAKEN AT CALCUTTA AIRPORT BIMONTHLY FLUCTUATION IN POPULATION OF SOME HOMOPTERAN INSECTS (NOV.1977-OCT.78)



Graph 1

\* Quarantine and Fumigation Station, Calcutta Airport, Calcutta-52.

RECORDS OF LIGHT-ATTRACTED INSECTS TAKEN AT CALCUTTA AIR PORT  
 II. BIMONTHLY FLUCTUATION (NUMBER) IN POPULATION OF SOME  
 HETEROPTERAN INSECTS (Nov 1977-Oct. 78)



Graph II

The hemipteran individuals had been recorded by 86% of the total catch, family Corixiidae did cover 73% and remaining 13% included the families Hydrometridae, Fulgoridae, Miridae, Tingidae and Cicadellidae. The maximum abundance was represented in the graph I by *Kolla mimica* Dist. (4%), *Tettigella spectra* Dist. (1%)—family Tettigellidae; *Nephotettix virescens* (Fabr.) (1%),—family Euscelidae; *Nilaparvata lugens* (Stal) (2%)—family Delphacidae; *Cytorhinus lividipennis* Reuter (1%)—family Miridae and *Cantacadar quinquicostatus* Fabr. (1%)—family Tingidae. The two species namely *Nephotettix virescens* (Fabr.) and *Nilaparvata lugens* (Stal) were recorded viruliferous on paddy covering India, South East and Far East Asian countries. The graph II showed the flight activity of 73% *Micronecta* spp.—family Corixiidae; *Gerris fossarum* Fabr. (2.3%)—family Gerridae; *Eysarcoris ventralis* (Westw.)—family Pentatomidae, *Scotinophora limosa* Walker—*Hydrometra greeni* Kirk.—family Hydrometridae, *Staccia diluta* Stal—family Reduviidae, covered 0.7%. It was to be noted that the species, *Cytorhinus lividipennis* Reut. had the characteristics of predating on *Nilaparvata lugens* (Stal) but their incidence compared to *N. lugens* (Stal) had been insignificant. The rest 14% were consisted of 4% Coleoptera which had included the families Carabidae, Heteroceridae, Staphylinidae, Dytiscidae, Hydrophilidae of

maximum occurrence and other families were Scarabaeidae, Curculionidae, Elateridae, Tenebrionidae, Colydiidae and Cerambycidae of moderate occurrence ; out of 1% Lepidoptera, families Pyralidae and Noctuidae were dominant over the families Saturniidae, Arctiidae, Geometridae and Lymantriidae ; Orthoptera involved 5% of the total catch had Tetricidae of maximum incidence than the family Gryllidae ; of 0.4% Diptera, maximum abundance was reported on the families Dolichopodidae, Ephydriidae over the minimum incidence Ceratopogonidae, Chironomidae, Chloropidae, Culicidae, Drosophilidae, Tipulidae and Tephritidae. In Hymenoptera (3.6%) maximum flight activity was recorded on the families Formicidae, Ichneumonidae and Braconidae and minimum was observed of Chalcidae and Apidae.



## AN ECOLOGICAL STRESS OF INSECT COMPLEX ON SUNFLOWER IN UTTAR PRADESH (INDIA)

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### INTRODUCTION

*Helianthus annuus* Linn. has been introduced as another edible oil bearing crop. Due to an economic impact on human welfare, its cultivation is gaining prominence in the State. Except listing a few insects associated with the crop from Tamil Nadu (Lewin, Thandavarayan, Kumar and Sunderaraju, 1973 ; Rangarajan, Mahadevan and Iyemperumal, 1975), Punjab (Sandhu, Brar and Bhalla, 1973), Andhra (Ayyanna, Subbaratnam and Dharmaraju, 1976), and West Bengal (Nath, Sen and Pal, 1977) no description on population dynamics is available for such insect complex around the crop. Under present study the north-western part of Indogangetic plain described to be an another climatically different zone from regions so far studied for the sunflower cultivation. To establish a numerical dominance of the insect pest complex from western part of Uttar Pradesh an extensive survey was undertaken.

### MATERIAL AND METHOD

Four study sites, each of approximately  $7 \times 7$  m square were selected. Each plot contained about 270 plants in number and situated equidistant from each other ( $60 \times 30$  cm). Field sampling by direct counting and also aided by sweep nets was done each day in early hours. About 106 species belonging to 9 orders are described. The taxa tabulated further showed a significant dominance of individuals and species at Muzaffarnagar (latitude  $29^{\circ}27'20''$  N to  $27^{\circ}41'15''$  E longitude) (Goel, 1976). Based on day to day micrometeorological data, a correlation has been attempted between the 5-day total of insect population on the sunflower crop and the abiotic factors. The present study incorporates an observation on the summer irrigated crop during April to June, 1978.

### OBSERVATIONS

Majority of the insect orders which built up the community structure around summer irrigated crop of the sunflower are seen with unequal

distribution in two marked phases namely, the non-flowering and flowering (Table 2). The insect activity increases with the rise in maximum temperature and the two are directly correlated with each other. The value of coefficient of correlation for the maximum temperature ranges from 30°C to 42°C with  $\pm 5.9^\circ\text{C}$ . Besides, strong relationship between the two yet the insect activity remained poor in the non-flowering phase. With the initiation of the flowering the insects start hovering over the crop in large numbers (fig. 1). Likewise the coefficient of correlation has been significantly of high value in this phase (Table 1). The days mean minimum temperature ranges from 21°C to 31°C with  $\pm 5.2^\circ\text{C}$ . The insect catch is also strongly correlated with the minimum temperature. Comparing the two phases, the minimum temperature remained rather inversely

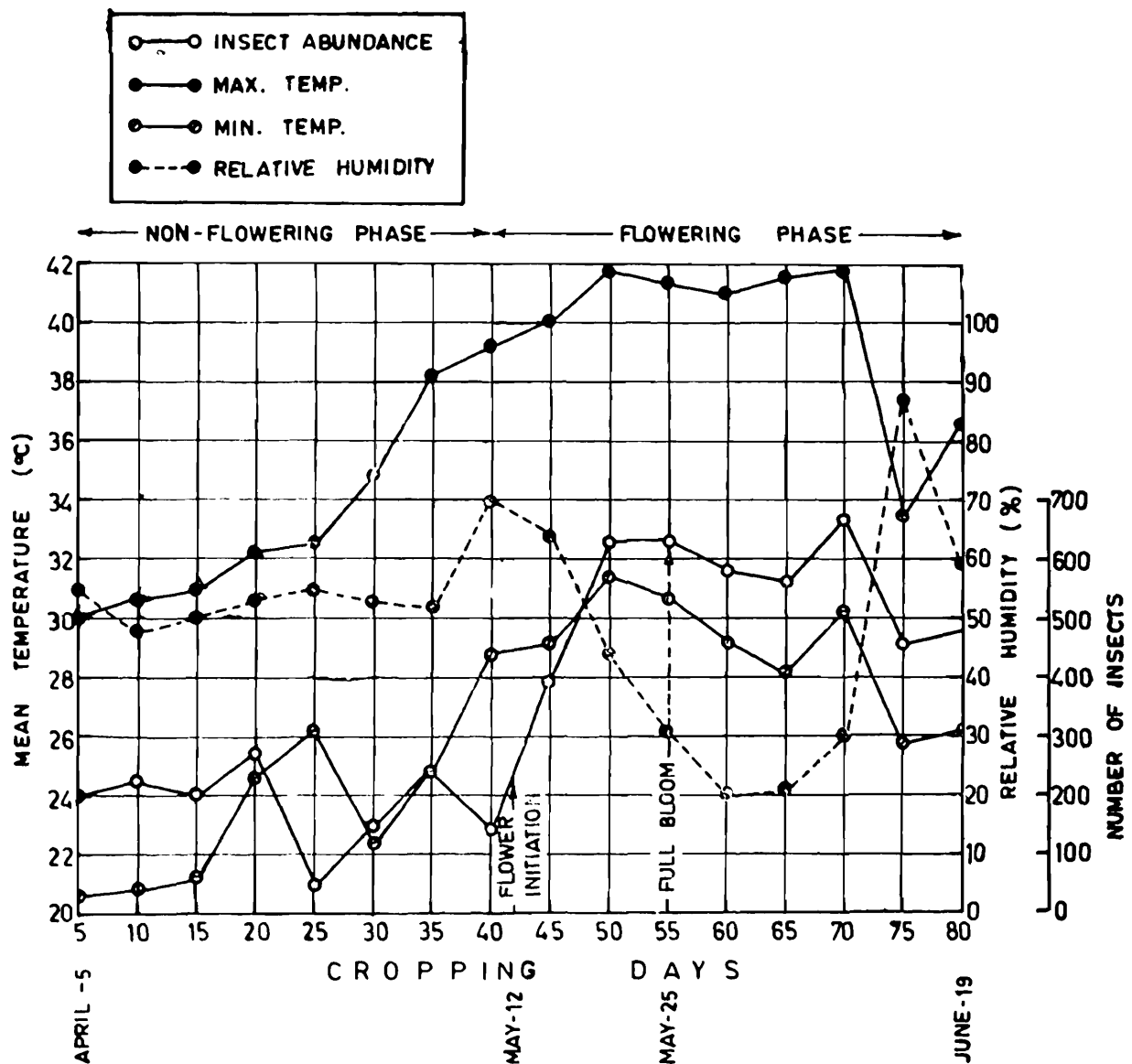


Fig. 1. The abundance of the insects and the climatic factors associated with the cropping days of the sunflower in western Uttar Pradesh.

correlated to the insect activity in the non-flowering phase, whilst strong positive correlation in the flowering stage (Table 1).

Table 1. Coefficients of correlation of the insect abundance with the climatic parameters

Coefficients of correlation	Mean temperature (°C)		Relative humidity (%)
	Maximum	Minimum	
With the total insect population	0.79**	0.73**	0.46*
With the insect population in non-flowering phase	0.40	-0.23	0.13
With the insect population in flowering phase	0.64*	0.67*	-0.84**

\* Significant at 5% level

\*\* Significant at 1% level

The relative humidity is another abiotic component influencing to such insect population. The entire cropping period had a varied condition regarding the relative humidity ( $\pm 33.5\%$ ). Though it ranged from 20% to 87% but has a high correlation with the insect abundance, with insignificant impact during the non-flowering phase (Table 1). More so, the insect abundance in the flowering phase has a negative correlation with the relative humidity but the two have been inversely proportional to each other (fig. 1). There has been no rainfall during the entire cropping days and it rained towards the second week of June when the crop already reached a withering stage.

The insects which run together with the age of the crop are mainly from Coleoptera, Hemiptera, Hymenoptera and Diptera (fig. 2). The dragon flies (Odonata) are active during the flowering phase on the plant except the flower heads. The insects from Orthoptera and Lepidoptera though injurious but have an interrupted distribution. The Mantidae and Chrysopidae are the casual visitors to the crop, probably due to their predatory habits. Except Coleoptera having almost equal number of individual both in the non-flowering and flowering phases of the crop ( $X^2 = 22.73$ ), the remaining major insect orders are significantly different in the later phase compared to the former (Table 2). The presence of the coccinellid beetles forming 73.29% of the total Coleoptera favoured to maintain a biological control. The Hemiptera, a group of sap-sucking insects are dominated by the lygaeid-bugs constituting 68.52% of the hemipteran population. Their activity starts in the non-flowering phase but vigorously multiply to attack the crop in the flowering phase, and suddenly becomes a predominant group (fig. 2). The family Apidae is

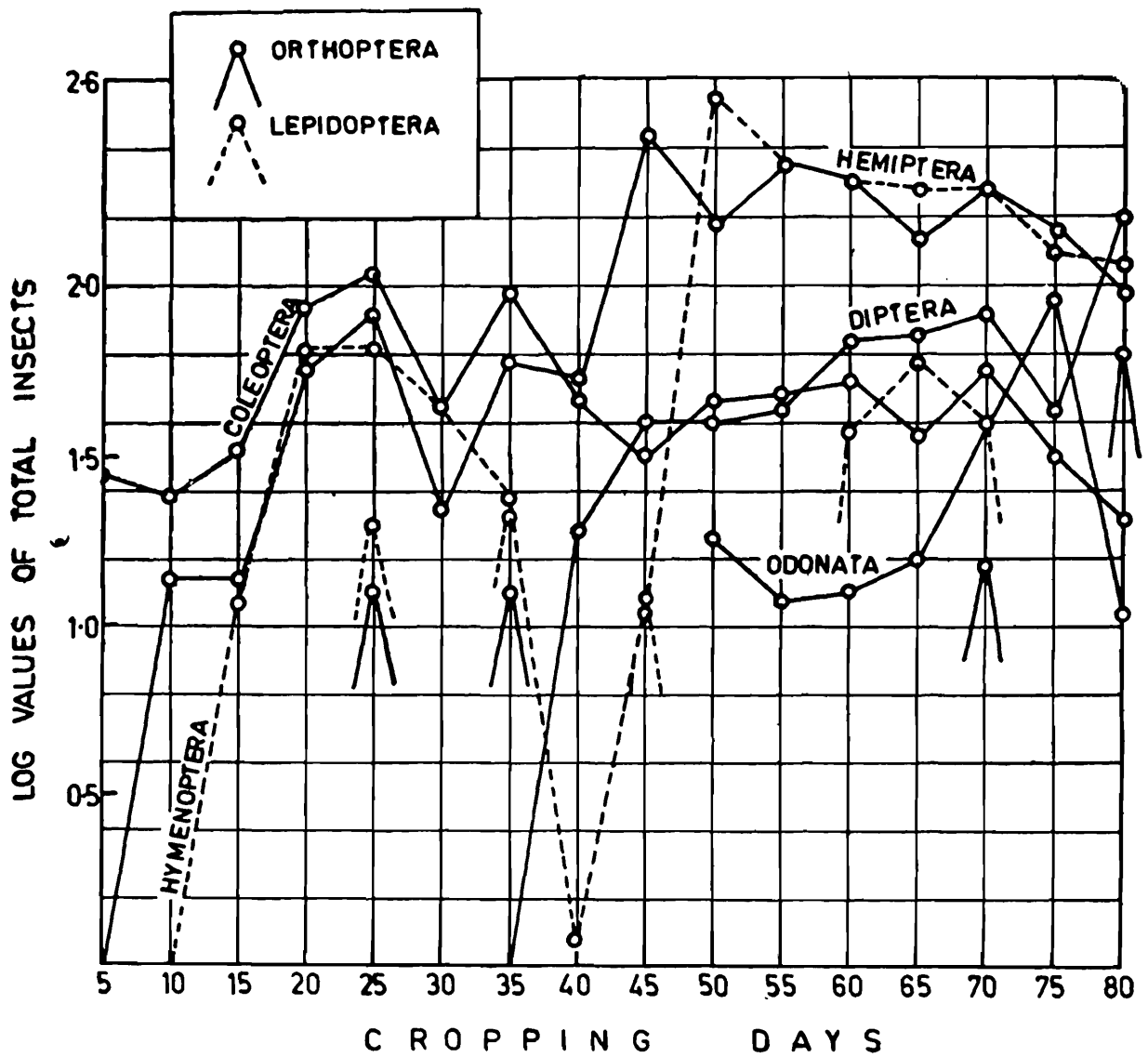


Fig. 2. The pattern of main families associated to the crop of the sunflower.

Table 2. Total number of individuals collected with number of species in parenthesis

Taxa	Total number of individuals collected from field		$\chi^2$
	Non-flowering phase	Flowering phase	
Hemiptera	306 (21)	1492 (3)	782.31**
Coleoptera	462 (18)	328 (2)	22.73**
Hymenoptera	226 (5)	1539 (16)	976.75**
Diptera	71 (12)	565 (1)	383.70**
Lepidoptera	62 (2)	158 (7)	41.89**
Orthoptera	14 (5)	84 (3)	34.29** <sup>(a)</sup>
	24 (4N)	25 (3N)	
Odonata	— (0)	208 (4)	208.00**
Mantoidea	—	11 (2)	10.89** <sup>(a)</sup>
	3 (2N)	4 (2N)	
Neuroptera	4 (1)	— (0)	4.00*

\* Significant at 5% level

\*\* Significant at 1% level

<sup>(a)</sup> Value inclusive of nymphs (N)

another aggregation making 59.72% of hymenopteran population during the flowering phase, and is of great economic value to the crop. Yet hymenopterans are a group with large number of individuals distinct in two phases but largest in the second phase (fig. 2). Owing to nectries in flowering phase, a good number of dipterans got active. However, oozing injured parts of the plants have considerably attracted a group of wingless hymenopteran forms, such as *Camponotus compressus* Fabr. The grasshoppers have invaded the crop in their nymphal stages in early April, but *Atractomorpha crenulata* (Fabr.), and *Trilophidia annulata* Thunb., are seen active in large numbers making holes in the foliage. The butterflies and moths are also attracted for feeding but good number of caterpillars (*Diacrisia obliqua* Walk., *Plusia orichalcea* Fabr., and *Odontestra submarginalis* (Walk.) have also infested a few plants scrapping the chlorophyll of the leaves (fig. 2).

The vertical distribution of the total insects over the crop are categorised (Table 3). Out of six, large number of species uncommon feeding over every part of the plant are *Nysius minor* Dist. forming 67.3% of the total hemipterans captured on each plant, whereas *Componotus compressus*

Table 3. Vertical distribution of individual insects on different parts of the crop

Crop	Individuals	No. of Species
Flower heads	1413	24
Seed milk (84)		
Oozing sap (126)		
Nector licking (114)		
Foraging (1055)		
Parasites (34)		
Apical leaves & Flower buds (green)	910	29
Entomophagous (635)		
Sap & nector licking (261)		
Chewers (14)		
Lower old leaves	1213	46
Entomophagous (358, 7N)		
Sap sucking (299)		
Chewers (233, 49N)		
Casual visitors (267)		
Stem & Petiole	167	4
Sap sucking (167)		
Seedlings & near ground	19	2
Nibbling types (19)		
Each part of plant	1864	6
Sap sucking (1210)		
Oozing sap (654)		
Total individuals in parenthesis	N=Nymph	

Fabr. have been 29.63% of the total hymenopterans considerably engaged on oozing sap in the field. Majority of the insects associated with the foliage are from seventy-three species. Out of them 69.78% have been predators with remainder 30.22% as injurious to apical leaves and the flower buds; whereas 30.09% and 69.91% are to the old leaves respectively. Much of the insects have been attracted to the flower heads with *Milipona irridepennis* Smith alone contributing 61.42% to the total foraging individuals.

For all the eighty-five cropping days in western Uttar Pradesh, eighteen species have been described inflicting minor to major injuries to the plants namely, *Nysius minor* Dist., *Leptocentrus taurus* Fabr., *Empoasca* sp., *Dysdercus koenigii* (Fabr.) (Hemiptera); *Milipona irridepennis* Smith, *Camponotus compressus* Fabr., *Apis dorsata* Fabr., *A. indica* Fabr. (Hymenoptera); *Brumus suturalis* Fabr., *Coccinella septempunctata* Linn., *Haltica cyanea* (Weber), *Chilomenes 6-maculata* Fabr. (Odonata); *Eristalis*

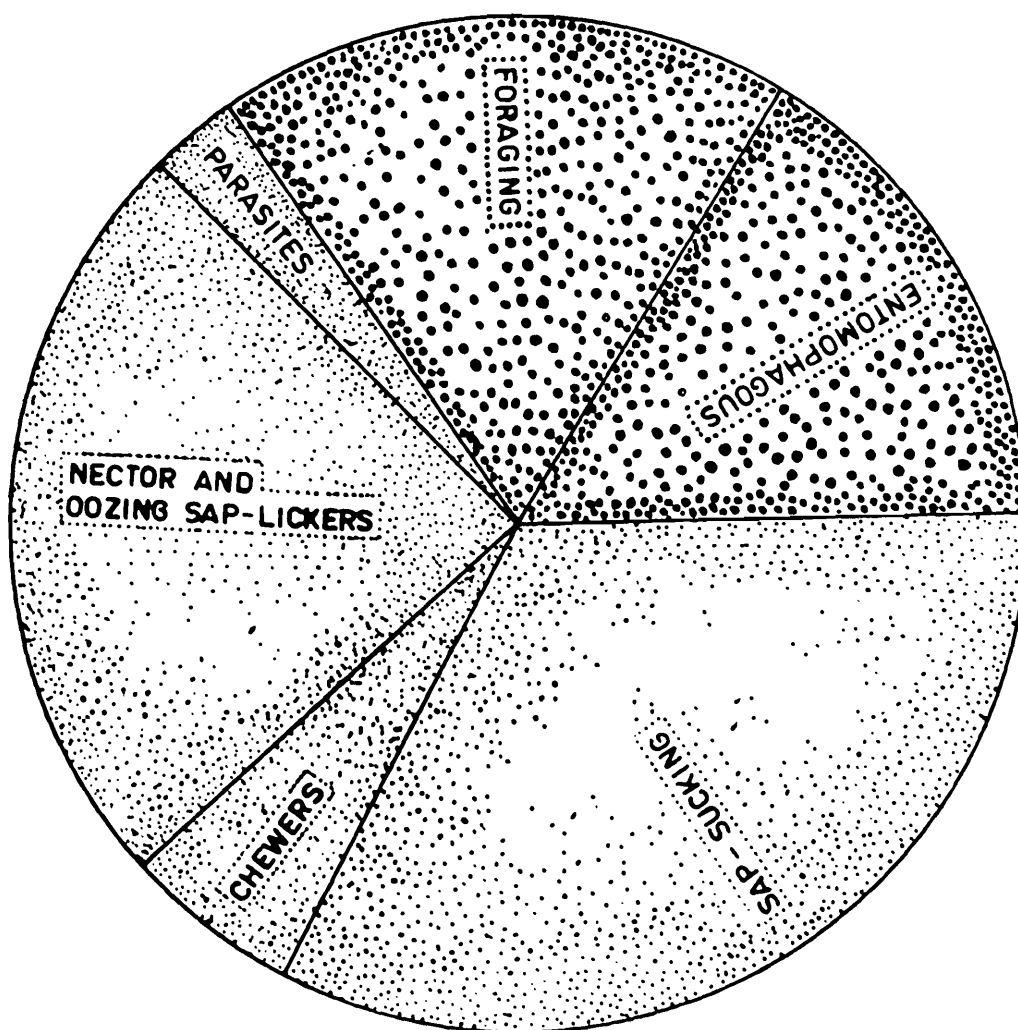


Fig. 3. Pie diagram to show the approximate type of insects of economic importance to the crop.

*quinquestriatus Tabanus orientalis* Wied. (Diptera); *Trilophidia annulata* Thunb. (Orthoptera); and *Danais chrysippus* Linn. (Lepidoptera). *Nysius minor* Dist. (Lygaeidae) preferred to attack in the non-flowering phase of the crop, and shifted to flower heads in the later stage. With the withering of the crop, it then meet its food requirement sucking at the pedicle. With the seed setting, *Dysdercus koenigii* (Fabr.) (Pyrrhocoridae) is another pest to shift from non-flowering phase. Associated with the stem, female *Drosicha mangifera* var. *octocaudata* (Fabr.) (Coccidae) is seen ascending the plant tops with several moults inbetween. About 65.27% of the total insects captured from summer crop are estimated injurious whilst remaining of 34.73% are predators and foraging (fig. 3).

The brood span of thirty-one species captured each month *viz.* April, May and June represented to a single brood. About nineteen species available during the total cropping days with largest number of individuals showed a brood size of the same period of eighty-five days. Individuals second highest in number are from thirty-seven species during the months of May and June with a brood size of two months, whilst poor in April and May for fifteen species. Four species recorded in April and June are possibly from two different broods (Table 4).

Table 4. Monthly distribution of total individuals and species shown in parenthesis

	April	April & May	April, May & June	May	May & June	June	April & June
Hemiptera	69 (1)	94 (2)	1408 (4)	65 (7)	161 (9)	1 (1)	—
Coleoptera	5 (4)	43 (3)	694 (7)	22 (3)	8 (1)	1 (1)	17 (1)
Hymenoptera	—	126 (3)	534 (2)	12 (2)	1071 (10)	9 (3)	13 (1)
Diptera	13 (1)	9 (2)	162 (2)	—	452 (5)	—	—
Lepidoptera	—	41 (3)	—	32 (3)	143 (6)	—	4 (1)
Orthoptera	—	4 (1)	12 (1)	2 (1)	68 (2)	9 (2)	3 (1)
		14 (2N)	13 (N)	11 (3N)	11 (N)		
Odonata	—	—	—	—	106 (3)	102 (1)	—
Mantoidea	—	—	—	—	8 (1)	3 (1)	—
		1 (N)		2 (N)	4 (N)		
Neuroptera	—	4 (1)	—	—	—	—	—
% of individuals in each area	1.58	6.0	50.54	2.61	36.38	2.24	0.66

#### DISCUSSION

Due to all positive and significantly correlated values of coefficients of correlation of the abiotic components with the insect abundance, the

entire insect congregation on the sunflower has been analysed in two distinct phases. Temperature being responsible for the growth and rapid multiplication of insects. The high percentage relative humidity makes such insects sexually mature quicker and, both further coupled together influenced the fecundity of such population (Andrewartha and Birch, 1954). Likewise, it would appear that hot and dry climatic conditions described in the flowering phase favoured the crop. Contrary to the generalization the moisture has been inversely proportional to such an aggregation. The insignificant correlation obtained in the non-flowering phase, however, could not support such generalization in the present study.

Based on day to day quantitative analysis of the population spectrum studied, favourable range of mean maximum 36°C, and 26°C minimum temperature coupled with 54% relative humidity provide optimum conditions for a large insect population on summer irrigated crop in western belt of Uttar Pradesh. The number of species invaded the crop are highest during May and June, whereas second highest in April, May and June. The abundance of individuals from these species, nonetheless, has been reverse reaching peak in the later and declining in the former phase respectively. This elucidates that multiplication of the species was mainly during the middle of May to middle of June when the sunflower crop enters a crucial productive phase.

Another reason for such aggregation might be the dietary preference for the texture of the foliage and subsequent development of the nector with the flower initiation thus making 79% of the total insect complex on the sunflower.

Aphids (Tamil Nadu, Andhra), and thrips (Punjab, Andhra) reported from other sunflower zones are not seen active on the summer crop in Uttar Pradesh. In the absence of the aphids and thrips, large number of entomophagous insects (15.84%) are seen feeding over the cicadellids. It has further been of interest that insects associated with young-old leaves, and green flower buds are dominated by several types of injurious ones *viz.* sap-suckers, chewers and casual visitors (62.6%). The availability of such density dependent predators (37.4%) assist to maintain an equilibrium by reducing the population of injurious ones (Smith, 1935). The abundance of such field population under intricate relationship with abiotic and density dependent ingredients (biotic) not only amount to a sound crop but also leads to minimize the residual hazards by the unnecessary use of pesticides. The numerical changes in the insect pest complex associated to the sunflower at Muzaffarnagar (Uttar Pradesh) thus depends upon the favourable range and optimum conditions of abiotic components, whereas to balance such population in nature involves another set of heterotrophs. However, the role of pollinators is one of

the significant aspects of the sunflower crop (Rangarajan, Mahadevan and Iyemperumal, 1974).

#### ACKNOWLEDGEMENTS

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# EFFECTS OF INDUSTRIAL EFFLUENTS ON POPULATION STRUCTURE OF SOIL MICROARTHROPODS AT DURGAPUR STEEL PLANT AREA A PRELIMINARY REPORT

*By*

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## INTRODUCTION

Although problems of the effects of industrial effluents on water and environment have been studied in general, their impact on soil fauna in tropical countries appear obscure. Significant informations on the influence of industrial pollution on soil animals pertains to that by Grony (1973), Van Rhee (1973) and Dindal *et al.*, (1973) from different parts of Europe and America. Observations presented here relate to preliminary investigations on the effects of pollution on soil microarthropods at Durgapur steel plant area.

## SAMPLING SITES

Field experiments were conducted at Durgapur steel Plant area, West Bengal for the purpose of establishing the effects of continuous discharge of steel plant effluents on the soil ecosystem. We used four plots ('DB' Durgapur Barrage area and "SP" Shampur area, 3 Km away from the Barrage area) for this analysis each measuring 25m X 15m. Two of the plots were kept as control.

## METHODS

Soil samples from all the plots were drawn at monthly intervals. The cores were taken by stainless steel corers having the inner (cross section's) diameter of 8 sq.cm. The extraction of the soil samples contained in each core continued for five days using Tullgren funnels modified by Macfadyen (1953). A 40 watt bulb was used for heating and drying the cores. The relative humidity of surface soil was recorded by using a dial hygrometer.

## OBSERVATIONS

*Faunal make up*: A list comprising a variety of soil microarthropod group from nine orders obtained in both polluted and control plots infunded in table 1. The majority of the total fauna obtained were Acarina in both polluted and control plots, next dominant group being Collembola, followed by Coleoptera comprising both adults and larvae, the larvae being more numerous than adults. The detailed picture indicat-

Table 1. Showing diversity of soil microarthropods from Durgapur steel plant area polluted (P) and control (C) plots.

	DB		SP	
	P	C	P	C
<i>Acarina</i>				
Prostigmata	—	12	—	60
Mesostigmata	26	11	51	60
Cryptostigmata	13	42	8	20
<i>Collembola</i>				
Entomobryidae	—	16	—	35
Hypogastruridae	6	7	—	10
Isotomidae	26	4	18	22
Sminthuridae	3	6	9	11
<i>Coleoptera</i>				
Ptiliidae	2	6	5	2
Staphylinidae	2	2	—	—
Coleoptera larvae (unidentified)	2	—	7	7
<i>Diptera</i>				
larvae	1	—	—	—
Milliped	3	4	2	2
Isopod	—	—	—	1
<i>Hymenoptera</i>				
Formicidae	—	1	3	6
Other unidentified	—	—	2	1
<i>Diplura</i>				
Camponidae	—	—	—	2
Protura	—	—	—	2

ing the diversity of fauna is obtained from table 1. Of the acarines Prostigmata were obtained only from control plots, being completely absent in polluted plots; of the collemboles, Entomobryidae was absent from polluted plots, but present in control plots; of the two Coleoptera families, Ptiliidae and Staphylinidae, the latter was completely absent from site 'SP' in both polluted and control. Diptera was represented by only one larva from polluted site, whereas millipeds were extracted from all the plots (from both polluted and control).

*Seasonal changes of fauna*: The total number of microarthropods in both the sites changes from month to month and from one site to another. In site 'DB' and 'SP' control plots showed its maximum in September and August and minimum in August and October respectively. Contrast to this both the polluted plots showed their peak population in November and lowest population in September and August in 'DB' and 'SP' sites respectively (fig. 1). The relative humidity content of surface soil ranged between 80.5% and 99.5% in control plots and 80.5% and 98.5% in polluted plots. Values of RH in all the plots are shown in table 2.

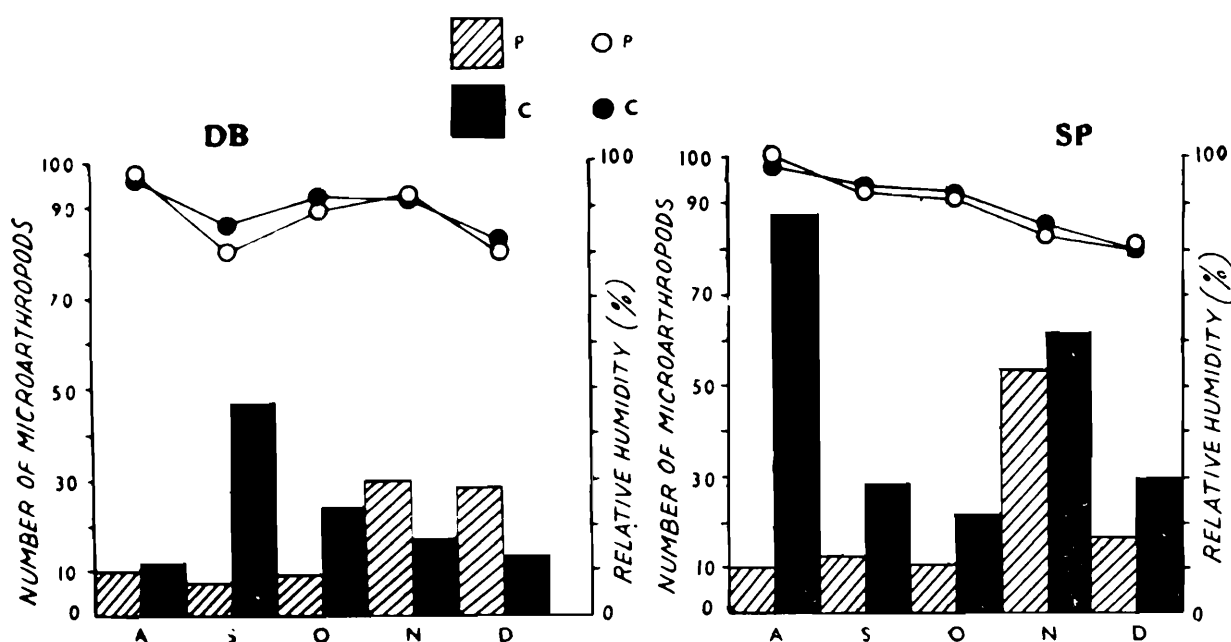


Fig. 1. Histogram illustrating the comparative microarthropod population at 'DB' site and 'SP' site, in relation to relative humidity (C = Control plot ; P = Polluted plots).

Table 2. Showing monthly total number of microarthropod population and RH values at Durgapur steel plant area.

Months	DB				SP			
	Total Microarthropods		Soil factor RH		Total Microarthropods		Soil factor RH	
	Polluted	Control	P	C	Polluted	Control	P	C
August '77	10	12	95.5%	97.2%	10	88	98.5%	99.5%
September '77	7	47	85.5%	81%	13	29	94.5%	93%
October '77	9	24	92%	89.5%	11	22	92.5%	91.75%
November '77	30	17	91.75%	92%	54	62	85.25%	83%
December '77	28	13	83.5%	80.5%	17	30	80.5%	81.5%
Total	84	113			105	231		

*Orderwise faunal change* : The number of animals extracted each month is shown in table 3. Figure 2 shows the monthly change in fauna of predominant groups in both polluted and control plots.

### DISCUSSION

The results of this study show significant differences between soil microarthropod population in control and polluted plots. The population densities recorded in this work appear remarkably lower in polluted plots than the control plots. The percentage of population is higher at 'SP' site (19.7%) than 'DB' site (15.9%) *i.e.*, density of population of microarthropods increases with the increase of distance from the discharge source of the effluents. This might be due to the toxicity of the effluents become lower as the site is away from the discharge source. Dindal *et*

Table 3. Number of microarthropods extracted in each month at Durgapur steel plant area.

	'DB' site						'SP' site						Total									
	Aug.	Sept.		Oct.		Nov.		Dec.		Aug.	Sept.			Oct.		Nov.		Dec.				
Microarthropods	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	P	C	Total	
Acarina	4	5	5	11	2	14	12	28	16	7	104	6	38	7	16	6	8	31	53	9	15	189
Collembola	3	5	2	6	6	8	15	11	9	3	68	4	41	5	6	3	12	9	7	6	12	105
Coleoptera (adult)	—	—	—	—	1	2	1	4	2	2	12	—	—	—	—	1	2	3	—	1	—	7
Coleoptera (larvae)	—	—	—	—	—	—	2	2	—	—	4	—	3	1	3	—	—	5	1	1	—	14
Diptera (larvae)	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—
Milliped	2	1	—	—	—	—	—	2	1	1	7	—	—	—	2	—	—	2	—	—	—	4
Isopod	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1
Hymenoptera	—	1	—	—	—	—	—	—	—	—	1	—	2	—	1	1	—	4	1	—	2	12
Protura	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	2
Diplura	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	2
Total	10	12	7	17	9	24	30	47	28	13		10	88	13	29	11	22	54	62	17	30	

P = Polluted

C = Control

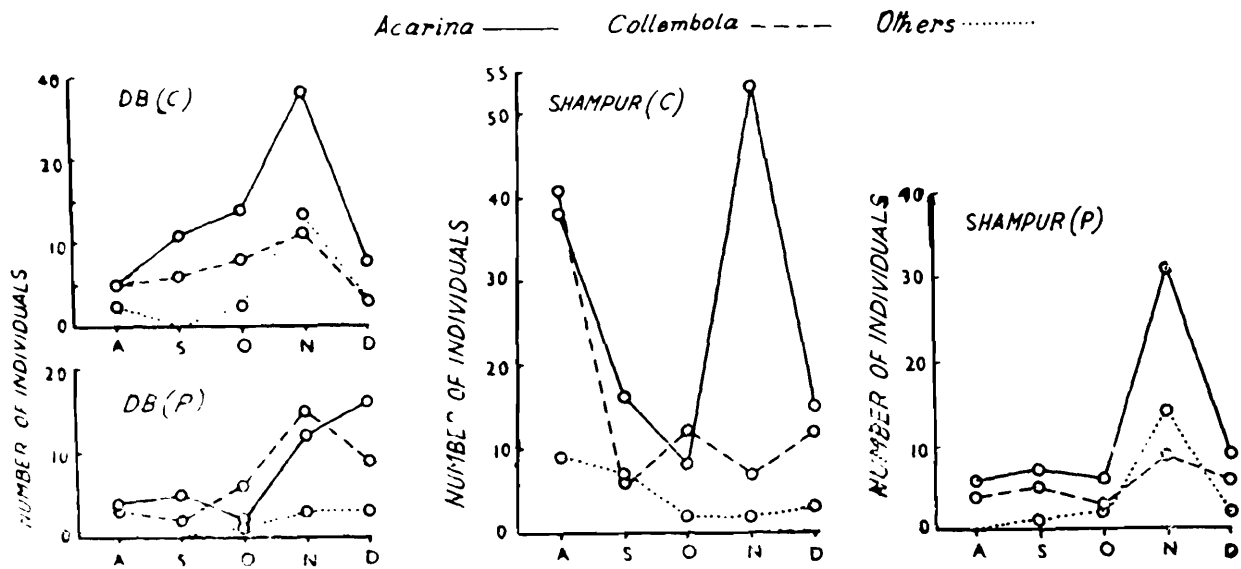


Fig. 2. Predominant microarthropod community characteristics in polluted (P) and control (C) plots at Durgapur steel plant area.

*al.*, (1973) reported from U.S.A. that sewage discharge decreased the microcommunity stability of Acari and Collembola which coincides with the present observations. From Fig. 2 an interesting observation could be seen in that the breeding season remains identical to the predominant microarthropods in both polluted and control sites *i.e.*, in the month of November except in 'SP' control site which showed its peak in the month of August.

The data on statistical analysis (Table 4 standard error of the mean is also shown) indicating the correlation coefficient values ( $r$ ) and regression values showed that in 'DB' site the microarthropods population in polluted plot is negatively correlated with the population of control plot, RH of polluted plot, and population of control plot with RH of control plot. But in 'SP' site there was a positive correlation among the above parameters except between population of polluted plot and relative humidity of polluted plot, which is negatively correlated. But the values were not sufficiently high to be significant as evident from the table 4.

#### ACKNOWLEDGEMENT

We are grateful to Director, Zoological Survey of India for his keen interest and constant inspiration and for laboratory facilities for this project. We wish to express our sincere thanks to Prof. D.K. Choudhuri, Head, Department of Zoology, University of Burdwan, for the constructive criticism and suggestions.

Table 4. Showing standard error of the mean, correlation coefficient (r) values and regression values of soil factor and microarthropod population at 'DB' and 'SP' sites.

<i>Site-DB</i>			
<i>Population</i>	<i>Mean</i>		<i>S.E.</i>
Polluted	16.80	±	5.0151
Control	22.60	±	6.4538
<i>RH</i>			
Polluted	89.65	±	2.2272
Control	88.04	±	3.2260
<i>Site-Shampur</i>			
<i>Population</i>			
Polluted	21.00	±	8.5368
Control	46.20	±	12.5323
<i>RH</i>			
Polluted	90.25	±	3.2501
Control	89.75	±	3.3411
<i>DB Site</i>	<i>'r' value</i>	<i>Regression value</i>	
Population of polluted with	-0.5548	Y = 26.54	— .43X
Population of control			
Population of polluted with	-0.2624	Y = 69.76	— .59X
RH of polluted			
Population of control with	-0.5203	Y = 114.16	— 1.04X
RH at control			
<i>Shampur site</i>			
Population of polluted with	0.2422	Y = 13.61	— .16X
Population of control			
Population of polluted with	-0.5043	Y = 137.42	— 1.29X
RH at polluted			
Population of control with	0.3944	Y = 86.63	+ 1.48X
RH at control			

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## OBSERVATIONS ON THE POPULATION FLUCTUATIONS OF TWO SPECIES OF GALL THIRPS (TUBULIFERA THYSANOPTERA)

By

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Information relating to population fluctuations of thrips inhabiting leaf galls is meagre and during the present investigation an attempt has been made to study the population fluctuations of two species of thrips viz. *Mesothrips jordani* Zimm. and *Gynaikothrips bengalensis* Anan. inhabiting leaf galls of *Ficus benjamina*.

During the period of study, regular samples of 25 leaf galls were collected and care was taken to collect galls of almost the same age.

Both the species of Tubulifera were present throughout the period of observation and it has been found that the total population of *Mesothrips jordani* is larger than that of *Gynaikothrips bengalensis* (fig. 1). The

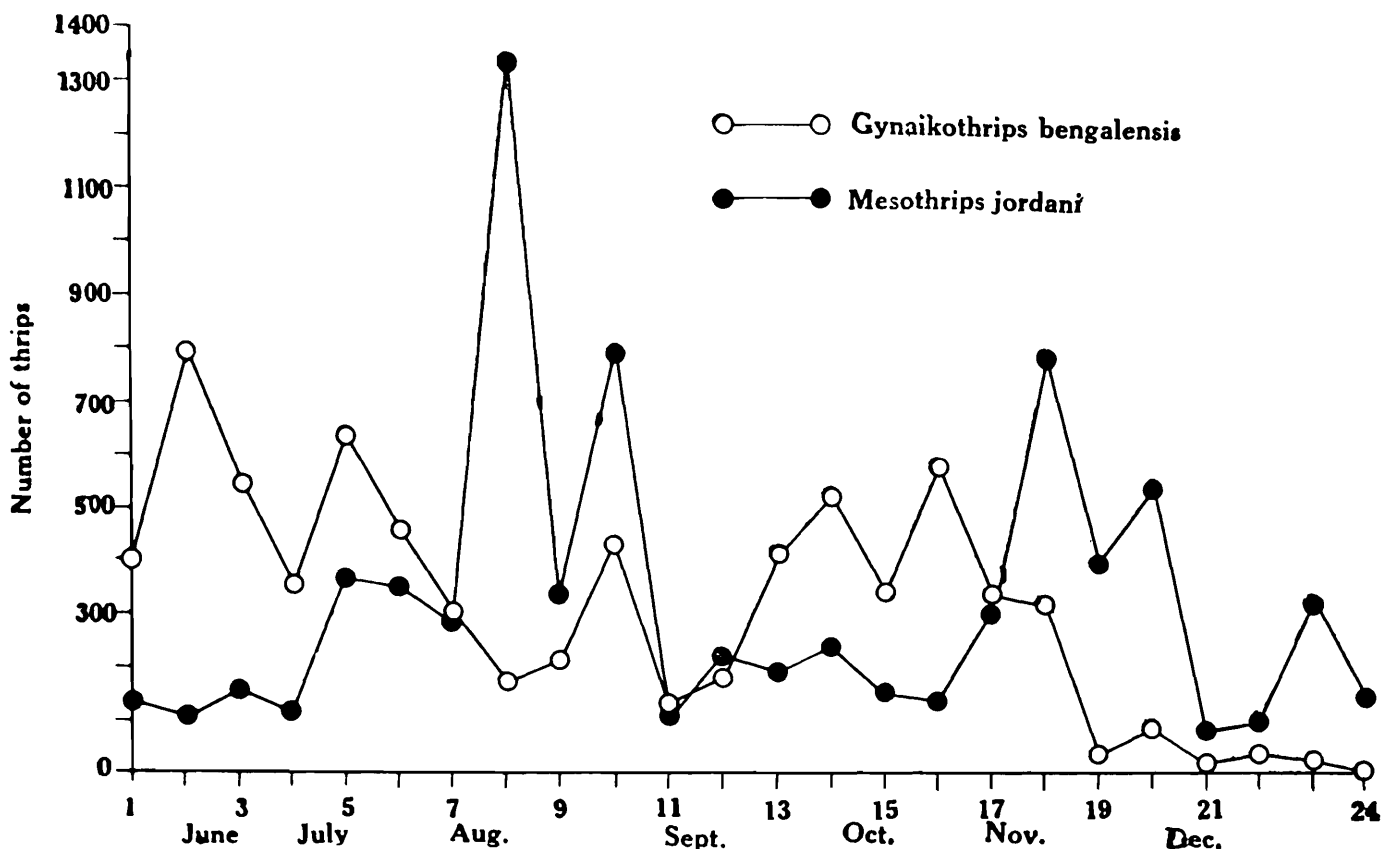


Fig. 1. Population fluctuations of *Mesothrips jordani* and *Gynaikothrips bengalensis* during 1977-78

population of *Mesothrips jordani* reached the peak during the months of August to September and the population of *Gynaikothrips bengalensis* had the maximum abundance during June-July and during this period *Mesothrips jordani* population considerably decreased. However, during the colder months of December and January there has been a sudden decrease in both the populations, indicating a negative preference of the two species for low temperature. The populations of thrips in general are controlled by abiotic factors like temperature and humidity and the present case is also no exception to this. During the period of rainfall also the temperature had been generally high and the two populations maintained a steady level during this period. With the onset of winter, characterised by low temperature and high humidity, the populations specially that of *Gynaikothrips bengalensis* showed a definite downward trend.

Davidson and Andrewartha (1948a, b) had shown that temperature, humidity and rainfall are the main factors influencing the population of thrips. Statistical analysis of the populations of *Gynaikothrips bengalensis* and *Mesothrips jordani* (Table 1.) indicate that they are negatively correlated. The relationship of the population of *Gynaikothrips bengalensis* with physical factors like temperature and humidity (maximum & minimum) have also been analysed. It is of interest of note that population of this species maintained a positive, highly significant correlation with temperature (fig. 2) and a significant correlation with minimum humidity (fig. 3). However, the population does not show a significant correlation with maximum humidity. Statistical analysis on the population fluctua-

Table 1.

	Correlation coefficient between thrips popula- tions and different factors	Regression line of number of thrips (Y) and different factors (X) $Y = a + bx$
Population of <i>Gynaikothrips bengalensis</i> X Population of <i>Mesothrips jordani</i>	-.0941	$Y = 320.89 - .07 X$
<i>Gynaikothrips bengalensis</i> X temperature	0.6948**	$Y = -664.96 + 36.73 X$
<i>Gynaikothrips bengalensis</i> X Rh. (Max.)	0.3116	$Y = -1801.54 + 21.76 X$
<i>Gynaikothrips bengalensis</i> X Rh.(Min.)	0.4741*	$Y = -45.77 + 6.30 X$
<i>Mesothrips jordani</i> X temperature	0.0563	$Y = 211.68 + 3.91 X$
<i>Mesothrips jordani</i> X Rh. (Max.)	-.2254	$Y = 2309.79 - 20.68 X$
<i>Mesothrips jordani</i> X Rh. (Min )	0.0261	$Y = 289.40 + .46 X$

N.B. \*\*Significant at 1% level

\*Significant at 5% level

tions of *Mesothrips jordani* reveals its positive correlation with temperature and minimum humidity and negative correlation with maximum humidity. The absence of any significant correlation with physical factors in the case of *Mesothrips jordani* probably indicate that the fluctuations of this species are mostly due to biological factors.

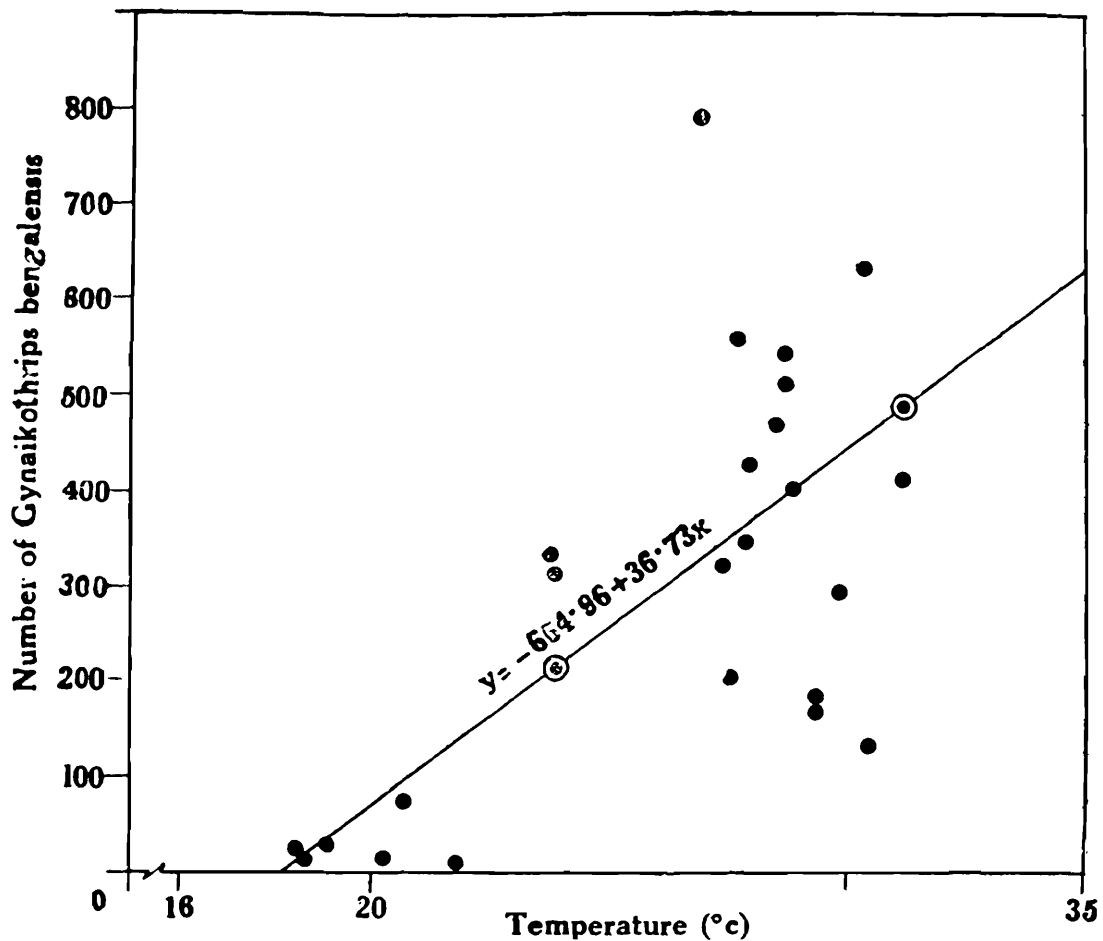


Fig. 2. The relationship between the population density of *Gynaikothrips bengalensis* and temperature

It may be pointed out that there are no major predators with the exception of an accidental anthocorid *Montandoniola moraguesi* (Puton) or an occasional spider and their effect seems to be very negligible. In the present case in addition to the abiotic factors, the competition between the two species inhabiting the same gall and feeding on the same plant sap must have been another important biotic factor, determining the size of the natural populations of the two species.

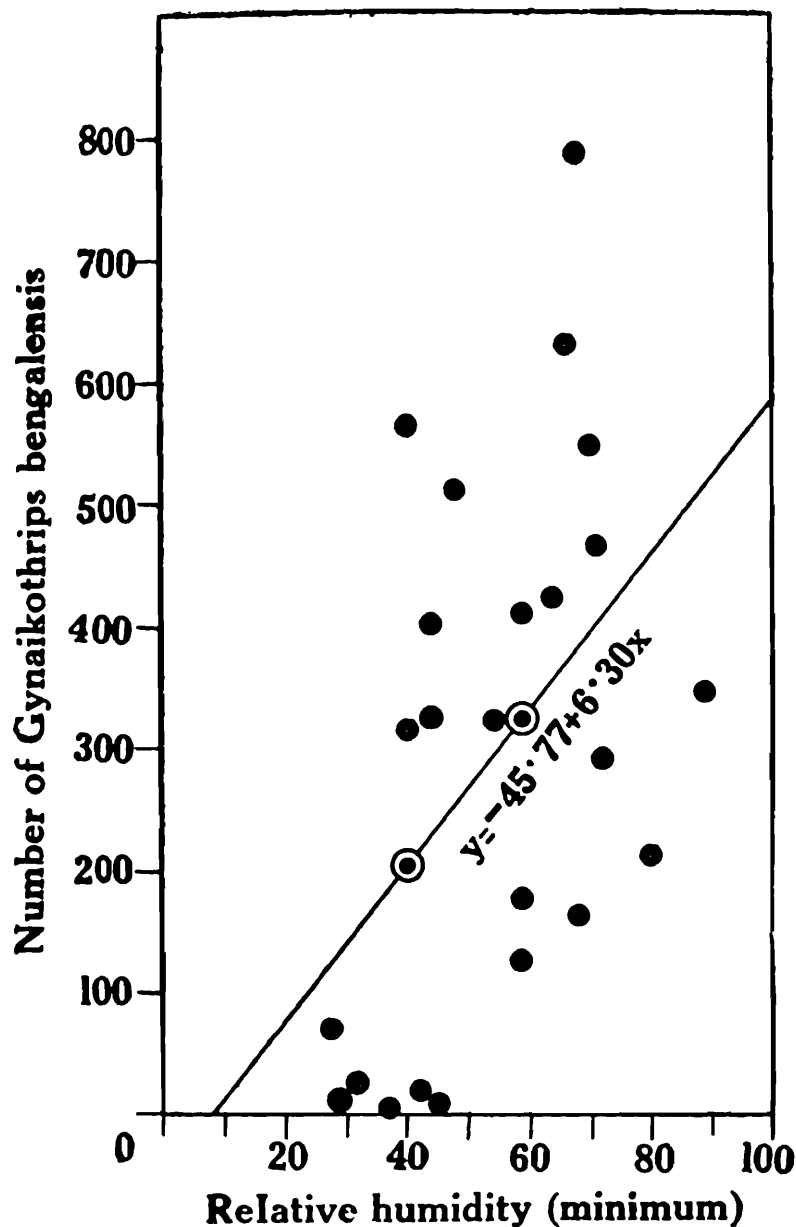


Fig. 3. The relationship between humidity (Minimum) and population density of *Gynaikothrips bengalensis*

#### ACKNOWLEDGEMENT

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STUDIES ON THE FLUCTUATION OF POPULATION  
DENSITY OF *MACROSIPHONIELLA SANBORNI*  
(GILLETTE) (HOMOPTERA APHIDIDAE)  
INFESTING CHRYSANTHEMUM

By

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INTRODUCTION

*Macrosiphoniella sanborni* (Gillette) is of common occurrence on different types of chrysanthemum plants. These ornamental plants are grown in plains as well as in altitudes. These are generally cultivated during the winter season and the flowering time is January-February. The plant can also survive during the other seasons of the year specially in altitudes. With the wide range of distribution of host plants the species seems to be cosmopolitan in distribution and leads anholocyclic life cycle in the Indian sub-region.

The primary intention of such investigation is to record the actual period of occurrence of *Macrosiphoniella sanborni* (Gillette) and to make an idea about the peak period of activity under the natural environmental conditions and also to observe the fluctuation of population density with regard to the change of climatic factors.

During the course of investigation, a second species *viz.*, *Capitophorus mitegoni* Eastop was observed to infest the same host plant in association with the main species. Both the species maintained a gradual succession with regard to the population density depending on the natural environmental condition.

MATERIAL AND METHOD

Ten healthy potted plants of chrysanthemum prepared from the cuttings were isolated from the other plants of the garden for the present investigation. All these plants were kept in the natural environmental condition. Each of the plant was seen with mild infestation of the aphid species *Macrosiphoniella sanborni* (Gillette) chiefly on the very apical twigs encircled by some leaf buds. Weekly field observations were made so as to record the trend of the population increase under natural field condition and the physiological conditions of the plants. Together with the aphid population the site of infestation was also noticed. Field conditions with regard to the minimum and maximum temperature, relative humidity,

rain fall etc. were recorded accordingly. All the morphs viz., apterae, alatae and nymphs available in the colonies were taken into consideration.

#### OBSERVATION

The investigation was initiated since 3rd week of November 1977. The observational data were recorded upto the end of September 1978. All the experimental plants were kept isolated under the natural conditions of the field and were seen with the minimum infestation by *Macrosiphoniella sanborni* (Gillette.) The minimum and maximum temperatures recorded in the field at that time were 21.3° C and 28° C respectively with the relative humidity of about 96% as maximum and 66% as minimum. At the very beginning the aphids prefer tender twigs and the surrounding leaf buds; then with the gradual maturity of the plants, they started colonizing on the young shoots and leaves. With the gradual fall of atmospheric temperature the density of aphid population increased with more extensive infestation on senile shoot system of the plants. The period of optimum infestation of the species concerned could be observed between first week of January and that of February with the temperature ranging between 10.5-16.9° C at minimum and 22-30.6° C at maximum and the relative humidity 22%-39% at minimum and 93%-100% at maximum. The period of maximum infestation was recorded during second week of January when the atmospheric temperature was the lowest (10.5° C) for the season. The phase of infestation was observed to be lowered momentarily upto 3rd week of January and they augmented further towards the end of the said month though the seasonal climatological factors remain the same during the peak end of the season.

With the advent of spring the population density was found to decline and reached at a very negligible point when the infestation became totally nil during the end of March. The period of non-infestation continued throughout the summer and monsoon when the minimum temperature varied between 19.6° C and 27° C and the maximum between 31° C and 36.6° C with the relative humidity as 27%-66% as the minimum and 89%-99% as the maximum. With the end of monsoon the infestation reappeared to a mild extent with the tendency of forming minor colonies particularly during the 3rd week of September when the atmospheric temperature lowered down at 24.4° C.

Incidentally during the 3rd week of December a few specimens of another species *Capitophorus mitegoni* Eastop was seen in association with the present species. Gradually this second species tried to establish colony in an increasing number until reached the peak period of activity and virtually out numbered the species under study during the last week of January when the minimum temperature recorded at 12.7° C and the

maximum at 26.3° C with the relative humidity 32% as minimum and 96% as maximum. Like the main species this species also attended a second peak in the second week of February at a slightly higher atmospheric temperature and more or less within the same range of atmospheric humidity. Subsequently it also followed the declining trend its existence fell drastically during the last week of March when the atmospheric temperature was rather high.

It has been noted that the aphids preferred ventral surface of leaves. Initially the infestation started on the tender twigs later with the maturity of the plants population shows random dispersal to the older shoots. During the entire course of investigation each colony was dominated for all the time by the apterae and nymphs. the alates are of lesser occurrence within the colonies. During later stage when the physiological condition of the plant was deteriorating a greater number of alatae were observed probably with a view of effecting dispersal to the suitable environment for the perpetuation of the generation.

A few coccinellid beetles of *Menochilus sexmaculata* (Fabr.) seem to act as predator on aphids. Small reddish ants *Tetramorium* sp. were seen in association with the aphid colony.

#### DISCUSSION

In view it can be summarised that just after the monsoon the species *Macrosiphoniella sanborni* (Gillette) starts infesting the chrysanthemum plants in the Indoganetics Plain. The establishment of the species reaches the peak period of infestation during the coldest season of the year and then show a gradual declining trend with the increased trend of activity of the second species viz., *Capitophorus mitegoni* Eastop which maintained the peak period of activity and outnumbered the former species during the last week of January under little higher field temperature. Here atmospheric temperature plays the vital role for the establishment and increase of population density though the humidity acts as the supporting factor. Nayak and Behura (1969) while making observation on the biology of this monophagous species in Orissa noted the polyphagous species *Aphis gossypii* Glover in association with *Macrosiphoniella sanborni* (Gillette) and they did not record any ant association in the colony. It is note worthy in the present investigation that *Capitophorus mitegoni* Eastop whose usual host plant is Polygonaceae was found colonizing on chrysanthemum with *Macrosiphoniella sanborni* (Gillette) and both the species were attended by ants. However, succession of two species viz., *Aphis gossypii* Glover and *Macrosiphoniella sanborni* (Gillette) observed by Nayak and Behura holds good with *Capitophorus mitegoni* Eastop and *M. sanborni* (Gillette) noticed in the present investigation.

## ACKNOWLEDGEMENT

Authors are indebted to the Director, Zoological Survey of India for his kind interest and encouragement for the study and providing all necessary facilities.

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## ON THE SEASONAL RELATIVE ABUNDANCE OF INSECT CONSUMER POPULATION IN A PINE (*PINUS KESIYA* ROYLE) FOREST ECOSYSTEM OF NORTH EASTERN INDIA

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### INTRODUCTION

Khasi pine (*Pinus kesiya* Royle) is an important timber species that occurs both naturally and in plantations through much of Meghalaya, North Eastern India. An holistic understanding of the ecological principles governing the primary and secondary production is necessary to establish and improve the stands of this principal tree and to develop sound management strategies for insects which either threaten (Mattson and Addy, 1975) or ameliorate the vigour and stability of these ecosystems. One of the useful approaches to this understanding is to analyse the insect subcomponent as it constitutes a major bulk in the total consumer component of the forest ecosystem (Keen, 1952 ; Mattson and Addy, 1975). As primary consumers they link the food chains and divert the energy produced by the plants into animal system (Strand and Nagel, 1972) and vice versa. Mattson and Addy (1975) reported that normal insect grazing (5 to 30 percent of annual foliage crops) usually never impairs the annual plant production, on the other hand it accelerates the tree growth. They are one of the best regulator groups of the forest primary production. While reducing the primary production they accelerate the tree growth bringing excess grown plant material to the process of nutrient cycling, in the form of frass and faeces. Despite these above mentioned suggestions that these insects are important in the functioning of these forest ecosystems, few population studies have been made on the entire insect subcomponent (holistic approach) of a particular ecosystem, primarily due to methodological limitations.

The present paper reports on the relative abundance of the photo-tactic insect consumer populations in relation to various abiotic factors from February 1976 to February 1977.

### STUDY AREA

The study has been carried out in Raitkhan Forest Area (Old

Shillong-Gauhati Road) about six kms. from Shillong (91°66' E and 25°34' N) Meghalaya State (N.E. India), at an altitude of 1150 m. The Chief experimental site is a pine (*Pinus Kesiya* Royle) plantation of 23 years old, planted on the crown of a hill. This site is of 20 ha. (approximately 50 acres) and surrounded by pine plantations of different ages. The present investigation was performed in the central part of the chief Experimental site. The undergrowth in the experimental site consists of different herbs, such as *Anaphalis* sp., *Gnephaliium lutoalbum*, *Eupatorium adenopharum*, *Artemisia yulgarius*, *Oxalis corionbosa*, *Digitaria* sp. and *Panicum* sp. The forest fire is a very common feature of this experimental site. During summer months (March, April and May) every year, the undergrowth gets completely burnt. When rains begin, it gets fresh leaves. Fire has never effected the crown of the plantation structurally.

#### MATERIALS AND METHODS

The insect light-trapping method described by Reddy and Alfred (1978) was used in this study. Catches were sorted at the laboratory and deposited at NEHU, Zoology Museum. Many of the smaller insects specially Lepidoptera which were caught in large numbers were not identified to species.

#### RESULTS

During the present study all insects, as collected by light trap may not be the resident consumers of the ecosystem. Some of them may be the occasional visitors to the ecosystem. All insects were grouped into fourteen orders, such as Lepidoptera, Diptera, Coleoptera, Hymenoptera, Hemiptera, Heteroptera, Orthoptera, Dictyoptera, Trichoptera, Neuroptera, Arachnida, Dermaptera, Isoptera and Odonata. Among all these insect taxa Lepidoptera was most dominant and Odonata was most decendent. A perusal of fig. 1 reveals that the total insect was maximum in the month of May representing 3069 individuals, 27.97% of the total annual insect catch (10971 numbers) and minimum in the month of January reckoning 15 numbers, 0.14 per cent of the total annual catch. The monthly abundance of different insect orders is presented in fig. 2 which displays that Lepidoptera was the most abundant insect group. The total annual Lepidoptera catch was numbered 3823 inds, representing 34.81 per cent of the total annual insect catch. This group was caught maximum in the month of May numbering 1469 individuals, 38.41 per cent and gradually receded to a minimum in the month of January numbering only 3 individuals, 0.07 per cent of the total annual Lepidoptera collection. The order Lepidoptera was followed by Diptera in abundance. Diptera was represented by an annual collection of 3773 individuals, constituting

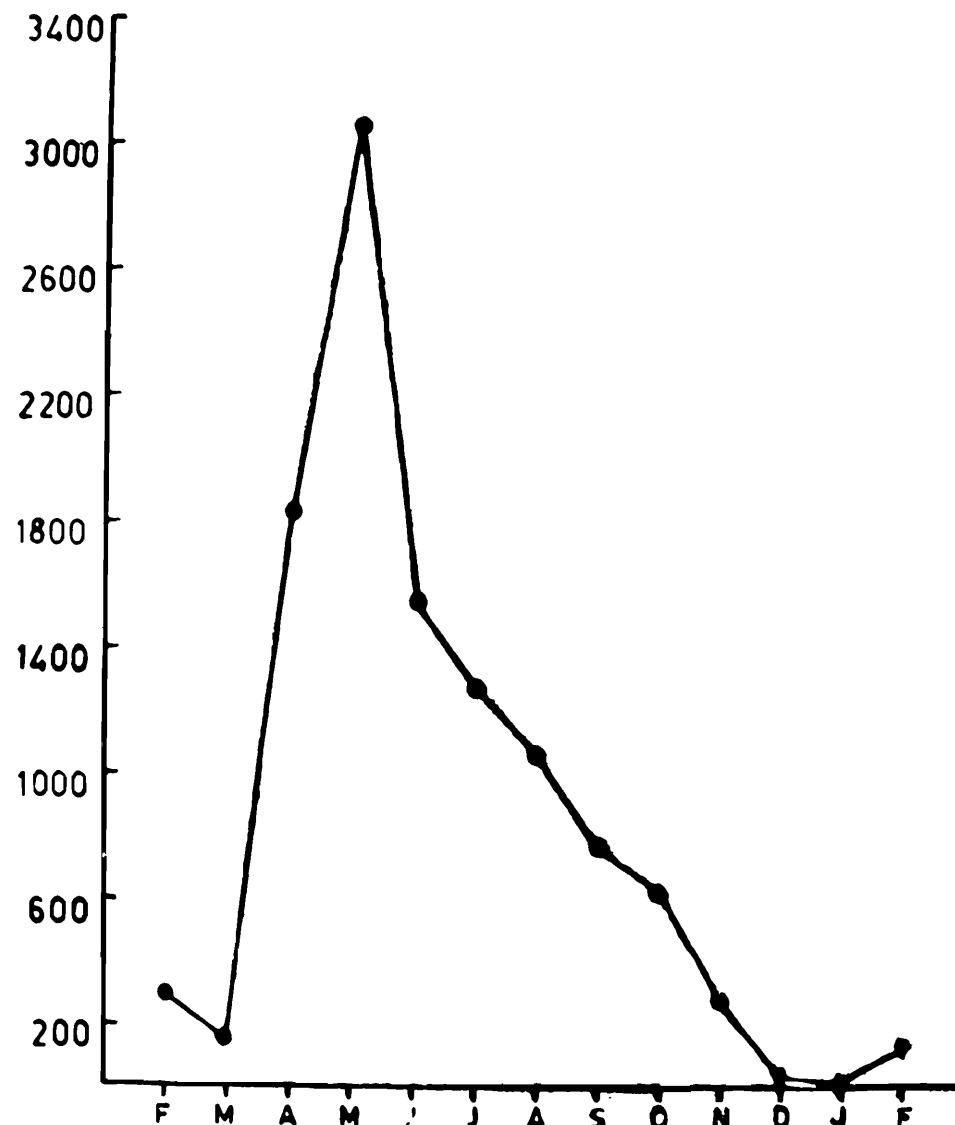


Fig. 1. Seasonal relative abundance of total insects in the Pine (*Pinus kesiya* Royle) forest ecosystem of Meghalaya, N.E. India.

34.39 per cent of the total annual insect collection. The order Diptera was also caught maximum in the month of May representing 926 individuals, 24.5 per cent and gradually decreased to minimum in the month of January representing only 4 individuals, 0.1 per cent of the total annual diptera collection. Lepidoptera and Diptera constituted more than half (69.2 per cent) of the total insect catch. Heteroptera was the third most abundant group representing a total collection of 698 numbers, 6.36 per cent of the total insect collection. This group suddenly increased from 6 individuals (0.85 per cent) to 444 numbers (63.61 per cent) in the month of April and gradually decreased to minimum in the month of January representing only one individual, 0.14 per cent of the total annual Heteropteran collection. The next in order of abundance is Hymenoptera representing a total annual catch of 592 individuals, 5.4 per cent of the total annual insect collection. This order was

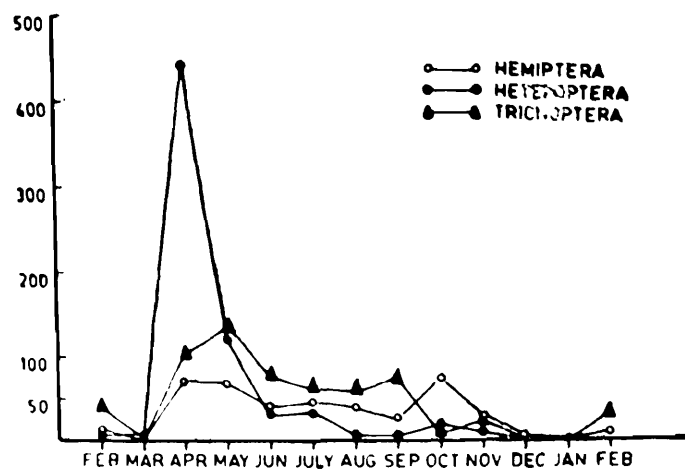
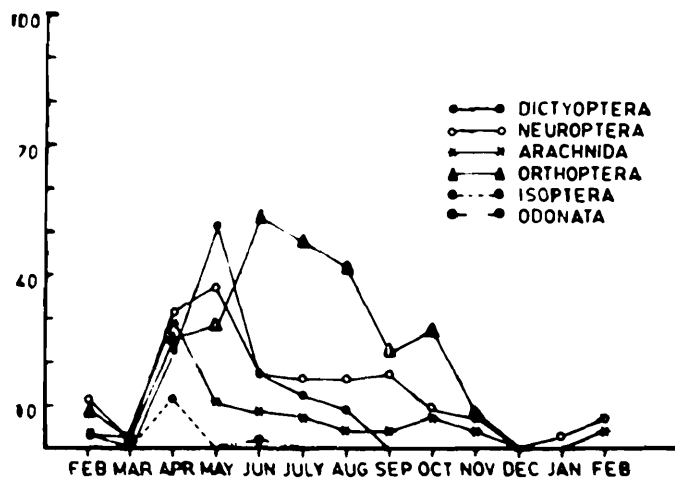
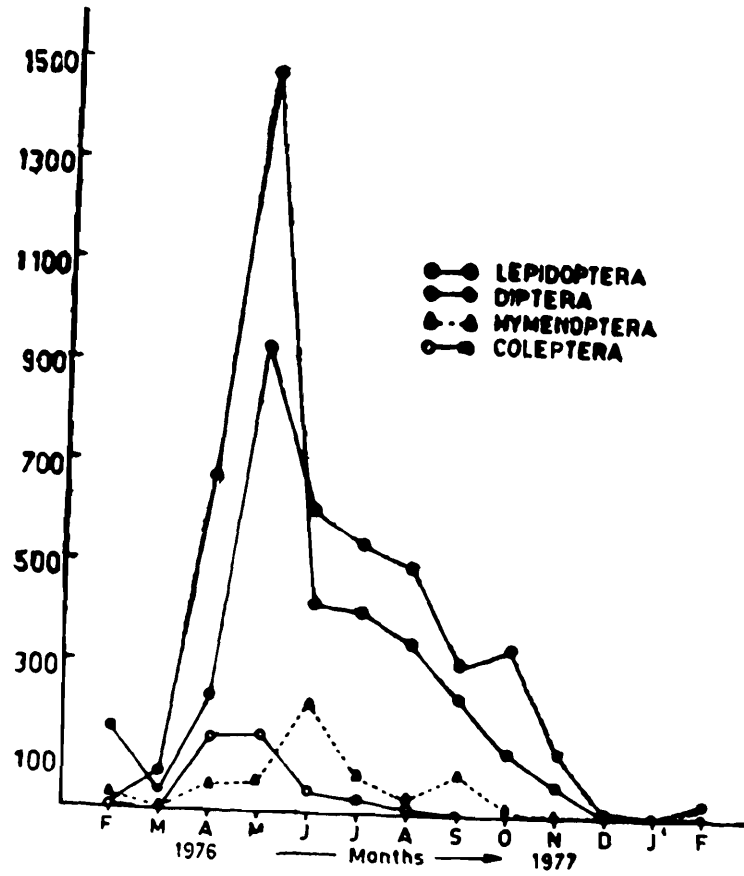


Fig. 2. Seasonal relative abundance of different insect orders in the pine (*Pinus kesiya* Royle) forest ecosystem of Meghalaya, N.E. India.

maximum in the month of June representing 225 numbers, 38 percent and gradually decreased to minimum in the month of January numbering only 3 numbers, 0.33 per cent of the total annual Hymenopteran collection, with a small increase in the month of September. The order Trichoptera represented 589 numbers, 5.37 percent of the total annual insect catch, These insects were recorded minimum in the month of March representing only 3 numbers, 0.5 per cent and increased to maximum in the month of May numbering 136 numbers, 23.08 percent of the total annual Trichopteran collection. The population was in a state of fluctuation through out the annum being completely absent during December and January. The next order of abundance was Coleoptera followed by Hemiptera, representing 426 numbers (3.88 per cent) and 420 numbers (3.82 per cent) of the total annual insect catch respectively. The order Coleoptera was caught maximum in the month of May representing 153 numbers, 35.91 per cent and gradually decreased to minimum in the month of November numbering 5 inds., 1.17 per cent of the total annual Coleopteran collection. These insects were completely absent during December, January and March. The order Hemiptera showed two peaks of abundances of more or less similar size during the annual cycle, one in the month of April and the other in the month of October, representing 70 numbers, 16.66 per cent and 75 numbers, 17.85 per cent of the total Hemipteran catch respectively. The minimum Hemipteran catch was recorded in the month of January and March, each time representing only one number 0.23, per cent. The Hemipteran abundance was seen fluctuating throughout the year. The order Orthoptera was represented by 273 numbers, 2.5 per cent of the total annual insect catch. These insects were caught maximum in the month of June representing 53 numbers, 19.41 per cent and gradually decreased to minimum in the month of December representing only one individual, 0.36 per cent of the total Orthopteran catch. The order Neuroptera represented a total annual catch of 166 numbers, 1.51 per cent of the total annual insect catch. This order was recorded minimum in the month of March and January, each time representing only two individuals, 1.2 per cent and increased to maximum in the month of May representing 37 numbers, 22.28 per cent of the total Neuropteran collection. This order was completely absent in the collection during December. The order Dictyoptera was represented by a total annual collection of 114 numbers, representing 1.04 per cent of the total annual insect catch. This order was recorded in March and from April to August only, being minimum in number in the month of February representing 3 numbers, 2.63 per cent and maximum in May numbering 51 numbers, 44.73 per cent of the total Dictyopteran catch. The order Arachnida was represented by a total annual catch of 80 numbers, repre-

senting 0.63 per cent of the total insect catch. The abundance was fluctuating throughout the year ranging from 1 number (1.25 per cent) to 29 numbers (36.25 per cent), the former being recorded in the month of December and the latter in April. They were completely absent in January. The order Isoptera was represented by a total annual collection of 11 numbers, 0.1 per cent of the total annual insect collection, only in the month of April. The order Dermaptera was represented by 3 number, 0.03 per cent of the total annual insect catch and was confined to April May and November. The order Odonata was represented by 2 numbers, 0.02 per cent of the total insect catch and recorded only in the month of June.

Climatological records were obtained from the Meteorological Survey of India, Shillong and presented in Fig. 3, a perusal of which reveals that the rainfall was 92.5 mm in the month of April but suddenly increased to 334.7 mm in May, reached the maximum in June with 720 mm and gradually decreased to minimum in the month of December representing only 2.2 mm. It was completely absent in January. The maximum temperature ranged from  $14.6 \pm 0.13^\circ\text{C}$  to  $23.89 \pm 0.63^\circ\text{C}$ , the minimum

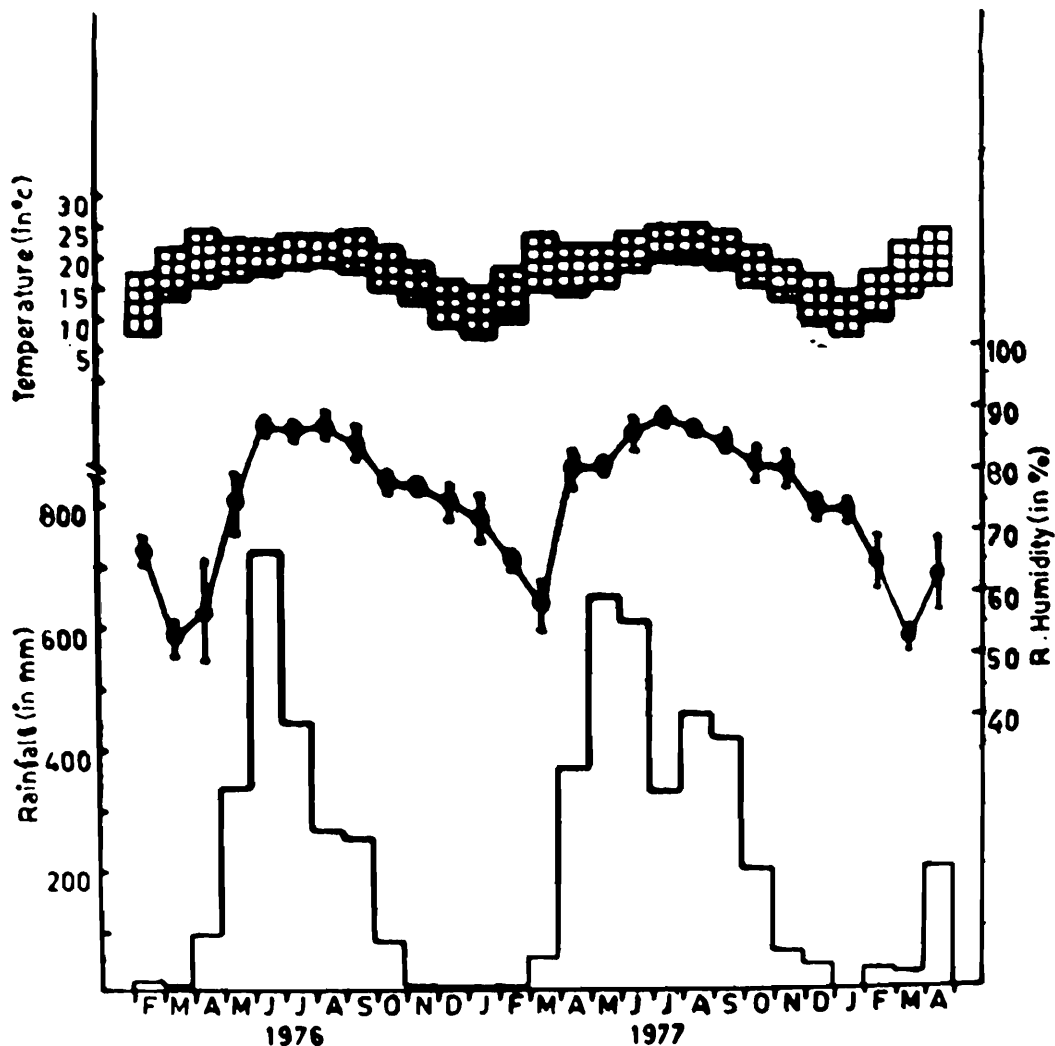


Fig. 3. Monthly climatic data during 1976-1978.

being recorded in the month of January and maximum in September respectively. The minimum temperature range was  $6.98 \pm 0.22^\circ\text{C}$  to  $18.43 \pm 0.28^\circ\text{C}$ , the former being recorded in the month of January and the latter in August. The relative humidity of the air ranged from  $53.25 \pm 2.57$  to  $87.42 \pm 1.55$  per cent, the former being recorded in the month of March and latter in August. The wind velocity was recorded at the experimental site which ranged from 0.6 to  $8.81 \text{ m S}^{-1}$ , The maximum wind velocity was recorded in the month of March and minimum in May. The wind velocity and relative humidity reading were fluctuating throughout the year.

#### DISCUSSION

The present study is a synecological study during which 14 orders of insects such as Lepidoptera, Diptera, Heteroptera, Trichoptera, Coleoptera, Hemiptera, Orthoptera, Neuroptera, Dictyoptera, Arachnida, Isoptera, Dermaptera and Odonata were caught. This catch is supported by other such investigations such as Owen (1969) who reported the positive photosensitiveness of sixteen orders such as Lepidoptera, Diptera, Hymenoptera, Ephemeroptera, Neuroptera, Orthoptera, Hemiptera, Coleoptera, Trichoptera, Thysanoptera and Siphonoptera, Milne and Milne (1944) were also recorded a collection of 11 orders in their light traps. They were Lepidoptera, Diptera, Hymenoptera, Coleoptera, Homoptera, Heteroptera, Trichoptera, Corrodentia, Neuroptera, Plecoptera and Mecoptera. All these Insects and their orders fluctuated in their seasonal abundance due to seasonal changes in their abiotic environment (Cantelo, 1974; Van Ark, 1975). From climatological data it is clear that the Shillong plateau has distinct wet and dry seasons but monthly rainfall differs from year to year. During the present study, Insects of different orders increased suddenly in the month of April, and May and June to maximum numbers with the sudden increase in rainfall. The relative monthly abundance of insects and rainfall showed a positive significant correlation (Table-1). This sudden increase in precipitation encouraging an increase in abundance and/or activity of flying insects, is in support of the observations of Frith (1975), because the amount of rainfall influences the rate of emergence of moths from pupae. Cantelo *et al.*, (1973) reported that the populations of many species of insects were affected by pattern of rainfall. The largest populations of most species of insects followed the period of rainfall or immediate after rain season (Owen, 1969; Janzen, 1973). Rainfall stimulates the plant growth which in turn provides food for insect development thus increasing their abundance. Yearly rainfall increasing from below average to above average increase the population of most species of insects, unless suppres-

Table I. Coefficient correlation (r) between the total insect abundance and individual environmental factors.

Different environmental factors	Coefficient correlation (r)	Level of significance
Maximum Temperature	+ 0.6530	P < 0.05
Minimum Temperature	+ 0.6168	P < 0.05
Total Rainfall	+ 0.5885	P < 0.05
Relative Humidity	+ 0.6095	P < 0.05
Wind Velocity	+ 0.1294	Not significant.

sed by other factors such as trapping (Cantelo, 1974). Further, he stated that the decrease of most of the insect species occurred despite steady increase in the annual rainfall. During the present study the rainfall reached the maximum in the month of June and was in an increased state in July and August despite the decrease in insect abundance from the month of June. The minimum number of insects captured during winter season when the weather was dry conforms the observations of Deay *et al.*, (1964) who recorded less number of months in extremely dry weathers. Thus rainfall is an "operationally significant" factor for insect abundance.

Studies on the relationship between temperature, humidity and wind velocity with insect abundance in nature are very scanty. During the present study it has been seen that the insect abundance started increasing when the temperature also increased from the Month of April and were recorded maximum in April, May and June when the temperature was high. Analysing the relationship between insect catch and temperature (maximum and minimum) it has been seen that the correlation coefficient was positively significant (Table-1). This strongly indicates that temperature (maximum 20 to 25°C and minimum 15 to 20°C) was a requirement for the production of large insect populations in pine forest ecosystems of North Eastern India. This observation is in support of Van Ark (1975) who reported that the maximum temperature did influence the insect activity. Kline and Axtell (1976) found a positive correlation between the temperature and abundance of Dipteran species in light traps and reported that most of the gnats were trapped during periods when the average weekly temperature was 17 to 21°C and 21 to 26°C. Broersma *et al.*, (1976) working with the flight activity of European corn borer in relation to temperature reported that more than 80 per cent of moths flew immediately in the temperature range of 20 to 30°C which confirms the suitability of this range of temperature for moth activity. It supports the inference of the present study. In contrast, Yates and Ebel (1970) reported that the number of *Laspeyresia* sp. captured has no relation with maximum and minimum temperature. Gentry and Davis (1973) did not find any

significant relationship with temperature and moth catch ( $r=0.096$  with mean night temperature and  $r=-0.168$  with maximum temperature of the day preceeding).

A persual of Table-1 reveals that the fairly high levels of humidity has a significant correlation with insect abundance. The humidity increased to  $75.85\pm 5.64$  per cent in the month of May, from  $85\pm 8.22$  per cent and remained above 70 per cent upto January. The sudden increase in insect abundance in the month of May may have been affected by humidity. But the same humidity record in winter months with the decrease in insect abundance to minimum is unexplainable with the present data. The increase in insect abundance with increasing humidity is in favour of the reports by Rudolfs (1923) ; Platt *et al.*, (1958) and Dow and Gerrish (1970), which stated that the fairly high levels of relative humidity increased the mosquito activity. In contrast, Gentry and Davis, (1973) reported that the catches of cabbage loopers significantly decreased in the nights when the humidity is highest.

Wind velocity which seemed to influence the other factors such as temperature, was observed reducing insect catches. Statistical analysis between the insect catch and wind velocity of the night showed little significance (Table-1). Even very light winds produce a major effect, is not seen during the present investigation and is not generally appreciated (Bidlingmayer, 1974). Further, he reported that wind velocity reduces the size of the trap collection. Cook (1961) stated that a wind velocity of 10 miles per hour is sufficient to reduce the night's catch to nearly zero. Hanna (1969) obtained highly significant negative correlations between the wind velocity and the coleopteran catch. In contrast, Stirrett (1938) stated that the flight of the European Corn Borer was not affected by winds with velocity upto 17 miles per hour. Hanna (1973) reported that wind velocity was insignificant for coleopteran catch in light trap. He recorded high catches of coleopterans with high wind velocities. Glick and Hollingsworth (1954) reported that with favourable temperatures few moths (bollworm) were captured when the wind velocity was 10 mph or more, but at 6 mph many were captured.

Thus from the above study it is understandable that rainfall and temperature were operationally more significant than the relative humidity and wind velocity, in triggering the insect activity in pine forest ecosystem of North Eastern India.

#### ACKNOWLEDGEMENT

The authors are grateful to Prof; Dr. R.G. Micheal and Prof. Dr. P.S. Ramakrishnan, Head of the Department of Zoology and Botany respectively, for providing laboratory and field facilities. We are also

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SEASONAL CHANGES IN THE DENSITY OF SOIL  
ORIBATID MITES IN RELATION TO TEMPER-  
ATURE AND WATER CONTENT OF SOIL  
AT SAGAR ISLAND, 24-PARGANAS,  
WEST BENGAL

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INTRODUCTION

The important role played by soil animals in the complicated process of decomposition and soil formation has recently been recognised by soil biologists, resulting in publication of numerous papers on soil animal ecology. But until recently very little attention has been paid to the ecology of soil oribatid fauna in relation to physico-chemical parameters of soil in India.

The role played by soil temperature and water content on the population density and distribution of soil oribatid mites was investigated by workers like Choudhuri and Banerjee (1975), Singh and Mukherjee (1975), Singh, J. and Singh, A.K. (1975), Singh, J. and Singh, U.R. (1975), Singh, J. and Singh (1975), Bhattacharya and Raychaudhuri (1977) and Joy and Bhattacharya (1977). On the other hand, no ecological investigation on soil oribatid fauna has hitherto been undertaken at Sagar Island, 24-Parganas, West Bengal. In the present investigation an attempt was made to ascertain the influence of soil temperature and water content on the seasonal changes of population density of soil oribatid mites at Sagar Island.

SITES AND METHOD OF STUDY

The site studied is situated on the north-east corner of Sagar Island, the largest delta in the Western sector of Sundarbans. It is surrounded by large water bodies of the estuary, river Hooghly in the north and western side and river Mooriganga in the eastern side. The southern part of the island faces the bay of Bengal.

Three uncultivated plots, each 5m<sup>2</sup> were selected for this study. The plots were covered with thick carpet of grass and the predominant plants and weeds are *Pongamia pinnata* (L.) Merr. (Papilionaceae), *Clerodendron inerme* (L.) Gaertn. (Verbenaceae), *Jatropha* sp. (Euphorbiaceae), *Derris scandens* Benth. (Papilionaceae), *Tylophora indica* Merr. (Asclepiadaceae),

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*Coccinia indica* W & H. (Cucurbitaceae), *Cayratia carnos*a Gagnep. (Vitaceae) and *Acanthus illicifolius* Linn. (Acanthaceae). A part of the sampling area was found to prevail under shade throughout the day. Each plot was sampled at monthly intervals by stainless steel samplers each having 5 cm depth and 17.36 cm<sup>2</sup> surface area. Altogether 36 soil samples were drawn from a depth of 5 cm and the extraction of materials from the soil was carried out in an expedition funnel apparatus, as devised by Macfadyen (1953). The extraction process was continued for 6 days at a temperature of 38°C inside the apparatus. The soil of the study site is alluvial in nature, sandy and greyish in colour. The soil temperature was recorded by means of mercury thermometer inserted into the soil and the water content of soil was estimated as a percentage difference between dry and wet weight of soil after drying for 24 hours at 105°C to constant weight.

### RESULTS

*Faunal Makeup* : A list of oribatid obtained together with individual number of genera/species at each month is given in Table 1. In total ten genera of oribatid were ascertained of which *Scheloribates* was most dominant comprising 60.25% of the total adult population. The remaining genera in order of dominance were as follows : *Rhysotritia* (12.65%), *Lamellobates* (9.64%), *Haplochthonius* (8.44%), *Hoplophthiracarus* (2.41%), *Hoplophorella* (2.41%), *Oppia* (1.80%), *Haplozetes* (1.20%),

Table 1. Individual number of oribatid genera and nymph.

Genera/Species	Months												Total
	J	F	M	A	M	J	J	A	S	O	N	D	
<i>Scheloribates</i> sp.	4	15	18	—	20	5	7	4	9	5	10	3	100
<i>Rhysotritia ardua</i> (C. L. Koch) var. <i>otaheitensis</i> Hammer, 1972	—	—	—	13	—	8	—	—	—	—	—	—	21
<i>Lamellobates palustris</i> Hammer, 1958	—	—	3	—	3	—	—	—	—	—	9	1	16
<i>Haplochthonius</i> sp.	—	—	2	—	—	—	—	3	3	2	4	—	14
<i>Hoplophthiracarus</i> sp.	—	3	—	1	—	—	—	—	—	—	—	—	4
<i>Hoplophorella</i> sp.	—	—	—	—	4	—	—	—	—	—	—	—	4
<i>Oppia</i> sp.	—	—	—	1	—	—	—	2	—	—	—	—	3
<i>Haplozetes</i> sp.	—	—	—	2	—	—	—	—	—	—	—	—	2
<i>Cosmochthonius</i> sp.	—	—	1	—	—	—	—	—	—	—	—	—	1
<i>Euscheloribates</i> sp.	—	—	—	—	1	—	—	—	—	—	—	—	1
Nymph	2	10	4	3	3	4	2	2	3	1	8	1	43
Total :	6	28	28	20	31	17	9	11	15	8	31	5	209

*Cosmochthonius* (0.60%) and *Euscheloribates* (0.60%). Nymphae of oribatid were found in all months and comprised 20.57% of the total population.

*Monthly fluctuation* : Monthly fluctuation of Oribatei in total (fig. 1) appears to show two peaks, namely in May and November. Gradual increase of oribatid number started from February and attained the peak in May. It then started gradual decrease upto October and exhibited the second peak in November. From fig. 2 it would be seen that same

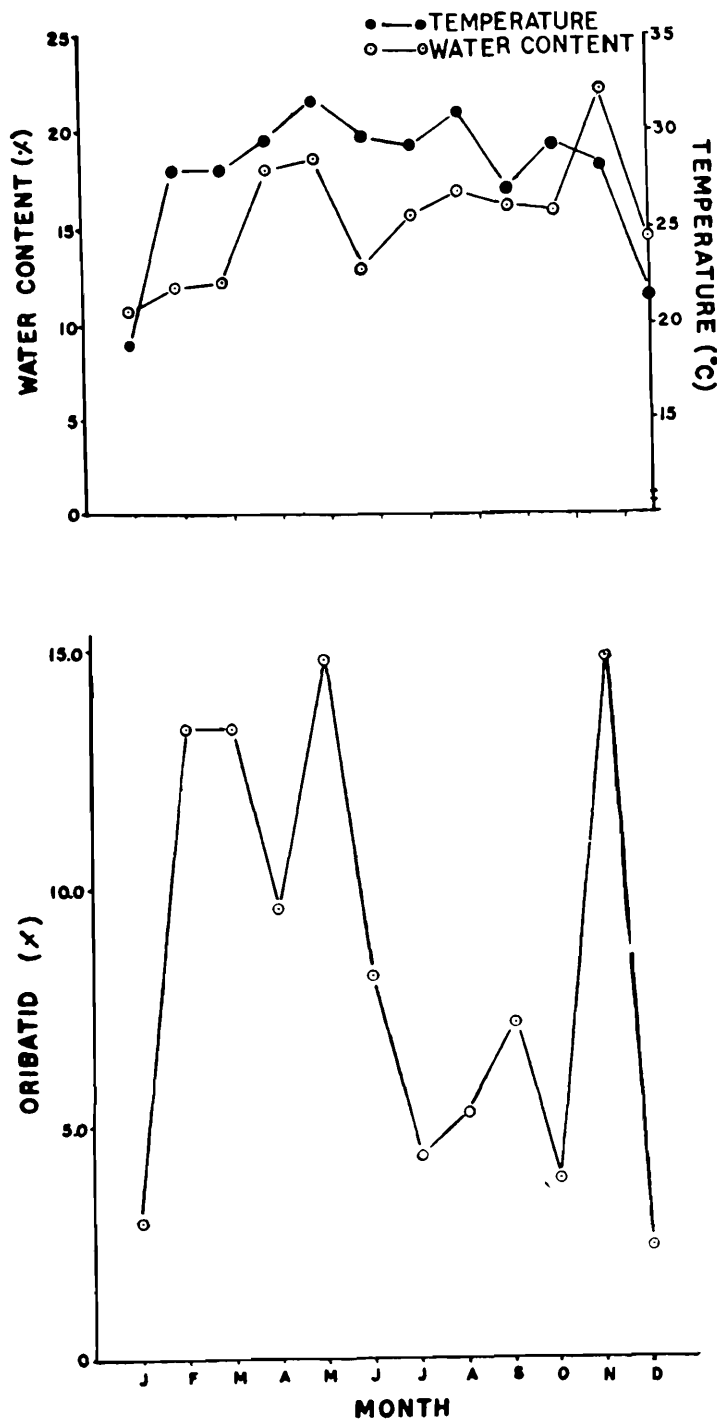


Fig. 1. Monthly fluctuations of oribatid population at Sagar Island in relation to soil temperature and water content.

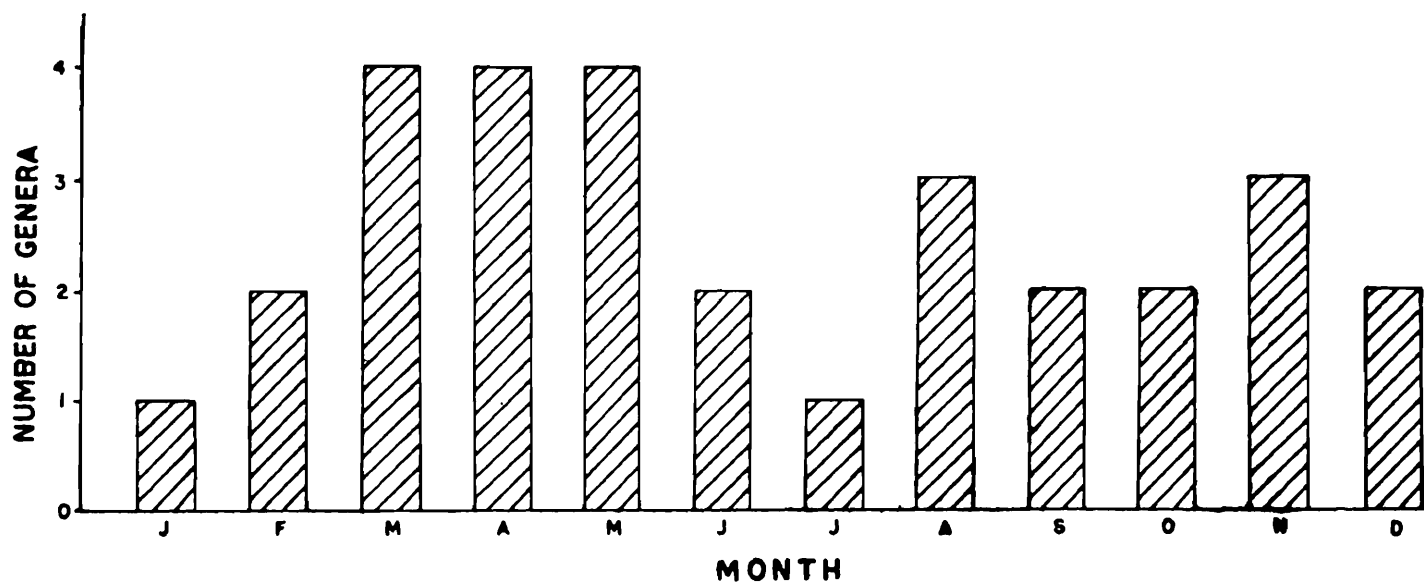


Fig. 2. Monthly fluctuations in number of oribatid genera at Sagar Island.

number of oribatid genera were obtained in March, April and May and attained the highest number. The month of January and July were represented by one genus only.

The genus *Scheloribates* was found in all months except April but the genera *Haplochthonius* and *Lamellobates* were present in the collections of five and four months respectively. The genus *Rhysotritia* was recorded as dominant in the month of April and June. Nymphs of *Oribatei* were counted only as the total number, because of difficulty in determining their systematical position. Seasonal change in the percentage of nymphs is shown in fig. 3 and two distinct peaks in the month of February and November were obtained.

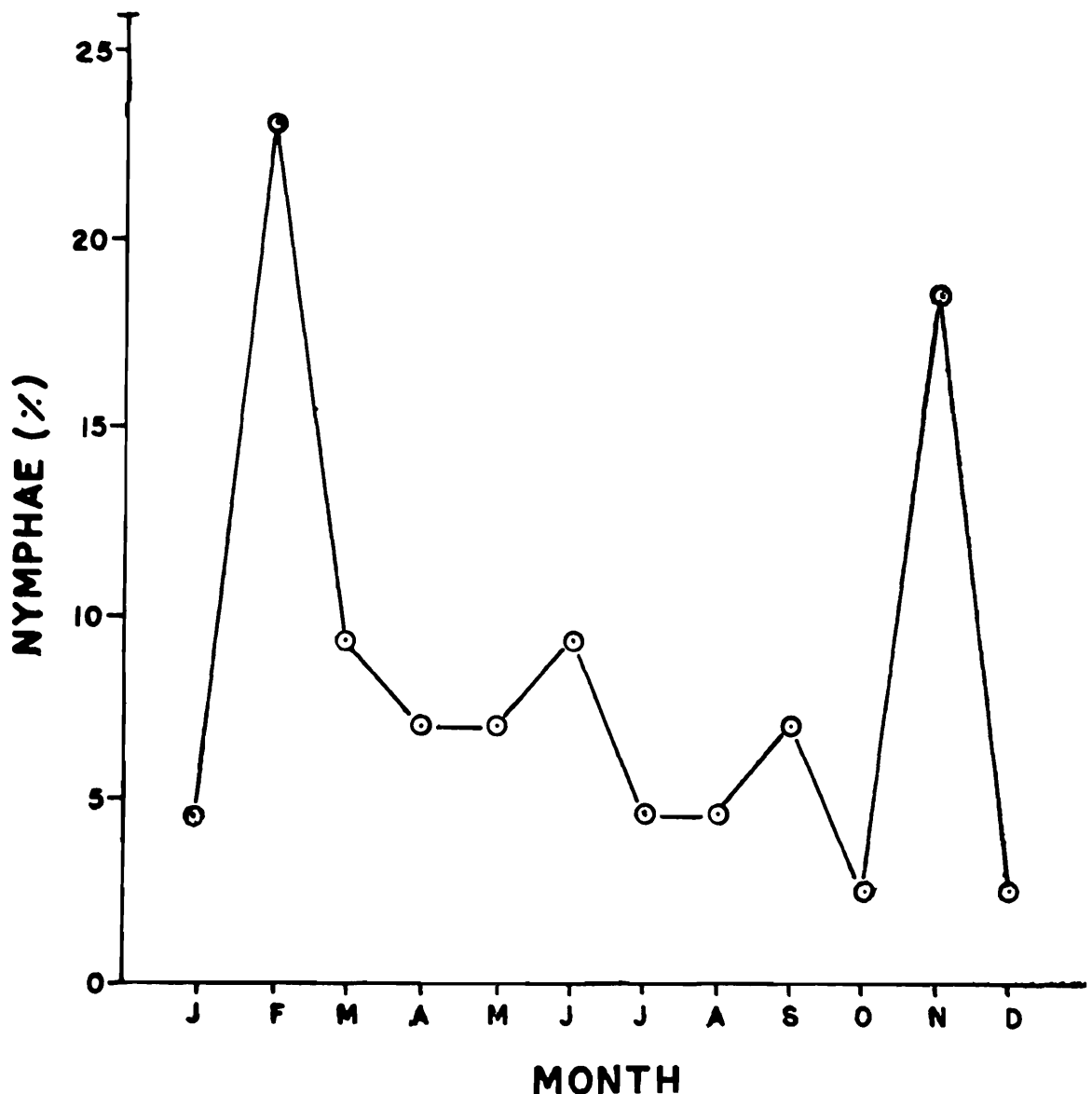


Fig. 3. Monthly fluctuations of oribatid nymphae (% of the total nymphae collected) at Sagar Island.

## ORIBATID POPULATION AND SOIL FACTORS

From fig. 1 it appears that the seasonal fluctuation of oribatid population is related to soil temperature and soil water content. Table 2 showed that the highest soil water content was associated with highest oribatid population in the month of May and November when the corresponding temperature was maximum (unusual rainfall was occurred during May, 1977). Relatively lowest percentage of oribatid occurred in the month of January when the soil temperature and water content were minimum.

Table 2. Number of oribatid and values of soil factors in different months.

Months	No. of oribatid	Temperature (Mean-°C)	Water Content (%)
January	6	19.00	10.74
February	28	28.00	12.00
March	28	28.00	12.15
April	20	29.66	18.00
May	31	31.60	18.65
June	17	29.83	13.14
July	9	29.33	15.52
August	11	31.00	16.99
September	15	27.26	16.11
October	8	29.40	15.90
November	31	28.43	22.15
December	5	21.66	14.65

In order to find out the exact relationship between the oribatid population and the soil factors under consideration, correlation coefficient values were calculated (Table 3). It was found that oribatid population was positively correlated with the temperature and water content of soil.

Table 3. Correlation co-efficient values (r) of oribatid population with soil factors.

Soil factors	Correlation-Coefficient values (r)
Temperature	0.485
Water Content	0.332

## DISCUSSION

It is evident from the foregoing results that the population density of soil oribatid mites was largely dependant on seasonal changes. The occurrence of two population peaks in the month of May and November partly confirmed the results of Bhattacharya and Raychaudhuri (1977), who observed two peaks, one in the month of September-October and the

other in May-June which again differed from the findings of Choudhuri and Banerjee (1975) who showed a single population peak during July-August and Minimum in April-May. The difference in monthly fluctuation in this study was probably due to influence of estuarian climate in contrast to the work of Choudhuri and Banerjee (1975) in pasture land in planes of West Bengal.

The influence of soil temperature and water content on the population density of oribatid was thoroughly studied by Bhattacharya and Raychaudhuri (1977) and Choudhuri and Banerjee (1977). They showed positive correlation of these two soil factors with the oribatid population. The present study also confirmed that change in soil temperature and increase of soil moisture content play an important role in limiting the population density of soil oribatid mites in estuarian soil.

#### ACKNOWLEDGEMENTS

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## POPULATION FLUCTUATION OF GRASSHOPPER FAUNA IN A FIELD NEAR CALCUTTA

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### INTRODUCTION

Numerous workers like Katiyar (1956), Uvarov (1967), Phipps (1970) and Parihar (1974) have studied the biology and ecology of some grasshoppers in India and abroad, but in India comprehensive ecological studies of grasshoppers in a grassland ecosystem have not been attempted so far except some fragmentary informations. The present work is a part of long term bioecological study in a grassland ecosystem near Calcutta.

### MATERIAL AND METHOD

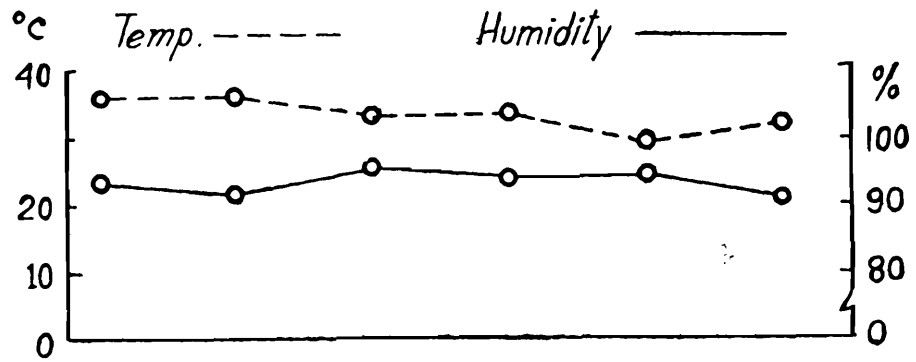
The area selected for study at Narendrapur, near Calcutta was divided into three plots of size 150 X 80, 100 X 50 and 80 X 30 meters. Maize, Jowar and Paddy were the main crop plants beside other vascular plants.

Collections were made in the morning hours after every ten days interval for a period of 2 hours by sweeping and hand picking methods. Temperature and humidity data were also recorded each time.

### OBSERVATIONS AND RESULT

In the present investigation when total population of all the species is considered it is observed that maximum population of all the species are associated with moderate temperature and relatively high atmospheric humidity *i.e.* 29.0°C and 94% respectively seem to be suitable for these species. But when it is considered species wise (figs. 1, 2, 3 and 4) it shows that the maximum number of species is associated with the highest temperature which may be seen from the tables 1 and 2 when most of the predominant species like *Atractomorpha crenulata* is recorded in maximum number in the month of May when the temperature increased upto 35.6°C. Therefore, different species have different temperature tolerance range.

The rise and fall in the numbers of different species appear independent from each other. Fluctuations occur due to the choice of the host in relation to season. With the growth of the maize and rice crops, the specimens migrate towards the maize and rice from the nearby wild vegetations, in particular the adjoining grasses.



*Phlaeoba infumata* .....  
*Spathosternum prasiniferum* PT. ———  
*Trilophiclia annulata* ●——●——●——  
*Oxya hyla hyla* —·—·—·—·—·—  
*Oxya fuscovittata* - - - - -

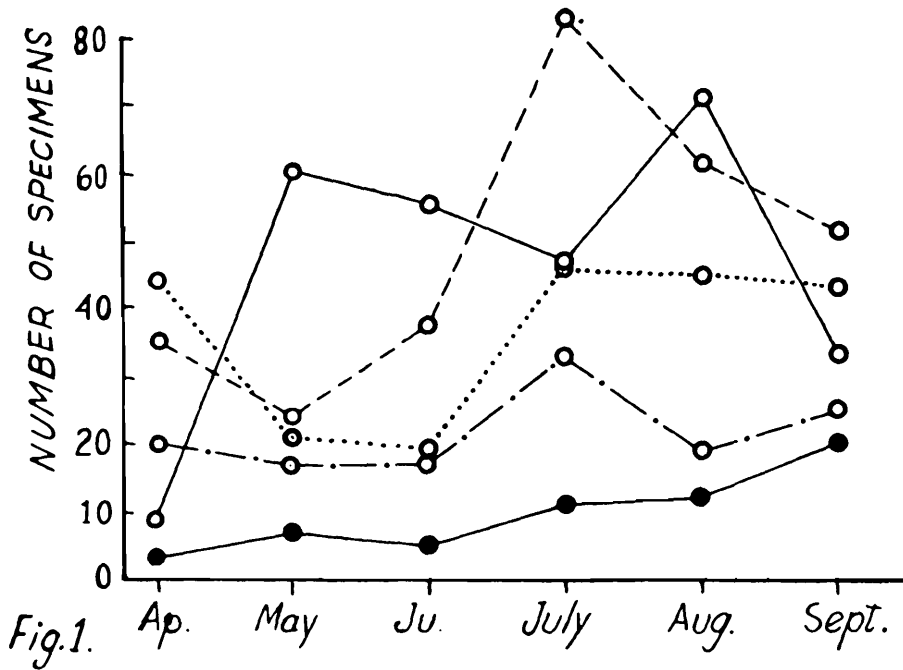


Fig. 1

Table 1. Maximum temperature and relative humidity in different months during collections at Narendrapur.

	April	May	June	July	Aug.	Sept.
Temp. (°C)	35	35.6	32.9	33.2	29.3	32.2
R. Humidity (%)	93.6	91.5	95.6	94	94	91

From table 3, it is clear that the number of nymphs were relatively greater during May and again in the month of September. It is also clear from this table that majority of the species hatch two times viz. once in May and then in the month of September. Therefore, it can

Table 2. Monthly population fluctuations of predominant Acridids species.

Name of the species	April	May	June	July	Aug.	Sept.
<i>Phlaeoba infumata</i> Brunner	44	21	19	46	45	43
<i>Spathosternum prasiniferum</i> pr. (Walk.)	09	60	55	47	71	33
<i>Trilophidia annulata</i> (Thunberg)	03	07	05	11	12	20
<i>Oxya hyla hyla</i> Serville	20	17	18	33	19	25
<i>Oxya fuscovittata</i> (Marschall)	35	24	37	82	61	51
<i>Atractomorpha crenulata</i> (Fabr.)	36	102	57	25	39	32
<i>Epistaurus sinetyi</i> Bolivar	06	02	00	01	00	05
<i>Leva indica</i> (Bolivar)	01	05	00	00	02	02
<i>Gesonula punctifrons</i> (Stal)	02	02	03	04	03	08
<i>Aulacobothrus</i> sp.	01	03	00	01	00	02
<i>Acrida exaltata</i> (Walk.)	04	24	27	11	08	06
<i>Tristria pulvinata</i> (Uvarov)	13	03	02	03	14	06
<i>Aiolopus thalassinus tamulus</i> (Fabr.)	01	01	08	16	12	06
<i>Heteropternis venusta</i> (Walker)	00	00	00	01	02	00
<i>Eyprepocnemis alacris alacris</i> (Serville)	09	05	03	07	06	02
Total	184	276	234	288	294	241

Table 3 : Percentage of Nymphs and Adults on host plants

Month	Nymphs	Adult
April	41.3	58.7
May	50.0	50.0
June	45.3	54.7
July	44.4	55.6
August	36.2	63.8
September	50.8	49.2

be concluded that these species might have more than two generations per year. More over crop plants are also sowed during this monsoon period which may serve favourable food for them, besides other grass species which are also abundant during the period. So all these parameters may be the causative factors for high nymphal percentage.

The increase in total number of specimens in July and August is due to rain and abundance of tall grasses (Table 2). The number of adults were slightly lesser during early July but increased very soon in late August. Consequently, the nymphs increased first and then became less in number.

*Interspecific fluctuation* : Four species viz. *Spathosternum prasiniferum prasiniferum* (Walker), *Atractomorpha crenulata* (Fabr.), *Oxya fuscovittata* (Marschall), *Phlaeoba infumata* Brunner, were predominant throughout our observations (figs. 1 and 4). The lowest frequency was found in the case of *Aulacobothrus* sp., *Gesonula punctifrons* (Stål),

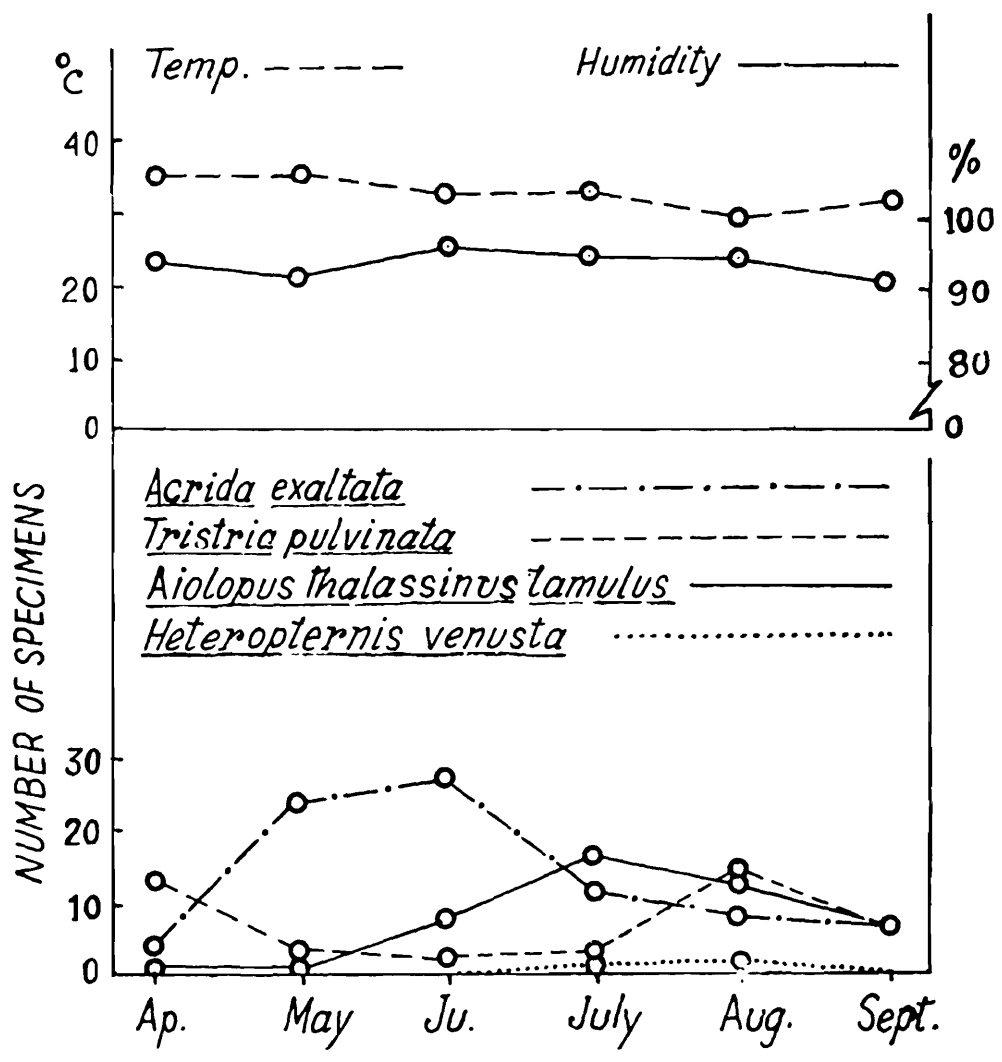
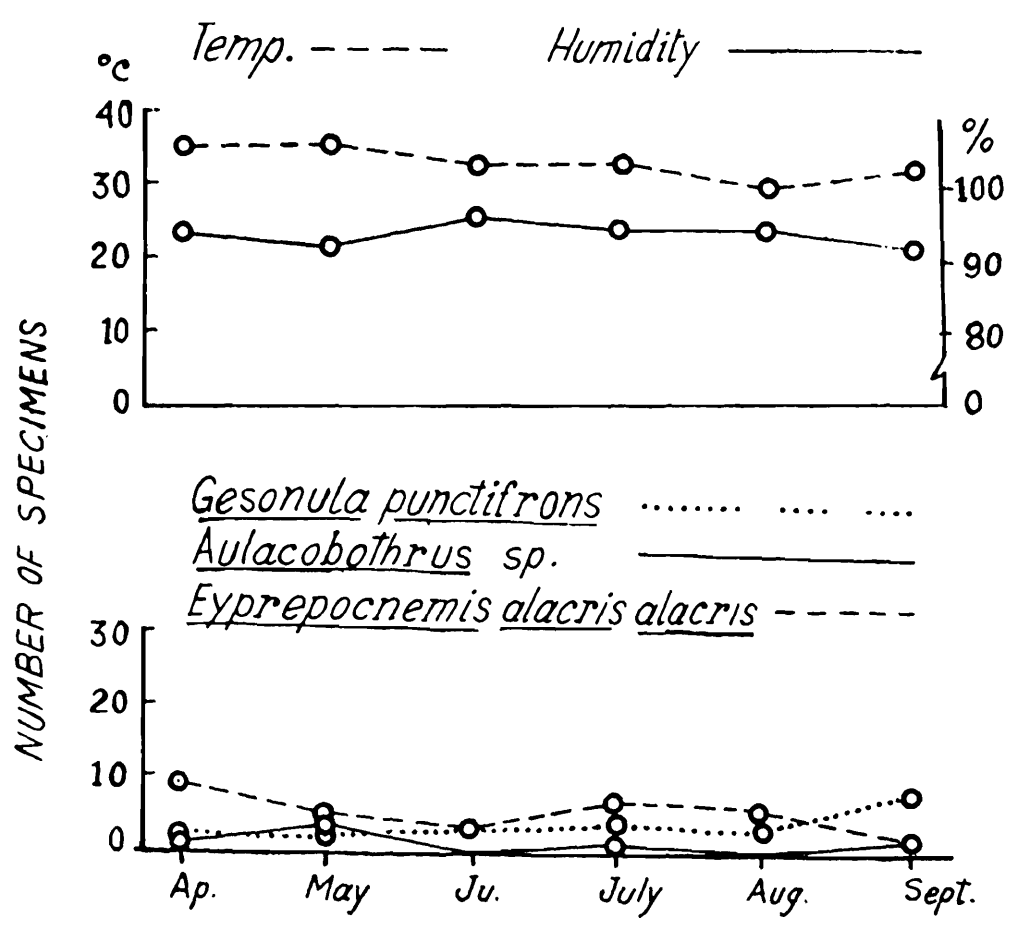


Fig. 2



*Heteropternis venusta* (Walker) and *Leva indica* (Bolivar) (figs. 2, 3 and 4). Relative abundance of the first four species are more or less constant with minor fluctuation in the month of April and September. There is a peak abundance of all the species during July-August and this falls suddenly in the 1st week of September. Population of grasshoppers for the period under observation reveals that the peak density of the insects is in July and August.

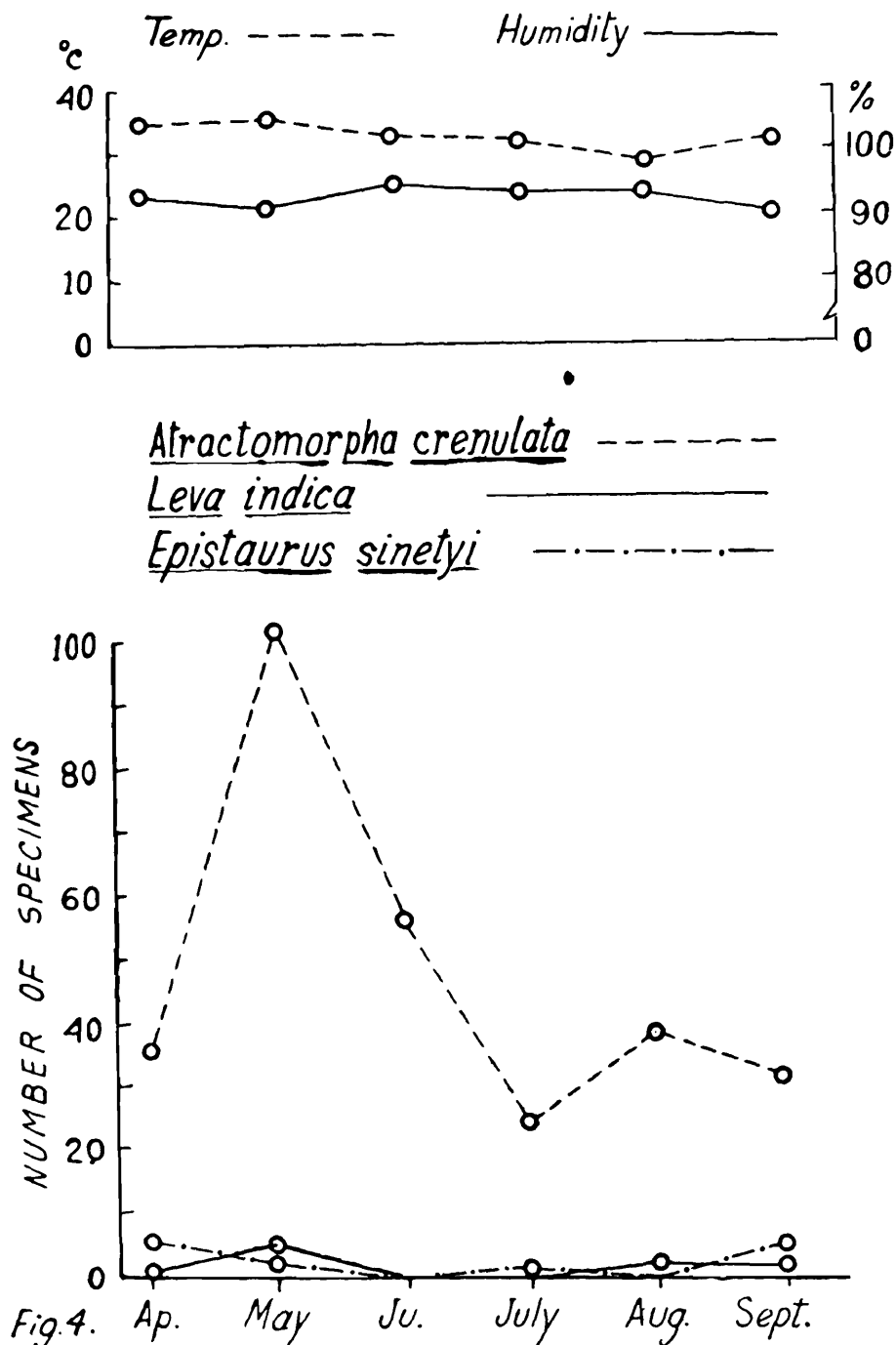


Fig. 4

## ACKNOWLEDGEMENTS

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SEASONAL OCCURRENCE OF *MUSCA DOMESTICA*  
L. (DIPT MUSCIDAE) AND OTHER FLIES IN  
RELATION TO THEIR PUPAL PARASITES  
IN ANIMAL MANURE IN AND  
AROUND BANGALORE

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INTRODUCTION

The housefly, *Musca domestica* L., as is well-known, has a high reproductive potential ; under ideal conditions a female fly can lay up to 900 eggs in her lifetime (West, 1951). However, high mortality at various stages of development and adult life caused by several abiotic and biotic regulatory factors (parasites, predators and pathogens) ensures that only a fraction of the offspring survive to maturity.

A large number of species of natural enemies, which attack *M. domestica* directly, and also coprophagous arthropods, which regulate fly populations indirectly by rendering the breeding habitat inaccessible or unsuitable to flies, are known (Jenkins, 1964 ; Legner & Olton, 1968, 1971 ; Legner & Poorbaugh, 1972 ; Legner *et al.*, 1974). Seasonal fluctuations in abundance of *M. domestica* and of the stable fly, *Stomoxys calcitrans* L. (Muscidae), in relation to their pupal parasites have been studied in East Africa (Legner and Greathead, 1969) and of *M. domestica* and its pupal parasites in Denmark (Mourier, 1971).

In India, studies on population fluctuations of *M. domestica* have been made by several workers but they did not consider the role of natural enemies (Pruthi, 1946 ; Sehgal & Pawan Kumar, 1966 and Roy & Dasgupta, 1975). Several natural enemies of *M. domestica* and other flies occurring in cattle manure are known (Geetha Bai & Sankaran, 1977). The present paper discusses investigations on fluctuations in seasonal abundance of flies and their parasites in cattle, pig and poultry manure, carried out during 1975-76.

METHODS AND MATERIALS

Monthly samples of cattle, pig and poultry manure were collected

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from three types of animal farm in the Bangalore area—(i) cattle farms of the Composite Livestock Farm & Research Station (CLFRS), Hessarghatta, the Military Dairy Farm (MDF), Hebbal and the National Dairy Research Institute (NDRI), Adugodi ; (ii) a piggery in CLFRS ; and (iii) two poultry farms at Gangenahalli (GH) and Sultanpalyam (SP), respectively. CLFRS is 26 km and MDF 4.5 km north-west of the CIBC laboratory, NDRI is 13 km and GH 0.5 km to the south-east while SP is 5 km east of CIBC. The cattle and pig manures were found heaped in open fields and used for growing various fodder crops and were therefore disturbed periodically. Poultry droppings at GH were gathered by the farm owner at weekly intervals from beneath cages with birds and stored in a pit about 1 metre deep in the front yard, whereas at SP poultry droppings were allowed to accumulate beneath the cages and removed once in six months.

Samples of manure, approximately 8 litres each, were collected at all sites. Fly larvae, puparia and associated arthropods were separated from entire samples of cattle and poultry manure but because of the abundance of fly larvae and puparia in pig manure each sample was thoroughly mixed and three sub-samples consisting of approximately 1 litre each were drawn. From the pooled means of the sub-samples fly larval and pupal density for 8 litres of manure was calculated. Fly larvae were hand-picked direct from the manure or extracted using a modified Berlese's funnel. After extraction of larvae the manure was stirred to a slurry in a bucket of water and allowed to settle to separate fly puparia, active predators and saprophagous arthropods which were collected with a wet brush and a wiremesh screen. The larvae and puparia were then sorted into species. The larvae were reared and the puparia dried and kept in screened plastic vials for two months for possible emergence of flies and parasites. Specimens of adult arthropods were identified by the Commonwealth Institute of Entomology, London. Puparia from which neither flies nor parasites emerged were dissected and the contents checked. Data was collected for twelve consecutive months during 1975-76, except April or July 1975 at some sampling sites. At SP data was collected for only 9 months because the farm closed down.

*Field observations :* Although *M. domestica* was present in all three types of manure, its numbers were highest in pig manure and lowest in cattle manure. Individual species in its parasite complex varied in importance with the type of fly breeding habitat and with the season. The species composition and abundance of other flies and their parasites varied with the type of manure. The various species of flies and their parasites are shown in fig. 1

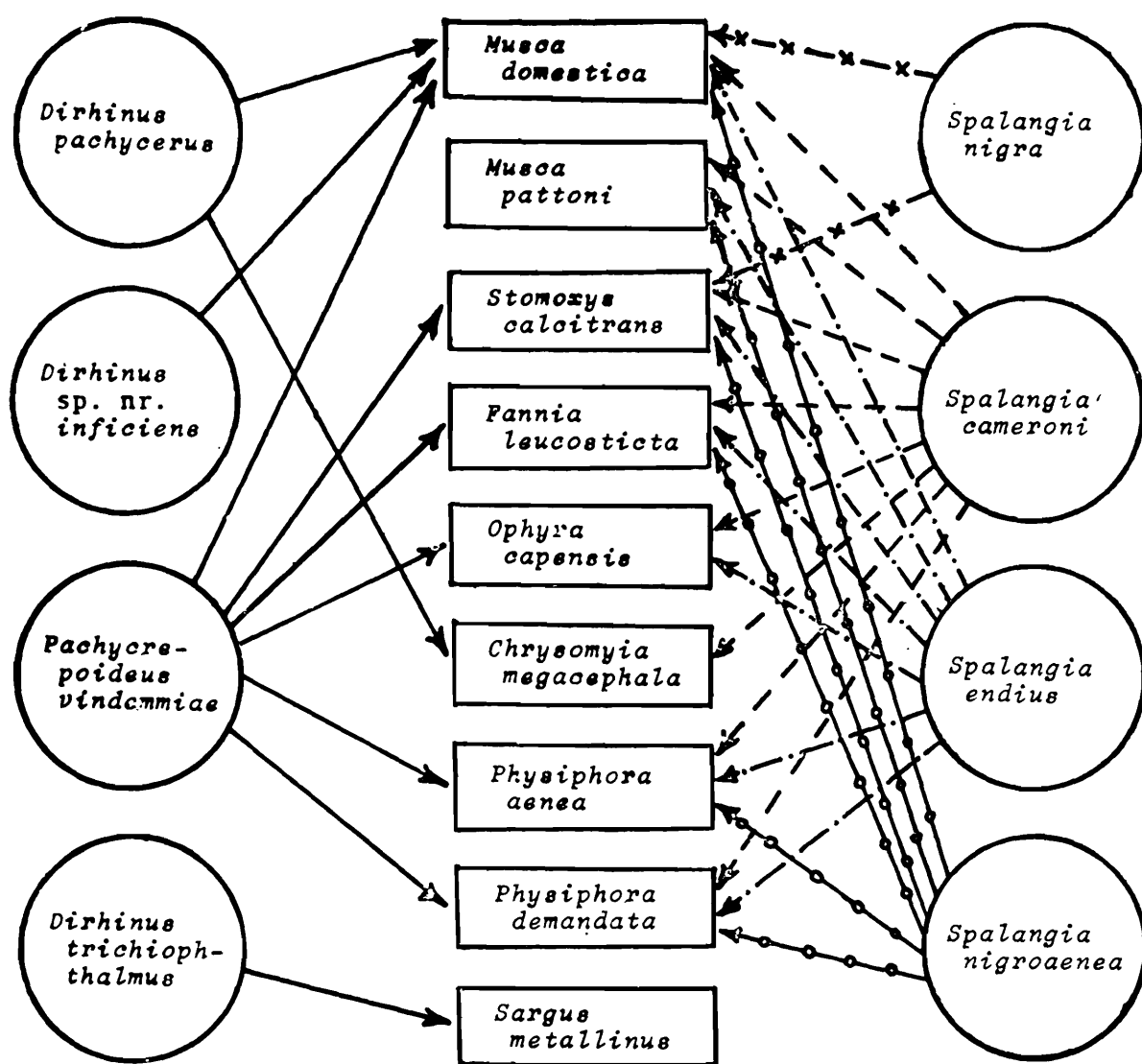


Fig. 1. Species of flies and their parasites studied.

*Cattle manure* : Larvae and puparia of *M. domestica* were found virtually throughout the sampling period at all the three sites, except during October at MDF. The maximum numbers of housefly larvae and puparia were collected during the warm and dry period of April to June 1975. With decrease in temperature and with the onset of rain the fly population declined and remained low until the end of January when it increased gradually. The maximum and minimum numbers of housefly puparia per sample were 167 and 3 at CLFRS, 218 and 0 at MDF, and 186 and 4 at NDRI. *Spalangia cameroni* (Perkins), *S. endius* Walker and *S. nigroaenea* Curtis (Hym., Pteromalidae) attacked the puparia. *S. nigra* Latreille was reared from puparia collected at CLFRS during March and April 1976. *S. cameroni* and *S. endius* were the most abundant but *S. nigroaenea* was present in small numbers only. The maximum combined percentage parasitism was 26.4 at CLFRS, 38.9 at MDF and 27.5 at NDRI.

*Musca pattoni* Austen, a haematophagous species distributed in Burma, India, Pakistan and Sri Lanka, was also present. Its numbers in the samples increased in September, reached a peak in October and had declined to a low level by the end of November. It is thus more common during the wet and cool season and scarce or absent at other times. The maximum numbers of puparia per sample were 31 at CLFRS, 53 at MDF and 62 at NDRI. The parasites reared were *S. cameroni* and *S. endius*, recorded by Geetha Bai & Sankaran (1977) but *S. nigroaenea*, now reported for the first time from *M. pattoni* in India, was obtained at CLFRS during November and December 1975. The maximum combined parasitism was low (2 out of 4 fly puparia in the sample from CLFRS, 4 out of 12 from MDF and 10 out of 31 at NDRI).

The stable fly, *Stomoxys calcitrans*, was present in relatively small numbers, except in May at CLFRS and NDRI and in September and October at MDF. Its density increased during the cool, dry season. The maximum numbers of puparia collected per sample were 17 at CLFRS, 29 at MDF and 24 at NDRI. *S. cameroni*, *S. endius* and *S. nigroaenea* were reared.

Other species of flies of lesser importance included *Dolichomecus crassus* F. (Syrphidae); *Physiphora aenea* F., *P. demandata* F. (Otitidae); *Sargus metallinus* F. (Stratiomyidae); *Sepsis thoracica* R.-D., *Sepsis nitens* Wiedemann (Sepsidae); *Sphaerocera scabricula* Hal. and *Leptocera (Coproica) hirtula* Rondani (Sphaeroceridae). *Spalangia cameroni* was reared from puparia of *P. aenea* and *P. demandata* at all three sites. Both the *Physiphora* spp. did not show marked seasonal fluctuations.

*Dirhinus trichiophthalmus* Masi attacks *Sargus metallinus* F. in this habitat but both host and parasite were scarce.

Females of all parasite species usually predominated. *Spalangia cameroni* and *S. endius* were abundant during the warm weather while *S. nigroaenea* was reared only occasionally when the temperature was low. Parasitism of *M. domestica* by *S. nigra* was negligible.

**Pig manure :** Pig manure is very productive of houseflies. A maximum of 824 puparia/litre was collected during January 1976. The pattern of fluctuations in abundance of *M. domestica* and its pupal parasites was similar to that found in cattle and poultry manure. Five species of puparial parasites, *S. cameroni*, *S. endius*, *S. nigra*, *S. nigroaenea* and *Pachycrepoideus vindemmiae* Rondani (Hym., Pteromalidae) were reared.

*Chrysomyia megacephala* F. (Calliphoridae), *C. saffrana* Bigot and *Stomoxys calcitrans* were occasionally reared in very small numbers. The same five species of parasites were reared from *S. calcitrans*.

*Poultry manure* : Poultry manure is an important fly-breeding habitat because of the greater abundance and variety of fly species found in it. *M. domestica* was present throughout the study period with maximum numbers of puparia collected per sample 818 and 834 in June, and the minimum 72 in October and 92 in December at GH and SP, respectively. Six species of parasites, *Spalangia cameroni*, *S. endius*, *S. nigra*, *S. nigroaenea*, *Pachycrepoideus vindemmiae* and *Dirhinus pachycerus* Masi (Hym., Chalcididae), attacked the puparia at SP. In addition, *Dirhinus* sp. nr. *inficiens* (Walker) was occasionally reared from puparia at GH. The maximum total percentage parasitism recorded was 52.6 and 30.2 and the minimum 12.5 and 10.9 at GH and SP, respectively. *S. cameroni*, *S. endius* and *D. pachycerus* were dominant during the warm weather, when the host density was at a peak. *P. vindemmiae* and *S. nigroaenea* were more common when the host density was low. *S. nigra* was reared at irregular intervals only. *Stomoxys calcitrans* was present throughout the year, being more abundant during the cold season with a maximum of 39 puparia collected per sample during January 1976 and 25 during December 1975 and a minimum number of 2 in May at GH and 1 each in May and June at SP. *Spalangia cameroni*, *S. endius*, *S. nigra*, *S. nigroaenea* and *P. vindemmiae* attacked the puparia. No parasites were reared at very low host densities. *Fannia leucosticta* Meigen and *Ophyra capensis* Wiedemann (Muscidae) were found in relatively small numbers at irregular intervals. The maximum numbers of *F. leucosticta* collected at GH and SP were 17 and 14 and those of *O. capensis* were 18 and 5 respectively. *S. cameroni*, *S. endius*, *S. nigroaenea* and *P. vindemmiae* were reared from puparia of *F. leucosticta* while *S. cameroni*, *S. endius* and *P. vindemmiae* were reared from *O. capensis*. *Physiphora aenea* was next in abundance to *M. domestica* and was present almost throughout the study period with little seasonal variation. The maximum numbers of puparia collected per sample at GH and SP were 76 and 61 and the minimum 12 and 7, respectively. *S. cameroni*, *S. endius*, *S. nigroaenea* and *Pachycrepoideus vindemmiae* were recorded from puparia of *P. aenea*.

*Physiphora demandata* was present in relatively small numbers in some samples and was parasitised by *S. cameroni*, *S. endius*, *S. nigroaenea* and *P. vindemmiae*.

*Chrysomya megacephala* was collected from both the sampling sites almost throughout the year and did not show marked seasonal fluctuations in abundance. *S. cameroni* and *D. pachycerus* were reared from puparia. *Chrysomya saffrana*, *Leptocera hirtula*, *Microchrysa ? flaviventris* Wiedemann (Stratiomyidae) and *Sphaerocera scabriculla* occurred in very small numbers at irregular intervals. No parasites were reared from these flies.

*D. pachycerus* is now recorded for the first time from field-collected puparia of *M. domestica* and *C. megacephala*. *Spalangia cameroni* is also recorded for the first time from *C. megacephala*.

#### DISCUSSION

Temperature and rainfall play an important role in regulating fly populations. Higher temperatures favour *M. domestica* while *Stomoxys calcitrans* is more prevalent when the temperature is low. Similar observations have been reported by other workers (Legner & Greathead, 1969; Roy & Dasgupta, 1975). *M. pattoni* breeds in large numbers during the wet and cool season. Some pupal parasites also showed fluctuations in numbers in different seasons. *Dirhinus pachycerus*, *Spalangia cameroni* and *S. endius* were more abundant at higher temperatures while *Pachycrepoideus vindemmiae* and *S. nigroaenea* occurred in large numbers at lower temperatures. *D. sp. nr. inficiens* and *S. nigra* were present in relatively small numbers. Although *Spalangia* spp. and *P. vindemmiae* attacked various other fly species like *F. leucosticta*, *O. capensis*, *P. aenea* and *P. demandata*, which did not show marked seasonal fluctuations, these flies do not seem to be important alternative hosts when *M. domestica*, *M. pattoni* and *Stomoxys calcitrans* are scarce, since no marked increase in parasitism of these hosts was observed.

The species of flies and their parasites present varied in importance between the three types of habitat examined (fig. 2). Pig manure was one of the most important breeding habitats of *M. domestica* in Hungary (Mihalyi, 1967), North China (Meng & Winfield, 1951) and Kazakhstan (Bakiev, 1975) as in the Bangalore area. However, the complex of flies and the parasites attacking them was less varied than in poultry manure. It is interesting to note that *D. pachycerus* and *D. sp. nr. inficiens* were reared from *M. domestica* puparia collected from poultry manure only. *D. pachycerus* had previously been recorded in India only from puparia of *Sarcophaga tuberosa* Pand. under natural conditions (Roy & Siddons, 1939) although in the laboratory it attacked *Musca inferior* Stein., *M. vicina* Macq., *M. nebulo* F., *Sarcophaga ruficornis* Wied., *S. dux* Thoms and *C. megacephala* (Roy *et al.* 1940).

Cattle manure was not an important breeding habitat of *M. domestica* but it was an important site for *M. pattoni* and *S. calcitrans* which bite cattle.

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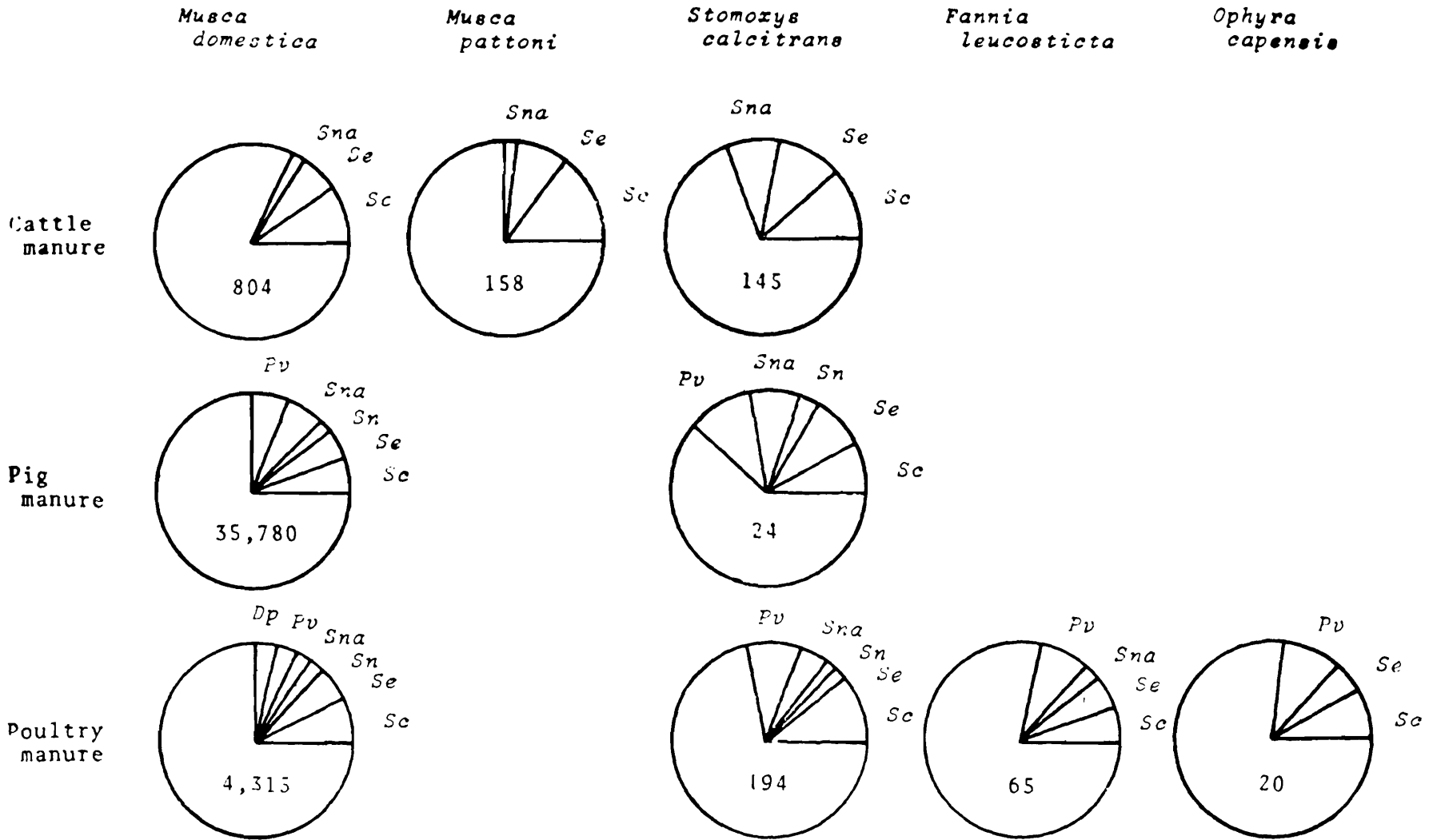


Fig. 2. Variations in species of flies and their parasites between habitat types.

indebted also to the Indian Council of Medical Research, New Delhi, for the award of a Junior Research Fellowship which enabled her to complete this work.

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