

4: MATERIALS AND METHODS

i. Survey of fern flora :

To mark the area that constitute the foothill and plain of Darjeeling district (Fig.1) help of detailed maps and information were taken from a District Census Handbook (Ghosh, 1981). Using the accessible road maps, surveys were conducted across the Darjeeling plain i.e. areas under the police stations of Siliguri, Phansidewa, Khoribari, Naxalbari, and Kurseong (Fig.2). Over a period of four years (1989-1992), random searches were made to prepare a list of the available terrestrial ferns. Ferns were collected in polythene bags and brought to laboratory where they were poisoned for preservation and pressed for herbarium sheets following techniques of Dwivedi and Singh (1985). These specimens were later sent to Botanical Survey of India, Calcutta for identification.

A survey was also undertaken with a special eye to find out the frequency of occurrence of fern species in patches of fern vegetation. It was done in a random manner covering by and large the cross sections of the aforesaid stations. The transect method was adopted using a rope of length 15 m. (Michael, 1984). Sampling was done from every 3-5 Km. depending upon the availability of fern patches. The rope marked off in metres was laid across the observation site. The presence or absence of the fern species (Fig. 7a-9) were

recorded on the basis of four transect readings at each patch. The percentage frequency was calculated using the formula:-

$$\% \text{ Frequency} = \frac{\text{No. of transects in which the species or structural type occurred}}{\text{Total No. of transects}}$$

ii. Monitoring and collection of fern associated insects :

The more apparent fern species that constituted the major terrestrial fern flora were taken into consideration for studying the fern entomofauna. Random fortnightly surveys were done for four years (1989-1992) to collect the fern insects. Collection methods like hand picking, beating, sweeping and siphoning by aspirator were done. Hence, it may be assumed that all the types of insects i.e. whether true feeders or not, roosters and temporary visitors might have been included in the collection process. Only the insects associated with the above-ground part of the sporophyte of all ages (young, middle, sporulating and senescent) were closely observed. The collected insects were brought to the laboratory in polythene packets and containers and poisoned in a killing bottle. Hard bodied insects were pinned, mounted, oven dried and preserved in collection boxes. Soft bodied insects were preserved in 70% alcohol. Eggs and immature forms collected in field were brought to the laboratory along with the host plant and were reared to adult stage for identification. The identification of specimens were mostly done with help of authorities like the Zoological Survey of India, (Calcutta),

Indian Agricultural Research Institute (New Delhi), and some competent authorities. Those distinct species that could not be identified has been kept as 'in det' and denoted in the list as species A, species B, etc. Some insects suspected parasitised in nature were kept in laboratory for emergence of parasitoids. During the course of survey, the crops growing adjacent to the patches of ferns were observed for any common species that could be recorded on both the vegetations. For some of the insects that were more frequent, a study on their seasonality of occurrence on specific fern host were noted. Field notes on those insects were taken that appeared to be of interest.

iii. Host-plant preference:

Eggs of S. obliqua were collected from jute fields while the eggs of S. casigneta were collected from the fern vegetation. Eggs of A. crenulata were collected from culture kept on fern host. After the emergence of the arctiid larvae and the acridid nymphs, two sets of experiments were done with each species of pests selected for study. Laboratory reared individuals of S. obliqua, S. casigneta, and A. crenulata were used for the purpose. Host plant preference experiments were conducted using ten specimens at a time for each stage of a species and each test was repeated thrice. The larval stages for the two lepidopteran species were used under two categories:

- i. the early instar represented by III stage larva and
- ii. advanced instar represented by V stage larva.

For A. crenulata the three categories were:-

- a) the early instar represented by the III stage nymph
- b) the advanced instar represented by the V stage nymph and
- c) the adults.

Each category used, were starved for four hours, and not any longer to avoid emaciation and death out of starvation.

In the first set of experiments, five of the more apparent terrestrial ferns species, i.e. Diplazium esculentum (Retg.) Sw., Christella crinipes (HK) Holtt., Lindsea ensifolia Sw., Microlepia speluncae (L.) Moore. and Dicranopteris linearis (Brum. f) Underus were chosen as food plants. Fresh and middle aged fern fronds of all the five species were provided to the insects. To maintain turgor pressure and prevent wilting, the petiole of the fronds were kept dipped in water in a 150 ml. conical flask. The whole set-up was kept in a plastic container with a perforated lid. Each category of the experimental insect were released in the central place and allowed to feed freely for 24 hours. Xerox copies of the fronds were made before and after feeding.

In the second set of experiment, in order to understand the choice exercised by each category between the most preferred fern species and the angiospermic crop plant, a similar experiment as above was conducted using the two food plants in question. D. esculentum and Corchorus capsularis L. for S. obliqua; D.

esculentum and Morus indica L. for S. casigneta; and C. crinipes and C. capsularis for A. crenulata. An approximate assessment of the food preference was made with some modifications after Hendrix and Marquis (1983) using the extent of leaf blade (pinna) of the host plant consumed or damaged.

The formula applied for calculating the consumption of leaf in terms of area was :-

$$\text{Leaf area consumed} = \frac{A}{B} \times 100$$

where, A = total area of intact leaf blade

B = total area of leaf blade eaten.

The thickness of the leaves and other cuticular structures have not been considered for simplicity of calculation.

iv. Post embryonic development :

Observations on stadia periods and number of instars were made in laboratory during the season of availability of eggs adults of the three species, S. obliqua, S. casigneta and A. crenulata on the respective economic hosts. Eggs of A. crenulata laid under soil were collected from lab. culture. The study was conducted in an environment chamber kept at $27^{\circ}\text{C} \pm 1^{\circ}\text{C}$, $80^{\circ} \pm 5\%$ R.H. under L :D 12 hours each. Twenty five individuals were reared in groups of five. Each group was kept in sterilized plastic containers measuring 22 cms X 11 cms. closed with finely perforated lids. Parallel mass culture of the species were also maintained to give replacement to individuals dying in course of the study. The containers were regularly cleaned for proper sanitation and whenever

felt necessary fresh sterilized containers were used. Fresh food (frond leaf) in sufficient amount were provided twice a day with their petioles dipped in water to prevent wilting. Change in instar was noted everyday by detecting head capsule or exuvium.

For the holometabolous form i.e. S. obliqua and S. casigneta the pupae were also observed under the above conditions till eclosion. The longevity of the adults was recorded. For A. crenulata the adult longevity was observed with the food and conditions as that of their nymphs.

V. Survivorship study :

Survivorship studies were done for immature stages under laboratory conditions as mentioned earlier. Rearing cages measuring 40 cm X 30 cm X30 cm were used. In each of the observation 100 individuals of newly hatched larvae were reared separately in small batches. Observations were made both on fern and the economic host plant for all the species, at a time interval of 48 hours (X). The number of larvae surviving at each age interval (nx), and also the number of larvae dying within the age interval (dx), and the average number of individuals alive during a particular age interval (LX), were noted and calculated. The rate of mortality (qx) and mean expectation of further life for larvae alive at start of an age (ex) were also computed after Krebs (1978). For comparison of the observed survivorship curves, a figure with three hypothetical situations was adopted from Pearl (1928). [Fig. 6.]

VI. Reproductive performance :

Ten pairs of freshly emerged individuals obtained from cultures reared on specific host plants were kept in separate containers under the aforesaid laboratory conditions to observe the fecundity and hatchability of the eggs laid by each pair. Fresh frond leaves were provided for egg laying to both the species of arctiid moths, and 4 cm thick moist soil was provided in a petridish inside the plastic container for underground laying by the acridid species. Pre-, postoviposition and the egg-laying periods were also observed.

VII. Body weight and mass budget :

Body weight of the immature stages, pupae, and newly emerged adults and faecal matter were recorded after drying them in an oven at 50°C to a constant weight. Only freshly ecdysed larvae /nymphs were taken for initial dry weight to avoid presence of any ingested food stuff. Weight of exuviae and pupal cases were also considered for finding out the final body weight of the instar. Dry weight of food consumed was determined by subtracting dry weight of leaf after consumption from the dry weight of an equivalent intact leaf of same age. The nutritional budget was calculated using formulae of Waldbaur (1968) and I.B.P. formula after Petruszewicz and Mac Fadyen (1970), Muthukrishnan and Pandian (1987) and Farrar et al. (1989). The estimation and calculations of the nutritional indices and budget were done on a dry

mass basis. Units used : weights in mg; time in days;
and efficiencies in percent.

a. Assimilation (As) = Food consumed (C) - Faeces (Fu)

b. Production (P) = Final body weight (W_2) - Initial
body weight (W_1)

c. Respiration (R) = As - P

d. Maintenance cost = R/P

e. Production index = P/A

f. Assimilation efficiency (Ase)

$$= \frac{As}{C} \times 100$$

g. Gross production (growth) efficiency (Pe_1)

$$= \frac{P}{C} \times 100$$

h. Net production (growth) efficiency (Pe_2)

$$= \frac{P}{Ase} \times 100$$

i. Relative consumption rate (RCR)

$$= \frac{C}{\overline{BA} \times T}$$

j. Relative growth rate (RGR)

$$= \frac{P}{\overline{BA} \times T}$$

where, \overline{BA} = arithmetic mean of body weight of a stage

and

T = feeding period in days.

VIII. Analysis of some dietary components of fern and crop plants:

a. Preparation of dry leaf powder : (Banerjee and Haque, 1985) Middle aged fronds of five fern species and leaves of jute and mulberry were collected from the fields. These were shade dried for 24 hours and finally oven dried at 50°C for 48 hours. Later the leaves were crushed to fine powder in a grinder and kept in sealed polythene packets in a desiccator over fused calcium which were given a specific code for each type. Most biochemical estimations have been based on atleast three replicates unless otherwise mentioned.

b. Storage protein : (Draper 1976 ; Lowry et al 1951)

EXTRACTION

i) The dried leaf powder (500 mg) was extracted with 5 % K_2SO_4 and filtered after three hours. The filtrate was used for the estimation of salt soluble proteins i.e. albumin and globulin.

ii) The residue was then ground with 70 % ethanol and kept at 50°C for 4-5 hours and then filtered while hot. The filtrate was used for the estimation of prolamin.

iii) The residue was again treated with .05 (N) NaOH in 50 % (V/V) ethanol for three hours and filtered. The filtrate was used for the estimation of glutelin.

ESTIMATION :

An 'alkaline solution ' was prepared by mixing 50 ml of alkaline Na_2CO_3 solution (20g/l Na_2CO_3 in 0.1 mol/l NaOH) and 1 ml of CuSO_4 - sodium potassium tartrate solution (5g/l $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ in 10g/l NaK tartrate).

5ml of the alkaline solution was added to 1 ml of the test solution, mixed thoroughly and allowed to stand at room temperature for 10-15 minutes. 0.5 ml of diluted Folin-Ciocalteu reagent (1:1) was added rapidly with immediate mixing. Reading was taken in a spectrophotometer (Systronic Model No. 106) against an appropriate blank at 750 nm after 30 minutes. BSA was used as standard. The quantities of the above classes of proteins were added to give total dietary protein in mg/g.

c. Nutritive Carbohydrate : (Ananthakrishnan, 1990 ; Plummer 1979)

EXTRACTION :

Dried leaf powder was initially made fat free by using petroleum ether and filtered. The residue was taken in 80% ethanol and heated in a water bath for five minutes. The extract was then blended with chromic acid treated sand and squeezed through a thick muslin cloth. The residue was re-extracted for 5 minutes, cooled and squeezed again. The total extract (filtrate) was used for estimation of mono- and oligosaccharides. This was followed by treatment of the residue with HCl and heating for hydrolysis of starch. The filtrate was used for estimation.

ESTIMATION :

The above filtrates were initially made protein free to avoid interference and to obtain better results. For dilution 1.5 ml of water was added to 0.1 ml of test solution. This was followed by adding 0.2 ml of BaOH and 0.2 ml of aqueous $ZnSO_4$ solution with thorough shaking and finally centrifugation. The supernatant was used for the estimation. To 1 ml of protein free test solution was added 4 ml of antrone reagent (2 gm/l in concentrated H_2SO_4) and mixed rapidly in glass test tube. The tubes were placed in a boiling water bath for 10 minutes with a marble on top to prevent loss of water by evaporation. This was followed by cooling and reading the extinction at 620nm against a reagent blank. Glucose was used as standard. Mono-, oligo-, and polysaccharides (starch) were added to give the total nutritive carbohydrate in mg/g.

d. Total lipid : (Ananthakrishnan ,1990)

The extraction and estimation of a total lipid in the dried leaf powder was done by gravimetric method. 500 mg of the leaf powder was ground with petroleum ether and filtered in a previously weighed glass tube. The residue was homogenised again with petroleum ether and filtered. Five such repetitions were done. The filtrate

was placed in an oven at 50°C for complete evaporation. The test tubes were reweighed and the difference in weight gave an account of the lipid present in mg/g.

e. Total phenol: (Ananthakrishnan, 1990 ; Hori, 1974)

EXTRACTION :

Dried leaf powder (fat free) was taken in 80% ethanol. The extract was taken in a hot water bath for five minutes followed by blending with chromic acid treated sand and squeezed through a thick muslin cloth. The residue was reextracted for five minutes, cooled and squeezed again.

ESTIMATION :

0.1 ml of the test solution was made upto 1 ml with the addition of distilled water and 3 ml of water was added for further dilution. 0.1 ml of Folin reagent (1:1) was added followed by addition of 1 ml of saturated Na_2CO_3 solution after 10 minutes. The reading was taken 30 minutes later at 660 nm. Quantity was expressed in percent. pyrogallol was used as standard.

f. Soluble and condensed tannin : (Harborne 1973; Bate-smith, 1973 ; Swain 1979).

EXTRACTION

A methanol extract was prepared by treating 500 mg

of leaf powder with hot 50% aqueous methanol. The residue obtained after filtration was used for further extraction.

ESTIMATION :

For the estimation of soluble tannin, known volume of extract was mixed with an equal volume of fresh sample of diluted human blood (1:50 with water). The mixture was centrifuged to remove the tannin-protein precipitate. The residual haemoglobin was determined by its absorbance at 578 nm. and from this the TAE (tannic acid equivalent) in percent calculated. Tannic acid was used as standard. The condensed tannin was estimated by concentrating a known volume of extract to 1/3 its volume by heating with n-butanol containing 5 % conc. HCl (0.5 ml extract with 4 ml reagent) for two hours at 95°C. The absorbance was then measured in a spectrophotometer at 545 nm (for cyanidin) and at 560 nm (for delphinidin). Catechin was used as standard. Quantity was expressed in percent.

g. Non-extractable components : (Rowell et al.1983)

500 mg of leaf powder was successively extracted with chloroform ether (3:1), 80% methanol and then hydrolyzed with 3% H₂SO₄ at 100°C for thirty minutes. The residue was then dried to constant weight and the weight was recorded and expressed in percent.

h. Moisture estimation : (Ananthakrishnan, 1990)

The amount of moisture in the fresh leaves/fronds was determined by weighing a known weight of fresh plant material. This was kept at 50°C in an incubator till a constant weight was obtained. The difference between the initial and final weight gave an estimate of the moisture content in percent.

i. Statistical calculations and computer software:

The essential statistical calculations were done using standard methods available from Daniel (1974), Bailey (1985), Palani Chamy and Manoharan (1990) and calculator model Casio Fx 82c. Computer software used for drawing graphs were based on programmes of HPG (Harvard presentation graphics). The programme was obtained from University Computer Centre and Commerce Department of the University.

Fig.10. Apanteles sp. -- a larval parasitoid
of Spilarctia obliqua.

Fig.11. Tachinid fly -- a larval pupal
parasite of Spilarctia insignata.



Fig.10.



Fig.11.

Table I : Terrestrial fern species of Darjeeling plain and their collection spots.

Fern species	Collection spots
1. <u>Blechnum orientale</u> Linn.	Kalabari
2. <u>Christella appendiculate</u> (Pr)Holt	New Chumpta, N.B.U. Bengdubi?
3. <u>Christella aridus</u> (Holt)*	New Chumpta, N.B.U.
4. <u>Christella crinipes</u> (HK) Holt	Chandmani, Dwara, Kalabari.
5. <u>Christella parasiticus</u> (L) Holt	Panighatta, N.B.U., Bengdubi.
6. <u>Cyathea spinulosa</u> Wall Hook	Bengdubi
7. <u>Diplazium esculentum</u> (Retg)Sw*	New Chumpta, N.B.U., Chandmani, Kalabari
8. <u>Dicranopteris linearis</u> (Brum.f)*	Atal, Bengdubi
9. <u>Lindsea ensifolia</u> Sw.*	Kalabari.
10. <u>Lygodium flexuosum</u> (L.)Sw	Kalabari, Chandmani
11. <u>Macrothelypteris torresiane</u> (Gaud) Ching	Kalabari, Patramjut

..contd..

Table I continued

Fern species	Collection spots
12. <u>Microlepia speluncae</u> (L.) Moore*	Patramjut, Kalabari
13. <u>Onichium siliculosum</u> (Desv)C. Chn.	Kalabari, Bengdubi.
14. <u>Pityrogramma calomelanos</u> (L.)Linx.	Bengdubi, Kalabari
15. <u>Pteris laiaurita</u> Linn.	New Chumpta.
16. <u>Pteris simipinnata</u> Linn.	Bengdubi
17. <u>Pteris vittata</u> Linn.	Kalabari, Kamalpur
18. <u>Thelypteris</u> sp.	Bengdubi, Panighatta
	N. B. U.

* Commonly occurring fern species.

Table II : Frequency of five apparent fern species occurring in patches

FERN	FREQUENCY OF OCCURRENCE (%)	INSECT HERBIVORES (%)
<u>Diplazium</u> <u>esculentum</u>	71.95	87.50
<u>Christella</u> <u>crinipes</u>	57.92	43.75
<u>Microlepia</u> <u>speluncae</u>	23.17	6.25
<u>Lindsea</u> <u>ensifolia</u>	10.36	6.25
<u>Dicranopteris</u> <u>linearis</u>	3.65	0

Table III : Insects associated with ferns
of Darjeeling plain

Insect name and Order	Family
<u>LEPIDOPTERA</u>	
1. <u>Callopietria placodoides</u> (Guen.)	Noctuidae
2. <u>Prodenia litura</u> (Fabr.)	" "
3. <u>Spodoptera mauritia</u> (Boisd)	" "
4. <u>Eriopus</u> sp.	" "
5. <u>Spilarctia casigneta</u> (Koll.)	Arctiidae
6. <u>Spilarctia obliqua</u> (Wlk.)	" "
7. <u>Spilosoma</u> sp.	" "
8. <u>Diacrisia punctata</u> (Moore)	" "
9. <u>Nacoleia vulgaris</u> (Hampson)	Pyralidae
10. <u>Psara ustulalis</u> (Hampson)	" "
11. <u>Amata cyssea</u> Cramer	Ctenuchidae
12. <u>Microlepidopteran</u> sp. (indet)	
<u>COLEOPTERA</u>	
1. <u>Anthicus</u> sp.	Anthicidae
2. <u>Chrysolina inconstans</u> Wied.	Chrysomelidae
3. <u>Aspidomorpha dorsata</u> (F.)	" "
4. <u>Aspidomorpha nr indica</u> Boh.	" "
5. <u>Aspidomorpha sanctaerueis</u> (F.)	" "
6. <u>Hoplasoma unicolour</u> (Tu)	" "

.....Contd.

Table III continued

Insect name and order	Family
7. <u>Manoba</u> sp.	Chrysomelidae
8. <u>Monolepta</u> sp.	" "
9. <u>Altica</u> sp.	" "
10. <u>Aphaniptera</u> sp.	Buprestidae
11. <u>Afissa dumerili</u> (Muls.)	Coccinellidae
12. <u>Cryptogonus quadriguttatus</u>	" "
13. <u>Nanophyes</u> sp.	Curculionidae
14. <u>Alcides</u> sp.	" " °
15. <u>Astycus lateralis</u> (F)	" "
16. <u>Mylocerus discolour</u> (Boh).	" "
17. <u>Phytoscaphus</u> sp.	" "
18. <u>Lagria</u> sp.	Lagridae
19. Species A (indet)	Elateridae

HEMIPTERA

1. <u>Macromyzus</u> sp.	Aphididae
2. <u>Tinocallis himalayensis</u>	" "
3. <u>Cloviea conifera</u> (Walk)	Cercopidae
4. <u>Typhlocyba</u> sp.	Cicadellidae

...contd..

Table III continued

Insect name and order	Family
5. <u>Bathrogonia ferruginea</u> Fabr.	Cicadellidae
6. <u>penthmia juno</u> Dist	" "
7. <u>Gargara robusta</u> (Dist)	Membracidae
8. <u>Homoeocerus</u> sp.	Coreidae
9. <u>Cletus bipunctatus</u> Westw.	" "
10. <u>Leptocorisa acuta</u> (Thunb)	" "
11. <u>Spilostethus pandurus militaris</u> (Fabr)	Lygaeidae
12. <u>Graptostethus trisignatus</u> Dist	" "
13. <u>Agonoscelis nubila</u> Fabr.	Pentatomidae
14. <u>Erthesina guttata</u> (Fabr)	" "
15. <u>Eusarcocoris ventralis</u> Westw.	" "
16. <u>Dysdercus koenigii</u> (Fabr)	Pyrrhocoridae
17. <u>Iphite limbata</u> stal.	" "
18. <u>Chrysocoris stollii</u> (Wolff.)	Scutellenidae
19. Species A (indet)	Miridae
20. Species B (indet)	" "

HYMENOPTERA

1. <u>Stromoboceros congener</u> knw.	Tenthredinidae
2. <u>Apanteles</u> sp.	Braconidae
3. Species A (indet)	Ichneumonidae
4. Species B (indet)	Chalcidae

...contd...

Table III continued

Insect name and order	Family
<u>ORTHOPTERA</u>	
1. <u>Atractomorpha crenulata</u> (Fabr.)	Acrididae
2. <u>Phlaeoba panteli</u> (Bolivar)	" "
<u>THYSANOPTERA</u>	
1. <u>Heliothrips haemorrhoidalis</u> (Bouche)	Thripidae
2. <u>Elaphrothrips</u> sp.	Phlaeothripidae
<u>DIPTERA</u>	
1. <u>Exorista</u> sp.	Tachynidae

Table IV : Familial distribution of fern
associated insects

Order/ Family	No. of genera	No. of species	Ordinal total
<u>LEPIDOPTERA</u>			
Noctuidae	4	4	...
Arctiidae	3	4	...
Ctenuchidae	1	1	...
Pyralidae	2	2	11
<u>COLEOPTERA</u>			
Anthicidae	1	1	...
Buprestidae	1	1	...
Chrysomelidae	6	8	...
Coccinellidae	2	3	...
Curculionidae	5	5	...
Lagridae	1	1	...
Elateridae	1	1	20
<u>HEMIPTERA</u>			
Aphididae	2	2	...
Cercopidae	1	1	...
Cicadellidae	3	3	...
Membracidae	1	1	...

..contd...

Table IV continued

Order / Family	No. of genera	No. of species	Ordinal Total
Miridae	2	2	...
Coridae	3	3	...
Lygaeidae	2	2	...
Pentatomidae	3	3	...
Pyrrhocoridae	2	2	...
Scutellenidae	1	1	20
<u>HYMENOPTERA</u>			
Braconidae	1	1	...
Chalcidae	1	1	...
Ichneumonidae	1	1	...
Tenthredinidae	1	1	4
<u>ORTHOPTERA</u>			
Acrididae	2	2	2
<u>THYSANOPTERA</u>			
Thripidae	2	2	2
<u>DIPTERA</u>			
Tachinidae	1	1	1

Table V : Fern infesting species attacking other
economic plants

INSECT SPECIES	ECONOMIC PLANTS
<u>LEPIDOPTERA</u>	
<u>Spodoptera mauritia</u>	Rice, wheat foliage and millets
<u>Spilarctia casigneta</u>	Black gram, sunflower, castor
<u>Spilarctia obliqua</u>	Jute, sesamun, castor, sunflower, mulberry, sugarbeat, ladies finger, groundnut, potato
<u>COLEOPTERA</u>	
<u>Astycus lateralis</u>	Tea, millets, jute, cotton and sunhemp
<u>Mylocerus discolour</u>	Drumstick, rice, wheat, cotton.
<u>HEMIPTERA</u>	
<u>Agnoscelis nubila</u>	Ber, tobacco, pulses, rice, wheat and millets.
<u>Eusarcocoris ventralis</u>	Sesamun
<u>THYSANOPTERA</u>	
<u>Heliothrips haemorrhoidalis</u>	Citrus, tea , coffee.
<u>ORTHOPTERA</u>	
<u>Atractomorpha crenulata</u>	Tobacco, sunflower, castor groundnut.

Insect species

JAN FEB MAR APR MAY JUN JLY AUG SEP OCT NOV DEC

LEPIDOPTERA

Spilarctia casigneta

Spilarctia obliqua

Psara ustulalis

Microlepidopteran sp.

Callopietria placodoides

COLEOPTERA

Anthicus sp

Aphaniptera sp.

Astycus lateralis

Myloceros discolour

Weevil (indet)

HEMIPTERA

Eusarcocoris ventralis

Gargara robusta

Penthimia juno

Tinocallis sp.

Macromyzus sp.

Mirid (Species A)

Mirid (Species B)

....contd..

Insect species	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
<u>ORTHOPTERA</u>												
<u>Atractomorpha crenulata</u>						—————						
<u>Phlaeoba panteli</u>						—————						
<u>HYMENOPTERA</u>												
<u>Stromboceros congener</u>							—————				—————	
<u>Apanteles sp.</u>						—————						
Chalcids							—————					
Percent of species occurring	20	20	23.3	16.6	16.6	33.3	50	33.3	20	10	16.6	16.6

: Horizontal bars represent the period of occurrence of the insects