STUDIES ON THE ARTHROPOD PESTS INFESTING MULBERRY PLANTS AT BHUBANESWAR

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BY
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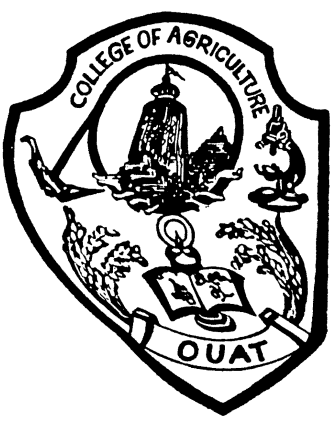

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MY BELOVED PARENTS

ABSTRACT

In Bhubaneswar locality the mulberry crop was attacked by 35 species of arthropod pests. Two species of leaf-tiers (Margaronia pulverulentalis Hmps., M. pyloalis Walker), mealy bug (Maconellicoccus hirsutus (Green)), two species of bagworms (Mahesena sp. and and Manatha albipes) and five species of grasshoppers (Cyrtocanthacris ranacea Stoll, Attractomorpha crenulata Fab., Letana inflata Brunner including two unidentified ones) regularly occurred and caused mild to moderate leaf damage during the period from February, 1992 to April, 1993. The cumulative leaf damage due to the recorded pests at Bhubaneswar was 10.123%. The two species of bagworms, Mahesena sp. and Manatha albipes and the sphecid wasp, Crabro orientalis Cameron were recorded for the first time as the pests of mulberry. Myllocerus weevils, although appeared regularly caused negligible damage to the leaf. In summer season mulberry crop was attacked mostly by leaf-tiers, bagworm, (Mahesena sp.) & mealy bug whereas, during the winter season the following pests namely M. pyloalis, Manatha albipes, Euproctis fraterna Moore, Myllocerus weevils infested mulberry plants. Correlation studies showed that the mealy bug infestation was positively correlated with temperature ($r=0.61^*$). Leaf infestation due to leaf-tiers was negatively correlated with relative humidity ($r=-0.41^*$). Sporadic pests like Spodoptera litura Fab., Pthonandria sp. appeared and caused damage for a brief period. In confinement, the lepidopterous larvae consumed 17.69% to 45.70% leaf lamina/insect/day. Adult grasshoppers consumed 11.09 to 33.89% of the leaf lamina/insect/day. In terms of green weight consumption, the respective figures were from 0.029 to 0.379 gm and from 0.142 to 0.504 gm/insect/day. Mulberry pests at Bhubaneswar were associated with 18 species of natural enemies which included seven species of insect predators, two species of parasites and nine species of spiders. The ladybird beetle Illeis cincta was found to be mildewvorous and insectivorous in its grub and adult stages.

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CERTIFICATE - I

This is to certify that the thesis entitled **"ARTHROPOD PESTS INFESTING MULBERRY PLANTS AT BHUBANESWAR"** submitted in partial fulfilment of the requirements for the award for the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** to the Orissa University of Agriculture & Technology Bhubaneswar, is a faithful record of bona fide research carried out by **SRI KASHINATH KHUNTIA** under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma or published in other form. The assistance received by him from various sources during the course of investigation has been duly acknowledged.

(Dr. N.C. Patnaik)
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CERTIFICATE-II

This is to certify that the thesis entitled **"ARTHROPOD PESTS INFESTING MULBERRY PLANTS AT BHUBANESWAR"** submitted by **SRI KASHINATH KHUNTIA** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE (ENTOMOLOGY)** has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with an external examiner.

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CHAPTER I

INTRODUCTION

INTRODUCTION

Sericulture is one of the agro-based rural industries having sizeable potential for alleviating rural poverty in Orissa. Advantages of sericulture over other land-based activities lies in the facts that sericulture has short gestation period, low capital investment, high employment potential, good market and sizeable return, conserves soil, water and environment, checks migration of population from rural to urban areas and ensures flow of resources from rich to poor. It is, therefore, often said, "Sericulture is a pleasure of the rich and treasure of the poor".

Orissa produces three types of silk, viz., Mulberry, tasar and eri. The first one is comparatively a new introduction into the state, Karnataka, Andhra Pradesh, Tamil Nadu, Jammu and Kashmir and West Bengal being the traditional mulberry states contributing more than 90% of the national production of 11,487 tonnes of raw silk, (Anon., 1992). Orissa is traditional a tasar growing state where the tribal folk of Mayurbhanj, Keonjhar, Sundargarh, Dhenkanal and Sambalpur grow the tasar worms outdoors from time immemorial, Eri silkworm is

grown in very small pockets in the state. Since eri fibre is spun, its market value is low.

Though Orissa is a non-traditional mulberry growing state, yet certain pockets of the state have been identified to have immense potentiality for mulberry sericulture. The agro-climatic conditions prevailing in these areas and the socio-economic conditions of people offer great scope for the trade. Moreover, there is good market for silk yarn which finds its use in the strong handloom sector of the state.

Mulberry sericulture was introduced in the state during the Sixth Five Year Plan. During the 7th plan period it was extended upto the beneficiary level in 32 blocks. A special Bivoltine Sericulture Development Project (BSDP) was started by the Central Silk Board in Mohana and R.Udayagiri blocks of Ganjam districts which operated for four years from 1987-91. A National Serculture Project (NSP) is operating in Koraput district by CSB from 1989-90.

The Directorate of Textiles, Govt. of Orissa is operating the mulberry sericulture in 40 community blocks in 9 districts as follows-Phulbani (No. of blocks=10), Koraput (12), Kalahandi (3) Ganjam (3) Puri (3), Sambalpur (3), Keonjhar (4) Mayurbhanj (1), and Dhenkanal (1). The Orissa State Tasar and Silk Co-operative Society Ltd. (OSTSC) looks into the marketing aspects of silkworm cocoons and silk yarn through its 61

primary Tasar Co-operative Societies, 37 Mulberry Rearers Co-operative Society is looking the marketing of cocoons and yarns. Various state-sponsored and OSTSC-sponsored schemes have been launched to help the silkworm rearers and reelers of the state.

The mulberry plant (Morus alba L.) is the only food plant of the mulberry silkworm (Bombyx mori L.). The leaf is the commercial part of the plant as the silkworm feeds upon them and synthesizes the valuable protein (fibroin and Sericin) that is the produced as the silk. Various injurious insects and non-insect pests attack to the different parts of the mulberry plant, viz., leaf, shoot, stem, fruit and root and lower the leaf yield and deteriorate the quality. The crop is frequently prunned and during the course of silkworm rearing leaves are regularly plucked to feed the worms. These processes remove a considerable number of immature stages of the pests which fail to build up their population upto economic injury level. Nevertheless, some pests get sufficient opportunity and time to breed and attain pest status on the crop. Most of the mulberry pests are polyphagous in nature and migrate to the mulberry plant from adjacent crop fields. Another favourable position for the pests is that the mulberry crop sparsely receives insecticidal protection and the pests, therefore, enjoy a comfortable and ambient environment to sustain themselves in the mulberry garden.

Apart from directly damaging to the leaves, some sucking pests like mealy bugs and leafhoppers transmit viral diseases, thus lower the quality of the leaf which in turn affects health of the silkworms.

In Orissa the mean productivity of green Cocoon/ 100 dfls. is only about 15 kg. Well managed crop and adoption of modern technologies in silkworm rearing can of course give yield of atleast 60 kg. green Cocoon/100 dfls. if not more. The reasons attributable to such low yield are poor yield of leaves both quantity-wise and quality-wise, disease infection in worms, low ERR and high leaf : Cocoon ratio. It is estimated that silk worms from 100 dfls. would need about 800 kg. of mulberry leaf and cross-bred worm need more (Anon.,1991).

No exact estimate is available on the leaf yield loss due to diseases and pests of mulberry. However, the rough estimate of crop loss particularly in the tropical region due to disease and pests of mulberry comes around 5-10% and due to diseases of silk-worm comes to 20-25% (Sengupta et al., 1990).

Under Orissa conditions very little information is available on the spectrum of mulberry pests and much less information on their behaviour and extent of loss they cause during the year. The sketchy information which is presently available on the pest complex is highly speculative basing from elsewhere

and not based on experiments or tests done in Orissa. It is in this context that a detailed study on the complexity of the pest problem is warranted.

The present study "Arthropod pests infesting mulberry plants at Bhubaneswar" was, therefore, undertaken with the following objectives in view (i) determination of pest complex of mulberry plants, (ii) nature and extent of their damage, (iii) seasonal incidence of pests and correlation of pest activities with meteorological data, (iv) quantity of leaf consumed by some important pests in laboratory conditions, (vi) the complex of natural enemies of mulberry pests and their seasonal activities.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

1.0 FAUNAL COMPOSITION

Mulberry plants are grown in both temperate and tropical area of the globe. Obviously, therefore, the pest spectrum of mulberry undergoes great variability depending upon the climatic conditions. But inspite of this climatic dissimilarity, some pests are common to all the mulberry zones.

Maki (1916) listed 87 insect and six non-insect species injurious to mulberry crop in Taiwan. Umeya and Omi (1935) reported 118 insect pests of mulberry from Korea. According to Chu (1936), 136 species of insects attack mulberry in China. Kikuchi (1976) reported that in Japan 200 species of insects attacked the mulberry plant.

In India as many as 66 arthropod pests infesting mulberry have been reported by various workers (13 species by Sidhu et al., 1966; 8 species by Ullal and Narasimhanna, 1971; 30 species by Rangaswami et al., 1976; 23 species by Puttarudriah, 1977; 66 species by Kotikal, 1982 and 13 species by Sharma and Tara, 1985).

In Orissa no systematic population census has been undertaken for the mulberry pests. However, the occurrence of six insect pests has been reported in Orissa (Anon, 1991). For ready reference a check list of mulberry pests recorded till date in published literature is embodied hereunder (Table 1).

2.0 HOST RANGE AND BIONOMICS OF MULBERRY PESTS

2.1 FOLIAGE FEEDERS

2.1.1 Lepidoptera

Bihar hairy caterpillar : The Bihar hairy caterpillar, Spilosoma (Diacrisia) obliqua Walker is a polyphagous pest and mulberry is one among the favourite host plants. It has been reported on mulberry plants from Taiwan (Maki, 1916), China (Djou, 1938) and India (Rangaswami et al., 1976; Puttarudriah, 1977 and Sengupta et al., 1990). The pest has a variety of alternative hosts like groundnut, sunflower, sesamum, jute, sunhemp, cotton, rice pea, lucern, pearl-millet, pulses and maize (Rai, 1976).

Rangaswami et al. (1976) reported that the pest was responsible for the highest damage to the mulbery plants. The caterpillars are voracious leaf eaters and they devour the leaves very fast causing extensive damage to the leaves. During the time of silkworm rearing the growers are very much handicapped as sufficient quantities of healthy leaves are not available due to its infestation. In Karnataka high

Table 1. A check list of arthropod pests of mulberry

Sl. No.	Common name	Scientific name	Family
A.	FOLIAGE FEEDERS	LEPIDOPTERA	
1.	Tobacco caterpillar	Spodoptera litura Fabricius	Noctuidae
2.	Bihar hairy caterpiller	Spilosoma obliqua Walker	Arctiidae
3.	Moringa hairy caterpillor	Eupterote mollifera Walker	Eupterotidae
4.	Tussock caterpiller	Euproctis fraterna Moore	Lymantriidae
5.		E. Lunata Walker	Lymantriidae
6.	Leaf tier	Archips micaceana Walker	Totricidae
7.		Margaronia pyloalis Walker	Pyralidae
8.		M. Pulverulentalis (Hmps)	Pyralidae
9.	Wasp moth	Amata passalis Fab.	Amatidae
10.		Ceryx godarti Bdv.	Amatidae
11.	Spanworm	Pthonandria atrilineata (Butler)	Geometridae
12.	Slugcaterpillar	Laotia (Parasa) lepida (Cramer)	Cochlidiidae
13.	Tigermoth	Spilarotia imparilia Butler	Arctiidae
14.	Wild silk worm	Bombyx mandarina Leech	Bombycidae
15.	White caterpillar	Rondotia menciana Moore	Bombycidae
		ORTHOPTERA	
16.	Short horned grasshopper	Aiolopus simulatrix simulatrix Walker	Acrididae
17.	Cotton grasshopper	Cyrtacanthacris ranacea Stoll	-do-
18.	Tobacco grasshopper	Attractomorpha crenulata Fab.	-do-
19.	Wingless grasshopper	Neorthacris acuticeps nilgriensis Uvarov	-do-
20.	Deccan grasshopper	Colemanis sphenerioidea Bolivar	-do-
21.	Longhorned grasshopper	Phaneroptera gracilis Burmeistor	Tettigonidae
22.	-	Letana inflata Brunner	Tettigonidae
23.	Longhorned grasshopper	Tettigona albifrons Fab.	Tettigonidae
24.	-	Holochlora brevifissa Brunner	Tettigonidae
25.	Cricket	Brachytrupes portentosus echlenetein (Re.)	Gryllidae
		COLEOPTERA	
26.	Myllocerus weevil	Myllocerus discolor var Variegata Bohemann	Curculionidae
27.	-	M. subfasciatus Guer	Curculionidae

Sl. No.	Common name	Scientific name	Family
28.	Myllocerus weevil	*M. viridanus* Fabricius	Curculionidae
29.	-	*M. postfasciatus* M.	Curculionidae
30.	-	*M. undecimpustulatus* Faust	Curculionidae
31.	-	*Apion ampulum* Fabricius	Curculionidae
32.	-	*Baris deplanata* Roclofs	Curculionidae
B. SAP FEEDERS:			
		THYSANOPTERA	
33.	Thrips	*Agaphothrips sudanensis* (Trybom)	Thripidae
34.	-	*Baliothrips mori* (Niwa)	Thripidae
35.	-	*Dendothrips mori* (Linnaeus)	Thripidae
36.	-	*Hoplothrips coloratus* (Trybom)	Thripidae
37.	-	*Pseudodendothrips mori* Niwa	Thripidae
38.	-	*Scirtothrips dorsalis* (Hood)	Thripidae
39.	-	*Thrips flavus* (Schrank)	Thripidae
40.	-	*Taeniothrips glycines* (Okomoto)	Thripidae
41.	-	*T. melanicornis* (Shumsher)	Thripidae
42.	-	*T. claratris* (Shumsher)	Thripidae
43.	-	*Tryphactothrips rutherfordi* Bagnall	Thripidae
		HOMOPTERA	
44.	Leaf hopper	*Asymmetrasca decidens*	Cicadellidae
45.	-	*Empoasca flavescens* Fb.	Cicadellidae
46.	-	*E. pecipiens*	Cicadellidae
47.	-	*Flata ferrugata* (Fb.)	Cicadellidae
48.	-	*Helavrita discolratus* Dist.	acicadellidae
49.	-	*Kolla* Sp.	Cicadellidae
50.	-	*Macrosteles sexnotatus*	Cicadellidae
51.	-	*Nisia atrovenosa* (Linn.)	Cicadellidae
52.	Mealy bug	*Drosicha contrahens* (Walker)	Coccidae
53.	-	*Drosicha mangiferae* (Green)	Coccidae
54.	-	*Dysmicoccus brevipes* Cockrell	Psendococcidae
55.	-	*Icerya aegyptica* Douglass	Coccidae
56.	-	*Perissopneumon tamarinda* (Green)	Margarodidae
57.	-	*Maconellicoccus hirsutus* (Green)	Pseudococcidae

Sl. No.	Common name	Scientific name	Family
58.	Mealy bug	Nippaecoccus viridis (Newstead)	Pseudococcidae
59.	Aphid	Aphis gossypii Glover	Aphididae
60.	-	Rhopalosiphum maidis Fitch	Aphididae
61.	Green peach aphid	Myzus persicae Sulz	Aphididae
62.	Marlatto Whitefly	Aleurolobus marlatti (Quaintance)	Aleyrodidae
63.	White fly	Bemisia sp.	Aleyrodidae
64.	Cow bug	Hbsauchenia subfusca Buckton	Membracidae
		HEMIPTERA	
65.	Pentatomid bug	Eusarcocoris ventralis Walker	Pentatomidae
66.	Mulberry bug	Halys denrtus Fabricius	Pentatomidae
67.	Nezara bug	Nezara virudula Linn.	Pentatomidae
68.	Bug	Histrio menida Fab.	Pentatomidae
C. STEM FEEDING INSECTS			
		DIPTERA	
69.	Mulberry shoot midge	Daplosi mori Yokoyama	Cecidomyiidae
		COLEOPTERA	
70.	Stem borer	Apriona cinerea Chevelat	Lamiidae
71.	-	Apriona germari (Hope)	Lamiidae
72.	-	Apriona japonica Thomson	Cerambycidae
73.	-	Batocera rufomaculata (De Geer)	Cerambycidae
74.	-	B. rubus (Linnaeus)	Cerambycidae
75.	Yellow spotted longicorn beetle	Psacothea hilaris (Psacoe)	Cerambycidae
76.	Mulberry borer	Xylotrea chinensis Chevrolant	Cerambycidae
77.	Stem girdler	Sthenias grisator Fab.	Cerambycidae
78.	Stem borer	Cabro orientalis Comeron	Sphegdoe (Hymeroptera)
		HOMOPTERA	
79.	Red scale insect	Aonidiella aurantii (Maskell)	Coccidae
80.	Scale insect	Aonidiella citrina (Coquellett)	Coccidae
81.	-	A. orientalis (Newstead)	Coccidae
82.	Purple scale insect	Chrysomphalus aonidum (Linn)	Coccidae
83.	Japanese wax scale	Ceroplastes ceriferus (Anderson)	Coccidae
84.	Scale insect	Diaspis pentagona (Torgioni & Tozzetti)	Diaspidae
85.	-	Parlatoria aleae (Colvee)	Diaspidae

Sl. No.	Common name	Scientific name	Family
86.	Mulbery scale insect	Pseudaulacapsis pentagona (Torgioni, Tazzettii)	Coccidae
87.	Soft scale insect	Puluinaria maxima Gr.	Coccidae
88.	San jose scale	Quadraspidiotus pernicosus (Comstock)	Diaspidae
89.	Black scale	Saissetia nigra (Niet)	Coccidae
90.	Powder post beetle	Sinoxylon pubens	Lyctidae Coleoptera
91.	Bark beetle	Indarbela quadrinotata Walker	Metarbelidae Coleoptera
92.	Clearwinged moth	Paradoxecia pieli Lieu	Aegeriidae Lepidoptera
D. PEST OF FRUITS			
93.	Fruitfly	Dacus tau Walker	Tripetidae Diptera
94.	Shoot and capsule borer	Dichocrosis punctiferalis Guenee	Paurastidae Ord, Lepidopter
E. ROOT FEEDERS			
95.	Termite	Odontotermes spp.	Termitidae Isoptera
96.	Myllocerus weevil	Myllocerus spp.	Curculionidae Coleoptera
F. DISEASE TRANSMITTER			
97.	Hibiscus mealy bug	Maconellicoccus hirsutus (Green)	Pseudococcidae Ord. Homoptera
G. ARTHROPOD NON-INSECT PESTS			
		ACARINA (PROSTIGMATA)	
98.	Mite	Tetranychus equitorius Ms Gr.	Tetranychidae
99.	-	T. telarius Linnaeus	Tetranychidae
100.	-	T ludeni Zacher	Tetranychidae
101.	-	T. bimaculatus (Harv.)	Tetranychidae
102.	-	T. truncatus (Ehara)	Tetranychidae
103.	-	T. neocoledonicus (Andre)	Tetranychidae

incidence is observed from November to January. The life cycle of the insect is completed in 48 days with a larval duration of 30 days. About 1000-1200 green eggs with a metallic shinning colour are laid by the female moth on small batches on the lower surface of the leaves. The incubation period is from 5-7 days. The newly hatched larvae are gregarious in habit and cluster together on a single leaf. These gregarious larvae devour the chlorophyll region during their early stage and leave behind the veins which look like a dried leaf. When the larvae attain third instar they start dispersing to different branches. The larva completes six moults before attaining full size. The full grown larva pupates in loose soils. It lies inside a thin silken cocoon formed by the interwoven shed hairs of the larva. The pupal period lasts for 12-14 days.

Kotikal (1982) recorded the incidence of this pest on mulberry from the last week of August to mid October.

Larvae of Bihar hairy caterpillars are parasitised by Apanteles obliquae Wilkinson. The parasites after completing the larval stage come out from the host body for pupation thus killing the host (Rangaswami et al., 1976). Lefroy (1907) studied the biology and bionomics of A. obliquae in Bihar. The percentage of larval parasitism was 5-20 in the field from August to March, the highest being during November.

Tobacco caterpillar : The tobacco caterpillar, Spodoptera litura (Fab.) is another group of destructive foliage pests of mulberry.

Butani (1978) reported this pest feeding upon leaves of mulberry, tobacco, apple, banana and citrus and bore into the fruits of chillies and tomatoes. The other host plants are groundnut, caster, brinjal, tobacco, tomato, maize, colocasia, jute, indigo, lucern, cabbages, elephant yam, peas, banana leaves, green gram, black gram and cowpea (Amin, 1988).

Sengupta et al. (1990) reported the feeding habit and biology of Spodoptera on mulberry. The caterpillars attack the shoots of young plants and cut them. The cut portions of the shoot dry up and fall down. Young plants or newly sprouted mulberry plants are often found without branches and having dried leaves.

The female moth lays 200-300 eggs in clusters on the lower surface of the leaves. The egg masses are covered with brown hairs. The caterpillars emerge after 4-5 days and the larval period lasts for 2-3 weeks. The full grown larvae pupate inside soil in earthern cocoons. The pupal period in normal condition lasts for two weeks. The total life cycle is completed within 30-40 days.

Kotikal (1982) observed that the pest was active from September to October. Mishra and Sontakke (1992) observed at Chipilima, Orissa that the pest was very active from the last week of August to the first week of September on groundnut.

The extent of leaf damage by this pest has not been worked out on mulberry by previous workers. However, on groundnut Dhir et al. (1992) reported that one larva / plant of groundnut in seedling stage consumed 54.7% leaf area and reduced the pod yield by 25.8% later. At flowering stage one larva/plant consumed 49.1% leaf area and reduced the yield by 19%.. The corresponding figures during the pegging stage were 38.8% and 5.7% respectively. The authors concluded that the seedling and flowering stages of groundnut were most vulnerable to Spodoptera attack.

Several parasites and predators have been reported on this pest. According to Patel et al. (1969), the larvae are parasitised by Euplecturus gopimohani Mani, Charops obtusus Morl (Ichneumonidae), Stronliomyia aegyptica Vill. (Tachinidae), Apanteles colemani Viereck (Braconidae) and eggs are parasitised by Chelonus heliopae Gupta and C. formosanus (Braconidae) in Gujarat.

Moringa hairy caterpillar : The moringa hairy caterpillar, Eupterote mollifera Walker is a brownish hairy caterpillar, commonly found in tropical countries (Venugopala Pillai, 1968). Caterpillars feed on mulberry leaves thus reducing

the leaf yield. Eggs are laid in closely attached mass around the tender twigs or on the petiole of the leaves. The egg period lasts for 9-13 days, larval period 68 days and pupal period 35-60 days. They pupate inside a silken cocoon. These caterpillars are mostly active during August to February (Sengupta et al., 1990). Nair (1975) described its morphology, habits on moringa plant.

Tussock caterpillar : The tussock caterpillars, Euproctis fraterna Moore and E. lunata Walker have polyphagous habits. Apart from mulberry they feed on many other oil seeds, tapioca, fruit crops and plantation crops (Mohana Sundaram, 1973 and Nair, 1975). These hairy caterpillars feed gregariously for a couple of days during the early stages and later disperse to different parts of the plant and feed voraciously on the entire tree (Butani, 1978 and Sengupta et al., 1990). The larvae are yellow in colour with dark tufts of hairs on the second and third abdominal segments. Very long tufts are present on the first thoracic and on the last abdominal segments. The final stage larvae are dark brownish with the presence of large hairy warts measuring 20-25 mm. The first and second abdominal segments have larger warts which give it a humplike appearance.

The biology of E. fraterna and E. lunata have been reported by pillai (1968), Rangaswami et al. (1976), Puttarudriah (1977), Govindan et al. (1980) and Kotikal (1982). According to the last author, the larvae completed 5-6 instars in 31.6

days and the full grown larvae pupated in a thin loose silken cocoon in the folds of the leaves or upto 5 cms below the soil. The pupal period lasts for 9.6 days. The activity of the pest depends upon the cropping season. But according to Govindan et al. (1980) and Kotikal (1982), the pests were very active in the mulberry field from October to March.

Sengupta et al. (1990) recorded the incidence of another species of lymantriid in mulberry commonly called the brown-tail moth (Euproctis similis xanthocampa Dyar), the caterpillar of this insect attack to mulberry buds and devour mulberry leaves. Attack of this pest reduces the leaf yield.

The females lay eggs in heaps on mulberry leaves which are covered with brownish yellow hairs. The body of the caterpillar is clothed with plenty of venomous setae which are irritating to human beings. They cause itching and rashes on contact. It may even cause death if too much of these setae are inhaled. The peak period of incidence of this pest is from spring season and incidence continues upto autumn.

Leaf-tiers : Two species of leaf-tiers namely, Margaronia pyloalis W. and M. pulverulentalis Hmps. have been reported on mulberry plants. Their biology and nature of damage have been described by Rangaswami et al., 1976; Sengupta et al., 1990 and Kotikal, 1982. The caterpillars from third instar onwards generally tie or fold several blades of mulberry leaves with

the silken thread secreted by the larva. The caterpillars devour the mesophyll and lower epidermis from under surface of the leaves leaving only a transparent layer of upper epidermis which are often catted "attic windows".

In Japan this pyralid is commonly known as "Sukhi-mushi" and occurs in serious proportions in summer and late autumn. Fields nearer to rivers and sea are more prone to the pest attack. The pest has also been recorded in Malayasia and China (Rangaswami et al., 1976 and Sengupta et al., 1990). Malik (1986) observed that the pest was serious in mulberry in Jammu and Kashmir. Severe infestation was observed from July to October. Under the prevailing climatic conditions of Kashmir, the pests completed four generations. The pest appears in summer season and continues to damage upto autumn season. For the development of all the life stages, the optimum temperature was found to be 22-25° C.

In warm zones the pest completed ten generations a year. Females lay eggs on the ventral side of the leaf near the margin of veins. Since the larvae are green in colour they are often called "green caterpillars". Larvae moult 5-6 times. Pupae are formed within the leaf folds (Rangaswami et al., 1976). Sengupta (1990) reported that M. pulverulentalis was more active during the dry season.

Many parasites like Macrocentrus Philippiensis Ashmead, Apanteles sp., Diadegma sp. parasitize the larvae of leaf-tier (Sengupta et al., 1990).

Wasp moth : Two species of wasp moths, i.e., Amata passalis Fab. and Ceryx godarti Bdv. have been recorded on mulberry plants. Pillai (1968) recorded C. godarti as a minor pest of mulberry. Kamala Singh (1983) recorded A. passalis as a minor pest of mulberry in mysore and Tamil Nadu. The morphology of the pest has been described and the life history of the insect worker out. The entire life cycle is completed in 77 days. Adults feign death with a slight jerk and fall down. Sengupta et al. (1990) gave a brief account of A passalis infesting mulberry plants. The pest occurs mostly during February to August.

Spanworm : The spanworm, Pathonandria atrilineata Butler is a semilooper pest. The caterpillar begin feeding on mulberry winder buds which just begin to unfold after the dormant season is over. This is the critial stage of damage of the pest. They also feed voraciously on mulberry buds after summer prunning decreasing summer-autumn leaf yield. Besides buds, they also feed on mulberry leaves.

The pest has 2-4 generations in a year in China where hibernation occurs in the caterpillar stage. The young caterpillars are active in day time whereas, in the latter stages, they are more active during the night time. Caterpillars are greyish brown and resemble dead twig. Pupation takes place on surface layers of soil. The pest occurs in summer, autumn and winter seasons (Sengupta et al., 1990).

Slug caterpillar : The slug caterpillar, Laotia (Parasa) lepida (Cramer) has been occasionally recorded feeding on mulberry leaves. It is a polyphagous pest, its main hosts being castor and coconut. It has also been reported feeding on young leaves of banana, citrus, country almond, fig, mango, pomegranate, wood apple, rose and other ornamental plants. On hatching, the caterpillars feed gregariously on leaves and later disperse and feed voraciously on leaves leaving only the midribs. These caterpillars are commonly known as slug caterpillars because they are thick, flat, fleshy and apple green in colour with greenish blue dorsal stripes and two yellowish green lateral stripes. There are a series of tufts of spines on their body which are highly irritant to touch. The egg, larval and pupal periods last for 6-8, 30-38 and 24-30 days respectively. The pest is active from July to September (Butani, 1978).

Tiger moth : The tiger moth, Spilarotia imparilia Butler has been recorded as a minor pest of mulberry by Rangaswami et al. (1976). In Japan, during the spring season, severe damage is caused by this pest to the mulberry crop. The larvae eat up young leaves at the time of bud sprouting and often upset the plans of silkworm rearers. This pest has also been recorded on rice, barly, vegetables and fruit trees. The larvae pupate inside the soil. The life cycle of the insect laste for a year. The larva undergoes diapause in the fourth moult in Japan.

2.1.2 **Other lepidopteran insects of minor importance :** The mulberry plants are often attacked by the wild silkworm Bombyx mandarina Leech and Rondotia menciana Moore and the leaftier, Archips micaceana Walker (Rajashekar-Gouda et al., 1987; Sengupta et al., 1990).

Orthoptera

Nine species of grasshoppers belonging to families Acrididae and Tettigonidae and one species of cricket belonging to family Gryllidae have been reported to feed on leaves of mulberry (Table 1) (Ramachandra Rao, 1921; Tomi-zowa, 1925; Sidhu et al., 1966; Puttarudriah, 1977; Butani, 1978; Kariappa and Narasimhanna, 1981; Kotikal, 1982; Sengupta et al., 1990). A brief summary on the feeding habits of some of these grasshoppers as observed by various workers is presented below.

The Madras locust, Cyrotocanthacris ranacea Stoll was observed especially from March to August and September to January (Sidhu et al., 1966 and Kotikal, 1982). According to kotikal (1982), two long-horned grasshopper species, Letana inflata Brunner and Pheneroptera gracilis Brumeisteir damaged the mulberry leaves from May to September.

The short-horned grasshopper, Aiolopus simulatrix simulatrix Walker and Attractomorpha crenulata F. are active in the months of January and April/May respectively whereas

the Deccan wingless grasshopper, Colemanis sphenerioidea Bolivar causes damage in September and October in Dharwad. Sengupta et al. (1990) observed that the wingless grasshopper, N. a. nigriensis was a minor pest in Southern India.

The cricket, Brachyptrupes portentosus echlenetein (Re.) damages young shoots and buds. The seedlings are particularly vulnerable.. The nymphs and adults collect seedings, leaves and other soft part of the plant and drag them into their burrows where they are stored and consumed. Fresh sappy materials are often left on the surface for a day or two to wilt before being taken into the burrow. This pest generally attacks mulberry grown on such soils where burrows can be easily excavated.

Female lays 300 elongate eggs over a period of 3-4 months. Egg period is about one month. Newly hatched nymph leaves the burrow of the mother cricket and constructs its own. There are four nympnal instars with a total nymphal period of about eight months. They occur in mulberry fields throughout the year (Sengupta et al., 1990).

2.1.3 Coleoptera

Several myllocerus weevils attack the foliage of mulberry plants in India. They include Myllocerus discolor var. Varielgata Bohemann, M. subfasciatus Guer, M. viridanus Fabricius, M. postfasciatus M., M. undecimpustulatus Faust,

and Apion aupulum (Fab.). (Siddapaji, 1976 and Rangaswami et al., 1976). Sengupta et al., 1990 mentioned that Baris deplanata Roelofs attacked mulberry in China, Japan and Korea.

The adult weevils cause injury by feeding on leaves and buds. Irregular serrated margins are observed on foligae by their feeding. The grubs feed on the under ground parts of mulberry. In case severe attack, plants wilt and dry up (Sengupta et al., 1990). The weevils are active from October till December (Kotikal, 1982).

Sengupta et al., (1990) reported that adult females Laid 150-350 eggs in superficial layer of soil over a period of 20-90 days. Egg period lasted for 4-5 days, grub period 40-75 days and the insect completed 3-5 generations in a year. The author observed that the M. discolor breeds on field crops (cereals) and migrate to perennial crops and to the trees during cold and summer months respectively and the adults undergo diapause thereafter.

The weevil, B. deplanata which is found in Japan has only one generation in a year. The grubs bite the cortex of branches and tunnel into the xylem. In about two months, grubs turn into pupae. When the adults emerge from the pupae they overwinter in these tunnels and when the temperature is more than 15°C the adults come out of the holes (Sengupta et al., 1990).

2.2 SAP FEEDERS

2.2.1 Thysonoptera

Rangaswami et al. (1976) reported five species of thrips and Kotikal (1982) recorded six species of thrips which attack mulberry (Table 7). Female thrips lay nearly 30 eggs below the epidermis of the leaf particularly towards the tip. The incubation period last for 4-8 days. The nymphs suck the juice of the mulberry leaf. In about 15-18 days of hatcting, they reach the final stage. The population of P. mori was comparatively higher in March-April, July-August and November-December. Rainfall reduced their population (Pillai and Krishnaswami, 1980). Thrips infestation is very severe in rainfed gardens in Karnataka as compared to irrigated gardens (Ragaswami et al. 1976).

The attack is neglegible in Kolar (Karnataka) where whole shoot harvest is practised and they are more frequent during summer (February-June) (Ragaswami et al., 1976 and Ullal and Narasimhanna, 1981). Majority of the thrips are confined to the terminal tender leaves (Kariappa and Narasimhanna, 1978). Population of thrips/leaf was maximum (24.2) during August. There is a significant positive correlation of thrips population with temperature and negative correlation with rainfall (Kotikal, 1982).

2.2.2 Homoptera

Leafhoppers : Eight species of leafhoppers attack mulberry plants (Table 1) and among them Empoasca flavescens Fab.

is most important. The nymph and adults suck sap from the tender shoots and leaves of mulberry and depleting the nutritional value of the affected leaves. Hopper attack results in development of characteristic symptoms. The tips become brown in colour followed by development of brown patches along the margin. It starts from the periphery and extends towards the midrib of the leaf. This is known as "hopper burn". In the final stage of attack the leaves become cup-shaped and wither up. (Sengupta et al., 1990).

E. flavescens remains active from October till May (Ullal and Narasimhanna, 1981 and Kotikal, 1982). Kariappa and Narasimhanna (1978) observed that in severe cases "hopper burn" to the tune of 40% was observed. Asraf Khan et al. (1990) reported that E. decipiens, Asymmetrasca decidens and Macrosteles sexnotatus were associated mulberry plants in Kashmir. Mostly the terminal portion of the plants were attacked by the leaf hopper and due to heavy curling of leaves futher growth was affected which subsequently resulted in the loss in leaf yield.

2.2.3 **Mealy bugs**

Apart from the common mealybug, Maconellicoccus hirsutus (Green) which transmits "tukra disease" in mulberry. Seven other species of mealybugs also attack mulberry and inflict injury upon the crop (Table 1). Among these four spacies, the habits and injury pattern of Drosicha mangiferae (Green) and D. contrahens Walker have been well documented (Butani, 1974). The former species prefers mango and the latter apart

from mulberry also attacks apricot, citrus, peach and plum in China. D. contrahens has one generation a year. Each female lays 300-400 eggs in soil at a depth of 25-40 mm. The eggs over winter in soil and hatch early in spring. Nymphs soon crawl up the tree around April. The nymphs flock arround the winter buds and suck the sap thereby reducing the plant vigour. During the period of gestation, the female adults fall to the ground and oviposit in soil (Sengupta et al., 1990).

2.2.4 Other leaf sucking pests of mulberry

Among the other homopteran pests which suck cell sap from the leaves, mention may be made on aphids, white flies, psyllids and tree hoppers (cow bug) and pentatomid bugs (Table 1) (Hsieh [illegible] et al., 1985).

Occasionally aphids appear in large colonies and suck the cell sap specially from tender shoots and ventral side of new leaves. They excrete honey dew on the lower leaves on which the black shooty mould develops. The foliage contains a black incrustations which interferes with the photosynthetic activity of the plant (Butani, 1978).

Whiteflies are active through out the year and have several overlapping generations. The nymphs suck cell sap (Butani, 1978).

Chatterjee (1960) observed that in North Bengal mulberry plants were attacked by cow bugs. The nymphs and adults drain out sap from tender parts of the mulberry plant. Rangaswami et al. (1976) reported that pentatomid bugs suck cell sap from tender buds and leaves and made them weak.

2.3 STEM FEEDING INSECTS

The mulberry stem is attacked by various species of insect pests which can be broadly classified into six categories, viz., mulberry shoot gall midge, stem borers, stem girdlers, scale insects, powder-post beetles and bark caterpillars.

2.3.1 Mulberry shoot gall midge

The mulberry shoot gall midge Diplosis mori Yokoyama is a dipteran pest found in Japan. The maggot of the midge lives near the apical leaf exils and eats the growing part. This results in a stunted or abnormal growth of the shoot (Rangaswami et al., 1976).

2.3.2 Stemborer

The stem borer Batocera rufomaculata (DeGeer) is a polyphagous pest. Apart from mulberry, it also attacks apple, fig, guava, jack fruit, mango, pomegranate and walnut. Eggs are laid singly on bark or in crevices on tree trunks. On hatching the grubs tunnel into the main stem and branches

and feed within. Large quantity of frass is exuded by the insect and thrown out from the bored holes which fall on ground below in small heaps. The feeding of the grub within the stem causes withering and falling off of the leaves and if not cared, the attacked branches suddenly collapse. The grub stage is six months and there is only one generation a year. B. rubus is another species of cerambycid beetle of mulberry whose life cycle and feeding habits are similar to B. rufomaculate (Butani, 1978). Another species of stem borer, i.e., Apriona cinerea Chevelat and A. germari Hope have been reported boring mulberry trees (Fletcher, 1921). Both the species attack mulberry plant apart from other fruit crops. The former species has been reported from Kashmir, Himachal Pradesh and Uttar Pradesh (Butani, 1978).

Rangaswami et al. (1976) reported that in Japan A. japonica causes extensive damage to the mulberry stems by laying eggs in tunnels. The young ones grow at the expense of xylem causing the plant to wilt and die. The adults gnaw the epidermis of the green wood. It bites at the xylem and makes a long thin groove where it lays eggs one at a time. The yellow-spotted longicorn beetle, Psacothea hilaris (Pascoe) also inflicts similar type of stem damage as Batocera does in mulberry.

2.3.2 Stem girdler

The stem girdler, Sthenias grisator Fabricius has a peculiar habit of ringing the stem. The bark and wood

are cut neatly by the powerful mandible of the adult beetle all around the main stem or branch leaving a clear girdle. The portion above the girdle gets gradually wilted and dry and is often cut off. Early stages of the pests are passed on girdled branches. The female oviposit during night, beneath the bark often ringing the same. Apart from attacking mulberry, the stem girdler also attacks grapevine, almond, jack fruit, mango, bougainvillaeas, oleander and roses (Butani, 1946). The bionomics of this pest has been worked out by Sanjeeva Raj (1959). According to the author, the grub period occupies seven months with one generation a year. Rangaswami et al. (1976) reported that the adult beetle attacked during night time to allow the girdled branches to dry up so as to enable the grub to tunnel into the dry wood.

2.3.3 Scale insects

Eleven species of scale insects have been reported in literature which injure the bark of the mulberry plant (Table 1). These groups of insects are sap suckers. The scale insects of mulberry are catagorised into black scale, purple scale, red scale, soft scale and wax scale. The stems and shoots of mulberry trees frequently suffer badly from attack of these scales. The affected shoots start drying from the distal end. Yellowish or mottled appearance of the leaf blade can also be noticed. Infested mulberry plants yield scanty amount of leaves of inferior quality and the

budding percentage of the infested tree is decreased. The soft scale attacks the young shoots and young leaves. Affected leaves gradually wilt and honey dew secreted by the insect causes shooty mould formation on the lower leaves, soft scales are usually attended by ants for feeding honey dew. The red scale attacks mulberry plants which are one and half years old. Older plants are rarely attacked. The red scale causes 15-20% mortality of the young plants warranting at times replanting in the field. The black scale, soft scale and red scales are mostly prevalent during summer months whereas, the wax scale is present throughout the year excepting winter months (Nigam, 1971; Rangaswami et al., 1976 and Sengupta et al., 1990).

Scale insects are parasitised by a number of hymenopterous parasites, viz., Prospaltella perniciosi Tower and P. berlesei (Howard) (Sengupta et al., 1990). Besides, three species of coccinelid beetles like Chilochorus kuwane Silvestri, Rodolia cardinalis, Scymnus sp. predate upon the scales (Siddapaji et al., 1984).

2.3.4 **Powder-post beetle**

The powder-post beetles attack the stem of mulberry plants. From the affected stems white powdery substances exude from the injured holes. The affected stem is gradually killed due to extensive tunneling by the insect (Rangaswami et al., 1976).

2.3.5 Bark beetle

The bark eating caterpillar, Inderbela quadrinotata (Walker) feeds in the barks in its early stages and bores into the wood later. It constructs galleries of silk and wood fragments on the bark surface and remains within them. These insects have large number of host plants which apart from mulberry include mango, citrus, guava, tea, ber, cashew and rose.

2.4 PESTS OF FRUITS

The fruit fly Dacus tau Walker attacks the berries of the mulberry plant. Overwintering of the insects takes place in adult stage. Apart from mulberry, it attacks a number of vegetables, citrus, mango and sapota (Butani, 1978). Besides, the shoot and capsule borer, Dichocrosis punctiferalis Guenea attacks the shoot and capsule of mulberry.

2.5 ROOT FEEDERS

Termites, Odontotermes spp. are very destructive pests of mulberry particularly when new cuttings are planted in the field. When the roots are damaged, the attacked plant wilts and withers away. These insects are very serious in soils which are lateritic and sandy (Ullal and Narasimhanna, 1981 ~~1978~~).

As mentioned in earlier sections, the grubs of myllocerus weavils also damage roots of young mulberry plants (Sengupta et al., 1990).

2.6 VECTORS OF MULBERRY DISEASES

Among the serious vectors which transmit mulberry diseases, mention may be made on the mulberry mealy bug, Maconellicoccus hirsutus (Green). According to Rangaswami et al. (1976), the pest is a vector of virus disease called "tukra disease". The mulberry plants affected by tukra disease exhibits curled up and crinkled leaves. The growing tip becomes thick, dark-green in colour with flattening of the apical shoot. In the attacked plant the growth is arrested and they become dwarf. Sinchaisri and Isrankul (1973) mentioned that the mealybug always attacks young shoots, leaves and buds.

Sriharen et al. (1979) observed that the egg laying by M. hirsutus was poor in colder months i.e., November to January and was high from February to August. The percentage of hatching was low in colder months.

Sengupta et al. (1990) in their review described the life cycle and seasonal activity of the mealy bug. The female deposits 350-500 eggs parthenogenetically in a loose cottony terminal ovisac within a week. Eggs hatch in about 5-10 days. The eggs and the crawlers are orange coloured. Nymphs are covered with mealy substances. The four nymphal stages are completed in about 25 days. The pest was very active during the summer months.

2.7 NON INSECT ARTHROPOD PESTS OF MULBERRY

Four species of spider mites have been reported in literature (Table 1) infesting mulberry plants (Sinchaisri and Israrkul, 1973; Rangaswami et al., 1976; Pillai et al., 1980 and Kotikal, 1982). The infested leaves present a sicky appearance with pale spots throughout the blade and in severe cases the entire leaf appears rusty, light in colour and later dries up. The under side of the leaf shows silken thread spun across under which the mites crawl and lay their eggs (Rangaswami et al., 1976). Tetranychus ludeni (Zaher) attacks, besides mulberry, cotton, cucurbits, egg-plant, potato, pulses and tomato (Banerjee, 1988). Occurrence of mite population in mulberry in different agro-climatic regions was observed throughout the year, but the heavy mite infestation was noted during the dry hot season with peak population occurred during month of April and there was considerable reduction in population from June onwards upto August. In case of Tetranychus equitorius Ms Gr, T. telarius L. and T. neocalidonicus Andre, heavy infestation was observed in Dharwad during the winter months i.e., December and no or low infestation during the summer months.

The female mite lays 75-100 eggs at the rate of 2-10 eggs/day which are attached to under surface of leaf within the web which after hatching moult into protonymph, then

to deutonymph and to the adult. Female moults thrice while male moults twice. Generally one generation is completed within 18-40 days and several overlapping generations are common (Rangaswami *et al.*, 1976 and Pillai *et al.*, 1980).

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

1. *EXPERIMENTAL SITE AND SEASON*

A number of field and laboratory experiments were conducted at the Central Research Station of the Orissa University of Agriculture and Technology (O.U.A.T.), Bhubaneswar and in the Department of Entomology, College of Agriculture during the period from February, 1992 to April, 1993. The Central Research Station, O.U.A.T., Bhubaneswar is situated at 20° 15' North latitude and 85° 52' East longitude with an elevation of 30 meters above the mean sea level. The meteorological data of the field pertaining to the period of study are presented in Table 2.

2. *THE MULBERRY CROP AND AGRICULTURAL OPERATIONS*

In the Central Research Station, observations were recorded in the mulberry field which had been raised earlier. Variety Kanva-2 had been planted on 11.11.1991 in pit system at a spacing of 90 x 90 cm. From time to time cultural operations were given as per the standard package. In order to encourage the build up of pest population, the field was not applied with any pesticide. To avoid pesticidal drift, plots on the windward side were kept fallow and on the other sides crops were not treated with any pesticide.

Table 2. Climatological data of the Meteorological station of O.U.A.T., Bhubaneswar during January, 1992 to April, 1993

Standard week	Mean temperature (°C) Max.	Min.	Average	Mean R.H (%)	Mean R.F. (mm)	Rainy days (No.)
1992						
1	22.0	11.3	16.65	70.0	20.5	2
2	27.2	12.5	19.85	64.0	0.0	
3	27.1	14.3	20.7	73.5	0.0	
4	28.6	15.9	22.25	67.0	0.0	
5	28.8	17.7	23.25	76.0	0.0	
6	28.7	18.8	23.75	74.0	0.8	1
7	22.4	17.6	23.5	65.5	0.0	
8	29.6	19.3	24.45	74.5	54.1	2
9	31.3	18.1	24.7	64.0	0.0	
10	34.2	20.5	27.35	64.5	0.0	
11	34.9	21.7	28.30	67.0	0.0	
12	33.7	23.5	28.6	72.0	0.0	
13	35.9	22.6	29.25	66.5	7.5	1
14	39.9	23.1	29.5	65.00	0.0	
15	36.5	24.4	30.45	69.00	2.3	1
16	36.6	24.2	30.40	68.5	0.0	
17	38.7	24.0	31.35	58.5	1.2	1
18	36.3	24.0	30.15	68.0	86.1	3
19	37.7	26.2	31.95	71.0	0.0	
20	36.9	26.7	31.80	71.5	0.0	
21	35.5	24.7	30.1	76.0	155.8	5
22	35.3	26.6	30.95	80.0	9.5	1
23	36.9	26.2	31.55	71.0	37.8	2
24	37.1	26.5	31.80	74.0	11.0	2
25	31.6	25.6	28.60	86.0	68.2	7
26	34.9	26.2	30.55	77.5	77.8	3
27	32.5	25.1	28.80	83.0	27.9	3
28	32.9	25.5	29.20	81.0	5.1	2
29	31.7	25.2	28.45	86.0	92.4	6
30	32.2	24.9	28.55	86.5	171.2	6
31	32.5	25.4	28.95	88.0	119.3	6
32	32.3	24.5	28.4	84.5	86.4	4
33	31.5	24.8	28.15	88.5	129.9	7
34	31.8	24.6	28.2	82.0	20.9	4
35	33.1	25.1	29.1	82.5	5.5	3
36	31.6	24.9	28.25	90.5	94.9	7
37	32.4	24.6	28.5	79.5	14.6	1
38	34.4	24.4	29.4	77.5	0.0	
39	33.1	23.7	28.4	84.0	111.5	3
40	34.1	23.9	29.0	79.5	71.4	2
41	30.8	23.9	27.35	84.0	90.9	5
42	32.8	22.9	27.85	76.5	1.6	1

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Standard week	Mean temperature (°C)			Mean R.H. (%)	Mean R.F. (mm)	Rainy days (No.)
	Max.	Min	Average			
43	33.4	20.7	27.05	68.0	0.0	
44	32.3	21.1	26.7	66.0	0.7	2
45	31.1	21.2	26.15	74.5	0.0	
46	30.9	20.3	25.6	72.0	0.0	
47	31.0	18.7	24.85	65.0	0.0	
48	29.5	16.3	22.9	62.0	0.0	
49	29.5	15.0	22.25	67.0	0.0	
50	28.2	13.5	20.85	63.0	0.0	
51	28.9	12.9	20.9	66.0	0.0	
52	29.9	12.7	21.3	61.5	0.0	
1993						
1	31.4	15.7	23.55	64.0	0.0	
2	31.6	18.8	25.20	71.5	0.0	
3	29.9	15.0	22.45	60.0	0.0	
4	29.1	12.9	21.00	60.5	0.0	
5	30.3	45.7	23.00	62.5	0.0	
6	31.6	16.5	24.05	68.5	0.0	
7	34.8	19.7	27.25	62.0	0.0	
8	32.3	18.4	25.35	60.0	0.0	
9	33.2	18.2	25.70	62.5	1.8	1
10	34.5	20.0	27.25	65.5	0.0	
11	37.7	21.5	29.60	57.5	0.0	
12	34.7	23.9	29.3	71.0	6.1	2
13	34.9	23.1	29.00	67.0	1.8	2
14	37.5	23.3	30.40	62.0	41.9	2
15	34.9	23.0	28.95	68.0	45.8	2
16	37.3	25.3	31.30	68.0	0.0	
17	37.8	26.2	32.00	66.5	0.0	

3. RECORD OF PEST INCIDENCE AND PEST POPULATION

The incidence of pests was recorded once at weekly intervals from February, 1992 to April, 1993. Observations on pest activity was made during morning hours between 7.00 AM and 8.00 AM. Every week twenty plants were selected at random in stratified random sampling technique. In each plant one representative branch was selected and the total number of leaves damaged by different foliage feeding insects was recorded separately for each pest. The number of different pests present at that point of time was counted specieswise and recorded. For stem feeding insects, the number of healthy and affected stems was recorded. For recording termite infestation, the total number of healthy plants and number of termite infested plants were separately recorded.

In each observation, apart from counting the arthropod pests, the population of natural enemies like ladybird beetles, spiders, Chrysoperla larvae etc. were recorded.

4. POT CULTURE EXPERIMENT

Mulberry saplings were planted in earthen pots filled with a mixture of soil and compost. These plants were utilised for studying the life history and for observing damage symptoms caused by sucking pests and other small insects. For these purposes, the insects were enclosed in mylar cages over healthy branches.

5. STUDIES ON THE LIFE HISTORY AND FEEDING POTENTIALITY OF MULBERRY PESTS

The life history of some lepidopterous pests was studied in the laboratory. The prevailing meteorological data during the course of study are presented in Table 3. To start with, newly emerged males and females were captivated in glass jars covered with muslin cloth and the mouth tied with a rubber band. The eggs were incubated at ambient temperature and R.H. After hatching of the eggs, the young larvae were supplied with either tender leaves of mulberry or they were released on cut branches of mulberry placed in clay pots filled with moist sand. The cut branches of mulberry were enclosed in glass chimneys to check the migration of the larvae. Food was changed daily twice, i.e., in morning and afternoon in order to give the larvae a chance to feed on fresh leaves. The larvae were transferred to clean petridishes/rearing jars every day to keep them free from contamination. The full grown larvae were either transferred to soil or to dried leaves to enable them to pupate. The larval stage, pupal stage, adult longivity, fecundity, sex-ratio were studied in the laboratory for some important pests of mulberry.

For rearing thrips and to study their nature of damage micro-cages were prepared. These micro-cages were made with glass tubes having 2.5 cm diameter and opened at both

the ends. A small branch containing 3-4 leaves from the top was inserted into the micro-cage and the buds and lower leaves were incised. The micro-cage was held in position on plant by a support. The top end of the micro-cage was tied with a muslin cloth. Ten numbers of freshly hatched thrips were introduced into each micro-cage with the help of a camel hair brush and the lower end of the micro-cage was plugged with cotton. The symptoms developed by thrips injury was observed after a week.

The feeding potentiality of some lepidopteran pests, grasshoppers and myllocerus weavils (adults) was also investigated in the laboratory. Before supplying fresh leaves, the area of the leaves supplied was measured with the help of graph paper and after an interval of 24 hr, the area consumed was again measured in order to ascertain the total area consumed during 24 hr by each test insect. Food was always supplied in excess of their requirement so as to prevent stress for food by the insects.

6. *PRESERVATION AND STORAGE OF INSECTS*

Adult insects were stored in insect store boxes after properly pinning, stretching, and drying the specimens. Immature stages were preserved in 70% alcohol. The specimens were sent to the Zoological Survey of India, Calcutta for identification. The mites were mounted on Hoyer's medium in slides.

Table 3. Mean weekly temperature and R.H of the insectary of the Entomology Department from April to December, 1992

Standard week	Temperature (°C)			R. H. (%)
	Maximum	Minimum	Average	
14	32.2	30.2	31.20	77.6
15	33.1	30.8	31.95	77.3
16	32.5	31.4	31.95	76.0
17	33.0	31.6	32.30	85.5
18	33.3	31.7	32.50	82.7
19	32.2	30.0	31.1	90.4
20	32.8	31.7	32.25	87.3
21	33.3	31.7	32.5	79.5
22	31.7	30.5	31.1	83.8
23	32.8	31.7	32.25	81.5
24	32.8	31.7	32.25	75.6
25	31.7	30.5	31.1	85.6
26	31.1	30.5	30.8	84.0
27	31.7	30.0	30.85	86.0
28	31.1	30.5	30.8	84.0
29	31.1	30.0	30.55	83.3
30	30.0	28.9	29.45	72.8
31	30.0	28.9	29.45	89.3
32	30.0	28.9	29.45	90.0
33	30.5	28.9	29.7	89.3
34	30.0	28.9	29.45	92.0
35	30.5	28.9	29.7	89.3
36	31.1	29.4	30.25	88.8
37	30.0	28.3	29.15	92.0
38	31.7	30.5	31.10	87.2
39	31.7	30.5	32.1	90.8
40	30.5	30.0	30.25	88.0
41	30.5	28.9	29.7	88.6
42	30.5	28.9	29.7	90.4
43	31.1	29.4	30.25	86.0
44	30.5	29.4	29.95	90.0
45	29.4	28.3	28.85	90.6
46	30.0	28.9	29.45	88.8
47	29.4	27.8	28.6	96.2
48	28.3	26.7	27.5	91.3
49	28.3	26.7	27.5	88.3
50	26.7	25.5	26.1	87.0
51	27.5	26.7	27.1	87.2
52	26.7	25.5	26.1	85.2

7. STATISTICAL ANALYSIS OF DATA

The extent of leaf infestation/damage by different leaf feeding insects in the field was correlated with the prevailing meteorological data to know the impact of climate on the pest activity (Snedecor and Cochran, 1959).

CHAPTER IV

RESULTS

RESULTS

During the year 1992, several field and laboratory experiments were conducted on arthropod pests infesting mulberry plants. For this purpose a mulberry garden was maintained in the Central Research Station, O.U.A.T., Bhubaneswar. The various aspects of the studies include -

(i) determination of pest complex of mulberry plants, (ii) nature and extent of their damage, (iii) seasonal incidence of pests and correlation of pest activities with meteorological data, (iv) quantity of leaf consumed by some important pests, (v) preliminary observations on the life-history of selected mulberry pests and (vi) association of natural enemies with mulberry pests and their seasonal activities.

1. ARTHROPOD PESTS INFESTING MULBERY PLANTS AT BHUBANESWAR

The faunal complex of mulberry plants was investigated throughout the year. The study revealed that the mulberry crop at Bhubaneswar was attacked by 35 pests (Table 4). Depending upon their nature of damage, these pests were grouped under 6 categories, viz., leaf feeders (external leaf feeders and sap suckers), stem feeders, fruit borrers, disease transmitters and acarine pests.

Table 4. Arthropod pests infesting mulberry plants at Bhubaneswar (Orissa)

Sl. No.	Common name	Scientific name	Family	Order
A) Leaf feeders				
(i) External leaf feeders				
1.	Tobacco caterpillar	Spodoptera litura Fab.	Noctuidae	Lepidoptera
2.	Moringa caterpillar	Eupterote mollifera W.	Eupterotidae	Lepidoptera
3.	Tussock catterpillar	Euproctis fraterna Moore	Lymantriidae	Lepidoptera
4.	Leaf tiers	Margaronia pulverulentalis Hmps	Pyralidae	Lepidoptera
5.	-	M. pyloalis Walker	Pyralidae	Lepidoptera
6.	Span worm (Semilooper)	Pthonandria atrilineata Butler	Geometridae	Lepidoptera
7.	Slug caterpillar	Lactia (Parasa) lepida Cramer	Euleidae	Lepidoptera
8.	Wild silkworm	Bombyx mandarina Leech	Bombycidae	Lepidoptera
9.	Bagworms	Mahasena sp.	Psychiidae	Lepidoptera
10.	-	Manatha albipes	Psychiidae	Lepidoptera
11.	Wasp. moth	Amata passalis Fab.	Amatidae	Lepidoptera
12.	Cotton grasshopper	Cyrtocanthacris ranacea Stoll	Acrididae	Orthoptera
13.	Short horned grasshopper	Unidentified	Acrididae	Orthoptera
14.	Tobacco grasshopper (3)	Attractomorpha crenulata Fab.	Acrididae	Orthoptera
15.	-	Letana inflata Brunner	Tettigonidae	Orthoptera
16.	-	Unidentified	Tettigonidae	Orthoptera
17.	Myllocerus weevils	Myllocerus discolor Bohomann	Curculionidae	Coleoptera
18.	-	M. subfasciatus Guer	Curculionidae	Coleoptera
(ii) Sap suckers:				
19.	Thrips	Pseudodendrothrips mori Niwa	Thripidae	Thsanoptera
20.	-	Hoplothrips coloratus (Trybom)	Thripidae	Thysanoptera
21.	Leafhopper	Empoasca flavescens (Green)	Cicadellidae	Homoptera
22.	Mealy bug	Maconellicoccus hirsutus (Green)	Pseudococcidae	Homoptera
23.	Aphid	Aphis sp.	Aphididae	Homoptera
24.	White fly	Aleurolobus marlatii Quintance	Aleyrodidae	Homoptera
25.	Cow bug	Otinotus oneratus Walk	Membracidae	Homoptera
26.	Pentatomid bugs	Eusarcocoris ventralis W.	Pentatomidae	Hemiptera
27.	Pentatomid bugs	Histrio mendia Fab.	Pentatomidae	Hemiptera
28.	Pentatomid bugs	Nezara virudula L.	Pentatomidae	Hemiptera

Contd...

Sl. No.	Common name	Scientific name	Family	Order
(B) Stem feeding insects				
29.	Red scale insect	*Aonidella aurantii* (Maskell)	Coccidae	Homoptera
30.	Black scale insect	*Saissetia nigra* (Niet)	Coccidae	Homoptera
31.	Stem borer	*Apriona japonica* Thomson	Cerambycidae	Coleoptera
32.	Sphecid wasp	*Crabro orientalis* Cameron	Sphecidae	Hymenoptera
(C) Pest of fruits				
33.	Fruit fly	*Dacus tau* walker	Tripetidae	Diptera
(D) Root feeders				
34.	Termite	*Odontotermes obesus*	Termitidae	Isoptera
(a)	Myllocerus	*Myllocerus* sp.	Curculionidae	Coleoptera
(E) Disease transmitter				
(b)	Hibiscus mealy bug	*Maconellicoccus hirsutus* (Green)	Pseudococcidae	Homoptera
(F) Acarine pests				
35.	Red spider mite	*Tetranychus equitorius* Ms. Gr.	Tetranychidae	Acarina

1.1 LEAF FEEDERS

External leaf feeders : Eighteen different types of insects, eleven belonging to Lepidotera, five belonging to Orthoptera, two belonging to Coleoptera were observed. They include tobacco caterpillar (Spodoptera litura), moringa caterpillar (Eupterote mollifera), tussock caterpillar (Euproctis lunata), two species of leaf-tiers (Margaronia pulverulentalis), (Margaronia pyloalis), spanworm (Pthonandria atrilineata), slug caterpillar (Laotia (Parasa) lepida), bagworms (Mahesena sp. and Manatha albipes), three species of short-horned grasshoppers (Cyrotocanthacris ranacea, Attractomorpha crenulata and one unidentified species), two species of long-horned grasshoppers (Letana inflata and one unidentified species) and two species of myllocerus weevils (Myllocerus discolor and M. subfasciatus). The typical type of leaf damage inflicted by these external feeders are depicted in photographs. Some peculiarities observed with respect to the feeding habit are mentioned below.

The tobacco caterpillars in their earlier instars remained in gregarious stage on the under surface of the leaf and skeletonised the leaf by feeding the chlorophyll portion of the leaf (Fig. 1 and 2). From the third instar onwards they dispersed to different parts of the plant and devoured the leaves. The infested leaves imparted a parching appearances from a distance. The insect was found to be nocturnal in habit. The full grown larvae pupated inside soil (Fig.3).

Fig.1. Third instar gregarious larvae of Spodoptera litura.

Fig. 2. Spodoptera larvae after third instar feeding on mulberry leaf.

Fig. 3. Pupae of Spodoptera inside earthern cocoons.

The moringa caterpillars were very active during the night and when at rest remained in congregation in early as well as in latter instars on the leaves and on the mulberry branches. They were having profuse number of hairs which were irritating in nature (Fig. 4A and Fig.4B).

The tussock caterpillars could be easily identified by their peculiar dense tuft of hairs on the first and second abdominal segments which looked like humps. Also the first thoracic and last abdominal segments contained tuft of hairs (Fig. 5).

The leaf-tiers were regularly observed through out the year in the mulberry field in varying numbers. These caterpillars were always found in the folds of tender unopened or freshly opened leaves and the older leaves were not preferred. The caterpillars were very much agile and jumped when slightly disturbed. The biology of the pest was worked out and presented in a separate section (Fig. 6, and 25).

The spanworm is a greyish brown coloured semilooper resembling the dead twig. The caterpillars stayed on the branches of mulberry plant and while feeding remained anchored on the abdominal legs. When disturbed they balooned by means of silken thread. They fed on the young mulberry leaves and buds (Fig. 7).

Fig. 4(a) Gregarious larvae of Eupterote sp.

Fig. 4(b) Larvae pupae and moth of Eupterote sp.

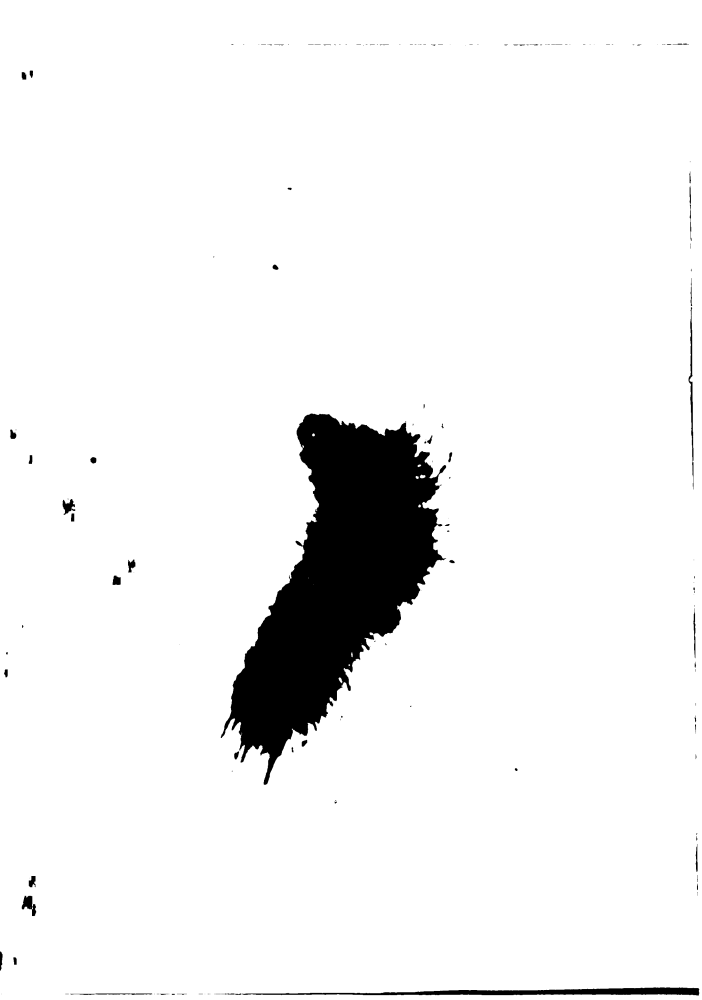


Fig. 5. Larva of Euproctis fraterna.

Fig. 6. Larvae, pupa, moth and damage symptom of leaf-tiers.

Fig. 7. Larva and moth of semilooper (Pthonandria sp.).

The slug caterpillars were thick, flat, fleshy apple-green in colour with greenish-blue dorsal stripe and having yellowish green stripe on each lateral side. They had a series of tufts of spines on their body which gave them an ornamental appearance. These spines were very much irritating to touch. They appeared occasionaly during winter months on mulberry plants. The young and late instar larvae destroyed the leaves (Fig. 8,9).

Two species of bagworms were observed on the mulberry plant. Mahesena sp. constructed a case on which the tender cut twigs were horizontally fixed in a characteristic fashion paralell to the body axis of larva (Fig. 10). The latter remained in a secured position inside a tough silken bag which it spun. While feeding it protruded its head and when any danger was scented it dragged its body inside the case. The larvae devoured younger leaves from the margins (Fig. 10 & 11). The case remained hung on the lower leaf surface. This species was recorded for the first time on mulberry plant.

The second species of bagworm, Manatha albipes larvae were small-sized and were different in their shape and size from the one described earlier. The outer body case was conical in the earlier stage but latter, the case became cylindrical with slight tappering at the distal end. This species did

Fig. 8. Early instar larva of slug caterpillar (Laotia lepida).

Fig. 9. Full grown larva of slugcaterpillar.

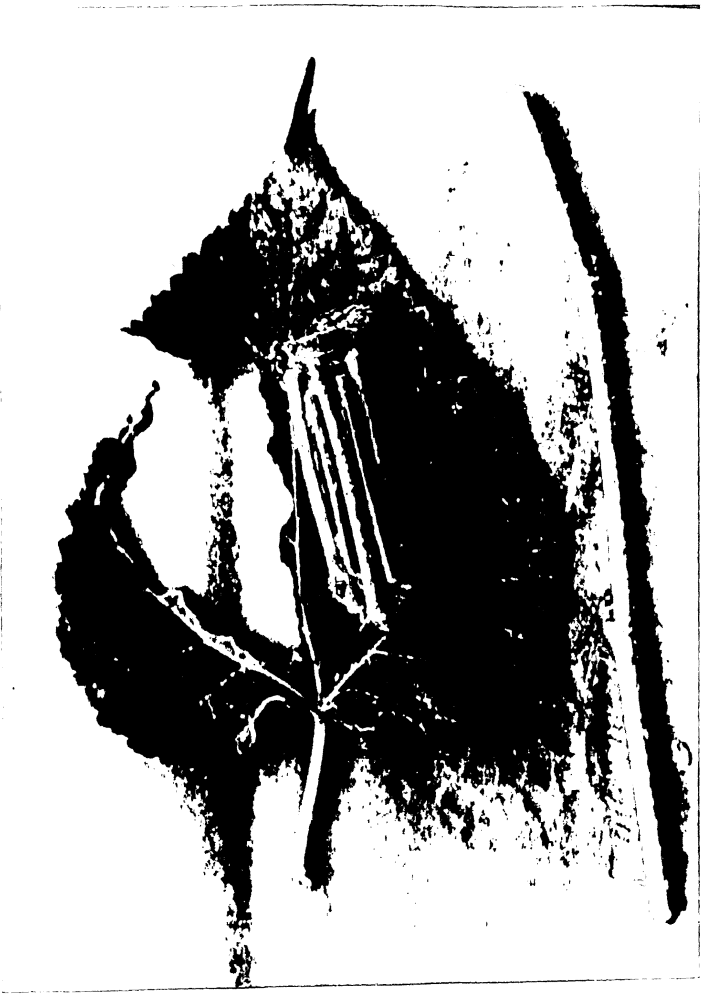


Fig. 10. Larva of bagworm, Mahesena sp. and symptoms of damage on leaf and shoot.

Fig. 12. Bagworm, Manatha albipes larvae and their peculiar damage symptom

Fig. 11. Pupa (exposed) and moth of Mahesena sp.

not attach sticks on its case. The larvae made characteristic bullet-shot holes which later coalesced each other. The older veins of the leaves were not eaten (Fig. 12).

The short-horned grasshopper, Cyrtocanthacris ranacea was medium sized (2.5 cm), bright green coloured in nymphal stage. The adults were 6.5 cm, strong and stout brown coloured with distinguishing black patches on tegmina (Fig. 13a). They damaged the leaf lamina usually from the margins (Fig. 14). The tobacco grasshopper was another species of grasshopper which was easily distinguished from other grasshoppers in the field by its conical head. They are dull green in colour (Fig. 13c).

The long-horned grasshopper, Letana inflata (Fig.13d) was large sized and dull green in colour. They have powerful long and dentated hind legs. The adult did not prefer young leaves. On the other hand they relished mostly the partly matured leaves and young shoots of the mulberry plant. Peculiar enough, they started feeding on the petiole, mid-ribs, lamina in order (Fig. 14d). The second species of tettigonid preferred younger leaves and made shot-holes and also fed from margins.

Among the two species of mylllocerus weevils, the Myllocerus discolor were abudantly found on the mulberry plants feeding preferably the older leaves. The grubs of these weevils were found to be root feeders, whereas, the

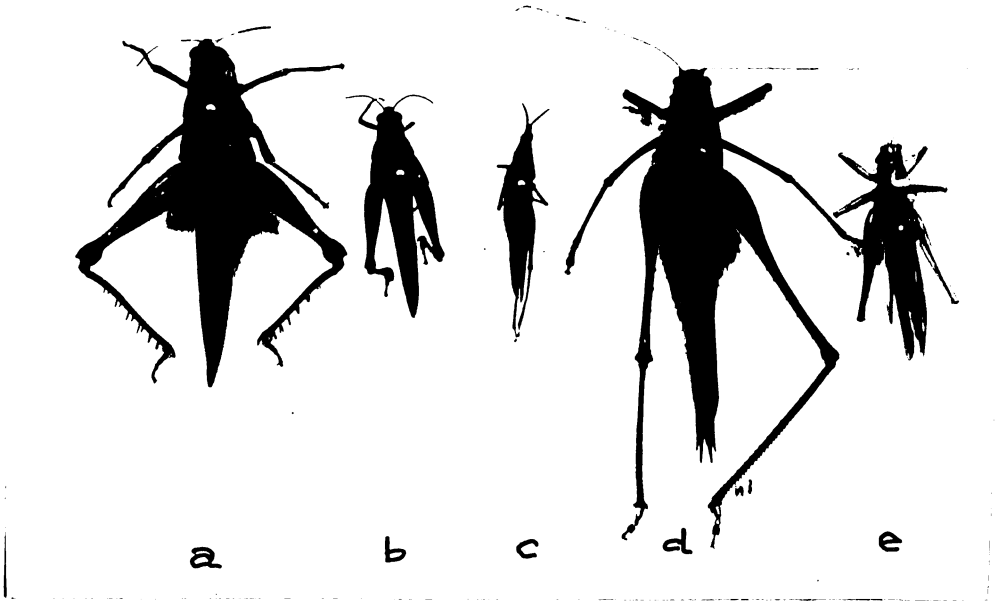


Fig. 13. Grasshoppers infecting mulberry plants at Bhubaneswar

(a) Adult grasshopper (Cyrtocanthacris ranacea)
(b) Unidentified short-horned grasshopper
(c) Adult grasshopper (Attractomorpha crenulata)
(d) Adult Letana inflata
(e) Unidentified long-horned grasshopper

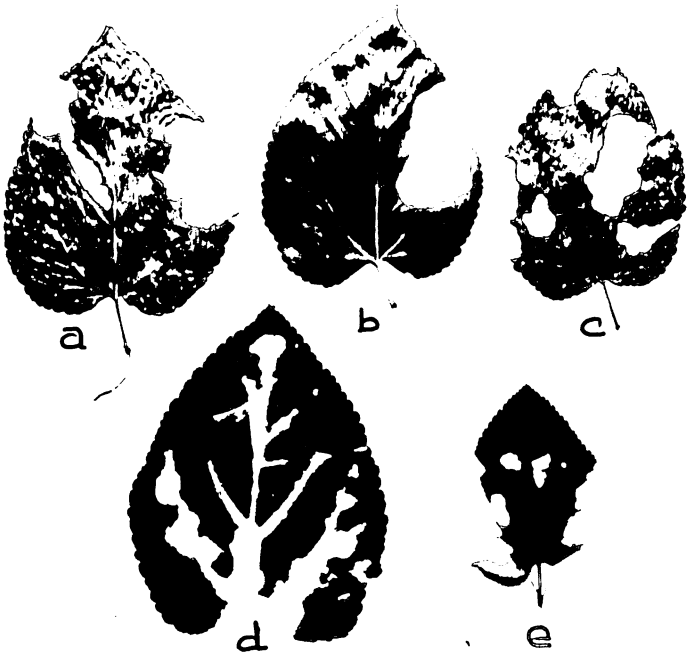


Fig. 14. Peculiarity in leaf feeding habits of grasshoppers of Fig. 13a, 13b, 13c, 13d, 13e.

adult weevils attacked both the young as well as the older leaves. When younger leaves were attacked, they scrapped the surface and made several small irregular biting holes (Fig. 15). When the weevils chose to attack older leaves they attacked from the margins (Fig. 16). In newly prunned crop, tender leaves were not usually preferred by the weevils. When the leaves of the prunned plants got older, the weevils preferred to feed on them.

1.2 SAP SUCKERS

Two types of thrips were recorded on mulberry in the present investigation. The nymphs and adults remained in the young opened and half-opened leaf whorls in the axils. The affected leaves imparted a speckling appearance in initial stage. In case of severe infestation the leaves looked crumpled and puckered (Fig. 17).

Both the nymphs and adults of green leafhopper remained on the under surface of the young leaves and sucked the cell sap. The nymphs and adults walked diagonally when distrubed. In case of severe infestation "hopper burn" symptom appeared particularly in the young leaves. Hopper burn was characterised by drying of the leaves from the top which proceeded along the leaf margin.

The other sucking pests like aphids, whiteflies, pentatomid bugs, cow bugs were observed feeding on mulberry leaves and young shoots at different periods. Their occurrence

Fig. 15. Early symptom of leaf damage by feeding of Myllocerus weevils.

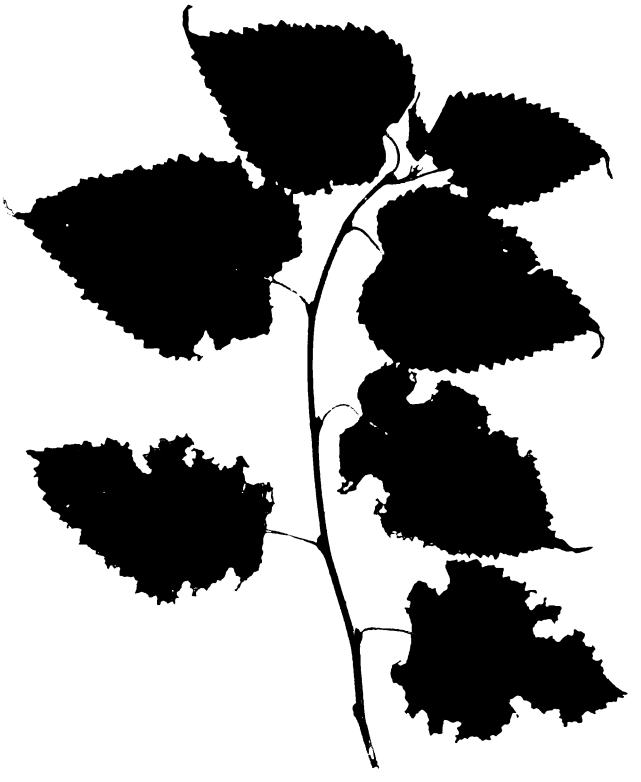


Fig. 16. Preferential leaf damage by feeding of Myllocerus weevil

Fig. 17. Thrips damage symptom on mulberry leaves.

was casual in the present investigation. The mealy bug, Maconellicoccus hirsutus, besides sucking sap from the young leaves and twigs also transmitted "tukra disease" which has been described in a separate section (Page No.50).

1.3 *STEM FEEDER*

The scale insects are sessile in nature. They were found attached to the young shoot, twigs and even on upper surface of the leaves and sucked sap. They were especially observed on the older branches. Cuttings propagated from the scale attacked branches also contained some scale on the planting material (Fig. 18, 19).

Damage by the cerambycid stem borer was observed on medium sized branches. The beetle grub tunneled the stem and later attacked the pith of the stem. The entry hole on the branch was very distinct. When the attacked branch was split open the black colour of the pith was clearly visible. Moreover, the bark of the branch appeared completely charred due to exudation of black fluid through the entry hole (Fig. 20).

The sphecid wasp was another species of wood borer recorded for the first time on mulberry. The adult wasp drilled a hole into branches of 3-4 mm diameter and laid eggs inside. The grubs later completely damaged the wood as well as pith leaving only the outer bark. This resulted in drying of the apical shoot above the point of attack. The

Fig. 19 . Black scale insects on mulberry leaf and shoot.

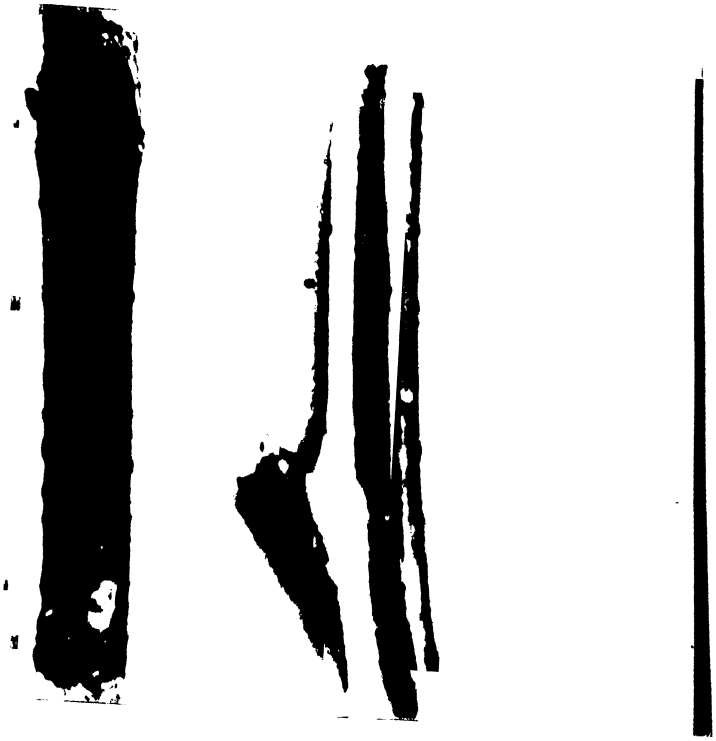


Fig. 20. Damage symptoms of stem borer, Apriona sp.

attacked portion easily breaks into pieces on slight pressure. A noteworthy feature was that there was distinct difference between the symptoms of attack due to cerambycid beetles and that of the sphecid wasp. In the former case black charring dry exudations were the distinguishing feature whereas, in the latter case there was no such charring colouration.

1.4 ROOT FEEDERS

The termites destroyed the roots of the newly planted crop. The older plants were seldom attacked. However, in the prunned crop, termite attack in the stumps were observed in dry season.

The myllocerus grubs were found damaging the roots of mulberry plants. However, only in one or two cases such damage was recorded.

1.5 DISEASE TRANSMITTERS

The hibiscus mealy bug was a fleshy and light pinkish coloured insect. The body remained covered with a whitish encrustation made up of waxy substances (Fig. 21). They sucked cell sap remaining inside unfolded or freshly opened young leaves. Occasionally the crawlers were also noticed on the ventral side of the leaf. The affected leaves become dark green, crinkled, deformed in early infestation stages. The affected apical shoot between the crinkled leaves, which became yellow later on, were flattened and the base of the

Fig. 21. Mealy bugs sucking on the lower surface of mulberry leaf.

Fig. 22. Early symptoms of "Tukra disease" on mulberry leaf.

shoots were found swollen. In advanced stages of infestation, the growth of the shoot was arrested and the affected shoot remained bent either to the left or the right of the stem axis instead of growing straight. When the infestation ceased, the growth of the new emerging shoot was normal. The texture and the leaf quality of the affected branches were severely deteriorated and were unfit for feeding to the worms. The new shoots that came up later from below the affected portion gave rise to small sized leaves. This typical symptoms of infestation had been described by many authors as "Tukra disease of mulberry" (Fig. 22, 23, 24). Presence of even one or two nymphs was enough to incite injury by causing deformities on the tender shoots and in the ontogeny leaves.

1.6 *ACARINE PESTS*

The red spider mite sucked sap remaining on under surface of leaves. The nymphs and adults made dense webbings beside the margin of the leaf. In the mat of the webbings all stages of mite, viz., egg, nymph and adults were present. These mites confined mostly in colonies on the underside of the leaves. Generally the older leaves were preferred. The infested leaves appeared yellowish which turned to rusty colour and later on dried up.

2.0 SEASONAL INCIDENCE OF MAJOR MULBERRY PESTS

The seasonal abudance of pests infesting mulberry plants was trekked throughout the year basing on the extent of damage and population fluctuation of pests (Table 5, 6 and 7).

Fig. 23. Tukra disease symptom on mulberry leaf and twig.

Fig. 24. Advanced symptoms of "Tukra disease" on mulberry twig.

Fig. 25 (a). Moth of leaf-tier (Margaronia pulverulentalis)

(b). Moth of leaf-tier (M. pyloalis)

Table 5. Extent of leaf infestion (%) by mulberry pests commonly occurring at Bhubaneswar (Orissa) during February, 1992 - April, 1993

Standard week	Period (Month & date)	No. of leaves examined	Leaf infestation (%)								Stem damage(%) Stemborer
			Grass-hopper	Mylloc-erus weevil	Leaf tier	Spodo-ptera	Bagworm	Tuss-ock cater-pillar	Mealy bug	Thrips	Mite	
1992												
1.	Jan., 29 - Feb.,4	579		1.04					0.23			
2.	Feb., 5 - 11	589		0.68	0.50				1.37			
3.	12 - 18	438	1.60	2.74	0.68							
8.	19 - 25	634		1.58	1.89				0.52			
9.	26 - March,3	829	0.60	1.21	2.41							
10.	4 - 10	868	0.58		3.23							
11.	11 - 17	1323	0.23		3.70				0.24			
12.	18 - 24	971			5.97							
13.	25 - 31	1267	0.63		7.89				0.47			
14.	April 1 - 7	1326	0.60		10.56				0.82			
15.	8 - 14	1586	0.25		17.40				0.95			
16.	15 - 21	1110	1.62		13.24				1.26			
17.	22 - 28	877	2.05	2.62	14.32							
18.	29 - May, 5	1190	1.01	3.52	8.57				0.76			
19.	6 - 12	1312	1.22	4.65	3.73				0.28			
20.	13 - 19	1312	0.69	3.05	2.06				0.56			
21.	20 - 26	1633	0.61	4.28	6.12				0.79			
22.	27 - June,2	1777	0.11	2.81	1.74		0.22		4.67			
23.	3 - 9	1663	0.36	2.95	2.95				3.61			
24.	10 - 16	1812	0.44	2.59	2.92		0.22		4.13			
25.	17 - 23	2106	0.56	4.37	0.61		0.28		1.80			
26.	24 - 30	2038	0.63	4.17	1.57		0.03		2.84			
27.	July, 1 - 7	1803	1.61	5.10	1.32				2.44			
28.	8 - 14	1734	0.52	5.54		0.52			1.67			
29.	15 - 21	1974	0.56	8.36			0.35		0.41			
30.	22 - 28	1529		3.14		10.66	0.19		0.98			
31.	29 - Aug.,4	1488	0.60	4.84		4.64	0.20		0.60			
32.	5 - 11	1899	0.37	5.13		3.32						
33.	12 - 18	1518	1.58	5.27			0.40		0.39			
34.	19 - 25	1634	0.98	4.10			0.31			0.61		
35.	26 - Sep.,1	1397	2.94	4.15	1.36		0.36		0.50			
36.	2 - 8	1266	2.69	0.63	0.24		0.16		0.87	0.79		

Contd.....

Standard week	Period (Month & date)	No. of leaves examined	Leaf infestation (%)									Stem damage(%) Stemborer
			Grass-hopper	Mylloc erus weevil	Leaf tier	Spodo-ptera	Bogworm	Tussock caterpi-llar	Mealy bug	Thrips	Mite	
37.	9 - 15	1286	1.25	5.13	0.08		1.17		0.23	0.01		
38.	Sept.,16 - 22	1894	1.0	2.11	4.42	1.16	0.58		1.37	0.32		
39.	23 - 29	1182	0.85	2.28	2.88		1.78		0.34			
40.	30 - Oct.,6	1112	0.36	6.83	2.70		0.72		0.54	0.54		
41.	7 - 13	1185	0.61	6.06	2.42	0.34	0.72		1.05			
42.	14 - 20	1276	0.94	2.19	3.45		1.80		1.96	0.63	0.78	0.83
43.	21 - 27	1416	0.56	2.33	2.75		0.65		0.14	0.14		
44.	28 - Nov.,3	1080	0.09	6.29	4.14		1.22		0.28			0.83
45.	4 - 10	1159		4.40	7.77		2.50		0.52	1.00		9.16
46.	11 - 17	788		3.30	6.22	1.14	1.65	0.63	0.63			9.16
47.	18 - 24	703	1.14	1.99	6.69		1.28	2.28	1.14			
48.	25 - Dec., 1	296	3.12	8.78			2.00		2.00			
49.	2 - 8	133	3.00	4.51	6.02		3.0	0.75	2.78			
50.	9 - 15	339	2.65	4.42	8.55		2.75		1.83			
51.	16 - 22	348	1.72	3.16	6.61		0.29	0.86	1.45			1.66
52.	23 - 31	306		6.54	0.19		2.61		1.96			3.27
1993												1.66
1.	Jan., 1 - 7	140		8.57	2.14		0.71		2.14		3.7	
2.	8 - 14	233							2.70			0.78
3.	15 - 21	851						0.82		0.94		
4.	21 - 28	783	0.11	0.06	0.06				0.11	0.28		
5.	29 - Feb., 4	792	0.05				0.06	0.50	0.45	0.28		
6.	5 - 11	1282		0.16	0.16			0.39	1.72	1.09		
7.	17 - 18	1311	0.06	0.50	0.50			0.31		0.69		
8.	19 - 25	1589	0.54						0.48	0.66		
9.	26 - March,4	1662		1.14								
10.	5 - 11	1583										
11.	12 - 18	1282		0.84	1.30				0.47			
12.	19 - 25	1076		3.01					0.15			
13.	26 - April,1	1296		3.26	0.01				0.39			
14.	2 - 8	1566	0.15	3.36					0.67			
15.	9 - 15	1341	0.30	7.99					0.15			
16.	16 - 22	1351	0.32	5.10	0.16				1.13			
17.	23 - 29	1235		8.73	0.64				1.73			

Table 6. Seasonal incidence of mulberry pests commonly occurring at Bhubaneswar (Orissa) during February, 1992 to April, 1993

Standard week	Period (Month & date)	Pest population (No.)/20 branches									
		G.H.	Myllo.	L.F.	Spo.	B.W.	Tuss.	S.L.	M.B.	Th.	Mite
1992											
5	Jan. 29 - Feb. 4	1	5							3	9
6	Feb., 5 - 11								1	4	10
7	12 - 18	1								5	1
8	19 - 25		3								1
9	26 - March,3		2						1	1	
10	Mar., 4 - 10	2	8								
11	11 - 17	1	8	5							
12	18 - 24		8	1							
13	25 - 31	4	22	2					11		
14	Apr., 1 - 7	3	17						3		
15	8 - 14	2	21						1		
16	15 - 21		24						2		
17	22 - 28	4	6								
18	29 - May, 5	4	21	51							
19	6 - 12	2	13								
20	13 - 19		17								
21	20 - 26	2	22						9		
22	27 - June, 2	1	22			2			27		
23	3 - 9	2	14	1		1			41		
24	10 - 16	4	26			4			33		
25	17 - 23	5	43			2					
26	24 - 30		39			3			4		
27	July, 1 - 2		38								
28	8 - 14		24		468						
29	15 - 21	1	49			3					
30	22 - 28		9	1		1			21		
31	29 - Aug., 4	1	13						1		
32	5 - 11	2	30								
33	12 - 18	1	11						8	18	
34	19 - 25		8							85	
35	26 - Sept., 1		13	3		1				33	
36	2 - 8	1	12			1				18	

Contd.....

Standard week	Period (Month & date)	Pest population (No.)/20 branches									
		G.H.	Myllo.	L.F.	Spo.	B.W.	Tuss.	S.L.	M.B.	Th.	Mite
37	9 - 15	2	30			1			6	28	
38	Sept.,16-22	2	31	3	3	4			8	14	
39	23 - 29		10	25		1			2		
40	30 - Oct., 6	1	40	15		5			6	24	
41	7 - 13		20	4			2	1	1	21	
42	14 - 20		10	16		1	1		1	8	
43	21 - 27		5	15		1			1		
44	28 - Nov., 3		2	27		5					
45	4 - 10		13	31		6	1		1		
46	11 - 17		5	14	214	1	7		4		
47	18 - 24		6	6		2	11	1			
48	25 - Dec., 1		5	1			2	1	6		20
49	2 - 8			1		3					39
50	9 - 15		5	10		4			9		
51	16 - 22		3	3		3			6		
52	23 - 31		2	13		5	1		5		
1993											
1	Jan., 1 - 7		2	4							
2	2 - 14						3		9		33
3	15 - 21		2				2		2	4	40
4	21 - 28									2	
5	29 - Feb., 4					6	6			8	8
6	5 - 11		16							4	
7	12 - 18			4							
8	19 - 25		4								
9	26 - March, 4		14								
10	5 - 11										
11	12 - 18		12								
12	19 - 25		14								
13	26 - April, 1		16								
14	2 - 8		32								
15	9 - 15		66								
16	16 - 22		8						2		
17	23 - 29		21						4		

G.H. = Grasshopper, Spo.=Spodoptera, S.L.=Semilooper, Myllo = Myllocerus weevil, B.W. = Bagworm
M.B. = Mealy bug, L.F. = Leaf folder, Tuss = Tossock caterpillar, Th = Thrips

Table 7. Seasonal incidence of mulberry pests occurring sporadically at Bhubaneswar (Orissa) during February, 1992 to April, 1993

Standard week	Pest population/20 branches							
	Cowbug	Scale-insect	Aphids	Whitefly	Black jassid	Green jassid	Planthopper	Pentatomid bugs
1992								
5	5		9			2		
6	5		1	3	1	1		
7	10		4	1	7	1		
8	7			7	2			
9	5		1	15	2	3	2	
10	2			49	2	6		
11	3			40		2	2	
12	6			30		2		
13				13		1		
14				30				
15				7				
16								1
17							1	1
18								
19								
20								
21								
22								
23							1	4
24								
25								
26								
27								
28								
29	1							2
30								
31							1	
32								
33	3							
34				5				
35								

Contd....

Standard week	Pest population/20 branches							
	Cowbug	Scale-insect	Aphids	Whitefly	Black jassid	Green jassid	Planthopper	Pentatomid bugs
36	16	1						
37			1			1	1	
38								
39								
40								
41		1						
42						28		
43								
44								
45								
46								
47								
48		1		24				
49		1						
50		2						
51		3						
52		4						
1993								
1		2					2	
2		3						
3			2			2		
4						2		
5								
6	2	28		6				
7	4	2		12	6	4		
8								
9								
10								
11		16						
12								
13								
14								
15								
16							2	
17								

Table 8. **Population fluctuation of natural enemies of mulberry pest at Bhubaneswar (Orissa)**

Standard week	Population/20 branches				Standard week	Population/20 branches			
	Preying-mantis	Chrysopid	Lady bird beetle	Spiders		Preying-mantis	Chrysopid	Lady bird beetle	Spiders
1992									
5			6	23	38			2	37
6			2	22	39			2	4
7			6	14	40			1	10
8			6	15	41			2	4
9			6	15	42			9	1
10	1		3	7	43			9	2
11	1		1	14	44			3	3
12		1		10	45			4	10
13			3	15	46			5	4
14		1	4	17	47			6	6
15				11	48			11	21
16			1	8	49		2	34	7
17				2	50			19	
18				9	51			43	19
19				1	52			22	10
20				1	**1993**				
21				2	1			16	8
22			7	5	2			2	3
23					3			2	6
24			6	4	4				14
25				2	5				14
26				2	6				6
27					7			2	10
28					8				6
29		1		5	9				12
30			1	1	10				
31			5	3	11				
32		2		3	12				
33		7		4	13				2
34		1		8	14				6
35				8	15				2
36			1	10	16				2
37			7	6	17				3

2.1 TOBACCO CATERPILLAR

The infestation of tobacco caterpillar was not regularly observed in mulberry field. However, in the first week of July and first fortnight of August moderate leaf damage (3.32-10.66%) was observed. The maximum of 10.66% was observed in July last week. During the year under observation, the first instar larvae in gregarious stage were available in the second week of July and again in the second week of November. During the other parts of the year, larvae were not available. The larvae were found to be noctural in habit.

2.2 TUSSOCK CATERPILLAR

The tussock caterpillars appeared in the plants more or less regularly during the winter months. Mild infestation (0.31 - 2.28%) was observed from the second week of November to December third week and again from the third week of January to the third week of February. During this period 1 to 11 larvae/20 branches were recorded.

2.3 LEAF-TIERS

The leaf- tier infestation appeared regularly in the mulberry garden excepting from the second week of July to the last week of August (Table 5 and Fig. 26). The pest exhibited bimodal peaks once during the summer season, i.e., mid April (17.40% leaf attack) and again during the

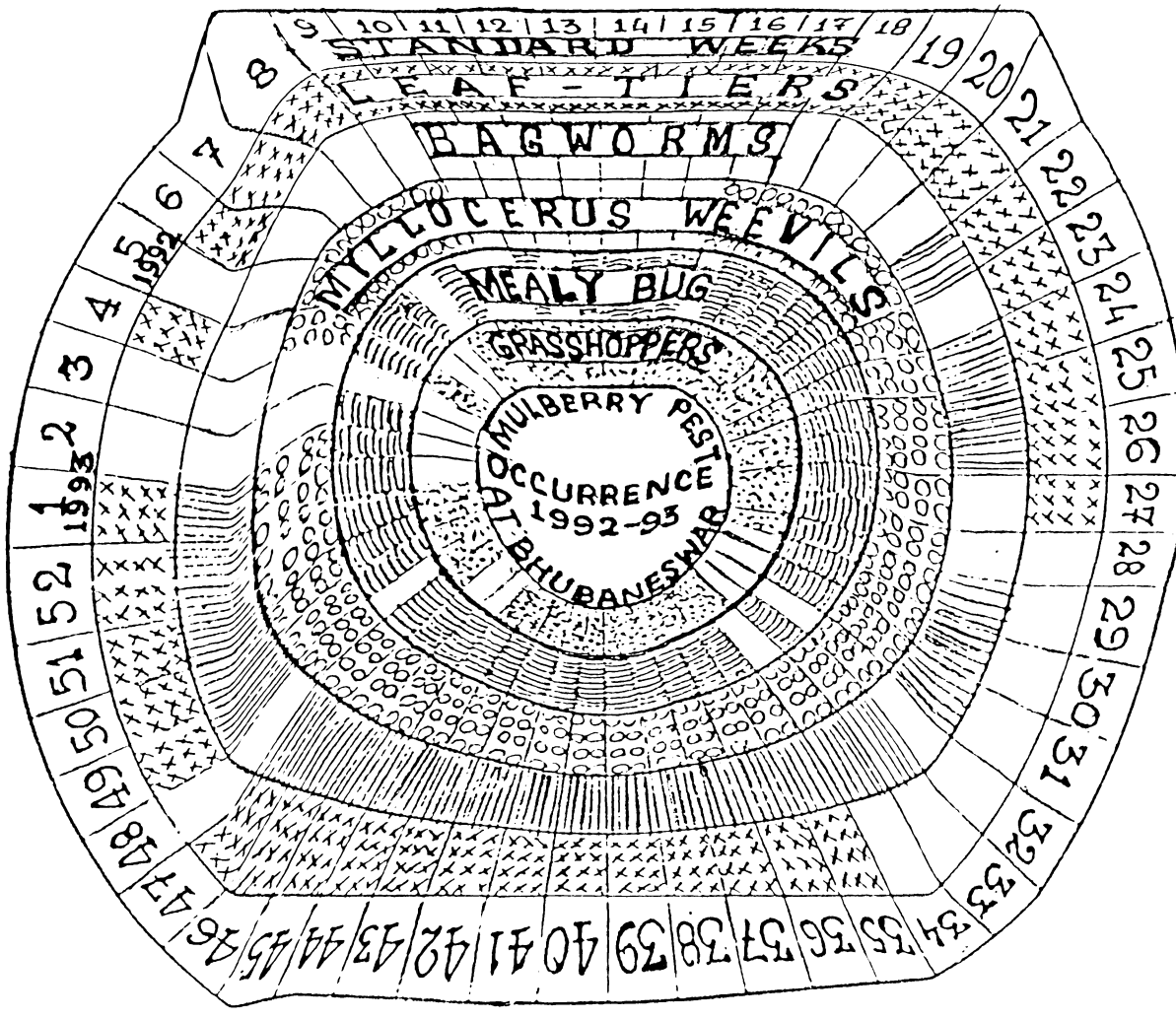


Fig.26 OCCURRENCE OF COMMON MULBERRY PESTS FROM FEBRUARY, 1992 TO APRIL, 1993 AT BHUBANESWAR

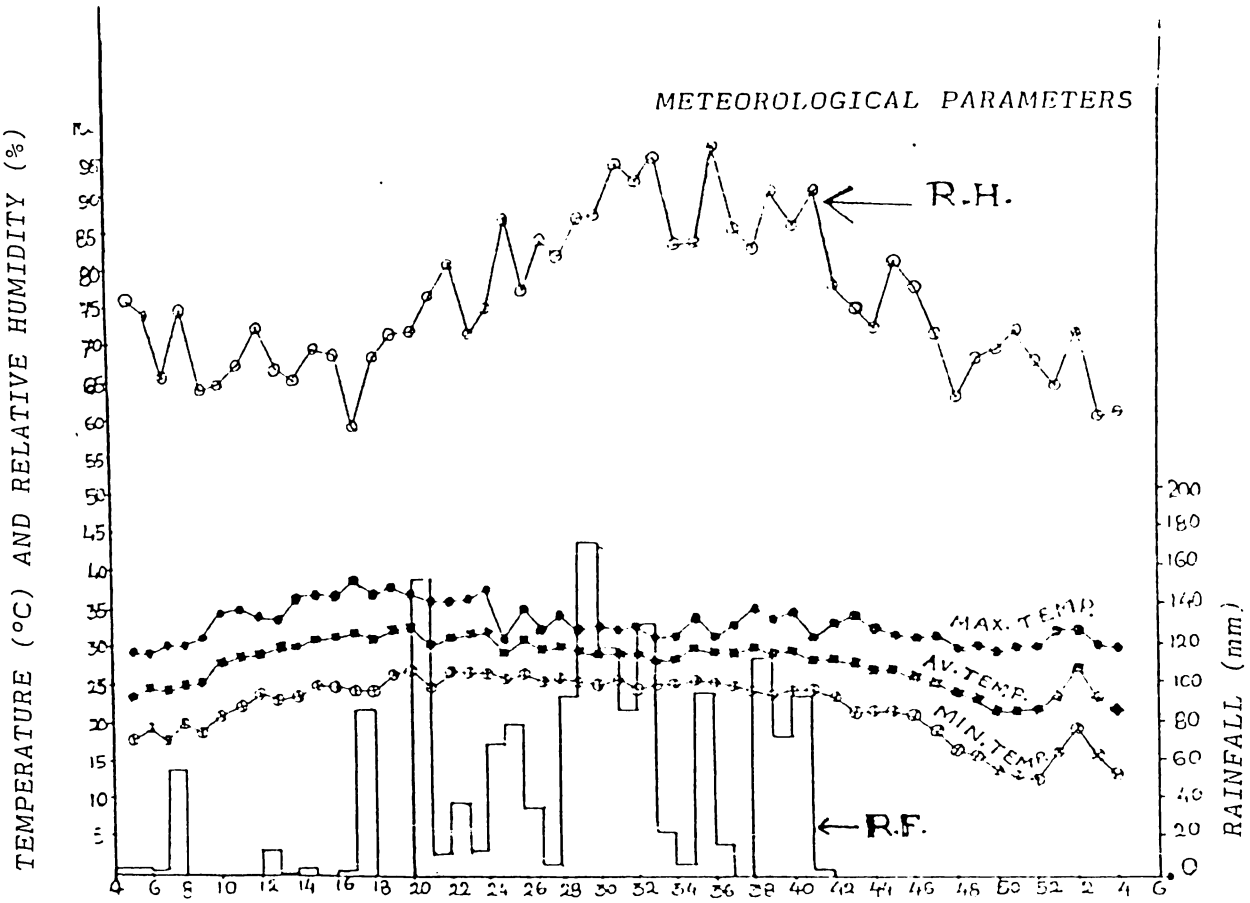
winter season, i.e., mid November (8.55% leaf damage) (Table 5 and Fig. 27). The green leaf-tier, Margaronia pulverulentalis was more prevalent in summer months whereas, M. pyloalis was more in winter months. It was interesting to observe that the leaf-tiers preferred very tender leaves of the axils and older leaves were not preferred. When pest population data were examined it was observed that larvae were frequently available during the second week of September to the first week of January (Fig. 27 & Table 6.)

2.4 BAGWORMS

Two species of bagworms infested mulberry plants at Bhubaneswar. They included Mahesena sp. and Manatha albipes (Fig. 11 and 12). The damage symptoms due to bagworms were observed from the last week of May and confined to the first week of January. During the summer months, the damage due to these two species were not observed. When the insect population during the above period was taken into consideration in conjuction with the damage, the same trend in population build up was observed (Table 5, Fig. 26, 27). It may be mentioned that during the rainy season, the former species was prevalent whereas the latter species was prevalent in the winter season.

2.5 GRASSHOPPERS

Five species of grasshoppers were found infesting mulberry plants at Bhubaneswar during the year under



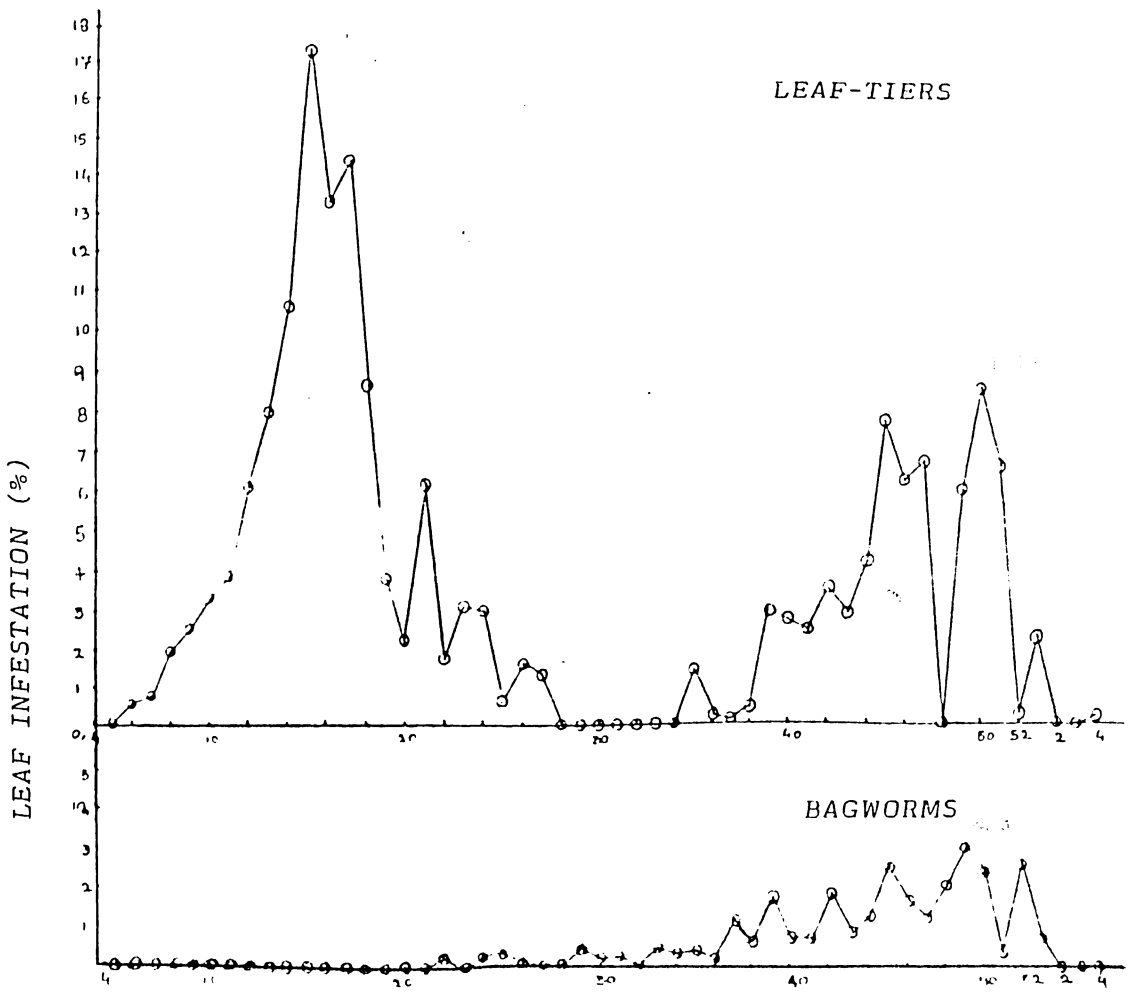


FIG. 27 STANDARD WEEK

observation. Leaf infestation due to combined affect of these five species were recorded.

It was revealed from the study that the grasshoppers remained active throughout the year. Three distinct peaks, once during the last week of April (Summer peak), once during the last week of August (rainy season peak) and again in November last week (winter peak) were observed. However, the level of infestation was mild and never exceeded 3.12% of leaf infestation (Table 5, Fig. 27). The population of the grasshopper has been presented in Table 6.

2.6 MYLLOCERUS WEEVILS

The population of adult myllocerus weevils was available throughout the year and the damage was also noticed regularly excepting during the hot months of March and April. Although high population of adult weevils was available in the field, yet the amount of biomass damaged by these weevils were of lower magnitude (Table 10, Fig. 26, and 28).

2.7 MEALY BUG

Mealy bug infested leaves were observed in the mulberry field throughout the year. However, the population of mealy bug could not be obtained regularly as evidenced from the data given in Table 6 and graph/Fig.28. The level of leaf infestation depicted in the graph revealed that infestation was more from fourth week of May (4.67%) to the second week of July (1.67%) (Table 5 , Fig. 28).

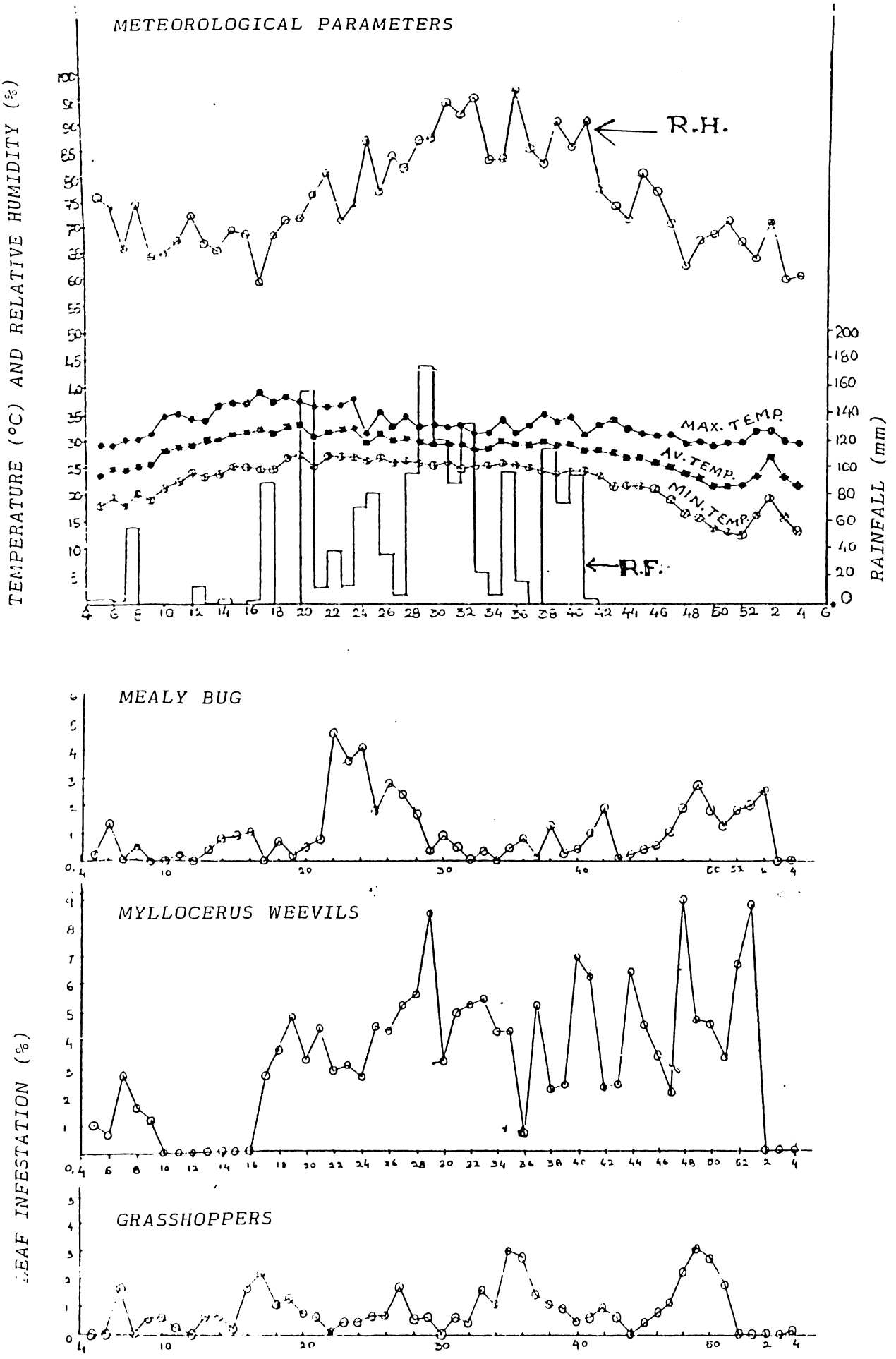

METEOROLOGICAL PARAMETERS
TEMPERATURE (°C) AND RELATIVE HUMIDITY (%)
RAINFALL (mm)
R.H.
MAX. TEMP.
AV. TEMP.
MIN. TEMP.
R.F.
MEALY BUG
MYLLOCERUS WEEVILS
GRASSHOPPERS
LEAF INFESTATION (%)
STANDARD WEEK

FIG. 28

2.8 STEM FEEDERS

The extent of stem damage due to the attack of cerambycid beetle and sphecid wasp has been presented in Table 5. It was revealed from the observations that during the first fortnight of November, maximum shoot damage was recorded. The damage due to these two types of borers remained confined to the winter months only.

2.9 SEASONAL INCIDENCE OF OTHER SPORADIC PESTS

Leaf infestation due to thrips, aphid, whitefly, cow bug, scale insect, green leafhoppers, black jassid, planthopper, semilooper, moringa caterpillar and mite was recorded (Table 4). But since incidence was at a very low level, a definite trend on their activity could not be established.

3.0 CORRELATION BETWEEN METEOROLOGICAL DATA AND LEAF INFESTATION

The meteorological data like mean temperature, relative humidity and rainfall of the year under observation were correlated with leaf infestation due to leaf-tiers, bagworm, myllocerus weevils, mealy bugs and grasshoppers with the help of correlation coefficient. The study revealed that leaf infestation due to leaf-tiers was negatively correlated with the relative humidity ($r = -0.41^*$). Likewise, the mean temperature was negatively correlated with leaf infestation due to the myllocerus weevils ($r = -0.54^*$). In case of the

Table 9. **Estimation of correlation co-efficient between meteorological parameters vs. leaf infestation due to important mulberry pests at Bhubaneswar**

Leaf infestation Vs.	Correlation co-efficient (r)				
	Leaf folder	Bagworm	Myllocerus	Mealy bug	Grasshopper
1. Temp. (°C)	0.18 (N.S.)	(-) 0.04(N.S.)	(-) 0.54 (Sig.)*	0.61(Sig)*	0.05 (N.S.)
2. Relative humidity(%)	(-) 0.41 (Sig.)*	(-) 0.04(N.S.)	(-) 0.33 (N.S.)	(-) 0.196(N.S.)	0.06 (N.S.)
3. Rainfall (mm)	(-) 0.33 (N.S.)	(-) 0.09(N.S.)	0.24 (N.S.)	(-) 0.062(N.S.)	0.09 (N.S.)

N.S. = Not significant

Sig. = Significant at P=(0.05)

Fig. 30. Egg mass of Spodoptera sp.

Fig. 31. Fourth instar Spodoptera larve

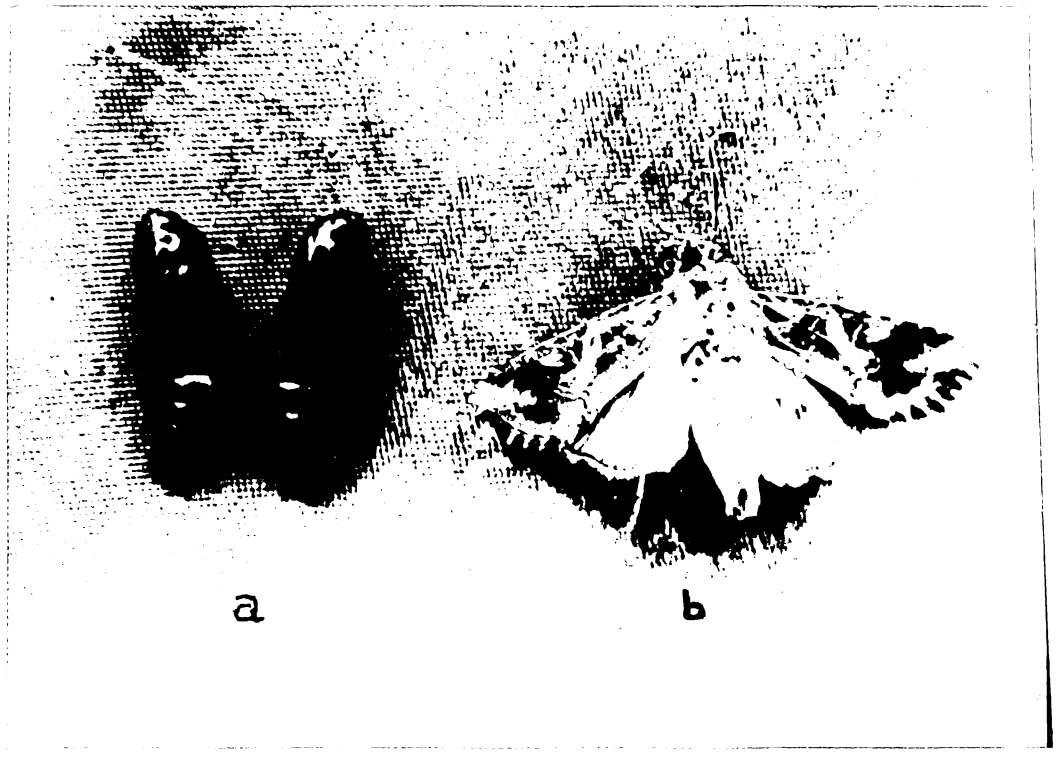


Fig. 32. Spodoptera litura, (a) Pupae, (b) Moth.

Larva : After hatching the larvae remained in a gregarious stage on the lower surface of the leaves for about 3-4 days and scrapped the chlorophyll (Fig. 1).

By the fourth day, the leaves became completely skeletonised. On the sixth day, larvae started migrating and started eating leaf margins. The total larval period lasted for 14-16 days of which 7-8days were utilised for active feeding. Before pupation they stopped feeding and entered into the soil for pupation.

Pupa : The larvae produced a lot of secretions from their mouth and prepared earthern cocoons for pupation (Fig.3, 32a). The pupal period lasted for 5.23 days on an average.

Adult : After emergence, the adults lived on an average for 4-6 days (Fig. 32).

4.2 LEAF-TIERS (*Margaronia pulverulentalis*)

Male and female moths were captivated in rearing cages for oviposition. The rearing cage assembly was prepared by placing a tender, healthy mulberry branch in moist sand kept inside a clay pot. This was covered by a glass chimney with its mouth closed by a muslin cloth and rubber band.

Egg : Eggs were laid on the under surface of the leaves. The eggs were covered with transparent gelatinous secretion produced by the mother. Eggs were thus firmly cemented

on the leaf surface or to the inner walls of the glass chimney. Eggs were laid in small batches of 74 eggs. Eggs were minute, round, greenish in colour and were transparent. Eggs were laid in four concentric circles. Before hatching, the eggs became greyish-black in colour. Unhatched eggs appeared white. Eggs stage, under laboratory conditions, lasted for 4-5 days. Most of the eggs (91.89%) hatched but about 90% of them were latter died due to unknown factors. Perhaps the prevailing conditions of the laboratory were not ambient for larval survival.

Larva : The larvae were bright-green in colour and measured 1.2-2.0 cm. They were agile and reacted very sharply when slightly disturbed. The dorsal blood vessel was very distinct from outside. The larvae started feeding on the chlorphyll of the young leaves. They preferred to remain inside the leaf folds and started feeding the leaf from that position. The larval period lasted for 14-15 days (Fig. 33 b).

Pupa : The larvae pupated within the folds of the leaves which were tied firmly by silken threads produced by the larva. The colour of the pupa was greenish brown and the pupa measured 0.7 to 0.8 cm. The pupal stage lasted for 8.3 days (8-9 days).

Imago : The adult is a greyish white moth (Fig. 25 a) and lived for three days.

4.3 LEAF-TIER (*Margaronia pyloalis*)

This is a second type of leaf tier that was observed in the field during the winter months.

Egg : Female moth laid eggs in captivity in small batches of 2-3, 24 hr after emergence. Eggs were laid on the lower surface of the leaves and these had close resemblance with the eggs of *M. pulverulentalis*. Each egg mass contained 42-68 eggs. The female laid 80-120 eggs during its life time. The egg stage lasted for 4-5 days.

Larva : Larvae were dull yellow in colour with a prominent large deep reddish-brown head. The larval size was 2.0-2.3 cm. The feeding habit of the larva was similar to those like *M. pulverulentalis*. Larval period lasted for 15-16 days (Fig. 33, a).

Pupa : The pupae of this species were reddish-brown in colour, measured 1.0-1.2 cm and were slightly robust as compared to the pupae of the former species. A slight difference in the behaviour of the pupae was observed. In most of the cases, the full grown larva folded a portion of leaf margin of the older leaf on the dorsal side, and pupated inside it by spinning fine silken thread within the leaf fold.

Imago : The adults measured 1.0-1.3 cm in their wing expansion. The forewings were greyish white in colour having brown

patches on their wings. After emergence adults lived for 3-4 days (Fig. 25, b).

4.4 TUSSOCK CATERPILLAR (Euproctis fraterna)

Egg : For studying the egg stage, gravid females were enclosed in ovipositional cages described in earlier sections. Eggs were laid on the lower surface of the leaf as well as on the inner wall of the glass chimney. A single female laid 112-242 eggs with an average of 160 eggs. Eggs were laid in 2-3 batches and the oviposition period lasted for two days. Each egg mass contained 63-107 eggs. Eggs were small, round and were covered with light yellowish brown coloured hairs. Egg period lasted for 8-9 days.

Larva : The young larvae were dark brown and the body was covered with hairs which looked like humps on the dorsal side. The newly hatched larvae remained congregated on the lower surface of the larves and scrapped chlorophyll. after two days of gregarious feeding, they dispersed to other parts of the rearing cage. The full grown larvae measured 2.0-3.5 cm. The larval stage lasted for 18-22 days (Fig. 34).

Pupa : Full grown larvae pupated in the folds of dried leaves by preparing a thin, loosely-spun silken cocoon measuring 2.0-2.4 cm and 1.0-1.2 cm in length and breadth respectively. The duration of the pupa was 8-12 days with an average of 9.4 days (Fig. 34 b).

Fig. 33. (a) Larva of M. pyloalis.
(b) Larva of M. pulverulentalis.

Fig. 34. Larva, pupa and moth of Tussock caterpillar.

Imago : The male moths have dull brown to grey coloured forewings having a number of dark spots on them. the hind wings were pale coloured. The antennae were bipectinate and were adorned with long hairs. The females were larger and stouter and had swollen abdomen. Adults lived for 3-4 days after emergence, (Fig. 34, ♀).

5.0 LEAF CONSUMPTION BY EXTERNAL LEAF FEEDERS UNDER LABORATORY CONDITIONS

The area of mulberry leaf consumed by external leaf feeders of mulberry pests and the weight loss due to such leaf damage were investigated under laboratory conditions. This study included eight lepidopteran pests, five species of grasshoppers and one species of weevil. In the feeding study the insects were provided the appropriate favoured mulberry leaf.

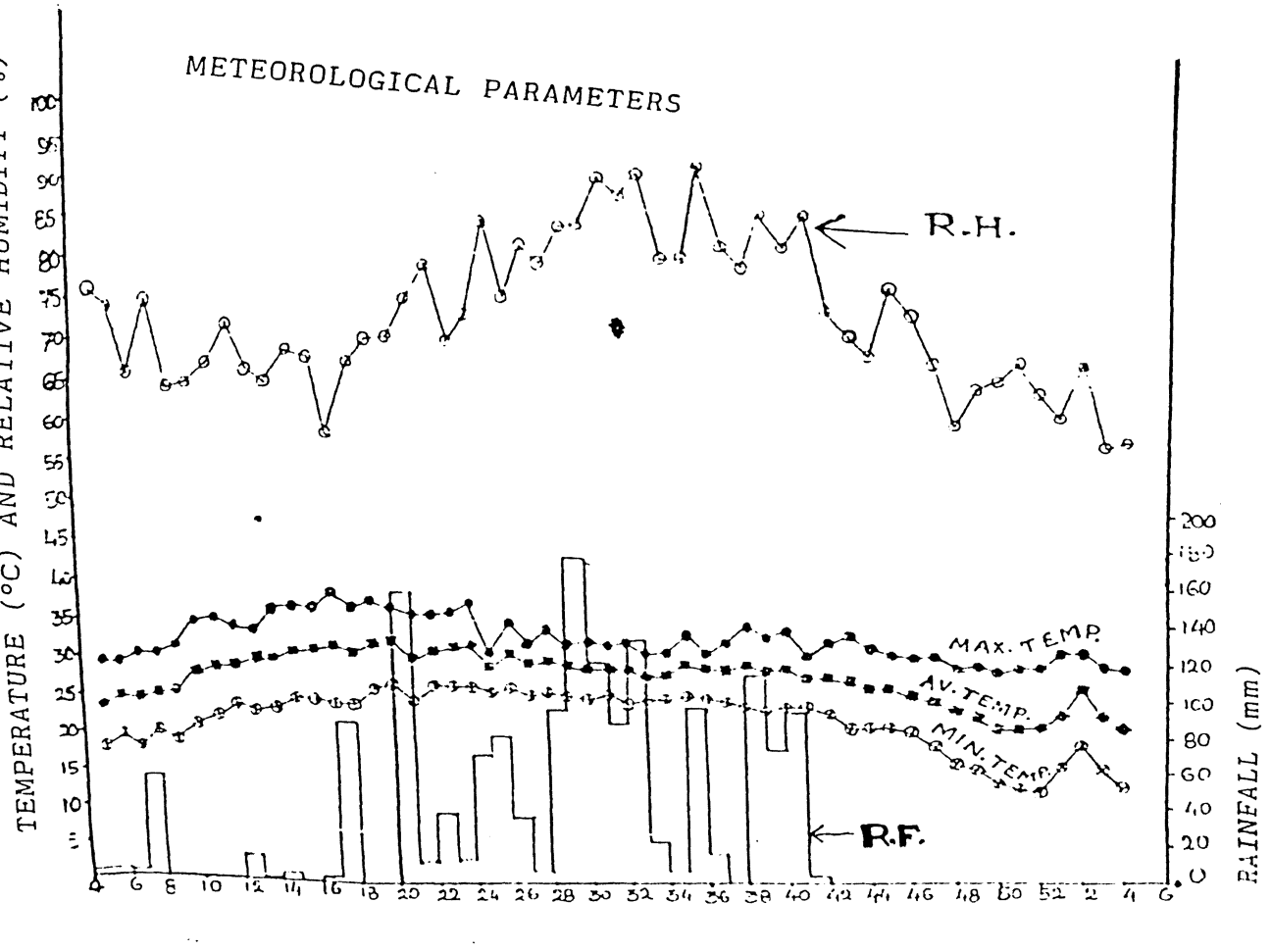
The data presented in Table 10 revealed that the eight species of caterpillars whose feeding potentiality was investigated, consumed 17.692 % to 45.760 % of the leaf area/insect/day which showed the magnitude of their damage potentiality when fed in captivity. Out of the eight test caterpillars, the bagworm, Mahesena sp. consumed 45.76 % of leaf area/day while Margaronia pyloalis damaged only 17.692 % leaf area/day.

Among the five species of grasshoppers, maximum damage was inflicted by the adults of the short horned grasshopper,

Fig. 35. Predatory pentatomid bug Cantheconoidea sp. feeding on semilooper larva.

Table 10. Leaf consumption by external leaf feeders of mulberry under insectary conditions (Period of study : 23.4.1992 - 27.12. 1992)

Sl. No.	Insect	Feeding stage	Leaf No. from top fed to insect	Leaf area(cm^2) consumed/ insect/day	Green wt.(gm) consumed/ insect/day	Leaf area(%) consumed/ insect/day
LEPIDOPTERA						
1.	Spodoptera litura	Full grown larva	6th	21.686	0.327	29.865
2.	Eupterote mollifera	Full grown larva	6th	20.998	0.317	30.190
3.	Euproctis fraterna	Full grown larva	5th	10.470	0.158	34.660
4.	Pthonandria sp.	Full grown larva	4th	27.630	0.379	40.084
5.	Mahesena sp.	Full grown larva	4th	21.480	0.294	45.760
6.	Manatha albipes	Full grown larva	4th	2.120	0.029	29.810
7.	Margaronia pulverulentalis	Full grown larva	3rd	2.607	0.036	17.692
8.	M. pyloalis	Full grown larva	3rd	3.129	0.043	25.000
ORTHOPTERA						
9.	Short horned grasshopper (Cyrtocanthacris ranacea)	Nymph	6th	25.680	0.388	29.130
		Adult	6th	33.380	0.504	33.890
10.	Short horned grasshopper(3) (Unidentified)	Nymph	5th	5.520	0.083	10.480
		Adult	5th	14.930	0.225	22.750
11.	Short horned grasshopper(3) Attractomorpha crenulata	Adult	5th	9.395	0.142	11.090
12.	Long horn grasshopper (1) (Letana inflata)	Adult	7th	29.420	0.444	32.100
13.	Long horned grasshopper(2) (Unidentified)	Adult	5th	9.890	0.149	20.865
COLEOPTERA						
14.	Myllocerus discolor	Adult	3rd	0.0014	Negligible	0.0041
			4th	0.0076	0.0001	0.0196
			5th	0.0390	0.0005	0.0753
			6th	0.0463	0.0006	0.0926
			7th	0.0467	0.0007	0.0972
			8th	0.0563	0.0009	0.1366


METEOROLOGICAL PARAMETERS
TEMPERATURE (°C) AND RELATIVE HUMIDITY (%)
RAINFALL (mm)
R.H.
MAX. TEMP.
AV. TEMP.
MIN. TEMP.
R.F.

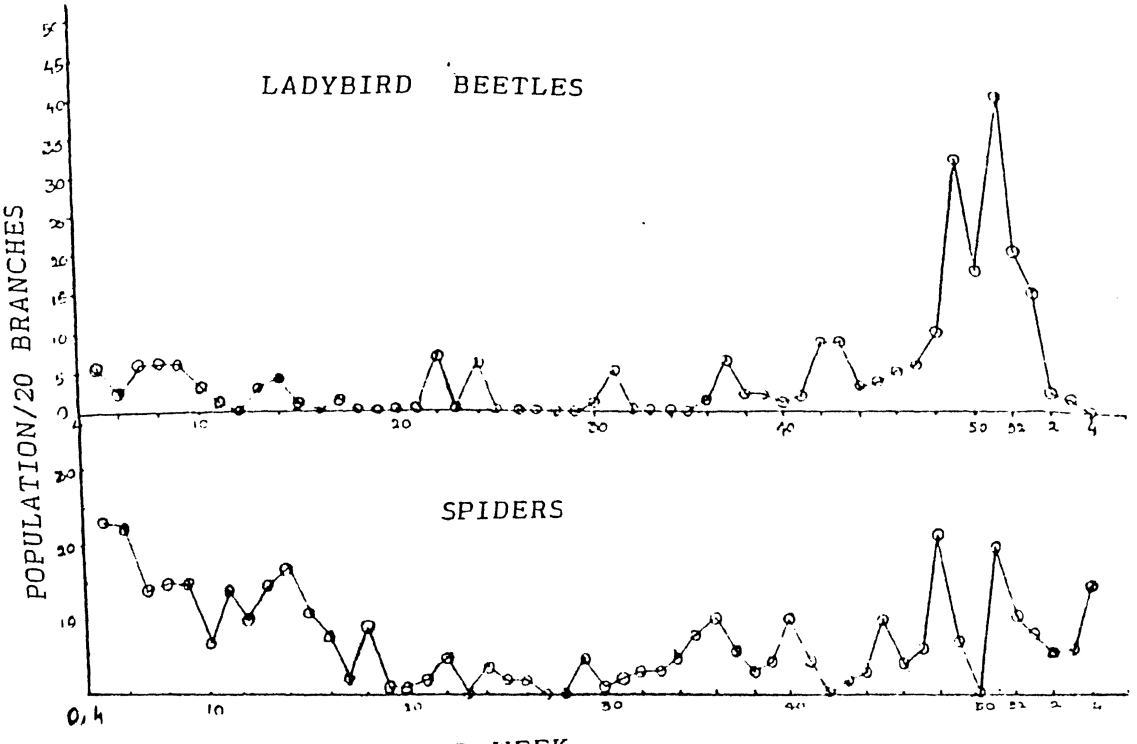

LADYBIRD BEETLES
SPIDERS
POPULATION/20 BRANCHES
STANDARD WEEK

FIG. 29.

present in the mulberry eco-system. Their exact host range and feeding capacity have not been studied. However, their population fluctuation over the year has been presented in Table 8 and Fig 25.

The data revealed that the ladybird beetle population was more prevalent in the month of December whereas, spider population was available more or less uniformly throughout the year. In the winter season mulberry leaves were attacked by powdery mildew disease and during that period ..... grubs, Pupae and adults of Illeis cincta were observed in very large numbers. The grubs and adults were found to be insectivorous and mildewvorous.

The pentatomid bug Cantheconoidea furcellata observed to predate upon semilooper, Pthonadria sp. (Fig, 35).

The spodoptera sp. pupae were parasitised by the tachnid parasite and leaf-tier larvae were parasitised by braconid parasites.

CHAPTER V

DISCUSSION

DISCUSSION

Orissa is a non-traditional mulberry growing state. The crop was introduced in commercial scale under the patronage of the Central Silk Board, Government of India and the Director of Textiles, Government of Orissa during the 6th Five year plan period. Since there was no research support to make a detailed study on the pest complex of mulberry crop, very little information was available on the pest fauna of mulberry. In order to generate information on different aspects of arthropod pests of mulberry, a study entitled "Arthropod pests infesting mulberry plants at Bhubaneswar" was undertaken during the year 1992-93. Although the study obviously was of general nature, nevertheless, it unfolded many new information on the subject.

1. FAUNAL COMPOSITION OF MULBERRY PESTS AT BHUBANESWAR

In Japan mulberry is attacked by 200 species of insects (Chu, 1936), in Korea 118 species (Omeya and Omi, 1935) and in Taiwan 87 species (Maki, 1976).

Kotikal (1982) recorded 62 insects and four non-insect pests of mulberry in India. In Orissa only six pests have been recorded on mulberry in literature (Anon. 1991).

In the present observation, it was observed that the mulberry crop at Bhubaneswar was attacked by 18 species of external leaf feeders which included 11 species from order Lepidoptera, five species of Orthoptera and two species of coleoptera. Apart from this ten species of sap sucking pests, four species of stem feeding insects, one species fruit pest, two species of root feeders and one species of mite.

Among these 35 pests recorded at Bhubaneswar, two species of bagworms, viz., Mahesena sp. and Manatha albipes were recorded for the first time on mulberry feeding upon the leaves. The sphecid wasp, Crabro orientalis was recorded as a new pest on mulberry which damaged the pith of the mulberry branches. The Bihar hairy caterpillar, Spilosoma (Diacrisia) obliqua, a major pest of mulberry, of course, was not recorded at Bhubaneswar although the same was recorded on mulberry in other parts of Orissa, viz., Phulbani, G. Udayagiri, Chandiput and Chandragiri.

2. SEASONAL INCIDENCE AND EXTENT OF DAMAGE

Of all the 35 pests recorded on mulberry crop at Bhubaneswar only five pests more or less regularly occurred throughout the year. The other pests appeared very sporadically and did not follow a regular population trend. The pests which occurred regularly are as follows-leaf-tiers, bagworms, myllocerus weevils, grasshoppers and mealy bugs. The period of general occurrence and peak period of occurrence of some

common pests are depicted in Fig. 26, 27 28 ~~and~~ ~~29~~ and Table 12. It is evident from the Fig. 26 & 27 and Table 12 that the leaf-tiers regularly appeared in the field and damaged to the tune of 17.4 % of the leaves. They were available in large number during the second fortnight of April and second fortnight of November. The Margaronia pulverulentalis were more prevalent during the summer months whereas M. pyoalis was more during the winter months, i.e., from the second week of September to the first week of January. Sengupta et al. (1990) reported that M. pulverulentalis was more active during dry seasons and our observations were in conformity with the author. Malik (1966) stated the pest infestation was very severe from July to October under Kashmir conditions. In Orissa the pest was not available from the second week of July to the last week of August. This pyralid commonly called "Sukhi-mushi" is a very serious pest in Japan during summer and late autumn. The symptom of damage is described as "Attic Window" in Japan. Similar damage symptom of this ubiquitous pest is found in Bhubaneswar locality.

Mild infestation due to tussock caterpillar was observed during the winter months, i.e., from the second week of November to the third week of December and again from the third week of January to the third week of February (Table 5). According to Kotikal (1982) this pest was very active on mulberry from October to March at Karnataka. This slight variation in

Table 12. **Peak period of activity of some pests of common occurrence on mulbery plants at Bhubaneswar**

Sl. No.	Insect	Peak period of activity (Months and weeks)	Maximum leaf/stem infestation (%)
1.	Tobacco caterpillar	July (1), August (1, 2)	10.66
2.	Tussock	November (2)	2.28
3.	Leaf-tiers	April (2)	17.40
		November (2)	7.77
4.	Bagworms	~~May (4) to January~~ (1)	
		November (1)	2.50
5.	Grasshoppers	April (4), August (4), November (4)	3.12
6.	Myllocerus weevils	May (1), February (4), November (4)	8.78
7.	Mealy bug	May (4) to July (2)	4.67
8.	Stemborers	November (1, 2)	9.16 (Stem)

activities of pests is due to the climatic variations at Bhubaneswar and Karnataka.

Five species of grasshoppers were observed in mulberry gardens at Bhubaneswar. It was interesting to observe ~~that~~ the feeding behaviour particularly of the long-horned grasshoper, Letana inflata. The adult did not prefer young leaves, on the other hand, they preferred semimatured leaves and young shoots of mulberry plant. The feeding habit of this adult grasshopper was very peculiar. They first started feeding on the petioles, then of the midribs and finally to the leaf lamina adjacent to main veins. Such feeding habit by this species has not been described by earlier workers. All the five species of grasshoppers remained active through out the year. However, three distinct peaks, i.e., once during last week of April, once during last week of August and again during the last week of November were observed. Ofcourse, the leaf damage never exceeded 3.12 %. The seasonal activity of grasshoppers reported by workers like Sidhu et al. (1968) and Kotikal (1982) is in the similar line with the one observed by the present author.

The two species of myllocerus weevils attacked roots in grub stage which was very uncommon to observe. Nevertheless damage by adult weevils to leaves was invariably found throughout the year. Maximum damage was during the first week of May and November and during the fourth week of

February. Althoguh these weevils were found throughout the year, the amount of biomass damaged by these weevils was very negligible which was also observed from glass house tests by confining the insects over caged plants. Kotikal (1982) mentioned the weevils were active from October to December and similar observations were made in the present study. It was further observed that myllocerus beetles attacked preferably the older leaves and newly prunned crop was not attacked. Therefore, it was concluded that deterioration of leaf quality due to myllocerus weevils would be of very smaller magnitude.

Mealy bugs caused appreciable damage to the leaves by causing malformation, distortions, curling, crinkling, puckering and atrophy of the leaves which were the common phenomenon with the mealy bug attack. Although many authors have described that mealy bug transmited tukra disease, yet whether such deformities occured due to involvement of a virus/mycoplasma or due to toximia remained unsolved. Investigation in this respect was beyond the scope of the study and it will be worth while for the future workers to throw light on this puzzling issue.

Regarding the seasonal activity, it was found that the mulberry mealy bug was a hot weather species with its peak observed during the fourth week of May to second week of July and during the other parts of the year, the population

of mealy bug was not traceable in the field even though, some diseased leaves came to notice.

Sriharan et al. (1979) mentioned that egg laying of mealy bug was poorer in winter months at Bangalore. According to Sengupta et al. (1990), the pest was very active in summer months. These observations find support with the observations made at Bhubaneswar.

3. CORRELATION STUDIES

The effect of temperature, relative humidity and rainfall on damage incidence due to leaf-tiers bagworms, mealy bugs and grasshoppers was investigated with the help of correlation co-efficient. Leaf infestation due to leaf-tiers was negatively correlated with relative humidity ($r = -0.41$ *). Likewise temperature was positively correlated with mealy bug damage ($r = 0.61$*). Such correlation co-efficients threw light on the activity of the pest which was perhaps attempted for the first time. These correlation co-efficients strongly supported the damage trends of the pests described in the previous sections.

4. LEAF CONSUMPTION BY EXTERNAL LEAF FEEDERS IN CAPTIVITY

The amount of biomass consumed by 14 insects was studied in captivity under laboratory conditions. Spodoptera, Eupterote, Euproctis, Pthonandria, Mahesena, shorthorned grasshoppers (2) and Letana sp. consumed roughly 30 % of

the preferred leaf/insect/day. In others excepting myllocerus weevils the damage was 10-25 %. In terms of green weight (gm) the weight loss was considered to be mild to moderate varying from 0.360 gm to 0.54 gm/insect/day. Such quantitative estimation under captivity has not been attempted earlier and the present study in this respect throw some light on damage potentiality of the insect.

5. NATURAL ENEMIES OF MULBERRY PESTS

During the course of observation 18 species of natural enemies which included seven species of insect predators two species of parasites and nine species of spiders were recorded in mulberry field. The preyingmantis, ladybird beetles, chrysopids and spiders were found to feed on different type of small insects present in the mulberry ecosystem. Among coccinellids, Menochilus sexmaculatus and Illeis cincta were prevalent. Illeis cincta grubs, pupae and adults were observed in large number during winters and found to be insectivorous and mildewvorus. The pentatomid bug Contheconoidea furcellata, observed feeding on the semilooper (Pthonandria sp.) larva. The Spodoptera sp. pupae were parasitised by the tachinid parasite and leaf-tiers larvae were parasitised braconid parasites which is in confirmation to the finding of Patel et al. (1969) and Sengupta et al. (1990).

Basing upon the mean percentage of leaf infestation studied over a year, the damage caused by the pests was

as follows Leaf-tier 3.469 %, bagworms 0.499 %, myllocerus weevil 3.385 %, grasshoppers 0.943 %, mealy bug 1. 495 % and due to sporadic pests 0.332 % and thus the cumulative leaf damage was approximately 10.123 %.

CHAPTER VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

A number of field and laboratory experiments were conducted at the Central Research Station of O.U.A.T., Bhubaneswar and in the Department of Entomology in College of Agriculture to study (1) the arthropod pest complex associated with mulberry crop, (2) to study their seasonal activity and the extent of damage under field conditions, (3) to study the natural enemies associated with mulberry pests, (4) to study the life cycle of some important pests under laboratory condition and (5) to study the extent of biomass damaged by pests in captivity. The period of study was from February, 1992 to April, 1993. Pest observation was recorded in mulberry field (Kanva 2) grown in the Central Research Station, Bhubaneswar. The salient research findings of the study are presented in the following paragraphs.

It was observed that the mulberry crop at Bhubaneswar was attacked by 35 species of arthropod pests which included 18 species of external leaf feeders, 10 species of sap sucking pests, four species of stem feeding insects, one species of fruit pest, one species of root feeder (excluding myllocerus weevil) and one acarine pest.

The scientific name of these 35 pests are (1) Spodoptera litura Fab. (2) Eupterote mollifera W., (3) Euproctis fraterna Moore, (4) Margaronia pulverulentalis Hmps., (5) M. Pyloalis W., (6) Pthonandria atrilineata Butler, (7) Laotia lepida Crammer, (8) Bombyx mandarina Leech, (9) Mahesena sp. (10) Manatha albipes, (11) Amata passalis stoll, (13) Unidentified short-horned grasshopper, (14) Attractomorpha crenulata Fab., (15) Letana inflata Brunner, (16) Unidentified long-horned grasshopper, (17) Myllocerus discolor Bohemann, (18) M. subfasciatus Guer, (19) Pseudodendrothrips mori Niwa, (20) Hoplothrips coloratus (Trybom), (21) Empoasca flavescens (Green) (22) Maconellicoccus hirsutus (Green), (23) Aphis sp., (24) Aleurolobus marlatii Quintance, (25) Otinotus oneratus W. (26) Eusarcocoris ventralis W., (27) Histrio menida Fab., (28) Nezara virudula L., (29) Aonidella aurantii (Maskell), (30) Saissetia nigra, (Niet), (31) Apriona japonica Thomson, (32) Crabro orientalis Cameron, (33) Dacus tau W., (34) Odonoto-termes obesus and (35) Tetrarychus equitorius Ms Gr.

Among the 35 pests enumerated above, the two species of bagworms, viz., Mahesena sp. and Manatha albipes were recorded for the first time as the pests of mulberry. Further, the sphecid wasp Crabro Orientalis was also recorded as a new pest which damaged the pith of the mulberry branches.

Of the 35 pests recorded on mulberry at Bhubaneswar, only five pests, viz., leaftiers (Margaronia Pulverulentalis, M. pyloalis) Bagworms (Mahesena sp., Manatha albipes) myllocerus

weevil (*Myllocerus discolor*), grass hoppers (*Cyrtocanthacris ranacea*, *Attractomorpha crenulata*, unidentified shorthorned grasshopper, *Letana inflata*, one unidentified longhorned grasshopper) and mealy bugs, *Maconellicoccus hirsutus* occurred more or less regularly throughout the year. The other pests appeared only sporadically and did not obey a regular population trend. Leaf-tiers which commonly occurred in the mulberry field, damaged to the tune of 17.4% of the leaves and appeared in large numbers during the second fortnight of April and November. The leaf - tier, *Margaronia pulverulentalis* was made prevalent during the summer months whereas, the second species, *i.e.*, *M. Pyloalis* was more active during the winter months, i.e.; from the second week of September to the first week of January. Mild infestation due to tussock caterpiller was observed during the winter months, i.e., during the 2nd week of November to the 3rd week of December again from the 3rd week of January to the 3rd week of February.

Five species of grasshoppers were observed in mulberry gardens at Bhubaneswar out of which two species are yet to be identified with authority. The feeding behaviour of long-horned grasshopper, *Letana inflata* was very much interesting. The adults did not prefer young leaves but damaged young shoots and semi-matured leaves. They first started feeding on the petioles then on the mid-ribs and finally to the leaf lamina adjacent to the main veins. This

type of damage symptom was kept on record for the first time. All the five species of grasshoppers remained active throughout the year but three distinct peaks were evident i.e., during the last weeks of April, August and November. Leaf damage by grasshopper never exceeded 3.12%.

Two species of myllocerus weevils attacked mulberry crop at Bhubaneswar. When they were in grub stage they attacked roots but such attack was not conspicuous. The adults nibbled the leaves and made irregular holes on the tender leaves. They also attacked the margins of the older leaves. Although these beetles were found throughout the year, maximum damage was recorded during 1st week of May and November and 4th week of February.

Mealy bugs caused appreciable damage to leaves both in quantity as well as quality by causing malformation, distortion, curlirg, crinckling, puckering and atrophy of leaves. Their attack also resulted in flattening of the apical shoot which did not grow straight but curved either towards right or left side. Mulberry mealy bug was a hot weather species with its peak observed during the 4th week of May and second week of July. During the other parts of year, the population either remained at its lowest ebb or not at all traceable. The tobacco caterpillar sporadically occurred in the mulberry field and at times caused significant damage which was confirmed from the laboratory feeding study. Each

larva on an average damaged 29.865% of the leaf and in terms of biomass it amounted to 0.327 gm. consumed/insect/day.

The effect of temperature, R.H. and rainfall on the damage incidence due to the leaf-tiers, bagworms, mealy bug and grasshoppers was investigated through study of correlation co-efficients. It was observed that rainfall had no instan simultaneous effect on the pest but there was lag effect on the damage. Leaf infestation due to leaf-tiers was negatively correlated with R.H. ($r = -0.41^*$). Temperature was positively correlated is its mealy bug damage ($r = 0.61^*$) and negatively correlated with myllocerus damage ($r = -0.54^*$). In all other cases correlation studies did not prove a significant relation between damage and climatic parameters

The amount of biomass consumed by 14 insects was studied in captivity under laboratory conditions. Spodoptera sp. Eupterote, sp. Euproctis, sp. Pthonandria, sp. Mahesena sp., shorthorned grasshoppers and Letana sp. consumed roughly 30% of the preferred leaf/insect/day. The other insects like Manatha albipes, unidentified longhorned grasshopper, M. Pulverulentalis and M. Pyloalis excepting myllocerus weevils, the damage varied from 10-25%. However, interms of biomass damaged by the insects, the figures were very very negligible. In terms of green weight, the damage varied from 0.360 gms. to 0.504 gm/insect/day.

During the course of observation 18 species of natural enemies which included 7 insect predators two species of parasites, and nine species of spider predators, were recorded in the mulberry field. The ladybird beetle, Menochilus sexmaculata was very common which exclusively attacked aphids small mealy bugs, thrips, whiteflies, and mites. The ladybird beetle, Illeis Cincta was found eating on the powdery mildew spores apart from attacking small homopterous insects.

It was concluded from the study that the mulberry crop was attacked by a wide array of 35 pests but only a few species like leaf-tiers, tussock caterpillars, grasshoppers and mealy bug damaged regularly and under favourable conditions may create concern for the silkworm growers in Orissa. Depending upon seasonal incidence, the pests can be grouped into two categories i.e., those causing major damage during the summer season, e.g. Margaronia pulverulentalis, Mahesena sp., grasshoppers, Maconellicoceus hirsutus, and those causing more damage during the winter season e.g. Spodoptera, Euproctis fraterna, Manatha albipes, Myllocerus sp.

Basing upon the mean percentage of infestation studied over a year, the damage caused by the pests was as follows-leaf-tiers 3.469% leaf damage, bagworm 0.499%, Myllocerus sp. 3.385%, grasshopper, 0.943%, mealy bug 1.495% and other sporadic pests 0.332% and thus the cumulative leaf damage was approximately 10.123%.