STATUS AND BIOECOLOGY OF MAJOR INSECT PARASITES OF THE TOBACCO CATERPILLAR, *SPODOPTERA LITURA* (FABRICIUS)

THESIS

suomitted to the

Rajasthan Agricultural University, Bikaner

in partial fulfilment

of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN AGRICULTURE

(ENTOMOLOGY)

by :

BINA SRIVASTAVA

1988

RAJASTHAN AGRICULTURAL UNIVERSITY, BIKANER

Dated 2nd June, 1988

CERTIFICATE I

This is to certify that ~~Miss~~ Mrs. Bina Srivastava has successfully completed the preliminary examination held on 16 July, 1987 as required under the regulation for Doctor of Philosophy.

Head 2.6.88

Department of Agricultural
Zoology and Entomology

RAJASTHAN AGRICULTURAL UNIVERSITY, BIKANER

Dated 2nd June, 1988

CERTIFICATE II

This is to certify that the thesis entitled "Status and bioecology of major insect parasites of the tobacco caterpillar, *Spodoptera litura* (Fabricius)" submitted for the degree of Doctor of Philosophy in the subject of Entomology of the Rajasthan Agricultural University, Bikaner is a bonafide research work carried out by ~~Miss~~ Mrs. Bina Srivastava under my supervision and that no part of this thesis has been submitted for any other degree. The assistance and help received during the course of investigation have been fully acknowledged.

2.6.88

Head,
Department of Agricultural
Zoology and Entomology

Major Advisor

Dean,
Rajasthan College of Agriculture,
Udaipur

RAJASTHAN AGRICULTURAL UNIVERSITY, BIKANER

Dated 9 .8 .1988

CERTIFICATE III

This is to certify that the thesis entitled "Status and bioecology of major insect parasites of the tobacco caterpillar, Spodoptera litura (Fabricius)" submitted by ~~Miss~~ Mrs. Bina Srivastava to the Rajasthan Agricultural University, Bikaner in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the subject of Entomology has been approved by the students advisory committee after getting the satisfactory reports of the external examiners and conducting the oral examination on the same.

Head of the Department

Major Advisor

APPROVED

Advisor

V. J. Shukhande 16/8/88

Advisor

DEAN

Dean, Post-Graduate Studies

Rajasthan Agricultural University, Bikaner

Rajasthan College of Agriculture

Camp-UDAIPUR

Advisor

ACKNOWLEDGEMENTS

I express my sincere and deep sense of gratitude to Professor K.S. Kushwaha, Emeritus Scientist and Ex-Professor of Eminence, Department of Agricultural Zoology and Entomology, Rajasthan College of Agriculture, Udaipur for able guidance and incessant encouragement.

I record my sincere thanks to Dr.L.S.Sharma, Head of the Department,Prof. R.P. Srivastava, the then Head of the Department, the Dean, Rajasthan College of Agriculture, Udaipur for providing necessary facilities, and Dr. V.J.Shrikhande for valuable suggestions from time to time. Thanks are also due to the I.C.A.R. for financial assistance; the Director, Commonwealth Institute of Entomology, British Museum (Natural History) for identification of the specimens; Dr. Y. Tanada, Professor of Entomology and Insect Pathology and Dr. G.M.Thomas, Diagnostician, Division of Entomology and Parasitology, University of California, Berkeley for identification of the pathogens.

I also feel obliged to Dr. S.C.Bharadwaj, Dr. P.C.Lodha, Dr. H.C.L. Gupta, Dr. R.C.Saxena, Dr. H.S. Rawat and Shri U.S.Sharma for their kind help at various stages.

The blessings of my parents and constant encouragements from them ultimately culminated in achieving the present academic objectives.

Bina Srivastava
(BINA SRIVASTAVA)

CONTENTS

	Page
INTRODUCTION	1
REVIEW OF LITERATURE	3
MATERIALS AND METHODS	17
EXPERIMENTAL FINDINGS	28
DISCUSSION	98
SUMMARY	112
REFERENCES	115
APPENDICES	i – l

LIST OF TABLES

Table		Page
1	Population incidence of S.litura infesting cauliflower crop in different localities at Udaipur (1985-86)	29
2	Population incidence of S.litura infesting cabbage crop in different localities at Udaipur (1986-87)	31
3	Population incidence of parasite-complex attacking S.litura in cauliflower crop in different localities at Udaipur (1985-86)	34
4	Population incidence of diseases in S.litura larvae in cauliflower crop in different localities at Udaipur (1985-86)	36
5	Population incidence of pupal mortality in cauliflower crop in different localities at Udaipur (1985-86)	37
6	Population incidence of parasite-complex attacking S.litura in cabbage crop in different localities at Udaipur (1986-87)	39
7	Population incidence of diseases in S.litura larvae in cabbage crop in different localities at Udaipur (1986-87)	40
8	Population incidence of pupal mortality in cabbage crop in different localities at Udaipur (1986-87)	41
9	Population incidence of cumulative biotic-mortality of S.litura larvae in cauliflower crop in different localities at Udaipur (1985-86)	43
10	Population incidence of cumulative biotic-mortality of S.litura larvae in cabbage crop in different localities at Udaipur (1986-87)	44
11	Crop and locality-wise summary of overall impact of mortality parameters on field larval populations of S.litura at Udaipur (1985-86,1986-87)	45
12.	Summary of the total parasitic-complex reared from the field collected larvae of Spodoptera litura infesting cauliflower and cabbage crops in different localities at Udaipur (1985-87)	47

Table		Page
13	Laboratory egg-mass cultures of S.litura exposed to T. chilonis in the cauliflower crop for parasitization (R.C.A. Farm, Udaipur, 1985)	49
14	Biology of P. orbata under laboratory conditions at Udaipur (1985)	61
15a	Correlation coefficient(r) of S.litura population and the biotic and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86)	62
15b	Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86)	62
16a	Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cauliflowler crop at village Chotinauka, Udaipur (1985-86)	63
16b	Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (1985-86)	63
17a	Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86)	64
17b	Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86)	64
18a	Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87)	68
18b	Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87)	68

Table		Page
19a	Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (1986-87)	69
19b	Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (1986-87)	69
20a	Correlation coefficient (r) of S.litura population and biotic and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87)	70
20b	Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87)	70
21	Correlation coefficient(r) of Peribaea orbata population with the pest population and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86)	71
22	Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (1985-86)	72
23	Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86)	73
24	Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87)	81
25	Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (1986-87)	81
26	Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87)	81

Table		Page
27a	Toxicity of insecticidal treatments to the emergence of *Trichogramma chilonis* from eggs of *Spodoptera litura*	87
27b	Interaction of insecticides and dose on the emergence of *T. chilonis*	89
28	Effect of insecticides on the adult parasite, *P. orbata* along with its host larvae (*S.litura*) under laboratory conditions (September - October, 1985)	93

LIST OF FIGURES AND GRAPHS

Fig.		Between pages
1	The egg parasite, Trichogramma chilonis Ishii in lateral view	30 - 31
2	The larval parasite, Apanteles species (vitripennis species-group) in lateral view.	32 - 33
3	The larval parasite, Chelonus sp. in lateral view	32-33
4	The larval parasite, Microplitis species in lateral view	32-33
5.	The larval parasite, Rogas species in lateral view	32-33
6	The larval parasite, Campoletis chlorideae Uchida in lateral view	32-33
7	The larval parasite, Eriborus sp.? argenteopilosus in lateral view	32-33
8	The larval parasite, Peribaea orbata (Wiedemann) in dorsal view	32-33
9	Natural larval populations of S. litura and mortality on account of natural enemies in its different stages in cauliflower crop at Kushalbag Farm	33-34
10	Natural larval populations of S. litura and mortality on account of natural enemies in its different stages in cauliflower crop at village Chotinauka	33-34
11	Natural larval populations of S. litura and mortality on account of natural enemies in its different stages in cauliflower crop at Horticulture Farm.	33-34

Fig.		Between pages
12	Natural larval populations of S.litura and mortality on account of natural enemies in its different stages in cabbage crop at Kushalbag Farm	38-39
13	Natural larval populations of S.litura and mortality on account of natural enemies in its different stages in cabbage crop at village Chotinauka	38-39
14	Natural larval populations of S. litura and mortality on account of natural enemies in its different stages in cabbage crop at Horticulture Farm	38-39
15	Larval population of S. litura and associated species of parasites in cauliflower crop at Kushalbag Farm	38-39
16	Larval population of S. litura and associated species of parasites in cauliflower crop at village Chotinauka	38-39
17	Larval population of S. litura and associated species of parasites in cauliflower crop at Horticulture Farm	38-39
18	Larval population of S. litura and associated species of parasites in cabbage crop at Kushalbag Farm	38-39
19	Larval population of S. litura and associated species of parasites in cabbage crop at village Chotinauka	38-39
20	Larval population of S. litura and associated speices of parasites in cabbage crop at Horticulture Farm	38-39
21a	Sequence of parasites in cauliflower crop (kharif) at three localities (1985-86)	50-51
21b	Sequence of parasites in cauliflower crop (rabi) at three localities (1985-86)	50-51

Fig.		Between pages
22	Immature stages of T. chilonis Ishii	53 - 54
23	Incidence of P.orbata parasitizing S.litura vis-a-vis abiotic factors (1985-86)	55-56
24	Immature stages of P. orbata (Wiedemann)	60 - 61
25a	Population of S.litura and the interacting biotic and abiotic factors in cauliflower crop at Kushalbag Farm (1985)	61 - 62
25b	Population of S. litura and the interacting biotic and abiotic factors in cauliflower crop at Kushalbag Farm, (1986)	61 - 62
26a	Population of S. litura and the interacting biotic and abiotic factors in cauliflower crop at village Chotinauka (1985)	61 - 62
26b	Population of S. litura and the interacting biotic and abiotic factors in cauliflower crop at village Chotinauka (1986)	61 - 62
27a	Population of S. litura and the interacting biotic and abiotic factors in cauliflower crop at Horticulture Farm (1985)	61 - 62
27b	Population of S. litura and the interacting biotic and abiotic factors in cauliflower crop at Horticulture Farm (1986)	61 - 62
28a	Population of S. litura and the interacting biotic and abiotic factors in cabbage crop at Kushalbag Farm (1986)	78-79
28b	Population of S. litura and the interacting biotic and abiotic factors in cabbage crop at Kushalbag Farm (1987)	78-79
29a	Population of S. litura and the interacting biotic and abiotic factors in cabbage crop at village Chotinauka (1986)	78-79

Fig.		Between pages
29b	Population of S. litura and the interacting biotic and abiotic factors in cabbage crop at village Chotinauka. (1987)	78-79
30a	Population of S. litura and the interacting biotic and abiotic factors in cabbage crop at Horticulture Farm (1986)	78-79
30b	Population of S. litura and the interacting biotic and abiotic factors in cabbage crop at Horticulture Farm (1987)	78-79

LIST OF APPENDICES

Appendix		Page
I	Insect parasites of the tobacco caterpillar, Spodoptera litura (Fabricius)	i
II	Quantitative incidence of Spodoptera litura and its related biotic components in cauliflower crop sampled on Kushalbag Farm, Udaipur, (1985-86)	iv
III	Quantitative incidence of S.litura and its related biotic components in cauliflower crop sampled at village Chotinauka, Udaipur (1985-86)	vi
IV	Quantitative incidence of S. litura and its related biotic components in cauliflower crop sampled at the Horticulture Farm, Udaipur (1985-86)	viii
V	Status of different parasites attacking S. litura infesting cauliflower crop at Kushalbag Farm, Udaipur (1985-86)	x
VI	Status of different parasites attacking S. litura infesting cauliflower grop at village Chotinauka, Udaipur (1985-86)	xii
VII	Status of different parasites attacking S.litura infesting cauliflower at Horticulture Farm, Udaipur (1985-86)	xiv
VIII	Quantitative incidence of S.litura and its related biotic components in cabbage crop sampled on Kushalbag Farm, Udaipur (1986-87)	xvi
IX	Quantitative incidence of S.litura and its related biotic components in cabbage crop sampled on farmer's field in village Chotinauka, Udaipur (1986-87)	xvii
X	Quantitative incidence of S.litura and its related biotic components in cabbage crop sampled at the Horticulture Farm, Udaipur (1986-87)	xviii

Appendix		Page
XI	Status of different parasites attacking S. litura infesting cabbage crop at the Kushalbag Farm, Udaipur (1986-87)	xix
XII	Status of different parasites attacking S. litura infesting cabbage crop at the village Chotinauka, Udaipur (1986-87)	xx
XIII	Status of different parasites attacking S. litura infesting cabbage crop at the Horticulture Farm at Udaipur (1986-87)	xxi
XIVa	Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (August - December, 1985)	xxii
XIVb	Field population of S. litura and the related data for biotic and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (July - December, 1986)	xxiii
XVa	Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (August - December, 1985)	xxiv
XVb	Field population of S. litura and the related data for biotic and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (July - November, 1986)	xxv
XVIa	Field population of S. litura and the related data for biotic and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (August - December, 1985)	xxvi
XVIb	Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (July - December, 1986)	xxvii
XVIIa	Field population of S. litura and the related data for biotic and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January - February, 1986)	xxviii

Appendix		Page
XVIIb	Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January - February, 1987)	xxviii
XVIIIa	Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (January - February, 1986)	xxix
XVIIIb	Field population of S. litura and the related data for biotic and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (January - February, 1987	xxix
XIXa	Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (January - February, 1986)	xxx
XIXb	Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at the Horticulture Farm, Udaipur (January - February, 1987)	xxx
XXa	Pupal population of S.litura and the related data for biotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86)	xxxi
XXb	Pupal population of S.litura and the related data for biotic factors in cauliflower crop at village Chotinauka, Udaipur (1985-86)	xxxiii
XXc	Pupal population of S. litura and the related data for biotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86)	xxxv
XXIa	Pupal population of S. litura and the related data for biotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87)	xxxvii
XXIb	Pupal population of S.litura and the related data for biotic factors in cabbage crop at village Chotinauka, Udaipur (1986-87)	xxxviii

Appendix		Page
XXIc	Pupal population of S. litura and the related data for biotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87)	xxxix
XXIIa	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (August - December, 1985)	xl
XXIIb	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (July -December,1986)	xli
XXIIIa	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (August - December, 1985)	xlii
XXIIIb	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (July - November, 1986)	xliii
XXIVa	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (August - December, 1985)	xliv
XXIVb	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (JUly - December, 1986)	xlv
XXVa	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January -February, 1986)	xlvi

Appendix		Page
XXVb	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January-February, 1987)	xlvi
XXVI	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cabbage crop at village Chotinauka, Udaipur (January - February, 1987)	xlvii
XXVIIa	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (January - February, 1986)	xlviii
XXVIIb	Field population of the parasite, P. orbata parasitizing S. litura and the related data for key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (January - February, 1987)	xlviii
XXVIII	Test of significance of effectiveness of insecticides on the emergence of T. chilonis under laboratory conditions (Ref. Table 27a,b)	xlix
XXIX	Test of significance of effect of insecticides on the adults of the parasite, P. orbata along with its host larvae (S. litura) under laboratory conditions (Ref. Table 28)	L

INTRODUCTION

INTRODUCTION

The rash of pest outbreaks which has occurred over the last few years in literally every country where certain new organic insecticides have been used is a testimony to this bifaced ecological impact.

The tobacco caterpillar, Spodoptera litura (Fabricius)- a cosmopolitan pest - has become a major and pernicious one in the past few years. It is a polyphagous noctuid, recorded on 112 species of host plants belonging to 44 families in tropical and temperate zones (Moussa et al., 1960). In India, it was recorded on 63 plant species belonging to 22 families (Prasad and Bhattacharya, 1975). A loss of about 282 lakhs in tobacco and Rs. 275 lakhs in chillies has been reported from Andhra Pradesh (Krishnamurthy Rao et al.,1983).

The strategic importance of biological control agents effective in limiting the endemic and migratory populations of the pest needs to be assessed. It implies an extensive knowledge of the ecobiological factors decisive for the activity of the parasitic-complex. As a sequal to this approach, sequence and status of individual species of the

parasitic-complex were investigated under crop ecosystems. Concurrently, ecobiological interactions/ correlations with the pest and the key abiotic factors in cabbage and cauliflower crops were studied. Presently, therefore, insecticidal efficacy to the pest and its relative safety to the major parasites (T. chilonis and P. orbata) was evaluated under the laboratofy conditions. But insecticidal treatments must be in consonance with the natural-enemies of the pest. The component of biological control in pest management is not to be viewed as a method that will necessarily exclude or altogether eliminate the use of chemical pesticides.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The tobacco caterpillar, S. litura is a widely distributed pest reported on 112 cultivated crop plants belonging to 44 families in tropical and temperate zones (Moussa et al., 1960). In India, 63 plant species, belonging to 22 families were recorded as hosts (Prasad and Bhattacharya, 1975). The major hosts included cabbage (Fletcher, 1914) and cauliflower (Fletcher, 1932; Basu,1943, 1945). A comprehensive review pertaining to host plants of the pest, related biotic components and use of insecticides has been provided (Prasad, 1978; Sheikh, 1984; Chelliah and Natarajan, 1985; Jayaraj and Santharam, 1985; Jayaraj, 1985; Vijayvergia , 1986). Annonated notes on pest incidence (Nasr, 1961; Rivney, 1961; Pandey, 1970; Patil and Devaiah, 1978; Sasitharan, 1980; Maheswara Reddy, 1982; Balasubramanian, 1983), outbreaks (Goco, 1921; Janisch, 1930; Moutia, 1935; Nasr, 1961; Pandey, 1970, 1976) and correlations with the abiotic factors (Nasr et al,1973; Chelliah and Natarajan, 1985) have also been contributed.

Incidence and status of parasites attacking the pest (S. litura)

A wide range of parasitic-complex comprised of about 74 species of insect parasites attackigg the pest in different stages. These included 10 egg, 3 egg-larval, 48 larval, 2 larval-pupal, 15 pupal and 1 larval-adult parasite species besides a pupal hyperparasite (Appendix I).

Utilization of egg parasites need our serious consideration since the crop damage can be greatly reduced if the parasites are released timely and in adequate numbers at frequent intervals. Of the egg parasites, there were three species of braconids, belonging to genus Chelonus (blackburni Gupta, formosanus Sonan, heliopae Gupta); two species of scelionid, Telenonus (nawaii Ashmead, remus Nixon), and five species of trichogrammatid, Trichogramma (australicum Girault, chilonis Ishii, evanescens Westwood, evanescens minutum Riley, pretiosa Riley).

The use of egg parasites such as Trichogramma species is promising. Mass-multiplication is cheap but needs proper timing and efficient field application techniques (Huffaker, 1977; Yadav and Patel, 1987). But, Trichogramma species in particular have poor searching ability (Nagarkatti,1982). Diets have been developed for in vitro rearing of

Trichogramma species (King et al., 1982). The species, T. chilonis was reported to be a major parasite of S. litura at Anand (Yadav and Patel, 1987), and Udaipur (Prasad, 1978; Vijayvergia , 1986). Telenomus remus Nixon also gave encouraging results by inundative releases and parasitized more than 50.0 per cent of the S. litura eggs in cabbage copr. (Krishnamoorthy and Mani, 1985). T. chilonis and Telenomus species were active even in the hottest parts of the season on S.litura (Anonymous, 1987b). The use of Trichogramma species and Chelonus blackburni was amply demonstrated in Gujarat against S. litura and Heliothis armigera (Anonymous, 1983). C. blackburni was capable of breeding successfully in the field (Anonymous, 1983) and suitability of laboratory hosts for its mass-rearing was discussed (Pradyumn Kumar and Ballal, 1987). In case of C. heliopae, mass-rearing was not economical since the parasite was not amenable to mass-multiplication (Nagarkatti, 1982).

The egg-larval parasites included three braconid species under Chelonus (blackburni Gupta, carbonator, formosanus Sonan).

The larval parasites are known for environmental resistance against increases in pest populations. Potential for using larval parasites in augmentative releases was indicated (King et al., 1982). The species of larval

parasites, arranged under family and genera, included the following:

Fannidae: Fannia leucostica Smith

Phoridae: Megaselia species

Sarcophagidae: Sarcophaga peregrina (Robineou-Desvoidy), Sarcosolomonia species

Tachinidae: Actia nigrutula L., Blepharella lateralis (Macquart), Cnephalia (Gonia) cinerascens Rond, Peribaea orbata (Wiedemann), Podomyia setosa Dol.,Sturmia species (aequalis Mall, incospicuoides Baranov), Tachina larvarum L., Winthemia dispar Macq.

Braconidae: Apanteles species (beneficiens Vies, species nr. colemani Viereck, flavipes (Cameron), glomeratus, marginiventris (Cress.), species (octonarius) group, prodeniae Viereck, risbeci species n., ruficrus Haliday, species (vitripennis species - group), Bracon gelicheae, Chelonus formosanus Sonan, Microbracon serinopae Ramskr, Microplitis (demolitor Welkn., prodeniae Rao and Kuriyan), Rogas species, Zele (chlorophthalma (Nees), nigricornis (Wlkn.))

Chalcididae: Lasiochalcidia erythropoda Cameron.

Eulophidae: Euplectrus (gopinomohani Mani, xanthocephalus),

Ichneumonidae: Barylypa humeralis (Brauns), Campoletis (chlorideae Uchida, flavicincta), Carops obtusus Morl., Charops species, Diadegma argenteopilosa Cameron,

Enicospilus species, Eriborus sp.? argenteopilosus (Cameron), Eulimneria xanthostoma (Grav.), Metopius (discolor Tosq., kapugawanus Mats.), Netelia ferruginea Cameron, Paniscus (productus Brulle, testaceus Gravenhorst).

In general, however, the mass-rearing of larval parasites, particularly those that are solitary, is laborius and uneconomical (King et al., 1982). Since Apanteles marginiventris Cress. had considerable potential for use in augmentation programmes it was imported from West Indies and introduced to attack and develop in S. litura (Lingren, 1969; Singh, 1985). Campoletis chlorideae and Eriborus species were not amenable to mass-rearing and the process was uneconomical (King et al., 1982; Sithanantham, 1987). Campoletis flavicincta parasitized the pest S. litura effectively (Anonymous, 1987b). Microplitis species proved to be an effective solitary larval parasite and more capable of withstanding adverse conditions than its host (Hegazi et al., 1977). The tachinid flies have high fecundity, ability to disperse well and also to search out the host (David, 1987). P. orbata could be mass-bred easily in the laboratory and was gregarious (Nagarkatti, 1982); 1 to 12 parasitic larvae emerged from a single host larva (Jayanth and Nagarkatti, 1984). It was more dominant on S. litura (Chari and Rao, 1987).

The larval-pupal parasites reported earlier comprised of a species each of Phoridae, Megaselia species and tachinidae, Blepharella lateralis (Macquart).

The pupal parasites, arranged under family and genera, included the following:

Phoridae: Megaselia species

Sarcophagidae: Parasarcophaga misera, Sarcophaga (dux Thoms, albiceps Mg.)

Tachinidae: Actia (Gymnopareia) aegyptia Villen, Stomatomyia bezziana Baranov, Strobliomyia aegyptia Vill.

Braconidae: Xanthopimpla stemmator Thnb.

Chalcidoidae: Brachymeria lassus Walker, Hybothoracini sp.

Eulophidae: Tetrastichus ayyari Rohwer, Trichospilus pupivora Ferr.

Ichneumonidae: Eucthromorpha species, Metopius rufus Cameron

Pteromalidae: Conomorium cremita (Forst)

Besides these, a pupal hyper-parasite, Aphanogamus fijiensis Ferriere was also reported. (Hym.: Ceraphronidae)

The larval-adult parasite reported included only one species of family eumeridae, Delta maxillosa dimidiatipennis Saussure.

Bioecology of the major egg and larval parasites

T. chilonis

T. chilonis was first collected from eggs of Chilo

simplex Butler and Diatraea on rice plants near Los Banos, Laguna in Phillipines (Ishii, 1941). Its diagnostic characters were discussed with different criteria (Tsen&heng, 1965;Manolache & Tian,1973;Nagarkatti and Nagaraja,1971,1977, 1979; Xia et al., 1982). The species is widely distributed in Australian and Oriental regions including Japan, Madagascar, Mauritius, Indian subcontinent and Sri Lanka (Nagarkathi and Nagaraja, 1971; Nagarkatti, 1982).

The adults of Trichogramma were markedly phototactic positively and their activity increased with light intensity. (Costas, 1951; Quednau, 1958). Pu et al. (1981) studied the habits of T. chilonis. The parasite interacted to host environment including light and temperature rather than the host (Laing, 1938; Metcalfe and Breniere, 1969).

The parasite in high intensity of population, was recorded during July - September and March - May at Anand in Gujarat (Anonymous, 1987b) and August to November at Udaipur (Zaz, 1982; Srivastava and Kushwaha, 1987a). It parasitized to the extent of 15.0 per cent (Zaz and Kushwaha, 1983). In another survey at Udaipur, T. chilonis alongwith Telenomus species parasitized upto 36.8 per cent (Vijayvergia , 1986). Thontadarya and Nangia (1983) reported it to parasitize upto 32.5 per cent of the S.litura eggs at Karnataka during May, 1983.

Valuable contributions have been made in developing

rearing techniques (Singh, 1969; Rajendram and Hagen, 1974; Li, 1982; Liu and Wu, 1982; David and Easwaramoorthy, 1986) and rearing cages (Ulrich, 1968) for mass multiplication of Trichogramma species. Reduction in effectiveness consequent to long term laboratory rearing of Trichogramma had been indicated (Ashley et al., 1973; Nagarkatti, 1979); and the species could be stored at 10°C for 35 days without significant mortality (Anonymous, 1987a).

Host preference of T. chilonis was highest on Corcyra cephalonica and followed in sequence H. armigera, Sitotroga cerealella and Cadra cautella (Navarajan Paul et al., 1981). It was earlier established that the female could distinguish parasitized eggs by the smell left by itself or other individuals (Salt, 1937). However, this response could be lost when there were excess of Trichogramma population which resulted in superparasitism. This could ultimately result in slower development, smaller adults with low fecundity and progressive degeneration of the stocks (Breniere, 1965; Metcalfe and Breniere, 1969). Drumming, oviposition or drilling of the egg-chorion was regardless of the stage of the development of the host egg (Quednau, 1960; Breniere, 1965; Klomp and Teerink, 1962). The duration of life-cycle of T. chilonis was influenced with variation in temperature. Accordingly, it was completed within 6.8 (33.32°C), 7 to 8

(26 -28°C) and 11.9 (22.1°C) days (Pan and Lim, 1981; Tuhan and Pawar, 1983). However, optimum temperature was reported to be 27°C (Savescu and Tien, 1972). The biology of the species was studied at Udaipur (Srivastava and Kushwaha,1987à). Other investigations pertaining to biology of the species are referrable to Nagarkatti and Nagaraja, (1978),Zaslavskii and Kvi, (1982),Fabritius and Hassan, (1984),and Mohasin and SomChoudhary (1987).

The optimum conditions for field release of parasites were concluded to include temperature 24-26°C, relative humidity 60 - 80 (%) and sunny weather (Savescu and Tien, 1972). T. chilonis could survive extreme summer temperature of more than 36°C of Bangalore (Nagarkatti, 1973). But high temperatures of 34.6 (1975) to 38.3°C (1974) adversely affected its survival at Anand (Yadav and Patel, 1981). The parasite was positively correlated with temperature and host density (Vargas and Nishida, 1982). Nagarkatti (1979) discussed intermixing of strains from different agroclimatic zones for inundative releases. On the field scale, releases of T. chilonis from 70,000 to 830,000 / ha were made successfully during 1980 to 1987 in crop seasons to control S.litura (Yadav and Patel, 1987). Mass releases of the species under field conditions were successful in Tamil Nadu and Hyderabad (Sithanantham, et al.,1982; Gupta et al., 1987).

P. orbata

Biotic efficiency of the tachinid flies relevant to sugarcane borers (moths) was elaborately discussed (Bennet, 1969). Tachinids are most important amongst entomophagous diptera, and their hosts were mostly the larvae of Lepidoptera, or adults of Coleoptera (Clausen, 1940).

P. orbata is an effective larval parasite of S.litura in India (Jayanth and Nagarkatti, 1984). Description of this species was given in detail under the name Strobliomyia aegyptia by Mesnil (1963). The detailed synonyms and identity of this species were discussed by Crosskey (1966, 1973) and Hegazi et al.(1977). Shima (1981) briefly discussed the geographical variations of the parasite.

The parasite is widespread from Africa through the South East Asia to Australasia, Melanesia and Micronesia (Shima, 1981).

The parasitization (%) by P. orbata was 6.5 to 8.9 at Rajahmundry in South India during October - November (Anonymous, 1983). Recently the parasitization was recorded upto

---

Synonyms: Gymnoparia aegyptiaca (Willcocks and Bahgat,1937), Actia palpalis (Kamal, 1951), Strobliomyia aegyptia (Mesnil, 1963), Strobliomyia (Peribaea) orbata(=aegyptia) (Hegazi et al., 1977).

24.0 per cent (Chari and Rao, 1987). At Anand in Gujarat, the parasitization was only 1.2 per cent (Anonymous,1983). Studies at Udaipur from 1975 to 1986 revealed that parasitization of S. litura was higher in cauliflower crop than in cabbage. The parasite was attacking the pest from July to January and assumed a major status during August to October, when it parasitized 14.0 to 25.0 per cent of the pest population in cauliflower crop. In cabbage, the pafasitization was only upto 5.0 per cent (Prasad, 1978; Zaz, 1982; Vijayvergia , 1986; Srivastava and Kushwaha, 1987b).

Cleare (1939) first observed that tachinid females could be guided to suitable oviposition site by smell. Simultaneously, Clausen (1940) contributed a review on the biology of tachinids. Basically, the temperature, light and age of the flies were attributed to be critical factors for mating of the tachinids. The period of gestation, larval and pupal, in tachinids was discussed under tropical conditions (Bennet, 1969). In Egypt at Alexandria, the species completed the life-cycle in 10 to 19 days (Hegazi et al., 1977).

Augmentative releases in P. orbata were convenient because the species could be mass-bred in the laboratory (Nagarkatti, 1982). Exposure to mild sunlight for 45 to 75

minutes / day stimulated the mating activity of the adults in the laboratory (Anonymous, 1980). Life-cycle of the parasite, at Rajahmundry was completed in about 15 days (Anonymous, 1981). At Udaipur, the biology, was studied in detail (Srivastava and Kushwaha, 1987b). Interestingly, the sexual dimorphism was present even in the pupal stage (Anonymous, 1980). Longevity of the laboratory bred adults was 6 to 10 days under field conditions as against 16 to 18 days in the laboratory (Anonymous, 1985).

Superparasitism was recorded and in an earlier observation, 8 to 10 puparia were recorded (Anonymous, 1980), and subsequently 1 to 12 maggots were noted emerging from a single full grown host larva (Jayanth and Nagarkatti, 1984).

Normal pupal development in tachinids was impaired at low humidity and temperature (Bennet, 1969).

Efficacy of insecticides against S.litura vis-a-vis safety to the parasites

T. chilonis

A series of insecticidal trials have revealed that only few like endosulfan, lindane and phosalone were relatively safer to the insect parasites (Rattan Lal and Prakash Sarup, 1970; Singh, 1970; Thobbi, 1970; Navarajan Paul et al.,

1976; Sukhoruchenko et al., 1977; Nagarkatti, 1982). General conclusions have indicated that insecticides at commonly used dosages in control of the pests had proved highly toxic to the parasites (Mabbet, 1979; Xie et al.,1984; Santharam and Kumaraswami, 1985). There was no incidence of T. chilonis in the fields which were regularly treated with insecticides (Yadav and Patel, 1987).

Considering safety to T. chilonis, after its adults were exposed to the toxic film in the laboratory, endosulfan (0.1%) was found to give least mortality followed by lindane and phosalone (Navarajan Paul et al., 1976; Sithanantham and Navarajan Paul,1980). It was also reported that the activity of T. chilonis was not hampered by Cypermethrin (Anonymous, 1987b).

The trials to evaluate emergence of parasites after treatment of host eggs have revealed that maximum emergence of parasite was noticed in case of endosulfan (0.1%) (Navarajan Paul et al., 1976; Sithanantham and Navarajan Paul, 1980), (0.035 %) (Santharam and Kumaraswami, 1985), (0.025 %) (Srivastava and Kushwaha, 1987c), malathion and lindane (0.1%) (Navarajan Paul et al., 1976), and monocrotophos (0.025 %) (Santharam and Kumaraswami, 1985). Low percentage of emergence was noticed from host eggs sprayed with insecticide just prior to emergence (Navarajan Paul

et al., 1976) and when host eggs were treated before parasitization (Santharam and Kumaraswami, 1985).

Differential mortality of the parasite consequent to treatment of pupal stage at different doses of insecticides has also been indicated (Mohasin and Somchoudhary, 1987).

P. orbata

There was no reference of work on this aspect of the parasite available. However, Yadav and Patel (1987) recorded no parasite population from fields sprayed with insecticides.

MATERIALS AND METHODS

MATERIALS AND METHODS

Field incidence for seasonal intensity of *Spodoptera litura* and associated parasites in cauliflower and cabbage

Sampling of major crop hosts vis-a-vis pest parasite intensity

Cauliflower (*Brassica oleracea* var. *botrytis*) and cabbage (*B. oleracea* var. *capitata*) being the most preferred host of *S. litura* were selected for regular population sampling.

Observations were taken on the University Horticulture (RCA) and Kushalbag Farms at Udaipur, and in the village Chotinauka adjoining Udaipur. Absolute sampling of the larval stages in crop fields was carried out weekly at intervals. The larvae thus collected were individually reared in the Biocontrol Laboratory in order to study the extent of mortality on account of biotic agents including diseases in successive stages of pest development.

Note - RCA, Rajasthan College of Agriculture.

The method of "Stratified random" sampling was followed. Accordingly, the field was divided into three subdivisions or strata; one sample was randomly drawn out from each strata. (vide Yates and Finney, 1942; Healy, 1962).

Sampling unit

Absolute population estimates, expressed as density per unit area of the crop, was taken, the unit area for cabbage as well as cauliflower was fixed as 20 sqm. (100 plants) per stratum*. Three samples were drawn - one from each stratum - to make a plant count of 100 each and cumulative count of 300 plants. The samples were taken in the fore-noon from 8.00 to 10.30 a.m. Distribution of the pest larvae in different stages of growth was recorded.

Laboratory rearing

The egg-masses collected from the laboratory pest cultures were pinned in batches for egg parasitization on the foliage of the crop host of the pest in the field

---

* The plant count corresponding to the unit area of the cabbage and cauliflower crops was based on the recommended plant population per hectare.

at the RCA Farm. The egg masses were exposed for duration of 24, 48 and 72 hours after which the respective lots were brought back for hatching in the laboratory.

In case of larval collections, rearing was done in separate plastic containers (6 x 6 cm). The lid of each container was cut centrally (3 cm diameter) and was replaced/ refixed with a plastic gauge of 20 mesh. Individual larval record was maintained pertaining to its locality, date of sampling, its fate during the period/ span of rearing till adult emergence, or its mortality on account of parasitism, pathogenicity or deformity. Each container was disinfected with 10 per cent formalin solution. Those larvae preparing to pupate were transferred to containers with sieved moist soil of about 3 cms. The emerged parasites if any, out of the parasitized larvae were marked and identified at the Commonwealth Institute of Entomology, British Museum (Natural History), London.

The parasitic-complex thus identified included one egg (Trichogrammatidae, Trichogramma chilonis Ishii) and 9 larval (Braconidae, Apanteles species (vitripennis species-group), Chelonus sp., Microplitis sp., Rogas sp., Ichneumonidae, Campoletis chlorideae Uchida, Eriborus sp.? argenteopilosus, Charops sp.; Tachinidae, Blepharella

lateralis (Macquart), Peribaea orbata (Wiedemann)) parasites.

Mass-rearing techniques

S. litura. - The larvae were reared on the natural crop hosts as well as on the artificial diet. The diet formulated by Patel et al. (1973) was found to be satisfactory for successful rearing. To start with, the glasswares to be used were autoclaved for 20 minutes at 15 p.s.i. and 120°C; 10 per cent formalin solution was used to disinfect other equipments. Green lucerne fodder was dried in open air under shade; the dried leaves and tender parts were thoroughly ground and sieved through 20 mesh screen to obtain the fine leaf powder. Agar was then dissolved by boiling in three-fourth water (1200 ml) and thoroughly mixed in leaf powder. The water added contained antimicrobial solution in it before it was mixed with leaf powder. At 15 p.s.i. the mixture was cooked for 25 minutes in a pressure-cooker and was allowed to cool; the remaining water was thoroughly mixed with the measured quantity

---

N.B. Ingredients of the semi-synthetic diet: Lucerne leaf powder 600 g.; Ascorbic acid 12 g; Agar 6 g; Vitamin solution 30 ml (Dissolve 12 mg biotin/100 ml water + nicotinic acid 600 mg; cal.pentothenate 600 mg; riboflavin 300 mg; pyridoxine hydrochloride 150 mg; and Vitamin B-12 1.2 mg); Antimicrobial solution (4 g sorbic acid and 3.0g methyl-parahydroxybenzoate dissolved in 34 ml ethyl alcohal); Formalin 1ml; Acetic acid 12 ml and Distilled water 1800 ml.

of acetic acid, vitamin solution and formalin. Plastic dishes with a thin layer of diet were kept upside down on wire screen support half inch above soil in the rearing cage.

To run the culture on artificial diet, the freshly hatched larvae were transferred from the laboratory culture of larvae. To start with, the larvae were transferred to a wide mouth glass jar containing fresh leaves of caster. The mouth of the jar was covered with a piece of finely perforated plastic sheet (on the inner sides). The jar was covered with black cloth to allow the larvae to settle on the leaf. On the next day, fresh leaf was provided below the older one. Within four days, most of the larvae developed into third instar. These were transferred to the cage containing plastic dishes with the artificial-diet, and then covered by black cloth. The larvae approached food through the wire screen support and fed from below. The excrement dropped through the screen; regular cleaning and fresh supply of food as and when required was practised. The full grown mature larvae entered the soil for pupation. Finally, the soil was sieved to separate pupae carefully.

The egg parasite, Trichogramma chilonis. - The initial parasite culture was raised through the pest eggs exposed in the crop for trapping the parasites (vide supra).

The subsequent cultures were raised on the eggs of S.litura as well as Corcyra cephalonica. The host eggs were uniformly glued to a card strip (preferably green simulating the green background of the crop) and introduced into glass-tubes (25 x 10 cm). A parasitized 'egg-card' from which the adults were about to emerge was introduced inside the tube and 2-3 streaks of 5 per cent honey were provided for nourishment. The relative number of host eggs and the parasites was adjusted to avoid superparasitism. The host eggs were exposed to freshly emerged egg parasites for about 12-24 hours for parasitization in a well lit atmosphere. It was then removed to fresh tubes where it was observed for emergence of the parasites. Ffesh eggs, as above, were exposed daily for further parasitization until the parasites died.

The larval parasite, Peribaea orbata - The initial culture of the parasite was raised from the parasitized host larvae (S. litura) collected from the cauliflower crop. The parasite culture was maintained on the laboratory reared host larvae.

Scaramuzza-Box-technique (Box, 1933, 1952,1956; Scaramuzza, 1930) was used for mass-breeding of P.orbata. The freshly developed pupae (maroon coloured) were placed on damp cotton in a wooden emergence box (30 x 25 x 20 cm)

into which two glass-tubes (4 x 16 cm) fitted securely on one side. Adults, positively phototactic on emergence, entered into these tubes and then were transferred to cages (20 x 20 x 20 cms) with nylon mesh sides and back panels, and a sliding plastic front designed for mating. Cotton-wool pads soaked in honey (water diluted) provided food and were changed daily to prevent fermentation. Mated females were removed and held until gravid. After 4-6 days the abdomen was opened, the uterus containing maggots in their egg-shells were removed and placed in a drop of saline or tap water. After rupture of the uterus, the maggots cracked open the egg shells. One to three maggots were placed on a host larva by means of a fine brush. The parasitized host larvae were kept in separate plastic containers (6 x 6 cm.). The parasite maggot emerged out and then pupated. The pupae were removed. This process was repeated again.

Biology of the parasites

To study the biology of the parasites (P. chilonis and P. orbata) the parasitized host stages (egg and larva) were carefully ruptured with fine needles under stereoscopic microscope. The developing stages obtained in series of such dissections were preserved in 70 per cent alcohol.

In order to study the searching behaviour of the larval parasite, P. orbata, ten host larvae of II and III instar were encaged along with 4 pairs of adult parasites of P. orbata. Fresh leaves of castor were provided from time to time and a cotton swab soaked in honey was hung from the top of the cage to provide nutrition to the pest larvae and the parasites. Searching behaviour of the female parasite was observed on several occasions.

Impact of key abiotic factors on the natural populations

To study the impact of key biotic and abiotic factors on the natural populations, correlations were worked out between (i) pest population and associated biotic-complex, and, abiotic factors, (ii) major larval parasite (P. orbata) and pest population and abiotic factors, for the crops and seasons for all the three locations.

Pathological techniques

The sampled larvae reared in the laboratory were also observed for microbial infections and consequent pathological symptoms and mortality (%). The

isolated microbial pathogens (fungi and bacteria) and virus infected larvae were sent for identification at the Division of Entomology and Parasitology, University of California, Berkeley.

Efficacy of insecticides against S. litura vis-a-vis safety to its parasites

T. chilonis

Laboratory trials were conducted to assess the toxicity of the insecticides to the developing stages of the parasite, T. chilonis within the host egg. Four insecticides, viz., endosulfan, monocrotophos, phosalone (0.05, 0.025 %) and fenvalerate (0.005, 0.0025%) were used besides control (water spray).

Fresh eggs of the host (S.litura) were glued on bits of cards exposed to adults of T. chilonis in ratio of 5 host eggs to a fertilized female parasite. The samples of 20 parasitized eggs were taken at intervals of 24 hours, serially from the day of parasitization till adult emergence (Ca. 8 days). The insecticides were sprayed on each such batch of samples with the help of an atomizer. These 'egg cards' were dried in shade, placed in glass tubes (10 x 4 cm), covered and kept to record parasite emergence. Each treatment was replicated three times. Emergence of parasites

was recorded; emergence in percentage was converted into corresponding angular transformations before subjecting to analysis of variance. Zero and hundred per cent values were substituted by applying 1/4n and 100 - 1/4n, respectively, where 'n' was the number of insects (eggs, in this case) as suggested by Bartlett, (1947).

P. orbata

A laboratory experiment was conducted to test three insecticides, viz., endosulfan, phosalone and fenvalerate against the pest, S. litura. Correspondingly, the safety to the related parasite, P. orbata was also evaluated. The insecticides were used in three concentrations: endosulfan, phosalone in 0.05, 0.04 and 0.02 per cent and fenvalerate in 0.005, 0.003 and 0.002 per cent.

Cauliflower plants in pots were sprayed with the insecticides by hand-compressor sprayer. After about an hour of the treatment, the plants were enclosed with glass chimneys. Ten III - instar larvae of the pest along with ten freshly emerged adults of the parasite were released in each chimney in replicated lots of three for each treatment besides control (water spray); each chimney was covered with muslin cloth to ensure proper aeration. A cotton swab soaked in 30 per cent honey solution was fixed on a string to hang centrally from the muslin cloth within, for

nourishment of the parasites. The mortality response (count) of the pest and the parasite was recorded after 18, 24, 48 and 72 hours of exposure.

Zero and hundred per cent values were substituted by applying 1/4n and 100 - 1/4n , respectively. where 'n' was the number of insects as suggested by Bartlett (1947). The data obtained were converted into corresponding angles before subjecting to analysis of variance.

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

Field incidence for seasonal intensity of *Spodoptera litura* and associated parasites in cauliflower and cabbage

Intensity of the pest population in the crops

Regular quantitative survey of *S.litura* was carried out in cauliflower (1985-86) and cabbage (1986-87) crops on the Horticulture Farm and Kushalbag Farm in Rajasthan College of Agriculture, Udaipur and in the adjoining village Chotinauka *ca.*5 km in South of College Campus (*vide* Materials and Methods).

Cauliflower crop.- The data (Table 1, Appendices II-IV) have revealed that the pest intensity was distinctly higher during kharif than in rabi. The period of peak incidence during kharif was III week of September while in rabi it was mostly IV week of October.

Table 1

Population incidence of S.litura infesting cauliflower crop in different localities at Udaipur (1985-86) +

Crop season/ Year	Locality	Crop duration	Range of incidence (No)	Peak incidence (month , week)
Kharif				
1985	Horticulture Farm	7.viii-23.x	10-115	September, III
	Village Chotinauka	6.viii-22.x	3-138	September, III
	Kushalbag Farm	13.viii-22.x	1-141	September, III
1986	Horticulture Farm	30.vii -24.ix	6-115	September, III
	Village Chotinauka	21.vii -29.ix	5-342	September, III
	Kushalbag Farm	26.vii -27.ix	8-129	September, III
Rabi				
1985	Horticulture Farm	30.x - 18.xii	31-65	October, IV
	Village Chotinauka	29.x - 17.xii	25-67	October, IV
	Kushalbag Farm	29.x - 17.xii	29-80	October, IV
1986	Horticulture Farm	1.x - 19.xi	5-35	October, III
	Village Chotinauka	6.x - 24.xi	2-73	October, I
	Kushalbag Farm	4.x - 6.xii	2-20	October, IV

+ vide Appendices II- IV (details of weekly population data)

Cabbage crop.- The data (Table 2, Appendices VIII - X) depicted that the pest intensity was more or less uniform. When compared to the pest intensity in this crop with that of the rabi cauliflower, the pest preference seemed to be evident for the latter. The peak incidence during 1986 was in II week while during 1987 it was in the III week of January.

Biotic mortality parameters of the pest in the crops

The insect parasites and the microbial pathogens (bacteria, fungus and virus) played significant role in regulating the intensity of pest population. The mortality on account of former was relatively lower compared to the latter. It may be pointed out that the individuals were reared separately in plastic containers and sanitary conditions.

Cauliflower

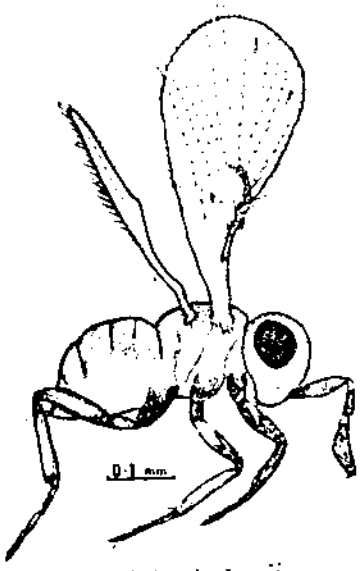
The associated parasitic-complex comprised of one egg and nine larval parasites:

Egg parasite

Family Trichogrammatidae

Trichogramma chilonis Ishii (Fig.1)

Fig. 1.



Trichogramma chilonis ISHII
FAM. Trichogrammatidae
EGG PARASITE

Table 2

Population incidence of S.litura infesting cabbage crop in different localities at Udaipur (1986-87)+

Year/ Locality	Crop duration	Range of incidence (No.)	Peak incidence (month, week)
1986			
Village Chotinauka	1.i - 19.ii	3 -12	January, II
Horticulture Farm	2.i - 20.ii	3 -10	January, II
Kushalbag Farm	1.i - 19.ii	2 -11	January, II
1987			
Village Chotinauka	5.i - 23.ii	1 -10	January, III
Horticulture Farm	7.i - 25.ii	1 - 9	January, III
Kushalbag Farm	3.i - 21.ii	2 -11	January, III

+ vide Appendices V - VII (details of weekly population data)

Larval parasites

Family Braconidae

Apanteles species (*vitripennis* species-group) (Fig.2)

Chelonus species (Fig.3)

Microplitis species (Fig.4)

Rogas species (Fig.5)

Family Ichneumonidae

Campoletis chlorideae Uchida (Fig.6)

Eriborus species? *argenteopilosus* (Cameron) (Fig.7)

Charops species

Family Tachinidae

Blepharella lateralis (Macquart)

Peribaea orbata (Wiedemann) (Fig.8)

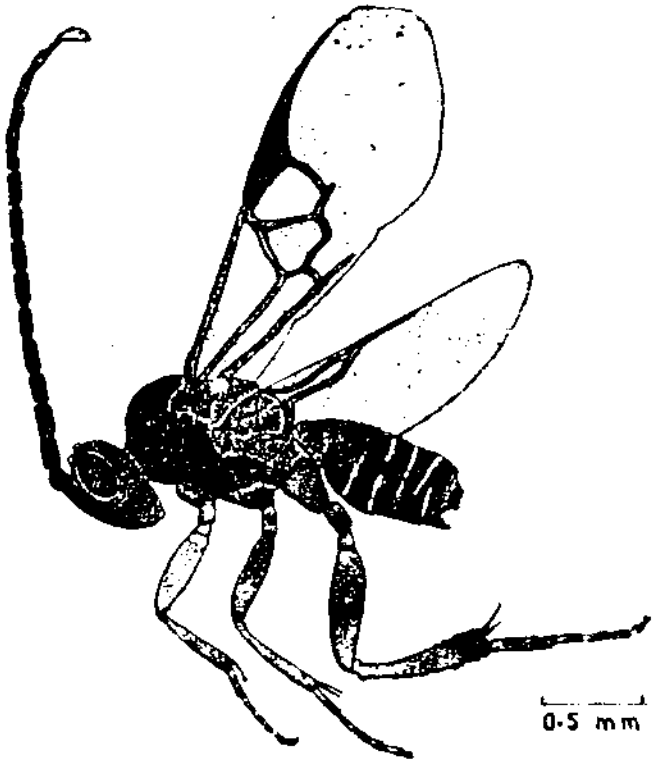
In the diseased larvae, following diagnostic symptoms observed are briefly referred to:

1. Voracious feeding; active movements; irritability to stimulus .... healthy
2. Loss of appetite; ceased feeding, sluggish movements .... diseased

   a.(i) Lying prostrate on leaf surface with decreased irritatability to stimulus

   (ii). Flaccid carcass usually darkened in colour; integument intact; dead larvae shrivelled and dried

Fig. 2.



APANTELES SP. (VITRIPENNIS SP. GROUP),
LARVAL PARASITE
HYMENOPTERA BRACONIDAE
HOST : SPODOPTERA LITURA

Fig. 3.

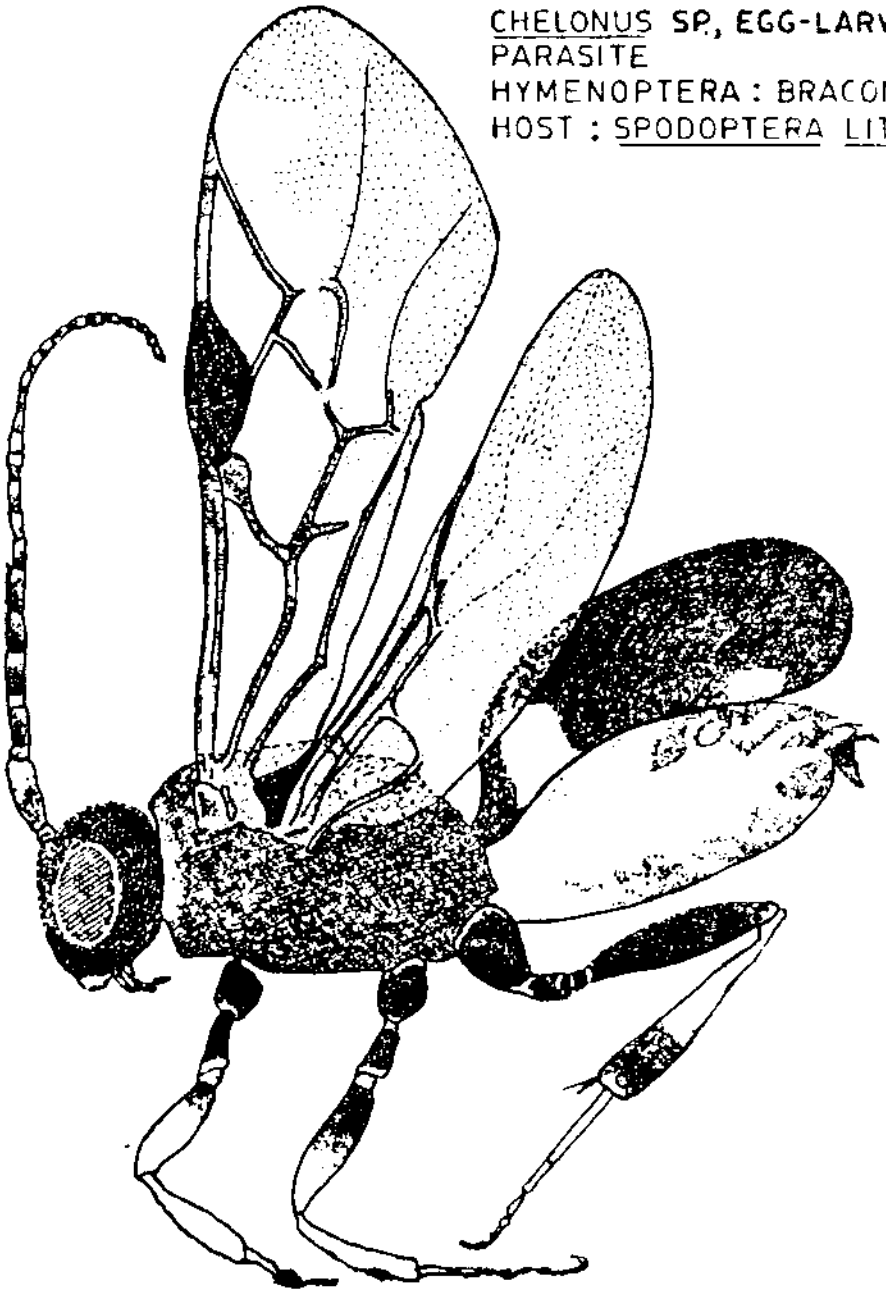
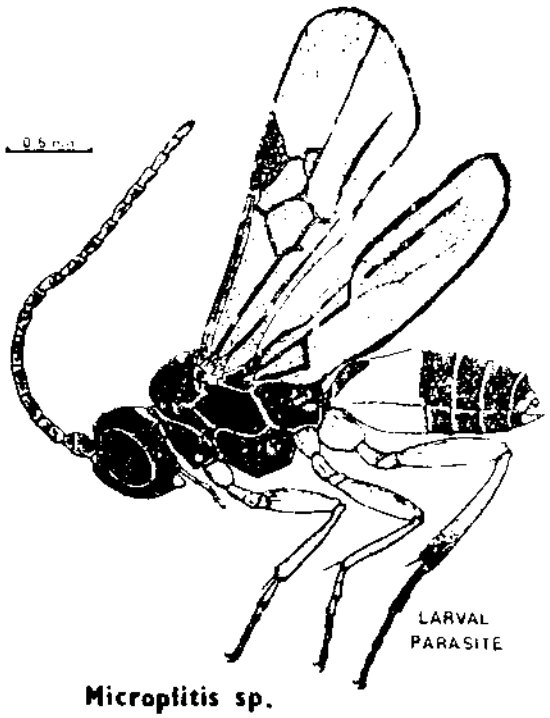

CHELONUS SP, EGG-LARVAL
PARASITE
HYMENOPTERA : BRACONIDAE
HOST : SPODOPTERA LITURA

Fig. 4.



Microplitis sp.
HYMENOPTERA : BRACONIDAE
HOST ***Spodoptera litura***

Fig. 5.

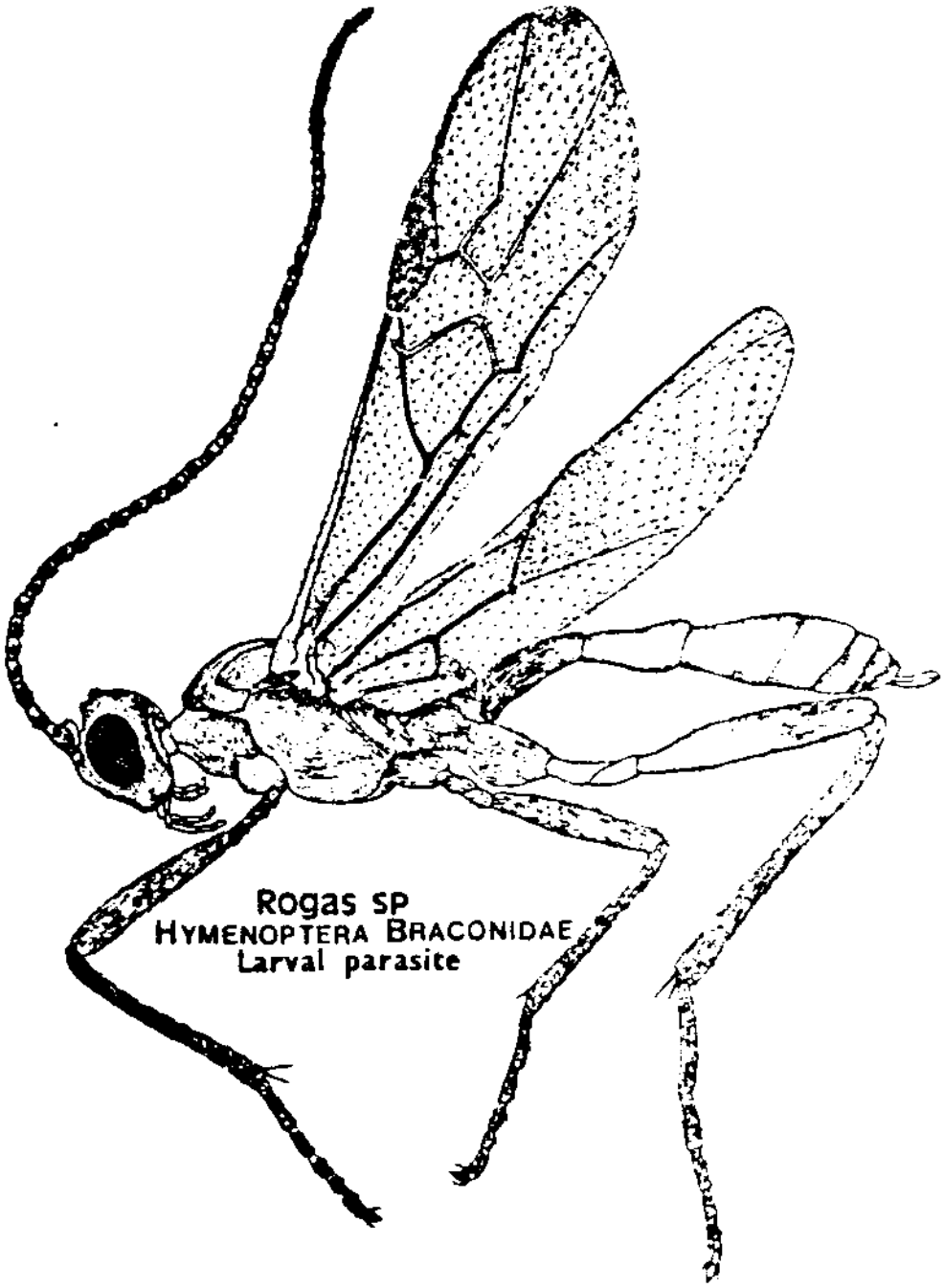


Fig. 6.

Campoletis chlorideae UCHIDA, LARVAL PARASITE
HYMENOPTERA : ICHNEUMONIDAE

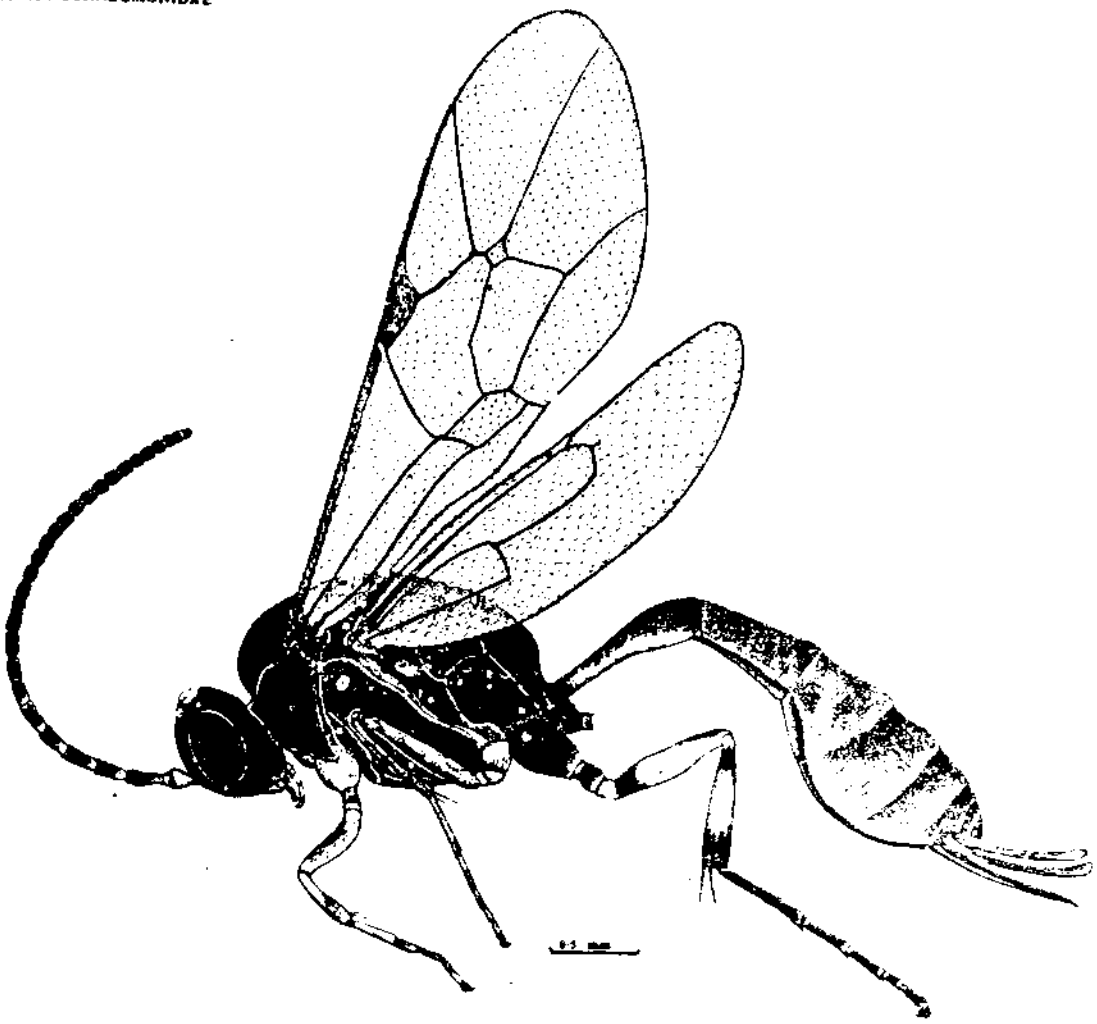
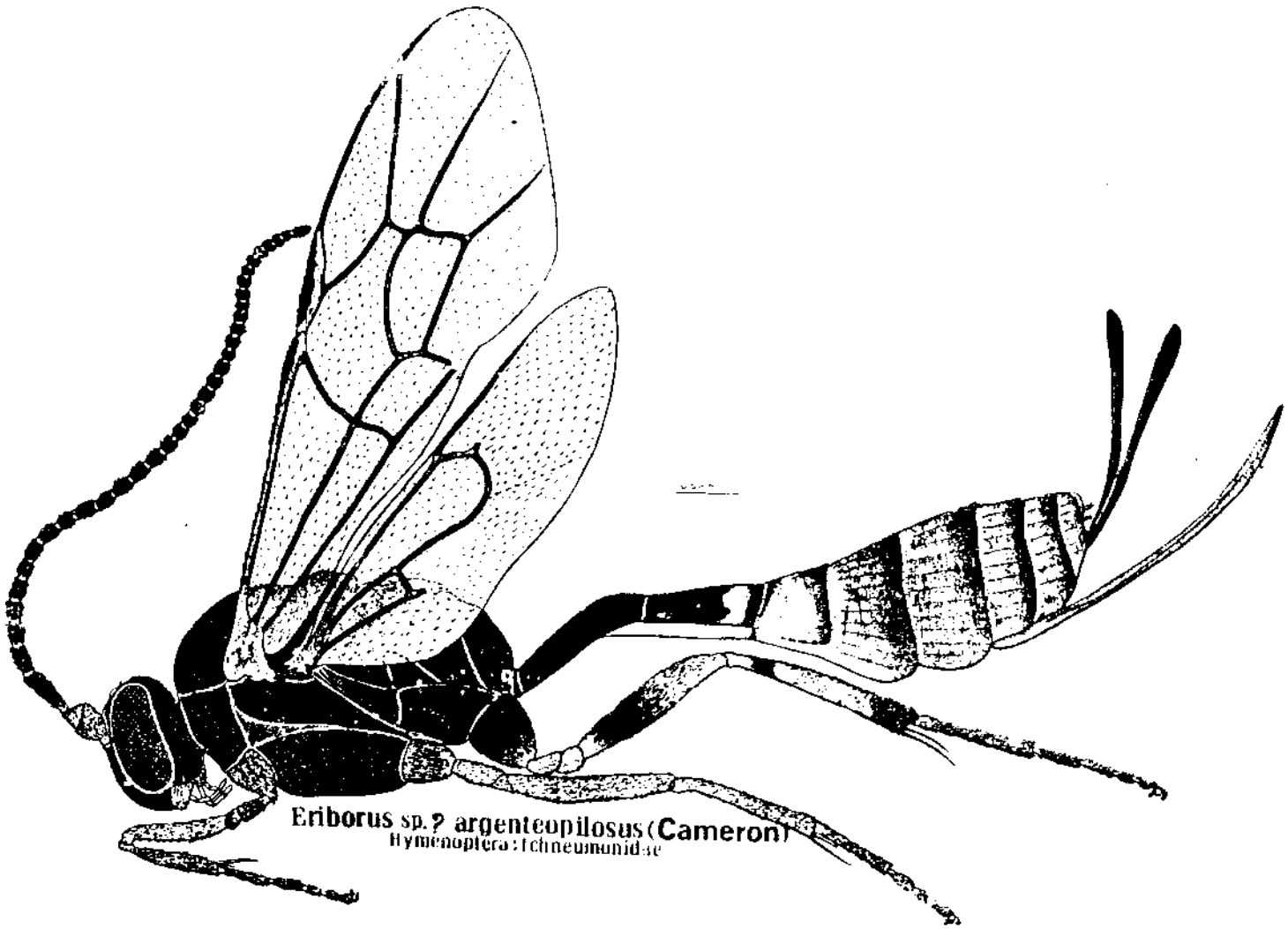
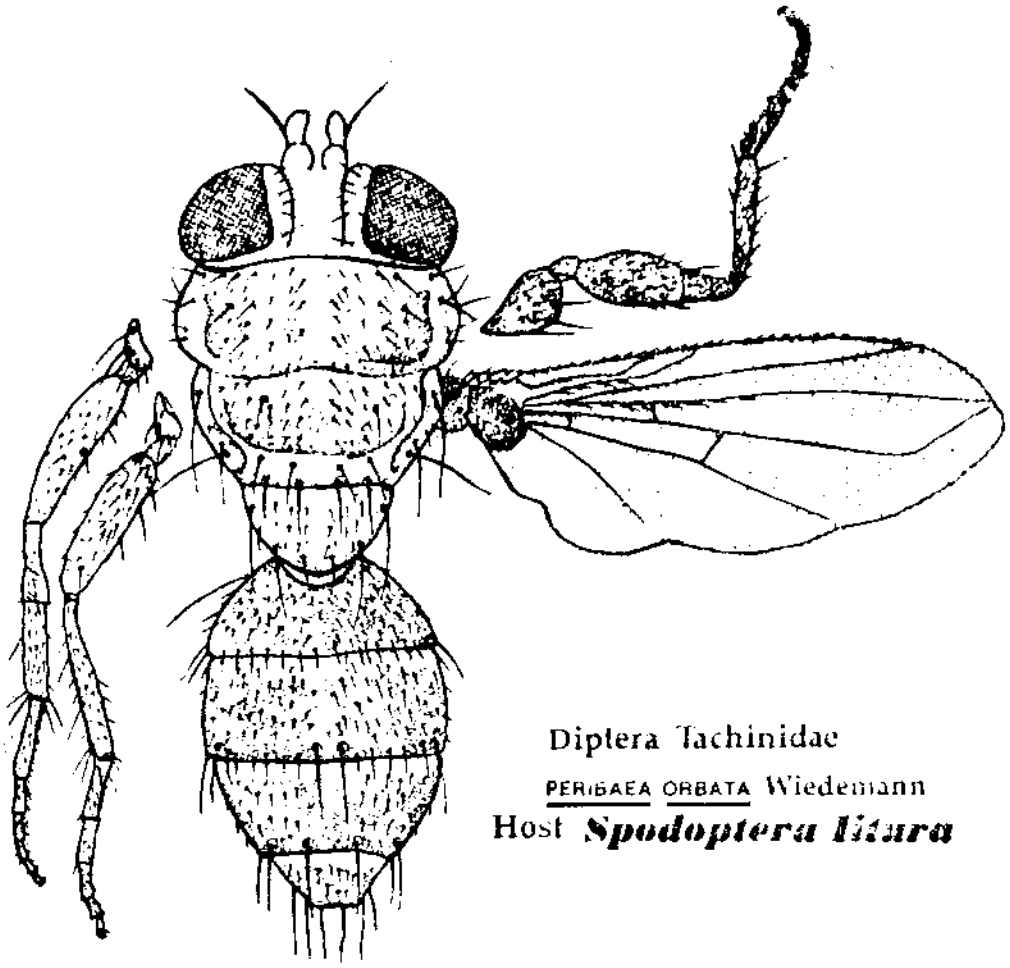


Fig. 7.



Eriborus sp.? argenteopilosus (Cameron)
Hymenoptera: Ichneumonidae

Fig. 8.



Diptera Tachinidae

PERIBAEA ORBATA Wiedemann

Host ***Spodoptera litura***

.... bacteriosis (Pseudomonas aeruginosa Schi., Streptococcus species)

b.(i). Restlessness, body mummified, hard and not disintegrating in water.

(ii). Body filled with filamentous hyphae with hyphal tufts growing out between segments ..... mycosis

. white cadaver ..... Beauveria bassiana

. green cadaver ..... Metarrhizium anisopliae

c (i) . Body size reduced, change in body colour from green to creamy-white and finally pink particularly on abdomen ventrally.

(ii). Diseased larvae hanging in an inverted position on the walls of the container and on the upper leaves; tree-top sickness' and sometimes adhering to the leaf-surface.

(iii). Fragile cuticle ruptured easily on touch, releasing liquified contents.

.....virosis (Nuclear Polyhedrosis virus)

Larval mortality (Appendices II - IV)

It was evident from the data(Table 3) that the parasites consistently contributed to the extent of 50 per cent towards pest mortality: the peak during kharif was mostly I to IV week of September, while in rabi it was mostly from I to III week of November (Figs. 9-11 and 15-17). The

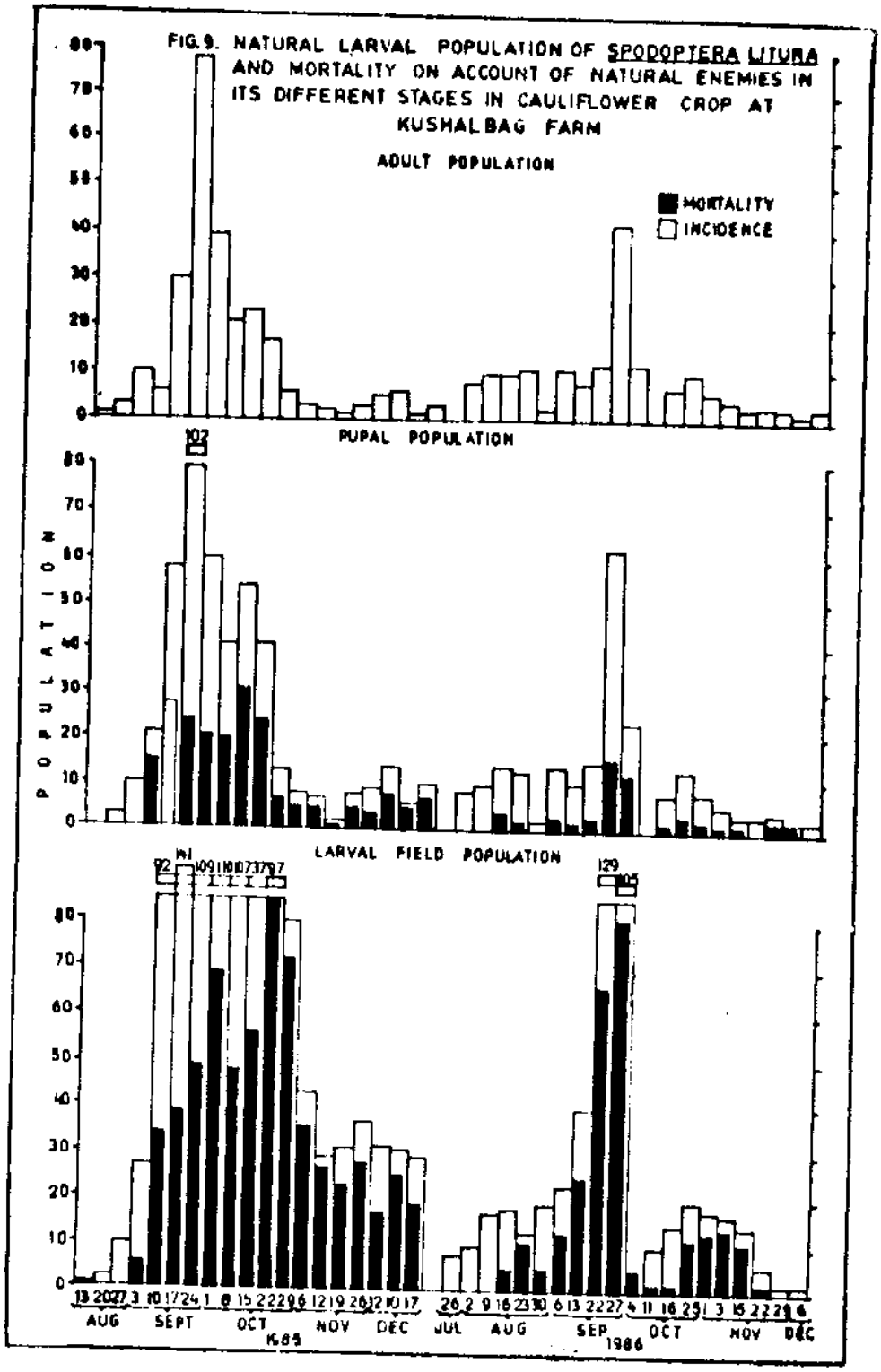
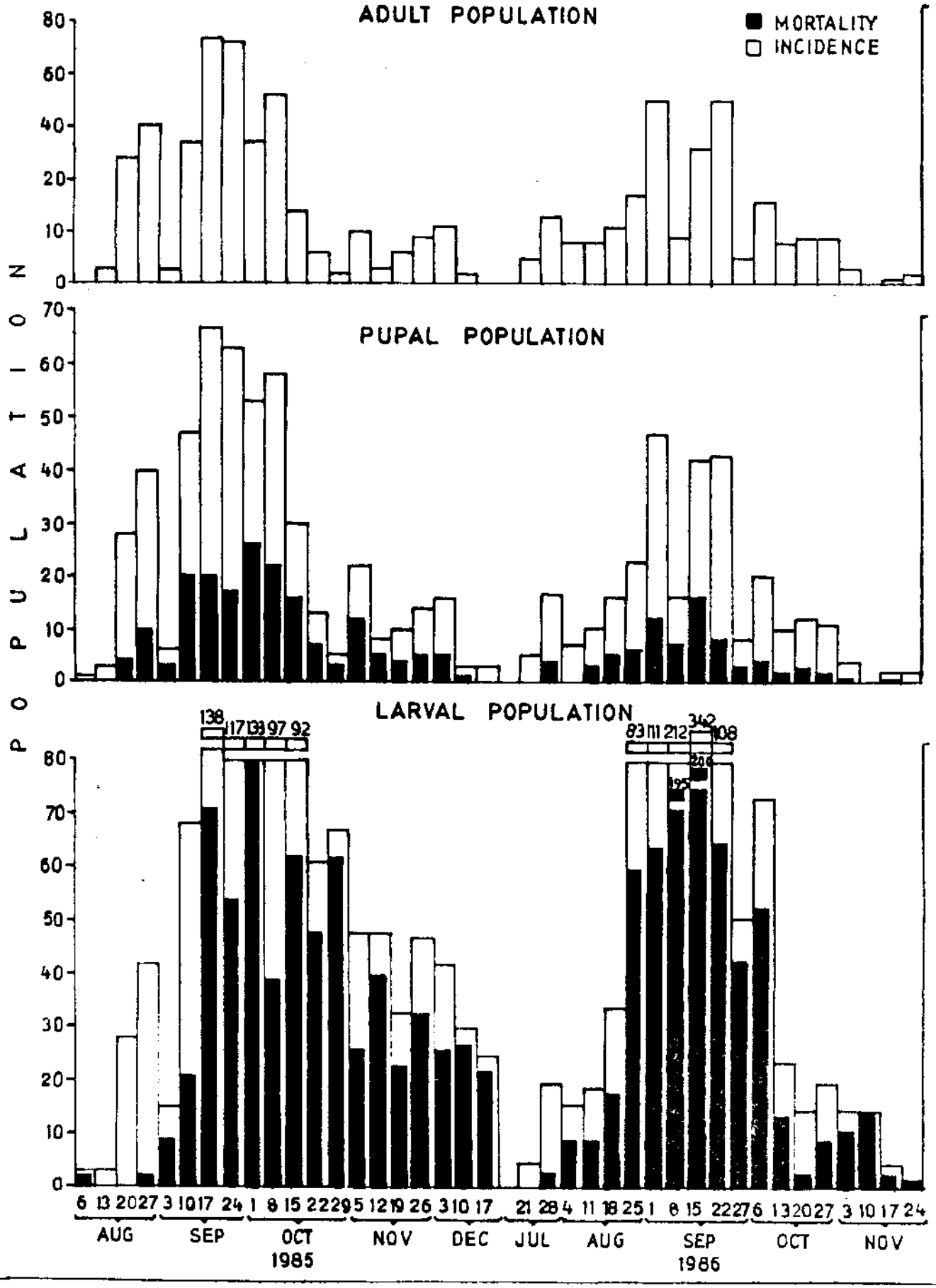


FIG.9. NATURAL LARVAL POPULATION OF SPODOPTERA LITURA AND MORTALITY ON ACCOUNT OF NATURAL ENEMIES IN ITS DIFFERENT STAGES IN CAULIFLOWER CROP AT KUSHALBAG FARM
ADULT POPULATION
MORTALITY
INCIDENCE
PUPAL POPULATION
POPULATION
LARVAL FIELD POPULATION
AUG
SEPT
OCT
NOV
DEC
JUL
AUG
SEP
OCT
NOV
DEC
1985
1986

FIG.10. NATURAL LARVAL POPULATIONS OF SPODOPTERA LITURA AND MORTALITY ON ACCOUNT OF NATURAL ENEMIES IN ITS DIFFERENT STAGES IN CAULIFLOWER CROP AT VILL. CHOTINAUKA



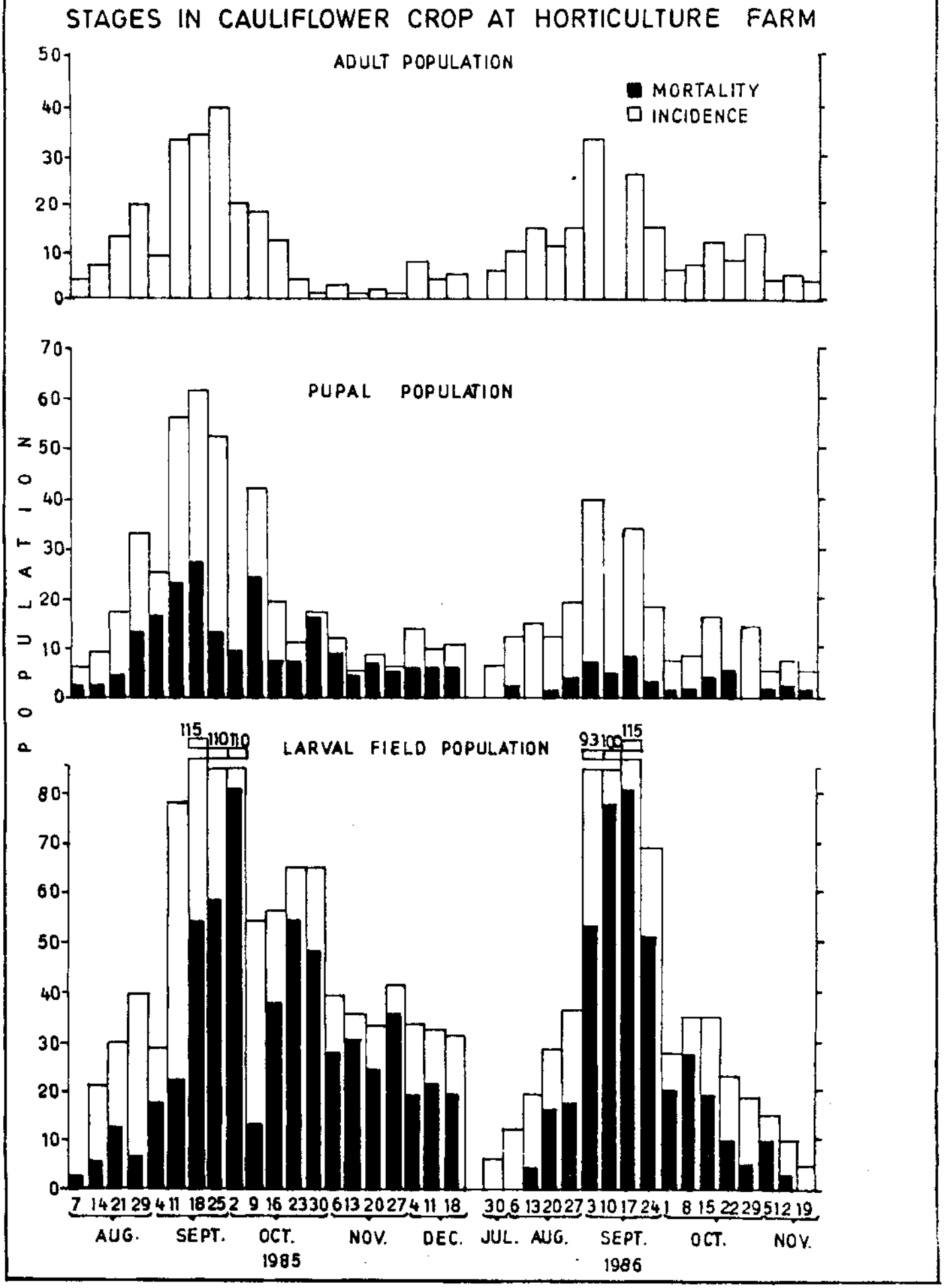

STAGES IN CAULIFLOWER CROP AT HORTICULTURE FARM
ADULT POPULATION
MORTALITY
INCIDENCE
PUPAL POPULATION
POPULATION
LARVAL FIELD POPULATION
115 110 110
93 100 115
7 14 21 29 4 11 18 25 2 9 16 23 30 6 13 20 27 4 11 18 30 6 13 20 27 3 10 17 24 1 8 15 22 29 5 12 19
AUG. SEPT. OCT. NOV. DEC. JUL. AUG. SEPT. OCT. NOV.
1985
1986

Table 3

Population incidence of parasite-complex attacking S.litura in cauliflower crop in different localities at Udaipur (1985-86) +

Crop season/ Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
Kharif				
1985	Horticulture Farm	7.viii-23.x	7.7 - 55.0	October, I
	Village Chotinauka	6.viii-22.x	4.8 - 40.0	September, I
	Kushalbag Farm	13.viii-22.x	2.1 - 41.8	October, I
1986	Horticulture Farm	30.vii -24.ix	11.8 - 30.4	September, IV
	Village Chotinauka	21.vii -29.ix	10.0 - 37.3	September, IV
	Kushalbag Farm	26.vii -27.ix	11.4 - 30.4	September, I
Rabi				
1985	Kushalbag Farm	29.x - 17.xii	9.3 - 55.1	December, III
	Horticulture Farm	30.x - 18.xii	2.6 - 54.5	November, III
	Village Chotinauka	29.x - 17.xii	2.1 - 42.4	November, III
1986	Kushalbag Farm	4.x - 6.xii	6.7 - 57.1	November, III
	Horticulture Farm	1.x - 19.xi	3.7 - 20.0	November, I
	Village Chotinauka	6.x - 24.xi	5.0 - 33.3	November, II

+ *vide* Appendices II-IV (details of weekly population data)

average mortality (%) on account of parasitic-complex collectively resulted to 20.9 at Kushalbag Farm, 20.3 at Horticulture Farm and 19.3 in farmer's field at village Chotinauka. This was calculated on the basis of total larval counts for the whole season. Peribaea orbata alone could parasitize to the extent of 12.9 to 14.1 per cent in the three localities (Tables 11 and 12).

The disease incidence in larval stage claimed more than 57 per cent on the basis of total larval count during both, the kharif and rabi seasons (Table 4). The maximum mortality was during September-October, and I week of November to II week of December. The average mortality on this account ranged from 35.7 to 46.6 per cent in the three locations. It may be pointed out that the maximum mortality on account of insect parasites was also recorded during the same corresponding period. But it was very evident that the entomopathogens played more decisive role than the insect parasites in regulating low intensity of the pest population.

Pupal mortality (Appendices XX a,b,c)

Mortality on account of disease (including some deformity) was recorded upto 57.0 per cent (100% when only two individuals pupated at Chotinauka) (Table 5). But overall average ranged from 11.2 to 16.8 per cent in the three localities (Table 11). There was higher incidence of disease

Table 4

Population incidence of diseases in S. litura larvae in cauliflower crop in different localities at Udaipur (1985-86) +

Crop season/ Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
Kharif				
1985	Village Chotinauka	6.viii-22.x	11.8-67.2	October, III
	Kushalbag Farm	13.viii-22.x	7.1-84.5	October, III
	Horticulture Farm	7.viii-23.x	3.4-83.1	October, III
1986	Village Chotinauka	21.vii -29.ix	5.0-73.1	September, I
	Kushalbag Farm	26.vii -27.ix	5.3-69.2	August, IV
	Horticulture Farm	30.vii -24.ix	21.0-57.3	September, II
Rabi				
1985	Village Chotinauka	29.x - 17.xii	27.3-83.3	December, II
	Horticulture Farm	30.x - 18.xii	18.2-71.4	September, II
	Kushalbag Farm	29.x - 17.xii	10.3-90.0	October, IV
1986	Village Chotinauka	6.x - 24.xi	20.0-66.7	November, I
	Horticulture Farm	1.x - 19.xi	10.5-71.4	October, I
	Kushalbag Farm	4.x - 6.xii	6.7-100.0	October, I

+ vide Appendices II - IV (details of weekly population data)

Table 5

Population incidence of pupal mortality in cauliflower crop in different localities at Udaipur (1985-86) +

Crop season/ Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
Kharif				
1985	Village Chotinauka	6.viii-29.ix	11.5-29.4	September, II
	Horticulture Farm	7.viii-23.x	9.5-57.1	September, I
	Kushalbag Farm	13.viii-22.x	7.2-55.5	September, I
1986	Village Chotinauka	21.vii -29.ix	3.3-20.0	August, IV
	Horticulture Farm	30.vii -24.ix	3.6-16.6	August, I
	Kushalbag Farm	26.vii -27.ix	7.5-23.5	August, II
Rabi				
1985	Horticulture Farm	30.x - 18.xii	11.4-24.6	October, IV
	Kushalbag Farm	29.x - 17.xii	3.4-25.8	December, I
	Village Chotinauka	29.x - 17.xii	3.3-25.0	November, I
1986	Horticulture Farm	1.x - 19.xi	2.8-21.7	October, I
	Kushalbag Farm	4.x - 6.xii	5.5-50.0	November, IV
	Village Chotinauka	6.x - 24.xi	5.5-100.0	November, IV

+ vide Appendices XX a-e (details of weekly population data)

during August-September and from last week of October to beginning of December.

Cabbage

The parasites associated with S.litura in this crop included only two species of larval parasites: Peribaea orbata (Wiedemann) (family Tachinidae) and Rogas species (family Braconidae).

Larval mortality (Appendices VIII -X)

The parasitization (%) of the pest was about 40 in the three localities; relatively higher intensity of parasitization was observed from I to III week of January (Table 6). An overall parasitization (average) ranged from 2.2 to 9.3 per cent in the three locations (Table 11, Figs.12-14,18-20).

The disease incidence was responsible for mortality toll of more than 50 per cent and was maximum during the month of January (II-IV week) (Table 7). The average mortality (%), in the three localities, ranged from 33.3 to 41.1 (Table 11).

Pupal mortality (Appendices XXI a,b,c)

In general, the mortality in this stage was always very low compared to that in larval stage. On the whole, the mortality was 18.8 per cent (Table 8, 11).

FIG. 12 NATURAL LARVAL POPULATIONS OF SPODOPTERA LITURA AND MORTALITY ON ACCOUNT OF NATURAL ENEMIES IN ITS DIFFERENT STAGES IN CABBAGE CROP AT KUSHALBAG FARM

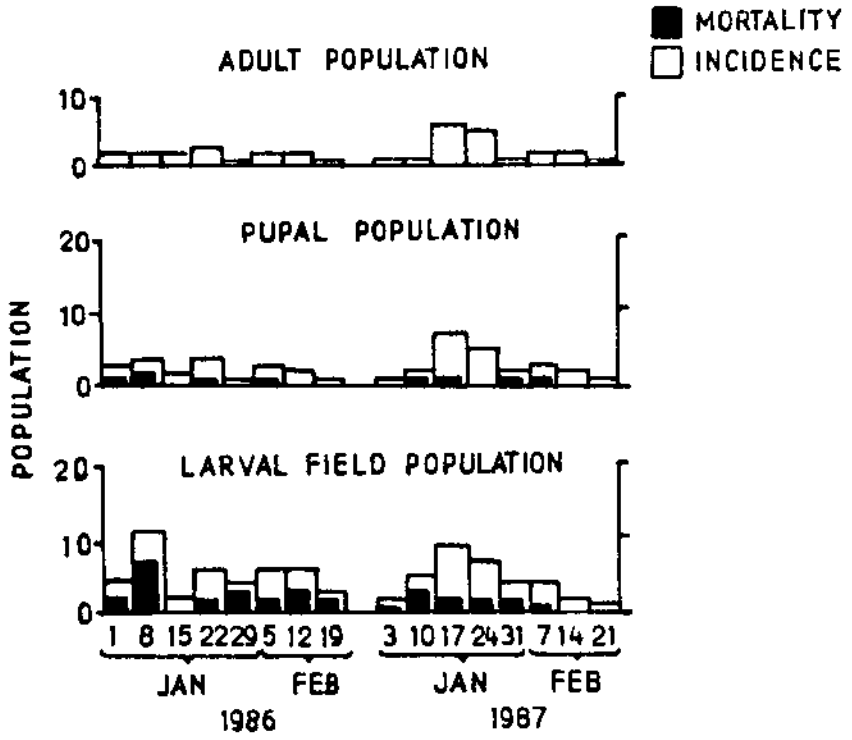


FIG. 13. NATURAL LARVAL POPULATIONS OF SPODOPTERA LITURA AND MORTALITY ON ACCOUNT OF NATURAL ENEMIES IN ITS DIFFERENT STAGES IN CABBAGE CROP AT VILLAGE CHOTINAUKA

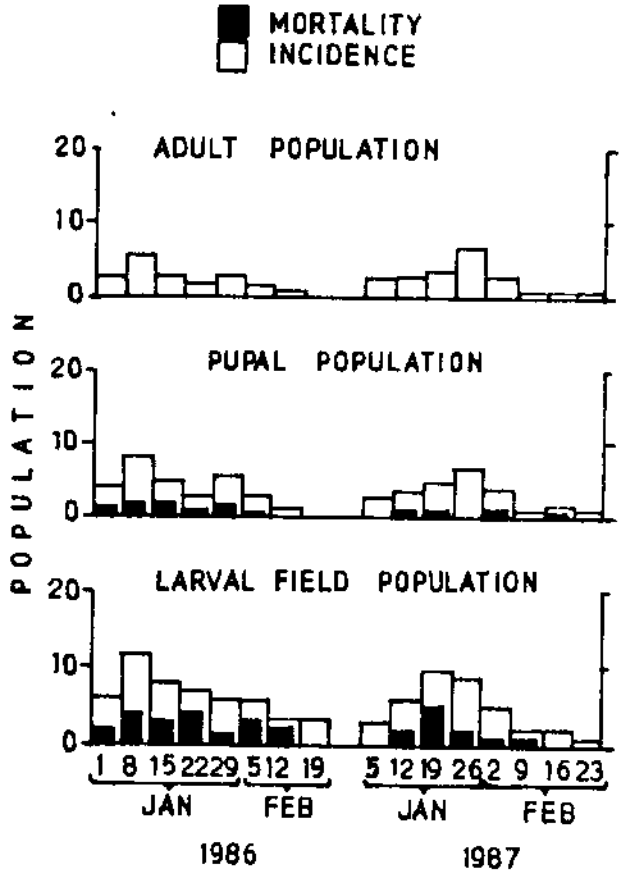


FIG. 14. NATURAL LARVAL POPULATIONS OF SPODOPTERA LITURA AND MORTALITY ON ACCOUNT OF NATURAL ENEMIES IN ITS DIFFERENT STAGES IN CABBAGE CROP AT HORTICULTURE FARM

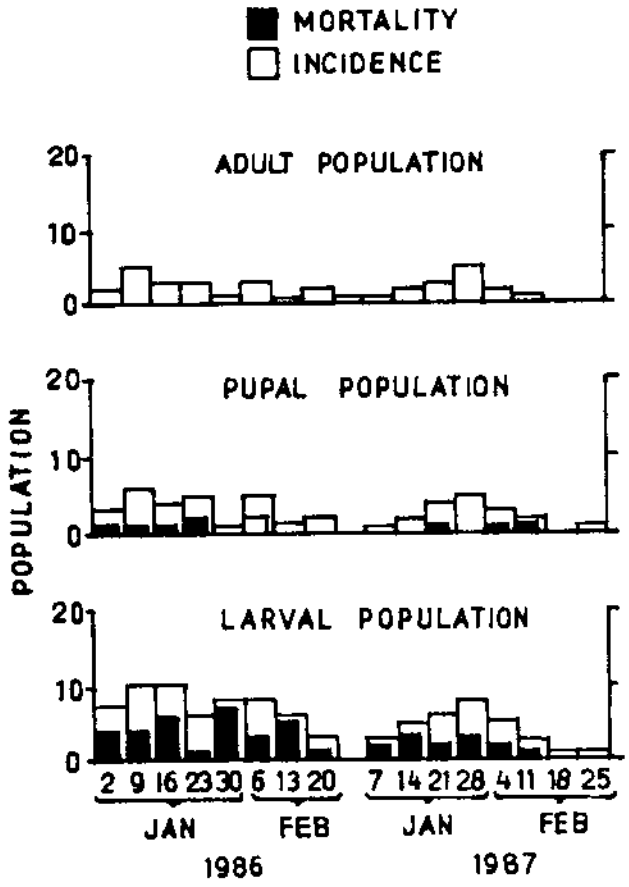


FIG.15. LARVAL POPULATION OF S. LITURA AND ASSOCIATED SPECIES OF PARASITES IN CAULIFLOWER CROP AT KUSHALBAG FARM

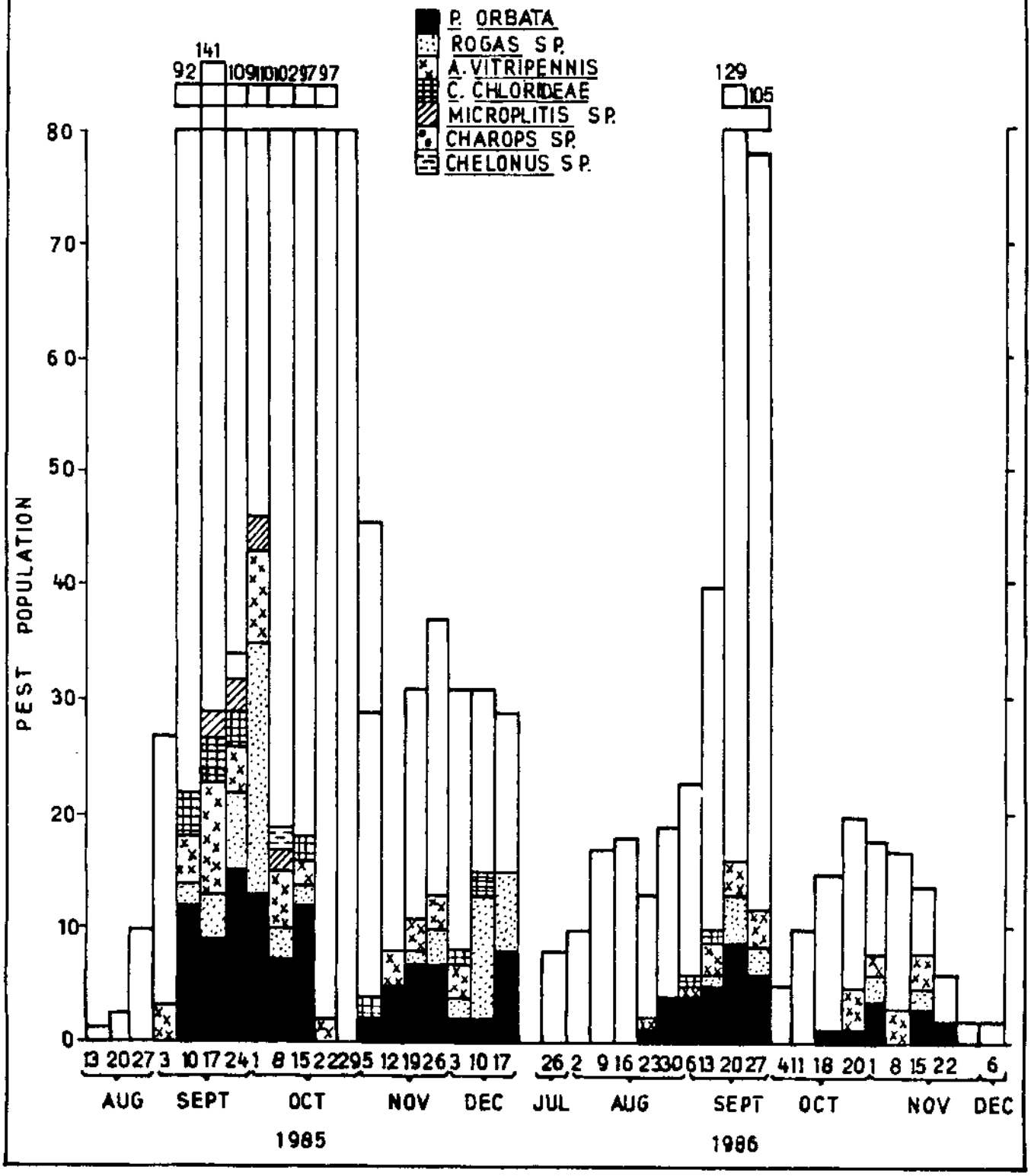


FIG. 16. LARVAL POPULATION OF S. LITURA AND ASSOCIATED SPECIES OF PARASITES IN CAULIFLOWER CROP AT VILLAGE CHOTINAUKA

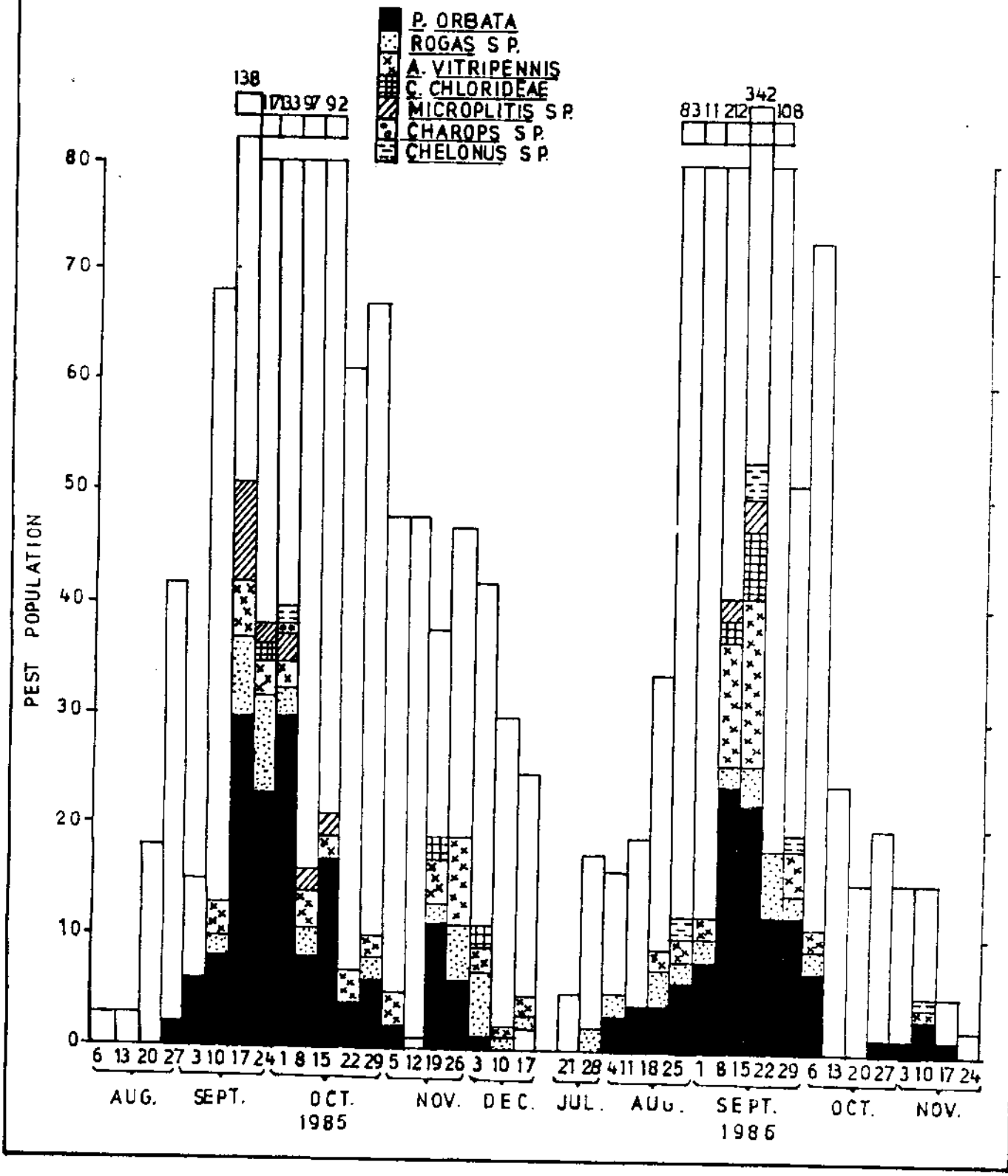


FIG.17. LARVAL POPULATION OF S. LITURA AND ASSOCIATED SPECIES OF PARASITES IN CAULIFLOWER CROP AT HORTICULTURE FARM

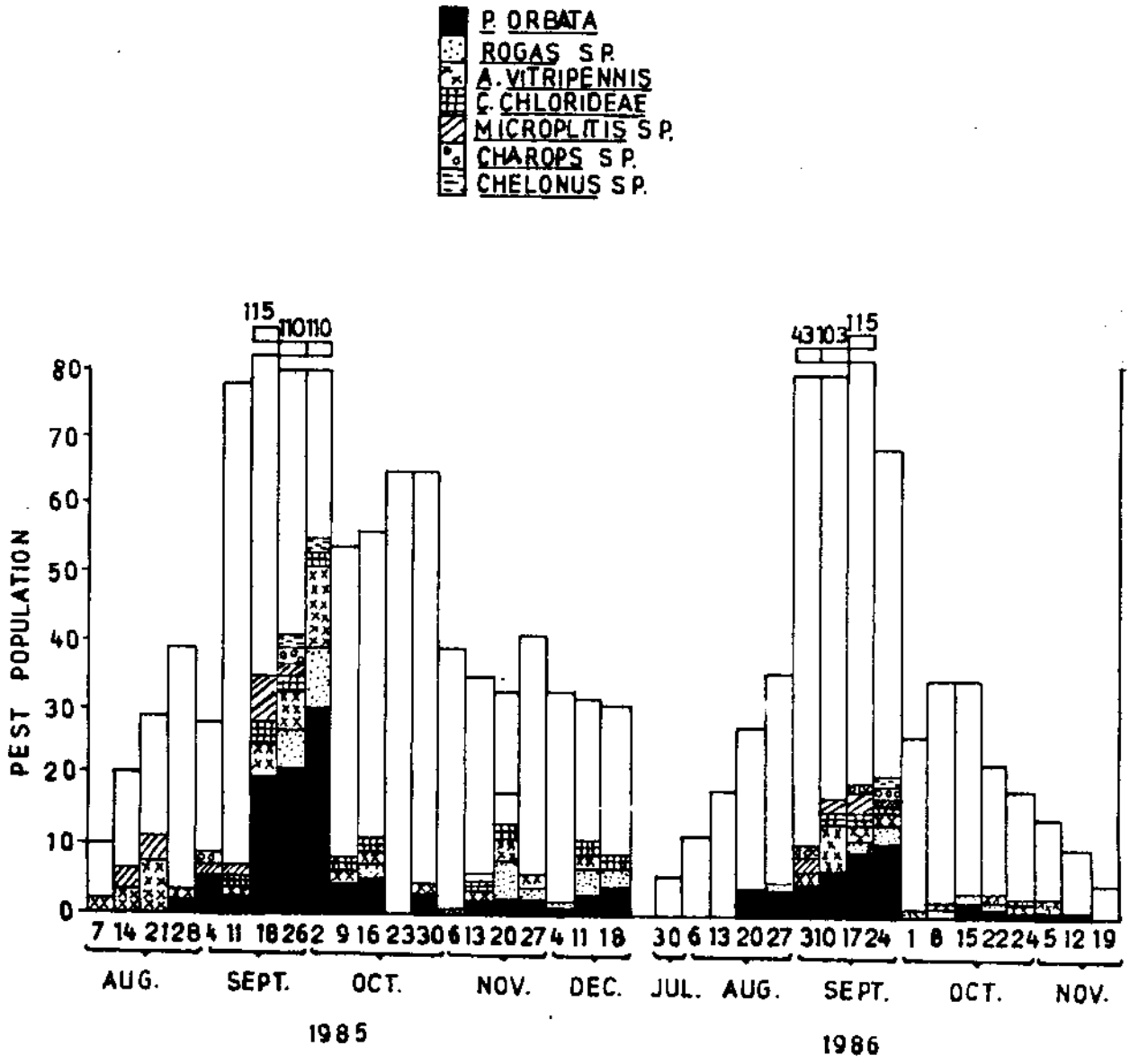


FIG. 18 LARVAL POPULATION OF S. LITURA AND ASSOCIATED SPECIES OF PARASITES IN CABBAGE CROP AT KUSHALBAG FARM

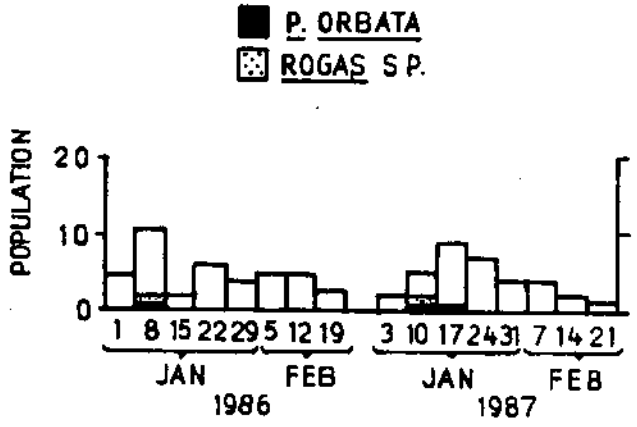


FIG. 19 LARVAL POPULATION OF S. LITURA AND ASSOCIATED SPECIES OF PARASITES IN CABBAGE CROP AT VILLAGE CHOTINAUKA

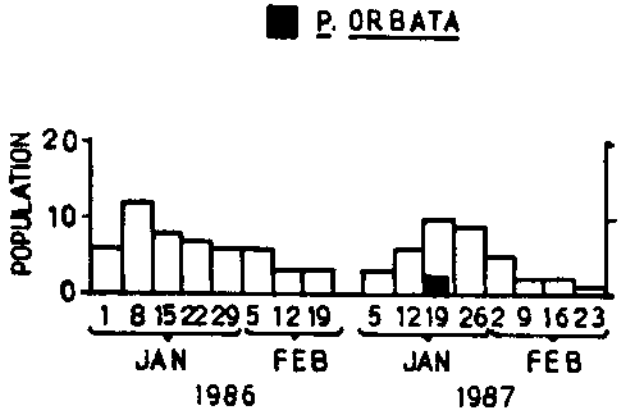


FIG. 20 LARVAL POPULATION OF S. LITURA AND ASSOCIATED SPECIES OF PARASITES IN CABBAGE CROP AT COLLEGE HORTICULTURE FARM

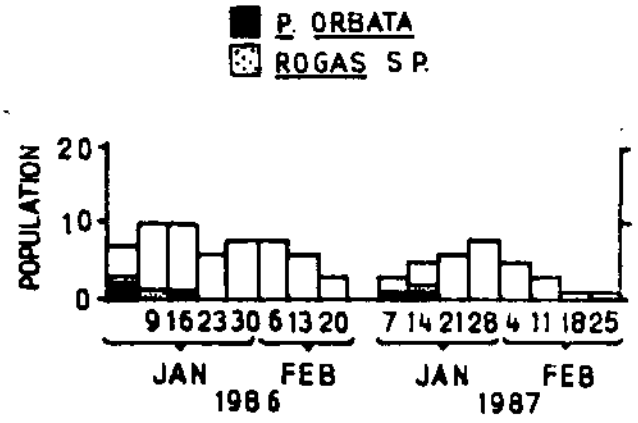


Table 6

Population incidence of parasite-complex attacking *S. litura* in cabbage crop in different localities at Udaipur (1986-87) +

Year / Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
1986			
Kushalbag Farm	1.i - 19.ii	0.0 -36.4	January, I
Horticulture Farm	2.i - 20.ii	10.0 -42.8	January, I
Village Chotinauka	1.i - 19.ii	-	-
1987			
Kushalbag Farm	3.i - 21.ii	11.1 -40.0	January, II
Horticulture Farm	7.i - 25.ii	33.3 -40.0	January, II
Village Chotinauka	5.i - 23.ii	0.0 -20.0	January, III

+ *vide* Appendices V - VII (details of weekly population data)

Table 7

Population incidence of diseases in S.litura larvae in cabbage crop in different localities at Udaipur (1986-87) +

Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
1986				
	Kushalbag Farm	1.i - 19.ii	27.3- 75.0	January, IV
	Village Chotinauka	1.i - 19.ii	16.7-100.0	January, III
	Horticulture Farm	2.i - 20.ii	14.3- 87.5	January, IV
1987				
	Kushalbag Farm	3.i - 21.ii	11.0 -50.0	January, IV
	Village Chotinauka	5.i - 23.ii	20.0 -50.0	January, II
	Horticulture Farm	7.i - 25.ii	20.0 -100.0	February, III

+ vide Appendices V - VII (details of weekly population data)

Table 8

Population incidence of pupal mortality in cabbage crop in different localities at Udaipur (1986-87)+

Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (Month, week)
1986				
	Kushalbag Farm	1.i - 19.ii	16.6 -20.0	January, I; February, II
	Village Chotinauka	1.i - 19.ii	14.3 -33.3	January, IV
	Horticulture Farm	2.i - 20.ii	10.0 -33.3	January, IV
1987				
	Kushalbag Farm	3.i - 21.ii	20.0 -100.0	February, II, III
	Village Chotinauka	5.i - 23.ii	10.0 - 50.0	February, III
	Horticulture Farm	7.i - 25.ii	16.6 -100.0	February, IV

+ vide Appendices XXI a-e (details of weekly population data)

Conclusively, the tabulated data have revealed that the total larval mortality on account of parasites and diseases was 61 per cent (parasites, 20.1 and diseases, 40.9%) in the cauliflower crop; and 43.3 per cent (parasites, 6.7 and diseases, 36.6%) in cabbage crop. In the pupal stage, the mortality was only on account of diseases; it was 13.9 in cauliflower and 18.8 per cent in the cabbage crop. Accordingly, the cumulative mortality worked out to be 75.04 per cent in cauliflower and 62.2 per cent in the cabbage crop on account of these biotic components (Tables 9-11). Evidently, the appropriate approach to augment the effectiveness of these components is unavoidably essential in management of the pest. It implies that the pesticidal schedule must provide for safety and efficacy of these components.

Status of the parasites under natural crop environment

Egg parasite (Table 13, Fig.1)

Synchronous appearance of the parasite with its host in the crop ecosystem is the pre-requisite of parasitic efficiency. *Trichogramma chilonis*, the only egg parasite, was recorded in the cauliflower crop in first week of September but the pest (*S.litura*) population was built up from the III week of September. Specific studies revealed that the eggs were parasitized upto 22.1, 31.8 and 29.8 per cent when exposed

Table 9

Population incidence of cumulative biotic-mortality of S.litura larvae in cauliflower crop in different localities at Udaipur (1985-86) +

Crop season/ Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
Kharif				
1985	Kushalbag Farm	13.viii-22.x	22.2 - 86.6	October, III
	Horticulture Farm	7.viii-23.x	15.4 - 83.1	October, IV
	Village Chotinauka	6.viii-22.x	4.8 - 78.7	October, III
1986	Kushalbag Farm	26.vii-27.ix	17.6 - 84.6	August, IV
	Horticulture Farm	30.vii-24.ix	21.0 - 74.8	September, II
	Village Chotinauka	21.vii-29.ix	15.0 - 92.4	September, I
Rabi				
1985	Horticulture Farm	30.x - 18.xii	57.6 - 85.7	November, II
	Kushalbag Farm	29.x - 17.xii	54.8 - 93.1	November, II
	Village Chotinauka	29.x - 17.xii	54.2 - 92.5	October, IV
1986	Horticulture Farm	1.x - 19.xi	26.3 - 77.1	October, I
	Kushalbag Farm	4.x - 6.xii	13.3 - 100.0	October, I
	Village Chotinauka	6.x - 24.xi	20.0 - 100.0	November, II

+ vide Appendices II - IV (details of weekly population data)

Table 10

Population incidence of cumulative biotic - mortality of S.litura larvae in cabbage crop in different localities at Udaipur (1986-87) +

Year	Locality	Crop duration	Range of incidence (%)	Peak incidence (month, week)
1986				
	Kushalbag Farm	1.i - 19.ii	33.3- 75.00	January, IV
	Village Chotinauka	1.i - 19.ii	16.7- 100.0	February, III
	Horticulture Farm	2.i - 20.ii	16.7- 87.5	January, IV
1987				
	Kushalbag Farm	3.i - 21.ii	22.2- 60.00	January, II
	Village Chotinauka	5.i - 23.ii	20.0- 50.00	January, III
	Horticulture Farm	7.i - 25.ii	33.3- 100.0	January, I

+ vide Appendices V - VII (details of weekly population data)

Table 11

Crop and localitywise summary of overall impact of mortality parameters on field larval populations of *S. litura* at Udaipur (1985-86, 1986-87)+

Crop/ Locality	Total larval population collected	Mortality parameters (in different stages of the pest)				
		Larva			Pupa	Total biotic mortality No.(%)
		Insect Parasites No.(%)	Diseases No. (%)	Total No.(%)	Mortality/ deformity No. (%)	
Cauliflower (1985-1986)						
Kushalbag Farm	1591	333 (20.9)	569 (35.7)	902 (56.7)	268 (16.8)	1170 (73.54)
Village Chotinauka	2307	446 (19.3)	1076 (46.6)	1522 (65.9)	260 (11.2)	1782 (77.24)
Horticulture Farm	1674	341 (20.3)	637 (38.0)	978 (58.4)	251 (14.9)	1229 (73.4)
Overall (%)	5572	1120 (20.1)	2282 (40.9)	3402 (61.0)	779 (13.9)	4181 (75.04)
Cabbage (1986-1987)						
Kushalbag Farm	75	7 (9.3)	25 (33.3)	32 (42.6)	24 (32.0)	56 (74.6)
Village Chotinauka	89	2 (2.2)	31 (34.8)	33 (37.1)	13 (14.6)	46 (51.69)
Horticulture Farm	90	8 (8.9)	37 (41.1)	45 (50.0)	11 (12.2)	56 (62.22)
Overall (%)	254	17 (6.7)	93 (36.6)	110 (43.3)	48 (18.8)	158 (62.2)

+ *vide* Appendices II - IV, VIII - X.

for staggered periods of 24,48 and 72 hours respectively under the natural crop environment (vide Materials and Methods).

Larval parasites (Appendices V-VII, XI-XIII, Figs.2-8)

In cauliflower crop, the total larval parasitization by nine species was, on an average, 20.1 per cent (Table 11). Of this, P. orbata contributed to the extent of 50.5 per cent. Individually, the maximum parasitization (%) was: P.orbata 14.1, Rogas sp.8.4, Apanteles sp. (vitripennis species-group) 8.3, Microplitis sp. 2.7, Blepharella lateralis 2.6, Charops sp. 1.8, Campoletis chlorideae 1.6, Chelonus sp. 0.6, Eriborus sp.? argenteopilosus 0.3 (Table 12).

In cabbage crop, only P. orbata and Rogas sp. were involved and parasitized to the extent of 6.3 and 4.9 per cent respectively. Lower parasitic activity in this crop than in the cauliflower appeared due to variable microclimate.

Sequence of parasites

While a single effective parasite on one stage of the host may bring about significant control of the pest, a sequence of parasites is very much desirable. Based on sequential frequency in parasitization during four crop seasons in the four localities, it was observed that P.orbata

Table 12

Summary of the total parasitic-complex reared from the field collected larvae of Spodoptera litura infesting cauliflower and cabbage crops in different localities at Udaipur (1985-87) +

Crop Year/ Locality	Crop duration	Total larval count (No.)	Parasitization (%) by larval parasitic species									Total (%)
			Braconidae				Ichneumonidae			Tachinidae		
			Av.	Ch.	M	R	Cc.	Ea.	Ca.	P	Bl.	
Cauliflower												
Kharif: 1985												
Kushalbag	13.viii-22.x	789	5.1	0.1	0.5	5.6	1.5	-	0.1	9.0	-	21.9
Chotinauka	6.viii-22.x	797	4.6	0.1	2.0	3.3	0.1	-	0.1	14.1	-	24.3
R.C.A.Farm	7.viii-23.x	715	6.4	0.3	2.7	2.5	1.1	-	0.3	13.0	-	26.3
1986												
Kushalbag	26.vii -22.ix	382	2.6	-	-	2.1	1.0	-	-	9.2	-	14.9
Chotinauka	21.vii -29.ix	1001	3.4	0.5	0.6	2.4	0.8	-	-	9.8	-	17.5
R.C.A.Farm	30.vii -24.ix	481	2.9	0.2	1.7	0.8	0.8	-	0.6	9.4	-	16.4
Rabi: 1985												
Kushalbag	29.x - 17.xii	311	2.2	-	-	8.4	1.0	-	-	12.9	-	24.4
Chotinauka	29.x - 17.xii	340	6.2	-	-	3.8	0.3	0.3	-	6.2	0.3	17.1
R.C.A.Farm	30.x - 18.xii	309	2.6	-	0.3	5.5	1.6	-	-	5.5	2.6	18.1

Contd. Table 12

			Av.	Ch.	M	R	Cc.	Ea.	Ca.	P	Bl.	Total
1986												
Kushalbag	4.x - 6.xii	109	8.3	-	-	4.6	-	-	1.8	10.1	-	24.8
Chotinauka	6.x - 24.xi	169	1.8	0.6	-	0.6	-	-	-	8.3	-	11.2
R.C.A.Farm.	1.x - 19.xi	169	3.0	-	-	1.8	0.6	-	-	5.3	-	10.7
Cabbage												
1986												
Kushalbag	1.i - 19.ii	41	-	-	-	4.9	-	-	-	4.9	-	9.8
Chotinauka	1.i - 19.ii	51	-	-	-	-	-	-	-	-	-	-
R.C.A.Farm	2.i - 20.ii	58	-	-	-	3.4	-	-	-	5.2	-	8.6
1987												
Kushalbag	3.i - 4.ii	34	-	-	-	3.0	-	-	-	5.9	-	8.8
Chotinauka	5.i - 23.ii	38	-	-	-	-	-	-	-	5.3	-	5.3
R.C.A.Farm	7.i - 25.ii	32	-	-	-	3.1	-	-	-	6.3	-	9.4

+ vide Appendices V - VII, XI -XIII

Abbrv.: (Hymenoptera) Av., Apanteles sp. (vitripennis species-group); Cc., Campoletis chlorideae; Ca., Charops sp.; Ch, Chelonus sp.; Ea., Eriborus sp.? argenteopilosus; M., Microplitis sp.; R., Rogas sp.
(Diptera) Bl., Blepharella lateralis ; P., Peribaea orbata.

Table 13

Laboratory egg-mass cultures of S.litura exposed to T. chilonis in the cauliflower crop for parasitization (R.C.A. Farm, Udaipur, 1985)

Date of exposure	No.of eggs exposed (No. parasitized, % parasitization)at three intervals		
	24 hrs.	48 hrs.	72 hrs.
17.viii	106 (-)	145 (-)	145 (-)
18.viii	106 (-)	101 (-)	136 (-)
19.viii	196 (-)	160 (-)	292 (-)
20.viii	360 (-)	187 (-)	176 (-)
23.viii	275 (-)	226 (-)	299 (-)
24.viii	119 (-)	127 (-)	115 (-)
25.viii	125 (-)	155 (-)	145 (-)
26.viii	113 (-)	126 (-)	160 (-)
27.viii	75 (-)	195 (-)	85 (-)
2.ix	126 (-)	125 (-)	124 (-)
5.ix	157 (-)	95 (3,3.2)	85 (.2, 2.3)
6.ix	105 (14, 13.3)	197 (19,9.6)	145 (23, 15.9)
7.ix	385 (-)	232 (5,2.1)	105 (7, 3.4)
8.ix	110 (-)	257 (-)	202 (5, 2.5)
9.ix	162 (-)	101 (-)	164 (2, 1.2)
10.ix	150 (-)	150 (-)	98 (-)
12.ix	187 (-)	139 (-)	209 (-)
15.ix	201 (3, 1.5)	198 (4,2.0)	125 (-)
16.ix	179 (2, 1.1)	157 (-)	151 (4, 2.6)
18.ix	271 (-)	152 (2,1.3)	154 (-)
19.ix	190 (4,2.1)	250 (6,2.4)	230 (7,3.0)
20.ix	118 (-)	200 (-)	101 (-)
22.ix	67 (-)	93 (2, 2.1)	149 (12, 8.0)
24.ix	298 (-)	132 (-)	134 (-)
25.ix	118 (-)	162 (11,6.8)	179 (9,5.0)
26.ix	130 (12, 9.2)	151 (-)	97 (-)
27.ix	159 (-)	109 (7, 6.4)	178 (10,5.6)
28.ix	160 (-)	102 (-)	117 (-)
29.ix	104 (-)	142 (-)	109 (-)
1.x	102 (-)	142 (8, 5.6)	162 (10, 6.2)
2.x	139 (9, 6.5)	114 (31, 27.2)	134 (40,29.8)
3.x	125 (-)	138 (8,5.8)	149 (12, 8.0)
4.x	68 (15, 22.1)	154 (49,31.8)	185 (42,22.7)
6.x	135 (9,6.7)	120 (11,9.2)	170 (17,10.0)

Table 13 continued

Date of exposure	No.of eggs exposed (No.parasitized,% parasitization)at three intervals		
	24 hrs.	48 hrs.	72 hrs.
7.x	123 (-)	88 (7, 7.9)	98 (9, 9.2)
8.x	115 (3, 2.6)	138 (4, 2.9)	149 (13, 8.7)
9.x	70 (-)	76 (-)	44 (-)
10.x	194 (-)	189 (-)	98 (2, 2.0)
12.x	126 (1, 0.8)	129 (3, 2.3)	143 (4, 2.8)
13.x	105 (-)	93 (23,24.7)	120 (35,29.2)
15.x	152 (-)	161 (10,6.2)	103 (9, 8.7)
16.x	102 (-)	85 (7, 8.2)	101 (3, 3.0)
17.x	110 (-)	130 (-)	75 (-)
18.x	-	98 (-)	176 (-)
19.x	150 (-)	98 (-)	276 (-)
21.x	101 (-)	195 (-)	186 (-)
22.x	-	103 (-)	105 (-)
26.x	-	33 (-)	85 (-)
27.x	-	-	99 (-)
29.x	115 (-)	93 (-)	105 (-)
30.x	78 (-)	138 (3, 2.2)	176 (6, 3.4)
7.xi	109 (-)	156 (-)	178 (-)
13.xi	75 (-)	170 (9, 5.3)	175 (6, 3.4)
14.xi	99 (-)	106 (-)	107 (-)
15.xi	106 (-)	100 (-)	107 (-)
16.xi	71 (-)	29 (-)	99 (-)
28.xi	81 (-)	99 (-)	56 (-)
30.xi	-	98 (-)	119 (-)
1.xii	-	213 (-)	109 (-)
2.xii	-	76 (-)	69 (-)

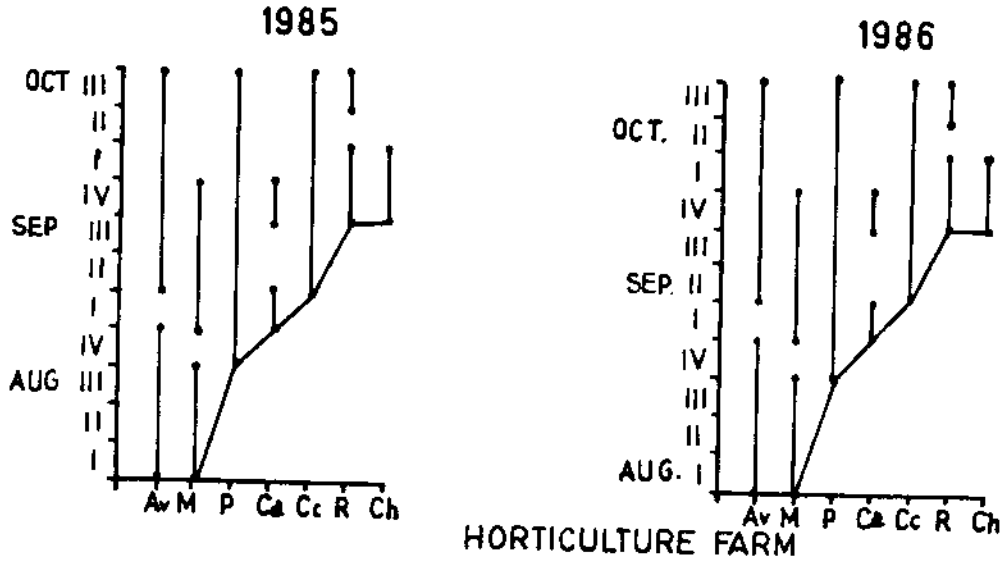
Total number of eggs exposed = 23,984

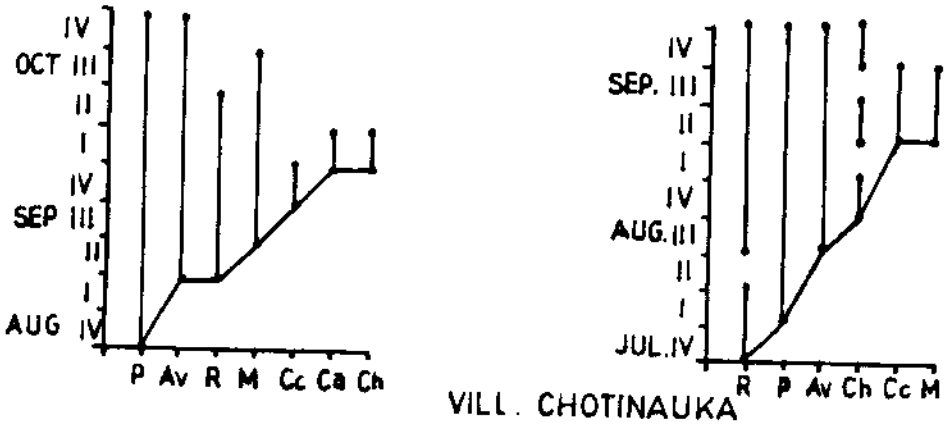
Number and percentage of parasitization = 593 (2.47%)

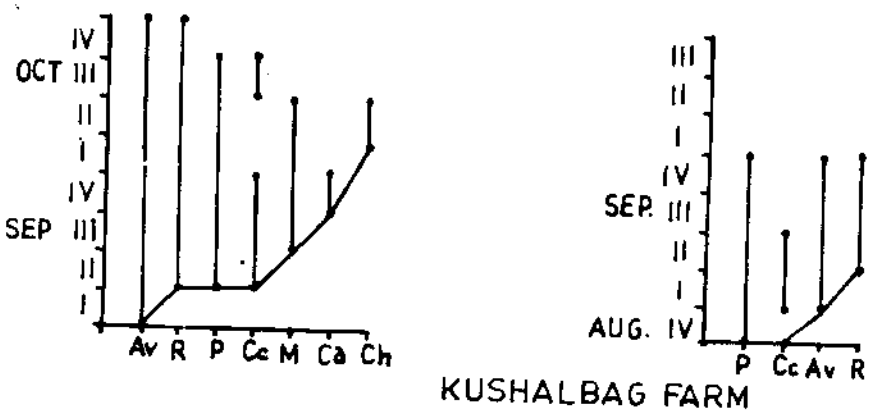
Number and percentage of hatchability =21,006 (87.58%)

Range of egg parasitization (%) = 0.8 to 31.8

...ERGENCE OF PARASITES IN CAULIFLOWER CROP (KHARIF) AT THREE LOCALITIES (1985-86)

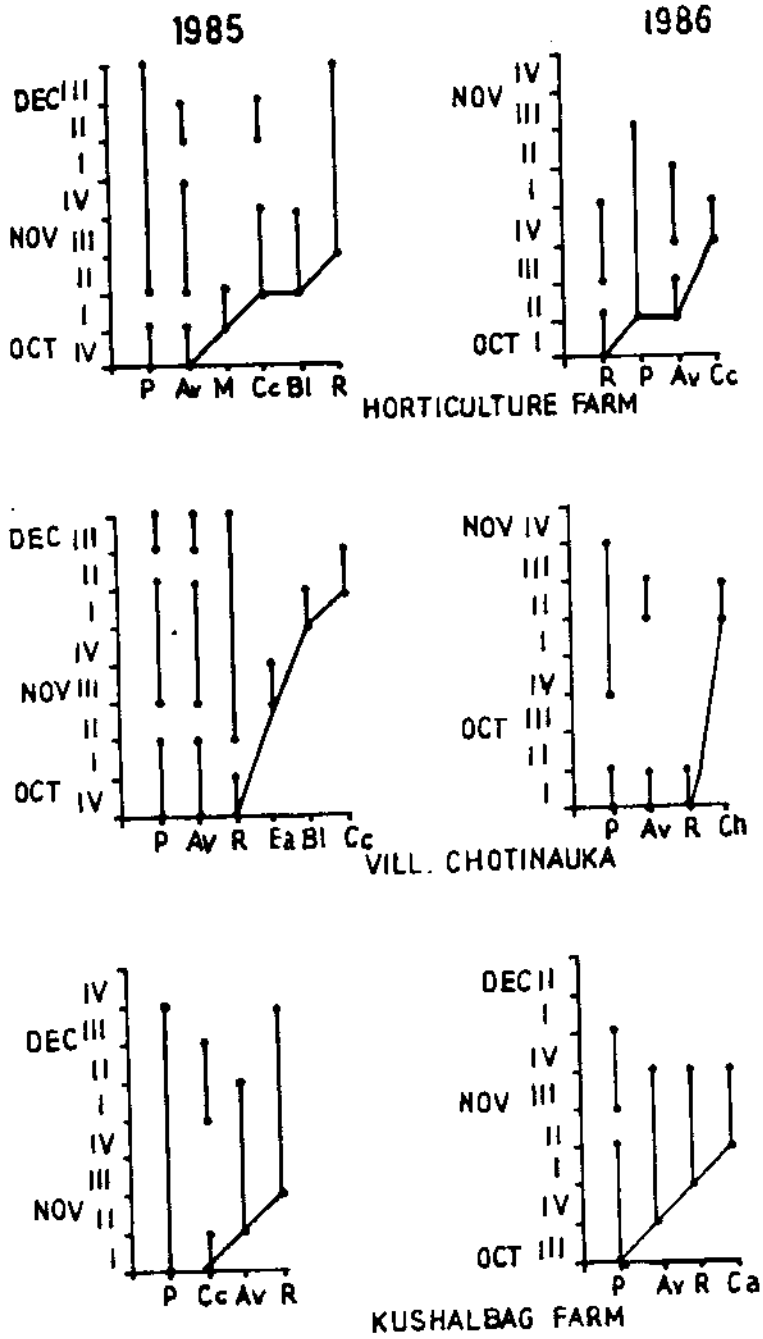






ABBREV. Av., Apanteles sp. (Vitripennis species-group),
Bl., Blepharella lateralis Ca., Charops sp.,
Cc., Campoletis chlorideae., Ch., Chelonus sp.,
Ea., Eriborus sp.? argenteopilosus; M., Microplitis sp.;
P., Peribaea orbata; R., Rogas sp.

FIG. 21 b. SEQUENCE OF PARASITES IN CAULIFLOWER CROP (RABI) AT THREE LOCALITIES(1985-86)



ABBREV. Av., Apanteles sp. (Vitripennis species-group)., Bl., Blepharella lateralis Ca., Charops sp., Cc., Campoletis chlorideae., Ch., Chelonus sp., Ea., Eriborus sp.? argenteopilosus, M., Microplitis sp.; P., Peribaea orbata; R., Rogas sp.

was invariably the foremost to appear in both the crops, followed by Apanteles sp. (vitripennis species-group), Rogas sp., C.chlorideae, Microplitis sp., Chelonus sp., B.lateralis, Charops sp. and E.sp.? argenteopilosus (Fig.21 a,b).

Bioecology of the major egg and larval parasites

The egg parasite, T.chilonis was recorded from September to November in cauliflower crop on the Horticulture Farm during 1985. Maximum parasitization continued during I and II weeks of October (upto 31.8 %).

Sexual behaviour

Copulation amongst the sexes commenced immediately following emergence of adults. The male approached the female with characteristic abdominal movements and antennal vibrations. The female amenable for copulation remained motionless for about 30 seconds, and the excited male mounted the partner. Preparatory to conjugation, male bent its abdomen downwards to articulate its genitalia within the female genital chamber; such behaviouristic sexual responses lasted for about six minutes. Curiously, the mated female did not refrain from the subsequent matings. Pre-oviposi-tional period for orientation was less than 30 seconds.

Host-parasite behaviour

Ovipositional behaviour

As maternal instinct, the fertilized female encountered the host eggs for appropriate site for oviposition. Thereafter, it rubbed its hindlegs with antennae and walked repeatedly (3-4 times) over the eggs; drumming of the host eggs with swift antennal movements lasted for about 15 seconds. Subsequently, the posterior abdominal portion was lowered and wings were raised vertically upwards; ultimately the ovipositor drilled into the egg. Oviposition period lasted upto three minutes, but exposure to light did enhance the responsive activity. Peripheral eggs of the egg-mass were mostly preferred.

Impact of parasite on the host egg

A normal egg of the host hatched on third day, but in case of parasitization, it provided for development of the parasite upto 8 days. The parasitized eggs characteristically turned black on third day. The parasite eggs apparently increased in size before hatching. Parasitism resulted in complete destruction of the host embryo.

Superpafasitism

It was specifically observed that a host egg was

repeatedly parasitized upto six times. Such superparasitism was observed when there was scarcity of host eggs under the laboratory conditions.

Biology

Egg stage.- The freshly laid minute eggs (ca.1 mm)dissected out of the host eggs were, translucent and fusiform in shape; but became oval-shaped prior to hatching after 24 hours.

Larval stage.- There were three larval instars, sacciform in shape. The larvae were white and opaque with membraneous body cuticle. The larval period of I, II and the III instar was completed within 21,27 and 48 hours. The total larval period was completed in about 4 days.

Pupal stage.- The pre-pupal stage was irregularly oval, but somewhat broader anteriorly. It lasted for a day. The pupa was cream coloured. The wing-pads and appendages were clearly demarcated. Eyes and ocelli were red. The stage lasted for two days.

Adult stage.- The fully developed adults emerged through a circular hole cut through the chorion of the host egg, and were photopositive. They were minute (0.5 mm), chrome yellow with blackish abdomen (Figs. 1 and 22).

Total life-cycle was completed within 8 days, and the adult longevity was 3-4 days.

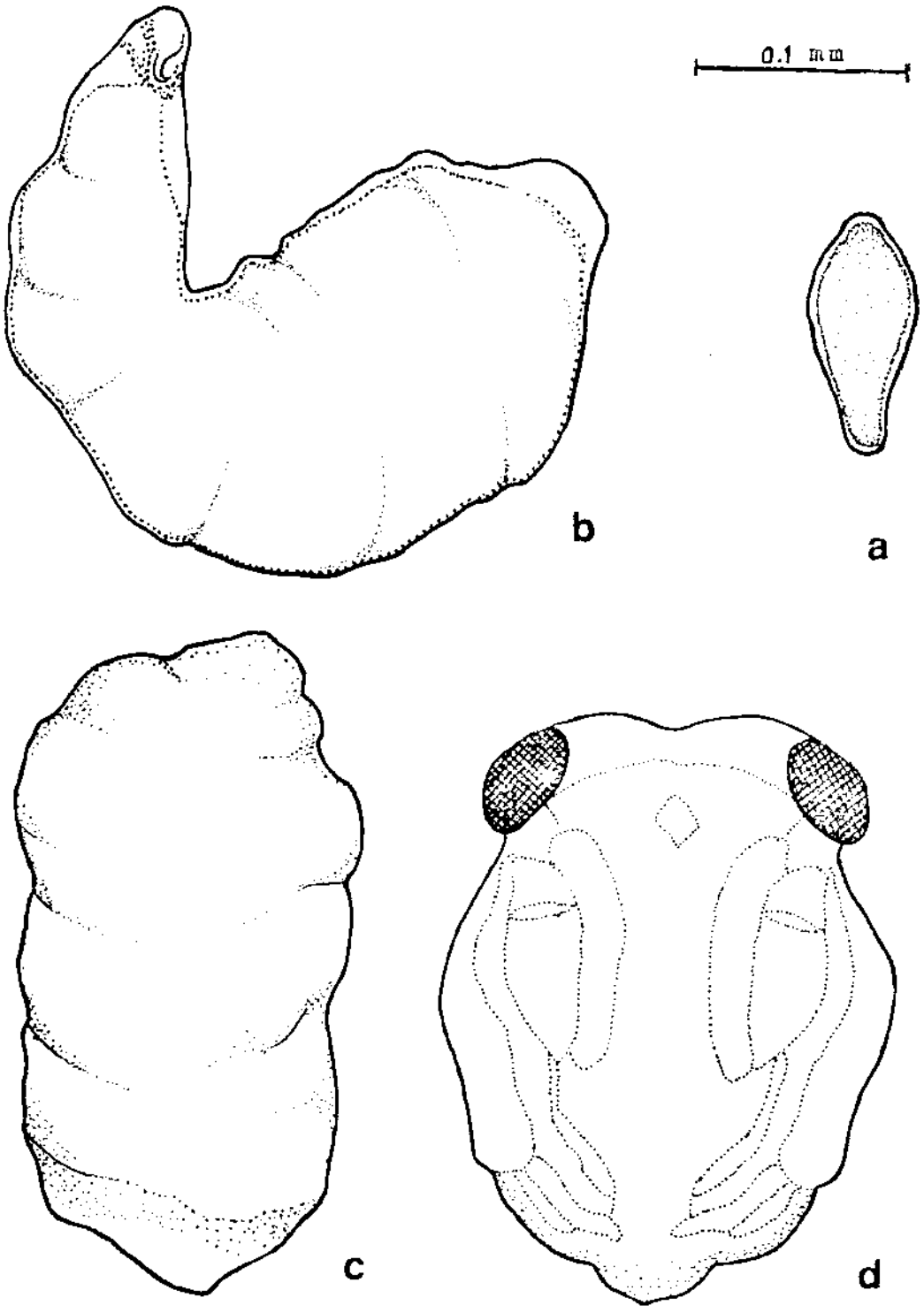


Fig. 22. IMMATURE STAGES OF TRICHOGRAMMA CHILONIS: a, EGG; b, III INSTAR LARVA; c, PRE-PUPA; d, PUPA

P. orbata

The tachinid, Peribaea orbata was a major larval parasite of S.litura. It was active from August to February; maximum parasitization was during September-October (1985-87) at Udaipur. It was an internal gregarious parasite.

Agroecosystems affecting level of parasitism

A very evident impact of the two ecosystems (cabbage and cauliflower) on P. orbata was imminent. Of the parasitic-complex in both the crops, P. orbata had higher parasitization upto 14.1 per cent of the pest population in cauliflower, and in cabbage crop it parasitized only upto 6.3 per cent(Table 12).

Based on the data of natural populations, the larval parasite (P.orbata) population was positively correlated with maximum temperature and evening humidity, but it was negatively correlated with minimum temperature, morning humidity and rainfall.

Weather acts to regulate insect population densities by interacting with other physical and biotic aspects of a habitat. As a sequel to this, the package of the interacting two major abiotic components will have to be considered to afrive at a possible interpretation for peak activity of the parasites. In present case study, the following package-range

(Fig.23, Appendices XXII a,b-XXIV a,b) seemed compatible for the high intensity of parasitization during sampling from September 8 to October 2,(1985-86): Temperature,maximum 30.5-33.9°C vs minimum 19.8-22.1°C vs Relative Humidity, morning 69.9-82.0% vs evening 36-51.3%.

Multiple parasitism

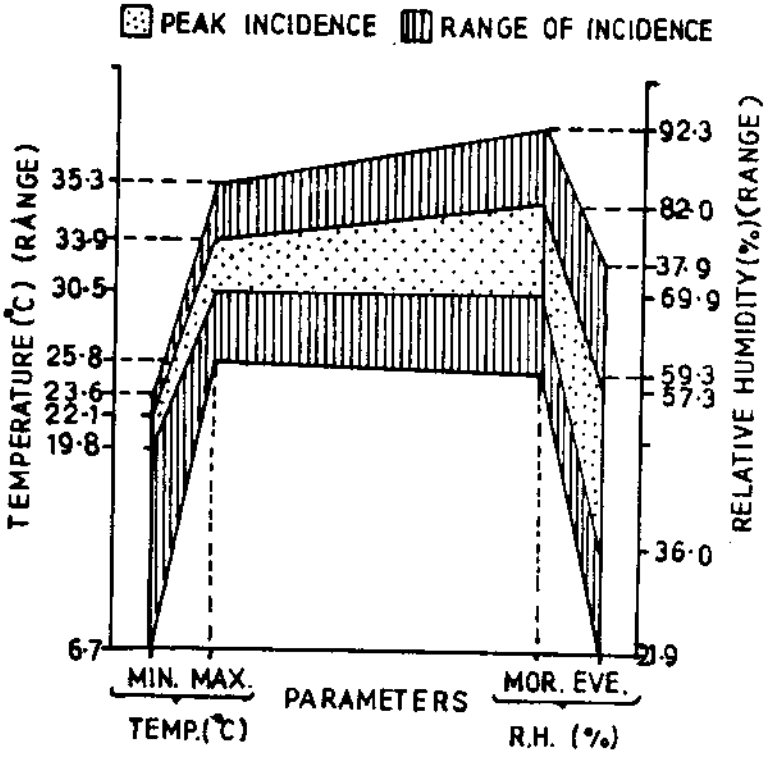
Interestingly, the same host larva was parasitized by two larval parasite species, a braconid Apanteles sp.(vitripennis species-group) and a tachinid, P.orbata. Curiously, puparia of A. sp. (vitripennis sp.-group) was observed a day earlier than the maggot of the co-parasite P.orbata from the common host larva. Of course, this was not a common observation and was recorded only in three instances.

Behaviouristic responses

Sexual behaviour

Freshly emerged females and males 2-3 days old on exposure to mild sunlight for 40 to 75 minutes per day stimulated the mating activity in the laboratory. The male followed the female fluttering its wings and holding the antennae just straight. Ultimately, it rested its antennae on the wings of the amenable female fly which remained motionless. The male fly then mounted on the dorsum and held it near the

FIG. 23. INCIDENCE OF P. ORBATA PARASITIZING S. LITURA VIS-A-VIS ABIOTIC FACTORS (1985-86)



base of the wings by forelegs; the midlegs hold the abdomen. Hind wings of the female rested on the substratum. In case of non-receptive female the male fly was avoided with characteristically fluttering of wings and by moving away.

During the act of copulation, the wings of the male fly remained vertically up; but following immediately it bent its abdomen downwards to conjoin its genitalia with that of the female. The female did respond by slightly raising its abdomen. Mating usually lasted for about 8 minutes on an average, but the duration varied from 2 to 10 minutes.

Host-parasite behaviour

Host searching and ovipositional behaviour

Host searching behaviour of the parasite was keenly observed in the laboratory cages. The adult tachinid flies located the host larva mostly by random wandering. But they were stimulated for oviposition by the remains of the dead larva of the host and damaged plant tissues in the vicinity. The fly was observed to be oviparous in habit. The pre-oviposition period ranged from 4 to 6 days. On locating a suitable instar of the host larva, the fly promptly availed herself of the chance to oviposit and lowered its abdomen towards host dorsally, in spite of the resistance offered by the host. The act of oviposition lasted for about 3 to 7 minutes. The eggs hatched immediately and the first instar

maggots entered the host by boring directly through the integument, leaving tiny ruptures on the host surface. More than one larva was parasitized by an individual fly.

Behaviour of the parasite towards host larva

It was observed that only young larvae were parasitized, preferably the second and third instar probably because the later instars resisted the attack besides the maternal instinct of preference on part of the parasite.

Behaviour of the host larva against the parasite

The host larva felt irritated and offered great resistance by jerking its body, raising upwards its head along with the thoracic portion. It moved its head on either sides to avoid parasitization. Occasionally, the parasite flew to another host or sat on the foliage momentarily, when disturbed by the host movements. The host larvae attempted to kill the parasitizing female fly by biting.

Effect of parasitism on the host

It was noticed that with each successive instar the survival of the parasitized hosts increased. The second and the third instar larvae were found to be highly susceptible but the final instar was the least susceptible stage. The parasitic maggots completely devoured the body contents

and internal tissues of the host. The parasitized host developed normally till the first 2 to 3 days of parasitization; thereafter its growth was checked and activities were almost suspended. Finally, it succumbed to death. However, some of the later instars, when parasitized, survived even after issue of the maggots and could pupate normally. It was able to overcome the damage caused by the parasite and thus survived.

Superparasitism (gregarious parasitism)

It was observed to be a common feature in this species: 3 to 4 matured maggots issued from a single host larva for pupation. In one observation, emergence upto 12 maggots was recorded.

Biology

Egg stage.- The eggs were macrotype, translucent and crescent-shaped with smoothly rounded ends. The chorion was thin and transparent. Incubation period was short, and the eggs hatched instantaneously on the host surface and bore directly into the host body. The point of entry was usually on intersegmental membrane.

Larval stage.- It was an endoparasitic stage; the maggots were cream coloured and oval in shape. There were three

instars. The creamish maggots fed on the host tissue until the III final instar. The host survived till the development of the parasitic maggots was completed. The developmental period within the host varied from 5 to 7 days. The fully developed creamish yellow maggots issued from the host by chewing its way out to pupate externally.

Pupal stage.- The maggots grown to 4 to 5 mm long exhibited strong wriggling movements, following their emergence from the host body; the movements ceased after about half an hour. Subsequently, it started contraction movements, the size was ultimately reduced to 3-4 mm. Finally the movements stopped. These were ultimately transformed to barrel-shaped pupae of maroonish hue with rounded ends. The pupal transformation was completed within 2-3.5 hours. The pupal stage lasted from 6 to 17 days; the average duration was 7.18 days.

Adult stage.- The fully developed parasite pushed its way by the front of its head out of the puparia. Within 2 to 4 minutes it attained its full posture and wing-expanse. The dark brownish-grey adults were active fliers and positively phototactic in nature. Notably, the females were found to be bigger in size and less active as compared to the males. The total life-cycle was completed within 18 to 29 days. The males lived from 2 to 5 days with an average longevity of 3 days. The female flies lived longer than

the males, ranging from 3 to 6 days with an average of 4 days under the laboratory condition (Table 14, Figs.8, 24).

Correlations of natural population components with key biotic and abiotic factors

Correlations of the natural pest populations with the interacting mortality factors, viz., biotic (parasites and microbialpathogens including bacteria, fungus and virus) and key abiotic (temperature, humidity and rainfall) factors as well as correlations of the biotic-complex with the abiotic factors have been worked out for three locations, viz., Kushalbag Farm (Kf), Horticulture Farm (Hf) and the village Chotinauka (Cv). Similarly, correlations have also been worked out between the natural populations of the major larval parasite, Peribaea orbata and the pest (S.litura), as also with the key abiotic factors. These correlations have been based on the data in cauliflower crop for six crop-seasons each in 1985 and 1986; and, in cabbage crop for three seasons each during 1986 and 1987.

Cauliflower crop

Impact of key biotic (parasite-complex and diseases) and abiotic factors on the pest population (Tables 15a-17a, Figs. 25aii - 27biii).-

Correlations for pest populations and related biotic

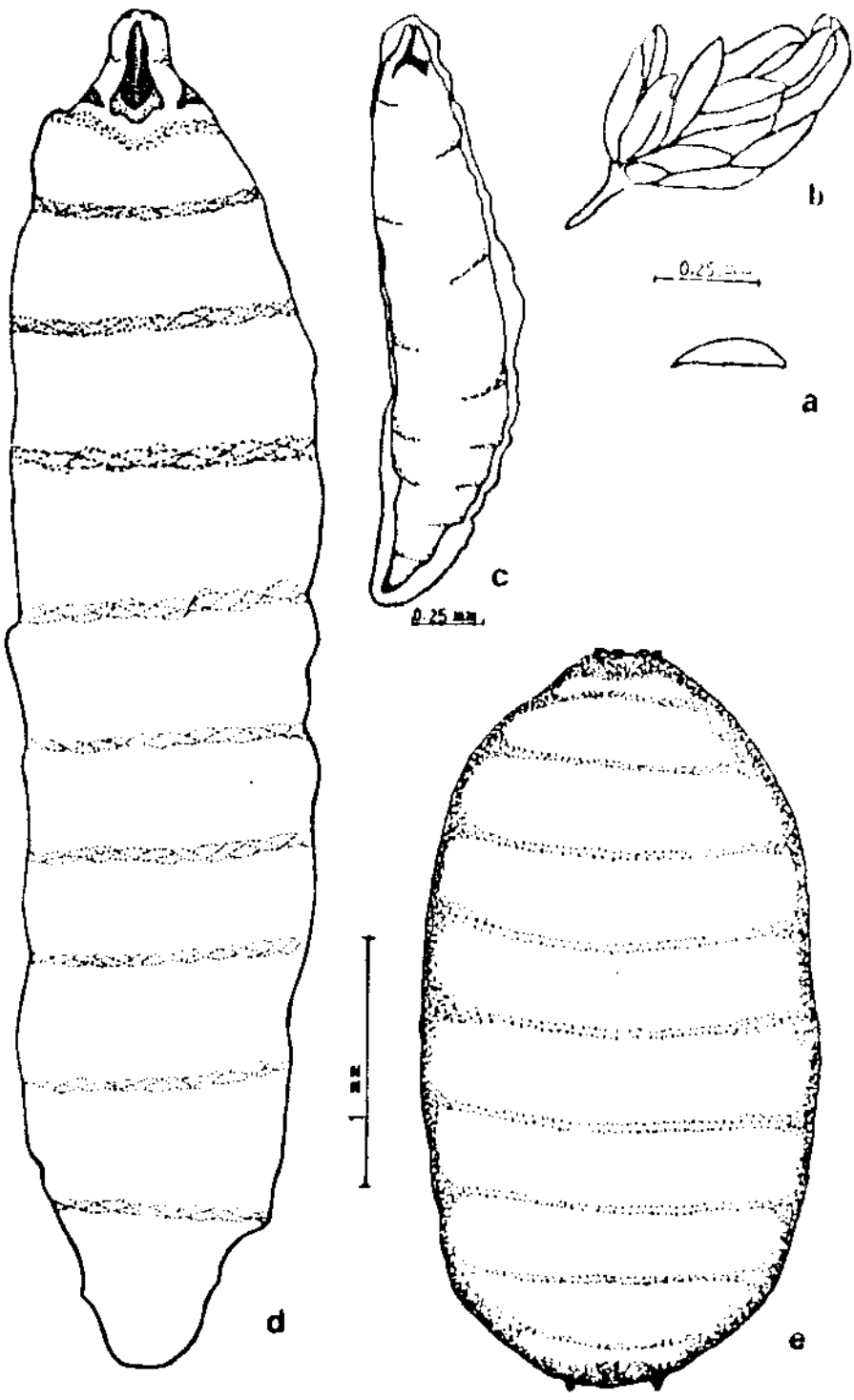


Fig. 24. IMMATURE STAGES OF THE TACHINID, PERIBAEA ORBATA:
a. EGG; b, EGG MASS DISSECTED OUT OF THE FEMALE UTERUS; c, II INSTAR LARVA; d III INSTAR LARVA;
e, PUPARIUM

Table 14

Biology of P. orbata under laboratory conditions at Udaipur (1985)

Characteristic phases	Duration	
	Range	Average
1. Mating period	2 - 10 min.	7.88 min.
2. Pre-oviposition period	4 - 6 days	4.8 days
3. Larval period	5 - 7 days	5.75 days
4. Pupal formation period	2 - 3.5 hours	2.42 hours
5. Pupal period	6 - 17 days	7.18 days
6. Life-cycle	18 - 29 days	25 days
7. Adult longevity		
(a) Males	2 - 5 days	3 days
(b) Females	3 - 6 days	4 days

N.B. Duration of cycle, September - October, 1985.
Temperature (°C) (range): Min. 10.6 - 24.8,
Max. 23.6 - 35.0
Relative humidity (%) (range): Morning, 66.0 - 94.0,
Evening, 18.0 - 98.0

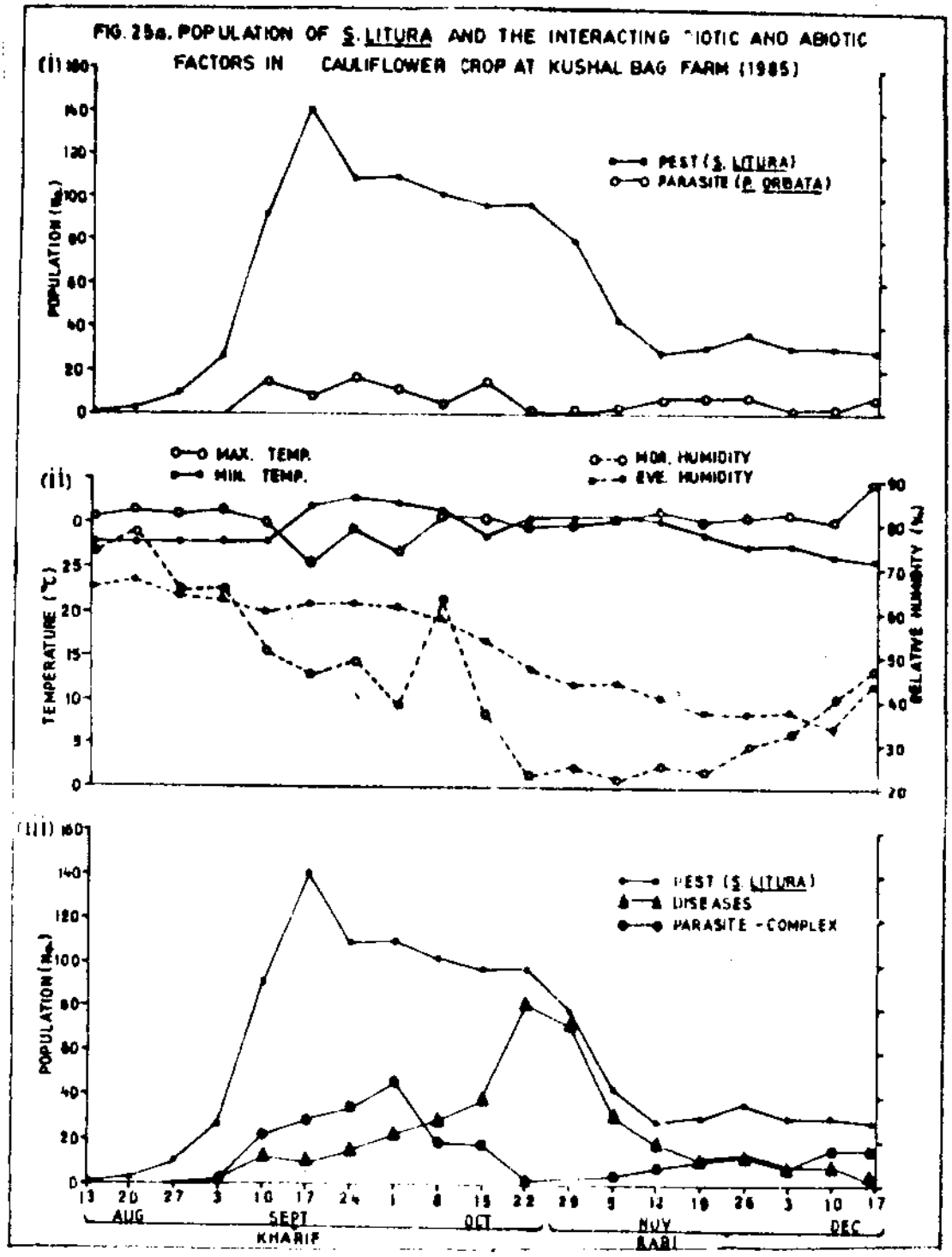
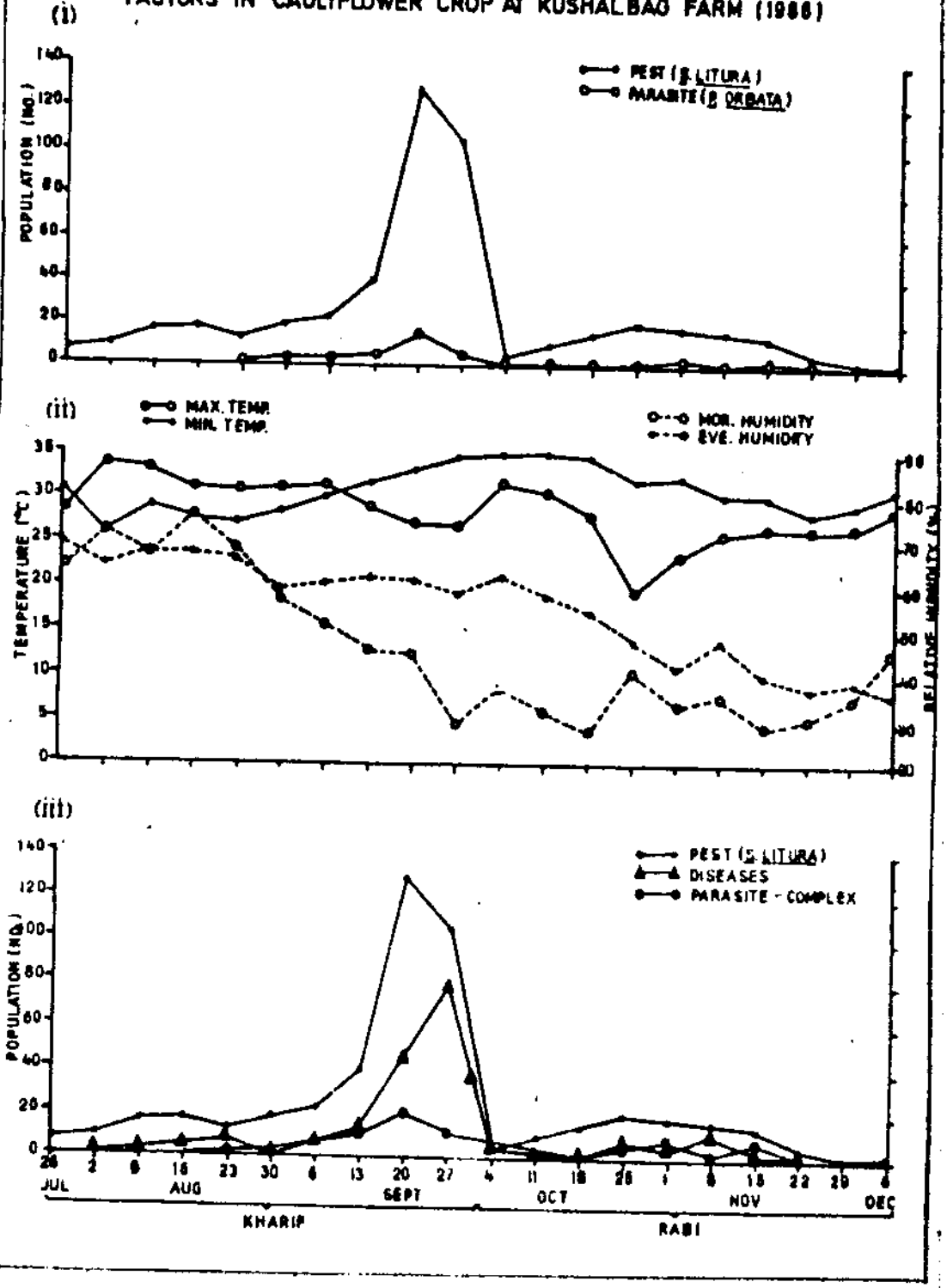


FIG. 25a. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CAULIFLOWER CROP AT KUSHAL BAG FARM (1985)

FIG. 25 b. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CAULIFLOWER CROP AT KUSHALBAG FARM (1986)



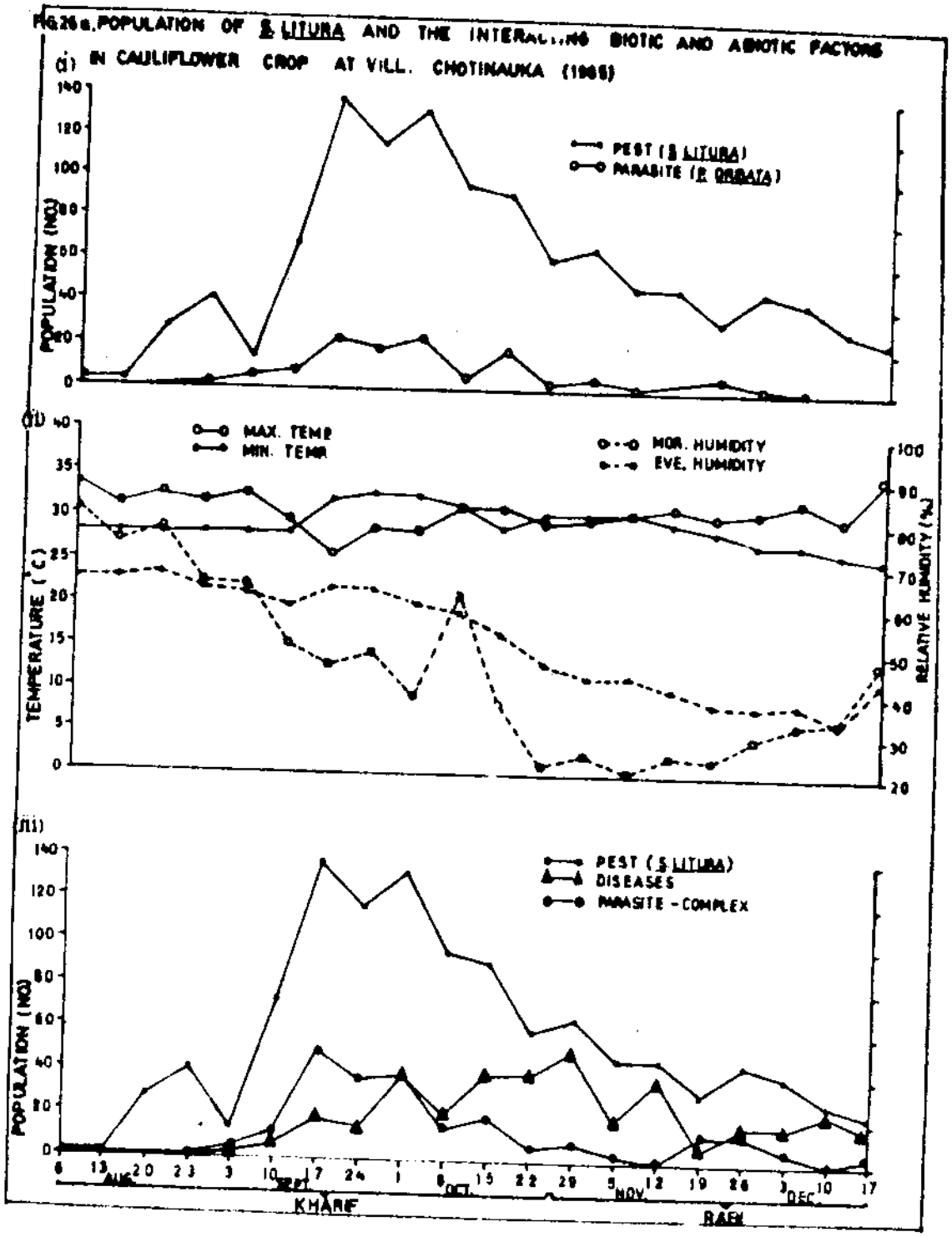


FIG.26 a. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS
(i) IN CAULIFLOWER CROP AT VILL. CHOTINAUKA (1985)
POPULATION (NO.)
PEST (S. LITURA)
PARASITE (P. ORBATA)
(ii)
TEMPERATURE (°C)
MAX. TEMP
MIN. TEMP
MOR. HUMIDITY
EVE. HUMIDITY
RELATIVE HUMIDITY (%)
(iii)
POPULATION (NO.)
PEST (S. LITURA)
DISEASES
PARASITE - COMPLEX
AUG
SEPT
OCT.
NOV
DEC.
KHARIF
RABI

FACTORS IN CAULIFLOWER CROP AT VILLAGE CHOTINAUKA (1988)

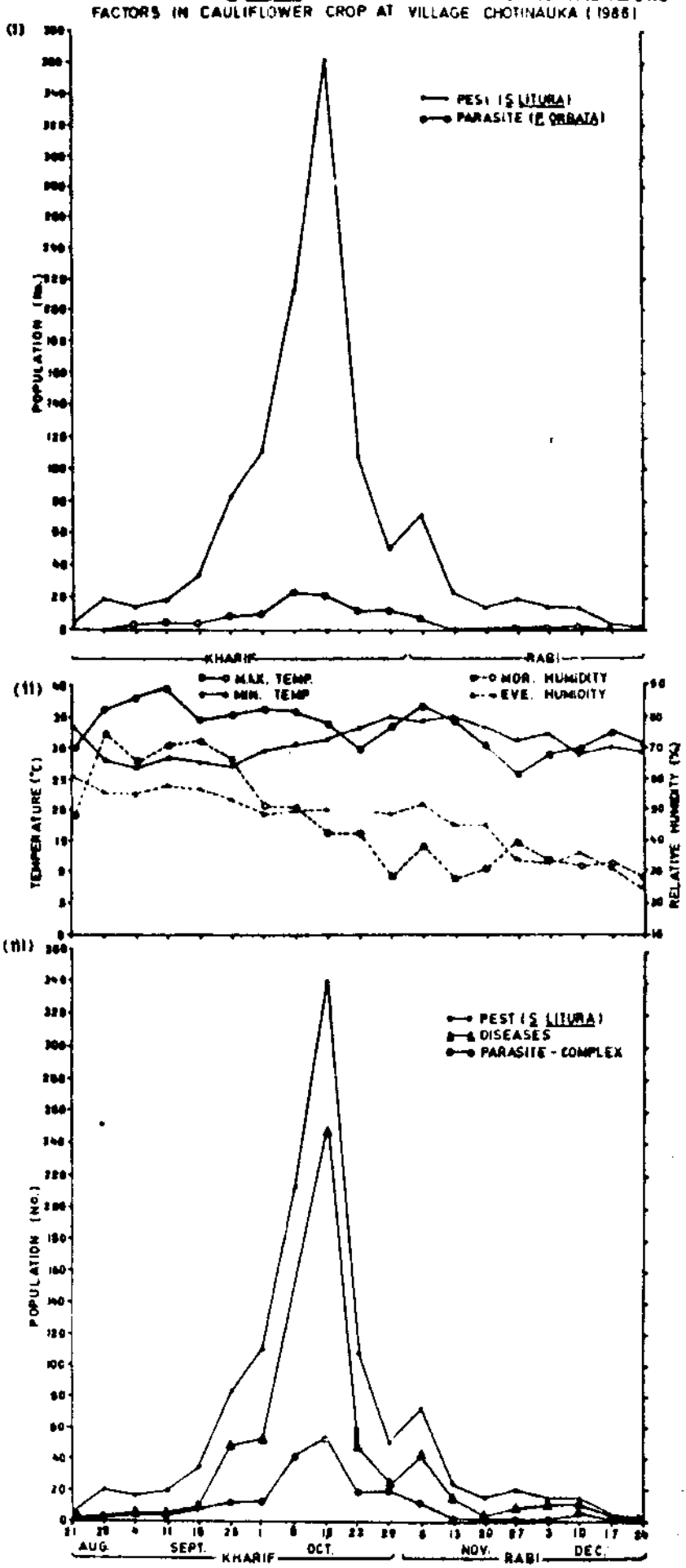


FIG. 27a. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CAULIFLOWER CROP AT HORTICULTURE FARM (1985)

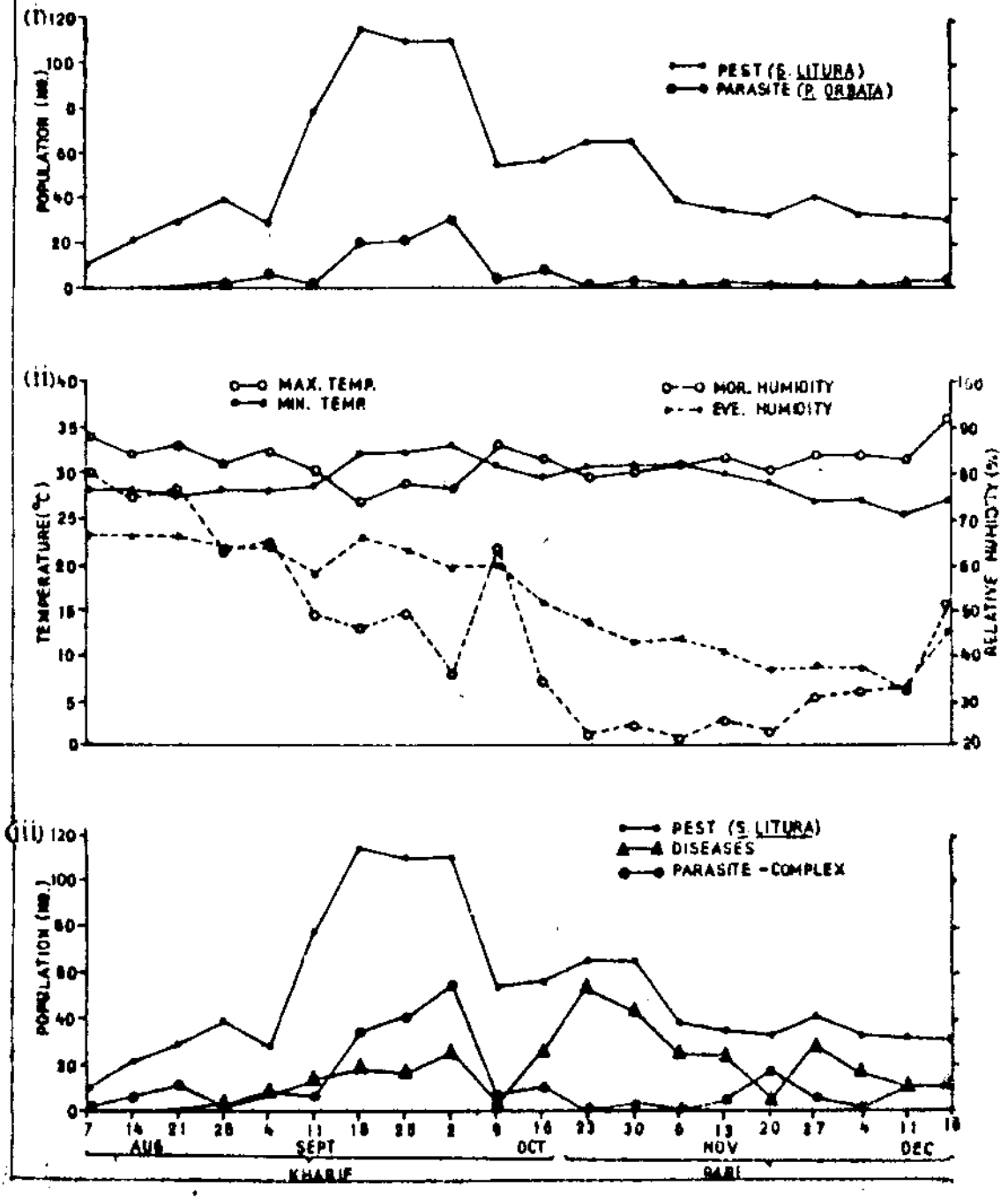


FIG. 27b. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CAULIFLOWER CROP AT HORTICULTURE FARM (1986)

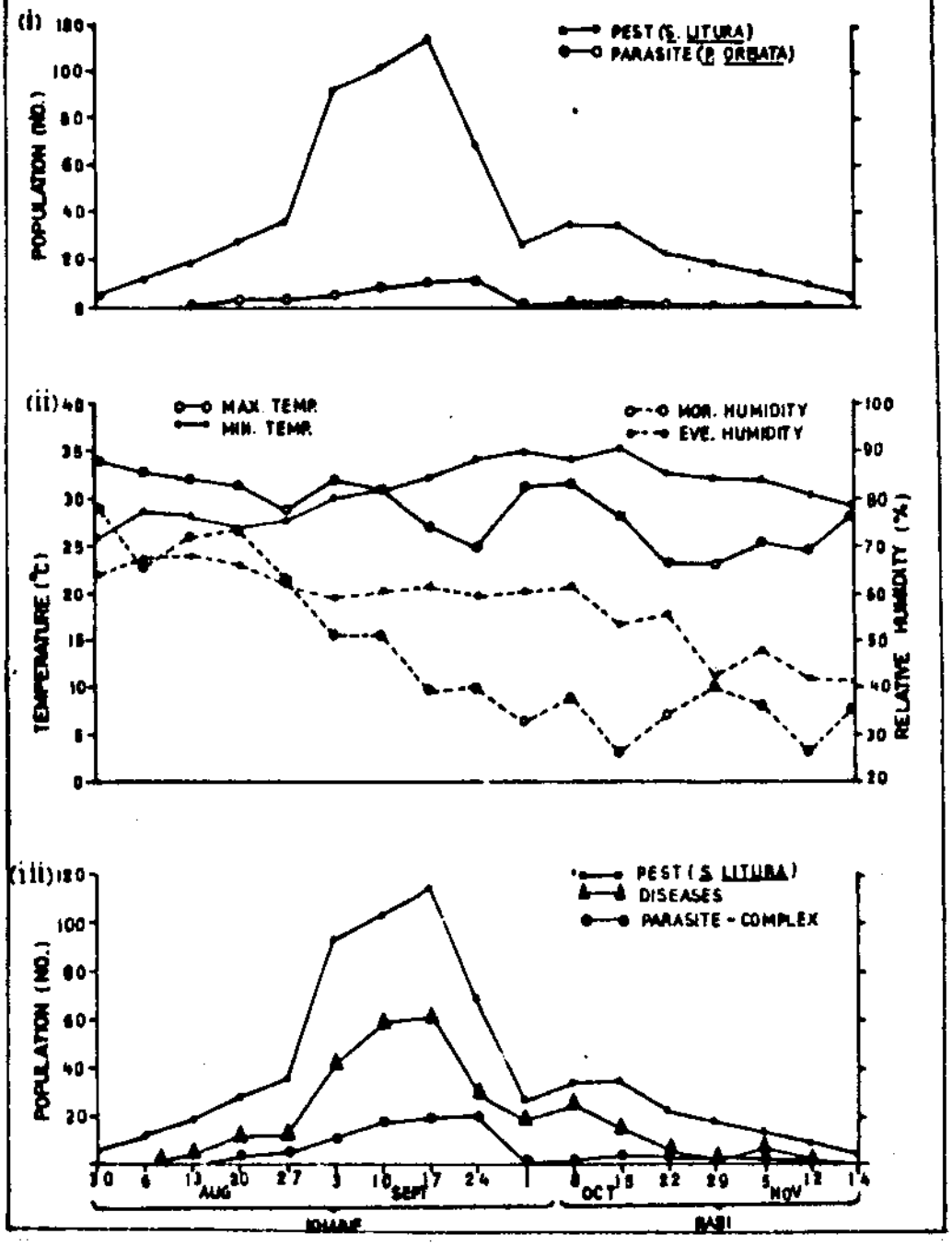


Table 15a

Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86)+

Year	Crop duration	Abiotic factors					Biotic factors	
		Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)	Parasite	Disease
		Max.	Min.	0735	1435			
1985	13.viii-22.x	0.8090**	-0.4579**	-0.7799**	-0.7595**	-0.2193**	0.7889**	0.4974**
	29.x - 17.xii	0.5110**	0.4710**	-0.4552**	-0.3693**	-0.2309	0.7602**	0.9713**
1986	26.vii-27.ix	0.8138**	-0.5660**	-0.7492**	-0.7811**	-0.4548**	0.9151**	0.9210**
	4.x - 6.xii	0.2022	0.2071	-0.6437**	-0.2499*	-0.3053**	0.7070**	0.6696**

Table 15b

Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86) +

Year	Crop duration	Temperature (°C)		Relative humidity (%) hrs.		Rainfall (mm)
		Max.	Min.	0735	1435	
a) 1985	13.viii-22.x	0.7799**	0.0056	-0.6646**	-0.4632**	-0.1926
	29.x - 17.xii	-0.8645**	-0.5795**	0.4559**	0.6761**	0.4644**
1986	26.vii-27.ix	0.7855**	-0.6789**	-0.7341**	-0.8157**	-0.6114**
	4.x - 6.xii	-0.2015	-0.2990**	-0.6502**	-0.2207*	-0.2934**
b) 1985	13.viii-22.x	0.3588**	-0.9563**	-0.2414**	-0.8171**	-0.1384
	29.x - 17.xii	0.6863**	0.5228**	-0.5215**	-0.5236**	-0.3339**
1986	26.vii-27.ix	0.8193**	-0.5668**	-0.7527**	-0.8236**	-0.4504**
	4.x - 6.xii	0.1003	0.3220**	-0.3707**	0.1513	0.1550

+ vide Appendices XIVa-d; Significant at 5 per cent*, 1 per cent **

Table 16a

Correlation coefficient(r) of S.litura population and the biotic and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (1985-86)+

Year	Crop duration	Abiotic factors					Biotic factors	
		Temperature (°C)		Relative humidity (%) hrs.		Rainfall (mm)	Parasite	Disease
		Max.	Min.	0735	1435			
1985	6.viii-22.x	0.8792**	-0.2854**	-0.8060**	-0.6779**	-0.3913**	0.9277**	0.6817**
	29.x - 17.xii	0.7345**	0.4066**	-0.5478**	-0.6439**	-0.5324**	0.1978	0.7676**
1986	21.vii - 29.ix	0.2211*	-0.6135**	-0.1079	-0.4357**	-0.4553**	0.9626**	0.9919**
	6.x - 24.xi	0.5936**	0.8051**	0.5905**	0.5448**	0.9456**	0.8643**	0.9837**

Table 16b

Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (1985-86) +

Year	Crop duration	Temperature (°C)		Relative humidity (%) hrs.		Rainfall (mm)
		Max.	Min.	0735	1435	
a)1985	6.viii-22.x	0.8447**	-0.0640	-0.8430**	-0.5537**	-0.3940**
	29.x - 17.xii	0.0549	-0.0769	-0.2649	-0.2270	-0.1816
1986	21.vii - 29.ix	0.3167**	-0.6501**	-0.1146	-0.5205**	-0.4978**
	6.x - 24.xi	0.1722	0.5621**	0.5142**	0.5219**	0.9047**
b)1985	6.viii-22.x	0.6366**	-0.7922**	-0.4922**	-0.8768**	-0.3431**
	29.x - 17.xii	0.4825**	0.3514**	-0.3333**	-0.2926*	-0.2381
1986	21.vii - 29.ix	0.2055*	-0.5442**	-0.0765	-0.4098**	-0.4322**
	6.x - 24.xi	0.5430**	0.7516**	0.6179**	0.4970**	0.9348**

+ vide Appendices XVa-d; Significant at 5 per cent *, 1 per cent **

Table 17a

Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86) +

Year	Crop duration	Abiotic factors					Biotic factors	
		Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)	Parasite	Disease
		Max.	Min.	0735	1435			
1985	7.viii-23.x	0.9038**	-0.2443**	-0.9115**	-0.6942**	-0.5337**	0.8089**	0.5187**
	30.x - 18.xii	0.5411**	0.3415**	-0.4701**	-0.3687**	-0.2746	0.3487**	0.8868**
1986	30.vii- 24.ix	0.7700**	-0.8081**	-0.5428**	-0.8765**	-0.6453**	0.9001**	0.9899**
	1.x - 19.xi	0.9523**	0.8484**	0.4384**	-0.0787	0.5828**	0.5297**	0.8657**

Table 17b

Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86) +

Year	Crop duration	Temperature (°C)		Relative humidity (%) hrs.		Rainfall (mm)
		Max.	Min.	0735	1435	
a) 1985	7.viii-23.x	0.8298**	0.1333	-0.6874**	-0.3592**	-0.0621
	30.x - 18.xii	0.3070*	-0.3799**	-0.0062	0.1224	0.1456
1986	30.vii- 24.ix	0.9102**	-0.8393**	-0.7839**	-0.9381**	-0.5943**
	1.x - 19.xi	0.4940**	0.2726	-0.4532**	-0.0009	-0.2020
b) 1985	7.viii-23.x	0.5384**	-0.8616**	-0.6067**	-0.9329**	-0.5545**
	30.x -18.xii	0.5774**	0.3958**	-0.3666**	-0.3900**	-0.3300**
1986	30.vii -24.ix	0.7286**	-0.7683**	-0.4954**	-0.8317**	-0.5908**
	1.x -19.xi	0.8340**	0.9096**	0.7660**	-0.0276	0.8385**

+ vide Appendices XVIa-d; Significant at 5 per cent*, 1 per cent **

data were worked out for twelve crop seasons at all the three locations. The correlations were found to be positively significant for eleven seasons with the parasites (non-significant during rabi crop of 1985 at village Chotinauka) and twelve seasons with the diseases. There were significant correlations of the pest population with minimum and maximum temperatures and morning and evening humidities each in eleven crop seasons, and with rainfall in ten crop seasons as summarised below:

Abiotic factors	Correlations*	Crop seasons	Localities(Year)
Temp. (°C)			
Maximum	+	kharif	Kf,Cv,Hf (1985-86)
	+	rabi	Kf,Cv,Hf (1985);Cv,Hf(1986)
Minimum	+	rabi	Kf,Cv,Hf (1985);Cv,Hf(1986)
	-	kharif	Kf, Cv,Hf,(1985-86)
R.H. (%)			
Morning	+	rabi	CV,HF (1986)
	-	kharif	Kf,Cv,Hf (1985);Kf,Hf(1986)
	-	rabi	Kf,Cv,Hf (1985); Kf (1986)
Evening	+	rabi	Cv (1986)
	-	kharif	Kf, Cv,Hf (1985-86)
	-	rabi	Kf,Cv,Hf (1985); Kf (1986)
Rainfall (mm)	+	rabi	Cv,Hf (1986)
	-	kharif	Kf,Cv,Hf (1985-86)
	-	rabi	Cv (1985); Kf (1986)

* Only the significant correlations have been indicated in the summary.

Impact of key abiotic factors on the parasite-complex

(Tables 15b-17b, Figs. 25aii-27biii).-

There were significant correlations of the parasite-complex in seven crop seasons with minimum temperature and in nine crop seasons with maximum temperature; and with the relative humidities, both morning and evening in nine crop seasons each; and with rainfall in seven crops seasons. These are summarised below:

Abiotic factors	Correlations	Crop seasons	Localities(year)
Temp. (°C)			
Maximum	+	kharif	Kf,Cv,Hf (1985-86)
	+	rabi	Hf (1985-86)
	-	rabi	Kf (1985)
Minimum	+	rabi	Cv (1986)
	-	kharif	Kf,Cv,Hf (1986)
	-	rabi	Kf,Hf (1985); Kf (1986)
R.H. (%)			
Morning	+	rabi	Kf,(1985); Cv (1986)
	-	kharif	Kf,Cv,Hf(1985);Kf,Hf(1986)
	-	rabi	Kf,Hf, (1986)
Evening	+	rabi	Kf (1985); Cv (1986)
	-	kharif	Kf,Cv,Hf (1985-86)
	-	rabi	Kf (1986)
Rainfall (mm)	+	rabi	Kf (1985); Cv (1986)
	-	kharif	Cv (1985); Kf,Cv,Hf(1986)
	-	rabi	Kf (1986)

Impact of P.orbata population on the pest (S.litura) population (Tables 21-23, Figs. 25ai-27bi).-

Correlations for parasite (P.orbata) populations with the pest populations were worked out for twelve crop seasons at all three locations. It was positively significant for eleven crop-seasons as summarised below:

	Correlation	Crop seasons	Localities (year)
Pest	+	Kharif	Kf, Cv, Hf (1985-86)
	+	rabi	Kf, Cv, (1985); Kf, Cv, Hf (1986)

Impact of key abiotic factors on the P.orbata population (Tables 21-23, Figs. 25ai-27bii).-

There were significant correlations of the factors with the parasite in ten seasons with maximum temperature and five seasons with minimum temperature; with the relative humidities, both morning and evening in eleven and twelve seasons respectively; and with rainfall in ten crop seasons. These are summarised below:

Abiotic factors	Correlations	Crop seasons	Localities (year)
Temp. (°C)			
Maximum	+	kharif	Kf, Cv, Hf (1985-1986)
	+	rabi	Cv (1985); Hf (1986)

Contd...

Table 18a

Correlation coefficient(r) of S.litura population and the biotic and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87)+

Year	Crop duration	Abiotic factors					Biotic factors	
		Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)	Parasite	Disease
		Max.	Min.	0735	1435			
1986	1.i - 19.ii	-0.7112**	-0.6758**	0.1780	-0.1101	0.0187	0.8805**	0.5815**
1987	3.i - 21.ii	-0.7436**	0.3336**	0.5872**	0.5564**	0.7075**	0.4425**	0.5573**

Table 18b

Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87)+

Year	Crop duration	Temperature (°C)		Relative humidity (%) hrs.		Rainfall (mm)
		Max.	Min.	0735	1435	
a) 1986	1.i - 19.ii	-0.7434**	-0.8643**	0.1995	-0.4003*	-0.1429
1987	3.i - 21.ii	-0.4142**	0.5660**	0.4792**	0.7528**	0.3394**
b) 1986	1.i - 19.ii	-0.0393	0.0524	-0.3233**	0.4721**	0.3567**
1987	3.i - 21.ii	-0.4193**	-0.4464**	0.5486**	-0.0805	-

+ vide Appendices XVIIa-b; Significant at 5 per cent*, 1 per cent **

Table 19a

Correlation coefficient (r) of S.litura population and the biotic and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (1986-87)+

Year	Crop duration	Abiotic factors					Biotic factors	
		Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)		
		Max.	Min.	0735	1435		Parasite	Disease
1986	1.i-19.ii	-0.6452**	-0.9584**	0.5918**	-0.4145**	-0.4743**	-	0.5159**
1987	5.i-23.ii	-0.7682**	-0.0972	0.6523**	0.2776*	0.6293**	0.6295**	0.9129**

Table 19b

Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (1986-87)+

Year	Crop duration	Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)
		Max.	Min.	0735	1435	
a) 1986	1.i-19.ii	-	-	-	-	-
1987	5.i-23.ii	-0.5858**	0.3115*	0.3893**	0.2107	1.0
b) 1986	1.i-19.ii	-0.6703**	0.5013**	0.2022	-0.6273**	-0.2928*
1987	5.i-23.ii	-0.7859**	0.1401	0.7119**	0.4887**	0.6729**

+ vide Appendices XVIIIa-b; Significant at 5 per cent*, 1 per cent **

Table 20a

Correlation coefficient (r) of S.litura population and biotic and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87) +

Year	Crop duration	Abiotic factors					Biotic factors	
		Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)	Parasite	Disease
		Max.	Min.	0735	1435			
1986	2.i - 20.ii	-0.5495**	-0.6127**	0.2712	0.0271	-0.2182	0.2764	0.4797**
1987	7.i - 25.ii	-0.5693**	-0.4590**	0.6200**	0.1722	0.3298**	0.0784	0.8912**

Table 20b

Correlation coefficient (r) of (a) insect parasites and (b) microbial diseases (attacking S.litura) and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87) +

Year	Crop duration	Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)
		Max.	Min.	0735	1435	
a) 1986	2.i-20.ii	-0.3997**	-0.5231**	0.5866**	-0.3330**	-0.2381
1987	7.i-25.ii	-0.6584**	0.3205*	0.7498**	0.8776**	-0.2037
b) 1986	2.i-20.ii	0.2307	0.2251	0.0275	0.6807*	0.3140*
1987	7.i-25.ii	-0.2711	-0.6797**	0.2982*	-0.1985	0.2757*

+ vide Appendices XIXa-b; Significant at 5 per cent*, 1 per cent **

Table 21

Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985-86) +

Year	Crop duration	Pest larval population	Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
1985	13.viii-22.x	0.6960**	0.4819**	0.1096	- 0.4562**	- 0.4664**	- 0.2758**
	29.x - 17.xii	0.6918**	- 0.3238**	- 0.1456	0.4702**	0.2960*	0.3889**
1986	26.vii-27.ix	0.8935**	0.6929**	(-)0.6352**	- 0.6681**	- 0.7071**	- 0.5624**
	4.x - 6.xii	0.4642**	- 0.1780	- 0.3672**	- 0.4517**	- 0.4105**	- 0.2667**

+ vide Appendices XXIIa-b; Significant at 5 per cent*, 1 per cent**

Table 22

Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (1985-86) +

Year	Crop duration	Pest larval population	Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
1985	6.viii-29.x	0.8968**	0.7409**	- 0.1666	- 0.7478**	- 0.6330**	- 0.5042**
	29.x - 17.xii	0.2859*	0.3334**	0.2337	- 0.3114*	- 0 3227**	- 0.0966
1986	21.vii- 29.ix	0.9042**	0.3565**	- 0.7723**	- 0.0992	- 0.5902**	- 0.6138**
	6.x - 24.xi	0.8868**	0.2073	0.5630**	0.5162**	0.5755**	0.9311**

+ vide Appendices XXIII a-b; Significant at 5 per cent*, 1 per cent**

Table 23

Correlation coefficient (r) of Pericbaea orbata population with the pest population and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985-86) +

Year	Crop duration	Pest larval population	Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
1985	7.viii-23.x	0.8327**	0.8624**	0.0316	- 0.7241**	- 0.4577**	- 0.3923**
	30.x - 18.xii	0.0960	- 0.4309**	0.1099	0.4701**	0.6679**	0.6078**
1986	30.vii- 24.ix	0.8499**	0.8877**	- 0.8300**	- 0.8563**	- 0.9192**	- 0.6137**
	1.x - 19.xi	0.5221**	0.4447**	0.1801	- 0.3235**	- 0.4345**	- 0.2333

+ vide Appendices XXIVa-b ; Significant at 5 per cent *, 1 per cent **

1.	2.	3.	4.
	-	rabi	Kf, Hf (1985)
Minimum	+	rabi	Cv (1986)
	-	kharif	Kf, Cv, Hf (1986)
	-	rabi	Kf (1986)
R.H (%)			
Morning	+	rabi	Kf, Hf (1985); Cv (1986)
	-	kharif	Kf, Cv, Hf (1985); Kf, Hf (1986)
	-	rabi	Cv (1985); Kf, Hf (1986)
Evening	+	rabi	Kf, Hf (1985); Cv (1986)
	-	kharif	Kf, Cv, Hf (1985-86)
	-	rabi	Cv (1985); Kf, Hf (1986)
Rainfall (mm)	+	rabi	Kf, Hf (1985); Cv (1986)
	-	kharif	Kf, Cv, Hf (1985-86)
	-	rabi	Kf (1986)

Impact of key abiotic factors on the incidence of diseases (Tables 15b - 17b, Figs. 25ai - 27bii).-

There were significant correlations of disease in twelve crop seasons with minimum and in eleven crop seasons with maximum temperatures; with morning and evening humidities in eleven and ten crop seasons respectively; and with rainfall in nine crop seasons. These are summarised below:

Abiotic factors	Correlations	Crop seasons	Localities (year)
Temp. (°C)			
Maximum	+	kharif	Kf, Cv, Hf (1985-86)
	+	rabi	Kf, Cv, Hf (1985); Cv, Hf (1986)
Minimum	+	rabi	Kf, Cv, Hf (1985-86)
	-	kharif	Kf, Cv, Hf (1985-86)
R.H. (%)			
Morning	+	rabi	Cv, Hf (1986)
	-	kharif	Kf, Cv, Hf (1985); Kf, Hf, (1986)
	-	rabi	Kf, Cv, Hf (1985); Kf (1986)
Evening	+	rabi	Cv (1986)
	-	kharif	Kf, Cv, Hf (1985-86)
	-	rabi	Kf, Cv, Hf (1985)
Rainfall (mm)	+	rabi	Cv, Hf (1986)
	-	kharif	Cv, Hf (1985); Kf, Cv, Hf (1986)
	-	rabi	Kf, Hf (1985)

For this crop, it may thus be broadly concluded that the correlations between the pest population and the biotic factors was exclusively positively significant. Such significance was found to the extent of 91.66 per cent with

parasite-complex and cent per cent with diseases. The correlations with abiotic factors depicted relatively more of negative trend except that the maximum temperature was correlated exclusively positively. More specifically, the correlations of pest population with abiotic factors indicated in frequency of 'significance' in percentage of each factor out of 12 crop seasons (proportional positive and negative) was as follows:

Maximum temperature ... 91.66 (positive)
Minimum temperature ... 91.66 (41.66, positive; 50.0, negative)
Morning humidity ... 91.66 (16.66, positive; 75.0, negative)
Evening humidity ... 91.66 (8.33, positive; 83.33, negative)
Rainfall ... 83.33 (16.66, positive; 66.66, negative)

The correlations of the parasite (complex) with the abiotic factors also indicated more of negative trend, except with maximum temperature, where the trend was more towards positive. The correlations indicated in frequency of 'significance' in percentage of each factor was as follows:

Maximum temperature ... 75.0 (66.66, positive; 8.33, negative)
Minimum temperature ... 58.33 (8.33, positive; 50.0, negative)
Morning humidity ... 75.0 (16.66, positive; 58.33, negative)
Evening humidity ... 75.00 (16.66, positive; 58.33, negative)
Rainfall ... 58.33 (16.66, positive; 41.66, negative)

Correlations of diseases with the abiotic factors, indicated in frequency of 'significance' in percentage of each factor, out of twelve crop seasons was as follows:

Maximum temperature ... 100.0 (positive)

Minimum temperature ... 83.33 (16.66, positive; 66.66, negative)

Morning humidity ... 66.66 (positive)

Evening humidity ... 50.0 (33.33, positive; 16.66, negative)

Rainfall ... 66.66 (50.0, positive; 16.66, negative)

Correlations between the major larval parasite (P.orbata) population and the pest (S.litura) population during kharif depicted the trend of correlation to be exclusively positive. With maximum temperature also similar trend of positive correlation existed, whereas it was exclusively negative with minimum temperature, morning and evening humidities, and, rainfall. The rabi crop did show significant correlations but the responses were negative as well as positive during crop seasons at the three locations.

The correlations between the major larval (P.orbata) parasite population and the pest population was positively significant to the extent of 91.66 per cent. The correlations with abiotic factors indicated in percentage of each factor out of twelve crop seasons was as follows:

Maximum temperature ... 83.33(66.66,positive;16.66,negative)

Minimum temperature ... 41.66(8.33,positive; 33.33,negative)

Morning humidity ... 91.66(25.0,positive;66.66, negative)

Evening humidity ... 100.0(25.0,positive;75.0, negative)

Rainfall ... 83.33(25.0, positive;58.33,negative)

Cabbage crop

Impact of key biotic (parasite-complex and diseases) and abiotic factors on the pest population (Tables 18a-20a, Figs. 28aii-30biii). -

Correlations of the natural pest populations with the related biotic data were worked out for six crops* cultivated in the said three locations (1986-87). No parasitization of the pest was recorded during the sampling of fields at Chotinauka village (1986). The parasitization and disease incidence were positively significant with pest population. Such significance was found for the data in all the six crop seasons with reference to disease whereas parasitization was significant only for three crops. The host and parasite populations sampled from Horticulture Farm (1986-87) were non-significant for correlations. There were significant correlations of the pest population in six crops with maximum and in five crops with minimum temperatures,in four

* Cabbage is cultivated as winter crop only on both the Farms of the University whereas at vill.Chotinauka two crops are grown, but to maintain uniformity only one crop was sampled at all the localities.

FIG. 28a

POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CABBAGE CROP AT KUSHALBAG FARM (1986)

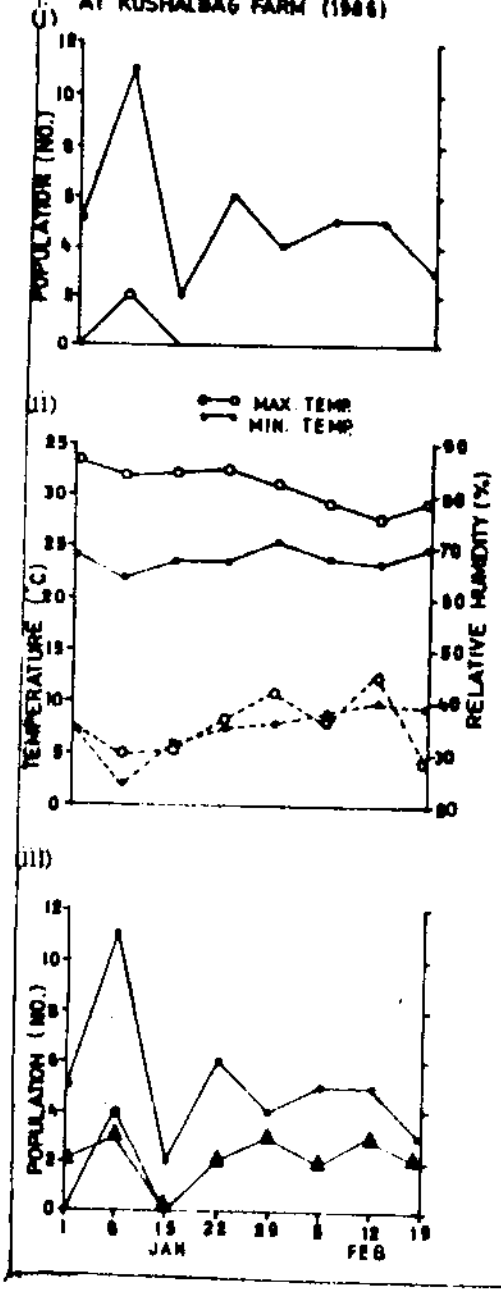


FIG. 28b

POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CABBAGE CROP AT KUSHALBAG FARM (1987)

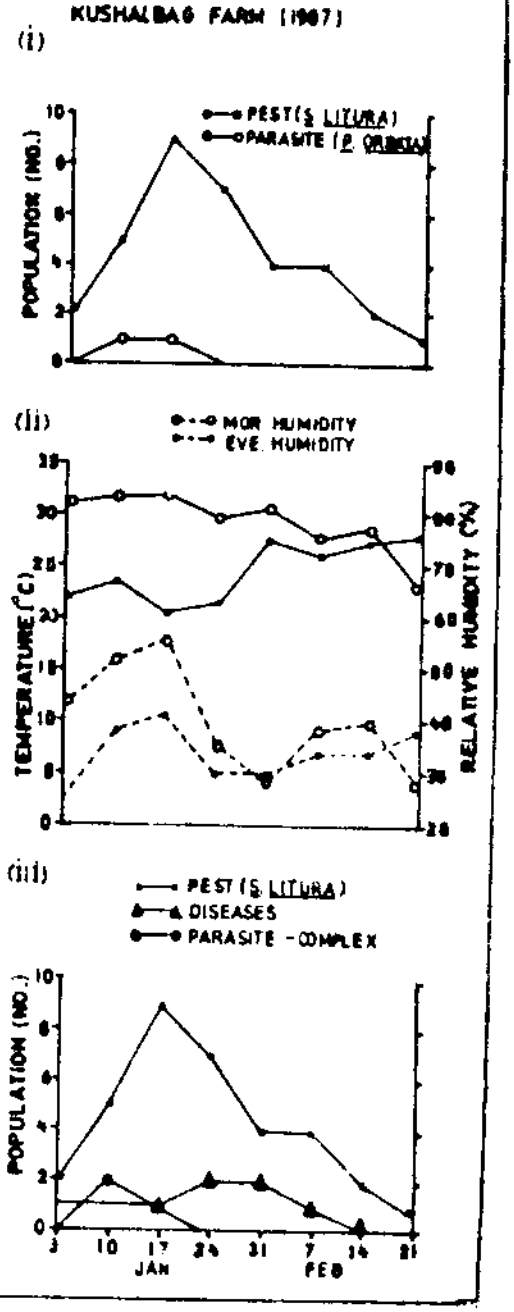


FIG 29a. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CABBAGE CROP AT VILL. CHOTINAUKA (1986)

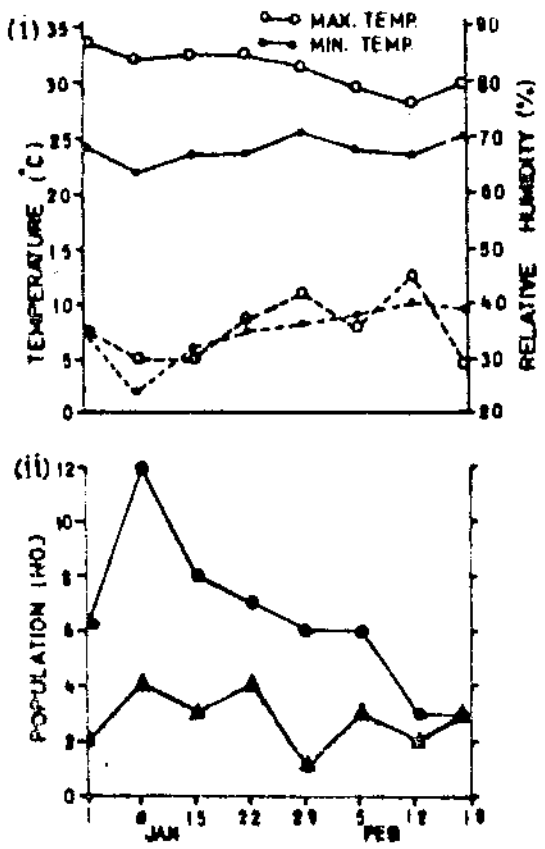


FIG 29 b. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CABBAGE CROP AT VILL. CHOTINAUKA (1987)

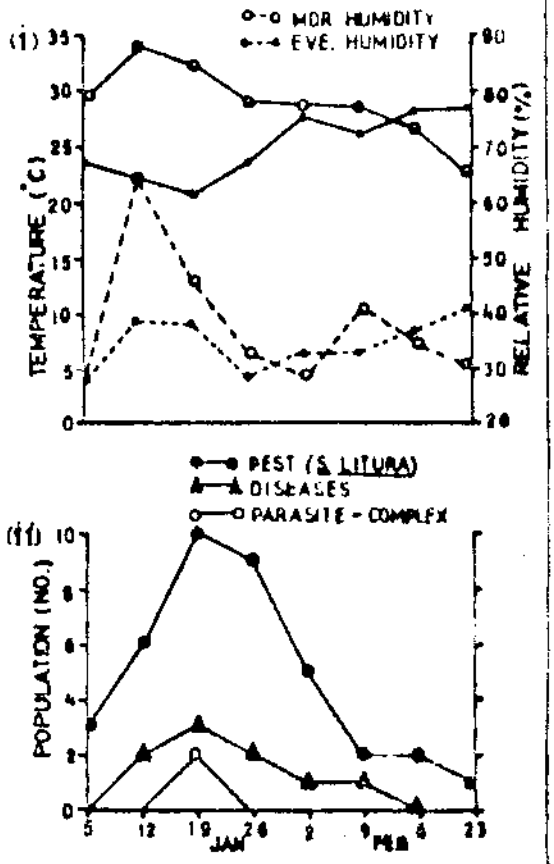


FIG. 30 a. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CABBAGE CROP AT HORTICULTURE FARM (1986)

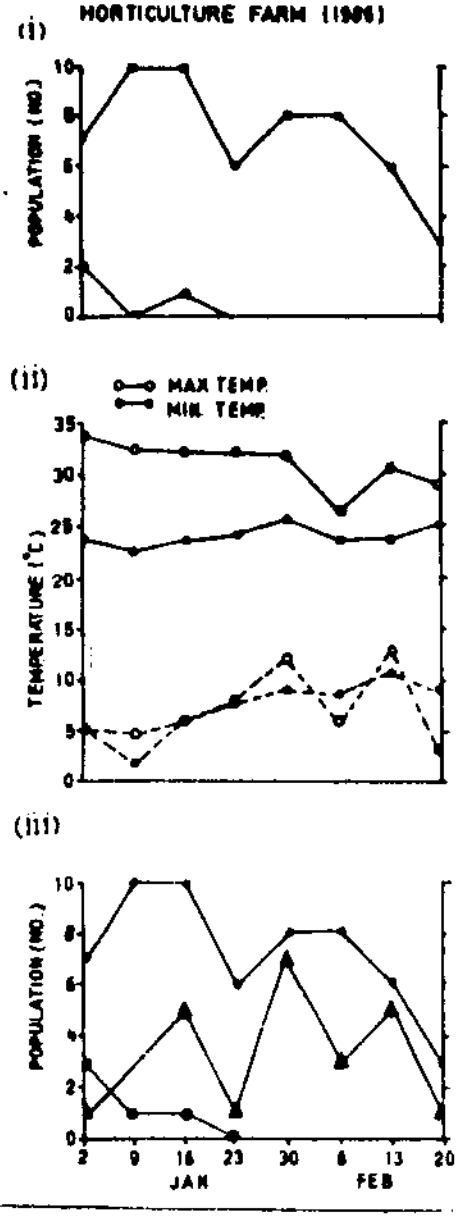
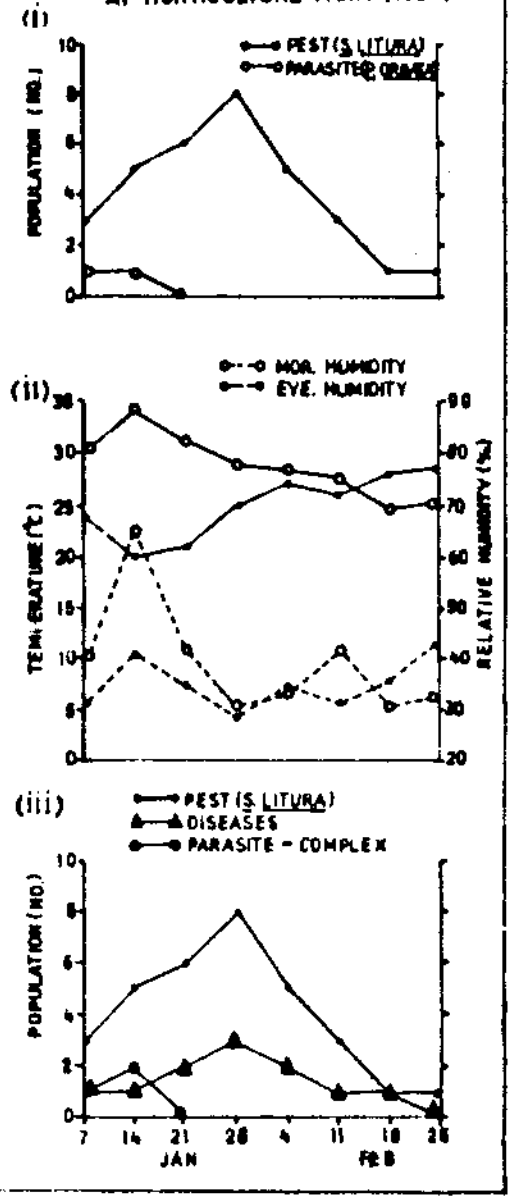


FIG. 30 b. POPULATION OF S. LITURA AND THE INTERACTING BIOTIC AND ABIOTIC FACTORS IN CABBAGE CROP AT HORTICULTURE FARM (1987)



crops with morning and in three crops with evening humidities, and with rainfall in four crops as summarised below:

Abiotic factors	Correlations	Localities (year)
Temp. (°C)		
Maximum	-	Kf, Cv, Hf (1986-87)
Minimum	+	Kf (1987)
	-	Kf, Cv, Hf (1986); Hf (1987)
R.H. (%)		
Morning	+	Cv (1986); Kf, Cv, Hf (1987)
Evening	+	Kf, Cv (1987)
	-	Cv (1986)
Rainfall (mm)	+	Kf, Cv, Hf (1987)
	-	Cv (1986)

Impact of key abiotic factors on the parasite-complex (Tables 18b - 20b, Figs. 28aii - 30biii). -

There were significant correlations of the parasite-complex in five crops, each with maximum and minimum temperatures, morning and evening humidities; and only in one crop with rainfall. In rest of the crops it was non-significantly correlated. The significant correlations are summarised below:

Abiotic factors	Correlations	Localities (year)
Temp. (°C)		
Maximum	-	Kf, Hf (1986); Kf, Cv, Hf (1987)
Minimum	+	Kf, Cv, Hf (1987)
	-	Kf, Hf (1986)
R.H. (%)		
Morning	+	Hf (1986); Kf, Cv, Hf (1987)
Evening	+	Kf, Hf (1987)
	-	Kf, Hf (1986)
Rainfall (mm)	+	Kf (1987)

Impact of P.orbata population on the pest (S.litura) population (Tables 24 -26, Figs. 28ai - 30bi).-

Correlations for the parasite populations with the pest population were worked out for five crops at all the three locations during 1986-87. However, no incidence of the parasite was recorded during 1986 at Chotinauka village. The correlations were positively significant in three crops viz., Kushalbag Farm (1986-87) and village Chotinauka (1987).

Impact of key abiotic factors on the P.orbata population (Tables 24 - 26, Figs. 28ai-30bii).-

There were significant correlations of the factors with the parasite in four crops with maximum temperature and three

Table 24

Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986-87) +

Year	Crop duration	Pest larval population	Temperature (°C)		Relative humidity (%) hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
1	2.	3	4.	5.	6.	7.	8.
1986	1.i-19.ii	0.8806**	-0.7434**	-0.8643**	0.1995	-0.4003**	-0.1429
1987	3.i-21.ii	0.6258**	-0.5412**	0.6731**	0.5256**	0.8442**	0.6547**

+ vide Appendices XXVa-b; Significant at 5 per cent *, 1 per cent **

Table 25

Correlation coefficient(r) of Peribaea orbata population with the pest population and key abiotic factors in cabbage crop at village Chotinauka, Udaipur, (1986-87)+

1.	2.	3.	4.	5.	6.	7.	8.
1986	1.i-19.ii	No parasitization recorded					
1987	5.i-23.ii	0.6295**	-0.5858**	0.3115*	0.3893**	0.2107	1.00

+ vide Appendices XXVIa-b; Significant at 5 per cent*, 1 per cent**

Table 26

Correlation coefficient (r) of Peribaea orbata population with the pest population and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (1986-87)

1.	2.	3.	4.	5.	6.	7.	8.
1986	2.i-20.ii	0.1867	-0.2022	-0.2601	0.5052**	-0.2433	-0.2037
1987	7.i-25.ii	-	-0.5808**	0.1324	0.6798**	0.7220**	-0.2182

+ vide Appendices XXVIIa-b; Significant at 5 per cent*, 1 per cent**

crops with minimum temperature; with morning and evening humidities in four and three crops respectively; and with rainfall in one crop season. These are summarised below:

Abiotic factors	Correlations	Localities (year)
Temp. (°C)		
Maximum	-	Kf (1986); Kf, Cv, Hf (1987)
Minimum	-	Kf, Cv (1987)
	-	Kf (1986)
R.H (%)		
Morning	+	Hf (1986); Kf, Cv, Hf (1987)
Evening	+	Kf, Hf (1987)
	-	Kf (1986)
Rainfall (mm)	+	Kf (1987)

Impact of key abiotic factors on the incidence of disease (Tables 18b - 20b, Figs. 28aii-30biii). -

There were significant correlations of disease (complex) with maximum and minimum temperatures in three crops each; with both morning and evening humidities in four crops each and in five crops with rainfall. These are summarised below:

Abiotic factors	Correlations	Localities (year)
Temp. (°C)		
Maximum	-	Cv (1986); Kf, Cv (1987)
Minimum	-	Cv (1986); Kf, Hf (1987)
R.H. (%)		
Morning	+	Kf, Cv, Hf (1987)
	-	Kf (1986)
Evening	+	Kf, Hf (1986); Cv (1987)
	-	Cv (1986)
Rainfall (mm)	+	Kf, Hf (1986); Cv, Hf (1987)
	-	Cv (1986)

For the cabbage crop, it may thus be concluded that the correlations between the pest population and the biotic factors were exclusively positively significant. Such significance indicated in frequency of 'significance' in percentage was found to be 60.0 per cent with parasite complex and cent per cent with diseases. The correlations with abiotic factors depicted relatively more of positive trend except that the minimum temperature which was more of negative. However, maximum temperature and morning humidity were exclusively positively correlated. The correlations of pest population with the abiotic factors, indicated in frequency of 'significance' in percentage of each factor, out of six crops was

as follows:

Maximum temperature ... 100. (postive)

Minimum temperature ... 83.33 (16.66,positive;66.66,negative)

Morning humidity ... 66.66 (positive)

Evening humidity ... 50.0 (33.33,positive;16.66,negative)

Rainfall ... 66.66(50.0,positive;16.66,negative)

The correlations of the parasite (complex) with the abiotic factors also indicated more of positive trend except that the maximum temperature was exclusively and evening humidity was mostly negatively correlated. The correlations of the parasites with the abiotic factors, indicated in frequency of 'significance' in percentage of each factor, out of five crops was as follows:

Maximum temperature ... 100.0 (negative)

Minimum temperature ... 100.0(60.0,positive;40.0,negative)

Morning humidity ... 100.0(80.0,positive)

Evening humidity ... 100.0(40.0,positive,60.0,negative)

Rainfall ... 20.0 (positive)

The correlations of the diseases with the abiotic factors, indicated in frequency of 'significance' in percentage of each factor, out of six crops was as follows:

Maximum temperature ... 50.0 (negative)

Minimum temperature ... 50.0 (negative)

Morning humidity ... 66.66 (50.0, positive; 16.66, negative)

Evening humidity ... 66.66 (50.0, positive; 16.66, negative)

Rainfall ... 83.33 (66.66, positive; 16.66, negative)

There were significant positive correlations between the P.orbata populations, and morning humidity and rainfall whereas negative correlation existed with maximum temperature. However, the response was negative as well as positive with minimum temperature and evening humidity. Correlations between the P. orbata population and the pest population was positively significant to the extent of 60.0 per cent.

The correlations of P.orbata population with the abiotic factors indicated in frequency of 'significance' in percentage of each factor was as follows:

Maximum temperature ... 80.0 (negative)

Minimum temperature ... 60.0 (40.0, positive; 20.0 negative)

Morning humidity .... 80.0 (positive)

Evening humidity ... 60.0 (40.0, positive; 20.0, negative)

Rainfall ... 20.0 (positive)

Efficacy of insecticides against S.litura vis-a-vis safety to the parasites

T.chilonis

The present laboratory trials were conducted to study

the effect of four insecticides on the emergence of the egg parasite, Trichogramma chilonis parasitizing S.litura eggs. The insecticides (lower and higher doses) included were endosulfan, monocrotophos and phosalone in concentrations of 0.05 and 0.025 per cent and fenvalerate in 0.005 and 0.0025 per cent.

The data have revealed that the emergence of parasites in control was significantly higher as compared to that in the treated eggs (Tables 27a,b). However, the developing stages of the parasite-consequent to the exposure of parasitized host eggs to insecticidal treatments-responded differently in adult emergence subject to insecticides/ doses/age-intervals.

Emergence vis-a-vis period x treatments (Table 27a).-

It was noticed that maximum mean emergence commenced after 7 and 4 days of post parasitization following insecticidal treatments, and was comparably at par (statistically no significant difference among both the treatments). Next in descending sequence of emergence were the eggs treated after 0, 1, 8, 6,2,5 and 3 days of parasitization. Relatively higher emergence after 4 and 7 days of pest parasitization following treatment may be attributed to the mid-larval and mid-pupal stages. The mean data pertaining to emergence was the lowest after 3 days. This

Table 27 a

Toxicity of insecticidal treatments to the emergence of Trichogramma chilonis from eggs of Spodoptera litura (mean of three replications)

Treatments/ Concentrations (%)	Per cent emergence of adults* Period after oviposition (days)								
	0	1	2	3	4	5	6	7	8
Endosulfan									
0.05	60.0	56.7	31.6	21.6	50.0	31.6	50.0	56.7	50.0
	(50.8)	(48.8)	(34.2)	(27.7)	(45.0)	(34.2)	(45.0)	(48.8)	(45.0)
0.025	90.4	85.2	51.7	31.6	76.7	51.7	76.7	95.2	75.1
	(71.9)	(67.4)	(45.9)	(34.2)	(61.1)	(45.9)	(61.1)	(67.4)	(60.1)
Monocrotophos									
0.05	31.6	40.0	0.01	0.01	41.7	0.01	0.01	53.3	11.6
	(34.2)	(39.2)	(0.57)	(0.57)	(40.2)	(0.57)	(0.57)	(46.9)	(19.9)
0.025	68.3	71.7	0.01	0.01	73.3	0.01	0.01	80.1	13.2
	(55.8)	(57.9)	(0.57)	(0.57)	(58.9)	(0.57)	(0.57)	(63.5)	(21.3)
Phosalone									
0.05	46.7	46.7	48.3	46.7	46.7	45.0	45.0	29.9	16.6
	(43.1)	(43.1)	(44.0)	(43.1)	(43.1)	(42.1)	(42.1)	(33.2)	(24.0)
0.025	56.7	53.3	58.3	51.7	70.1	56.7	50.0	58.3	21.6
	(48.8)	(46.9)	(49.8)	(45.9)	(56.8)	(48.8)	(45.0)	(49.8)	(27.7)

Contd. Table 27 a

	0	1	2	3	4	5	6	7.	8
Fenvalerate									
0.005	0.01	0.01	0.01	0.01	18.2	0.01	0.01	21.6	16.6
	(0.57)	(0.57)	(0.57)	(0.57)	(25.3)	(0.57)	(0.57)	(27.7)	(24.0)
0.0025	11.6	8.2	0.01	0.01	20.0	0.01	0.01	31.6	8.2
	(19.9)	(16.6)	(0.57)	(0.57)	(26.6)	(0.57)	(0.57)	(34.2)	(16.6)
Control	97.6	97.6	99.3	99.9	99.3	99.3	99.9	97.6	99.9
	(81.2)	(81.2)	(85.3)	(89.4)	(85.3)	(85.3)	(89.4)	(81.2)	(89.4)
Mean	50.2	49.3	23.6	19.9	58.0	23.1	27.5	59.2	35.3
	(45.1)	(44.6)	(29.1)	(26.5)	(49.6)	(28.7)	(31.7)	(50.3)	(36.4)
Control Mean	99.3	(85.3)							

	S.Em	C.D.	
		1%	5%
Periods	0.40	1.13	1.48
Periods x treatment	1.22	3.39	4.44

Cv = 5.5729 (%)

* Figures in parenthesis are angular values, outside are their corresponding back transformations.

Table 27 b

Interaction of insecticides and doses on the emergence of *T. chilonis*

Doses/ Insecticide	Higher	Lower	Mean
Endosulfan	45.1 (42.2)	70.7 (57.2)	58.2 (49.7)
Monocrotophos	12.0 (20.3)	23.3 (28.8)	17.3 (24.6)
Phosalone	40.9 (39.8)	52.8 (46.6)	46.8 (43.2)
Fenvalerate	2.4 (8.9)	5.0 (12.9)	3.6 (10.9)
Mean	21.7 (27.8)	35.2 (36.4)	
	S.Em	C.D.	
		1%	5%
Insecticides	0.29	0.80	1.05
Doses	0.20	0.56	0.74
Insecticides x doses	0.41	1.13	1.48

critical time referred to one of the most sensitive instars in the transitional stage, i.e. second instar in transformation to third instar.

The two components, viz., periods and treatments, seemed to interact in a way to produce distinctly significant maximum emergence of 90.4 per cent on account of endosulfan (0.025%, ' day) as compared to the emergence in control ranging from 97.65 to 99.99 per cent. Next in descending sequence (range, 90.40 to 68.35) were endosulfan (0.025%, 1,7 days); monocrotophos (0.025%, 7 days); endosulfan (0.025%, 4,6 days), (0.025%,8 days); monocrotophos (0.025%, 4 days,(0.025%, 1 day); phosalone (0.025%, 4 days) and monocrotophos (0.025%, 0 day). Rest of the treatments gave emergence less than 60.0 per cent. Parity amongst interacting components cited above is mentioned group-wise below:

(a) Monocrotophos (0.025 %, 7 days);endosulfan (0.025%, 4, 6 days).

(b) Endosulfan (0.025%, 4,6 days),(0.025%, 8 days).

(c) Endosulfan (0.025%, 4,6 days),(0.025%, 8 days); monocrotophos (0.025%, 4 days).

(d) Endosulfan (0.025%, 4,6 days), (0.025%, 8 days); monocrotophos (0.025%, 4 days), 0.025%, 1 day.

(e) Endosulfan (0.025%, 8 days; monocrotophos (0.025%, 4 days), (0.025%, 1 day); phosalone (0.025%, 4 days).

(f) Monocrotophos (0.025%, 4 days), (0.025%, 1 day); phosalone (0.025%, 4 days); monocrotophos (0.025%, 0 day).

Emergence vis-a-vis insecticide x doses (Table 27b).-

Presently insecticides and their doses-irrespective of the period discussed (vide supra) - depicted that endosulfan (0.025%) permitted the maximum mean emergence of 70.7 per cent. The emergence in sequential descending order was influenced serially by phosalone (0.025); endosulfan (0.05), phosalone (0.05); monocrotophos (0.025), (0.05); fenvalerate (0.0025) and (0.005).

In another situation, 'exclusive influence of insecticides' revealed that endosulfan proved to be least toxic and spared emergence of 58.2 per cent, only next to control (99.3%).

Still another situation was considered when, only the 'two doses of insecticides' were interpreted to be involved. Accordingly, the lower dose favoured maximum emergence of 35.2 per cent when the higher dose permitted only 21.7 per cent.

Conclusively, endosulfan at 0.025 per cent concentration proved least toxic whereas fenvalerate at 0.005 per cent proved most toxic, on the basis of various interactions pertaining to insecticides/doses/age-intervals discussed

above. Evidently, there is need for rethinking seriously to revise insecticidal recommendations presently in vogue to conserve and augment the natural enemies.

P.orbata

The present laboratory trials were conducted to evaluate the efficacy of insecticides against S.litura (III instar larva) and its parasite, P.orbata. The insecticides included endosulfan and phosalone said to be relatively safer against the parasites, and fenvalerate, a pyrethroid prevalently recommended commonly for pest management. Three concentrations were used in each case. Accordingly endosulfan and phosalone were used in concentrations of 0.05, 0.04 and 0.02 per cent and fenvalerate in 0.005, 0.003 and 0.002 per cent.

With reference to the pest mortality, the insecticidal treatments had proved significantly superior over control (water-spray). No mortality was recorded in control. Fenvalerate was significantly superior to other insecticides at all the concentrations except endosulfan, tested after 18 hours for its efficacy with highest concentration. Further, all the three insecticides were found to be comparable after 18 hours with lowest concentration whereas fenvalerate and endosulfan were comparable after 24 hours with all the concentrations. As seen from the table 28, fenvalerate knocked

Table 28

Effect of insecticides on the adult parasite, P. orbata along with its host larvae, (S.litura) under laboratory conditions (September - October, 1985)

Treatments/ Concentration (%)	Serial cumulative mortality (%)							
	18 hrs		24 hrs		48 hrs		72 hrs	
	Parasite	Host	Parasite	Host	Parasite	Host	Parasite	Host
1	2	3	4	5	6	7	8	9
Endosulfan								
0.02	43.3	30.0	46.6	36.6	60.1	39.8	87.0	50.0
	(41.1)	(33.2)	(43.1)	(37.2)	(50.8)	(39.1)	(68.8)	(45.0)
0.04	60.1	40.0	95.2	43.3	99.9	46.6	99.9	74.5
	(50.8)	(39.2)	(77.4)	(41.1)	(89.0)	(43.1)	(89.0)	(59.7)
0.05	87.0	63.4	99.9	70.0	99.9	73.5	99.9	95.2
	(68.8)	(52.8)	(89.0)	(56.8)	(89.0)	(59.0)	(89.0)	(77.4)
Fenvalerate								
0.002	50.0	30.0	66.7	46.6	98.6	80.7	99.9	98.6
	(45.0)	(32.2)	(54.8)	(43.1)	(83.2)	(63.9)	(89.0)	(83.2)
0.003	83.6	46.6	93.0	53.3	99.9	87.0	99.9	99.9
	(66.1)	(43.1)	(74.6)	(46.9)	(89.0)	(68.8)	(89.0)	(89.0)
0.005	90.0	50.0	98.6	70.3	99.9	90.0	99.9	99.9
	(71.6)	(45.0)	(83.2)	(57.0)	(89.0)	(71.6)	(89.0)	(89.0)

Contd. Table 28

1	2	3	4	5	6	7	8	9
Phosalone								
0.02	39.8	26.5	43.3	33.2	60.2	36.6	73.5	46.6
	(39.1)	(30.9)	(41.1)	(35.2)	(50.8)	(37.2)	(59.0)	(43.1)
0.04	53.4	30.0	56.7	36.6	73.5	50.0	95.2	66.7
	(46.9)	(33.2)	(48.8)	(37.2)	(59.0)	(45.0)	(77.1)	(54.8)
0.05	60.0	40.0	63.4	53.3	76.8	63.4	99.9	80.0
	(50.8)	(39.2)	(52.8)	(46.9)	(61.2)	(52.8)	(89.0)	(63.4)
Control	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
(Watersprayed)	(0.81)	(0.81)	(0.81)	(0.81)	(0.81)	(0.81)	(0.81)	(0.81)
S.Em ±	2.1272	1.1243	3.7918	2.0066	2.5841	2.3189	2.1486	3.3714
C.D. (P=0.05)	6.2754	3.3166	11.1860	5.9196	7.6232	6.8409	6.3385	9.9458

Each figure is an average of 3 replications.
Figures in parenthesis are angular values, outside are the corresponding back transformations. There was no mortality in control.

down upto 70.0 per cent of the pest population after 24 hours with 0.005% concentration, and more than 80.0 per cent with all the three concentrations after 48 hours. Absolute mortality incurred after 72 hours with 0.003 and 0.005 per cent concentrations.

Endosulfan was found to be the next best in efficacy, and proved inferior to phosalone only after 48 hours when used in medium (0.04%) concentration. Endosulfan and phosalone were comparable after 24 and 72 hours with lowest and middle concentrations and after 48 hours with all the three concentrations. After 48 and 72 hours it inflicted mortality to more than 70.0 per cent of the pest larvae with 0.05% and 0.04 % concentrations respectively. But after 72 hours it inflicted mortality upto 95.0 per cent with 0.05% concentration.

Phosalone was the least toxic of all the three insecticides. After 72 hours it accounted for mortality upto 46.0 per cent and 66.7 per cent with 0.02 (%) and 0.04 (%) concentrations respectively. After 48 and 72 hours, when used in highest concentrations (0.05%) it inflicted mortality upto 63.5 and 80.0 per cent respectively.

Toxicity of the insecticides, fenvalerate, endosulfan and phosalone in three concentrations each was considered against the parasite for different durations.

Fenvalerate proved significantly most toxic after 48 and 72 hours followed in sequence by endosulfan and phosalone when used in their lowest concentrations. Considering the residual toxicity at the end of 72 hours, fenvalerate, endosulfan and phosalone gave 100.0, 87.0 and 73.5 per cent mortality respectively.

When used in medium concentration, fenvalerate and endosulfan were equally effective and superior to phosalone at the end of 24, 48 and 72 hours, whereas endosulfan and phosalone were comparable after 18 hours. The residual toxicity at the end of 72 hours was 100.0 per cent with fenvalerate and endosulfan and 95.2 per cent with phosalone.

The highest concentration in case of fenvalerate and endosulfan were equally effective after 18, 24 and 48 hours and were significantly superior to phosalone. At the end of 72 hours all the insecticides were equally effective and gave 100.0 per cent kill.

The said trials of insecticidal toxicity to the pest and the parasite need to be considered for eco-ordinated management approach of pest kill together with parasite safety. Apparently, parasite individuals were spared at the end of 72 hours to the extent of about 5.0 per cent and 6.0 per cent with medium (0.04%) and low (0.02%) concentrations

of phosalone alone. Correspondingly, mortality to the pest was about 67.0 per cent and 47.0 per cent. Rejecting the concentration (0.02%) giving less than 50.0 per cent of the pest mortality, medium concentration (0.04%) of phosalone seemed to be the only alternative for use in the eco-oriented pest management with special reference to biological control.

DISCUSSION

DISCUSSION

Field survey for seasonal incidence of the pest, S. litura and associated parasites

During the present investigation, the important observations based on protracted field data, pertaining to the tobacco caterpillar (S. litura) are discussed. As a sequel to eco-oriented management strategy under specific agroecosystem, regular quantitative sample surveys were made. Observations were recorded throughout the crop seasons of cauliflower and cabbage for intensity of the pest and the related parasitic-complex. Incidence of the pest per unit area was recorded simultaneously in three locations viz., Horticulture Farm and Kushalbag Farm at the College of Agriculture, Udaipur and on Farmers field in the adjoining village Chotinauka (vide Materials and Methods).

The data (Table 12) revealed that the intensity of the pest during all the crop seasons (1985, 1986) was distinctly higher in cauliflower crop as compared to that in the cabbage crop (1986, 1987). It appears that longer season for cauliflower cultivation, i.e. two crops of cauliflower from July to December, provided conducive

monoculture environment.for the pest as is also evident from the correlations between pest population and abiotic factors. Evidently, the pest intensity in cauliflower was distinctly higher than in the single cabbage crop cultivated during December - March. Again,the intensity of the pest amongst the successive kharif and rabi cauliflower crops was invariably higher in former than during the latter. The period of peak incidence during kharif cauliflower was III week of September (115 to 342 larval count / 300 plants) while in rabi it was mostly IV week of October (20 to 80 larval count / 300 plants). The peak incidence in cabbage was II and III week of January (9 to 12 larval count / 300 plants).

Earlier observations similarly indicated that the pest generations continued incessantly throughout the year under intensive cultivation of these crops in this region. However, additional intensity peaks of the pest population were recorded during IV week of August - III week of September, II week of August/ III week of November, and IV week of September - I week of October in cauliflower,and III week of January - February, I - II week of March and II week of April in cabbage crop (Prasad, 1978; Zaz, 1982; Vijayvergia , 1986).

The biotic components were equally competitive in follow up to subjugate the pest activity. The parasites

consistently contributed to the extent of 50.0 per cent and 40.0 per cent towards pest parasitization in cauliflower and cabbage crops. The peak during kharif was shifted from I week of September to the IV week of October. Likewise, in the rabi crop the peak was mostly from I week to III week of November. The average mortality (%) in the three locations ranged from 19.3 to 20.9 per cent in cauliflower and 2.2 to 9.3 per cent in cabbage crop (Table 11). In all, the parasitic-complex locally comprised of 22 species including eight braconids, four ichneumonids, two each of sarcophagids and tachinids and one each from eulophidae, eumeridae, fannidae, phoridae, scelionidae and trichogrammatidae. Of these, ten species were recorded during present investigations, while twelve additional species, viz., Telenomus species, Apanteles flavipes, A. glomeratus, A. ruficrus, A. species (octonarius group), Diadegma species, Fannia leucostica, Megaselia species, Sarcophaga peregrina, Sarcosolomonia species, Delta maxillosa dimidiatipennis and a hyperparasite Tetrastichus species nr. glactopus were recorded earlier. The pest mortality on this account recorded earlier was to a maximum of 26.8 per cent (Prasad and Kushwaha, 1979; Zaz and Kushwaha, 1983; Vijayvergia , 1986).

The parasite component was simultaneously followed by disease. It was very evident that the microbial

pathogens (bacteria-Pseudomonas aeruginosa and Streptococcus species, fungus - Beauveria bassiana and Metarrhizium anisopliae and a virus - Nuclear polyhedrosis virus) played relatively more significant role in pest mortality. The average mortality (%) ranged from 35.7 to 46.6 in cauliflower (maximum mortality (%): kharif, 84.5, III week of October and rabi, 100.0,I week of October) and 33.3 to 41.1 in cabbage (maximum mortality (%): 100.0, III week of January, February) (Table 11). During 1985, the larval infection was upto 90.0 per cent but it was upto 100.0 per cent during 1986. The earlier reports indicated larval infection (%) in cauliflower and cabbage crops to the extent of 11.3, 28.8 during 1975-76 (Prasad, 1978), 18.9, 21.2 during 1979-81 (Zaz, 1982) and 41.5, 35.4 during 1981-83 (Vijayvergia ., 1986) respectively.

It was significant to note that both the parasitic-complex and the microbial diseases collectively killed the larval population to the extent of 75.0 and 50.0 per cent on cauliflower and cabbage crops respectively. The maximum mortality on account of both these components synchronously was during III week of September and IV week of October in cauliflower,and, II week of January and III week of February in cabbage crop.

The diagnostic symptoms of diseased larvae were

keenly observed and have been discussed earlier.

It was specifically advocated that the role of natural biotic agents in regulating the pest population was not merely host specific but also crop specific, reflecting the complicated relationship amongst the organisms in an ecosystem (Kushwaha, 1983).

Status of parasites

The only egg parasite recorded was T. chilonis which parasitized from I week of September to II week of November. Specific studies revealed that the parasitization ranged from 0.8 to 31.8 per cent when the eggs were exposed in the crop fields at staggered duration of 24, 48 and 72 hours. Maximum parasitization was 31.8 per cent after 48 hours during I week of October.

The parasite was earlier recorded at Udaipur from August to October with peak incidence of 15.0 per cent during I week of August (Zaz and Kushwaha, 1983). In another survey at Udaipur, T. chilonis along with Telenomus species parasitized upto 36.8 per cent during II week of October (Vijayvergia, 1986). It appeared in high intensity during July - September and March - May at Anand in Gujarat (Anonymous, 1987b).

Individually, P. orbata parasitized the pest to the extent of 14.1, Rogas species, 8.4, Apanteles species (vitripennis srecies - group), 8.3, Microplitis species, 2.7 Blepharella lateralis , 2.6, Charops species, 1.8, Campoletis chlorideae, 1.6, Chelonus species, 0.6, and Eriborus argenteopilosus, 0.3 per cent in cauliflower crop. In cabbage, only P. orbata and Rogas species were involved and parasitized to the extent of 6.3 and 4.9 per cent respectively.

P. orbata was earlier reported at Udaipur to parasitize S. litura in cauliflower from 14.0 to 25.0 per cent and in cabbage upto 5.0 per cent (Prasad, 1978; Zaz, 1982; Vijayvergia , 1986). The parasitization ranged from 6.5 to 8.9 at Rajahmundry in South India during October - November (Anonymous, 1983). Recently parasitization was recorded upto 24.0 per cent (Chari and Rao, 1987). At Anand in Gujarat, the parasitization was only upto 1.2 per cent (Anonymous, 1983).

The sequence of parasites based on sequential frequency in parasitization revealed that P. orbata was invariably the foremost to appear, in both the crops followed by Apanteles sp(vitripennis species-group), Rogas species, C. chlorideae, Microplitis species, Chelonus species, B. lateralis , Charops species and E. argenteopilosus. A single species of parasite is incapable of

destroying as many of a host population as is destroyed by a succession of different enemies.

Bioecology of the major parasites

T. chilonis

The eggs of S.litura parasitized by T.chilonis, characteristically turned black on the third day on account of black granules deposited on the inner surface of the chorion (Flanders, 1937; Krishnamurti, 1938; Marchal,1936; Moutia and Courtois, 1952). The endoparasite completed the life-cycle within 8 days and emerged as adults which copulated soon after. Drumming and drilling of the egg chorion was regardless of the stage of the development of the host egg (Quednau, 1960; Breniere, 1965; Klomp and Teerink, 1962). The period of oviposition, egg, larval and pupal stages were 3 minutes, 24 hours, 4 days and 2 days respectively. The adult longevity was about 3 to 4 days. Studies on biology elsewhere conducted under variable ecological situations have revealed that the duration of life-cycle was 6.8 (33.32 °C), 7 to 8 (26-28°C) and 11.9 (22.1 °C) days (Pan and Lim, 1981; Tuhan and Pawar, 1983). However, optimum temperature was reported to be 27°C (Savescu and Tien, 1972).

Since the parasite was positively phototactic, its activity increased with light intensity. Similar observations were made by Costas (1951) and Quednau (1958). The parasite interacted to host environment including light and

temperature rather than the host (Laing, 1938; Metcalfe and Breniere, 1969). Peripheral eggs were mostly preferred. Elaborate reviews by Imms (1937) and, Metcalfe and Breniere (1969) have interestingly referred to these aspects. It was earlier established that the female could distinguish parasitized eggs by the smell left by itself or other individuals (Salt, 1937). However, such response of paternal care could be lost when there were excess of Trichogramma population which resulted in superparasitism (Smith, 1916; Lund, 1938). It was speculated that this behaviouristic tendency of superparasitism could ultimately lead to low fecundity and progressive degeneration of the stocks (Breniere, 1965; Metcalfe and Breniere, 1969).

P. orbata

The tachinid, P. orbata preferred the second and third instar larvae of S. litura as a maternal instinct and possibly that these offered least resistance. Nevertheless, some of the later instars, when parasitized, survived even after issue of the maggots and could pupate normally. It was able to overcome the damage caused by the parasite and thus survived. The life-cycle was completed within 18-29 days and the freshly emerged adults got stimulated for mating after exposure to mild sunlight for 40 - 75 minutes/ day in the laboratory. The period of

mating, pre-oviposition, oviposition, endoparasitic stages, pupal, formation and pupal periods were 7.88 minutes, 4.8 days, 5.75 days, 2.42 hours and 7.18 days on an average respectively. Interestingly, sexual dimorphism was present even in pupal stage. The female tachinid was oviparous in habit and the oviposition period was 3 to 7 minutes. The adult longevity of male and female parasites was 3 and 4 days on an average respectively under the laboratory conditions. Reportedly, the longevity differed under field and laboratory conditions and was 6 - 10 days and 16 - 18 days respectively (Anonymous, 1985). Studies on biology elsewhere conducted under variable ecological conditions revealed that the duration of life-cycle was 10 - 19 days at Alexandria in Egypt (Hegazi et al.,1977) and 15 days on an average at Rajahmundry (Anonymous, 1981).

As already described the female parasite tried to locate the host larva by random wandering guided by the remains of the dead host larva and damaged plant tissues in the vicinity. But the host larva countered the attack through body movements and wandered to seek shelter under the leaves provided as food. Cleare (1939) also reported that the tachinid flies could be guided to suitable oviposition site by smell. Superparasitism resulted in development of 3 to 4 maggots from a host larva, but even 12 were noticed in a solitary case. Similar observations

have indicated emergence of 1 - 12 larvae from a single host (Anonymous, 1980; Jayanth and Nagarkatti, 1984). Multiple parasitism was also recorded, and a single host larva harboured a parasitic larva each of Apanteles species (vitripennis species-group) as well as P. orbata.

Impact of key abiotic factors on parasite population

The general trend of correlation of coefficient (r) of the parasite, P. orbata with the pest population was found to be significant and depicted the activity of the parasite as density-dependent. Correlation of coefficient in cauliflower depicted a more or less regular trend of positive with maximum temperature, and negative with minimum temperature, morning and evening humidity, and, rainfall. But in cabbage, it was erratic and irregular.

The package-range of the interacting two key abiotic components which seemed compatible for the high intensity of parasitization during sampling was: temperature, maximum 30.5 - 33.9 °C Vs minimum 19.8 - 22.1 °C Vs relative humidity (%), morning 69.9 - 82.0 Vs evening 36.0 - 51.3.

Bennet (1969) observed that normal pupal development in tachinids was impaired at low humidity and temperature.

Correlation coefficients worked out between pest population, parasite-complex and diseases separately with key abiotic factors have depicted a pattern characteristic of cauliflower and cabbage crop ecosystems. The general trend of correlation of the key abiotic factors with the pest and parasite-complex was negative while that with disease was positive in cauliflower crop. But in cabbage, it was positive pertaining to all the three components, i.e. pest, parasite-complex and disease. However, there were some exceptions of contrary trends mostly with maximum and minimum temperature (vide Experimental findings).

It is implied that the environmental factors do not interact in isolation; rather a complex of self-regulatory natural phenomenon operates under multipronged factorial interactions. The factors of environment do affect the pest activity to a great extent but it was more difficult to quantify such effect on a precise scale of influence (Williams, 1940).

Similar correlations have also been discussed for studies for the period during 1975-1983 (Prasad, 1978; Zaz, 1982; Vijayvergia , 1986).

Efficacy of insecticides against S. litura vis-a-vis safety to the parasites

T. chilonis. -

Toxic vulnerability of insecticides could vary with the developmental stages of the parasite (Croft and Brown, 1975). While evaluating the effect of four insecticides, viz., endosulfan, monocrotophos, phosalone and fenvalerate on emergence of T. chilonis from parasitized eggs of S. litura, endosulfan (0.025 %) proved to be safest and fenvalerate (0.005%) most toxic. The order of adult emergence (%) was 70.7 (endosulfan, 0.025%), 52.85 (phosalone, 0.025%), 45.10 (endosulfan, 0.05%), 40.90 (phosalone,0.05%), 23.3 (monocrotophos, 0.025%), 12.0 (monocrotophos, 0.05%), 5.0 fenvalerate (0.0025%) and 2.45 (fenvalerate, 0.005 %). Earlier studies indicated that endosulfan (0.1%) was least toxic to emergence of T. australicum (Sithanantham and Navarajan Paul, 1980). In more or less similar studies, investigations have been made on impact of endosulfan @ 0.1 per cent (Navarajan Paul et al., 1976), 0.07 per cent and 0.035 per cent (Santharam and Kumaraswami, 1985) concentrations on the survival and emergence of T. australicum, T. japonicum and T. chilonis. Maximum mean emergence commenced after 7 and 4 days of post parasitization. Relatively higher emergence at 4 and 7 days may be attributed

to the mid-larval and mid-pupal stages as also referable to earlier studies (Breniere, 1965; Sithanantham and Navarajan Paul, 1980; Srivastava and Kushwaha, 1987a). The mean data pertaining to emergence was the lowest after 3 days. This critical time referred to one of the most sensitive instars in the transitional stage, i.e. second instar in transformation to third instar. Similar observations were made by Sithanantham and Navarajan Paul (1980). The two components, viz., periods and treatments seemed to interact in a way to produce distinctly significant maximum emergence of 90.4 per cent on account of endosulfan (0.025 %) after zero days of post parasitization treatment as compared to 97.65 to 99.99 per cent emergence in control. Considering the two doses of insecticides, the lower dose favoured maximum mean emergence (35.2 %) when the higher dose permitted only 21.7 per cent. Insecticides at commonly used dosages were highly toxic to the egg parasitic wasps including T. chilonis (Mabbet, 1979; Xie et al., 1984; Santharam and Kumaraswami, 1985).

P. orbata. -

Evaluation of insecticides toxic to the pest with reference to safety of the parasite revealed that fenvalerate (0.005%) proved significantly most toxic and phosalone was the least toxic of all the insecticides. Phosalone spared the parasite species to the extent of 5.0 and 6.0

per cent with 0.04 and 0.02 per cent concentrations at the end of 72 hours. Correspondingly, the mortality of the pest was about 67.0 and 47.0 per cent. Thus Phosalone (0.04%) seemed to be the only alternative for use in the eco-oriented pest management with special reference to biological control. Yadav and Patel (1987) reported that no parasite population was recorded from fields regularly sprayed with insecticides.

SUMMARY

SUMMARY

Investigations were carried cut on the status and ecobiology of the majer insect parasites of the tobacco caterpillar, Spodoptera litura at Udaipur during 1985-87. Three locations including Horticulture Farm, Kushalbag Farm and an adjoining village Chotinauka were regularly surveyed for incidence of the pest and the related parasites in cabbage and cauliflower crops. The main objective was to develop a strategy based on ecobiological management of the pest.

1. The pest intensity in cauliflower crop was distinctly higher with peak incidence of 342 larval count/ sample unit than the cabbage crop with 12 larval count / sample unit.

2. The parasitic-complex of S. litura (maximum parasitization %) comprised of ten species, viz., Trichogramma chilonis (31.8 %), Peribaea orbata (14.1%), Rogas species (8.4%), Apanteles species (vitripennis species-group) (8.3%), Microplitis species (2.7%), Blepharella lateralis (2.6%), Charops species (1.8%), Campoletis chlorideae (1.6%), Chelonus species (0.6%) and Eriborus sp.? argenteopilosus

(0.3%) in cauliflower crop. Whereas in cabbage, only P. orbata and Rogas species, were found parasitizing the pest to the extent of 6.3 and 4.9 per cent respectively. The sequence of parasites based on sequential frequency in parasitization revealed that P. orbata was invariably the foremost to appear, in both the crops.

The average parasitization (%) in the three locations ranged from 19.3 to 20.9 per cent in cauliflower and 2.2 to 9.3 per cent in cabbage crop.

3. The average mortality (%) on account of entomopathogens (bacteria-Pseudomonas aeruginosa and Streptococcus species, fungus- Beauveria bassiana and Metarrhizium anisopliae, and, a virus - Nuclear polyhedrosis virus) ranged from 35.7 to 46.6 in cauliflower and 33.3 to 41.1 in cabbage.

It was significant to note that both, the parasitic-complex and the microbial diseases collectively killed the larval population to the extent of 75.0 and 50.0 per cent on cauliflower and cabbage crops respectively.

4. Trichogramma chilonis completed its life-cycle within 8 days during the months of September - October. Life-cycle of the tachinid, Peribaea orbata was completed in about 15 to 25 days during September - October.

5. The general trend of correlation of coefficient (r) of the parasite, P. orbata in cauliflower depicted a more or less regular trend of positive with maximum temperature; and negative with minimum temperature, morning and evening humidity, and, rainfall. But in cabbage, it was erratic and irregular.

6. The general trend of correlation of the key abiotic factors with the pest and parasite-complex was negative while that with disease was positive in cauliflower crop. But in cabbage it was positive pertaining to all the three components, i.e. pest, parasite-complex and disease.

7. While evaluating the effect of four insecticides on emergence of T. chilonis consequent to the exposure of parasitized host eggs, the order of adult emergence (%) was 70.7 (endosulfan, 0.025 %), 52.85 (phosalone, 0.025 %), 45.1 (endosulfan, 0.05%), 40.9 (phosalone, 0.05%), 23.3 (monocrotophos, 0.025%), 12.0 (monocrotophos, 0.05%), 5.0 (fenvalerate, 0.0025%) and 2.45 (fenvalerate, 0.005%).

8. Evaluation of insecticides toxic to the pest with reference to safety of the parasite, P. orbata revealed phosalone (0.04 %) to be the safest.

REFERENCES

REFERENCES

Anantanarayanan, K.P. 1934. On the bionomics of a Eulophid (Trichospilus pupivora, Ferr.) a natural enemy of the coconut caterpillar (Nephantis serinopa, Meyr.) in South India. Bull. ent. Res. 25: 343-8.

Anonymous. 1913. Mededeelingen Van het Deli Proefstation. Jahrgang 8: 129-46.

Anonymous. 1980. Annual Report on All India Coordinated Research Project on Biological Control of Crop Pests and Weeds, I.I.H.R. Bangalore, India.

Anonymous. 1981. Annual Report, All India Coordinated Research Project on Biological Control of Crop Pests and Weeds. (April 1980 to March 1981), I.I.H.R. Bangalore, India.

Anonymous. 1983. Research reports of work under All India Coordinated Research Project on Biological Control of Crop Pests and Weeds. Fourth All India Workshop on Biological Control, 22-24 February, Bangalore, India.

Anonymous. 1985. Annual Report on All India Coordinated Research Project on Biological Control of Crop Pests and Weeds (13-16 September, 1985), I.I.H.R. Bangalore, India.

Anonymous. 1987a. Annual Report on All India Coordinated Research Project on Biological Control of Crop Pests and Weeds. Jan, 1986 to Dec. 1986, I.I.H.R. Bangalore, India.

Anonymous. 1987b. Biannual Report (1985-87) on All India Coordinated Research Project on Biological Control of Crop Pests and Weeds. I.I.H.R. Bangalore, India.

Ashley, T.R., Gonzalez, D. and Leigh, T.F. 1973. Reduction in effectiveness of laboratory-reared Trichogramma. Environ. Entomol. 2: 1069-1073.

Ayyar, T.V.R. 1927. The parasitic hymenoptera of economic importance noted from South India. Bull. ent.Res. 18: 73.

Balasubramanian, G. 1983. The tobacco cutworm, Spodoptera litura Fabricius - Ecology, food utilization and the effect of insecticides. Ph.D. Thesis, Tamil Nadu Agric. Univ., Coimbatore.

Bartlett, M.S. 1947. The use of transformations. Biometrics 3: 39-52.

Basu, A.C. 1943. Effect of different foods on the larval and post-larval development of the moth Prodenia litura Fb. (Lepidoptera: Noctuidae) J. Bombay nat.Hist.Soc. 44: 275-88.

Basu, A.C. 1945. Life history and bionomics of the cauliflower pest, Prodenia litura F. in Bengal. Sci. & Cult, 10: 420-22.

Battu, G.S. 1977. Occurrence of Parasarcophaga misera (Walker) and Campoletis sp. as parasites of Spodoptera litura (Fabricius) from India. Curr. Sci. 46:568-9.

Bennet, D. Fred. 1969. Tachinid flies as biological control agents for Sugarcane Moth borers, 119-148. (In) Pests of Sugarcane (eds.) J.R. Williams, J.R.Metcalfe, R.W. Mungomery and R. Mathes. Elsevier Publishing Company, Amsterdam-London-New York.

Bhatnagar, S.P. 1948. Studies on Apanteles Forester (Vipionidae: Parasitic Hymenoptera) from India. Ind. J.Ent. 10: 133-203.

Bishara, I. 1934. The cutworm, Prodenia litura F. in Egypt. Bull. Soc. ent. Egypte 18 : 288-420.

Box,H.E. 1933. Further observations on Sugarcane moth borers (Diatraea spp.) in St. Lucia. Introduction of the Cuban parasite, Lixophaga diatraea Townsend.Report upon a visit to St. Lucia August-September 1933. Castries, St. Lucia Govt. Print Office. 10 pp.

Box, H.E. 1952. Investigaciones sobre los teladradores de la cana de azucar, Diatraea spp. en. Venezuela. Informe del progressa durante, 1947-49. Boln tec. Inst. nac. Agric. Venez. 3, 39 pp.

Box, H.E. 1956. The biological control of moth-borers (Diatraea) in Venezuela. Battle against Venezuela's cane borer. Sugar, N.Y. 51 (5): 25-27, 30,45; (6): 34-36, 57; (7): 30-34.

Braune, H.J. 1980. Field studies on taro cluster caterpillar. Alafua agric. Bull 5: 42-6.

Breniere, J. 1965. Les Trichogrammes parasites de Procerasi sacchariphagus Boj borer de la canne a 'sucre:a' Madagascar. III. Realisation de l' e' leavage massal du parasite. Entomophaga 10: 119-31.

Chari, M.S. and Rao,R.S.N. 1987. Biological control of tobacco pests. 121-126. Proc. First National Seminar-cum-Sixth Workshop of Biological Control of Crop Pests and Weeds. June 29 -July 2, 1987. Gujarat Agricultural University, Anand.

Chelliah, S. and Natarajan, N. 1985. The tobacco cutworm, Spodoptera litura F. - Problems and Prospects of Management. (In) Integrated Pest and Disease Management (ed.) S. Jayaraj Tamil Nadu Agric. Univ., Coimbatore, pp. 139-149.

Cherian, M.C. 1930. Life history notes on Microbracon serinopae Ramskr. (M.S.) - A parasite of Nephantis serinopa. Yb. Dept. Agric. Madras, 1928, pp. 12-22.

Chiu, S.C. and Chou, L.Y. 1976. Hymenopterous parasitoids of Spodoptera litura Fab. J. agric. Res. China 25: 227-41.

Chu, Jao-Tso and Yung-hsi, Hu. 1937. Biological studies of Trichogramma evanescens Westwood (Hymenoptera: Trichogrammatidae). Yb. Bur. Ent. Chekiang Prov. 5: 164-77.

Clausen, C.P. 1940. Entomophagous insects. McGraw Hill. New York, 688pp.

Cleare, L.D. 1939. The Amazon fly (Metagonistylum minense Towns.) in British Guiana. Bull ent. Res. 30: 85-102.

Costas, L.A. 1951. The effect of varying conditions on oviposition by Trichogramma on eggs of Angoumois grain moths. J. econ. Ent. 34: 57-58.

Croft, B.A. and Brown, A.W.A. 1975. Responses of arthropod natural enemies to insecticides. Ann. Rev. Entomol. 20: 285-335.

Crosskey, R.W. 1966. New generic and specific synonymy in Australian Tachinidae (Diptera). Proc. R.Entomol. Soc. London (B) 35 (7-8): 95-104.

Crosskey, R.W. 1973. A conspectus of the Tachinidae (Diptera) of Australia, including keys to the supraspecific taxa and taxonomic and host catalogoues. Bulletin of the British Museum (Natural History) Entomology, Suppl. 21, 221 pp.

David, H. 1987. Biological control of Sugarcane Pests. 63-68. Proc. First National Seminar-cum-Sixth Workshop of Biological Control of Crop Pests and Weeds. June 29 - July 2, 1987. Gujarat Agricultural University, Anand.

David, H. and Easwaramoorthy, S. 1986. Biological control. (In) Sugarcane Entomology in India (eds.) H.David, S. Easwaramoorthy and R. Jayanthi. Sugarcane Breeding Institute, I.C.A.R., Coimbatore, pp.383-421.

Desaeger, H. 1942. Apanteles risbeci sp. n. from larvae of Prodenia litura F. Revue Zool. Bot. afr. 36:61-3.

Fabritius, K. and Hassan, S.A. 1984. Recommendations for gathering biological data on parasitic Hymenoptera on index cards. Z.ang. Ent. 97(5): 425-430.

Flanders, S.E. 1937. Notes on the life-history and anatomy of Trichogramma. Ann. ent. Soc. Am. 30: 304-308.

Fletcher, T.B. 1914. Some south Indian insects. Madras Govt. Press, pp.565.

Fletcher, T.B. 1932. Report of the imperial entomologist. Scient. Rep. imp. Inst. agric. pp.87-92.

Gahan, A.B. 1925. Interesting records of the little known parasitic Hymenoptera. Proc. Ent. Soc. Wash.27:188.

Goco, A. 1921. Rice pests. Philipp. agric. Rev. 14: 57-62.

Gupta, Meera, Rao, P.P. and Pawar, A.D. 1987. Role of parasites and predators in rice ecosystem. National Symposium on Integrated Pest Control - Progress and Perspectives, Oct. 15-17, 1987. Trivandrum (Abstract, p.20).

Hafez, M. 1951. Notes on the introduction and biology of Microplitis demolitor Wilk. (Hymenoptera: Braconidae). Bull. Soc. Fouad.Lor.Ent. 35:107-21.

Healy, M.J.R. 1962. Some basic statistical techniques in soil zoology. (In) Murph, P.W. (ed.), Progress in soil zoology: 3-9.

Hegazi, E.M., Hammad, S.M. & El-Minshawy, A .M . 1977. Field and laboratory observations on the parasitoids of Spodoptera littoralis (Boisd.) (Lepidoptera: Noctuidae) in Alexandria. Z. ang. Ent. 84(3)316-321.

Hoyt, C.P. 1955. Notes on Larvaevorid-flies reared from Prodenia litura Fab. and Othreis fullonia (Clerck) larvae in American Samoa. Proc. Hawaii ent. Soc. 15: 419-21.

Huffaker, C.B. 1977. Augmentation of Natural Enemies in the People's Republic of China. 329-339. (In) Biological control by Augmentation of Natural Enemies (eds.) R.L. Ridgway and S.B. Vinson. Plenum Press, New York-London, 480 pp.

Hutson, J.C. 1939. Report on the work of the entomological division. Ceylon Adm. Rep. Agric. 1937 pp.37-42.

Imms, A.D. 1937. Recent advances in entomology. J & A, Churchill Ltd., London, 431 pp.

Ishii, Tei. 1941. The species of Trichogramma in Japan with descriptions of two new species Kontyu 14: 169-176.

Janisch, E. 1930. Experimental investigations on the effects of environmental factors on insects. II. The outbreak of Prodenia litura in Egypt. Z.Morph. Okol. Tiere 17: 339-46.

Jayanth, K.P. and Nagarkatti, S. 1984. Record of true parasitism in Peribaea orbata (Wied.) (Diptera: Tachinidae). Entomon 9(1) 77-78.

Jayaraj, S. 1985. Biological suppression of insect pests through the use of entomopathogens, 319-331. (In) Integrated Pest and Disease Management, Proceedings of the National Seminar (ed.) S. Jayaraj. Coimbatore, India, 433pp.

Jayaraj, S. and Santharam, G. 1985. Ecology based integrated control of Spodoptera litura (F.) on cotton. 256-64. (In) Microbial Control and Pest Management (ed.)S. Jayaraj. Tamil Nadu Agric. Univ., Coimbatore, pp.256-64.

Joshi, B.G., Sitaramaiah, S. Satyanarayama, S.V.V. and Ramaprasad, G. 1979. Note on natural enemies of Spodoptera litura (F.) and Myzus persicae(Sulz) on flue cured tobacco in Andhra Pradesh.Sci. & Cult. 45: 251-52.

Kamal, M. 1951. The biological control of the cotton leafworm (Prodenia litura F.) in Egypt. Bull.Soc. Fouad. I. Ent. 35: 221-70.

King, E.G., Powell, J.E. and Smith, J.W. 1982. Prospects for utilization of parasites and predators for management of Heliothis spp. 102-122. (In) Proceedings International Workshop on Heliothis Management 15-20 November,1981, ICRISAT, Patancheru A.P., India.

Klomp, H. and Teerink, B.J. 1962. Host selection and number of eggs per oviposition in the egg parasite Trichogramma embryophagum Htg. Nature, Lond.195: 1020-1021.

Krishnamurti, B.S.C. 1938. A microscopical study of the development of Trichogramma minutum Riley (the egg parasite of the sugar cane borers in Mysore). Proc. Indian Acad. Sci. 7: 36-45.

Krishnamoorthy, A. and Mani, M. 1985. Investigations on Telenomus remus Nixon and Apanteles marginiventris Cress. against Spodoptera litura (F.) on cabbage. Entomon 10: 277-80

Krishnamurthy, B. and Usman, S. 1954. Some insect parasites of economic importance noted in Mysore State. Indian J. Ent. 16: 327-44.

Krishnamurthy Rao, B.H., Subbaratnam, G.V. and Murthy, K.S.R.K. 1983. Losses due to insect pests in Andhra Pradesh. (In) Crop losses due to insect pests (Special issue Indian J. Ent. 1983) E.S.I. Hyderabad, India, pp.2-15.

Kushwaha, K.S. 1983. Shifting priorities in plant protection. Indian J. Ent. 45(1): 96-99.

Laing, J. 1938. Host finding by insect parasites.II. The chance of Trichogramma evanescens finding its hosts. J. exp. Biol. 15: 281-302.

Lever, R.J.A.W. 1935. Some insect pests of local economic plants. Brit. Solomon Is. agric. Gaz. 3:3-5.

Lever, R.J.A.W. 1943. The cutworm, Prodenia litura Fabr. Agric. J. Fiji 14: 11-3

Lever, R.J.A.W. 1944. Entomological notes. Agric. J.Dep. Agric. Fiji 15: 45-50.

Li, L.Y. 1982. Trichogramma sp. and their utilization in People's Republic of China, 23-29. (In) Les trichogrammes. Ier Symposium International, Antibes 20-23 avril 1982 Paris, France.

Lingren, P.D. 1969. Approaches to the management of Heliothis spp. in cotton with Trichogramma spp. pp.207-217. Proceedings, Tall Timbers Conference on Ecological Animal Control by Habitat Management. 26-29 Feb. 1969, Tallahassee, Fla, U.S.A.

Liu, W.H. and Wu, Z.X 1982. Recent results in rearing Trichogramma in vitro with artificial media devoid of insect additives. Acta Entomologica Sincia 25 (2): 160-163.

Lund, H.O. 1938. Studies on longevity and productivity in Trichogramma evanescens J. agric, Res. 56:421-39.

Mabbet, T.H. 1979. A review of the economic insect pests of cotton in Thailand. Description infestation and control. Bangkok, Thailand; Cotton pests Research Branch, Department of Agriculture, 80 pp.

Maheswara Reddy, A. 1982. Studies on the biology, ecology and control of tobacco cutworm, Spodoptera litura Fabricius (Noctuidae: Lepidoptera). M.Sc.(Ag.) Thesis, Tamil Nadu Agric. Univ., Coimbatore.

Manolache, C. and Tien, N. 1973. Contributions to the morphology of two species of Trichogramma: Trichogramma evanescens Westw. and Trichogramma chilonis Ishii (Hymenoptera-Trichogrammatidae) and results of releasing them in field for the control of the corn borer (Ostrinia nubilalis Hubn.) Analele Institueui de cercetari pentru. Protectia Plantelor 9: 349-361.

Marchal, P. 1936. Les Trichogrammes. Annls.Epiphyt. 2: 447-513.

Mason, C. 1915. Report of the Entomologist for the year ending 31st March, 1915. Dept. Agric., Nyassaland Protectorate Zomba, Nyassaland, 29th April 1975, p.16.

Mesnil, L.P. 1963. Larvaevorinae (Tachinidae). 801-48, Lieferung 235. (In) Lindner, Die Fliegen der palaearktischen Region. Vol. 64g.

Metcalfe, J.R. and Breniere, J. 1969. Egg Parasites (Trichogramma spp.) for Control of Sugar Cane Moth Borers. 81-115. (In) Pests of Sugar Cane (eds.) J.R.Williams, J.R. Metcalfe, R.W. Mungomery, R. Mathes. Elsevier Publishing Company, Amsterdam-London-New York.

Miller, N.C.E. 1933. Insect pests of tobacco in Malaya. Malayan agric. J. 21: 66-72.

Mohasin, M.D. and Som Choudhary, A.K. 1987. Response of two strains of Trichogramma chilonis Ishii to humidity and insecticidal treatment. National Symposium on Integrated Pest Control - Progress and Perspectives, October 15-17, 1987. Trivandrum (Abstract, p.36).

Moussa, M.A., Zaher, M.A. and Kotby, F. 1960. Abundance of cotton leafworm, Prodenia litura (F.) in relation to host plants and their effect on biology (Lepidoptera: Noctuidae). Bull. Soc. Ent.Egypte 44: 241-51.

Moutia, A. 1955. Entomological Division. Rep. Dep. Agric. Maurit. 1934, pp.25-26.

Moutia, L.A. and Courtois, C.M. 1952. Parasites of the moth borers of sugar cane in Mauritius. Bull. ent.Res. 43: 325-359.

Nagarkatti, Sudha, 1973. A note on egg parasitism of Agrius convolvuli (L) in Karnataka. Tech.Bull. Commonw. Inst. Biol. Control 16: 23-28.

Nagarkatti, S. 1979. Experimental comparison of laboratory-reared vs. wild-type Trichogramma chilonis (Hym: Trichogrammatidae). II.Tolerance of non-optimal temperatures. Entomophaga, 24 (4): 417-421.

Nagarkatti, S. 1982. The utilization of biological control in Heliothis management in India. 156-67. (In) Proceedings International Workshop on Heliothis Management 15-20 November 1981, ICRISAT, Patancheru, A.P., India.

Nagarkatti, Sudha and Nagaraja, H. 1971. Redescriptions of some known species of Trichogramma, showing the importance of the male genitalia as a diagnostic character. Bull. ent. Res. 61: 13-31.

Nagarkatti, Sudha and Nagaraja, H. 1977. Biosystematics of Trichogramma and Trichogrammatoidea species. Ann. Rev. Ent. 22: 157-176.

Nagarkatti, Sudha and Nagaraja, H. 1978. Experimental comparison of laboratory-reared vs wild-type Trichogramma confusum Vigg. (Hym.: Trichogrammatidae). I. Fertility, fecundity and longevity. Entomophaga 23 (2) :129-136.

Nagarkatti, S. and Nagaraja, H. 1979. The status of Trichogramma chilonis Ishii (Hym.: Trichogrammatidae). Oriental Insects. 13 (1-2): 115-118.

Narendran, T.C. and Joseph, K.J. 1977. Studies on some aspects of host-specificity with reference to Brachymeria lasus Walker, a polyphagous Chalcid parasite of Lepidopterous insects. (In) Insects and Host Specificity. The Macmillan Co. of India Ltd.

Nasr, El-Sayed Abdel-Naby. 1961. Abundance of the early stages and adults of Prodenia litura (F.) in berseem field (Lepidoptera: Noctuidae). Bull.Soc. ent. Egypte 45: 229-32.

Nasr, E.S.A., El-Rafie K.,Hosny, M.M. and Badawi, A. 1973. Effect of type and pH of soil on the pupal stage and rate of moth emergence of the cotton leaf-worm, Spodoptera littoralis (Boisd.) (Lepidoptera: Noctuidae). Bull.Soc. ent. Egypte 57:299-302.

Navarajan Paul, A.V., Dass, R. and Parshad, B. 1981. Influence of different hosts on parasitism by Trichogramma chilonis Ishii and T.exiguum Pinto and Platner (Hymenoptera: Trichogrammatidae). Z.ang. Ent. 92(2):160-164.

Navarajan Paul, A.V.,Mohanasundaram, M. and Subramanian, T.R. 1976. Effect of insecticides on the survival and emergence of the egg parasite, Trichogramma spp. Madras agric. J. 63: 557-60.

Pan, Y.C. and Lim, G.T. 1981. The biological control of sugarcane borers in Gula Perak plantation, Malaysia. Malaysian Journal of Agriculture, 52 (2): 129-134.

Pandey, S.N. 1970. Ecological Studies on Prodenia litura Fabricius (Lepidoptera: Noctuidae). Ph.D. Thesis, Univ. of Udaipur, Udaipur, India.

Pandey, S.N. 1976. Ecological studies on Spodoptera litura (F.).II. Outbreak. Indian J. Ent. 38(2): 160-66.

Patel, J.C. and Patel, R.C. 1971. Studies on the biology of Chelonus heliopae Gupta, an egg-larval parasite of Spodoptera litura (F.) Indian J. Ent.33:50-54.

Patel, R.C., Patel, J.C. and Patel, J.K. 1971. New records of parasites of Spodoptera exigua (Hb.) and Spodoptera litura F. from Gujarat. Indian J.Ent. 33:92-3.

Patel, R.C., Patel, J.C. and Patel, J.K. 1973. Biology and mass breeding of the tobacco caterpillar, Spodoptera litura (F.). Israel J.Ent. 8:131-42.

Patil, B.V. and Devaiah, M.C. 1978. Seasonal activity of five Lepidopterous pests as indicated by a mercury bulb light trap. Bull. Ent. 19:211-21.

Peacock, A.D. 1913. Entomological pests and problems of Southern Nigeria. Bull. ent. Res. 4: 191-220.

Pradyumn, Kumar and Ballal Chandish, R. 1987. Suitability of laboratory hosts for the mass-rearing of Chelonus blackburni Cameron (Hym.:Braconidae). First National Seminar on Biological Suppression of Crop Pests and Weeds. June 29, 1987. Gujarat Agricultural University, Anand (Abst. p.1).

Prasad, J. 1978. Survey and evaluation of the effectiveness of pathogens and parasitic fauna of the tobacco caterpillar, Spodoptera litura (Fabricius) (Lepidoptera: Noctuidae).Ph. D. Thesis, Sukhadia University, Udaipur.

Prasad, J. and Bhattacharya, A.K. 1975. Growth and development of Spodoptera littoralis (Boisd.) on several plants. Z. ang. Ent. 79:34-48.

Prasad, J. and Kushwaha, K.S. 1979. Survey and evaluation of the effectiveness of pathogen and parasitic fauna of tabacco caterpillar, Spodoptera litura (F.) (Lepidoptera: Noctuidae). Univ. U. Res. J. 15:123-29.

Pu, T.S., Liu, Z.J. and Zhang, Y. X. 1981. On the habits of Trichogramma confusum Viggiani (T. chilonis Ishii) and Trichogramma dendrolimi Matsmura. Natural Enemies of Insects 3(3): 6-9.

Quednau, W. 1958. Uber einige Orientierungsweisen des Epiparasiten Trichogramma (Hym., Chalcididae) auf grund von Licht and Schwerereizen. Anz. Schadlingsk. 31: 83-85.

Quednau, W. 1960. Uber die Idertitat der Trichogramma - Arten und einiger ihrer Okotypen (Hymenoptera, Chalcidoidea, Trichogrammatidae). - Das Trichogramma-problem. Mitt. Biol. Bundesanstalt. 100:11-50.

Rai, P.S. 1974. Record of Chelonus formosanus Sonan. (Hymenoptera: Braconidae), a parasite of Spodoptera litura (Fabricius) from Mysore State. Curr. Sci. 43: 30.

Rajendram, G.F. and Hagen, K.S. 1974. Trichogramma oviposition into artificial substrates. Environ. Entomol. 3: 399-401.

Rao, B.N. and Patel, R.C. 1974. Bionomics of Chelonus formosanus Sonan, an egg-larval parasite of Spodoptera litura (F.) Indian J.Ent.36:105-09.

Rao, S.N. and Kuriyan, C. 1950. Description of eleven new, and records of fifteen known species of Ichneumonidae (Hymenoptera: Parasitica) from India. Indian J. Ent. 12: 167-90.

Rao, R.S.N., Satyanarayana, S.V.V. and Soundarrajan, V. 1981. Note on new additions to the natural enemies of Spodoptera litura F. and Myzus persicae Sulz. on flue cured tobacco in Andhra Pradesh. Sci. & Cult. 47(3): 98-99.

Rattan Lal and Prakash Sarup. 1970. Role of bioassay in pesticides in the integrated control of crop pests Proc. Int. Sem. Integ. Pest Control, E.S.I., I.A.R.I, New Delhi, pp. 16 (Abst.).

Rivnay, E. 1961. The phenology of Prodenia litura (F.) in Israel with reference to its occurence in the near east at large. Bull. Res. Coun. Israel (B) 10: 100-106.

Salt, G. 1937. The sense used by Trichogramma to distinguish between parasitised and unparasitised hosts. Proc. R. Soc. (B) 122: 57-75.

Santharam, G. and Kumaraswami, T. 1985. Effects of some insecticides on the emergence of the parasitoid, Trichogramma chilonis Ishii. (Hymenoptera: Trichogrammatidae). Entomon 10 (1): 47-48.

Sasitharan, P. 1980. Studies on light trap catches under wetland and garden land systems. M.Sc. (Ag.) Thesis. Tamil Nadu Agric. Univ. Coimbatore.

Sathe, T.V. 1987. New records of Natural enemies of Spodoptera litura (Fab.) in Kolhapur, India Curr. Sci. 56 (20): 1083-1084.

Savescu, A. and Tien, N.N. 1972. Analysis of the conditions necessary for the growth and development of the oophagous wasp, Trichogramma chilonis Ishii with a view to establishing the conditions of its release into crops infested by the European corn borer. Analele Institueui . de cercetari pentru Protectia Plantelor 8:179-189.

Scaramuzza, L.C. 1930. Preliminary report on a study of the biology of Lixophaga diatraeae. J. econ.Ent.23: 999-1004.

Sheikh, A.G. 1984. Economic threshold of tobacco caterpillar, Spodoptera litura (Fabricius) on cauliflower and selectivity of some insecticides relevant to its biotic components. Ph.D. Thesis, Sukhadia University, Udaipur.

Shima, H. 1981. Description of a new species of Peribaea from New Guinea, with notes on Peribaea orbata (Diptera: Tachinidae). Pacific Insects 23(3-4): 445-450.

Simmonds, H.W. 1937. Division of Entomology, annual report for 1936. A. Bull. div. Rep. Agric.Fiji.1936, pp. 27-29.

Singh, J.P. 1970. Role of endosulfan in integrated pest control. Proc. Int. Sem. Integ.Pest Contrl.,New Delhi. (Abst., p.15).

Singh, R.P. 1969. A simple technique for rendering host eggs inviable for the laboratory rearing of Trichogramma spp. Ind. J. Ent. 31(1) 83-84.

Singh, S.P. 1985. Biological control of insect pests of national importance. 309-318. (In) Integrated Pest and Disease Management (ed.) S. Jayaraj. Proceedings of the National Seminar on Integrated Pest and Disease Management, Coimbatore, 433pp.

Sithanantham, S. 1987. Insect pests of pigeonpea and chickpea and their management. (In) Plant Protection in Field crops, pp.159-73 (eds.) Vecrabhadra Rao and S. Sithanantham. Plant Protection Association of India, Rajendranagar, Hyderabad, India.

Sithanantham, S. and Navarajan Paul, A.V. 1980. Toxicity of some insecticidal spray to the parasitoid, Trichogramma australicum Gir. Pestology IV,(3): 21-24.

Sithanantham, S., Solayappan, A.R. and Sankaran, T. 1982. The role of trichogrammatids in biological control of sugarcane borers in India.239-249. (In) Les trichogrammes Ier Symposium International, Antibes, 20-23 avril 1982. Paris, France.

Smee, C. 1930. Report of the entomological division. Ann.Rep. Dep. Agric. Nyassaland 1929, pp. 13-21.

Smith, H.S. 1916. An attempt to redefine the host relationships exhibited by entomophagous insects. J. econ. Ent. 9: 477-486.

Sonan, J. 1925. On six species of Ichneumonidae with known hosts. Formosa Agric. Rev. 19: 149-63.

Sonan, J. 1932. Notes on some Braconidae. and Ichneumonidae from Formosa, with descriptions of 18 new species. Trans.Nat. Hist. Soc. Formosa. 22: 66-87.

Sonan, J. 1937. Studies on the tobacco caterpillar, Prodenia litura in Formosa. Kontyu 11:175-77.

Srivastava, Bina and Kushwaha, K.S. 1987a. Biology of major parasitoids of Spodoptera litura Fab. recorded at Udaipur. p.158. Proc. First National Seminar-cum-Sixth Workshop of Biological Control of Crop Pests and Weeds. June 29-July 2,1987. Gujarat Agricultural University,Anand.

Srivastava, Bina and Kushwaha, K.S. 1987b. Bioecological interactions regulating populations of Peribaea orbata Wied. parasitizing Spodoptera litura. National Symposium on Integrated Pest Control - Progress and Perspectives. October 15-17,1987. Trivandrum (Abstract, p.33).

Srivastava, Bina and Kushwaha, K.S. 1987c. Effects of insecticides on parasitized eggs of Spodoptera litura (Fabricius) Indian J. Appl. Ent. 1:63-70.

Sukhoruchenko, G.I., Niyazoo, O.D. and Alekseev, Yu.A. 1977. The effect of modern pesticides on beneficial and injurious fauna of cotton. Entomologichekoe Obozrenie. 56 (1): 3-14.

Thobbi, V.V. 1970. Integrated control of castor semilooper, Achaea janata L. and leaf eating caterpillar, Prodenia litura. Proc. Int. Sem. Integ. Pest Control, E.S.I., I.A.R.I., New Delhi. 16 pp. (Abstr.)

Thompson, N.R. 1946. A catalogue of the parasites and predators of insect pests. p.475.

Thontadarya, T.S. and Nangia, N. 1983. Natural enemies of tobacco caterpillar infesting Soybean. Current Research 12 (10/12): 105-106.

Tseng Sheng. 1965. On the identification of Trichogramma insects. Acta ent. sin. 14: 404-410.

Tuhan, N.C. and Pawar, A.D. 1983. Life-history, host suitability and effectiveness of Trichogramma chilonis (Ishii) for controlling sugarcane borers in the Punjab. Journal of Advanced Zoology 4(2) 71-76.

Ulrich, H. 1968. Ein verbesserter Kafig fur die Massenzucht des Eiparasiten Trichogramma (Hymenoptera, chalcidoidea). Entomophaga 13: 233-236.

Usman, S. and Puttarudriah, M. 1955. A list of the insects of Mysore, including the mites. Bull. No.16, Ent. Ser. 4, Dept. agric. Mysore, p.194.

Vargas, R.I. and Nishida, T. 1982. Parasitization by Trichogramma chilonis Ishii (Hymenoptera: Trichogrammatidae) of corn earworm eggs on sweet corn in Hawaii. Proceedings of the Hawaiian Entomological Society 24 (1):123-126.

Vijayvergia, J. 1986. Management of tobacco caterpillar, Spodoptera litura (Fabricius) based on life-tables. Ph.D. Thesis. Sukhadia University, Udaipur, India.

Vinson, J. 1942. Biological control of Diatraea mauriciella Wek. in Mauritius. I. Investigations in Ceylon in 1939. Bull.ent. Res. 33: 39-65.

Willcocks, F.C. and Bahgat, S. 1937. The insect and related pests of Egypt. Vol.1. Part 2. Insects and mites injurious to the cotton plant. Royal Agri. Soc., Entomological Section, Cairo. Egypt.

Williams, C.B. 1940. An analysis of four years capture of insects in a light trap. Part II. Trans. R. Soc. Lond. Ser. B. 90: 227-306.

Xia, B., Wang, M., Xia, H. and Yan, Y. 1982. Observations on the morphology of the overwintering host eggs of Trichogramma spp. using the scanning electron microscope. Zoological Research 3(2): 153-156.

Xie, D.L., Li, T.J., Chen, W.R., Xie, Y.Y. and He, S.F. 1984. Effects of pesticides on egg- parasitic wasps. Insect Knowledge (Kunchong Zhishi) 21 (1):17-19.

Yadav, D.N. and Patel, R.C. 1981. Egg parasitism of Heliothis armigera (Hb.) (Lepidoptera:Noctuidae) in Gujarat. Gujarat Agricultural University Research Journal 7 (1): 19-22.

Yadav, D.N. and Patel, R.C. 1987. Biological control of cotton pests with special reference to cotton bollworms. 51-62. Proc. Seminar-cum-Sixth Workshop of Biological Control of Crop Pests and Weeds, June 29-July 2. Gujarat Agricultural University, Anand.

Yates, F. and Finney, D.J. 1942. Statistical problems in field sampling for wireworms. Ann. appl. Biol. 29: 156-67.

Zaslavskii, V.A. and Kvi, M.F. 1982. Experimental study of some factors influencing the fecundity of Trichogramma Westw. (Hymenoptera: Trichogrammatidae). Entomologicheskoe Obozrenie 61(4): 724-737.

Zaz, G.M. 1982. Incidence of tobacco caterpillar, Spodoptera litura (Fabricius) and its natural enemies with special reference to control by the bacterium, Bacillus cereus Fr. & Fr. Ph.D. Thesis, Univ. of Udaipur, Udaipur, India.

Zaz, G.M. and Kushwaha, K.S. 1983. Quantitative incidence of tobacco caterpillar, Spodoptera litura (F.) and related natural enemies in cole crops. Indian J. Ent. 45(2):201-2.

APPENDICES

APPENDIX I

Insect parasites of the tobacco caterpillar, Spodoptera litura (Fabricius)

(a) Egg parasites

(i) Order: Hymenoptera

Fam. Braconidae: Chelonus sp. (Miller, 1933), C. blackburni Gupta (Anonymous, 1983), C. formosanus Sonan (Sonan, 1932; Patel et al.,1971; Rai, 1974), C. heliopae Gupta (Patel and Patel, 1971; Patel et al., 1971)

Fam. Scelionidae : Telenomus sp. (Zaz and Kushwaha, 1983), T. nawaii Ashm.(Gahan, 1925; Simmonds, 1937), T. remus Nixon (Anonymous, 1983)

Fam. Trichogrammatidae : Trichogramma australicum Girault (Joshi et al., 1979), T. chilonis Ishii (Zaz and Kushwaha, 1983), T. evanescens Westwood (Chu and Hu, 1937; Kamal, 1951), T. evanescens minutum Riley (Krishnamurthy and Usman, 1954), T. pretiosa Riley (Anonymous, 1913)

(b) Egg-larval parasites

(i) Order: Hymenoptera

Fam. Braconidae: Chelonus blackburni Gupta (Anonymous,1983), C. formosanus Sonan (Rao and Patel, 1974; Joshi et al.,1979), C. carbonator (Rao et al., 1981)

(c) Larval parasites

(i) Order : Diptera

Fam. Faniidae : Fannia leucostica Smith (Zaz and Kushwaha, 1983)

Fam. Phoridae: Megaselia sp. (Pandey, 1970)

Fam. Sarcophagidae : Sarcophaga sp. (Sonan, 1937), Sarcophaga peregrina (Robineau- Desvoidy) (Zaz and Kushwaha,1983), Sarcosolomonia (Vijayvergia , 1986)

Fam. Tachinidae: Actia nigritula L. (Hafez, 1951), Blepharella lateralis (Anonymous, 1983), Cnephalia (Gonia) cinerascens Rond (Sonan, 1937), Peribaea orbata (Wiedemann) (Prasad and Kushwaha, 1979; Zaz and Kushwaha, 1983), Podomyia setosa Dol (Miller, 1933), Strobiomyia orbata Weid. (Pandey, 1970),

Sturmia sp. (Smee, 1930), S. aequalis Mall (Hoyt, 1955), S. inconspicuoides Baranov (Lever, 1935, 1943), Tachina larvarum L. (Bishara, 1934; Kamal, 1951), Winthema dispar Macq. (Hoyt, 1955).

(c) (i) Order : Hymenoptera

Fam. Braconidae : Apanteles sp.(Lever, 1944; Braune, 1980), A. beneficiens Vies (Anonymous, 1983), A. sp. nr. colemani Viereck (Patel et al.,1971), A. marginiventris (Cress) (Anonymous, 1983), A. sp. (octonarius group) (Joshi et al., 1979; Prasad and Kushwaha, 1979), A. prodeniae Viereck (Ayyar, 1927; Bhatnagar, 1948; Krishnamurthy and Usman, 1954), A. risbeci sp. n. (De Saeger, 1942), A. ruficrus Haliday (Sonan, 1937; Chiu and Chou, 1976; Zaz and Kushwaha, 1983), A. sp. (vitripennis species-group) (Sheikh,1984),Bracon gelicheae (Anonymous,1987b) , Chelonus formosanus Sonan (Rai, 1974), Microbacon serinopae Ramskr. (Cherian,1930), Microplitis sp. (Prasad and Kushwaha,1979; Zaz and Kushwaha, 1983), M. demolitor Welkn (Hafez, 1951), M.prodeniae Rao and Kuriyan (Rao and Kuriyan, 1950), Rogas sp. (Prasad and Kushwaha, 1979), Zele chlorophthalma (Nees) (Kamal, 1951), Z. nigricornis (Wlkn.) (Kamal, 1951)

Fam. Chalcidoidae : Lasiochalcidia erythropoda Cameron (Rao et al.,1981)

Fam. Eulophidae : Euplectrus sp. (Lever, 1944), E.gopinomohani Mani (Patel et al., 1971), E. xanthocephalus (Anonymous,1983)

Fam. Ichneumonidae : Barylypa humeralis (Brauns) (Kamal,1951), Campoletis sp. (Battu, 1977), C. flavicincta (Anonymous,1983), Carops obtusus Morl. (Patel et al., 1971), Diadegma sp. (Prasad and Kushwaha, 1979), D. argenteopilosa Cameron (Ayyar, 1927), Enicospilus species (Sathe, 1987), Eriborus sp.? argenteopilosus (Vijayvergia , 1986), Eulimneria xanthostoma (Grav) (Kamal, 1951), Metopius discolor Tosq. (Peacock,1913; Mason, 1915), M. kapugawanus Mats. (Sonan, 1937), Netelia ferruginea Cameron (Krishnamurthy and Usman,1954; Usman and Puttarudriah, 1955), Paniscus productus Brulle (Hafez,1951), P. testaceus Gravenhorst (Krishnamurthy and Usman,1954)

(d) Larval-pupal parasites

(i) Order : Diptera

Fam. Phoridae : Megaselia sp.(Prasad and Kushwaha, 1979)

Fam. Tachinidae: Blepharella lateralis (Anonymous, 1983)

(e) Pupal parasites

(i) Order : Diptera

Fam. Phoridae : Megaselia sp. (Pandey, 1970)

Fam. Sarcophagidae : Parasarcophaga misera (Battu, 1977),

Sarcophaga dux Thoms (Joshi et al., 1979), S.albiceps Mg. (Rao et al., 1981)

Fam. Tachinidae : Actia (Gymnopareia) aegyptia Villen (Bishara, 1934), Stomatomyia bezziana Baranov (Hutson,1939), Strobliomyia aegyptia Vill. (Patel et al.,1971)

(ii) Order : Hymenoptera

Fam. Braconidae: Xanthopimpla stemmator Thnb. (Vinson,1942)

Fam. Chalcidoidae : Brachymeria lassus walker (Narendran and Joseph, 1977), Hybothoracini species (Rao et al.,1981)

Fam. Eulophidae : Tetrastichus ayyari Rohwer (Krishnamurthy and Usman, 1954; Usman and Puttarudriah, 1955), Trichospilus pupivora Ferr. (Anantanarayanan, 1934)

Fam. Ichneumonidae : Eucthromorpha species (Thompson,1946), Metopius rufus Cameron (Sonan, 1925)

Fam. Pteromalidae : Conomorium cremita (Forst) (Kamal,1951)

(f) Pupal hyperparasite

(i)Order: Hymenoptera

Fam. Ceraphronidae : Aphanogamus fijiensis Ferriere (Chari and Rao, 1987)

(g) Larval-adult parasite

(i) Order : Hymenoptera

Fam. Eumeridae: Delta maxillosa dimidiatipennis (Prasad and Kushwaha, 1979).

APPENDIX II

Quantitative incidence of Spodoptera litura and its related biotic components in cauliflower crop sampled on Kushalbag Farm, Udaipur (1985-86)

Date of sample	Larvae No./ 300 plants	Mortality factors						Pupation		Adult emergence	
		Insect parasites		Disease		Total					
		No.	%	No.	%	No.	%	No.	%	No	%
1985											
13.viii	1	-	-	-	-	-	-	1	100	1	100
20.viii	3	-	-	-	-	-	-	3	100	3	100
27.viii	10	-	-	-	-	-	-	10	100	10	100
3.ix	27	3	11.1	3	11.1	6	22.2	21	77.8	6	22.2
10.ix	92	22	23.9	12	13.0	34	37.0	58	63.0	30	32.6
17.ix	141	29	20.6	10	7.1	39	27.7	102	72.3	78	55.3
24.ix	109	34	31.2	15	13.8	49	44.9	60	55.0	39	35.8
1.x	110	46	41.8	23	20.9	69	62.7	41	37.3	21	19.1
8.x	102	19	18.6	29	28.4	48	47.1	54	52.9	23	22.5
15.x	97	18	18.6	38	39.2	56	57.7	41	42.3	17	17.5
22.x	97	2	2.1	82	84.5	84	86.6	13	13.4	6	6.2
29.x	80	-	-	72	90.0	72	90.0	8	10.0	3	3.7
5.xi	43	4	9.3	32	74.4	36	83.7	7	16.3	2	4.6
12.xi	29	8	27.6	19	65.5	27	93.1	2	6.9	1	3.4
19.xi	31	11	35.5	12	38.7	23	74.2	8	25.8	3	9.7
26.xi	37	13	35.1	15	40.5	28	75.7	9	24.3	5	13.5
3.xii	31	8	25.8	9	29.0	17	54.8	14	45.2	6	19.4
10.xii	31	16	51.6	9	29.0	25	80.6	6	19.3	1	3.2
17.xii	29	16	55.1	3	10.3	19	65.5	10	34.5	3	10.3

Contd. Appendix II

1.	2.	3.	4.	5.	6.	7..	8.	9.	10	11	12
1986											
26.vii	8	-	-	-	-	-	-	8	100	8	100
2.viii	10	-	-	-	-	-	-	10	100	10	100
9.viii	17	-	-	3	17.6	3	17.6	14	82.3	10	58.8
16.viii	18	-	-	5	27.8	5	27.8	13	72.2	11	61.1
23.viii	13	2	15.4	9	69.2	11	84.6	2	15.4	2	15.4
30.viii	19	4	21.0	1	5.3	5	26.3	14	73.7	11	57.9
6.ix	23	7	30.4	6	26.0	13	56.5	10	43.5	8	34.8
13.ix	40	11	27.5	14	35.0	25	62.5	15	37.5	12	30.0
20.ix	129	21	16.3	45	34.9	66	51.2	63	48.8	42	32.6
27.ix	105	12	11.4	69	65.7	81	77.1	24	22.9	12	11.4
4.x	5	-	-	5	100.0	5	100.0	-	-	-	-
11.x	10	-	-	2	20.0	2	20.0	8	80.0	7	70.0
18.x	15	1	6.7	1	6.7	2	13.3	13	86.7	10	66.7
25.x	20	5	25.0	7	35.0	12	60.0	8	40.0	6	30.0
1.xi	18	8	44.4	5	27.8	13	72.2	5	27.8	4	22.2
8.xi	17	3	17.6	11	64.7	14	82.4	3	17.6	2	11.8
15.xi	14	8	57.1	3	21.4	11	78.6	3	21.4	3	21.4
22.xi	6	2	33.3	-	-	2	33.3	4	66.7	2	33.3
29.xi	2	-	-	-	-	-	-	2	100.0	1	50.0
6.xii	2	-	-	-	-	-	-	2	100.0	2	100.0

APPENDIX III

Quantitative incidence of S.litura and its related biotic components in cauliflower crop sampled at village Chotinauka, Udaipur (1985-86)

Date of sample	Larvae No./ 300 Plants	Mortality factors						Pupation		Adult emergence	
		Insect parasites		Disease		Total					
		No.	%	No.	%	No.	%	No.	%	No	%
1985											
6.viii	3	-	-	2	66.7	2	66.7	1	33.3	1	33.3
13.viii	3	-	-	-	-	-	-	3	100.0	3	100.0
20.viii	28	-	-	-	-	-	-	28	100.0	24	85.7
27.viii	42	2	4.8	-	-	2	4.8	40	95.2	30	71.4
3.ix	15	6	40.0	3	20.0	9	60.0	6	40.0	3	20.0
10.ix	68	13	19.1	8	11.8	21	30.8	47	69.1	27	39.7
17.ix	138	51	36.9	20	14.5	71	51.4	67	48.5	47	34.1
24.ix	117	38	32.5	16	13.7	54	46.2	63	53.8	46	39.3
1.x	133	40	30.1	40	30.1	80	60.2	53	39.8	27	20.3
8.x	97	16	16.5	23	23.7	39	40.2	58	59.8	36	37.1
15.x	92	21	22.8	41	44.6	62	67.4	30	32.6	14	15.2
22.x	61	7	11.5	41	67.2	48	78.7	13	21.3	6	9.8
29.x	67	10	14.9	52	77.6	62	92.5	5	7.5	2	3.0
5.xi	48	5	10.4	21	43.8	26	54.2	22	45.8	10	20.8
12.xi	48	1	2.1	39	81.3	40	83.3	8	16.7	3	6.3
19.xi	33	14	42.4	9	27.3	23	69.7	10	30.3	6	18.2
26.xi	47	14	29.8	19	40.4	33	70.2	14	29.8	6	19.1
3.xii	42	7	16.7	19	45.2	26	61.9	16	38.1	11	26.2
10.xii	30	2	6.7	25	83.3	27	90.0	3	10.0	2	6.7
17.xii	25	5	20.0	17	68.0	22	88.0	3	12.0	-	-

Contd. Appendix III

1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11.	12.
1986											
21.vii	5	-	-	-	-	-	-	5	100.0	5	100.0
28.vii	20	2	10.0	1	5.0	3	15.0	17	85.0	13	65.0
4.viii	16	5	31.2	4	25.0	9	56.2	7	43.7	7	43.7
11.viii	19	4	21.0	5	26.3	9	47.4	10	52.6	7	36.8
18.viii	34	9	26.5	9	26.5	18	52.9	16	47.0	11	32.4
25.viii	83	12	14.5	48	57.8	60	72.3	23	27.7	17	20.5
1.ix	111	12	10.8	52	46.8	64	57.7	47	42.3	35	31.5
8.ix	212	41	19.3	155	73.1	196	92.4	16	7.5	9	4.2
15.ix	342	53	15.5	247	72.2	300	87.7	42	12.3	26	7.6
22.ix	108	18	16.7	47	43.5	65	60.2	43	39.8	35	32.4
29.ix	51	19	37.3	24	47.0	43	84.3	8	15.7	5	9.8
6.x	73	11	15.0	42	57.5	53	72.6	20	27.4	16	21.9
13.x	24	-	-	14	58.3	14	58.3	10	41.6	8	33.3
20.x	15	-	-	3	20.0	3	20.0	12	80.0	9	60.0
27.x	20	1	5.0	8	40.0	9	45.0	11	55.0	9	45.0
3. xi	15	1	6.7	10	66.7	11	73.3	4	26.6	3	20.0
10.xi	15	5	33.3	10	66.7	15	100.0	-	-	-	-
17.xi	5	1	20.0	2	40.0	3	60.0	2	40.0	1	20.0
24.xi	2	-	-	-	-	-	-	2	100.0	2	100.0

APPENDIX IV

Quantitative incidence of S.litura and its related biotic components in cauliflower crop sampled at the Horticulture Farm, Udaipur (1985-86)

Date of sample	Larvae No./300 plants	Mortality factors						Pupation		Adult emergence	
		Insect parasites		Disease		Total					
		No.	%	No.	%	No.	%	No.	%	No.	%
1985											
7.viii	10	2	20.0	-	-	2	20.0	6	60.0	4	40.0
14.viii	21	6	28.6	-	-	6	28.6	9	42.9	7	33.3
21.viii	29	11	37.9	1	3.4	12	41.4	17	58.6	13	44.8
28.viii	39	3	7.7	3	7.7	6	15.4	33	84.6	20	51.3
4.ix	28	9	32.1	8	28.6	17	60.7	25	89.3	9	32.1
11.ix	78	7	8.9	14	17.9	22	28.2	56	71.8	33	42.3
18.ix	115	35	30.4	19	16.5	54	46.9	61	53.0	34	29.6
25.ix	110	41	37.3	17	15.5	58	52.7	52	47.3	39	35.5
2.x	110	55	50.0	26	23.6	81	73.6	29	26.4	20	18.2
9.x	54	8	14.8	4	7.4	12	22.2	42	77.8	18	33.3
16.x	56	11	19.6	26	46.4	37	66.1	19	33.9	12	21.4
23.x	65	-	-	54	83.1	54	83.1	11	16.9	4	6.2
30.x	65	4	6.2	44	67.7	48	73.8	17	26.2	1	1.5
6.xi	39	1	2.6	26	66.7	27	69.2	12	30.8	3	7.7
13.xi	35	5	14.3	25	71.4	30	85.7	5	14.3	1	2.8
20.xi	33	18	54.5	6	18.2	24	72.7	9	27.3	2	6.1
27.xi	41	6	14.6	29	70.7	35	85.4	6	14.6	1	2.4
4.xii	33	2	6.1	17	51.5	19	57.6	14.	42.4	8	24.2
11.xii	32	11	34.4	11	34.4	22	68.7	10	31.2	4	12.5
18.xii	31	9	29.0	11	35.5	19	61.3	11	35.5	5	16.1

Contd. Appendix IV

1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11.	12.
1986											
30.vii	6	-	-	-	-	-	-	6	100.0	6	100.00
6.viii	12	-	-	-	-	-	-	12	100.0	10	83.3
13.viii	19	-	-	4	21.0	4	21.0	15	78.9	15	78.9
20.viii	28	4	14.3	12	42.9	16	57.1	12	42.9	11	39.3
27.viii	36	5	13.9	12	33.3	17	47.2	19	52.8	15	41.7
3.ix	93	11	11.8	42	45.1	53	57.0	40	43.0	33	35.5
10.ix	103	18	17.5	59	57.3	77	74.8	26	25.2	21	20.4
17.ix	115	20	17.4	61	53.0	81	70.4	34	29.6	26	22.6
24.ix	69	21	30.4	30	43.5	51	73.9	18	26.1	15	21.7
1.x	27	1	3.7	19	70.3	20	74.0	7	25.9	6	22.2
8.x	35	2	5.7	25	71.4	27	77.1	8	22.8	7	20.0
15.x	35	4	11.4	15	42.8	19	54.3	16	45.7	12	34.3
22.x	23	4	17.4	6	26.0	10	43.5	13	56.5	8	34.7
29.x	19	3	15.8	2	10.5	5	26.3	14	73.6	14	73.6
5.xi	15	3	20.0	7	46.6	10	66.6	5	33.3	4	26.6
12.xi	10	1	10.0	2	20.0	3	30.0	7	70.0	5	50.0
19.xi	5	-	-	-	-	-	-	5	100.0	4	80.0

APPENDIX V

Status of different parasites attacking S.litura infesting cauliflower crop at Kushalbag Farm, Udaipur (1985-86)

Date of sample	Host larvae collected	Larvae parasitized (No.) by parasite spp *							Total
		P	R	Av	Cc	M	Ca	Ch	
1985									
13.viii	1	-	-	-	-	-	-	-	-
20.viii	3	-	-	-	-	-	-	-	-
27.viii	10	-	-	-	-	-	-	-	-
3.ix	27	-	-	3	-	-	-	-	3
10.ix	92	14	1	3	4	-	-	-	22
17.ix	141	8	5	10	5	1	-	-	29
24.ix	109	17	8	5	2	1	1	-	34
1.x	110	12	26	7	-	1	-	-	46
8.x	102	5	2	10	-	1	-	1	19
15.x	97	15	1	1	1	-	-	-	18
22.x	97	-	1	1	-	-	-	-	8
29.x	80	-	-	-	-	-	-	-	-
5.xi	43	3	-	-	1	-	-	-	4
12.xi	29	7	-	1	-	-	-	-	8
19.xi	31	8	1	2	-	-	-	-	11
26.xi	37	8	4	1	-	-	-	-	13
3.xii	31	3	1	3	1	-	-	-	8
10.xii	31	3	12	-	1	-	-	-	16
17.xii	29	8	8	-	-	-	-	-	16

Contd. Appendix V

1.	2.	3.	4.	5.	6.	7.	8.	9.	10
1986									
26.vii	8	-	-	-	-	-	-	-	-
2.viii	10	-	-	-	-	-	-	-	-
9.viii	17	-	-	-	-	-	-	-	-
16.viii	18	-	-	-	-	-	-	-	-
23.viii	13	1	-	-	1	-	-	-	2
30.viii	19	4	-	-	-	-	-	-	4
6.ix	23	4	-	1	2	-	-	-	7
13.ix	40	5	2	3	1	-	-	-	11
20.ix	129	15	3	3	-	-	-	-	21
27.ix	105	6	3	3	-	-	-	-	12
4.x	5	-	-	-	-	-	-	-	-
11.x	10	-	-	-	-	-	-	-	-
18.x	15	1	-	-	-	-	-	-	1
25.x	20	1	-	4	-	-	-	-	5
1.xi	18	4	2	2	-	-	-	-	8
8.xi	17	-	1	1	-	-	1	-	3
15.xi	14	3	2	2	-	-	1	-	8
22.xi	6	2	-	-	-	-	-	-	2
29.xi	2	-	-	-	-	-	-	-	-
6.xii	2	-	-	-	-	-	-	-	-

* Abbrev.: Av, Apanteles sp. (vitripennis species-group); Ca, Charops sp.; Cc, Campoletis chlorideae Uchida; Ch, Chelonus sp.; M, Microplitis sp.; P., Peribaea orbata (Wiedemann); R, Rogas sp.

APPENDIX VI

Status of different parasites attacking S.litura infesting cauliflower crop at village Chotinauka, Udaipur (1985-86)

Date of sample	Host larvae sampled	Larvae parasitized (Nos.)by parasite spp*									Total
		P	R	Av	Cc	M	Ca	Ch	Bl	Ea	
1985											
6.viii	3	-	-	-	-	-	-	-	-	-	-
13.viii	3	-	-	-	-	-	-	-	-	-	-
20.viii	28	-	-	-	-	-	-	-	-	-	-
27.viii	42	2	-	-	-	-	-	-	-	-	2
3.ix	15	6	-	-	-	-	-	-	-	-	6
10.ix	68	8	2	3	-	-	-	-	-	-	13
17.ix	138	24	12	6	-	9	-	-	-	-	51
24.ix	117	19	7	8	1	3	-	-	-	-	38
1.x	133	24	4	8	-	2	1	1	-	-	40
8.x	97	6	1	8	-	1	-	-	-	-	16
15.x	92	19	-	1	-	1	-	-	-	-	21
22.x	61	4	-	3	-	-	-	-	-	-	7
29.x	67	6	2	2	-	-	-	-	-	-	10
5.xi	48	2	-	3	-	-	-	-	-	-	5
12.xi	48	-	1	-	-	-	-	-	-	-	1
19.xi	33	7	2	4	-	-	-	-	-	1	14
26.xi	47	3	2	9	-	-	-	-	-	-	14
3.xii	42	1	4	1	-	-	-	-	1	-	7
10.xii	30	-	1	-	1	-	-	-	-	-	2
17.xii	25	2	1	2	-	-	-	-	-	-	5

Contd. Appendix VI

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
1986											
21.vii	5	-	-	-	-	-	-	-	-	-	-
28.vii	20	-	2	-	-	-	-	-	-	-	2
4.viii	16	3	2	-	-	-	-	-	-	-	5
11.viii	19	4	-	-	-	-	-	-	-	-	4
18.viii	34	4	3	2	-	-	-	-	-	-	9
25.viii	83	8	1	2	-	-	-	1	-	-	12
1.ix	111	10	1	1	-	-	-	-	-	-	12
8.ix	212	23	3	10	2	3	-	-	-	-	41
15.ix	342	22	4	15	6	3	-	3	-	-	53
22.ix	108	12	6	-	-	-	-	-	-	-	18
29.ix	51	12	2	4	-	-	-	1	-	-	19
6.x	73	8	1	2	-	-	-	-	-	-	11
13.x	24	-	-	-	-	-	-	-	-	-	-
20.x	15	-	-	-	-	-	-	-	-	-	-
27.x	20	1	-	-	-	-	-	-	-	-	1
3.xi	15	1	-	-	-	-	-	-	-	-	1
10.xi	15	3	-	1	-	-	-	1	-	-	5
17.xi	5	1	-	-	-	-	-	-	-	-	1
24.xi	2	-	-	-	-	-	-	-	-	-	-

* Abbrev.: Av, Apanteles sp. (vitripennis species-group); Bl, Blepharella lateralis (Macquart); Ca, Charops sp.; Cc, Campoletis chlorideae Uchida; Ch, Chelonus sp.; Ea, Eriborus sp.? argenteopilosus (Cameron); M, Microplitis sp.; P, Peribaea orbata (Wiedemann); R, Rogas sp.

APPENDIX VII

Status of different parasites attacking S.litura infesting cauliflower at Horticulture Farm, Udaipur (1985-86)

Date of sample	Host larvae sampled	Larvae parasitized (Nos.) by parasite spp *								Total
		P	R	Av	Cc	M	Ca	Ch	Bl	
1985										
7.viii	10	-	-	1	-	1	-	-	-	2
14.viii	21	-	-	4	-	2	-	-	-	6
21.viii	29	-	-	7	-	4	-	-	-	11
28.viii	39	2	-	1	-	-	-	-	-	3
4.ix	28	6	-	-	-	2	1	-	-	9
11.ix	78	2	-	2	1	2	-	-	-	7
18.ix	115	20	-	5	3	7	-	-	-	35
25.ix	110	21	8	8	1	1	1	1	-	41
2.x	110	30	9	14	1	-	-	1	-	55
9.x	54	4	-	3	1	-	-	-	-	8
16.x	56	8	1	1	1	-	-	-	-	11
23.x	65	-	-	-	-	-	-	-	-	-
30.x	65	3	-	1	-	-	-	-	-	4
6.xi	39	-	-	-	-	1	-	-	-	1
13.xi	35	2	-	1	1	-	-	-	1	5
20.xi	33	2	6	2	1	-	-	-	7	18
27.xi	41	2	1	3	-	-	-	-	-	6
4.xii	33	1	1	-	-	-	-	-	-	2
11.xii	32	3	5	1	2	-	-	-	-	11
18.xii	31	4	4	-	1	-	-	-	-	9

Contd. Appendix VII

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11
1986										
30.vii	6	-	-	-	-	-	-	-	-	-
6.viii	12	-	-	-	-	-	-	-	-	-
13.viii	19	-	-	-	-	-	-	-	-	-
20.viii	28	4	-	-	-	-	-	-	-	4
27.viii	36	4	-	-	1	-	-	-	-	5
3.ix	93	6	-	3	-	1	1	-	-	11
10.ix	103	8	-	8	1	1	-	-	-	18
17.ix	115	11	1	1	1	5	1	-	-	20
24.ix	69	12	3	2	1	1	1	1	-	21
1.x	27	-	1	-	-	-	-	-	-	1
8.x	35	1	-	1	-	-	-	-	-	2
15.x	35	3	1	-	-	-	-	-	-	4
22.x	23	2	1	1	-	-	-	-	-	4
29.x	19	1	-	1	1	-	-	-	-	3
5.xi	15	1	-	2	-	-	-	-	-	3
12.xi	10	1	-	-	-	-	-	-	-	1
19.xi	5	-	-	-	-	-	-	-	-	-

* Abbrev.: Av, Apanteles sp. (vitripennis species-group); Bl, Blepharella lateralis (MacQuart); Ca, Charops sp.; Cc, Campoletis chlorideae Uchida; Ch, Chelonus sp.; M, Microplitis sp.; P. Peribaea orbata (Wiedemann); R, Rogas sp.

APPENDIX VIII

Quantitative incidence of S.litura and its related biotic components in cabbage crop sampled on Kushalbag Farm, Udaipur (1986-87)

Date of sample	Larvae No./300 plants	Mortality factors: Insect parasites No.	Insect parasites %	Disease No.	Disease %	Total No	Total %	Pupation No.	Pupation %	Adult emergence No.	Adult emergence %
1986											
1.i	5	-	-	2	40.0	2	40.0	3	60.0	2	40.0
8.i	11	4	36.4	3	27.3	7	63.6	4	36.4	2	18.2
15.i	2	-	-	-	-	-	-	2	100.0	2	100.0
22.i	6	-	-	2	33.3	2	33.3	4	66.7	3	50.0
29.i	4	-	-	3	75.0	3	75.0	1	25.0	1	25.0
5.ii	5	-	-	2	40.0	2	40.0	3	60.0	2	40.0
12.ii	5	-	-	3	60.0	3	60.0	2	40.0	2	40.0
19.ii	3	-	-	2	66.7	2	66.7	1	33.3	1	33.3
1987											
3.i	2	-	-	1	50.0	1	50.0	1	50.0	1	50.0
10.i	5	2	40.0	1	20.0	3	60.0	2	40.0	1	20.0
17.i	9	1	11.1	1	11.1	2	22.2	7	77.7	6	66.6
24.i	7	-	-	2	28.5	2	28.5	5	71.4	5	71.4
31.i	4	-	-	2	50.0	2	50.0	2	50.0	1	25.0
7.ii	4	-	-	1	25.0	1	25.0	3	75.0	2	50.0
14.ii	2	-	-	-	-	-	-	2	100.0	2	100.0
21.ii	1	-	-	-	-	-	-	1	100.0	1	100.0

APPENDIX IX

Quantitative incidence of S.litura and its related biotic components in cabbage crop sampled on farmer's field in village Chotinauka, Udaipur (1986-87)

Date of sample	Larvae No./300 plants	Mortality factors: Insect parasites No.	Insect parasites %	Disease No.	Disease %	Total No.	Total %	Pupation No	Pupation %	Adult emergence No	Adult emergence %
1986											
1 .i	6	-	-	2	33.3	2	33.3	4	66.7	3	50.0
8 .i	12	-	-	4	33.3	4	33.3	8	66.7	6	50.0
15.i	8	-	-	3	37.5	3	37.5	5	62.5	3	37.5
22.i	7	-	-	4	57.1	4	57.1	3	42.9	2	28.6
29.i	6	-	-	1	16.7	1	16.7	5	83.3	3	50.0
5.ii	6	-	-	3	50.0	3	50.0	3	50.0	2	33.3
12.ii	3	-	-	2	66.7	2	66.7	1	33.3	1	33.3
19.ii	3	-	-	3	100.0	3	100.0	-	-	-	-
1987											
5.i	3	-	-	-	-	-	-	3	100.0	3	100.0
12.i	6	-	-	2	33.3	2	33.3	4	66.6	3	50.0
19.i	10	2	20.0	3	30.0	5	50.0	5	50.0	4	40.0
26.i	9	-	-	2	22.2	2	22.2	7	77.7	7	77.7
2.ii	5	-	-	1	20.0	1	20.0	4	80.0	3	60.0
9.ii	2	-	-	1	50.0	1	50.0	1	50.0	1	50.0
16.ii	2	-	-	-	-	-	-	2	100.0	1	50.0
23.ii	1	-	-	-	-	-	-	1	100.0	1	100.0

APPENDIX X

Quantitative incidence of S.litura and its related biotic components in cabbage crop sampled at the Horticulture Farm, Udaipur (1986-87)

Date of sample	Larvae No./300 plants	Mortality factors						Pupation		Adult emergence	
		Insect parasites		Disease		Total					
		No.	%	No.	%	No.	%	No	%	No	%
1986											
2.i	7	3	42.8	1	14.3	4	57.1	3	42.8	2	28.6
9.i	10	1	10.0	3	30.0	4	40.0	6	60.0	5	50.0
16.i	10	1	10.0	5	50.0	6	60.0	4	40.0	3	30.0
23.i	6	-	-	1	16.7	1	16.7	5	83.3	3	50.0
30.i	8	-	-	7	87.5	7	87.5	1	12.5	1	12.5
6.ii	8	-	-	3	37.5	3	37.5	5	62.5	3	37.5
13.ii	6	-	-	5	83.3	5	83.3	1	16.7	1	16.7
20.ii	3	-	-	1	33.3	1	33.3	2	66.7	2	66.7
1987											
7.i	3	1	33.3	1	33.3	2	66.6	1	33.3	1	33.3
14.i	5	2	40.0	1	20.0	3	60.0	2	40.2	2	40.0
21.i	6	-	-	2	33.3	2	33.3	4	66.6	3	50.0
28.i	8	-	-	3	37.5	3	37.5	5	62.5	5	62.5
4.ii	5	-	-	2	40.0	2	40.0	3	60.0	2	40.0
11.ii	3	-	-	1	33.3	1	33.3	2	66.6	1	33.3
18.ii	1	-	-	1	100.0	1	100.0	-	-	-	-
25.ii	1	-	-	-	-	-	-	1	100.0	-	-

APPENDIX XI

Status of different parasites attacking S.litura infesting cabbage crop at the Kushalbag Farm, Udaipur (1986-87)

Date of sample	Host larvae collected	Larvae parasitized (No.) by parasite spp*							Total
		P	R	Av	Cc	M	Ca	Ch	
1986									
1.i	5	-	-	-	-	-	-	-	-
8.i	11	2	2	-	-	-	-	-	4
15.i	2	-	-	-	-	-	-	-	-
22.i	6	-	-	-	-	-	-	-	-
29.i	4	-	-	-	-	-	-	-	-
5.ii	5	-	-	-	-	-	-	-	-
12.ii	5	-	-	-	-	-	-	-	-
19.ii	3	-	-	-	-	-	-	-	-
1987									
3.i	2	-	-	-	-	-	-	-	-
10.i	5	1	1	-	-	-	-	-	2
17.i	9	1	-	-	-	-	-	-	1
24.i	7	-	-	-	-	-	-	-	-
31.i	4	-	-	-	-	-	-	-	-
7.ii	4	-	-	-	-	-	-	-	-
14.ii	2	-	-	-	-	-	-	-	-
21.ii	1	-	-	-	-	-	-	-	-

* Abbrev.: Av, Apanteles sp. (vitripennis species-group); Ca, Charops sp.; Cc, Campoletis chlorideae Uchida; Ch, Chelonus sp.; M, Microplitis sp.; P, Peribaea orbata (Wiedemann); R, Rogas sp.

APPENDIX XII

Status of different parasites attacking S.litura infesting cabbage crop at the village Chotinauka, Udaipur (1986-87)

Date of sample	Host larvae collected	Larvae parasitized (No.) by parasite spp*							Total
		P	R	Av	Cc	M	Ca	Ch	
1986									
1.i	6								
8.i	12								
15.i	8	No parasitization recorded							
22.i	7								
29.i	6								
5.ii	6								
12.ii	3								
19.ii	3								
1987									
5.i	3	-	-	-	-	-	-	-	-
12.i	6	-	-	-	-	-	-	-	-
19.i	10	2	-	-	-	-	-	-	2
26.i	9	-	-	-	-	-	-	-	-
2 .i	5	-	-	-	-	-	-	-	-
9 .ii	2	-	-	-	-	-	-	-	-
16.ii	2	-	-	-	-	-	-	-	-
23.ii	1	-	-	-	-	-	-	-	-

* Abbrev.: Av, Apanteles sp. (vitripennis species-group); Ca, Charops sp.; Cc, Campoletis chlorideae Uchida; Ch, Chelonus sp.; M, Microplitis sp; P, Peribaea orbata (Wiedemann); R, Rogas sp.

APPENDIX XIII

Status of different parasites attacking S.litura infesting cabbage crop at the Horticulture Farm at Udaipur (1986-87)

Date of sample	Host larvae collected	Larvae parasitized (Nos.) by parasite spp*							Total
		P	R	Av	Cc	M	Ca	Ch	
1986									
2.i	7	2	1	-	-	-	-	-	3
9.i	10	-	1	-	-	-	-	-	1
16.i	10	1	-	-	-	-	-	-	1
23.i	6	-	-	-	-	-	-	-	-
30.i	8	-	-	-	-	-	-	-	-
6.ii	8	-	-	-	-	-	-	-	-
13.ii	6	-	-	-	-	-	-	-	-
20.ii	3	-	-	-	-	-	-	-	-
1987									
7.i	3	1	-	-	-	-	-	-	1
14.i	5	1	1	-	-	-	-	-	2
21.i	6	-	-	-	-	-	-	-	-
28.i	8	-	-	-	-	-	-	-	-
4.ii	5	-	-	-	-	-	-	-	-
11.ii	3	-	-	-	-	-	-	-	-
18.ii	1	-	-	-	-	-	-	-	-
25.ii	1	-	-	-	-	-	-	-	-

* Abbrev.: Av, Apanteles sp. (vitripennis species-group); Ca, Charops sp.; Cc, Campoletis chlorideae Uchida; Ch, Chelonus sp.; Microplitis sp.; P, Peribaea orbata (Wiedemann); R, Rogas sp.

APPENDIX XIV a

Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (August - December,1985)

Date of sample	Larvae No./300 plants	Biotic factors		Abiotic factors				Rainfall (mm)
		Parasite No.	Disease No.	Temp(°C) Max.	Min.	R.H.(%)hrs 0735	1435	
13.viii	1	-	-	28.0	23.1	83.1	73.9	59.4
20.viii	3	-	-	28.0	23.6	85.9	77.6	78.6
27.viii	10	-	-	28.2	22.2	84.0	64.8	-
3.ix	27	3	3	28.2	21.5	86.0	65.0	0.4
10.ix	92	22	12	28.2	20.0	80.4	51.1	-
17.ix	141	29	10	32.1	22.0	72.1	46.4	-
24.ix	109	34	15	32.8	22.1	78.0	49.0	21.5
1.x	110	46	23	32.5	20.6	77.9	38.7	0.2
8.x	102	19	29	31.7	19.6	83.6	62.6	128.9
15.x	97	18	38	29.1	17.1	83.4	37.4	1.6
22.x	97	2	82	30.7	13.7	78.9	22.9	-
29.x	80	-	72	30.6	12.0	80.6	25.1	-
5.xi	43	4	32	31.0	12.2	82.4	21.9	-
12.xi	29	8	19	30.4	10.5	83.9	25.3	-
19.xi	31	11	12	29.3	9.1	81.9	24.4	-
26.xi	37	13	15	27.6	8.7	82.6	29.6	-
3.xii	31	8	9	27.7	9.0	85.0	33.1	-
10.xii	31	16	9	26.5	6.9	81.3	33.6	-
17.xii	29	16	3	26.1	11.9	91.0	48.1	2.9

APPENDIX XIV b

Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (July - December, 1986)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				Rainfall (mm)
		Parasite No.	Disease No.	Temp. (°C) Max.	Min.	R.H. (%) hrs 0735	1435	
26.vii	8	-	-	30.8	24.7	77.1	64.1	98.2
2.viii	10	-	-	26.4	22.3	87.6	72.7	50.0
9.viii	17	-	3	29.0	24.2	86.9	67.3	51.8
16.viii	18	-	5	27.7	23.7	82.3	75.6	46.0
23.viii	13	2	9	27.3	22.8	81.6	68.3	0.2
30.viii	19	4	1	28.7	19.6	82.1	57.3	-
6.ix	23	7	6	30.0	20.2	82.7	51.6	-
13.ix	40	11	14	31.6	20.8	77.7	46.0	-
20.ix	129	21	45	33.0	20.6	74.3	45.1	4.0
27.ix	105	12	69	34.5	19.2	73.6	29.6	-
4.x	5	-	5	34.7	21.0	83.4	37.0	11.0
11.x	10	-	2	34.6	18.9	81.0	32.1	-
18.x	15	1	1	34.4	17.3	76.1	28.1	-
25.x	20	5	7	31.8	14.2	59.3	41.1	-
1.xi	18	8	5	32.4	11.3	67.1	34.3	-
8.xi	17	3	11	30.3	14.0	72.3	35.6	-
15.xi	14	8	3	30.4	10.4	73.3	29.0	-
22.xi	6	2	-	28.4	8.7	73.0	31.0	-
29.xi	2	-	-	29.4	9.6	73.3	35.6	-
6.xii	2	-	-	30.9	8.1	77.6	45.7	-

APPENDIX XV a

Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (August - December, 1985)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				Rainfall (mm)
		Parasite No.	Disease No.	Temp.(°C) Max.	Min.	R.H.(%) hrs. 0735	1435	
6.viii	3	-	2	28.0	23.4	88.4	82.4	165.9
13.viii	3	-	-	28.0	23.1	83.1	73.9	59.4
20.viii	28	-	-	28.0	23.6	85.9	77.6	78.6
27.viii	42	2	-	28.2	22.2	84.0	64.8	-
3.ix	15	6	3	28.2	21.5	86.0	65.0	0.4
10.x	68	13	8	28.2	20.0	80.4	51.1	-
17.ix	138	51	20	32.1	22.0	72.1	46.4	-
24.ix	117	38	16	32.8	22.1	78.0	49.0	21.5
1. x	133	40	40	32.5	20.6	77.9	38.7	0.2
8. x	97	16	23	31.7	19.6	83.6	62.6	128.9
15.x	92	21	41	29.1	17.1	83.4	37.4	1.6
22.x	61	7	41	30.7	13.7	78.9	22.9	-
29.x	67	10	52	30.6	12.0	80.6	25.1	-
5.xi	48	5	21	31.0	12.2	82.4	21.9	-
12.xi	48	1	39	30.4	10.5	83.9	25.3	-
19.xi	33	14	9	29.3	9.1	81.9	24.4	-
26.xi	47	14	19	27.6	8.7	82.6	29.6	-
3.xii	42	7	19	27.7	9.0	85.0	33.1	-
10.xii	30	2	25	26.5	6.9	81.3	33.6	-
17.xii	25	5	17	26.1	11.9	91.0	48.1	2.9

APPENDIX XV b

Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (July - November, 1986)

Date of sample	Larvae No./300 plants	Biotic Factors Parasite No.	Disease No.	Abiotic Factors Temp. (°C) Max.	Mini.	R.H. (%) hrs. 0735	1435	Rainfall (mm)
21.vii	5	-	-	33.33	25.6	70.1	49.4	34.2
28.vii	20	2	1	28.2	23.3	82.7	75.7	138.1
4.viii	16	5	4	27.3	22.8	86.4	66.9	10.5
11.viii	19	4	5	28.5	24.2	89.3	71.9	55.4
18.viii	34	9	9	27.8	23.6	79.5	73.0	42.0
25.viii	83	12	48	27.4	21.8	81.0	67.1	0.2
1.ix	111	12	52	29.5	19.6	82.9	52.3	-
8.ix	212	41	155	30.5	20.4	82.0	51.3	-
15.ix	342	53	247	31.7	20.3	78.3	43.3	-
22.ix	108	18	47	33.2	20.2	70.3	43.1	4.0
29.ix	51	19	24	35.2	19.6	77.4	29.0	-
6.x	73	11	42	34.2	21.2	83.9	39.0	11.0
13.x	24	-	14	35.0	17.8	79.7	28.3	-
20.x	15	-	3	33.7	17.7	71.7	31.4	-
27.x	20	1	8	31.6	12.3	62.3	40.4	-
3.xi	15	1	10	32.7	11.9	67.9	34.1	-
10.xi	15	5	10	29.4	13.3	70.4	32.0	-
17.xi	5	1	2	30.4	10.9	75.7	33.6	-
24.xi	2	-	-	28.6	7.9	72.4	28.7	-

APPENDIX XVI a

Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (August - December, 1985)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				
		Parasite: No.	Disease No.	Temp.(°C) Max.	Min.	R.H.(%) hrs. 0735	1435	Rainfall (mm)
7.viii	10	2	-	28.0	23.4	88.3	80.0	160.0
14.viii	21	6	-	28.3	23.3	84.1	74.9	64.3
21.viii	29	11	1	27.8	23.4	86.3	76.6	73.2
28.viii	39	3	3	28.0	21.9	82.3	63.7	-
4.ix	28	9	8	28.2	21.9	84.7	65.1	0.4
11.ix	78	7	14	28.9	19.4	80.1	48.9	-
18.ix	115	35	19	32.1	22.8	73.7	46.7	-
25.ix	110	41	17	32.4	21.7	77.9	49.6	21.7
2.x	110	55	26	33.2	19.8	76.5	36.0	-
9.x	54	8	4	30.8	20.1	86.0	63.6	130.5
16.x	56	11	26	29.6	16.2	83.3	34.7	-
23.x	65	-	54	30.6	13.7	78.7	23.3	-
30.x	65	4	44	30.8	11.7	80.1	25.4	-
6.xi	39	1	26	30.9	11.8	82.3	22.0	-
13.xi	35	5	25	30.3	10.6	83.6	26.0	-
20.xi	33	18	6	29.3	8.7	80.7	23.7	-
27.xi	41	6	29	27.4	9.0	84.4	31.4	-
4.xii	33	2	17	27.4	8.6	83.9	32.5	-
11.xii	32	11	11	25.8	6.7	83.0	33.7	-
18.xii	31	9	11	26.9	12.9	92.3	52.3	2.9

APPENDIX XVI b

Field population of S.litura and the related data for biotic and key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (July - December, 1986)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				Rainfall (mm)
		Parasite. No.	Disease No.	Temp.(°C) Max.	Min.	R.H.(%) hrs 0735	1435	
30.vii	6	-	-	26.1	22.2	88.1	78.6	143.4
6.viii	12	-	-	28.6	23.6	85.6	65.6	21.8
13.viii	19	-	4	28.3	24.1	84.0	72.0	45.8
20.viii	28	4	12	27.0	23.0	83.4	73.9	36.2
27.viii	36	5	12	27.9	21.1	78.4	63.3	-
3.ix	93	11	42	30.0	19.8	84.1	51.3	-
10.ix	103	18	59	30.8	20.4	82.1	51.0	-
17.ix	115	20	61	32.4	20.5	74.0	39.4	-
24.ix	69	21	30	33.9	19.8	69.9	39.9	4.0
1.x	27	1	19	34.8	20.0	82.6	32.9	3.2
8.x	35	2	25	34.0	20.6	83.4	37.6	7.8
15.x	35	4	15	35.3	16.6	76.1	26.4	-
22.x	23	4	6	32.6	17.6	66.3	34.3	-
29.x	19	3	2	32.0	11.4	66.3	40.3	-
5.xi	15	3	7	31.7	13.9	70.7	36.3	-
12.xi	10	1	2	30.1	10.7	69.0	26.3	-
19.xi	5	-	-	29.3	10.5	77.4	35.7	-

APPENDIX XVII a

Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January - February, 1986)

Date of sample	Larvae No/300 plants	Biotic Factors Parasite No.	Disease No.	Abiotic Factors Temp.(°C) Max.	Min.	R.H.(%) hrs 0735	1435	Rainfall (mm)
1.i	5	-	-	24.8	7.6	87.6	35.3	-
8.i	11	4	3	22.0	2.3	84.3	30.0	-
15.i	2	-	-	23.7	6.1	84.6	31.3	-
22.i	6	-	2	23.9	7.8	85.4	37.1	-
29.i	4	-	3	25.7	8.3	82.6	42.3	-
5.ii	5	-	2	24.1	9.1	78.9	36.3	-
12.ii	5	-	3	23.5	10.1	76.0	45.0	5.3
19.ii	3	-	2	25.2	9.5	79.7	28.6	-

APPENDIX XVII b

Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January - February, 1987)

Date of sample	Larvae No./300 plants	Biotic Factors Parasite No	Disease No.	Abiotic Factors Temp.(°C) Max.	Min.	R.H.(%) hrs 0735	1435	Rainfall (mm)
3.i	2	-	1	22.4	3.0	82.7	43.6	-
10.i	5	2	1	23.5	9.2	83.6	52.1	-
17.i	9	1	1	20.6	10.9	84.3	55.7	1.0
24.i	7	-	2	21.6	5.3	79.6	35.9	-
31.i	4	-	2	27.6	5.1	81.7	28.6	-
7.ii	4	-	1	26.2	7.4	75.1	38.7	-
14.ii	2	-	-	27.7	7.2	77.7	40.0	-
21.ii	1	-	-	28.3	9.4	66.3	28.7	-

APPENDIX XVIII a

Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (January - February, 1986)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				Rainfall (mm)
		Parasite. No.	Disease No.	Temp. (°C) Max.	Min.	R.H. (%) 0735	hrs 1435	
1.i	6	-	2	24.8	7.6	87.6	35.3	-
8.i	12	-	4	22.1	2.3	84.3	30.0	-
15.i	8	-	3	23.7	6.1	84.6	31.3	-
22.i	7	-	4	23.9	7.8	85.4	37.1	-
29.i	6	-	1	25.7	8.3	82.6	42.3	-
5.ii	6	-	3	24.1	9.1	78.9	36.3	-
12.ii	3	-	2	23.5	10.1	76.0	45.0	5.3
19.ii	3	-	3	25.2	9.5	79.7	28.6	-

APPENDIX XVIII b

Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at village Chotinauka, Udaipur (January - February, 1987)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				Rainfall (mm)
		Parasite No.	Disease No.	Temp. (°C) Max.	Min.	R.H. (%) 0735	hrs. 1435	
5.i	3	-	-	23.7	4.4	79.9	39.7	-
12.i	6	-	2	22.0	9.9	88.0	64.6	-
19.i	10	2	3	20.7	9.4	84.6	46.0	1.0
26.i	9	-	2	23.6	4.6	78.0	33.4	-
2.ii	5	-	1	27.8	6.7	77.7	29.4	-
9.ii	2	-	1	26.0	6.7	77.3	41.1	-
16.ii	2	-	-	28.3	7.8	73.7	35.0	-
23.ii	1	-	-	28.7	10.9	65.7	31.7	-

APPENDIX XIX a

Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (January - February, 1986)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				
		Parasite No.	Disease No.	Temp.(°C) Max.	Min.	R.H.(%)hrs 0735	1435	Rainfall (mm)
2.i	7	3	1	23.7	6.4	87.1	31.9	-
9.i	10	1	3	22.5	2.4	84.9	29.6	-
16.i	10	1	5	23.8	6.5	84.0	32.3	-
23.i	6	-	1	24.1	7.8	84.4	36.7	-
30.i	8	-	7	25.8	9.1	83.6	44.9	-
6.ii	8	-	3	23.7	8.8	73.0	32.0	-
13.ii	6	-	5	23.8	10.5	81.7	46.3	5.3
20.ii	3	-	1	25.4	9.0	78.3	26.6	-

APPENDIX XIX b

Field population of S.litura and the related data for biotic and key abiotic factors in cabbage crop at the Horticulture Farm, Udaipur (January - February, 1987)

Date of sample	Larvae No./300 plants	Biotic Factors		Abiotic Factors				
		Parasite: No.	Disease No.	Temp.(°C) Max.	Min.	R.H.(%)hrs. 0735	1435	Rainfall (mm)
7.i	3	1	1	24.2	5.9	81.3	40.7	-
14.i	5	2	1	20.4	10.8	88.9	65.6	-
21.i	6	-	2	21.2	7.7	82.9	42.1	1.0
28.i	8	-	3	25.4	4.6	78.4	31.4	-
4.ii	5	-	2	27.2	7.8	77.4	33.6	-
11.ii	3	-	1	26.4	6.2	75.7	42.1	-
18.ii	1	-	1	28.3	8.1	69.9	31.1	-
25.ii	1	-	-	28.9	11.6	70.6	33.1	

APPENDIX XX a

Pupal population of S.litura and the related data for biotic factors in cauliflower crop at Kushalbag Farm, Udaipur (1985 - 86)

Date of sample	Larvae No./300 plants	Pupation		Pupal mortality	
		No.	%	No.	%
1.	2.	3.	4.	5.	6.
1985					
13.viii	1	1	100.0	-	-
20.viii	3	3	100.0	-	-
27.viii	10	10	100.0	-	-
3.ix	27	21	77.8	15	55.5
10.ix	92	58	63.0	28	30.4
17.ix	141	102	72.3	24	17.0
24.ix	109	60	55.0	21	19.2
1.x	110	41	37.3	20	18.2
8.x	102	54	52.9	31	30.4
15.x	97	41	42.3	24	24.7
22.x	97	13	13.4	7	7.2
29.x	80	8	10.0	5	6.2
5.xi	43	7	16.3	5	11.6
12.xi	29	2	6.9	1	3.4
19.xi	31	8	25.8	5	16.1
26.xi	37	9	24.3	4	10.8
3.xii	31	14	45.2	8	25.8
10.xii	31	6	19.3	5	16.1
17.xii	29	10	34.5	7	24.1

Contd..

Contd. Appendix XX a

1.	2.	3.	4.	5.	6.
1986					
26.vii	8	8	100.0	-	-
2 .viii	10	10	100.0	-	-
9 .viii	17	14	82.3	4	23.5
16.viii	18	13	72.2	2	11.1
23.viii	13	2	15.4	-	-
30.viii	19	14	73.7	3	15.8
6.ix	23	10	43.5	2	8.7
13.ix	40	15	37.5	3	7.5
20.ix	129	63	48.8	21	16.3
27.ix	105	24	22.9	12	11.4
4.x	5	-	-	-	-
11.x	10	8	80.0	1	10.0
18.x	15	13	86.7	3	20.0
25.x	20	8	40.0	2	10.0
1.xi	18	5	27.8	1	5.5
8.xi	17	3	17.6	1	5.9
15.xi	14	3	21.4	-	-
22.xi	6	4	66.7	2	33.3
29.xi	2	2	100.0	1	50.0
6.xii	2	2	100.0	-	-

APPENDIX XX b

Pupal population of S.litura and the related data for biotic factors in cauliflower crop at village Chotinauka, Udaipur (1985 - 86)

Date of sample	Larvae No./300 plants	Pupation		Pupal mortality	
		No.	%	No.	%
1985					
6.viii	3	1	33.3	-	-
13.viii	3	3	100.0	-	-
20.viii	28	28	100.0	4	14.3
27.viii	42	40	95.2	10	23.8
3.ix	15	6	40.0	3	20.0
10.ix	68	47	69.1	20	29.4
17.ix	138	67	48.5	20	14.5
24.ix	117	63	53.8	17	14.5
1.x	133	53	39.8	26	19.5
8.x	97	58	59.8	22	22.7
15.x	92	30	32.6	16	17.4
22.x	61	13	21.3	7	11.5
29.x	67	5	7.5	3	4.5
5.xi	48	22	45.8	12	25.0
12.xi	48	8	16.7	5	10.4
19.xi	33	10	30.3	4	12.1
26.xi	47	14	29.8	5	10.6
3.xii	42	16	38.1	5	11.9
10.xii	30	3	10.0	1	3.3
17.xii	25	3	12.0	3	12.0

Contd..

Contd. Appendix XX b

1.	2.	3.	4.	5.	6.
1986					
21.vii	5	5	100.0	-	-
28.vii	20	17	85.0	4	20.0
4.viii	16	7	43.7	-	-
11.viii	19	10	52.6	3	15.7
18.viii	34	16	47.0	5	14.7
25.viii	83	23	27.7	6	7.2
1.ix	111	47	42.3	12	10.8
8.ix	212	16	7.5	7	3.3
15.ix	342	42	12.3	16	4.7
22.ix	108	43	39.8	8	7.4
29.ix	51	8	15.7	3	5.8
6.x	73	20	27.4	4	5.5
13.x	24	10	41.6	2	8.3
20.x	15	12	80.0	3	20.0
27.x	20	11	55.0	2	10.0
3.xi	15	4	26.6	1	6.6
10.xi	15	-	-	-	-
17.xi	5	2	40.0	1	20.0
24.xi	2	2	100.0	2	100.0

APPENDIX XX c

Pupal population of S.litura and the related data for biotic factors in cauliflower crop at Horticulture Farm, Udaipur (1985 - 86)

Date of sample	Larvae No./300 plants	Pupation		Pupal mortality	
		No.	%	No.	%
1985					
7.viii	10	6	60.0	2	20.0
14.viii	21	9	42.9	2	9.5
21.viii	29	17	58.6	4	13.8
28.viii	39	33	84.6	13	33.3
4.ix	28	25	89.3	16	57.1
11.ix	78	56	71.8	23	29.5
18.ix	115	61	53.0	27	23.5
25.ix	110	52	47.3	13	11.8
2.x	110	29	26.4	9	8.2
9.x	54	42	77.8	24	44.4
16.x	56	19	33.9	7	12.5
23.x	65	11	16.9	7	10.7
30.x	65	17	26.2	16	24.6
6.xi	39	12	30.8	9	23.0
13.xi	35	5	14.3	4	11.4
20.xi	33	9	27.3	7	21.2
27.xi	41	6	14.6	5	12.2
4.xii	33	14	42.4	6	18.2
11.xii	32	10	31.2	6	18.7
18.xii	31	11	35.5	6	19.3

Contd..

1.	2.	3.	4.	5.	6.
1986					
30.vii	6	6	100.0	-	-
6.viii	12	12	100.0	2	16.6
13.viii	19	15	78.9	-	-
20.viii	28	12	42.9	1	3.6
27.viii	36	19	52.8	4	11.1
3.ix	93	40	43.0	7	7.5
10.ix	103	26	25.2	5	4.8
17.ix	115	34	29.6	8	6.9
24.ix	69	18	26.1	3	4.3
1.x	27	7	25.9	1	3.7
8.x	35	8	22.8	1	2.8
15.x	35	16	45.7	4	11.4
22.x	23	13	56.5	5	21.7
29.x	19	14	73.6	-	-
5.xi	15	5	33.3	1	6.6
12.xi	10	7	70.0	2	20.0
19.xi	5	5	100.0	1	20.0

APPENDIX XXI a

Pupal population of S.litura and the related data for biotic factors in cabbage crop at Kushalbag Farm, Udaipur (1986 - 87)

Date of sample	Larvae No./300 plants	Pupation		Pupal mortality	
		No.	%	No.	%
1986					
1.i	5	3	60.0	1	20.0
8.i	11	4	36.4	2	18.1
15.i	2	2	100.0	-	-
22.i	6	4	66.7	1	16.6
29.i	4	1	25.0	-	-
5.ii	5	3	60.0	1	20.0
12.ii	5	2	40.0	-	-
19.ii	3	1	33.3	-	-
1987					
3 .i	2	1	50.0	1	50.0
10.i	5	2	40.0	1	20.0
17.i	9	7	77.7	6	66.6
24.i	7	5	71.4	5	71.4
31.i	4	2	50.0	1	25.0
7.ii	4	3	75.0	2	50.0
14.ii	2	2	100.0	2	100.0
21.ii	1	1	100.0	1	100.0

APPENDIX XXI b

Pupal population of S.litura and the related data for biotic factors in cabbage crop at village Chotinauka, Udaipur (1986 - 87)

Date of sample	Larvae No./300 plants	Pupation		Pupal mortality	
		No.	%	No.	%
1986					
1.i	6	4	66.7	1	16.6
8.i	12	8	66.7	2	16.6
15.i	8	5	62.5	2	25.0
22.i	7	3	42.9	1	14.3
29.i	6	5	83.3	2	33.3
5.ii	6	3	50.0	1	16.6
12.ii	3	1	33.3	-	-
19.ii	3	-	-	-	-
1987					
5.i	3	3	100.0	-	-
12.i	6	4	66.6	1	16.6
19.i	10	5	50.0	1	10.0
26.i	9	7	77.0	-	-
2.ii	5	4	80.0	1	20.0
9.ii	2	1	50.0	-	-
16.ii	2	2	100.0	1	50.0
23.ii	1	1	100.0	-	-

APPENDIX XXI c

Pupal population of S.litura and the related data for biotic factors in cabbage crop at Horticulture Farm, Udaipur (1986 - 87)

Date of sample	Larvae No./300 plants	Pupation		Pupal mortality	
		No.	%	No.	%
1986					
2.i	7	3	42.8	1	14.3
9.i	10	6	60.0	1	10.0
16.i	10	4	40.0	1	10.0
23.i	6	5	83.3	2	33.3
30.i	8	1	12.5	-	-
6.ii	8	5	62.5	2	25.0
13.ii	6	1	16.7	-	-
20.ii	3	2	66.7	-	-
1987					
7.i	3	1	33.3	-	-
14.i	5	2	40.0	-	-
21.i	6	4	66.6	1	16.6
28.i	8	5	62.5	-	-
4.ii	5	3	60.0	1	20.0
11.ii	3	2	66.6	1	33.3
18.ii	1	-	-	-	-
25.ii	1	1	100.0	1	100.0

APPENDIX XXII a

Field population of the parasite, *P.orbata* parasitizing *S.litura* and the related data for key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (August - December, 1985)

Date of sample	Larvae No./300 plants	*P.orbata* No.	Abiotic factors				Rainfall (mm)
			Temp. (°C)		R.H. (%) hrs		
			Max.	Min.	0735	1435	
13.viii	1	-	28.0	23.1	83.1	73.9	59.4
20.viii	3	-	28.0	23.6	85.9	77.6	78.6
27.viii	10	-	28.2	22.2	84.0	64.8	-
3.ix	27	-	28.2	21.5	86.0	65.0	0.4
10.ix	92	14	28.2	20.0	80.4	51.1	-
17.ix	141	8	32.1	22.0	72.1	46.4	-
24.ix	109	17	32.8	22.1	78.0	49.0	21.5
1.x	110	12	32.5	20.6	77.9	38.7	0.2
8.x	102	5	31.7	19.6	83.6	62.6	128.9
15.x	97	15	29.1	17.1	83.4	37.4	1.6
22.x	97	-	30.7	13.7	78.9	22.9	-
29.x	80	-	30.6	12.0	80.6	25.1	-
5.xi	43	3	31.0	12.2	82.4	21.9	-
12.xi	29	7	30.4	10.5	83.9	25.3	-
19.xi	31	8	29.3	9.1	81.9	24.4	-
26.xi	37	8	27.6	8.7	82.6	29.6	-
3.xii	31	3	28.7	9.0	85.0	33.1	-
10.xii	31	3	26.5	6.9	81.3	33.6	-
17.xii	29	8	26.1	11.9	91.0	48.1	2.9

APPENDIX XXII b

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cauliflower crop at Kushalbag Farm, Udaipur (July - December, 1986)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				Rainfall (mm)
			Temp. (°C)		R.H. (%) hrs		
			Max.	Mini.	0735	1435	
26.vii	8	-	30.8	24.7	77.1	64.1	98.2
2.viii	10	-	26.4	22.3	87.6	72.7	50.0
9.viii	17	-	29.0	24.2	86.9	67.3	51.8
16.viii	18	-	27.7	23.7	82.3	75.6	46.0
23.viii	13	1	27.3	22.8	81.6	68.3	0.2
30.viii	19	4	28.7	19.6	82.1	57.3	-
6.ix	23	4	30.0	20.2	82.7	51.6	-
13.ix	40	5	31.6	20.8	77.7	46.0	-
20.ix	129	15	33.0	20.6	74.3	45.1	4.0
27.ix	105	6	34.5	19.2	73.6	29.6	-
4.x	5	-	34.7	21.0	83.4	37.0	11.0
11.x	10	-	34.6	18.9	81.0	32.1	-
18.x	15	1	34.4	17.3	76.1	28.1	-
25.x	20	1	31.8	14.2	59.3	41.1	-
1 .xi	18	4	32.4	11.3	67.1	34.3	-
8 .xi	17	-	30.3	14.0	72.3	35.6	-
15.xi	14	3	30.4	10.4	73.3	29.0	-
22.xi	6	2	28.4	8.7	73.0	31.0	-
29.xi	2	-	29.4	9.6	73.0	35.6	-
6.xii	2	-	30.9	8.1	77.6	45.7	-

APPENDIX XXIII a

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (August - December, 1985)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				Rainfall (mm)
			Temp. (°C)		R.H. (%) hrs		
			Max.	Min.	0735	1435	
6.viii	3	-	28.0	23.4	88.4	82.4	165.9
13.viii	3	-	28.0	23.1	83.1	73.9	59.4
20.viii	28	-	28.0	23.6	85.9	77.6	78.6
27.viii	42	2	28.2	22.2	84.0	64.8	-
3.ix	15	6	28.2	21.5	86.0	65.0	0.4
10.ix	68	8	28.2	20.0	80.4	51.1	-
17.ix	138	24	32.1	22.0	72.1	46.4	-
24.ix	117	19	32.8	22.1	78.0	49.0	21.5
1.x	133	24	32.5	20.6	77.9	38.7	0.2
8.x	97	6	31.7	19.6	83.6	62.6	128.9
15.x	92	19	29.1	17.1	83.4	37.4	1.6
22.x	61	4	30.7	13.1	78.9	22.9	-
29.x	67	6	30.6	12.0	80.6	25.1	-
5.xi	48	2	31.0	12.2	82.4	21.9	-
12.xi	48	-	30.4	10.5	83.9	25.3	-
19.xi	33	7	29.3	9.1	81.9	24.4	-
26.xi	47	3	27.6	8.7	82.6	29.6	-
3.xii	42	1	27.7	9.0	85.0	33.1	-
10.xii	30	-	26.5	6.9	81.3	33.6	-
17.xii	25	2	26.1	11.9	91.0	48.1	2.9

APPENDIX XXIII b

Field population of the parasite, *P.orbata* parasitizing *S.litura* and the related data for key abiotic factors in cauliflower crop at village Chotinauka, Udaipur (July - November, 1986)

Date of sample	Larvae No./300 plants	*P.orbata* No.	Abiotic factors				Rainfall (mm)
			Temp (°C)		R.H. (%) hrs		
			Max.	Min.	0735	1435	
21.vii	5	-	33.3	25.6	70.1	49.4	34.2
28.vii	20	-	28.2	23.3	82.7	75.7	138.1
4.viii	16	3	27.3	22.8	86.4	66.9	10.5
11.viii	19	4	28.5	24.2	89.3	71.9	55.4
18.viii	34	4	27.8	23.6	79.5	73.0	42.0
25.viii	83	8	27.4	21.8	81.0	67.1	0.2
1.ix	111	10	29.5	19.6	82.9	52.3	-
8.ix	212	23	30.5	20.4	82.0	51.3	-
15.ix	342	22	31.7	20.3	78.3	43.3	-
22.ix	108	12	33.2	20.2	70.3	43.1	4.0
29.ix	51	12	35.2	19.6	77.4	29.0	-
6.x	73	8	34.2	21.2	83.9	39.0	11.0
13.x	24	-	35.0	17.8	79.7	28.3	-
20.x	15	-	33.7	17.7	71.7	31.4	-
27.x	20	1	31.6	12.3	62.3	40.4	-
3.xi	15	1	32.7	11.9	67.9	34.1	-
10.xi	15	3	29.4	13.3	70.4	32.0	-
17.xi	5	1	30.4	10.9	75.7	33.6	-
24.xi	2	-	28.6	7.9	72.4	28.7	-

APPENDIX XXIV a

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (August - December, 1985)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp.(°C)		R.H.(%)	hrs	Rainfall (mm)
			Max.	Mini.	0735	1435	
7.viii	10	-	28.0	23.4	88.3	80.0	160.0
14.viii	21	-	28.3	23.3	84.1	74.9	64.3
21.viii	29	-	27.8	23.4	86.3	76.6	73.2
28.viii	39	2	28.0	21.9	82.3	63.7	-
4.ix	28	6	28.2	21.9	84.7	65.1	0.4
11.ix	78	2	28.9	19.4	80.1	48.9	-
18.ix	115	20	32.1	22.8	73.7	46.7	.
25.ix	110	21	32.4	21.7	77.9	49.6	21.7
2.x	110	30	33.2	19.8	76.5	36.0	-
9.x	54	4	30.8	20.1	86.0	63.6	130.5
16.x	56	8	29.6	16.2	83.3	34.7	-
23.x	65	-	30.6	13.7	78.7	23.3	-
30.x	65	3	30.8	11.7	80.1	25.4	-
6.xi	39	-	30.9	11.8	82.3	22.0	-
13.xi	35	2	30.3	10.6	83.6	26.0	-
20.xi	33	2	29.3	8.7	80.7	23.7	-
27.xi	41	2	27.4	9.0	84.4	31.4	-
4.xii	33	1	27.4	8.6	83.9	32.5	-
11.xii	32	3	25.8	6.7	83.0	33.7	-
18.xii	31	4	26.9	12.9	92.3	52.3	2.9

APPENDIX XXIV b

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cauliflower crop at Horticulture Farm, Udaipur (July - December, 1986)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp. (°C)		R.H. (%) hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
30.vii	6	-	26.1	22.2	88.1	78.6	143.4
6.viii	12	-	28.6	23.6	85.6	65.6	21.8
13.viii	19	-	28.3	24.1	84.0	72.0	45.8
20.viii	28	4	27.0	23.0	83.4	73.9	36.2
27.viii	36	4	27.9	21.1	78.4	63.3	-
3.ix	93	6	30.0	19.8	84.1	51.3	-
10.ix	103	8	30.8	20.4	82.1	51.0	-
17.ix	115	11	32.4	20.5	74.0	39.4	-
24.ix	69	12	33.9	19.8	69.9	39.9	4.0
1.x	27	-	34.8	20.0	82.6	32.9	3.2
8.x	35	1	34.0	20.6	83.4	37.6	7.8
15.x	35	3	35.3	16.6	76.1	26.4	-
22.x	23	2	32.6	17.6	66.3	34.3	-
29.x	19	1	32.0	11.4	66.3	40.3	-
5.xi	15	1	31.7	13.9	70.7	36.3	-
12.xi	10	1	30.1	10.7	69.0	26.3	-
19.xi	5	-	29.3	10.5	77.4	35.7	-

APPENDIX XXV a

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January-February, 1986)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp.(°C)		R.H.(%) hrs.		Rainfall (mm)
			Max.	Mini.	0735	1435	
1.i	5	-	24.8	7.6	87.6	35.3	-
8.i	11	2	22.0	2.3	84.3	30.0	-
15.i	2	-	23.7	6.1	84.6	31.3	-
22.i	6	-	23.9	7.8	85.4	37.1	-
29.i	4	-	25.7	8.3	82.6	42.3	-
5.ii	5	-	24.1	9.1	78.9	36.3	-
12.ii	5	-	23.5	10.1	76.0	45.0	5.3
19.ii	3	-	25.2	9.5	79.7	28.6	-

APPENDIX XXV b

Field population of the parasite, P. orbata parasitizing S.litura and the related data for key abiotic factors in cabbage crop at Kushalbag Farm, Udaipur (January - February, 1987)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp.(°C)		R.H.(%)hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
3.i	2	-	22.4	3.0	82.7	43.6	-
10.i	5	1	23.5	9.2	83.6	52.1	-
17.i	9	1	20.6	10.9	84.3	55.7	1.0
24.i	7	-	21.6	5.3	79.6	35.9	-
31.i	4	-	27.6	5.1	81.7	28.6	-
7.ii	4	-	26.2	7.4	75.1	38.7	-
14.ii	2	-	27.7	7.2	77.7	40.0	-
21.ii	1	-	28.3	9.4	66.3	20.7	-

APPENDIX XXVI

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cabbage crop at village Chotinauka, Udaipur (January - February, 1987)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp.(°C)		R.H.(%) hrs		Rainfall (mm)
			Max.	Mini.	0435	1435	
5.i	3	-	23.7	4.4	79.9	39.7	-
12.i	6	-	22.0	9.9	88.0	64.6	-
19.i	10	2	20.7	9.4	84.6	46.0	1.0
26.i	9	-	23.6	4.6	78.0	33.4	-
2.ii	5	-	27.8	6.7	77.7	29.4	-
9.ii	2	-	26.0	6.7	77.3	41.1	-
16.ii	2	-	28.3	7.8	73.7	35.0	-
23.ii	1	-	28.7	10.9	65.7	31.7	-

APPENDIX XXVII a

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (January - February, 1986)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp. (°C)		R.H. (%) hrs		Rainfall (mm)
			Max..	Min.	0735	1435	
2.i	7	2	23.7	6.4	87.1	31.9	-
9.i	10	-	22.5	2.4	84.9	29.6	-
16.i	10	1	23.8	6.5	84.0	32.3	-
23.i	6	-	24.1	7.8	84.4	36.7	-
30.i	8	-	25.8	9.1	83.6	44.9	-
6.ii	8	-	23.7	8.8	73.0	32.0	-
13.ii	6	-	23.8	10.5	81.7	46.3	5.3
20.ii	3	-	25.4	9.0	78.3	26.6	-

APPENDIX XXVII b

Field population of the parasite, P.orbata parasitizing S.litura and the related data for key abiotic factors in cabbage crop at Horticulture Farm, Udaipur (January - February, 1987)

Date of sample	Larvae No./300 plants	P.orbata No.	Abiotic factors				
			Temp. (°C)		R.H. (%) hrs		Rainfall (mm)
			Max.	Min.	0735	1435	
7.i	3	1	24.2	5.9	81.3	40.7	-
14.i	5	1	20.4	10.8	88.9	65.6	-
21.i	6	-	21.2	7.7	82.9	42.1	1.0
28.i	8	-	25.4	4.6	78.4	31.4	-
4.ii	5	-	27.2	7.8	77.4	33.6	-
11.ii	3	-	26.4	6.2	75.7	42.1	-
18.ii	1	-	28.3	8.1	69.9	31.1	-
25.ii	1	-	28.9	11.6	70.6	33.1	-

APPENDIX XXVIII

Test of significance of effectiveness of insecticides on the emergence of *T. chilonis* under laboratory conditions (Ref. Table 27 a,b)

Source of variance	Degrees of freedom	M.S.S.
Periods	8	2434.5213**
Treatments	8	15440.797**
Control / Rest	1	67947.405**
Rest	7	7939.8535**
Insecticide	3	16891.636**
Dose	1	4008.3922**
Insecticide x Dose	3	298.5576**
Period x Treatments	64	420.6817**
Error	262	4.4887

** Significant at 1.0 per cent level of significance.

APPENDIX XXIX

Test of significance of effect of insecticides on the adults of the parasite, P.orbata along with its host larvae (S. litura) under laboratory conditions (Ref. Table 28)

Source of variance	Degrees of freedom	Serial cumulative mortality (%)	
		Parasite M.S.S.	Host M.S.S.
(a)			
Treatment	9	1232.3882 **	570.5278 **
Error	20	13.5753	3.7919
(b)			
Treatment	9	2042.5914 **	750.4182 **
Error	20	43.1339	12.0796
(c)			
Treatment	9	2397.2600 **	1280.6667 **
Error	20	20.0330	16.1325
(d)			
Treatment	9	2323.4623 **	2190.8316 **
Error	20	13.85	34.1

** Significant at 1 per cent level of significance

N.B.- Observations at (a) 18 hours, (b) 24 hours, (c) 48 hours, and (d) 72 hours following exposure of parasite and host to treated plants.