ICAR - National Bureau of Agricultural Insect Resources
(Indian Council of Agricultural Research)
Bengaluru 560 024, India
(ISO 9001:2008 Certified Institution)

Annaul Report 2014 - 2015

ICAR - NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES

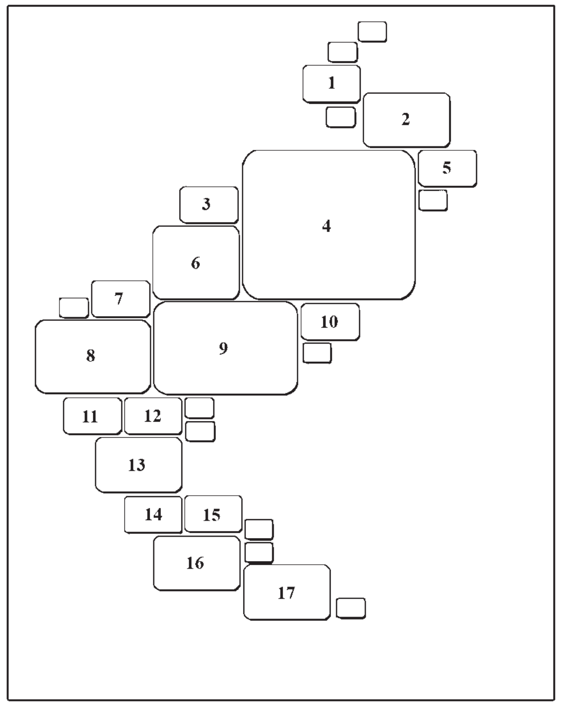
ICAR - NBAIR

भाकृअनुप
ICAR

ANNUAL REPORT 2014-15
वार्षिक प्रतिवेदन

NBAIR

ICAR - National Bureau of Agricultural Insect Resources
राष्ट्रीय कृषि कीट संसाधन ब्यूरो



Front cover

1. *Tuta absoluta* (Meyrick): a leafminer and borer that is assumming importance as a pest of tomato in our country
2. *Parapanteles arka* Gupta: A gregarious larval parasitoid of the Indian sunbeam butterfly
3. *Pseudococcus calceolariae* (Maskell): A mealybug recorded for the first time from India
4. Shri. Radha Mohan Singh, Honorable Union Minister for Agriculture with staff of NBAIR during his visit to the bureau on 2nd April, 2015
5. *Chakra sarvatra* Rajmohana and Veenakumari: A new genus and species of Platygastridae described from India
6. *Anisopteromalus indicus* Gupta and Sureshan: A gregarious pupal parasitoid of a lymantrid moth
7. *Phenacoccus madeirensis* Green: A mealybug that has been
8. *Protelenomus flavicornis* Kieffer: A platygastrid wasp that is phoretic on the coreid bug *Anoplocnemis phasiana* (F.)
9. *Calvia explanata* Poorani: A new species of Coccinellidae described from India
10. *Anthocoris muraleedharani* Yamada: A newly described species of anthocorid bug that feeds on the striped mealybug, *Ferrisia virgata* (Cockerell)
11. *Anagyrus aquilonaris* (Noyes and Hayat), a mealybug parasitoid
12. *Kikiki huna* Huber: The smallest flying insect in the world which has recently been found to occur in India too
13. *Formicoccus polysperes* Williams: A mealybug that is becoming important as a pest of turmeric
14. *Blaptostethus pallescens* Poppius: A potential anthocorid predator of primary and secondary stored product pests
15. *Uroleucon compositae* (Theobald): The aphid that continues to pose a problem to safflower cultivation in the country
16. *Parapanteles athamasae* Gupta *et. al.*: A gregarious larval parasitoid of the common nawab butterfly
17. *Oligosita giraulti* Crawford: A trichogrammatid being reported for the first time from India

Photo credits: 2,6,16 Ankita Gupta; 5,8,17 K. Veenakumari; 4 A.N. Shylesha; 3,7,13,15 Sunil Joshi; 1,10,11,12,14 J. Poorani

Back cover
Laboratory complex at the Yelahanka campus of NBAIR
Photo credit: T.M. Shivalingaswamy

Cover design: Sunil Joshi

A brainstorming session was conducted on 'Insects Related to Veterinary and Fishery Sciences' on 2nd August, 2014

86th ICAR Foundation Day was celebrated on 16th July, 2014. Dr. S.P. Singh and Dr. V.V. Ramamurthy were felicitated.

An international training programme on 'Bio-Intensive Pest and Disease Management' was organised for officials from Iraq from 1st -15th June, 2014

A three day 'International Training Programme on the Biosystematics of Potato Aphids' was organised from 3rd - 5th June, 2014

A brainstorming on 'Bio-security issues in Relation to Insects and Quarantine' and celebration of the success of 'Biological Control of Eucalyptus Gall Wasp' was organised on 26th August, 2014

Mr. R. Rajagopal, Secretary (ICAR) and Additional Secretary (DARE) visited NBAIR on 17th January, 2015

Dr. S. Ayyapan, Secretary, DARE and DG, ICAR inaguarated the office of the Society for Biocontrol Advencement on 19th April, 2014

NBAIR celebrated 'Hindi Pakhwada' from 15th - 29th September, 2014

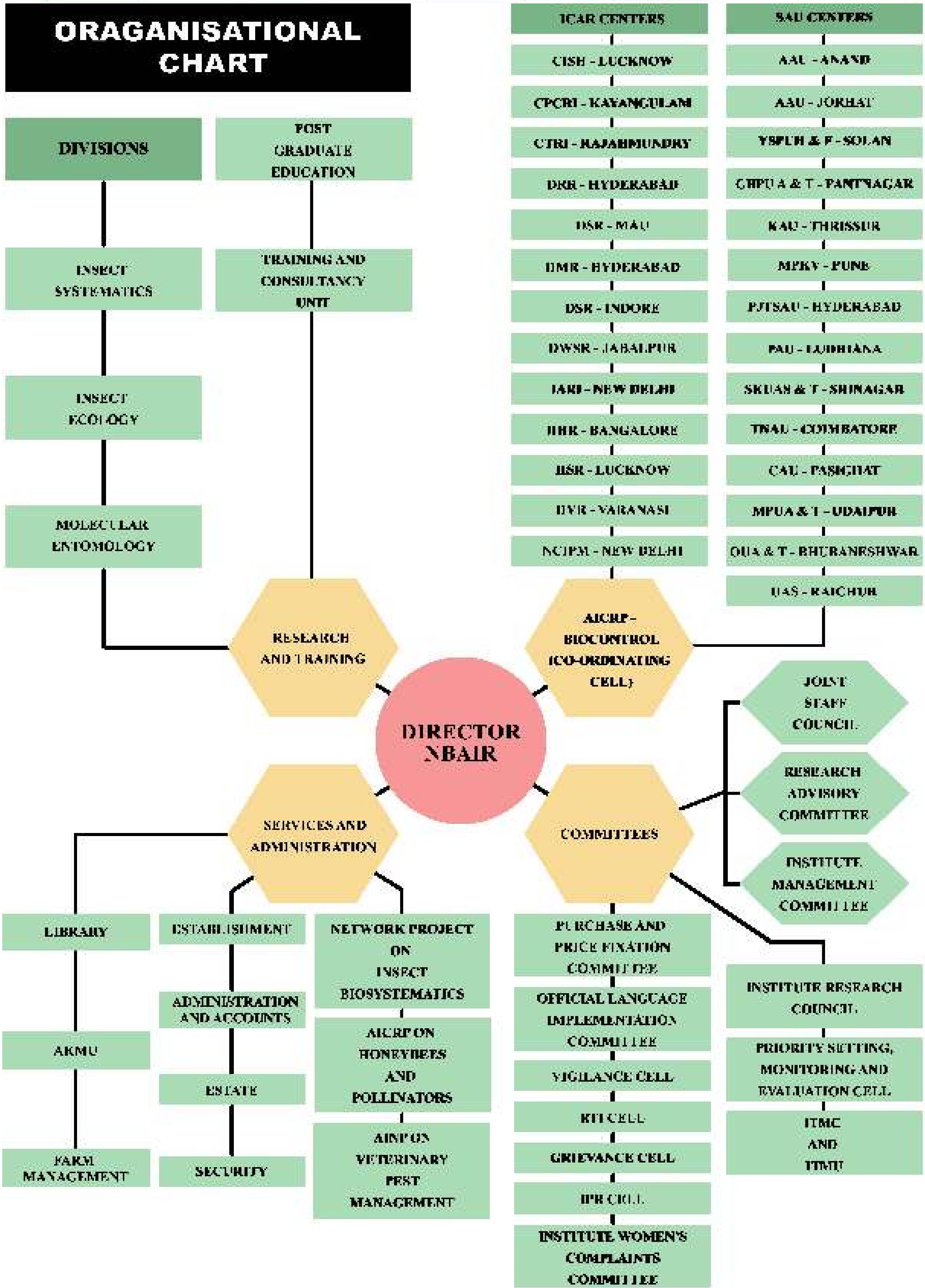


Fig. 1. Organisational Chart of NBAIR

CHAPTER 3

Financial Statement for 2014-15
National Bureau of Agricultural Insect Resources
Bengaluru

(₹ in lakhs)

Head	Plan	Non-Plan	Total
Pay & Allowances	0.00	664.37	664.37
T.A	11.00	5.00	16.00
Other charges including equipments	138.18	140.49	278.69
Information technology	0.00	0.00	0.00
Works/petty works	0.00	19.40	19.40
HRD	2.34	0.00	2.34
Pension	0.00	12.83	12.83
Loan	0.00	3.00	3.00
TOTAL	**151.52**	**845.09**	**996.61**

AICRP on Biological Control of Crop Pests
Expenditure (2014-15)
(ICAR share only)

(₹ in lakhs)

Sl. No	NAME OF THE CENTRE	Expenditure
1	AAU, ANAND	52.40
2	AAU, JORHAT	31.26
3	ANGRAU, HYDERABAD	32.40
4	DR.YSPUH&F, SOLAN	33.82
5	GBPUAT, PANTNAGAR	19.20
6	KAU, THRISSUR	34.60
7	MPKV, PUNE	34.57
8	PAU, LUDHIANA	67.70
9	SKUAT, SRINAGAR	34.50
10	TNAU, COIMBATORE	41.50
11	MPUAT, UDAIPUR	4.00
12	OUAT, BHUWANESHWAR	2.90
13	CAU, PASIGHAT	1.29
14	UAS, RAICHUR	1.86
15	P.C.CELL, NBAIR, BENGALURU	5.00
	TOTAL	**397.00**

RESEARCH ACHIEVEMENTS

National Bureau of Agricultural Insect Resources

DIVISION OF INSECT SYSTEMATICS

Surveys

Exploratory surveys were undertaken in twelve states of the country. Northeast India being an internationally recognized hotspot of biological diversity was a major area of study. The states of Arunachal Pradesh, Sikkim, Nagaland and Assam were surveyed by various teams for insects and insect related resources like entomopathogens and entomopathogenic nematodes.The other states surveyed were Uttar Pradesh, Uttarakhand, Himachal Pradesh, Punjab, Tamil Nadu, Kerala, Karnataka and Gujarat.

Digitization of type specimens in NBAII collections

A total of 184 types including 121 holotypes, 60 paratypes, 1 cotype and 2 allotypes were completed and hosted on NBAIR website. Details of original combination, current valid name, sex / stage of the type, type status, verbatim label data, and original publication are provided for the types at NBAIR. Images of the type specimen(s) featuring the diagnostic characters are provided, wherever available, for primary types. Hyperlinks are provided to the original publication in which the species description appears wherever open access is available **(Figs. 2, 3).**


Type Specimens in NBAIR Collections

Species List

1. ***acaciae*** Tyagi & Vikas Kumar 2011, ***Liophloeothrips*** Phlaeothripidae Thysanoptera Holotype
2. ***achaeae*** Nagaraja & Nagarkatti 1970, ***Trichogramma*** Trichogrammatidae Hymenoptera Paratype
3. ***adelgivora*** Poorani 2002, ***Oenopia*** Coccinellidae Coleoptera Holotype
4. ***aethes*** Hayat 2014, ***Encarsia*** Aphelinidae Hymenoptera Holotype
5. ***aitkeni*** Veenakumari & Buhl 2014, ***Synopeas*** Platygastridae Hymenoptera Holotype
6. ***albifuniculata*** Hayat 2014, ***Caenohomalopoda*** Encyrtidae Hymenoptera Holotype
7. ***amabilis*** Kapur 1949, ***Rodolia*** Coccinellidae Coleoptera Paratype
8. ***amaranthusa*** Narendran 1994, ***Eurytoma*** Eurytomidae Hymenoptera Paratype
9. ***amnestos*** Rameshkumar *et al.* 2013, ***Anagyrus*** Encyrtidae Hymenoptera Holotype
10. ***amoenus*** Hayat 2014, ***Coccophagus*** Aphelinidae Hymenoptera Holotype
11. ***andamana*** Hayat 2013, ***Anikera*** Encyrtidae Hymenoptera Holotype
12. ***andamanensis*** Gupta 2015, ***Diolcogaster*** Microgastrinae Braconidae Hymenoptera Holotype
13. ***andamanensis*** Gupta & van Achterberg 2014, ***Phanerotoma*** Braconidae Hymenoptera Holotype
14. ***andamanensis*** Veenakumari 2014, ***Phanuromyia*** Platygastridae Hymenoptera Holotype
15. ***andamanica*** Hayat 2014, ***Arrhenophagoidea*** Encyrtidae Hymenoptera Holotype
16. ***andamanica*** Hayat 2014, ***Encarsia*** Aphelinidae Hymenoptera Holotype
17. ***anomala*** Hayat 2014, ***Tetracnemoidea*** Encyrtidae Hymenoptera Holotype
18. ***apantelesi*** Narendran 1994, ***Eurytoma*** Eurytomidae Hymenoptera Holotype
19. ***arka*** Gupta *et al.* 2014, ***Parapanteles*** Microgastrinae Braconidae Hymenoptera Holotype
20. ***ashmeadi*** Veenakumari & Buhl 2013, ***Amblyaspis*** Platygastridae Hymenoptera Holotype
21. ***ashotus*** Narendran 2007, ***Aprostocetus*** Eulophidae Hymenoptera Paratype
22. ***asphondyliae*** Narendran 1994, ***Eurytoma*** Eurytomidae Hymenoptera Paratype

Fig. 2. Screen shot of partial list of type specimens in NBAIR collection

CHAPTER 4

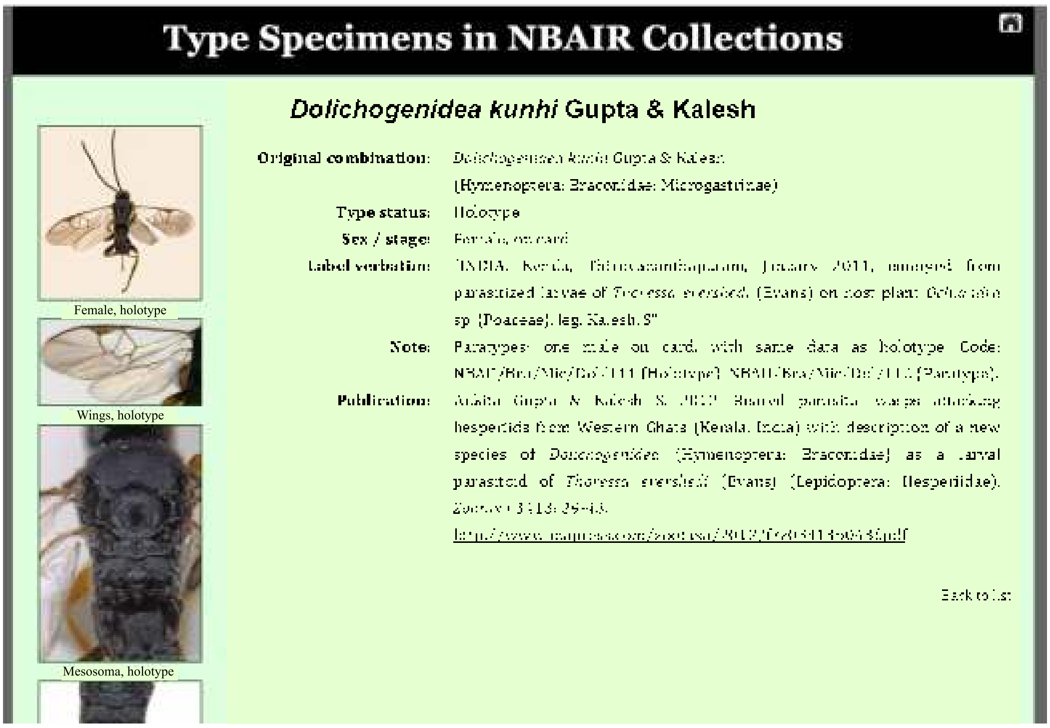


Fig. 3. Screen shot of entry for the type of *Dolichogenidea kunhi*

Biosystematics of Trichogrammatidae (Hymenoptera)

Ten genera of Trichogrammatidae (*Prestwichia, Chaetogramma, Burksiella, Lathromeris, Lathromeromyia, Pseudoligosita, Paracentrobia, Aphelinoidea, Mirufens* and *Tumidiclava)* were added to the collections of the Bureau. Of these, *Prestwichia, Burksiella, Paracentrobia, Aphelinoidea* and *Tumidiclava* are new genera being recorded from the Andaman islands. *Trichogramma flandersi, T.achaeae, T.manii, Trichogrammatoidea cryptophlebiae* and *T. nana* were all collected and recorded for the first time from the Andaman islands. *Oligosita giraulti,* a South American species (Fig. 4) was collected for the first time from India which extends its range to South and Southeast Asia. SEM studies were extended to four more species of *Trichogramma.*

Mymaromma ignatii, a new species of *Mymarommatoidea* was described from S. India (Fig. 5). This is the first record of a mymarommatoid from India.

Fig. 4. *Oligosita giraulti*

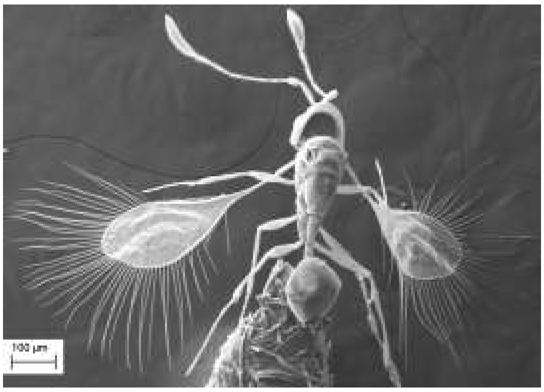


Fig. 5. *Mymaromma ignatii*

Biosystematics of oophagous parasitoids with special reference to Platygastroidea

A total of 1530 parasitoids were collected. So far 57 genera under five subfamilies of Platygastroidea have been recorded from India under this project. An additional five genera were added this year raising the total to 62 genera.

The genus *Apteroscelio* (Scelioninae) is reported for the first time from India. The genus *Heptascelio*, was recorded only from Kerala and Himachal Pradesh. The genus *Embidobia* was initially reported in 1912 from Kumoan, Himalayas and now reported for the first time from S. India (Karnataka and Tamil Nadu). The other two genera added are *Trichacoides* and *Inostemma.*

So far no Platygastridae have been reported from Sikkim. Recent surveys conducted in Sikkim reveal the presence of 30 genera. Forty five genera of Platygastridae are reported from Arunachal Pradesh, from where till now only a single genus *Protelenomus* was reported.

Protelenomus flavicornis Kieffer and *Amitus aleurolobi* Mani were redescribed. *P. flavicornis* is reported for the first time from India (Figs. 6, 7).

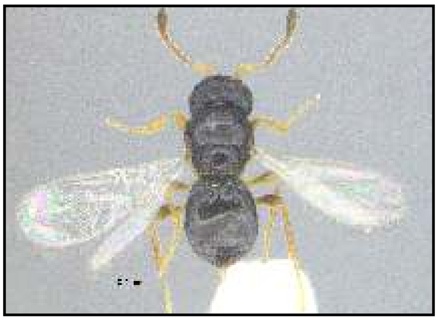
A new genus *Chakra,* with type species *Chakra sarvatra* was described from Andaman Islands (Fig. 8).

Twelve new species of Platygastroidea were described as new to science. Five new species of *Phanuromyia,* viz. *Phanuromyia andamanensis, P. kapilae, P. koenigi, P.nabakovi* and *P. jarawa* were described. Two new species of *Amitus* (Fig. 9) and two new species of *Synopeas* viz. *Amitus kiefferi, Amitus sikkimensis, Synopeas dohertyi* and *Synopeas aitkeni* were described. *Trichacoides ranganabettensis, Platygaster neostriatitergitis* and *Neotrimorus ferrari* were also described .

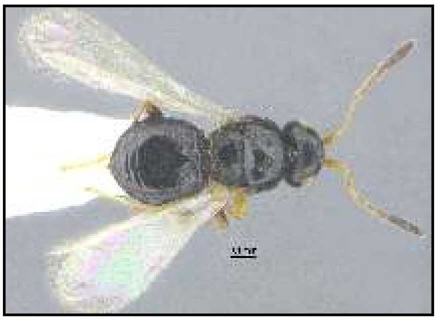
Fig. 6. Adults of *Protelenomus flavicornis* on adult of *Anoplocnemis* sp.

Fig. 7. *Protelenomus flavicornis*

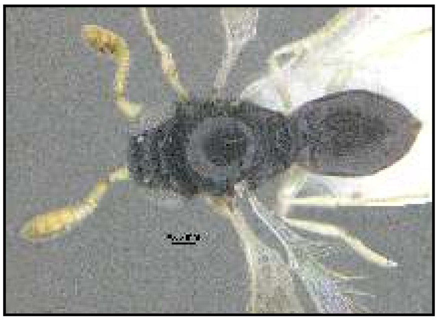
Fig. 8. ***Chakra sarvatra*** **– A new genus and species from India**



Amitus kiefferi



Amitus sikkimensis



Phanuromyia jarawa

Phanuromyia andamanensis

Fig. 9. New species of platygastrids from India

Biodiversity of economically important Indian Microgastrinae (Braconidae)

A total of 7 new species of Indian parasitic wasps were described of which *Anisopteromalus indicus* (Fig. 10) was reared from a lymantriid associated with sugarcane from southern India and *Phanerotoma andamanensis* (Fig. 11) was described from the Andaman Islands. One species was synonymised**:** *Phanerotoma agarwali* Varshney & Shujauddin, 1999 is considered a junior synonym of *P. syleptae* Zettel, 1990, syn. nov**.**

Reared lepidopterans from peninsular India yielded eleven species of Lycaenidae parasitized by ten species of wasps (Fig. 10, 11). Four new taxa of lycaenids were found associated with lycaenids. *Parapanteles eros, Parapanteles arka, Parapanteles esha* and *Parapanteles regale* were reared from *Chilades pandava* (Horsfield), *Curetis thetis* (Drury), *Prosotas dubiosa* (Semper) and *Tajuria cippus* (Fabricius), respectively. This is the first record of host-parasitoid association of lycaenid butterflies with *Parapanteles*. Wasps from three different families were recorded: Braconidae, Ichneumonidae and Chalcididae. The parasitoid species were reared from the following Lycaenidae hosts: *Anthene lycaenina* (Felder), *Arhopala amantes* Hewitson, *Chilades pandava* (Horsfield), *Curetis thetis* (Drury), *Jamides celeno* (Cramer), *Prosotas dubiosa* (Semper), *Rathinda amor* (Fabricius), *Spindasis vulcanus* (Fabricius), *Tajuria cippus* (Fabricius), *Tarucus balkanicus nigra* Bethune-Baker, and *Tarucus callinara* Butler. All lycaenids were collected from peninsular India, except *Tarucus callinara* (Madya Pradesh- central India). A comparative account of all newly described species is provided along with detailed illustrated descriptions and differences *vis-à-vis* closely allied Indian species.

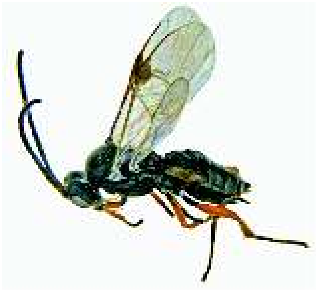
A new species of the gregarious endoparasitoid, *Parapanteles athamasae* (Hymenoptera: Braconidae), parasitising caterpillars of *Charaxes athamas* (Drury) (Lepidoptera: Nymphalidae) on the host plant *Senegalia catechu* (=*Acacia catechu*) (L.f.) Hurter & Mabb., was described from Maharashtra, India. This is the first time a species belonging to the family Nymphalidae is recorded in association with *Parapanteles* Ashmead, 1900. A key to the Indian species of *Parapanteles* based on females was developed.

The sexually dimorphic male of *Tetrastichus bilgiricus* Narendran was described from parasitized pupae of *Euthalia aconthea meridionalis* on *Mangifera indica* L.

Rearing records of nearly 3,500 specimens of microgastrine wasps (Hymenoptera: Braconidae) were compiled across India, covering 16 States and one Union Territory (Andaman & Nicobar islands). The caterpillar inventory recovered over two hundred morpho-species within 22 families of Lepidoptera and yielded over 90 morpho-species of microgastrine wasps distributed among 13 genera: *Apanteles* Förster, *Buluka* de Saeger, *Cotesia* Cameron, *Diolcogaster* Ashmead, *Distatrix* Mason, *Dolichogenidea* Viereck, *Fornicia* Brulle, *Glyptapanteles* Ashmead, *Microgaster* Latreille, *Microplitis* Förster, *Neoclarkinella* Rema & Narendran, *Parapanteles* Ashmead and P*rotapanteles* Ashmead. Records of hyperparasitoids are also included: *Mokrzeckia menzeli* Subba Rao (Pteromalidae), *Pachyneuron groenlandicum* (Holmgren) (Pteromalidae), *Pediobius foveolatus* (Crawford) (Eulophidae), *Trichomalopsis thekkadiensis* Sureshan & Narendran (Pteromalidae), *Eurytoma* sp., and *Pediobius* sp. (Eurytomidae). This study adds eight new host records and provides illustrations of 40 species of wasps (including types). A comprehensive list of microgastrine genera, host caterpillar species, host plants, cocoon colour, structure and spinning pattern, and hyperparasitoids was provided. 53 morphospecies of wasps were found to be gregarious while 39 were solitary. Noctuidae is the first host record for genus *Buluka* from the world. The Indian species *Deuterixys ruidus* (Wilkinson, 1928) is transferred to the genus *Cotesia*. *Microgaster carinicollis* Cameron is transferred to *Microplitis*.

Host relationships of Microgastrinae

Studies so far have revealed a total of 22 lepidopteran host families for the Indian Microgastrinae which are Brachodidae, Blastobasidae, Bombycidae, Crambidae, Erebidae (Arctiinae, Lymantriinae), Gelechiidae, Geometridae, Gracillariidae, Hesperiidae, Lasiocampidae, Limacodidae, Lycaenidae, Noctuidae, Nymphalidae, Oecophoridae, Papilionidae, Pieridae, Plutellidae, Pyralidae, Riodinidae, Sphingidae, and Tortricidae.



Adult

Lymantriid host

Anisopteromalus indicus

Female

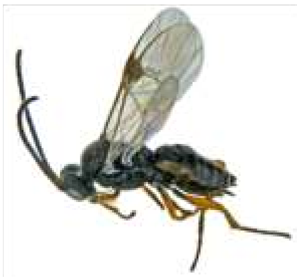
Male

Phanerotoma andamanensis

Parapanteles eros

Tetrastichus bilgiricus

Fig. 10. Microgastrine parasitoids of Lepidoptera



Parapanteles arka

Curetis thetis

Parapanteles esha

Prosotas dubiosa

Parapanteles regale

Tajuria cippus

Parapanteles athamasae

Charaxes athamas

Fig. 11. *Parapanteles* spp. and their lepidopteran hosts

Indian Pteromalidae

A checklist of Indian Pteromalidae was prepared and uploaded on the NBAIR website (Fig. 12).

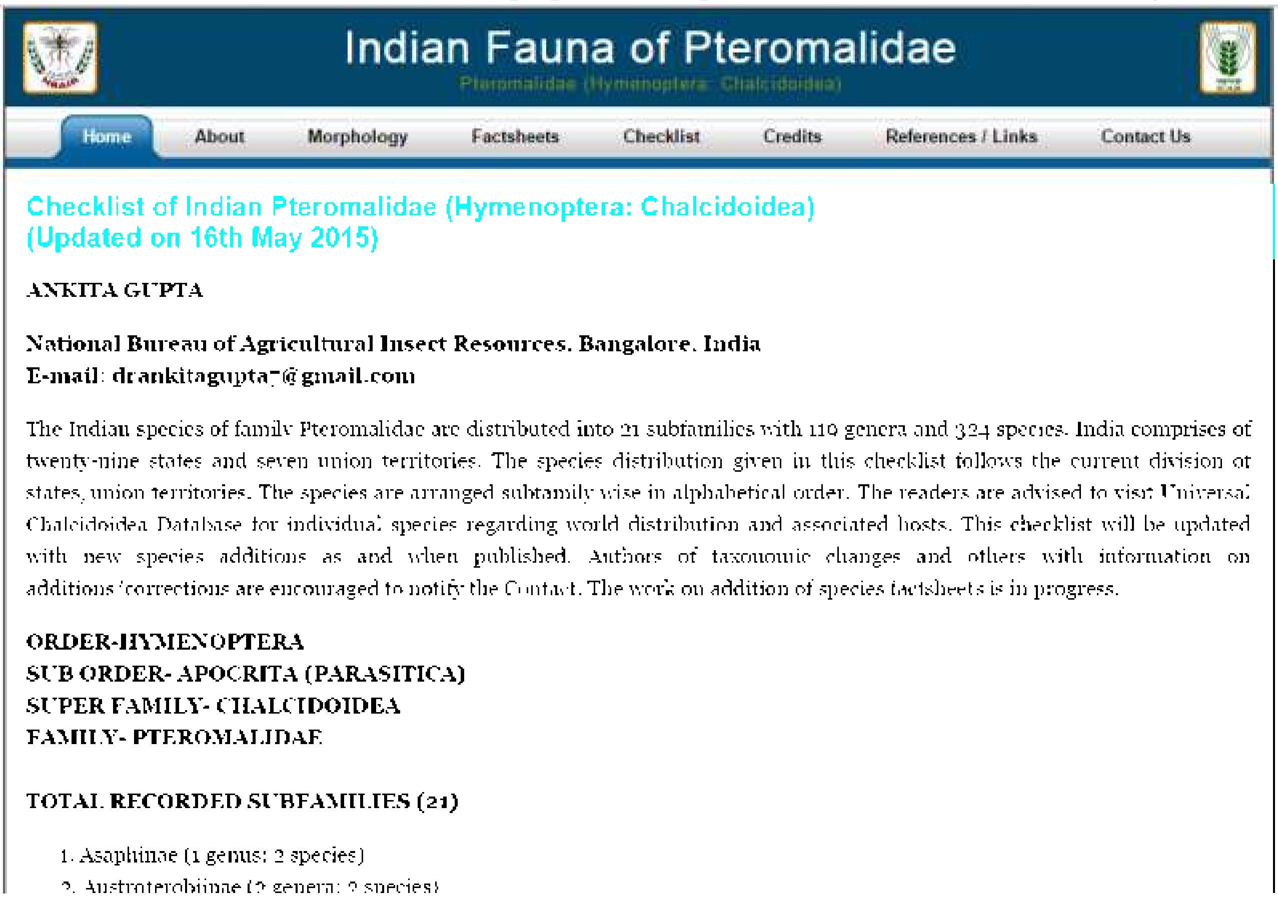


Fig. 12. Screen shot of home page of website of Indian Pteromalidae

Biodiversity of aphids, coccids and their natural enemies (Hemiptera)

Two families viz., Margarodidae and Kuwaniidae were added as new to the existing collection, similarly 23 species of aphids were added as new to the existing collection.

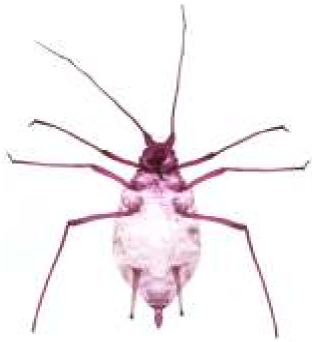
5 species of aphids, 2 species of mealybugs and 1 species of Diaspididae were collected for the first time from India (Fig. 13). These were: Aphids *viz., Liosomaphis ornata* Miyazaki, *Sitobion asirum* Aldryhim & Ilharco, *Uroleucon sonchellum* (Monell), *Pseudoregma montana* (van der Goot), *Hyperomyzus pallidus* Hille Ris Lambers, mealybugs viz., *Trionymus bruneiensis* Williams and *Pseudococcus calceolariae* (Maskell) and a diaspidiid viz., *Chionaspis salicis* (Linnaeus).

2 species of aphids and 1 species of mealybug were collected for the first time from North-East hilly region. These are *Myzaphis rosarum* (Kaltenbach), *Nippolachnus piri* Matsumura and *Trionymus palauensis* Beardsley, respectively. Two species of aphids viz., *Hyperomyzus lactucae* (Linnaeus)and *Matsumuraja rubifoliae* Hille Ris Lambers were collected for the first time from South India.

A species of *Anagyrus* viz., *A. amnestos* was collected from *Phenacoccus madeirensis. Anagyrus* sp. nr. *chrysos* was collected on *Rastrococcus invadens. Anagyrus kamali* was collected on *Maconellicoccus hirsutus.* In addition to this two species (indet.) of *Anagyrus* were collected on *Nipaecoccus viridis* and *Maconellicoccus hirsutus.*

Liosomaphis ornata **Miyazaki (Hemiptera: Aphididae)**

Uroleucon sonchellum **(Monell) (Hemiptera: Aphididae)**



Sitobionasirum **Aldryhim & Ilharco (Hemiptera: Aphididae)**

Trionymus bruneiensis **Williams (Pseudococcidae: Hemiptera)**

Pseudoregma montana **(van der Goot) (Hemiptera: Aphididae)**

Pseudococcus calceolariae **(Maskell) (Pseudococcidae: Hemiptera)**

Fig. 13. Aphids and mealybugs collected for the first time from India

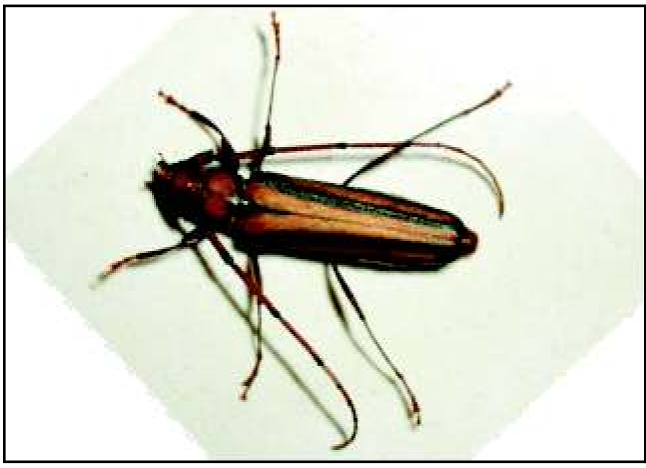
Biosystematics and Diversity of Agriculturally Important Cerambycidae

*Acanthophorus serraticornis (*Olivier)*,* *Batocera rufomaculata* (De Geer)*, Chelidonium cinctum* Guérin-Méneville, *Stromatium barbatum (Fabricius), Xylotrechus quadripes* Chev., *Macrochenus* sp., *Macrochenus isabellinus* Aurivillius, *Olenecamptus* sp. *nr. anogeissi* Gardner, *Olenecamptus bilobus* (Fabricius), *Polyzonus prasinus* (White), P*eudaristobia octofasciculata* (Aurivillius) *Pseudonemophas versteegi* (Ritsema), *Clenaria bicolor* Thomson (Fig. 14), *Xystrocera globosa* Oliv., and *Purpuricenus malaccensis* (Lacordaire) were the cerambycids collected and identified during the year.

Adult

Ixora leaf damaged by the beetle

Fig. 14. *Clenaria bicolor* Thomson (Lamiinae:Astathini)



Adult

Grubs in trunk of silver oak

Fig. 15. *Xystrocera globosa* Oliv. (Cerambycinae:Xystrocerini)

Taxonomy and diversity of Indian Sphecidae

Around 400 specimens were collected and specimens belonging to the following genera were identified, viz., *Ammophila, Ampulex, Trypoxylon, Sceliphron, Larra, Liris, Chalybion, Carinostigmus* and *Tzustigmus. C. (Carinostigmus) griphus* Korembein (Fig. 16) is a new record for India.

A morphological key was developed for the identification of Indian species of *Carinostigmus*. DNA extraction was done for all the identified specimens.

Fig. 16. *Carinostigmus (Carinostigmus) griphus*

Network Project on Insect Biosystematics

New taxa of Coccinellidae and nomenclatural acts

Calvia explanata (Fig. 17), a species externally similar to *C. albida* Bielawski, was described from Nepal and northeastern India. *Micraspis pusillus* (Fig. 18), an unusual species, was described from northeastern India (Sikkim, Assam and Meghalaya). *Platynaspis flavoguttata* (Gorham), a rare species from Karnataka, was redescribed and the male genitalia were illustrated for the first time. It was found to be associated with ants and is probably myrmecophilic. *Platynaspis bimaculata* Pang & Mao and *Platynaspis bimaculata* (Hoang) were synonymised. They were also found to be junior homonyms of *P. bimaculata* Weise. Hence, *Platynaspis kapuri* Chakraborty, the next available name was established as the valid name for this species. Thirty-two new species of *Cryptolaemus* Mulsant were described from New Guinea as part of a world revision.

Fig. 17. *Calvia explanata*

New records of parasitic Hymenoptera

Anagyrus amnestos (Encyrtidae), a

Aprostocetus sp. (*causalis* group) on erythrina gall wasp

The species of *Aprostocetus* hitherto identified as *A. gala* Walker on erythrina gall wasp (*Quadrastichus erythrinae*) in India was found to be a misidentification. Based on a recent publication on the parasitoids of erythrina gall wasp, the species commonly occurring in southern India was identified as *Aprostocetus* sp. (*causalis*-group). It was particularly close to A. *felix,* a parasitoid of erythrina gall wasp in southeast Asia. Further studies, including molecular characterization, are needed to identify this species positively as A. *felix.*

Fig. 18. *Micraspis pusillus*

Biosystematics and diversity of entomogenous nematodes in India

Samples were collected randomly with a hand shovel. Each soil sample (approximately 500g) was a composite of 5–7 random sub-samples taken at a depth of 0–15 cm in an area of approximately 25m^2. In total 220 soil samples were collected randomly from vegetable, banana, forest land and other places.

An insect associated nematode, *Oscheius* sp. was isolated from Utthanapalli village of Tamil Nadu during the year (Fig. 19).

Morphology and morphometrics of the isolated

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An insect associated nematode, *Oscheius* sp. was isolated from Utthanapalli village of Tamil Nadu during the year (Fig. 19).

Morphology and morphometrics of the isolated nematodes

Nematodes were cultured on *G. mellonella* larvae at 27-28°C. Mortality was recorded after 24-48 h. The first and second generation adults were obtained at 2-3 days and 3-4 days, respectively. Infective juveniles were collected from White traps on the 4th day of emergence and used for measurement. IJ and first and second generation males and females were killed by hot water, then fixed in TAF and processed to glycerin by the Seinhorst method. Permanent slides were made using glass supports to avoid flattening of the specimens. Twenty specimens of each stage were measured and observed (Figs. 20, 21).

First generation female

Body usually C-shaped, sometimes coiled when killed by gentle heat. Cuticle faintly striated anteriorly but otherwise appearing smooth under light microscope. Head rounded or slightly truncated, continuous with body contour. Mouth opening circular to slightly triangular. Ten sensory papillae comprising six labial and four cephalic papillae. Six prominent lips, each bearing a papilla. Amphids present, stoma short triangular, cheilorhabdions present but small. Pharynx with cylindrical procorpus, swollen muscular metacorpus, distinct isthmus and valvate basal bulb. Nerve ring usually surrounding isthmus, located just anterior to basal bulb. Excretory pore located anterior to nerve ring at about mid-point of pharynx. Gonads didelphic, amphidelphic, reflexed dorsally, oviduct well developed, vagina short, sclerotised. Terminal mucron present.

Second generation Female

General morphology similar to first generation female but smaller in size. Body arcuate when heat relaxed. Vulva with protruding lips. Tail conoid. Terminal mucron absent.

Infective juvenile

Body cylindrical, heat relaxed specimens mostly straight or slightly arcuate ventrally, tapering towards both ends. Ensheathed juvenile with six labial papillae, four cephalic papillae and distinct amphidial apertures, lip region slightly truncate, smooth, continuous with body contour. Cuticle finely annulated. Stoma closed. Excretory pore cuticularised. Nerve ring distinct, encircling isthmus, anterior to basal bulb. Pharynx narrow and long, leading to an elongate basal bulb with valvular apparatus.

Fig. 19. *Oscheius* infected and healthy pupae of *Bactrocera cucurbitae*

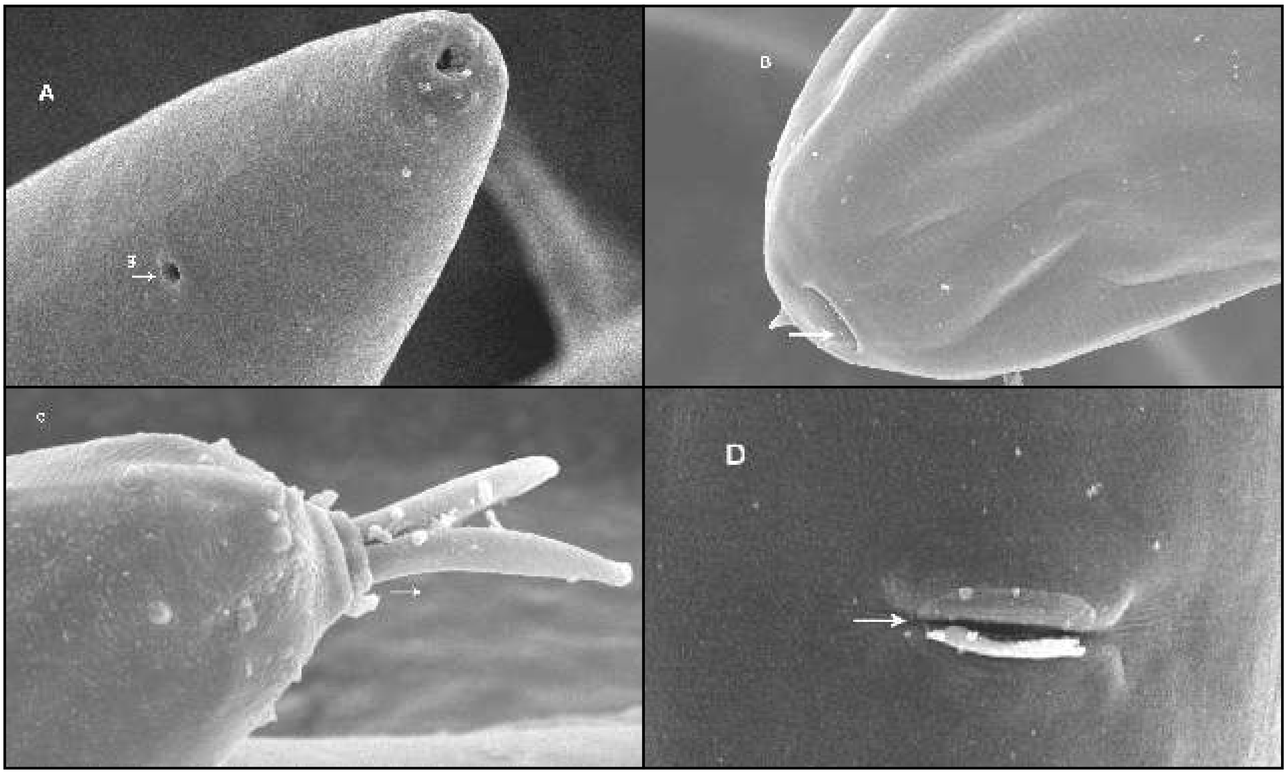


Fig. 20. ***Steinernema*** **sp. SEM photographs of males and femalesA: Head "*en face* view" B: Anus (arrow); E: Spicules (arrow); D: Vulva.EP –excretory pore, Scale bar = 10 µm.**

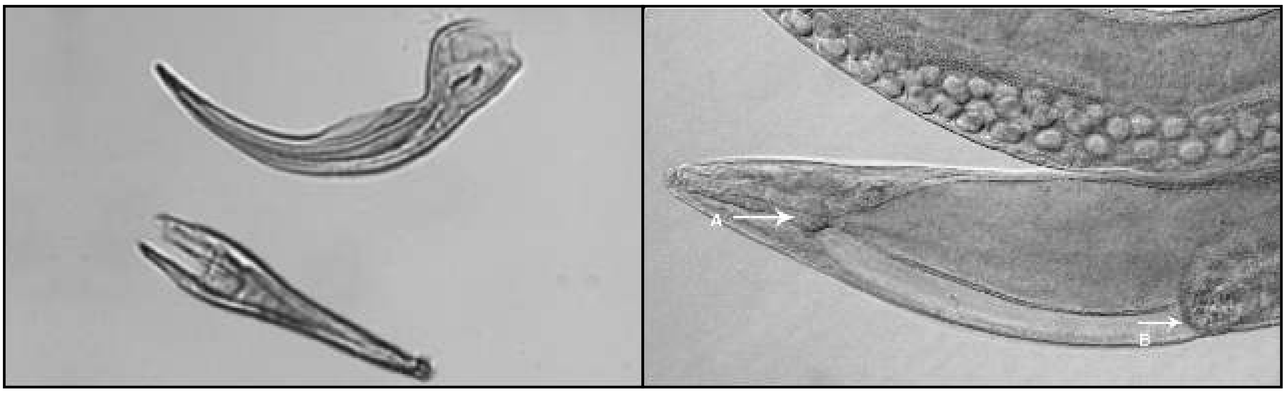


Fig. 21 ***Steinernema*** **sp. Light microscopy photographs. (Left) Pharynx and ovary reflexed region (Right) Spicule (lateral) and gubernaculum (ventral) of 1st generation female. Scale bar = 42 µm.**

Diversity and distribution of entomo-pathogenic nematodes in coconut and arecanut ecosystems (DST project)

A total of 143 soil samples were collected randomly from coconut and arecanut fields of Shivamoga, Soarb, Mundgadde places of Karnataka, Chittalandur, Thotipalayam, Perumpalikadu, Erumapalayam, Ellapalayam, Anai Malai, Valparai, Mettupalayam, Bhavani, Komarapalayam, Kangayam, Burliar, Thottiyam, Vattakotai, Kanyakumari, Colachel, Alagiyamandabam, Kullasekaram and Thirparappu placeses of Tamil Nadu. Vellayani Kayal, Muttakkad, Kovalam, Balaramapuram, Kollam, Kundara, Ezhukone, Kottarakkara and Thenmala places from Kerala. Ten entomopathogenic nematodes were isolated from these places.

DIVISION OF MOLECULAR ENTOMOLOGY

Molecular characterization and DNA barcoding of some agriculturally important insect pests

More than 1000 insect specimens belonging to different orders (Table 1) were collected from 10 different states. Specimens were kept in -70°C as well as in 95% alcohol.

Table 1. Insect orders and families included for molecular characterization

Sl. No.	Order	Families
1	Coleoptera	Brentidae, Cerambycidae, Cetoniidae, Chrysomelidae, Curcilionidae, Dryophthoridae, Staphylinidae
2	Diptera	Calliphoridae, Chironomidae, Chloropidae, Muscidae, Sepsidae, Tephritidae
3	Hemiptera	Aleyrodidae,Aphididae, Aphrophoridae, Cicadellidae, Coreidae, Lygaeidae, Pentatomidae, Tingidae
4	Lepidoptera	Gelechiidae, Noctuidae, Nymphalidae, Plutellidae, Sphingidae
5	Orthoptera	Acrididae, Gryllidae, Pyrgomorphidae
6	Hymenoptera	Evaniidae

Specimens were identified by Co-PIs and were also provided from some AICRP centres, UAS-GKVK, KVAFSU, Bangalore, Silk Board, etc. One hundred and one insect species were molecularly characterized. These consisted of 71 species and 30 populations and belonged to Coleoptera (14), Diptera (12), Hemiptera (33), Hymenoptera (1), Lepidoptera (37 including populations) and Orthoptera (4).

Protocol for museum specimens (up to 8 years old) was standardized for both mini-barcode (⩽ 130 bp) and also *Cox1* 658 bp. Two insects, *Cosmopsaltria* sp. (8 years old) and *Anoplocnemis phasianus* (5 years old) were characterized and sequences submitted to GenBank (KM459444, KM459441). Mini barcode (⩽ 130 bp) for five insects (up to 8 years old) was developed.

Genetic variation studies of *Plutella xylostella*

Genetic variation among different Indian populations of cabbage diamondback moth (*Plutella xylostella*; Lepidoptera: Plutellidae) based on mitochondrial DNA was determined. The populations collected from thirteen states (Table 2), spanning a geographic area of ~ 12250000 km^2, was sequenced. Sequence analysis of the 658bp *mtCOX1* gene from 13 populations resulted in 9 haplotypes, of which 5 populations clustered to form a haplotype group (Table 3). Among these populations, 11 polymorphic sites were observed, of which 5 were transitional and 6 were of transversional substitution.

CHAPTER 4

Table 2. Position wise nucleotide variations in *cox1* sequence among Indian populations of *Plutella xylostella*

Collection sites	Nucleotide position											Base pair
	71	154	205	433	451	514	540	541	543	548	599	
Varanasi	G	T	A	A	G	T	T	G	T	C	A	658
Shillong	A	C	T	G	A	T	T	A	T	C	A	658
Tirupati	G	C	T	G	G	G	T	G	T	C	A	658
Bhubaneswar	G	T	A	A	G	T	T	G	T	C	A	658
Hyderabad	G	T	A	A	G	T	G	G	A	A	A	658
Delhi	A	T	A	A	G	T	G	G	T	A	A	658
Rajahmundry	G	T	A	A	G	T	T	G	T	C	A	658
Coimbatore	G	T	A	A	G	T	T	G	T	C	T	658
Anand	G	T	A	A	G	T	G	G	T	C	A	658
Solan	G	T	A	A	G	T	T	G	T	C	A	658
Nawanshahr	G	C	A	A	G	T	T	G	T	C	A	658
Palani	G	T	A	A	G	T	T	G	T	C	A	658
Oddanchatram	A	C	T	G	G	T	G	G	A	A	A	658

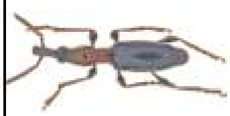
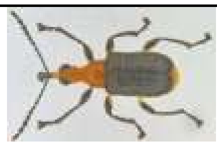
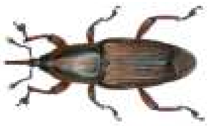
Table 3. Haplotypes of Indian populations of *Plutella xylostella*

Haplotype number	Number of sequences	Length of haplotype (bp)	Sequences belonging to a haplotype
NBPx1	5	658	KM226875_Varanasi_India KM226878_Bhubaneswar_India KM226881_Rajahmundry_India KM226884_Solan_India KM226886_Palani_India
NBPx 2	1	658	KM226876_Shillong_India
NBPx 3	1	658	KM226877_Tirupati_India
NBPx 4	1	658	KM226879_Hyderabad_India
NBPx 5	1	658	KM226880_Delhi_India
NBPx 6	1	658	KM226882_Coimbatore_India
NBPx 7	1	658	KM226883_Anand_India
NBPx 8	1	658	KM226885_Nawanshahr_India
NBPx 9	1	658	KM226887_Oddanchatram_India

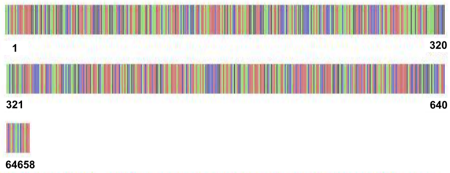
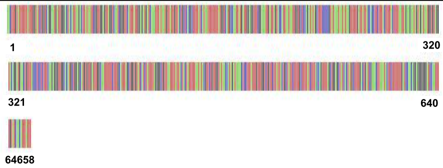
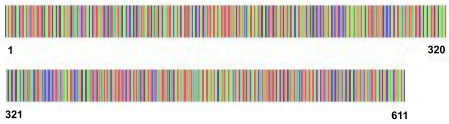
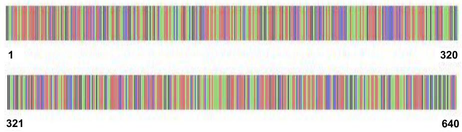
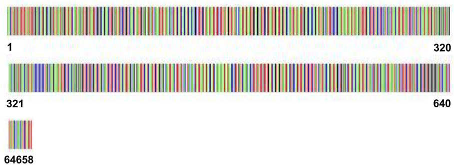
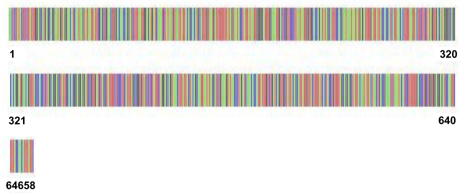
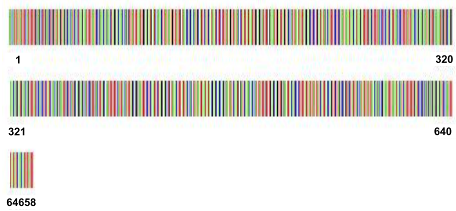
Out of 13 populations obtained from different places in India, the position of nucleotide that differed from Varanasi population (NBPx1) were considered as haplotypes

Barcodes for 54 insects were obtained based on sequences submitted to NCBI incorporating GPS data and other details (Table 4).

Table 4. Barcodes of some important insects

Coleoptera		
*Cylas formicarius*_KM459451		1 320 321 640 64658
*Deporaus marginatus*_KM505018		1 320 321 640 64658
*Euwallacea fornicatus*_KC590061		1 320 321 640 64658
*Sitophilus zeamais*_KM459446		1 320 321 640 64658
*Odoiporus longicollis*_KP233792		1 320 321 640 64658
Diptera		
*Bactrocera correcta*_KF289766		1 320 321 640
*Bactrocera rubigina*_ KM505012		1 320 321 640 64658
*Chrysomya megacephala*_JX430023		1 321 64655
*Hemipyrellia ligurriens*_KM268792		1 320 321 640 64658

CHAPTER 4

*Phytomyza orobanchia*_KC732453		
Hemiptera		
*Anoplocnemis phasianus*_KM459441		
*Clovia puncta*_ KJ817360		
Lepidoptera		
*Corcyra cephalonica*_KF289769		
*Chilo sacchariphagus indicus*_KC306951		
Orthoptera		
*Aularches miliaris*_KM459440		
*Aulacobothrus luteipes*_ KM226887		
*Gryllus bimaculatus*_ KJ850234		

CHAPTER 4

Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators

Molecular characterization using cytochrome oxidase 1 gene (CO1) was done for the following parasitoids namely encyrtid *Aenasius advena (KJ850498), Blepyrus insularis (KJ850500), Neastymachus axillaris (KM095502);* aphelinid, *Myiocnema comperei (KJ955498);* eulophid *Diglyphus isaea (KM016074);* braconid *Aphidius ervi (KM054518), Aphidius colemani (KM054519) Cotesia* sp. *(KM875666), Glyptapanteles* sp. (Bidar) *(KM887912), Glyptapanteles* sp. (Valparai) *(KM887913), Apanteles phycodis (KP055616), Bracon greeni (KP055617), Micropilitis maculipennis (KP759288);* vespid, *Ropalidia* sp. *(KM054517);* scelionid, *Macrotelia* sp. *KM095503), Idris* sp. *(KP271246);* ichneumonid, *Pristomerus sulci (KM875667),* chalcidid, *Brachymeria tachardiae (KP055618).*

Molecular characterization of trichogrammatids belonging to 21 species was completed using CO-1 and ITS-2 regions and phylogenetic tree was constructed. The species identified based on CO-1 and ITS-2 regions were *Trichogrammatoidea armigera*, *Tr. bactrae*, *Tr. robusta*, *Trichogramma achaeae*, *T. pretiosum* (Colombia), *T. pretiosum* (France), *T. pretiosum* (Germany), *T. chilonis*, *T. cacoeciae*, *T. embryophagum*, *T. evanescens* (arrhenotokous), *T. evanescens* (thelytokous), *T. semblidis*, *T. danausicida*, *T. cordubensis*, *T. japonicum*, *T. brassicae* (Italy), *T. brassicae* (Canada), *Trichogramma mwanzai*, *T. chilotraeae*, *T. pieridis*, *T. dendrolimi*, *T. hebbalensis*, *T. danaidiphaga*. GenBank Accession numbers were obtained for all the identified species. Molecular characterization using cytochrome oxidase 1 gene (CO1) was done for the following exotic biocontrol agents *Aphidius ervi, (KM054518), Aphidius colemani (KM054519), Orius laevigatus (KM016075), Phytoseiulus persimilis (KM035535), Diglyphus isaea (KM016074), Amblyseius swirskii (KM035534)* and *Cryptolaemus montrouzieri (KM0160730).*

Molecular characterization and DNA barcoding of subterranean insects

Collection of scarabaeid beetles and termites

Scarabaeid beetles and termites were collected from different geographical locations in the country viz., 1.Karnataka (Sringeri, Hubli, Chintamani, Chikkaballapur, Bagalkot, Bangalore, Hubli, Shimoga and Konnur), 2. Kerala (Thrissur), 3. Tamilnadu (Ooty, Dindigul, Dharmapuri, Hosur, Nagercoil, Valparai and Yercaud), 3. Andhra Pradesh (Horsely hills, Tirupathi), 4. Arunachal Pradesh (Pasighat), 5. Uttar Pradesh (Kushgal, Kapatganj), 6. Himachal Pradesh (Shimla), 7. Meghalaya (Shillong, Tondon) and Punjab (Ludhiana). The collection of the beetles was restricted to the phytophagous group belonging to the subfamilies, Melolonthinae, Rutelinae, Cetoninae and Dynastinae.

Identification of scarabaeids and termites

The beetle and termite specimens collected from different geographical locations in India were preserved in 70% absolute alcohol and stocked at the Division of Molecular Entomology, NBAIR. The beetle specimens were identified at the Department of Entomology, GKVK, Bangalore and Division of Entomology, IARI, New Delhi, and the termites were identified at the Division of Entomology, IARI, New Delhi and Institute of Wood Science and Technology, Bangalore.

The adult beetles were morphologically identified based on the types of antennae, mandibles, maxillae, presence and absence of stridulatory organs and tarsal claws, while the grubs were identified based on the anal slit, raster pattern , spiracles and legs (Fig. 22). The termites were identified based on the morphology of the soldier caste viz., length of the antennae, shape of the mandibles, relative position of mandibular tooth, shape and size of the head, labrum, fontanelle and shape of postmentum and pronotum.

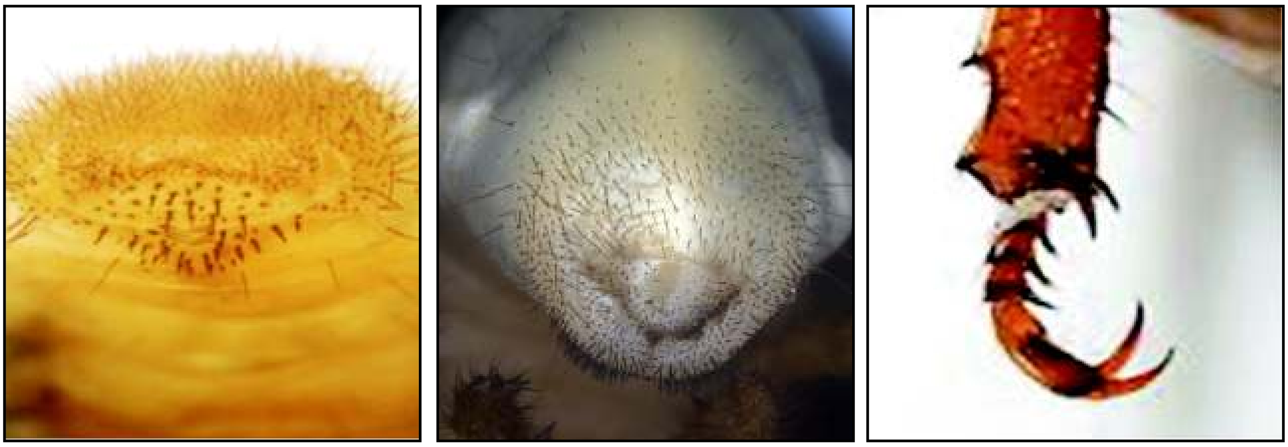


Fig.22. (Left to Right) Anal slit and raster in Melonthinae; anal slit and raster in Rutelinae; tarsal claws in Rutelinae

Characterization of field collected populations of scarabaeids and termites

The CO1 region was amplified using the CO1 forward (**F:**5'-GGTCAACAAATCA TAAAGATATTGG-3') and reverse primers (**CO1 R:** 5'-TAAACTTCAGGGTGAC CAAAAAATCA-3') for the isolated DNA from beetle samples. For termites, specific primers, forward primer -SR-J-14199) and reverse SR-N-14594 were used. PCR products were sequenced, analysed and submitted to BCBI (Tables 5, 6).

Table 5. Characterisation of some scarabaeids based on COI gene

S. No	Code	Identification	Sub family	Place of collection	Source	Genbank accession
1	MGH-SC-1	*Anomola* sp.	Rutelinae	Shillong	Light trap	KM657491
2	MGH-SC-2	*Protaetia* sp.	Cetoninae	Shillong	Light trap	KM657489
3	TPT-SC-5	*Protaetia* sp.	Cetoninae	Tirupathi	Pigeon pea	KM657490
4	DAS-SC-1	*Anomola* sp.	Rutelinae	Dasarahalli	Light trap	KM657492
5	OOTY-SC-11	*Heterorrhina* sp.	Cetoninae	Ooty	Light trap	KM657485
6	Ooty-SC-14	*Protaetia* sp.	Cetoninae	Ooty	Light trap	KM657486
7	PHAS-SC-1	*Protaetia*	Cetoninae	Pasighat	Light trap	1762766
8	PHAS-SC-3	*Protaetia* sp.	Cetoninae	Pasighat	Light trap	1762769
9	G-SC-1	*Protaetia* sp.	Cetoninae	Gudalur		1762776
10	G-SC-2	*Protaetia* sp.	Cetoninae	Gudalur	Light trap	1762777
11	Shimla-SC-1	*Anomala* sp.	Rutelinae	Shimla	Potato	1762765
14	Aliig-SC-1	*Apogonia* sp.	Melolonthinae	Aligarh	Millets	1762764
15	Shim-SC-1	*Schizonycha* sp.	Melolonthinae	Shimoga	Millets	1762749
16	KPT-SC-1	*Alissonotum* sp.	Dynastinae	Kapatganj	Light trap	1762754
17	Sring-SC-1	*Anomola singularis*	Rutelinae	Sringeri	Light trap	1762765

CHAPTER 4

Table 6. Characterization of termites based on CO1 gene

S. No	Code	Organism	Sub family	Location	Source	Genbank accession	Morphological identification
1	Mang-TE-1	*Odentotermes longignathus*	Macrotermitinae	Mangalore	Mango	KM015486	Workers *
2	Udup-TE-1	*Microtermes obesi*	Macrotermitinae	Udupi	Neem	KM657488	*O.obesus*
3	DAST-3	*Euhamitermes hamatus*	Apicotermitinae	Bangalore	Neem	KM657484	Workers *
4	Ooty-TE-4	*Nasutitermes octopilis*	Macrotermitinae	Ooty	Euclayptus	KM657478	Workers *
5	Ooty TE-5	*Nasutitermes exitiosus*	Macrotermitinae	Ooty	Mound	KM 015487	*N. exitiosus*
5	Phas-T-1	*Macrognathotermes errator*	Macrotermitinae	Pasighat	Mandarin	KM657477	Workers *
6	Phas-T-2	*Odontermes mathurai*	Macrotermitidae	Pasighat	Mandarin	KM657487	Workers
7	Thangdi T-1	*Neotermes koshunensis*	Kalotermitidae	Dindigul	Guava	KM657485	*N. koshunensis*
8	IBS-M-1	*Odontotermes gurdaspurensis*	Macrotermitinae	Bangalore	Mound	KM657482	*O. obesus*
9	IBS-M-4	*O.gurdaspurensis*	Macrotermitinae	Bangalore	Mound	KM657483	*O.obesus*
10	IBS_M-8	*O.gurdaspurensis*	Macrotermitinae	Bangalore	Mound	KM657481	*O. obesus*
11	IBS-Yelahanka	*O. gurdaspurensis*	Macrotermitinae	Yelahanka	Neem	KM657480	*O. obesus*
12	Rajan-T-2	*Microtermes mycophagus*	Macrotermitinae	Bangalore	Maize	KM657479	*M..mycophagus*
13	Megh-TE-1	*Odontotermes mathuri*	Macrotermitinae	Meghalaya	Pigeonpea	KM647487	*O.mathurai*
14	TPT-TE-1	*Odontermes obesus*	Macrotermitinae	Tirupathi	Forest	174056	*O.obesus*
15	KPT-TE-1	*Odontotermes obesus*	Kapatganj	Kapatganj	Sugarcane	KM657477	*O.obesus*

Phylogeny of scarabaeids and termites

Blast search analysis was done to compare all the sequences of COI available in the GenBank data base. Evolutionary tree was constructed using character based Maximum-Likelihood method based on the Tamura-Nei model (Tamura 1993) (Fig. 23). MEGA-6 bioinformatics tool was used to construct phylogenetic tree and the genetic relatedness between the isolates was analysed. The bootstrap analysis using 1000 iterations was done to test the accuracy of phylogeny. Constructed phylogenetic tree was visualized using tree viewer program.

Mapping of the cry gene diversity in hot and humid regions of India

A total of 80 *Bacillus thuringiensis* isolates were purified from soil and insect cadaver samples of Almora region. Forty of these isolates were screened for cry gene diversity using degenerate primers. All of them harboured *cry*1 and *cry*2 genes.

Cloning and expression studies of *vip*3A gene for broad spectrum activity: The *vip*3a gene was amplified using PCR and the 2.3 Kb product was sequenced and confirmed (Fig. 24). PCR amplicon (~2.3Kb) was successfully cloned into a cloning vector (pUC29) at NdeI and XhoI restriction sites (Fig. 25). Sub-Cloning of Sequence Confirmed vip3a gene in pET21a was confirmed by PCR amplification an SDS-PAGE (Figs. 26, 27).

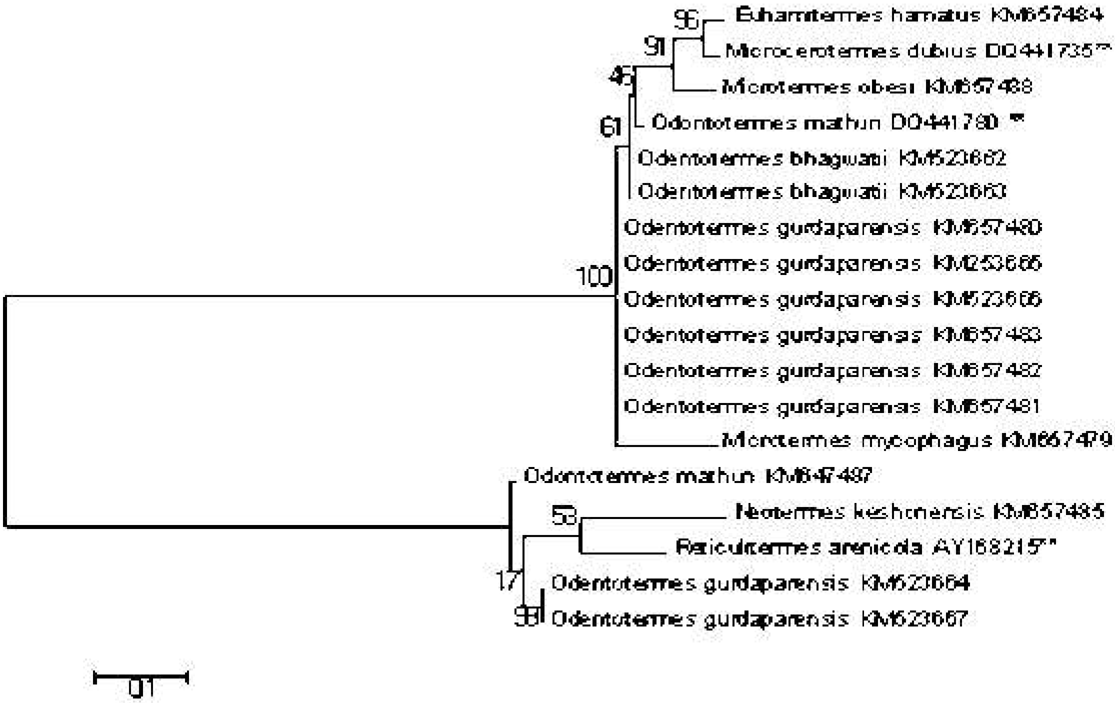


Fig. 23. Neighbour joining tree showing the relationship of COI sequences of termites with other sequences in GenBank (Numbers at nodes indicate percentage bootstrap values)

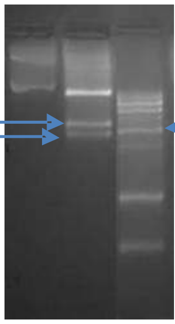


Fig. 24. PCR Amplified *vip3a* gene

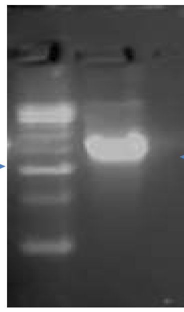


Fig.25. Restriction digestion of *pUC29-Vip3a* clone

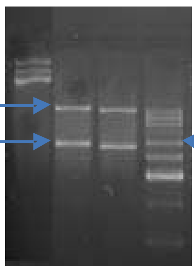


Fig. 26. Restriction digestion of *pET21a-vip3a* clone

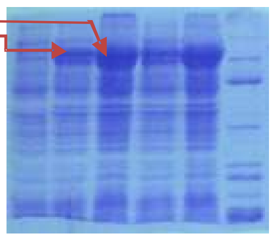


Fig. 27. SDS Protein expression

The *Vip3a* protein was purified from the *pET21a-Vip3a* clone by IPTG induction for 4h and 16 h and the induced protein collected at 4h exhibited an LC_{50} value of 1.9 µg/ml against *Plutella xylostella.* Induced protein collected at 16h exhibited an LC_{50} value of 0.423 µg/ml. Bioassay of purified cloned *Vip3a* protein was also studied against *Spodoptera litura*. Observations were recorded at 72h and 96h. At 72h the protein collected at 4h of induction with IPTG exhibited an LC_{50} value of 12.35 µg/ml and at 96h the LC_{50} value was calculated as 6.87 µg/ml. The protein collected at 16h of induction incited an LC_{50} value of 4.87 µg/ml at 72h and at 96h the LC_{50} was 2.68 µg/ml.

Degenerate primers were designed for partial *cry1* gene (277 bp), *cry2* gene (689–701 bp), *cry3* gene (589-604bp), *cry4* gene (439 bp), *cry* 5, 12, 14, 21 genes (474-489 bp), *cry 7-8* gene (420 bp), *cry*9 genes (351-359 bp), *cry*11 genes (305 bp), *vip3* genes (1000 bp), *cyt1* genes (522-525 bp) and *cyt2* genes (469 bp). Degenerate primers were also designed to detect cry gene sub types like *cry1Aa, cry3Aa, cry4Aa, cry7Aa, cry8Aa, cry9Aa, cry2Aa, cry11Aa* and *cry14Aa.*

Studies on microflora associated with soil insects and other arthropods

Protaetia aurichalcea. Thirty culturable microbes were identified. *Bacillus amyloliquefaciens, B. subtilis B. cereus, B. pumilus, Flavobacterium* sp. and *Pseudoxanthomonas* sp. were characterized as positive for cellulose, lignin or pectin degradation.

***Hermetia illucens* (Fig. 28).** Thirty culturable microbes were identified; *Brevibacterium epidermidis, B. cereus, Bacillus* sp. *B. flexus* and *Proteus mirabilis* were characterized as positive for cellulose, lignin or pectin degradation.

***Oryctes rhinoceros* (Fig. 29).** The thirtyeight culturable microbes identified; *Bacillus cereus, Bacillus* spp., *B. amyloliquefaciens, B. pumilus, B. megaterium, B. subtilis, B. altitudinis, B. marisflavi, B. bombysepticus, B. tequilensis, Microbacterium testaceum* and *Lysinibacillus sphaericus.* They were characterized as positive for cellulose, lignin or pectin degradation.

Metagenomics of *Hermetia illucens* and *Oryctes rhinoceros*

Studies were conducted to identify unculturable microflora associated with two soil insects viz., *Hermetia illucens* and *Oryctes rhinoceros* by using TFRLP analysis. 14 clones were identified as unculturables from *O. rhinoceros* and from *H. illucens.*

Fig. 28. *Hermetia illucens*

Fig. 29. *Oryctes rhinoceros*

Studies on role of microbial flora of aphids in insecticide resistance

A total of 29 isolates were obtained from two aphid species of Bangalore, Kolar and Dharwad. Phylogenetic affiliation and molecular identification of microflora indicated many bacteria as new reports from the current studies, which include *Bacillus aryabhattai, B. firmus, B. cereus* and *Stenotrophomonas maltophilia. Bacillus* was the dominant genus found invariably in all aphid species.

Bioassay for red gram aphid *Aphis craccivora* to imidacloprid 17.8% SL insecticide revealed that Dharwad population was 9.7 times more resistant to imidacloprid than Bangalore population. Bioassay for *Brevicoryne brassicae* to imidacloprid 17.8% insecticide revealed that Dharwad population was five times more resistant to imidacloprid (Fig. 30).

Database on genetic resources

Agricultural pests develop insecticide resistance and this is a serious concern in pest control programmes. Molecular data on insecticide resistance genes like Cytochrome P450, Acetylcholinesterase and Knock down are essential for important pests. Hence, Insecticide Resistant Gene Database (IRGD) has been developed for important pests and this database can be viewed at http://www.cib.res.in/irgd. Presently, IRGD contains 365 sequences for the pests *Helicoverpa armigera, Bemisia tabaci, Acrythosiphon pisum* and *Aphis gossypii* with key features like Search, View options etc. and this database will be updated regularly. The home page of IRGD is given in Fig. 31.

Fig. 30. Bioassay for *Brevicoryne brassicae* to imidacloprid 17.8% insecticide

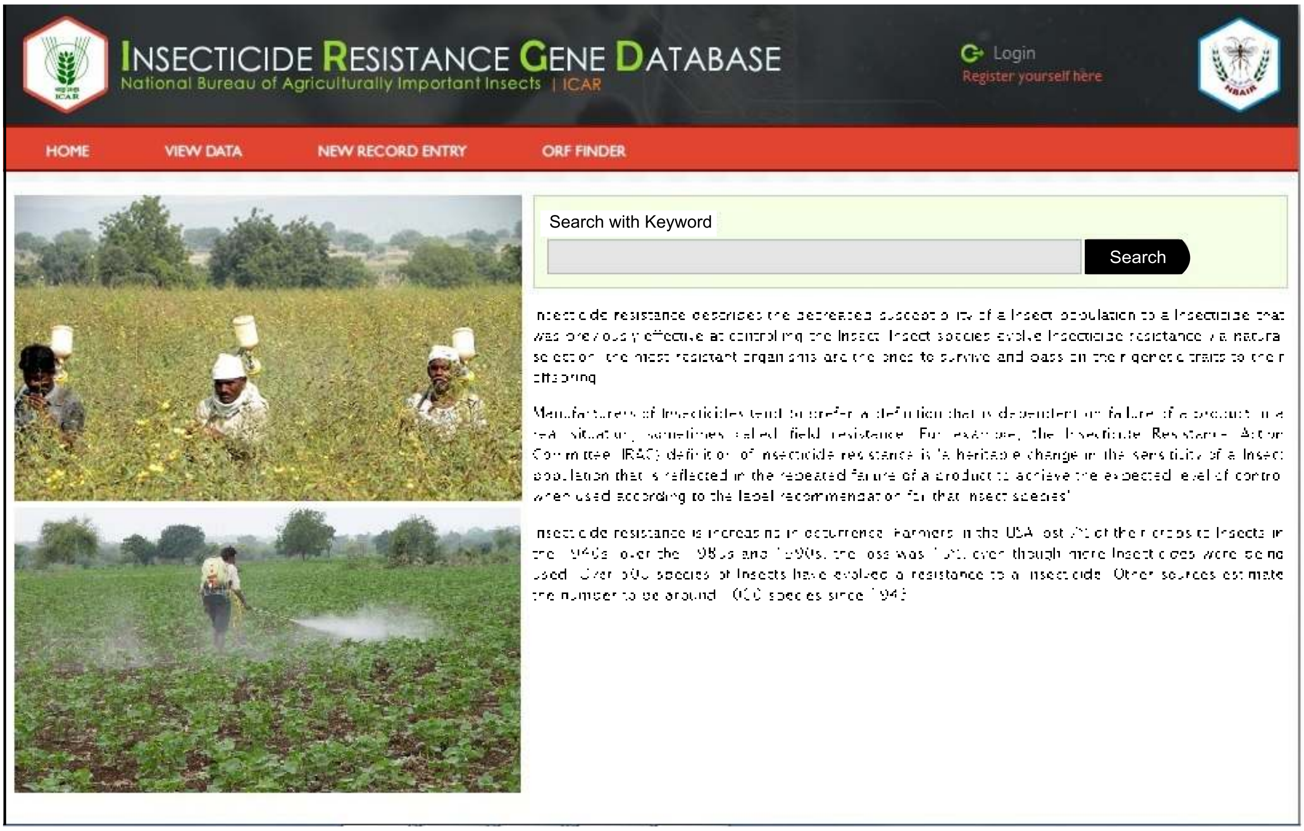


Fig. 31. Screenshot of home page of database on insecticide resistance genes

DIVISION OF INSECT ECOLOGY

Diversity of Indian Anthocoridae

New records for India

Orius minutus was ollected from Pasighat. *Physopleurella pessoni* and *Rajburicoris stysi* from Palani hills are new records for India.

Xylocoris complex in India

Studies were taken up to unravel the *Xylocoris* complex in India. Till recently *Xylocoris* (*Arrostelus*) *flavipes* (Fig. 32) was the only species under the genus *Xylocoris* known from India. Recently, three more *Xylocoris* spp. were documented: *Xylocoris* (*Proxylocoris*) *afer* which was collected from dry fruits of *Ficus* and *Lagerstromia; Xylocoris* (*Proxylocoris*) *confusus* (Fig. 33) and *Xylocoris* (*Arrostelus*) *ampoli* from maize ecosystem. All three are new records for India.

Fig. 32. *Xylocoris flavipes*

Fig. 33. *Xylocoris confusus*

Egg characters used for differentiating *Cardiastethus exiguus* from *Cardiastethus affinis*

Generally, male genitalia characters are used to differentiate *Cardiastethus exiguus* and *C. affinis*, both of which are predators of coconut black-headed caterpillar. Attempts were made to understand the differences in the structure of the eggs of the above two species. It was observed that the length of the eggs of *C. exiguus* was more than that of *C. affinis.* Besides, the surface of the eggs of *C. exiguus* has a speckled appearance and the central region of the operculum has distinct hexagonal cells. The surface of *C. affinis* eggs appeared smooth and the central region of the operculum has very faint markings.

Utilisation of anthocorid predators

Evaluation of *Amphiareus constrictus* against brown planthopper infesting paddy

Anthocorid predator *Amphiareus constrictus* was evaluated in cages against BPH infesting paddy. The pre-counts of number of adult and nymphal hoppers per tiller in control was 6.2 and 8.4, respectively, while the corresponding pre-count values in the treatment cages were 14.5 and 12.3, respectively. After five releases, the adult and nymphal counts in treatment cages were 1.8 and 1.4, respectively, while in control, the corresponding values were 6.3 and 3.3, respectively. This indicates that *A. constrictus* could be a potential predator of BPH.

Infestation by *Aleurothrixus trachoides* on capsicum and natural predation

This species of whitefly was originally described as *Aleurotrachelus trachoides* (solanum whitefly). This is reported for the first time in India. This was primarily found to attack *Duranta* spp. in Bengaluru. A widening of the host range is now being observed. Natural predation of the whitefly by the coccinellid *Axinoscymnus puttarudriahi* was observed on *Capsicum*. Highly significant correlation was recorded between the population of the predatory grubs and the populations of eggs+nymphs and pupae of *A. trachoides.*

Studies on the new invasive pest *Tuta absoluta*

Tuta absoluta infestation was observed to be severe in Karnataka, Andrha Pradesh, Telengana, Maharashtra, Gujarat and Tamil Nadu. Infestation was observed in all growth stages of tomato plant. The natural enemies, which could be recorded from the infested fields were *Nesidiocoris tenuis, Trichogramma achaeae, Neochrysocharis formosa, Habrobracon* sp. and *Goniozus* sp. Four species of *Trichogramma* were evaluated for their ability to parasitise *T. absoluta* eggs. *T. achaeae, Trichogramma pretiosum* and *Trichogrammatoidea bactrae* could parasitise the eggs of *T. absoluta.* Maximum parasitoid emergence was from eggs parasitized by *T. pretiosum* and *Tr. bactrae.*

Parasitism of eggs of banana skipper *Erionota thrax* by *Trichogramma chilonis*

Trichogramma chilonis could parasitize 10.5% eggs of *Erionota thrax,* but the parasitoid adults could not emerge from the parasitized eggs.

Studies on parasitoids of litchi stink bug *Tessaratoma javanica*

Eggs of eri silkworm (ESW) can be stored in the deep freeze for 2 to 6 days and used for rearing *Anastatus acherontiae* and *Anastatus bangaloriensis*; per cent parasitism varied from 41.4 to 63.3% in the former and 39.3 to 55% parasitism in the latter. Biological parameters of *A. bangaloriensis* were recorded: mean adult longevity 9.8 days; mean developmental period 17.3 days; mean per cent parasitism 19.9; mean total fecundity 38.9 and mean per cent female progeny 20.5. ESW eggs parasitized by *A. acherontiae* were stored for 7, 15 and 21 days and the per cent adult emergence recorded were 85.7, 72.5 and 63.8, respectively.

Charging of *Corcyra* boxes with lower dosage of eggs (0.125 cc per box) to improve production efficiency

The fecundity of *C. cephalonica* emerging from boxes charged with a lower dosage of 0.125 cc per box was 467 in comparison to the fecundity of adults emerging from the boxes with higher dosage (0.5 cc per box) recorded as 279. By reducing the dosage, the total utilisation of eggs for charging in one year was 106 cc and the yield recorded was 17.02 cc per box. When the higher dosage was used, the quantity of eggs used for charging ranged between 253 to 377 cc per year and the yield recorded was significantly lower (8.87 to 12 cc per box). This indicated that by adopting a lower dosage of 0.125 cc of *Corcyra* eggs for charging each box the production efficiency can be improved significantly.

Mass rearing of *Trichogramma chilonis*

Large cages (3ft x 2ft) can be used for large scale production of Tricho cards. Thirty to forty cards can be exposed to adult trichogrammatids (emerging from three mother cards) in large cages and parasitism ranging from 79 to 81% was recorded.

Live insect germplasm maintenance and supply

In the Live Insect Repository, a total of 139 live insect cultures were maintained, 1148 consignments of live insect cultures were supplied and a revenue of Rs.5,50,931 generated.

Screening of *Beauveria bassiana* isolates against maize stem borer, *Chilo partellus* (Laboratory bioassay)

Bioassay studies were conducted with 87 isolates of *B. bassiana* against second instar larvae of *Chilo partellus.* Five isolates *(Bb-7, 14, 19, 23* and *45)* showed significantly higher mortality (86.4.-100%). Among these five isolates, *Bb-14, 23* and *45* isolates showed significantly higher mycosis *(84.4*-97.8%*)* (Table 7 and Fig. 34). Dose mortality studies were carried out with six isolates (Bb-7,14,19,23,45 and 5a) at different conidial concentrations (10^4, 10^5, 10^6, 10^7 and 10^8 spores/ml) to work out LC_{50} values. Among the six isolates, Bb-45 showed the lowest LC_{50} (5.02 x10^4 conidia ml^{-1}) and LT_{50} (136.25 hr). The LC_{50} of other isolates ranged from 1.11x10^6 to 4.33 x10^7 conidia ml^{-1} (Table 8) and the LT_{50} values ranged from 169.281to 522.39 hrs (Table 9).

Table 7: *Effect of* different isolates of *Beauveria bassiana* on % mortality and % mycosis of *Chilo partellus*

Isolates	Mortality (%)	Isolates	Mycosis (%)
Bb-7,14,19,23,45	86.40-100[a]	Bb-14,23,45	84.44-97.78[a]
Bb-5a,8,42	59.58-77.42[b]	Bb-5a,7,19	71.11-80.00[b]
Bb5b,8a,11,12,18,26,28,30,37,77	39.19-57.15[c]	Bb-8,30,42,77	46.67-62.22[c]
Bb4,5,5c,6,9,10,13,15,16,22,24,27, 29,33,34,39,41a,41b,43,61,62,63, 65,66,67,69,71,72,73,74	20.95-39.08[d]	Bb5b,5c,8a,9,10,11,12,13,1 8,22,24,26,27,28,34,37,41a, 41b,43,62,65,71,72	26.67-40.00[d]
Bb1,2,3,17,20,25,31,32,34a,35,36,3 8,40,44,46,47,48,49,50,51,52,53,54, 55,56,57,58,59,60,64,68,70,75,76, 78,79,80,81,82	0.00-18.84[e]	Bb1,3,4,5,6,15,16,20,29,31, 32,33,39,50,54,55,57,59,60, 61,63,66,67,69,70,73,74,7 6,78,79,80,81	8.89-24.44[e]
		Bb2,17,25,34a,35,36,38,40, 44,46,47,48,49,51,52,53,56, 58,64,68,75,82	0.00-6.67[f]
CD 1%	**20.28**		**18.66**

Fig 34. Bb-45 isolate showing mycosis in *C. partellus*

Table 8. Dose mortality response of six isolate of *Beauveria bassiana* against *Chilo partellus*

Isolates	LC_{50} conidia/ml	95% fiducial limit	Slope±SE	x^2	p value
Bb5a	$1.88X10^6$	$1.06X10^6$-$3.42X10^6$	4.740±0.499	2.503	0.475
Bb7	$1.11X10^6$	$3.3X10^5$-$3.8X10^6$	5.047±0.509	1.433	0.698
Bb14	$1.18X10^6$	$2.7X10^5$-$5.4X10^6$	5.673±0.570	7.647	0.054
Bb19	$4.33X10^7$	$2.31X10^7$-$1.02X10^8$	6.425±0.860	3.52	0.317
Bb23	$1.4X10^6$	$2.7X10^5$-$7.97X10^6$	5.232±0.533	8.16	0.043
Bb45	$5.02X10^4$	$8.6X10^4$-$2.7X10^6$	4.602±0.494	7.945	0.047

Table 9. Time mortality response of is isolates of *B. bassiana* against *C. partellus*

Isolates	LT_{50} (hrs)	95% fiducial limit	Slope±SE	x^2	p value
Bb5a	247.60	201.72-921.34	0.0066±0.0032	4.42	0.0355
Bb7	169.281	124.241-596.935	0.0125±0.0047	7.14	0.0075
Bb14	199.01	134.79-5373.49	0.0079±0.0033	5.54	0.0186
Bb19	522.39	489.20-1034.51	0.0035±0.0026	1.77	0.1836
Bb23	186.75	135.02-616.79	0.0094±0.0034	7.82	0.0052
Bb45	136.255	98.040-556.307	0.0155±0.0060	6.60	0.0102

Establishment of *B. bassiana* as endophyte in maize (Pot experiment)

Six promising isolates of *B. bassiana* (Bb-5a, 7, 14, 19, 23 and 45) were tested for their ability to establish as endophytes in maize through seed treatment/foliar spray on two susceptible varieties of maize viz., COH(M)10 and Bio 9681 obtained from Directorate of Maize Research, Hyderabad. No colonization of the six isolates tested in root/stem/leaf of the seed-treated plants was observed till 90 DAT. In foliar application, colonization of Bb-45 isolate was observed in the leaf tissues up to 60 DAT, whereas Bb-23 isolate colonized the leaf tissues up to 30 DAT and Bb-14 isolate till 15 DAT of the maize variety- COH(M)10 as indicated in plating technique and PCR studies (Figs. 35, 36). No colonization of these 3 isolates in stem/root tissues was observed. Other isolates, Bb-5a, 7 and 19 did not colonize the leaf/stem/root tissues till 45 DAT. In untreated control plant tissues, *B. bassiana* was not detected by Plating and PCR methods at 15/30/ 45 / 60 DAT (Table 10).

Bb-23 leaf in COH(M) 10 Variety | Bb-45 leaf in COH(M) 10 Variety | Bb-19 leaf in Bio9681 Variety

Fig. 35. Confirmation of *Beauveria bassiana* colonization in leaf tissues of different isolates through plating

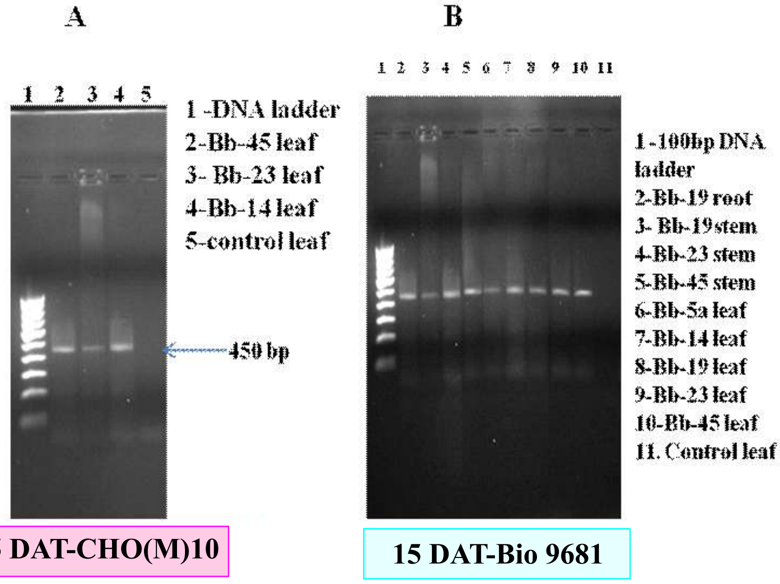


Fig. 36. (Left) Confirmation of endophytic *Beauveria bassiana* in leaf tissues of different isolates in COH(M)10 variety through PCR. (Right) Confirmation of endophytic *B. bassiana* in different isolates of plant tissues in Bio-9681 variety through PCR

Table 10. Confirmation of endophytic establishment of different *B. bassiana* isolates in leaf/stem/root tissues of two maize varieties (COH(M)10 & Bio 9681) through plating and PCR studies

Isolate	Plant tissues	COH(M)10 Variety								Bio 9681 Variety					
		15 DAT		30 DAT		45 DAT		60 DAT		15 DAT		30 DAT		45 DAT	
		PT	PCR	PT	PCR	PT	PCR	PT	PCR	PT	PCR	PT	PCR	PT	PCR
Bb-5a	Root	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Stem	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	leaf	-	-	-	-	-	-	-	-	+	+	+	+	-	-
Bb-7	Root	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Stem	-	-	-	-	-	-	-	-	-	-	+	+	-	-
	leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bb-14	Root	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Stem	-	-	-	-	-	-	-	-	-	-	+	+	-	-
	leaf	+	+	-	-	-	-	-	-	+	+	+	+	-	-
Bb-19	Root	-	-	-	-	-	-	-	-	+	+	+	+	-	-
	Stem	-	-	-	-	-	-	-	-	+	+	+	+	-	-
	leaf	-	-	-	-	-	-	-	-	+	+	-	-	-	-
Bb-23	Root	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Stem	-	-	-	-	-	-	-	-	+	+	-	-	-	-
	leaf	+	+	+	+	-	-	-	-	+	+	-	-	-	-
Bb-45	Root	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Stem	-	-	-	-	-	-	-	-	+	+	-	-	-	-
	leaf	+	+	+	+	+	+	+	+	+	+	-	-	-	-
Control	Root	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Stem	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	leaf	-	-	-	-	-	-	-	-	-	-	-	-	-	-

PT: Plating technique; PCR: PCR studies
+ indicates *B.bassiana* detection, - indicates no detection of *B.bassiana*

In Bio-9681, colonization of Bb-19 isolate was observed in stem and root tissues for a period of 30 days after treatment and in leaf tissues only for 15 DAT. Bb-14 isolate colonized leaf tissues for a period of 30 days after treatment and in stem tissues only for 30 DAT where as Bb-23 and Bb-45 isolates could colonize leaf and stem tissues for 15 days. Bb-5a colonization in leaf tissues till 30 DAT and Bb-7 colonization in stem tissues for 30 DAT was observed. In untreated control plant tissues, no *B. bassiana* colonization was detected by plating and PCR at 15/30/45 DAT.

Field trial experiment on the establishment of three isolates of *B. bassiana* in maize

A field trial was conducted with three isolates of *B. bassiana* (Bb-14, 23 and 45) at NBAIR Research Farm on a commercial maize hybrid (Nityashree) during December 2014-March 2015. In the case of foliar application, Bb-14 and Bb-45 (Fig. 37) isolates showed colonization in stem and leaf tissues for a period of 15 days after treatment and their colonization was not detected in root tissues. No further colonization of these two isolates was observed in 30 and 45 DAT in root/stem/leaf tissues. Bb-23 isolate did not colonize the root/stem/leaf tissues at 15/30/45 DAT. In untreated control plant tissues, no colonization of *B. bassiana* was observed at 15/30/45 DAT.

In crown application method, Bb-23 and Bb-45 isolates colonized in leaf tissues for a period of 15 days after treatment and no further colonization was observed at 30/45 DAT. Bb-14 isolate did not colonize the root/stem/leaf tissues at 15/30/45 DAT. In untreated control plant tissues, no colonization of *B. bassiana* was observed at 15/30/45 DAT.

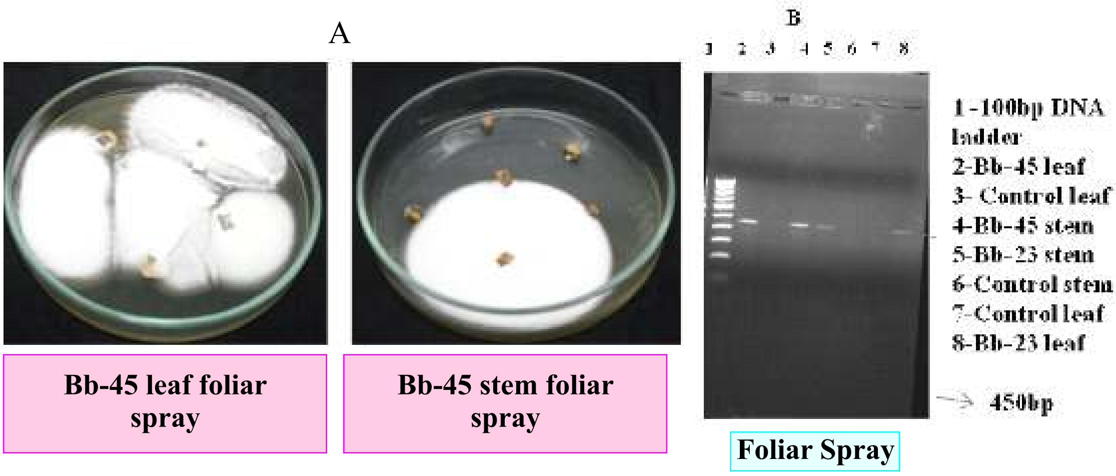


Fig. 37. (Left/Centre) Confirmation of *B. bassiana* colonization in Bb-45 isolate in leaf and stem tissues (foliar spray-field) through plating. (Right) Confirmation of endophytic *B. bassiana* in different isolates of plant tissues through PCR

Establishment of *Beauveria bassiana* as endophyte in sorghum (pot experiment)

Six isolates of *B. bassiana* (Bb-5a, 7, 14, 19, 23 & 45) were tested for their ability to establish as endophytes in sorghum through seed treatment on susceptible variety (DJ6514). In PCR assay, Bb-45 isolate showed colonization of root and stem tissues for a period of 30 DAT. Colonization in root tissues was observed with Bb-5a & Bb-7 for a period of 30 DAT. Bb-23 isolate colonized only stem tissues for a period of 30 DAT. Bb-14 isolate colonized leaf tissues for a period of 30 DAT (Fig 38). No further colonization was observed with any of the isolates at 60 & 90 DAT. In case of Bb-19 isolate, colonization was not detected in leaf/stem/root tissues till 90 DAT. In untreated control plant tissues, no colonization of *B. bassiana was* observed at 30/60/90 DAT.

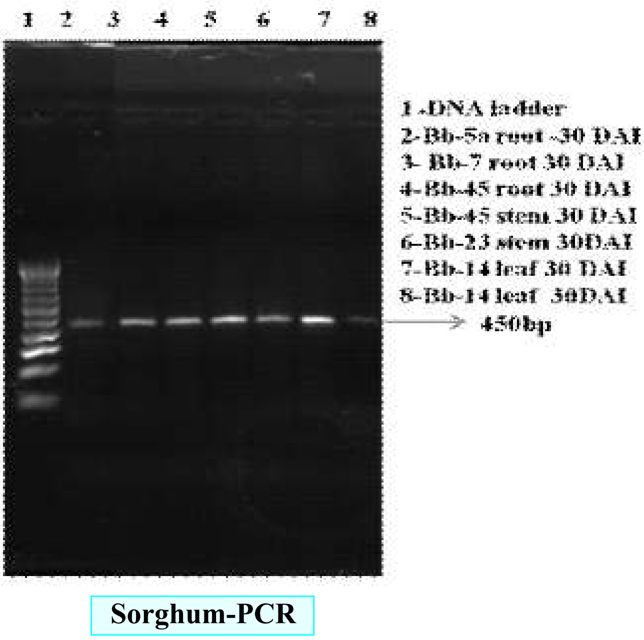


Fig. 38. Confirmation of endophytic *Beuveria bassiana* in different isolates of plant tissues by PCR

Monitoring of papaya mealybug and its natural enemies on papaya and other alternate hosts

Based on the survey conducted in different parts of the state and also the feedback from various AICRP (BC) centers revealed that the papaya mealybug, *Paracoccus marginatus* did not reach pest status in any of the commonly occurring crops like papaya, plumeria, parthenium, hibiscus, mulberry, and butter fruit (avocado). However, incidence at very low levels (< 5%) was recorded on tapioca in Salem and Dharmapuri. It was recorded in New Delhi in the polyhouse at IARI, and supply of two consignments of 500 adults of *Acereophagus papayae* reduced the infestation.

Papaya mealybug on mulberry

Infestation in mulberry was surveyed in the districts of Maddur, Hassan, Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Chikballapur. The occurrence of papaya mealybug was nil in the surveyed areas. In two places near Chamarajnagar and Kunigal it was found associated with *Maconellicoccus hirsutus* which was also below pest injury level (<025%). Number of sericulture farmers requesting for parasitoids was negligible in the entire year showing the complete suppression of papaya mealybug in mulberry.

Occurrence of papaya mealybug on papaya, weeds and other host plants in Karnataka

Incidence of papaya mealybug was very low in all the locations surveyed in Karnataka. Damages in the score of 1 (1-5 scale) and below were observed in homesteads. Surveys in about 41 orchards of papaya in Bangalore, Kanakapura, Mysore, Chamarajanagar, Nelamangala, Devanahalli, Kunigal, Mandya, Kolar, Tumkur road, Kollegal, Maddur and Hassan revealed not a single tree with papaya mealy bug. In the homesteads >85%

parasitization by *Acerophagus papayae* and *Pseudleptomastix mexicana* was found in all the places where ever papaya mealybug was observed (Table 11). *Spalgius epius* was also recorded as one of the major factors for reduction of the pest.

Hibiscus was found to harbour papaya mealybug in low populations in most of the localities and was found invariably associated with *Maconellicoccus hirsutus*, *Phenacoccus solenopsis* and *Ferrisia virgata*; on tapioca it was found associated with *P.madeirensis*. Parasitization by *A. papayae* was very high (>82%). Several weeds which were previously found to harbor papaya mealybug, viz., *Parthenium, Sida acuta, Acalypha, Abutilon* and crotons were free from papaya meal bug.

Classical biocontrol of papaya mealybug

There was incidence of papaya mealybug in Karnataka, Kerala, Andhra Pradesh, Maharashtra and Tamil Nadu. Reported from New Delhi and Gujarat in poly house but not in severe form. *A. papayae* was supplied to these areas (Table 12) and the per cent parasitization was observed in the new localities. Very high incidence of hyper parasitoids *Chartocerus* sp. was recorded in Bangalore (up to 15%) in one sample collected from RT Nagar.

Erythrina gall wasp management

Erythrina gall wasp *Quadrastichus erythrinae* was at low population levels in Kolar, Mandya and Ramnagar districts. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae*, 7-15% parasitization was observed in the field. It was clearly established that *Aprostocetus gala* was always found associated with *Q.erithrinae* and is not a gall former in *Erythrina* plants but a very good parasitoid of *Q. erythrinae.*

Table 11. Parasitization of *Paracoccus marginatus* in field collected samples

Month	Number of samples observed	Per cent parasitization by *Acerophagus papayae*	Per cent parasitization by *Pseudleptomastix mexicana*
March 2014	7	72.4	4
April	8	87.5	5
May	10	87.2	4
June	8	75.5	nil
July	9	72.0	nil
August	7	70.5	nil
September	8	69.2	nil
October	5	71.5	5
November	6	69.8	2
December	4	72.4	3
January 2015	5	75.7	2
February	8	76.50	4
March	7	81.00	3

Table 12. Distribution of *Acerophagus papayae* to farmers

Month	Number of people requesting culture	Number of parasitoids distributed
March 2014	4	1000
April	1	250
June	6	1500
July	7	1750
August	6	1500
September	9	4500
October	4	1000
November	4	1000
December	3	750
January 2015	2	1000

Establishment of gall fly, *C. connexa*

Chromolaena weed biocontrol agent *Cecidochares connexa* released at different places has established upto 15 galls per 5 minutes search in 450 m around the released spot. In Puttur, it has spread around 8 km from the released spot and in Tataguni estate it has spread to the nearby forest area. In GKVK it has been localised because of the non-availability of host plants. *Ormyrus* sp. parasitization was recorded upto 7% in GKVK.

Host range of invasive Jack Beardsley mealybug (*Pseudococcus jackbeardsleyi*) in Karnataka

Survey for invasive insects in South India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu and Karnataka. It was found associated with papaya mealybug on papaya and Madeira mealybug in hibiscus, *Cordyline terminalis*, *Diffenbachia* sp. In a recent survey it was found to be severe on cocoa.

This invasive mealybug is a very slow establishing species and is expanding slowly. Some of the local natural enemies like *Cryptolaemus montrouzieri*, *Spalgis epius* and indeterminate species of gnats are keeping the spread under check. *Nephus regularis* (Fig. 39) was found to be a major predator on eggs of *P. jackbeardsleyi.*

Fig. 39. *Nephus regularis,* a predator on eggs of *Pseudococcus jackbeardsleyi*

CHAPTER 4

New invasives and host extensions

- *Tuta absoluta* was recorded in Karnataka, Tamilnadu, Gujarat. Zoophytophagus plant bug *Nesidiocoris* sp. recorded associated with the pest. The invasive tomato leaf miner was first recorded as an invasive from Gujarat and has later spread to different parts of India. Currently severe in tomato growing ares of Karnataka and Tamilnadu.
- Western flower thrips, *Frankliniella occidentalis,* was reported from Bangalore by ZSI.
- Banana skipper *Erionota thrax* has become severe in Kerala, Karnataka, Mizoram, Assam and other states.
- Bruchid (*Althaeus* sp.) was found infesting seeds of *Hibiscus subdariffa.*
- *Pseudococcus jackbeardsleyi* was recorded on cocoa in South Canara.
- *Phenacoccus madeirensis* was recorded on cashew in Malur area.
- Root mealybug (*Formicococcus polyspheres*) was found on pepper.

Monitoring banana leaf skipper, *Erionota thrax*

Banana skipper is on the upsurge in homesteads and few orchards in Karnataka and is severe in Kerala and parts of Tamil Nadu. Incidence of up to 20-27% was recorded in Kerala. Severe damage caused to leaf has reduced farmers income due to non marketable leaves (Fig. 40). Surveys are being conducted for the identification of suitable biocontrol agents.

Post entry quarantine (PEQ) testing of exotic bioagents

The two bioagents *Neoseiulus californicus* and *Orius laevigatus* were imported by Koppert Biological Systems on 27 May 2014. The consignment was provided by Koppert Biological Systems along with the inert material, viz., wheat husk for *Neoseiulus californicus* and buck wheat husk in case of *Orius laevigatus*, clean and free from other organisms including hyperparasitoids. The predators did not feed on any of the natural

Fig. 40. Developmental stages of banana skipper and damage symptoms

enemies and productive insects viz., *Micromus igorotus, Chrysoperla zastrowi sillemi, Brumoides* sp., *Cryptolaemus montrouzieri, Goniozus nephantidis, Trichogramma chilonis, T. japanicum, Bombyx mori, Apis cerana indica, Kerria lacca, Scymnus coccivora* and *Spalgis epius* thus proving host selectivity towards its own prey. No predator induced injury was recorded on these natural enemies.

INIS Marketing Services imported *Amblyseius swirskii* and safety tests were conducted

No feeding injury by *Amblyseius swirskii* was observed on the test insects and the development of test insects was normal in both choice and no choice tests. The exotic predatory mite *Amblyseius swirskii* (KM035534) was identified and was true to type. No hyper parasitoids, pathogens or associated insects and extraneous materials or contaminants were found.

The predator *Amblyseius swirskii* did not feed on any of the natural enemies and productive insects *viz*., *Micromus igorotus, Chrysoperla zastrowi sillemi, Brumoides* sp., *Cryptolaemus montrouzieri, Goniozus nephantidis, Trichogramma chilonis, T. japonicum, Bombyx mori, Apis cerana indica, Kerria lacca, Scymnus coccivora,* and *Spalgis epius* thus proving its safety to selected indigenous parasitoids and predators. No predator induced injury was recorded on these natural enemies.

New invasive bruchid on *Hibiscus subdariffa* seeds

Seeds of *Hibiscus subdariffa* (Gongura) purchased from the local market were found infested with a bruchid. A review showed that in India no bruchid is reported on hibiscus seeds and this is probably an invasive species (*Althaeus* sp.) (Fig. 41).

Adult

Egg

Damaged seed

Fig. 41. Bruchid and infested seeds of *Hibiscus subdariffa*

Pollinators of cucurbits

Cucurbits were monitored for flower visitors. Seven different species of bees were collected from different flowers. Apidae was the major pollinator with *A. cerana* and *A. florea* dominating. *A. dorsata* was found on pumpkin and bottle gourd. The species collected were sent for identification. Several species of ants were also found to pollinate cucurbits (Fig. 42).

CHAPTER 4

Fig. 42. Pollination of cucurbits by different species of bees

Documentation of pollinator diversity in different agro climatic regions of India with focus on non-*Apis* species

A new patch of pollinator garden was developed with 47 species of diverse plant families. Over 100 specimens of bees belonging to Apidae, Megachilidae, Anthophoridae and Halictidae (Fig. 43) were collected on different host plants. *Gaillardia pulchella* was identified as an important drought tolerant plant flowers round the year that supports a wide range of pollinators. The bee visiting *Argyreia cuneata* was confirmed as *Tetralonia (Thygatina) macroceps* (Fig. 44). *Argyreia* starts flowering in July and ends in November. *Tetralonia* activity coincides with the flowering of *Argyreia* and has not so far been recorded on any other congeners of Convolvulaceae.

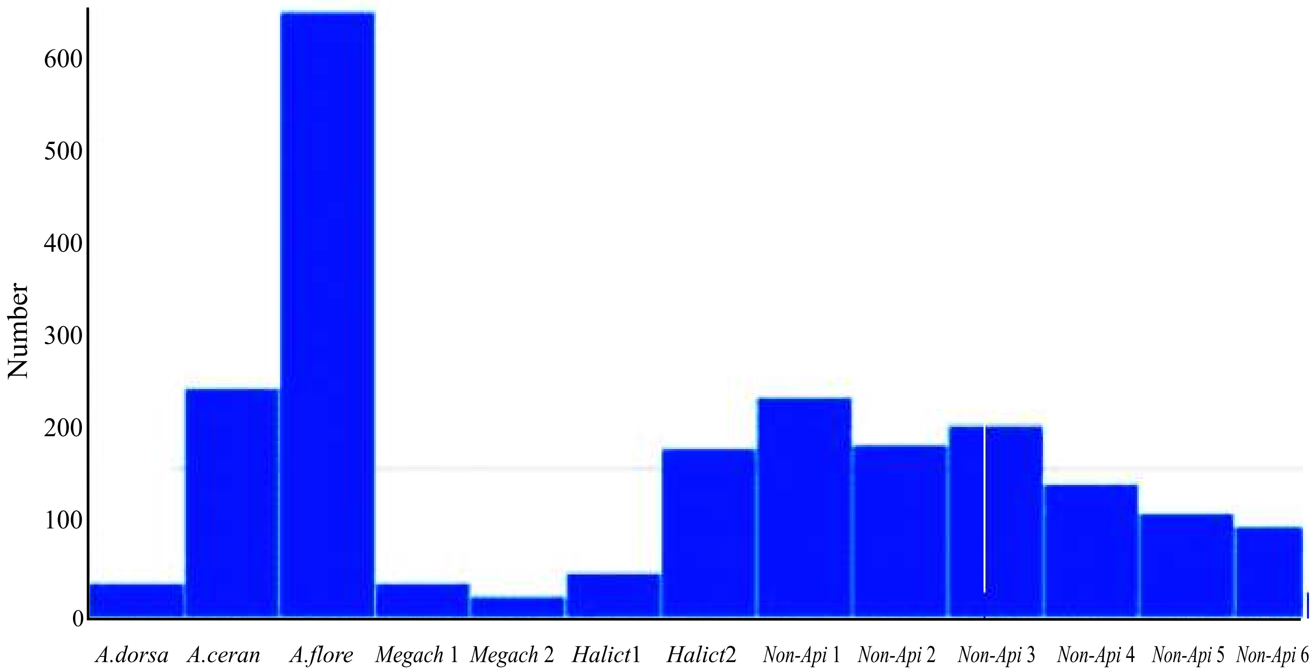


Fig. 43. Profile of pollinators in *Argyreia cuneata*

Table 13. Diversity indices of insect pollinators on different host plants

Host plant	Shannon index	Simpson index
Argyreia cuneata	2.267	0.138
Gaillardia pulchella	1.986	0.103
Ocimum basilicum	2.108	0.124
Woodfordia fructicosa	1.065	0.986
Caesalpinea pulcherrima	1.002	0.976

Argyreia cuneata, Gaillardia pulchella (Fig. 44), *Ocimum basilicum* were found to attract a wide array of pollinators as compared to *Woodfordia fructicosa* [attractive to *Apis cerana* only] and *Caesalpinea* (attractive to wasps and rarely to bees). Diversity indices were worked out for these plants. (Table 13).

Tetralonia macroceps

Argyreia cuneata

Fig. 44. Non-*Apis* pollinator and bee flower in pollinator garden

Microflora associated with insecticides resistance in *Amrasca biguttula biguttula*

LC_{50} values for field populations of *Amrasca biguttula biguttula*

The insecticides, acephate, acetamiprid and imidacloprid are widely used against sucking pests of cotton and *bhendi* as they have systemic action. The relative resistance of *Amrasca biguttula biguttula* population collected from cotton fields of Dharmapuri was higher (LC_{50} 1121.2 ppm) as compared to the population collected from Baita village, Bangalore (LC_{50} 823.6 ppm) based on 48 h bioassay data (Table 14). Similar difference was observed when the data of 72 h bioassay data was compared. The Dharmapuri population showed two fold resistance to acephate as compared to Bangalore population (Table 15).

In the case of imidacloprid, the population collected from Dharmapuri showed 6-7 fold resistance as compared to the population collected from Bangalore (Tables 16, 17).

Table 14. Susceptibility of *Amrasca biguttula biguttula* to Acephate (48 h)

Population	LC_{50} (48 h) Ppm	Slope±SE	Fiducial limits		χ^2 value
			Lower	Upper	
Acephate 75% SP					
Bangalore	823.6	1.07±0.13	423.82	2013.62	2.71
Dharmapuri	1121.2	1.0±0.12	568.46	2346.97	12.4

Table 15. Susceptibility of *Amrasca biguttula biguttula* to Acephate (72 h)

Population	LC_{50} (72 h) Ppm	Slope±SE	Fiducial limits		χ^2 value
			Lower	Upper	
Acephate 75% SP					
Bangalore	76.5	1.12±0.14	46.47	119.1	3.50
Dharmapuri	158.0	0.92±0.12	87.88	269.0	7.12

Table 16. Susceptibility of *Amrasca biguttula biguttula* to Imidacloprid (48 h)

Insecticide	LC_{50} (48 h) Ppm	Slope±SE	Fiducial limits		χ^2 value
			Lower	Upper	
Imidacloprid 17.8 SL					
Bangalore	1.06	0.85±0.14	0.59	1.87	14.4
Dharmapuri	6.61	0.85±0.21	3.467	24.365	4.7

Table 17. Susceptibility of *Amrasca biguttula biguttula* to Imidacloprid (72 h)

Insecticide	LC_{50} (72 h) ppm	Slope±SE	Fiducial limits		χ^2 value
			Lower	Upper	
Imidacloprid 17.8 SL					
Bangalore	0.41	0.79±0.13	0.198	0.723	15.2
Dharmapuri	2.91	0.82±0.19	1.601	6.736	7.19

Insecticide degradation by gut microflora of *Amrasca biguttula biguttula*

The gut bacteria *Bacillus pumilus, Stenotrophomonas matophilia, Enterobacter cloacae, Filobasidium floriforme, Bacillus subtilis, Staphylococcus aureus* and *Bacillus cereus* grew well in all the concentrations of acephate insecticide. These organisms are tolerant of the insecticide (Fig. 45).

Bacillus pumilus ***Stenotrophomonas matophilia***

Enterobacter cloacae ***Staphylococcus aureus***

Filobasidium floriforme

Fig. 45. Growth of gut microflora in Acephate incorporated solid minimal agar media

Maximum growth of *Bacillus pumilus* was recorded in the minimal broth after 3 days of inoculation in 50 ppm concentration of acephate as compared to control (Fig. 46). Maximum OD value (0.8) was recorded at 50 ppm concentration of acephate.

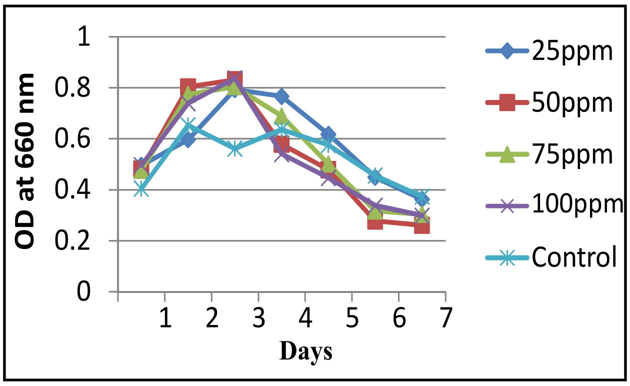


Fig. 46. Growth kinetics of *Bacillus pumilus* in minimal broth under different concentrations of Acephate

Mechanism of degradation of insecticides by gut micro flora of *Amrasca biguttula biguttula*

Esterase, an important enzyme involved in insecticide degradation was detected from *Bacillus pumilus* culture.

Endosymbionts of *Amrasca biguttula biguttula* inhibiting insect pathogens

The bacteria *E. cloacae, B.pumilus* and *Filobasidium floriforme* inhibited the entomopathogens *Beauveria bassiana* and *Paecilomyces fumosoroseus. Microbacterium imperiale* inhibited another entompathogen *Verticillium lecanii. Bacillus pumilus* exhibited maximum inhibition (3.5cm) against *Paecilomyces fumosoroseus. Microbacterium imperiale* exhibited maximum inhibition (3.3cm) against *Verticillium lecanii. Enterobacter cloacae* exhibited maximum inhibition (3.4 cm) against *Beauveria bassiana* (Table 18; Figs. 47, 48).

Table 18. Endosymbionts of *Amrasca biguttula biguttula* inhibiting entomopathogens

Endosymbionts	Inhibition Zone (cm)		
	Paecilomyces fumosoroseus	***Verticilium lecanii***	***Beauveria bassiana***
Bacillus pumilus	3.5	-	2.2
Enterobacter cloacae	3.1	-	3.4
Filobasidium floriforme	2.8	-	3.1
Microbacterium imperiale	-	3.3	-

B. pumilus **inhibiting *Paecilomyces fumosoroseus***

Enterobacter cloacae **inhibiting *P. fumosoroseus***

Filobasidium floriforme **inhibiting *P. fumosoroseus***

P. fumosoroseus **(control)**

Microbacterium imperiale **inhibiting *V. lecanii***

Verticilium lecanii **(control)**

Fig. 47.Endosymbionts of *Amrasca biguttula biguttula* inhibiting entomopathogens

Filobasidium floriforme **inhibiting** ***B. bassiana***

B. pumilus **inhibiting** ***B. bassiana***

Enterobacter cloacae **inhibiting** ***B. bassiana***

Fig. 48. Endosymbionts of *Amrasca biguttula biguttula* inhibiting *B.bassiana*

Synthesis of nanomaterials to act as sensor for semiochemicals in pest management

Here we have demonstrated the use of devices as a resonant mass sensor for the detection of the female sex pheromone of *Helicoverpa armigera, Scirphophaga incertulas* which are lepidopterous pests of cotton, tomato, rice, pigeon pea and chickpea. The need for a sensor that accurately detects pheromones in a label free manner has prompted us to use a device as a mass sensor. We developed novel methodologies for the covalent functionalization of metal oxides based on devices and to the best of our knowledge, there is no literature report till date on the selective insect/pest pheromone sensing with a femtogram level sensitivity.

The invention provides a pheromone detector for the early detection of pheromones in the field. The detector is comprised of a functionalized surface, a mount for embedding the functionalized surface and a perforated housing for replacably retaining the mount. The functionalized devices detect the pheromones at an early stage of pest infestation in a rapid and energy efficient way. Overall the inventions presented here have the following advantages or improvements over the known alternatives. The functionalized surfaces are specific towards the carbonyl group of insect pheromones and do not interact with other interfering moieties such as alcohol, amines, acid, simple aliphatic chains and kairomones of specific plant leaves and stems, e.g. tomato, cotton etc. The change in frequency is observed to be maximum with insect pheromone having free aldehyde functionality (e.g. female insect pheromone of *Helicoverpa armigera* and *Scirphophaga incertulas* and the like*)*. The sensitivity of detection is also assessed by estimating the area covered by a single pheromone detector. The limit of detection and the limit of quantification for the pheromone detector are estimated to be ~2.7 fg/mL and ~8.2 fg/mL, respectively. The pheromone detector is hung through the hanging means provided on the detector. The concentration of pheromone released by insects per acre per hour is estimated to deploy pheromone detectors needed to cover nearly one acre of the field to detect the incidence of pest infestation.

Chemical characterization and ethology of economically important dipteran pests of importance in veterinary and fisheries sciences

Dipteran pests of economic importance in veterinary and fisheries sciences viz., house fly, *Musca domestica*; blow fly, *Chrysomya megacephala*; flesh fly, *Sarcophaga dux*; phorid fly, stable fly *Stomoxys calcitrans* and

Tabanus sp. were collected from Bengaluru, Shivamoga (Karnataka), Thiruvananthapuram, Kasaragod (Kerala), Karnal (Haryana) and Pasighat (Arunachal Pradesh). DNA bar codes were generated for *M. domestica*, *C. megacephala* and *S. dux*. The cuiticular hydrocarbon (CHC) profile of adult *M. domestica* had nine compounds, among them, octadecanol and cycloeicosene were present over 10%. Alphadodecane, tridecane and butylphenol were present at the rate ranging from 5-9% (Fig.49).

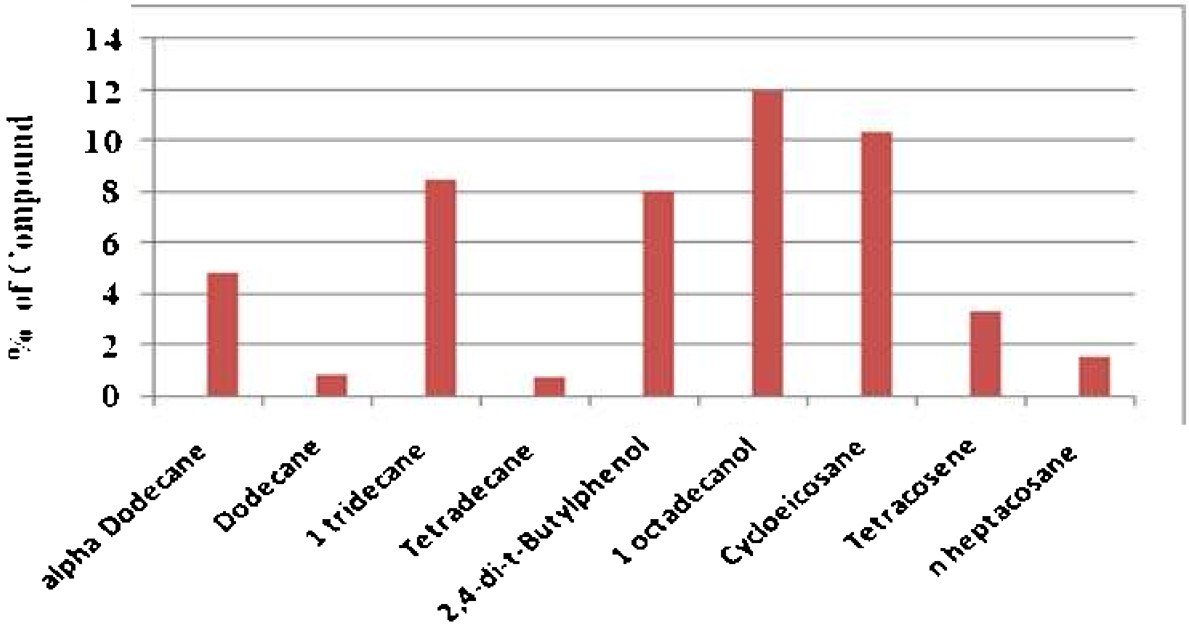


Fig. 49. The cuiticular hydrocarbon (CHC) profile of adult *Musca domestica*

On the efficacy of essential oils that were evaluated against housefly imago, ajowan oils was effective over citridora oil. In fumigant toxicity test ajowan oil, caused LD_{50} at 5.98 µg/cm^3 as against citridora oil that required 10.12 µg/cm^3.

Documentation of leafhoppers and other hemipterans

Insect species belonging to all the three suborders of Hemiptera, viz. Auchenorrhyncha, Sternorrhyncha and Heteroptera, were monitored and recorded on plant species that have been known to be susceptible to phytoplasma-associated diseases. A total of 960 leafhoppers (Cicadellidae) were captured from various plant species at the NBAIR Research Farm, Yelahanka, Bengaluru, for identification, documentation and use in various studies during 2014-15. Leafhoppers belonging to 10 tribes under five subfamilies were predominantly found. *Amrasca biguttula biguttula* was the most dominant leafhopper species during 2014-15. Its incidence was followed by *Balclutha* spp. and *Empoasca* spp.

Monitoring and testing of hemipterans other than leafhoppers for possible vectoring ability

Members of Delphacidae (65 planthoppers), Psyllidae (20 jumping plant lice), Cercopidae (30 froghoppers) and Membracidae (30 treehoppers) were collected from both crop plants and weeds for basic transmission studies. In total, 85 adults across families were tested and found to be aviruliferous.

Optimising a large-scale rearing methodology for *Hishimonus phycitis*

A large-scale rearing methodology for *Hishimonus phycitis* has been optimised to produce and maintain over 2,000 adults at any given time on 200 brinjal (MEBH-11) plants in a single bay of the greenhouse. In a 24”x18” x18” rearing cage with four brinjal plants, not less than 100 adults could be maintained continuously with plant replacement once a month.

Validating the large-scale rearing methodology developed for *H. phycitis*

The large-scale rearing methodology developed for *H. phycitis* was validated in the greenhouse. Through a sesame-brinjal sequence, an average of 10 adult leafhoppers could be produced per older/larger brinjal (MEBH-11) plants in the greenhouse. On younger/smaller plants, six leafhoppers could be obtained per plant. In a 24”x18” x18” rearing cage kept within the greenhouse, 25 insects could be realised per plant.

First field experiment on the natural incidence of insect vectors and phyllody in sesame

During 2014-15, the first field experiment on the natural incidence of insect vectors and phyllody in sesame was initiated on 04 June 2014. The experiment with 16 sub-plots was laid out at the NBAIR Research Farm, Yelahanka, Bengaluru. Insects were collected with an aspirator and let off after the counts. Vector incidence was negligible in the first month of the crop. In the first five weeks, eight leafhopper species could be collected from the vicinity of the field trial. By July, *Aphis gossypii* and *Myzus persicae* together caused crinkling of terminal leaves. However, incidence of the two aphids came down rapidly. Phyllody incidence was only 6.9% on 13 August 2014, but shot up to 16% in 40 days. Throughout the crop period, *H. phycitis* (11.9 & 16.9 adults/ infected plant in August & September, respectively) dominated over *O. albicinctus* (4.6 & 7.0 adults/ infected plant in August & September, respectively) (Table 19).

Table 19: Natural incidence of insect vectors in sesame (Field experiment 1)

Month	No./ infected plant		*t* test
	Hishimonus phycitis	*Orosius albicinctus*	
August 2014	11.9 ± 0.56 (3.5)	4.6 ± 0.34 (2.1)	*P*< 0.0001
September 2014	16.9 ± 0.89 (4.1)	7.0 ± 0.26 (2.6)	*P*< 0.0001

Note: Square-root-transformed values are in parentheses

Monitoring the incidence of viruliferous leafhoppers through transmission studies

Viruliferous *H. phycitis* and *O. albicinctus* were monitored by first attracting the populations to a sesame crop sown in June 2014. *H. phycitis* alone was monitored on two brinjal crops. In the greenhouse, directly field-collected *H. phycitis* induced symptoms in 65% brinjal plants, irrespective of the crop from which the insects originated. On the other hand, *O. albicinctus* could transmit the pathogen to only sesame at 50%. Ten other genera of leafhoppers were found to be aviruliferous when caged on periwinkle. When 100 each of randomly collected *Empoasca* and *Balclutha* species were tested for phytoplasma

CHAPTER 4

transmission, about 10% of test plants showed symptoms, thus pointing to the potential role of these unrecognised species as vectors.

Second field experiment on the natural incidence of insect vectors and phyllody in sesame

The second field experiment on the natural incidence of insect vectors and phyllody in sesame was initiated on 14 October 2014. Insects were collected with an aspirator and let off after the counts. As observed in the first trial, the vector incidence was negligible in the first month of the crop. Phyllody incidence was a meager 6.6% on 16 December 2014, but kept increasing as the crop matured. Throughout the crop period, *H. phycitis* (9.2 & 11.5 adults/ infected plant in December 2014 & January 2015, respectively) dominated over *O. albicinctus* (2.5 & 3.6 adults/ infected plant in December 2014 & January 2015, respectively) (Table 20).

Table 20: Natural incidence of insect vectors in sesame (Field experiment 2)

Month	No./ infected plant		*t* test result
	Hishimonus phycitis	*Orosius albicinctus*	
December 2014	9.2 ± 0.40 (3.0)	2.5 ± 0.24 (1.6)	*P*< 0.0001
January 2015	11.5 ± 0.49 (3.4)	3.6 ± 0.27 (1.9)	*P*< 0.0001

Note: Square-root-transformed values are in parentheses

Molecular confirmation of vector-transmitted phytoplasma in symptomatic plant species

Primary PCR followed by nested PCR indicated the association of the same phytoplasma with symptomatic plant species, thus confirming that *H. phycitis* transmitted the same organism to sesame, brinjal and sunn hemp from periwinkle. The pathogen was found to be closest to periwinkle phyllody rRNA gene (GenBank accession no. KC661072.1).

Establishment of a mite repository

A mite repository has been established at NBAIR. The facility became operational with its inauguration on 17 July 2014.

Collecting mites belonging to assorted orders of Acari for building up the mite repository

Collections came from 39 places in 18 districts across 10 states, viz. Andhra Pradesh, Arunachal Pradesh, Chhattisgarh, Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Meghalaya, Tamil Nadu and Uttar Pradesh. In Karnataka, collections were made in eight districts, viz. Bengaluru Urban, Belagavi, Chikkamagaluru, Dakshina Kannada, Dharwad, Hassan, Mandya and Tumakuru. Collections originated from a variety of flora, including agriculturally important plant species, forest trees, grasses, ornamental plants and avenue trees. Mites were also collected from other hosts like insects (which harboured parasitic and phoretic mites) and laboratory-reared insects and/or mites. In total, 172 plant species with possible mite infestation were collected for processing. Thirty-four hosts other than plants were also collected for separating mites.

Collecting, mounting and preserving specimens of phytophagous mites for building up the mite repository

Phytophagous mites belonging to suborder Prostigmata (Supercohorts Eleutherengonides and Eupodides) were predominantly found during the collections. They were collected with prior information about their damage potential on economically important plant species. In January-March 2015 alone, more than 100 specimens of phytophagous mites were mounted in Hoyer's medium and preserved. Specimens belonged to Tetranychidae, Tenuipalpidae, Tarsonemidae and Eriophyoidea. Some of the collected examples included the polyphagous two-spotted spider mite (*Tetranychus urticae*) and other closely related *Tetranychus* spp.; other serious tetranychids (*Eutetranychus orientalis*); flat mites or false spider mites (*Brevipalpus* spp. and *Raoiella indica*); thread-footed mites (*Polyphagotarsonemus latus* and *Tarsonemus* spp.) and eriophyoid mites (coconut mite, litchi erinose mite, citrus rust mite, unidentified *Aceria* spp., etc.).

Mounting and preserving specimens of predatory mites for building up the mite repository

In general, predatory mites belonging to Phytoseiidae (Mesostigmata: Phytoseioidea) dominated all other predators on various plant species. Predatory mites belonging to the families Ascidae, Melicharidae and Blattisocidae were separated and genus-level identifications done. Under order Trombidiformes, predatory mites belonging to the families Bdellidae, Cheyletidae, Cunaxidae, Stigmaeidae and Tydeidae were collected, mounted and preserved.

Identifying year-round plant hosts of predatory mites

Predatory mites that can flourish regardless of whether their primary food source (i.e., phytophagous mites) is present or not may be commercially exploitable. Surveys during 2014-15 uncovered several such predatory mites in Bengaluru. Out of 88 plant species, a few were identified as potential year-round hosts of predatory mites. For example, the solanaceous plant *Solanum virginianum*, known as thorny nightshade, generally harboured species of *Amblyseius*, *Phytoseius* and *Stigmaeus*. Across plant species, the phytoseiids *Amblyseius*, *Euseius*, *Neoseiulus*, *Phytoseius*, *Typhlodromalus* and *Typhlodromips* were the most dominant associates. Other predatory genera such as *Agistemus*, *Cunaxa*, *Lasioseius*, *Melichares*, *Paracheyletia* and *Stigmaeus* were also commonly encountered. All specimens were added to the repository.

Semiochemicals for the management of coleopteran pests

Lepidiota mansueta is a serious root grub pest in the Majuli islands of Assam. The grubs are highly pestiferous causing damage to sugarcane, potato and other important crops. In collaboration with Assam Agricultural University efforts were made to identify the pheromones for *L. mansueta*. Through various electrophysiological studies it was identified that prothoracic gland secretions may play the role of aggregation pheromone. The male pheromone from the prothoracic glands of root grub, *L. mansueta* was analyzed through GCMS and GCEAD (Figs. 50, 51).

Based on the GCEAD and GCMS analysis several electrophysiologically active substances were noticed at retention times 14.68, 17.52, 19.4 and 24.53. Volatiles such as cis-9-hexadecenal, cis-9-hexadecenoic acid, octadec-9-enoic acid and 1-hexacosene were identified from the thoracic gland secretions.

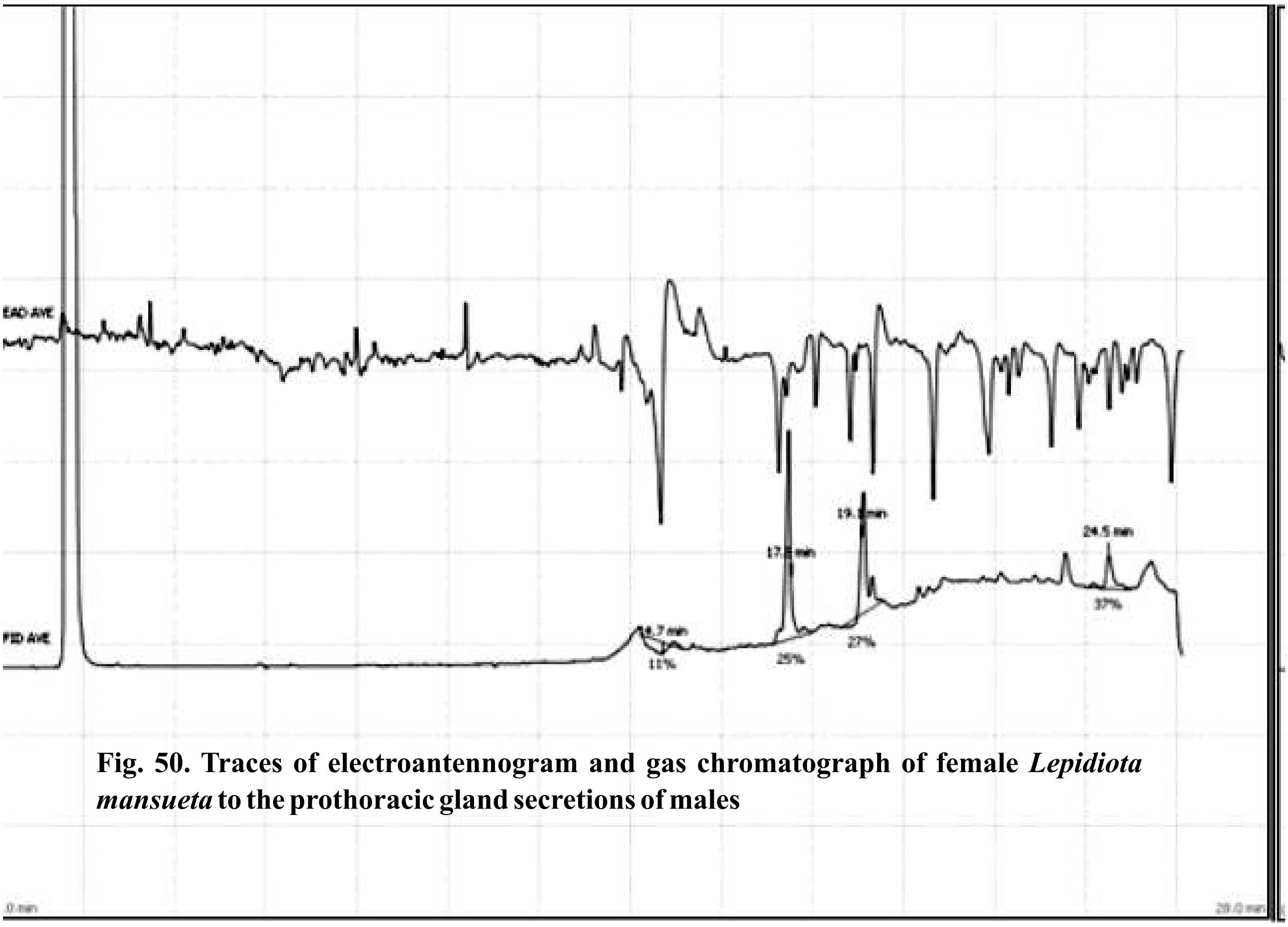


Fig. 50. Traces of electroantennogram and gas chromatograph of female *Lepidiota mansueta* to the prothoracic gland secretions of males

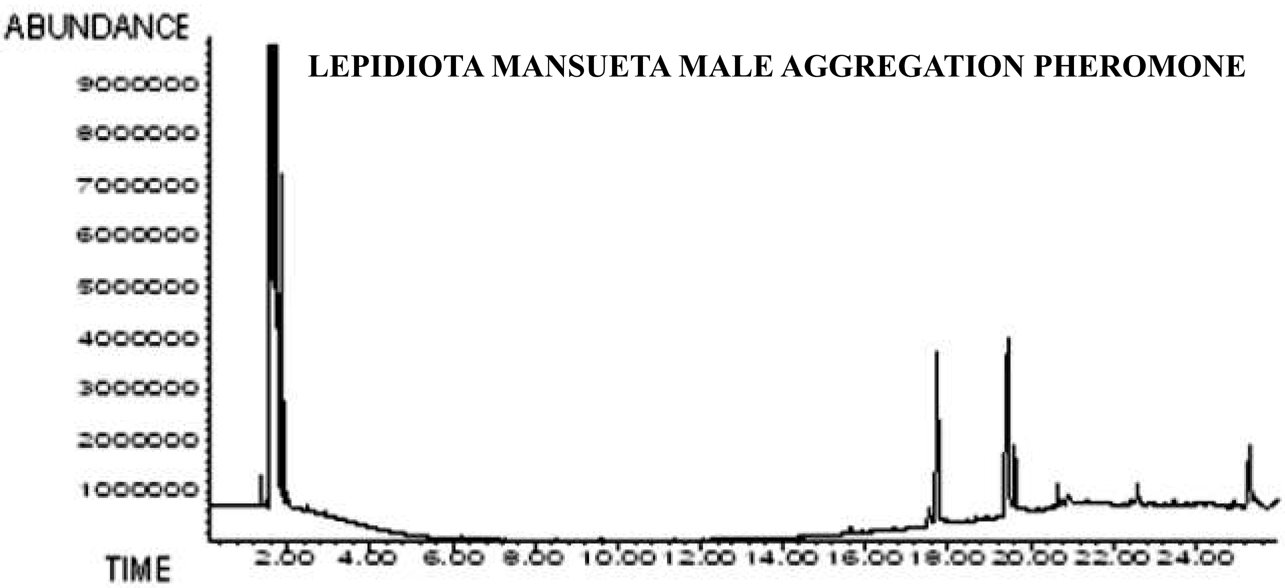


Fig. 51. Total ion chromatogram of male throracic gland extract of *Lepidiota mensuata*

ALL INDIA COORDINATED RESEARCH PROJECT ON BIOLOGICAL CONTROL

Biodiversity of biocontrol agents from various agro ecological zones

a. Parasitoids and predators

Trichogramma chilonis was the only *trichogrammatid* recorded during 2014-15, when cards with eggs of *Corcyra cephalonica* were placed in tomato, castor, groundnut and cotton fields (AAU). 10 species of parasitoids namely, *Trichogramma chilonis*, *T. japonicum*, *Telenomus* sp, *Stenobracon nicevillei*, *Cotesia* sp, *Bracon* sp, *Brachymeria* sp, *Tetrastichus* sp, *Xanthopimpla* sp were found associated with rice stem borer and leaf folder. An unidentified larval-pupal parasitoid belonging to Ichneumonidae for rice leaf folder was also reported (PAU).

Collection of *Trichogramma* from rice, sunflower, maize, castor, cabbage and chilli crops by using sentinel cards showed that natural parasitization varied among individual crop ecosystems. The parasitization ranged from nil in chilli and sunflower to a maximum of 7.9 per cent in castor. Rice crop recorded maximum of 6.05 per cent while in maize it was 2.6 per cent and in cabbage it was as low as 0.9 per cent. It is also inferred that parasitization is found to be marginally more in *Kharif* as compared to *Rabi*. Similar trend was noticed in the abundance of *Chrysoperla* (PJSTAU).

In J&K *Chrysoperla zastrowi sillemi* was collected from cucumber, cauliflower and apple infested with aphids and whiteflies. Two species of coccinellids namely *Alloneda dodecaspilota* and *Scymnus* sp. were added to the previous list increasing the total number of species to 39. Twelve species of predatory mites were recorded. Nine species of syrphids were recorded. *Anastatus* sp and *Trissolchus* sp. was collected from the eggs of *Nezara viridula. Brachyscapus galactopus* and an unidentified pteromalid were collected as hyperparasitoids of *Cotesia glomerata. Diadegma* sp., *Cotesia vestalis* and *Diadromus collaris* were collected as parasitoids of *Plutella xylostella.Campoletis chloridae* was recorded as a parasitoid of *Helicoverpa armigera. Oligota* sp. was collected from rose, apple and ashwagandha feeding on mites (YSPUHF**)**.

In J&K healthy populations of aphelinid parasitoids including *Encarsia perniciosus* and *Aphytis proclia* were found associated with San Jose scale, *Quadraspidiotus perniciosus* was found on apple in unmanaged orchards. Hyperparasitoids including *Marietta* sp. and *Azotus* sp. were also reared from San Jose scale. *Aphelinus mali* was found actively associated with woolly apple aphid, *Eriosoma lanigerum* (SKUAST**)**.

Survey was made in different rice fields of Pattambi, Kerala to record the pests and natural enemies. A total of 117 species belonging to 8 orders, 63 families of insects and spiders were collected and identified, of which 45 were pest species, 44 predators, 24 parasitoids and 4 in neutral or saprophagous group. Three speices of egg parasitoids were observed on eggs of *S. incertulus* and *S. fusciflua viz*., *Tetrastichus schoenobii*, *Trichogramma japonicum* and *Telenomus* spp. The yellow hairy caterpillar *Psalis pennatula* was found in large numbers and 10 per cent larvae were parasitized by *Brachymeria* sp. In West Bengal the skipper *Parnara guttata* was prevalent with 75 per cent parasitisation by *Apanteles* sp. At DRR research farm, fortnightly collection by sweep nets yielded 140 species of natural enemies of which 75 were predators and 65 parasitoids (DRR).

In Maharashtra the natural enemies recorded were coccinellids, *Coccinella septempunctata* L. *Menochilus sexmaculata* (F.), *Scymnus coccivora* Ayyar, *Encarsia flavoscuttellum, Dipha aphidivora* Meyrick, *Micromus igorotus* Bank., syrphids on SWA in sugarcane, *Coccinella transversalis* F., *M. sexmaculata, Brumoides suturalis* (F.), *Triommata coccidivora* and *B. suturalis* in mealybug colonies on custard apple, *Acerophagus papayae* and *Pseudleptomastix mexicana, Mallada boninensis* Okam. and *Spalgis epius* on papaya mealybug. The predator of lac insect, *Berginus maindron*, *Cybocephalus nipponicus* on scales, *Hyperaspis maindroni* Sicard on *M. hirsutus* on hibiscus, *Tetrastychus* sp., the parasitoid of sugarcane borer was collected from Pune region of Maharashtra. The chrysopid, *Chrysoperla zastrowi sillemi* Esb. was recorded in cotton, maize, pigeon pea, french bean, rabi jawar and brinjal while *Mallada boninensis* Okam on cotton, sunflower, french beans, mango and papaya. The *Cryptolaemus* adults were recovered from the pre-released plots of custard apple and papaya (MPKV).

Survey and collection of natural enemies of banana weevils, banana aphid and root mealybug of pepper was carried out in Kerala. The earwig *Auchenomus hincksi* Ramamurthi (Dermaptera: Labiidae) was found feeding on eggs of banana pseudostem weevil. Against banana rhizome weevil, *Cosmopolites sordidus* germ earwigs *viz*., *Paralabis dohrni* (Kisby) (Dermaptera: Labiidae), *Charhospania nigriceps* (Kisby), *Euborellia shabi* Dohrn were collected as predators of eggs and early instar grubs of rhizome weevil. Against banana aphid, *Pentalonia nigronervosa* Coq six coccinellids were collected as predators (KAU).

b. Surveillance for alien invasive pests

Mealybugs recorded on papaya were *Paracoccus marginatus* and *Pseudococcus jackbeardsleyi*. The alien invasive insect pests recorded included *Brontispa longissima, Aleurodicus dugesii, Phenacoccus manihoti* and *Phenacoccus madeirensis* (TNAU). *P. jackbeardsleyi* was recorded on custard apple in Pune, *P. marginatus* was observed in the papaya orchards of western Maharashtra along with the encyrtid parasitoid *A. papayae* and *P. mexicana* and a new parasitoid *Aprostocetes* nr. *purpureus* was reported for the first time from PMB colonies in Rahuri region.

c. Entomopathogens

Diseased rice bugs were found infected with *Beauveria bassiana*. The entomopathogens particularly the cadavers of *S. litura* and *H. armigera* infected with *Nomuraea rileyi, Metarhizium anisopliae, Sl*NPV, *Ha*NPV were collected from soybean, potato, pigeon pea. The *Icerya* sp. on fan palm was collected from RFRS, Pune which is generally observed in temperate climate. An isolate of entomopathogenic nematode, *Heterorhabditis* sp. has been recovered from a mango orchard in Sitapur district, Uttar Pradesh and it has been designated as *Heterorhabditis* sp. (CISH EPN-05).

Biological Suppression of Pests and Diseases in Field, Plant Diseases and Nematodes

a. Biological control of chilli anthracnose diseases

During 2014-15, the minimum disease intensity(10.27 %) was observed in treatment recommended fungicide (Carbendazim 50% WP @ 0.05%) with 85.72 per cent disease control over untreated control. The next best treatment was T_1 i.e. *Pichia guilliermondii* (Y12) Seed treatment, Seedling dip &Foliar

spray (2x10^{8}cfu ml-1) with 14.25 per cent DI and gave 72.78 per cent disease control over untreated check. The significantly higher green chilli fruit yield was recorded with recommended fungicide (105 q/ha) as compared to untreated check (70.0 q/ha). The other best treatment with respect of yield was *P. guilliermondii* (Y12) (95.00 q/ha) (AAU - Anand).

In rice among 21 *Trichoderma* isolates tested,TCMS 43, TCMS 9, TCMS 36 and Th-14 were found effective in improving plant health, reducing sheath blight and brown spot diseases and in increasing yield. In wheat TCMS 16 and TCMS 65 in combination with chitosan (500ppm) and cow urine (10%) reduced yellow and brown rust. In chickpea Th-75, Th-3 and TRPCh-4 were found very promising in reducing seed as well plant mortality in the field. Against chilli anthracnose in nursery, seedling growth was very good in *Pichia guilliermondii* (Y-12) and *Hanseniaspora uvarum* (Y73) as compared to other treatments (GBUAT).

b. Management of bacterial wilt of brinjal with *Pseudomonas fluorescens (CHPf-1)* (CAU)

In the susceptible variety Anamika (Brinjal) the lowest incidence of bacterial wilt with 16.00% wilted plant was recorded in the plot treated with seedling root dip + soil drenching with CHF*Pf*-1 and it was on par with soil drenching with CHFPf-1 (20.00% wilted plants). Soil drenching with CHFPf-1 was comparable with soil drenching with streptomycin (19.66% wilted plants), soil application with mustard oil cake (20.80% wilted plants), soil drenching with bleaching powder (20.92% wilted plants) and seedling root dip with CHFPf-1 (22.98% wilted plants). The highest average plant height (68.00cm), highest average number of fruits per plant (9.20 fruits) and average fruit weight (113.46g/fruit) was recorded in seedling root dip + soil drenching with CHFPf-1. The highest yield was recorded in treatment with seedling root dip + soil drenching with CHFPf-1 (242.60 q/ha) and it was comparable with soil drenching with CHFPf-1 (221.80 q/ha).

Biological suppression of sugarcane pests

Monitoring of sugarcane woolly aphid (SWA) incidence and impact assessment of natural enemies on its suppression was carried out. The average pest incidence and intensity were 1.27 per cent and 1.35, respectively. The natural enemies recorded in the SWA infested fields were mainly predators like *Dipha aphidivora* (0.8-2.7 larvae/leaf), *Micromus igorotus (*1.1-5.8 grubs/leaf), syrphid, *Eupeodes confrator* (0.4-0.8 larvae/leaf) and spider (0.1-0.3 /leaf) during July to March, 2015. The parasitoid, *Encarsia flavoscutellum* was distributed and established well in sugarcane fields and suppressed the SWA incidence in Solapur, Pune and Satara districts (MPKV).

The SWA was noted in patches and the occurrence of *D. aphidivora, M. igorotus* and *E. flavoscutellum* were also observed along with the population of SWA. In general, incidence of SWA was noted from November 2014 (0.0 -10.2 SWA/2.5 sq.cm). The population escalated from January 2015 and the maximum population ranged up to 1 4.2 SWA/2.5 sq.cm leaf area during February 2015 in Tiruppur district followed by Erode district (12.6 SWA /2-5 sq. cm) (TNAU).

Cotton

a. Bio-efficacy of microbial insecticides against sucking pests in *Bt* cotton

Pooled data showed that significantly minimum number of jassids (1.24 /leaf), whitefly (1.04 /leaf), aphids (2.49 /leaf) and thrips (0.71 /leaf) were registered in insecticide treated plots. However *Beauveria bassiana* or *Verticilium lecanii* @ 40 g/ 10 liter of water also proved better by recording lower number of the recorded pests. Similarly, the highest seed cotton yield was noted in plot treated with chemical insecticide and it was at par with *Beauveria bassiana* or *Verticilium lecanii* @ 40 g/ 10 liter of water treated plots (AAU-A).

Regular surveys of mealybugs and its natural enemies from different hosts during June to September 2014 revealed only one mealybug species, *Phenacoccus solenopsis* on cotton. There was no major outbreak of pests on cotton. However, coccinellid predators such as *C. sexmaculata, C. septempunctata, B. suturalis* and green lace wing, *Chrysoperla zastrowi sillemi* were noticed at the rate of 0.2 to 3.4 predators per plant. Parasitization by parasitoids under field conditions varied from 42-73 per cent, out of which endoparasitoid *Aenasius bambawalei* (75.7%) was predominant. The per cent emergence *of Aenasius females* (61.7 %) was more as compared to males (38.3 %) and ratio of male to female was 1: 1.61 (PAU).

Among sucking insect pests, leafhopper, *Amrasca biguttula biguttula* and whitefly *Bemisia tabaci* were key pests on Bt cotton hybrid (Ankur 3028 BG II) and remained active through the cropping season in Ludhiana. The populations of leafhoppers, whiteflies, thrips and aphid varied from 0.0 to 9.2, 0.2 to 55.6, 0.0 to 33.0 and 0.0 to 0.4 per three leaves, respectively. Among predators population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 9.5, 0.0 to 2.5 and 0.0 to 4.0 per 10 plants, respectively. The seasonal incidence of sucking pests was also recorded at the PAU Regional Station, Bathinda on Bt cotton hybrid (RCH 134 Bt). The population of leafhopper, whitefly and thrips varied from 0.00 to 14.8, 0.00 to 98.0, and 0.0 to 15.2 per 3 leaves, respectively. The population of coccinellids, *Chrysoperla* and spiders varied from 0.0 to 2.0, 0.0 to 0.5 and 0.0 to 2.5 per 10 plants, respectively (PAU).

c. Monitoring biodiversity of invasive mealybugs on cotton including sap sucking insects and mirids

Largely, three mealybugs, *viz*., cotton mealy bug, papaya mealybug and grape mealybug were noticed in *Bt* cotton. Among them, cotton mealybug, *Phenacoccus solenopsis* was found to be predominant with nearly 85.33 per cent incidence (PJTSAU). Surveys conducted in Coimbatore, Erode and Tiruppur districts of Tamil Nadu on cotton host plants indicated the incidence of five species of mealybugs and *Paracoccus* was predominant (TNAU).

d. Incidence of natural enemies of cotton mealybug and to work out the species richness of natural enemies (UAS-R)

To monitor the activity of cotton mealybug a cotton hybrid, RCH-668 BG-II was grown in an area of 500 sq. m under unprotected situation. The results indicated that the activity of mealybug appeared during second fortnight of August and continued till the harvest of the crop. The peak activity was noticed during January with average population of 191.69 crawlers per 10 cm shoot length. The peak activity of coccinellids (0.31/plant) was noticed during December while spider and *Chrysoperla* activity was high during September. The predominant parasitoids associated with mealybug were *Aenasius bambawalei* (12.30%) followed by *Anagyrus dactylopii* (3.01%), *Promuscidea unfasciativentris* (2.66%), *Hamalotylus eytelweinii* (2.43%) and *Prochiloneurus pulchellus* (1.68%).

Maize

Evaluation of *Trichogramma chilonis* against maize stem borer *Chilo partellus*

Sole application of *Trichogramma chilonis* was ineffective in managing stem borer emphasizing complementary nature of this parasitoid in maize ecosystem. The outcome of the study also indicated that colonization of *Trichogramma* can be achievable only after prolonged inundative releases but not in a single season (PJSTAU).

Sorghum

The application of *Metarhizium anisopliae* entomofungal formulation strain Ma 36, Ma 35 caused significantly low dead hearts (9.1, 9.3 %); low stem tunnelling (3.5 and 3.3%); less exit holes/ stalk (1.5, 1.4 nos/ stalk) and realized significantly higher grain yield (5.54 and 5.48 kg/ plot) over the control. However, application of Carbofuran 3G was the superior treatment in terms of damage reduction and yield increase (IIMR**)**.

Pulses

Large scale demonstration was carried out at village Dhavat Ta. Karjan to control *Helicoverpa armigera* in pigeonpea. Two farmers were selected for large scale demonstration of NBAII-BT liquid formulations against pod borer in pigeonpea. The pest was effectively controlled with NBAII-BTG4 (AAU-A).

Three years of experimentation on efficacy of *Bt* formulations showed that NBAII BTG 4 *Bt* @ 2g/lit was effective in reducing pod borer population with higher grain yield in pigeonpea ecosystem. Large scale demonstration of NBAII BTG 4 *Bt* was done in Raichur taluka over an area of 5 ha. Minimum per cent pod damage of 9.46 which was statistically superior compared to NBAII BTG 4 *Bt* (13.46%). Similarly lowest grain damage (1.44) was noticed in farmers practice compared to NBAII BTG 4 *Bt* (2.19%). Higher grain yield of 14.98 q/ha was noticed in farmers practice compared to NBAII BTG 4 *Bt* which recorded 12.14q/ha grain yield (UAS-R).

For control of lepidopteran pests in moong bean PDBC-BT1 (2%), both doses of Delfin (1 or 2 kh/ha) were at par with each other and recorded lowest pod damage followed by chlorpyriphos 20 EC @1.5 l/acre (PAU). Evaluation against pulse pod borers showed that NBAII-BTG 4 (2%) maintained its supremacy in *Helicoverpa* management by recording least number of larvae (0.4 to 0.9/plant) followed by *Beauveria bassiana* (0.8 to 1.1/plant /plant) and are comparable with insecticidal check (04 to 1.3/plant). Least pod damage was also noticed in NBAII-BTG4 (2%) followed by *Beauvera bassiana* confirming their supremacy in *Helicoverpa* management in pigeonpea (PJTSAU).

Oilseeds

a. Biological suppression of safflower aphid (PJSTAU)

Among the botanicals and bioesticides tested, *Verticillium lecanii* recorded significantly lesser populations of aphids (4.89 aphids) followed by Neem oil (7.01) on top five cm of shoot of five randomly selected plants per plot.

b. Biological control agent introduction – Entomopathogenic nematode (*Heterorhabditis* sp. Strain IARI) based treatments in groundnut (NCIPM)

The yields in seed treatment with chlorothalonil alone and in combination with

Tebuconazone were at par at 24.16 and 24.58 q/ha, respectively as compared to 8.33 q/ha in untreated check. The plant population was significantly higher in chlorothalonil alone followed by EPN as compared to other treatments. Thirteen different IPM treatments were carried out in groundnut field for the management of whitegrub (*Holotrichia consanguinea*) in 1 acre area of the sandy loam soil at village Phogat, Bhiwani, Haryana. Highest average yield (22.90 kg/100 sqm) was found in T_{12} (*Rhizobium* + seed treatment with chlorothalonil at 2 gm/kg seed) treatment. Treatments of *Rhizobium* alone and in combination with other treatments indicated comparatively more pod yield. Similarly, more root nodulation were also recorded in *Rhizobium* treatments ranging from 352 to 428 root nodules in per g dry weight of roots. Lowest root grub infestation (19%) was recorded in FYM+ *M. anisopliae* 500 ml/50 kg.

A field trial was conducted during *kharif* 2014 to evaluate the efficacy of native strains of *Beauveria bassiana* against major soybean lepidopteron defoliators; *Chrysodeixis acuta* (Walker), *Diachrysia orichalcea* (Fabricius), *Gesonia gemma* Swinhoe and *Spodoptera litura* (Fabricius). Treatment effects on number of larvae per meter crop row and yield were not significant and *B. bassiana* infection was not observed in the field. However, in treatments DSRBB1 and DSRBB3 lower semilooper population (7.7 and 10.0 respectively per mrl) was recorded as compared to the control (12.3 per mrl). Highest yield was recorded in the treatment DSRBB3 (1701 Kg ha^{-1}) followed by DSRBB1 (1693 Kg ha^{-1}) that is nearly 20 per cent increase over control (DSR).

Coconut (KAU)

Coconut leaf eating caterpillar (*Opisina arenosella*) infestation was noticed in Kottayam Dist., Kerala during April 2014 with 42.06% leaf damage. Significant reduction in pest population (49.3%) was notice in a period of 12 months by release of larval parasitoids *viz.,Goniozus nephantidis* and *Bracon brevicornis.* Demonstration on integrated management of *O.arenosella* initiated at Arsikere, Karnataka revealed complete recovery of palms (from initial level of 79.7% leaf damage to 0.5%).

For curative treatment of red palm weevil infestation placement of three filter paper sachets containing 12-15 *H. indica*-infected *Galleria mellonella* cadavers on the leaf axils after application of 0.002% imidacloprid could recover 60% of infested palms. Area -wide demonstration of biocontrol technology undertaken in southern Kerala covering 1500 ha for the management of coconut rhinoceros beetle resulted in 65.2 to 85.5% reduction in leaf damage over a period of 2 years.

Rice

a. Seasonal abundance of predatory spiders in rice ecosystem (PAU)

Regular surveys were conducted to collect spiders from rice growing areas (Ludhiana, Patiala, Bathinda, Fatehgarh Sahib) of Punjab. The maximum spider population (2.0 spiders/plant) was observed during 38th SMW (3rd week of September). Eight species in the areas of Ludhiana and six species of spiders in the areas of Nabha were noticed.

b. Laboratory and field evaluation of fungal pathogens on gundhi bug, *Leptocorisa acuta* (KAU)

During 2014-15,*Metarhizium anisopliae* and *Beauveria bassiana* (local isolate) were evaluated in the field at Vellanikkara. Precount of *Leptocorisa acuta* was 5-8 no./sq.m. There was reduction in rice bug count in all the treated plots.

Tropical Fruits

Field evaluation of *Metarhizium anisopliae* formulations against mango hoppers *Idioscopus niveosparsus* showed significant reduction in hopper population in Imidacloprid and Nimbicidine sprayed trees and they were on par. Liquid and talc formulations of *M. anisopliae* were on par in reducing hopper population and these treatments were significantly superior to control (KAU).

Laboratory and field evaluation of entomopathogenic fungi against pseudostem borer *Odoiporus longicollis* showed that *M. anisopliae* and *B. bassiana* @ 10^8 spores/ml were found on par with chemical control. Laboratory evaluation of entomopathogenic fungi against banana root mealybug *Geococcus citrinus* indicated that mycosis was found in *Lecanicillium lecanii* treated (@ 10^7, 10^8, 10^9 spores/ml) and *M. anisopliae* (@ 10^7, 10^8, 10^9 spores/ml). Laboratory evaluation of entomopathogenic fungi against pepper root mealybug *Formicoccus polysperes* showed that *Lecanicillium lecanii* (10^7, 10^8 and 10^9 spores/ml) produced mycosis on pepper root mealybug. Field evaluation of *Lecanicillium lecanii* against pineapple mealybug *Dysmicoccus brevipes* showed that 10^7, 10^8 and 10^9 spores/ml were on par in reducing the mealybug population and were significantly superior to control. Significantly low pest incidence was recorded in chemical control and it was significantly superior to all other treatments (KAU).

Monitoring and record of incidence of papaya mealybug and its natural enemies on papaya and other alternate hosts showed that Erode district harboured higher incidence of papaya mealybug which ranged from 3.6 to 7.5% (TNAU).

No fresh infestation by *Paracoccus marginatus* was found in and around Bangalore on papaya and other alternative host plants surveyed. Validation of BIPM trial against *Thrips tabaci*, on onion with var. Arka Niketan indicated a significant reduction in thrips population by 73 % and 79% with liquid spray of *Beauveria bassiana* @1x10^7 spores/ml and *Metarhizium anisopliae* @1x10^7 spores/ml, respectively (IIHR).

Bio-efficacy of EPNs against Citrus trunk borer, *Pseudonemophas* (=*Anoplophora*) *versteegi* (CAU)

Bio-efficacy of EPNs against citrus trunk borer, *Pseudonemophas versteegi* were carried out at two locations *viz.* Pasighat and Rengging of Arunachal Pradesh. In both the locations, all the treatments recorded a significant reduction in the trunk borer infestation than the untreated control. Stem injection with Dichlorvos gave the highest reduction of 86.50 and 80.00 per cent at Pasighat and Rengging, respectively. Among the EPN treatments, CAU-1 stem injection (40.5 % reduction) was observed as the best treatment and it was closely followed by CAUH-1 stem injection (36.50% reduction), NBAII-01 stem injection (33.64 % reduction) and CAUH-2 stem injection (32.08% reduction) at Pasighat. However, at Rengging, CAUH-1 stem injection gave the highest reduction in trunk borer infestation among the EPNs with 36.64% reduction and it was closely followed by CAU-1 stem injection (36.00% reduction), NBAII-01 stem injection (35.56% reduction) and CAUH-2 stem injection (33.84% reduction). The stem injections of the EPNs were found more effective than their respective cadaver treatments.

Temperate Fruits

Survey for identification of suitable natural enemies of codling moth showed unidentified braconids and ichneumonids associated with overwintering larvae of codling moth, *Cydia pomonella* at Kargil. No indigenous *Trichogramma* spp. were found at Kargil in apple orchards (SKUAST).

Bio-intensive management of codling moth, *Cydia pomonella* on apple in Laddakh

Efficacy of *Trichogramma cacoeciae* was found better than *T. embryophagum* as it resulted 15.7% reduction in fruit damage over control, as compared to 9.9% in the latter. Use of *Trichogramma* spp., along with Pheromone traps, trunk banding and disposal of damaged fruits caused 30.5 per cent reduction in fruit damage over control. Trunk banding during overwintering period of codling moth larvae showed average larval catch ranging 26.3- 41.3 per tree in different locations of Kargil. Pheromone traps showed average catch of adult moths ranging 45.1 to 107.8/ trap in different locations of Kargil (SKUAST).

Evaluation of predatory bug, *Blaptostethus pallescens* against European red mite, *Panonychus ulmi* on apple showed that 89.7, 37.9, 13.9 and 4.3 per cent eggs of *Panonychus ulmi* failed to hatch in three days, when predator: prey ratio was kept as 1:5, 1:10, 1:15 and 1:20 respectively (SKUAST).

Oligota sp. was collected from rose, apple and ashwagandha feeding on mites. Soil samples from apple orchards having root borer grubs were collected but no EPNs were collected/ trapped from any location (YSPUHF).

Vegetables

a. Evaluation of local and NBAIR entomopathogenic strains against soil insects in potato (AAU-J)

- Imidacloprid @ 20 g ai/ha significantly reduced the infestation of potato by *Dorylus orientalis* (10.25%) and *Agrotis ipsilon* (9.0%) with maximum yield of 89.5 q/ha.
- Out of different entomopathogenic strains, *Bb*-5a of NBAIR strains was the next best treatment which could significantly reduce the infestation of *D. orientalis* (15.57%) and *A. ipsilon* (17.25%) effectively with next higher yield of 85.00q/ha compared to the local strains of *M.a*,-Biometa and *Bb*-Biosona.
- Malathion 5% @ 40 kg /ha was on par in respect to yield (81.25q/ha) with local strain of Bb-Biosona (80.75 q/ha), NBAIR strain of Bb-23 (79.00 q/ha) and Ma-4 (78.75 q/ha).
- Maximum number of infested tuber due to attack of *D. orientalis* and *A. ipsilon* was 34.25 and 36.5 per cent, in untreated check.
- Application of entomopathogenic fungi contributed significantly higher marketable yield over untreated check (53.50 q/ha).

b. Evaluation of fungal pathogens against sucking pest of hot chilli, *Capsicum sinensis* (AAU-J)

- Imidacloprid @ 20 g ai/ha significantly reduced the mean population of *Aphis gossypi* and *Scirtothrips dorsalis* compared to untreated check. Average population of *A. gossypi* and *S. dorsalis* was 6.25 and 1.25 in Imidacloprid treated

CHAPTER 4

plot followed by Bb-5a (NBAIR strain) with 8.5 and 2.50 per 10 leaves and both the treatments were on par in their efficacies after third spray.

- Highest yield of 53.8 q/ha recorded in imidacloprid @ 20.g ai /ha treated plot followed by NBAIR strain of Bb-5a with 51.20 q/ha and both treatments were at par.
- Minimum yield of 26.75 q/ha was obtained in untreated control and it had no significant difference with Ma-35, Ma-4 (NBAIR strain) and Ma- Biometa (Local strain) with 30.58, 29.75 and 28.75 q/ha, respectively.

c. Demonstration of bio intensive package for the pest of tomato

- Chemical control plot was significantly superior to BIPM in reducing the larval population of *Helicoverpa armigera.* Average population of *H. armigera* in chemical control plot was 2.70 as against 4.10 per10 plants in BIPM 9AAU-J).
- Minimum fruit damage recorded was 11.8% in chemical control plot with higher yield of 153.8 q/ha whereas it was 17.3% in BIPM plot with 147.20 q/ha yield. In untreated control yield was 85.86 q/ha (AAU-J).
- Large scale demonstration of BIPM technology for management of *Helicoverpa armigera* in tomato was carried out at village Runaj near Sojitra in tomato. Tricho card distributed to 50 farmers. The crop is found to be effectively controlled by the IPM strategy (AAU-A).

d. Evaluation of predatory mite, *Blaptostethus pallescens* against saffron thrips, *Haplothrips* sp. on saffron (SKUAST)

The average mortality of saffron thrips, *Haplothrips* sp. on 3rd and 6th day was 5.5 and 25.8 per cent respectively. Corrected mortality of thrips was 22.0 per cent

e. Survey, collection and identification of mealybugs infesting major vegetable crops and their natural enemies

During extensive survey it was found that the dominant mealybug species was identified as *Phenacoccus solenopsis* (Tinsley). It was found to be infesting tomato, brinjal, *Capsicum*, cucurbits and okra almost thorough out the year. Another species *Centrococcus insolitus* (Green) was also recorded to infest brinjal. The prominent endoparasitoid *viz*., *Aenasius bombawalei* Hayat (Encyrtidae: Hymenoptera) of *P. solenopsis* was recorded. Tritrophic interaction (Host plant – *P. solenopsis* – parasitoid) was observed during the recovery of the parasitoid from different hosts and highest recovery was obtained from tomato (28.23%) followed by okra (26.5%) whereas lowest recovery (10.89%) was in case of cucurbits (IIHR).

The biocontrol based IPM module (Three releases of *Chrysoperla* @ 5 larvae/ plant + 5% Neemazal + mechanical collection and destruction of *Pieris brassicae* eggs + planting of mustard crop on the borders + Three releases of *T. pieridis* @ 1, 00,000/ ha + Three sprays of Delfin WG @ 300 gm/ acre) was at par with chemical control (Success 2.5 SC @ 250 ml/ acre) in minimizing the population of *P. brassicae* on the cauliflower and increasing the cauliflower yield. Further, BIPM module enhanced the population buildup of natural enemies in the cauliflower field. Against chilli anthracnose disease lowest per cent fruit rot (6.78%) was in chemical control and was at par with *Trichoderma harzanium* treatment (PAU).

Tea Mosquito Bug (AAU-J)

Evaluation of *Beauveria bassiana* (IIHR isolate) against tea mosquito bug (AAU-J)

Thiamethoxam @30 gm ai/ha was found superior to *B. bassiana* (IIHR strain) in reducing the *H.theivora* population in tea after 30 days of second spray. No significant difference was noticed in reducing the *H. theivora* population with *B. bassiana* IIHR strain (18.60/10 plants) and Pestoneem (20.30/10 plants).

Biological suppression of polyhouse crop pests

a. Evaluation of efficacy of predators against cabbage aphids in polyhouse (SKUAST)

Five weekly releases of 2nd instar grubs of *Coccinella septempunctata* and *Chrysoperla zastrowi sillemi* caused 62.7 and 50.7 per cent reduction in aphid population over control. Overall reduction in pest density by *C. septempunctata* and *C. zastrowi sillemi* was worked out as 40.6 and 23.8 per cent, respectively.

b. Identification and evaluation of predatory mite potential on *Tetranychus* spp. in tomato under greenhouse condition (UAS-R)

Standardization of mass multiplication technique for predatory mite was done under insectary by raising a susceptible cultivar of soybean in earthen pots and by stapling technique.

Biological suppression of storage pests

Evaluation of *Uscana* sp. (Trichogrammatidae) against *Callosobruchus* sp. on storability of pigeonpea seed

Parasitization by *Uscana* sp. on bruchid eggs increased with release of more number of parasitoids. It prefers freshly laid (1-2 day old) eggs than the older ones. The parasitization of *Uscana* sp. is effective only when it parasitizes cent per cent bruchid eggs on pigeonpea seed. It is very clear that the pigeonpea seeds infested with pulse beetle will not be suitable for seed even though the germ portions are not damaged (AAU-J).

Biological suppression of weeds

Chromolaena odorata, a problematic weed of North-East, Western Ghats, Karnataka and Tamil Nadu has spread its tentacles in Baster area of Chhattisgarh. Keeping in view its seriousness and to check its further invasion from this region of Chhattisgarh to Maharashtra and Madhya Pradesh, the present study has been taken up. In 2012 about 3000 galls infested with gall fly were released in the infested area. Symptoms of establishment of bioagent were not observed in 2013. Therefore, again 1500 infested galls were released in the three different sites of Jagdalpur area in September 2013. Again in 2014, about 500 galls were released in teak plantation site. Survey done during 2014 revealed the presence of galls on *Chromolaena odorata* indicating the start of establishment process. Samples taken from nine different plots for gall formation, revealed the presence of galls varying from mean 1.67 to 7.08 per 25 m^2 (NRCWS).

Enabling large scale adoption of proven biocontrol technologies

a. Rice

In large scale adoption of BIPM package, the mean incidence of WEH was 2.77% in BIPM package and was comparatively superior to farmers practice recorded which recorded 3.76% at 125 DAT. Higher number of spiders and coccinellids recorded in BPIM was 1.50 and 1.80 / m^2 as against 0.6 and 0.7/ m^2 in farmers' practice. Maximum mean yield was contributed by BIPM package with 4126.0 kg/ha, and it was on par with farmers practice (3984.4 Kg/ha) (AAU-J).

Demonstration trials were conducted at 42 farmers' fields covering an area of 36.8ha. By adopting biocontrol technologies an average yield of 43q/ha was obtained as compared to 36 q/ha with conventional practices (GBPUAT**).**

Large scale demonstration of biocontrol based IPM (six releases of *T. chilonis* and *T. japonicum* each @ 1, 00,000/ha) at four locations in village Saholi (Patiala) in organic *basmati* rice (var. Pusa 1121) over an area of 50 acres resulted in lower incidence of rice insect pests. The net returns over control in biocontrol package were Rs. 14652/- as compared to Rs. 8379/- in farmers' practice with cost benefit ratio of 1:3.88 and 1:2.76, respectively (PAU).

Demonstration in 100 acres of Angul district of Orissa showed IPM practice was superior to the farmers' practice in all locations. Dead and white hearts were recorded as 5.2 and 8.2% in IPM package while in farmers' practice the corresponding figures were 9.3 and 13.6%, respectively. Leaf folder, case worm and skipper population in IPM and non-IPM plots were 4.8, 3.2 and 1.8 %, respectively whereas, in the non-IPM plots it was 8.1, 6.3 and 3.9 %.The GLH population in IPM fields was 5.1/hill as against 9.3/hill in non IPM fields. It was observed that the beneficial fauna like spiders and ladybirds were more in number in IPM plots which were 7.1/hill and 4.9/hill whereas, the corresponding population in non IPM plots was 1.9 and 1.1/hill respectively. Yields obtained in IPM plots were significantly higher than the non IPM plots. The farmers obtained a net profit ranging from - Rs.24,640/ha over farmers' practice in different locations (OUAT).

b. Pea

Field demonstrations were conducted on pea variety Arkil, in 25 farmers' fields covering an area of 36 acres. Wilt incidence was very low due to the application of biocontrol technology. An average yield 50-55 q/acre of green pea was obtained with biocontrol technology as compared to conventional practices (25-30 q/acre).

c. Sugarcane

Large scale demonstration of effectiveness of temperature tolerant strain of *Trichogramma chilonis* (tts) @ 50,000 per ha at 10 days interval (eight releases) over an area of 1000 acres in farmers' fields in collaboration with two sugar mills reduced early shoot borer (*Chilo infuscatellus)* incidence by 54.1 per cent. Release of *T. chilonis* (tts) @ 50,000 per ha against early shoot borer, *C. infuscatellus* were carried out over an area of 100 acres at villages of Jalandhar and Hoshiarpur districts. The treatments reduced ESB incidence over and chemical (Padan 40G @ 25 kg/ ha) by 60.2 and 84.4 per cent, respectively. *T*he cost: benefit ratio (1: 35.92) was more in biocontrol as compared to chemical control (1: 17.40). Release of *T. chilonis* @ 50,000 per ha at 10 days interval during July to October, 2014 (twelve releases) over an area of 3800 acres at farmers' fields in collaboration with two sugar mills (of the state reduced the incidence of stalk borer, *Chilo auricilius* by 55.2 per cent. Similarly against stalk borer, *C. auricilius* covering an area of 140 acres in Jalandhar and Hoshiarpur districts of Punjab, reduced its incidence over control in release fields by 59.6 per cent. Large scale demonstration of effectiveness of *T. japonicum* against top borer, *Scirpophaga excerptalis* (tts) @ 50,000 per ha at 10 days interval during mid - April to end June, 2014 (eight releases) over an area of 900 acres in collaboration with two sugar mills of the state reduced the incidence of top borer by 53.2 per cent. Releases of *T. japonicum* against top borer, *S. excerptalis* were carried over an area of 175 acres at villages Paddi Khalsa (Dist. Jalandhar) and Rawalpindi (Dist. Hoshiapur) reduced its incidence over control by 54.4 and 57.4 per cent in released fields (PAU).

Large scale demonstration on the use of *T.chilonis* against early shoot borer and internode borer of sugarcane in farmers' field covering 100 acres of Korada village of Angul district of Orissa showed that the mean incidence of early shoot borer (ESB) ranged from 6.7 to 9.3%, in *T.chilonis* released plots. On the contrary, the incidence of ESB ranged from 29.4 to 39.1% in the fields where no parasitoids have been released and farmers took their own control measures of pesticide application. Similarly, internode borer incidence was also least in parasitoid released plots (13.8% and 16.3%) as compared to 24.45% and 30.3% in farmers practice. As regards the top shoot borer the pest incidence was least in parasitoid treatment (2.1% to 3.2%) as compared to the fields where no parasitoid has been released (7.9% to 9.8%). The yield was higher (149.8/ha to 159.4t/ha) in parasitoid released plots whereas, it was 111.5 t/ha to 115.8 t/ha in farmers practice (OUAT).

d. Maize

Large scale demonstration using *T. chilonis* @ 1, 00,000/ ha on 15 days crop in farmers' fields in an area of 202 acres in Hoshiarpur and Ropar districts of Punjab rendered effective control of maize stem borer, *Chilo partellus* as against untreated control and was comparable to chemical control (farmers' practice: Decis 2.8 EC @ 200 ml/ha). The net returns over control in biocontrol package was Rs. 8630.20/- as compared to Rs.10978.30/- in farmers' practice with cost benefit ratio of 1: 47.91 and 1: 15.25, respectively (PAU).

e. Soyabean

Large scale validation of IPM modules in soybean farmers' fields resulted in higher grain yield 14.6 q/ha **(**MPUAT**).**

f. Brinjal

Large scale demonstration of BIPM in brinjal covering 100 acres in village Karatapeta of Angul district of Orissa was carried out. BIPM adopted was; Pheromone traps erected @ 25/ha after 15 DAP; weekly release of egg parasitoid *Trichogramma chilonis* @ 50,000/ha / week after 20 DAP (total of 15 releases) (released till the final harvest) and two sprays of Bt (Dipel) @ 2 ml/L at 10 days intervals at peak flowering. Farmers' practice was Rynaxypyr (Coragen) @ 0.3ml/L at fortnightly intervals. The shoot borer and fruit borer incidence was significantly low in IPM plots recording 12.8 and 21.9 % respectively whereas, it was 29.1 and 43.7% in farmers' practice plots. Consequently the yield was also higher in the IPM plots (20,321 kg/ha) with cost: benefit ratio of 1:5.1 whereas, the yield in farmers practice plot was 12,209 kg/ha with C:B ratio of 1:1.22. The IPM practice gave a net return of Rs. 1,62,240 over the farmers' practice.

GENBANK ACCESSIONS SUBMITTED BY AND DNA BARCODES DEVELOPED AT NBAIR

Description	Accession Number
Termite (CO1)	
Odentotermes longignathus	KM015486
Microtermes obesi	KM657488
Euhamitermes hamatus	KM657484
Nasutitermes octopilis	KM657478
Nasutitermes exitiosus	KM 015487
Macrognathotermes errator	KM657477
Odontermes mathurai	KM657487
Neotermes koshunensis	KM657485
Odontotermes gurdaspurensis	KM657482
Odontotermes gurdaspurensis	KM657483
Odontotermes gurdaspurensis	KM657481
Odontotermes gurdaspurensis	KM657480
Microtermes mycophagus	KM657479
Odontotermes mathuri	KM647487
Odontotermes obesus	KM657477
Scarabeid beetles (CO1)	
Anomola sp.	KM657491
Protaetia sp.	KM657489
Protaetia sp.	KM657490
Anomola sp.	KM657492
Heterorrhina sp.	KM657485
Protaetia sp.	KM657486
Parasitoids and predators (CO1)	
Aenasius advena	KJ850498
Blepyrus insularis	KJ850500
Neastymachus axillaris	KM095502
Myiocnema comperei	KJ955498
Eulophid *Diglyphus isaea*	KM016074
Braconid *Aphidius ervi*	KM054518
Aphidius colemani	KM054519
Cotesia sp.	KM875666

CHAPTER 5

Glyptapanteles sp. (Bidar)	KM887912
Glyptapanteles sp. (Valparai)	KM887913
Apanteles phycodis	KP055616
Bracon greeni	KP055617
Micropilitis maculipennis	KP759288
Vespid *Ropalidia* sp.	KM054517
Scelionid *Macrotelia* sp.	KM095503
Idris sp.	KP271246
Ichneumonid *Pristomerus sulci*	KM875667
Chalcidid *Brachymeria tachardiae*	KP055618

Microbial 16s rDNA sequences (isolated from insects)

Bacillus cereus strain Hin5.1	KP962326
Bacillus flexus strain Hin5.2	KP962327
Paracoccus siganidrum strain Hin5.4	KP962328
Bacillus kochii strain Hin7.1	KP962329
Bacillus spp. strain Hin7.3	KP962330
Kocuria rosea strain Hin7.6	KP962331
Alcaligenes faecalis strain Hin10.1	KP962332
Kocuria turfanensis strain Hin10.2	KP962333
Kocuria polaris strain Hin12.1	KP962334
Proteus mirabilis strain BSFN12p	KM405328.1
Bacillus cereus strain Hin12.1	KP962335
Bacillus sp. strain HGG-22	KM405335.1
Bacillus sp. strain FGG1	KM405334.1
Bacillus subtilis strain OrM23	KM405333.1
Bacillus subtilis strain OrF12	KM05332.1
Bacillus pumilus strain C9	KM405331.1
Geobacillus stearothermophilus strain BSFN12q	KM405330.1
Bacillus cereus strain BSFN12r,	KM405329.1
Microbacterium trichothecenolyticum strain BSFN10	KM394283.1
Proteus vulgaris strain Hb1	KM394272.1
Microbacterium trichothecenolyticum strain BSFN10n	KM394282.1
Staphylococcus saprophyticus strain BSFN10m	KM394281.1
Bacillus flexus strain BSFN10l	KM394280.1
Bacillus cereus strain BSFN7k	KM394279.1
Bacillus subtilis strain Hb10	KM394278.1
Bacillus subtilis strain Hb9	KM394277.1
Bacillus licheniformis strain Hb8	KM394276.1

Bacillus cereus strain Hb6	KM394275.1
Bacillus amyloliquefaciens strain Hb5	KM394274.1
Pseudomonas sp. Hb2	KM394273.1
Citrobacter koseri strain C4	KM016946.1
Brevibacterium epidermidis strain BSFN5e	KM368324.1
Staphylococcus saprophyticus strain C5 16S	KM016945.1
Bacillus cereus strain C6	KM016944.1
Arthrobacter sp. C7	KM016943.1
Enterococcus pallens strain C8	KM016942.1
Bacillus safensis strain C11	KM016929.1
Bacillus amyloliquefaciens strain C10	KM016928.1
Bacillus megaterium strain BSFN7j	KM368327.1
Proteus mirabilis strain BSFN7i	KM368326.1
Bacillus altitudinis strain OrH32	KM081635.1
Bacillus aerophilus strain OrH31	KM081634.1
Bacillus methylotrophicus strain OrH30	KM081633.1
Myroides odoratimimus strain F1 GenBank	KJ197176.1
Bacillus tequilensis strain OrH27	KM081631.1
Bacillus bombysepticus	KM081629.1
Microbacterium testaceum strain HGG-20	KM101056.1
Bacillus amyloliquefaciens strain HGG-19	KM101055.1
Microbacterium aerolatum strain HGG-15	KM101053.1
Microbacterium phyllosphaerae strain HGG-11	KM101050.1
Bacillus bombysepticus strain HGG-10	KM101049.1
Neorhizobium huautlense strain HGG-6	KM101048.1
Xylanimicrobium pachnodae strain HGG-4	KM101046.1
Lysinibacillus sphaericus strain OrM22	KM067915.1
Bacillus marisflavi strain OrM21	KM067914.1
Bacillus altitudinis strain OrM19	KM067913.1
Bacillus megaterium strain OrM16	KM067910.1
Bacillus amyloliquefaciens strain OrF4	KM065516.1
Lysinibacillus sphaericus strain OrF3	KM065515.1
Citrobacter sp. C3	KM036500.1
Bradyrhizobiaceae bacterium C2	KM036499.1
Pseudoxanthomonas sp.	KJ997967.1
Pseudomonas putida strain F6	KJ197184.1
Zobellella taiwanensis strain F4	KJ197182.1
Providencia sp. F3	KJ197181.1
Bacillus pumilus strain F2	KJ197180.1

Insect Identification Services

The ICAR-NBAIR is one of the few centres in India offering identification services to institutions, scientists, students and other individuals. The identifications are effected on those groups for which expertise is available in the Bureau. For other groups the specimens are sent to experts in the country who provide the identities of the insects. Those groups for which no taxonomic expertise exists within the country are maintained in the museum of the Bureau for future studies.

Hymenoptera (Braconidae, Ichneumonidae, Pteromalidae, Eulophidae, Chalcididae, Encyrtidae, Eupelmidae, Aphelinidae and Bethylidae) (Ankita Gupta)

India–Manipur University Imphal; ICAR-NEH Region, Barapani; Central Silk Board- TN, Uttar Banga Kashi VV- Cooch Behar; IISR, Kozhikode; National Research Centre for Grapes, Manjri Farm, Pune; Calicut University, Calicut; Tamil Nadu Agricultural University, Coimbatore; IGKVV, Raipur; CSR&TI, Pampore; CSR&TI, Central Silk Board, Mysore; CSR&TI, Berhampore; UAS, Dharwad; UAS, Bangalore (multiple requests); IIHR, Bangalore; Pondicherry University; Monsanto company; Reva Institute of Science and Management, Bangalore.

Other countries- Online/ email identification through images- The Agriculture University, Peshawar, Pakistan.

Coleoptera, Diptera, Hemiptera, Hymenoptera, etc. (J. Poorani)

ICAR Research Complex for Goa, Ela; Central Sericultural Research and Training Institute (Central Silk Board), Berhampore, West Bengal; ICAR-SBI, Coimbatore; AICRP on Fruits, PAU, Ludhiana; Yashvantrao Chavan Institute of Science, Satara, Maharashtra; UAS(B), Chintamani; CICR, Nagpur; ICAR Complex, Medziphema; Freelance columnist / educationist; IIHR, Bangalore; ICAR Research Complex for NEH Region, Sikkim Centre, Tadong; MPKV, Rahuri; Sardarkrushingar, Gujarat; University of Burdwan, Burdwan, West Bengal; TNAU, Coimbatore; UPASI, Valparai; RRS-TNAU, Yethavur; NRC on Orchids, Sikkim; AICRP (BC), MPKV; UHF, Solan; M/s Fine Trap India, Nagpur, Maharashtra; Zoological Survey of India, Pune; KAU-RRS, Pattambi; H. S. Singh, Central Horticultural Experiment Station (ICAR) Aiginia, Bhubaneswar; UAS-Bangalore; GAU, Anand; Institute of Forest Genetics and Tree Breeding, Forest campus, R.S. Puram, Coimbatore; Chalapathi Rao, AICRP (Palms), Vegetable Research Station, Rajendrangar; MPKV; University of Gulbarga; (Acarology); SBI, Coimbatore; UHS, Bagalkot; Bijapur; CAE, Kumulur, Tamil Nadu; College of Agriculture, Nagpur; Coll. Agriculture, Mandya; amateur photographer; Fine Trap India, Nagpur; PAJANCOA, Karaikal; ICAR-NRC on Seed Spices, Ajmer; MPKV, Rahuri; Zoological Survey of India, Calicut; Reva Institute of Science and Management, Bangalore.

Other countries- Online/ email identification through images-University of Georgia, Athens, Georgia, US and Sri Lanka.

Hemiptera (Aphids, mealybugs and scale insects) (Sunil Joshi)

NBAIR; IIHR; KAU, Trivandrum; CSIR - IHBT, Palampur, H.P; PCI, Bengaluru; NRCG, Pune; CHES, Chettalli, Kodagu; MPKV, AICRP on Biological Control of Crop Pests; CPRIC, Modipuram, Meerut; CPRIC, Modipuram, Meerut; CPRI, Shimla; SBI, Coimbatore, T N.; MPKV, AICRP on Medicinal, Aromatic plants and Betelvine; CPCRI, Vittal, Karnataka; CSIR - IHBT, Palampur, H.P; PLant qurantine Station, Tiruchirapalli; UAS, Dharwad; ICAR, Umiam, Meghalaya; DSR, Rajendranagar, Hyderabad; GKVK, Bengaluru; Plant quarantine; TNAU, Coimbatore, T N; KAU, Kerala; CPRI, Shimla; IWST, Bengaluru; Orissa University of Agri & Tech.; AICRP on potato UAHS, Shimoga; NRCSS, Ajmeer; KAU; CRS, Pampadumpara; IISR, Calicut; KAU, Coll. of Horti. Thrissur KAU; CRS, Pampadumpara; CSR & TI, West Bengal; PAU, AICRP on Fruits, Ludhiana, Punjab; KVK, Mudigere; AAU, AICRP on Biological Control, Anand; DSR, Rajendranagar, Hyderabad; BCKV, AICRP on Potato, WB; IISR, Calicut, Kerala.

Hymenoptera (Platygastroidea) (K. Veenakumari)

University of Agricultural Sciences, GKVK, Bengaluru

Hymenoptera (Trichogrammatidae)

Professor Jayashankar Telengana State Agricultural University, Rajendranagar, Hyderabad; Punjab Agricultural University, Ludhiana

EXTENSION ACTIVITIES

Live insect cultures

During 2014-15, 139 live insect cultures were maintained, 1148 consignments supplied and a revenue of Rs 5,50,931 generated (Fig. 52)

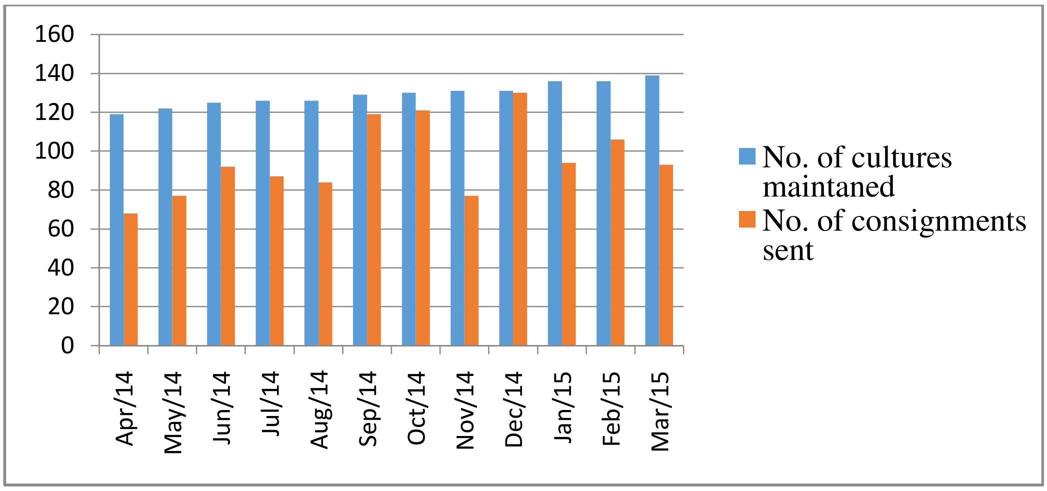
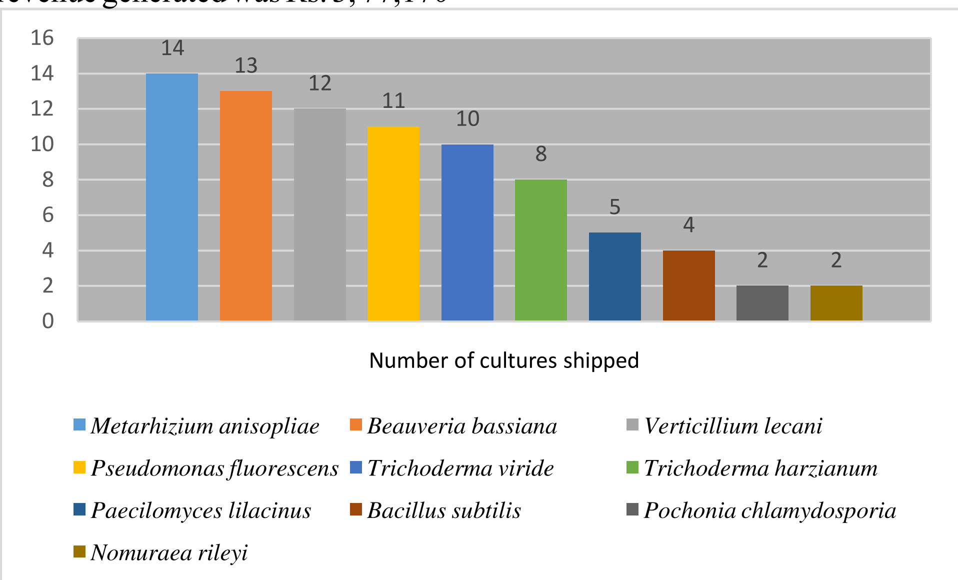


Fig.52. Live insect cultures maintained and supplied during 2014-15

Microbial cultures

A total of 72 microbial cultures were supplied to various producers during the period (Fig. 53) and 7 samples were analysed for quality parameters. Also EPN (*Heterorhabditis indica* (10000 Ijs) plus *Galleria mellonella* larvae (100) were supplied. Total revenue generated was Rs. 3, 77,170



AWARDS AND RECOGNITIONS

Abraham Verghese
Conferred with "Lifetime Achievement" award at World Biodiversity Congress (WBC-2014) held at Colombo, Sri Lanka, from 24th – 27th November, 2014 organized by the Global Scientific Research Foundation and Field Ornithology Group of Sri Lanka in association with University of Colombo and Rajarata

Received a medallion for fruit fly research from His Excellency Mr. Yukols Lomlaemthong, Deputy Prime Minister of Thailand, on 12th May 2104 at the 9th International in Bangkok

Recognized as a Faculty in Jain University, Bangalore

Recognized as a Member, Board of Management, University of Agricultural and Horticultural Sciences, Shivamoga

Recognized as Editor for the journal 'Insect Environment'

Recognized as Editorial Advisor for the 'Newsletter for Birdwatchers' and the journal 'Current Biotica'

Declared Fellow of Society for Biocontrol Advancement 2014.

Awarded 1st B. S. Bhumannavar award for Development and utilization of pesticide and abiotic stress tolerant natural enemies for crop pest management by Society for Biocontrol Advancement, Bangalore. As a team research award it was also conferred to Abraham Verghese, Venkatesan T, Murthy K S, Rangeshwaran R and Sivakumar G.

Ankita Gupta
Declared Fellow of Society for Biocontrol advancement 2014.

Bakthavatsalam N
Awarded the Prof. T. N. Ananthakrishnan Award for 2014 by TNA Foundation Institution for his contribution in the management of eucalyptus gall wasp.

Recognized as Chairman (Entomology) of Research Council of Indian Cardamom Research Institute, Myladumpara

Recognized as expert for evaluation of nomination to S.S. Bhatnagar Prize (CSIR)

Chandish R Ballal
Recognized as IMC member of NBAIM, Mau 2013-2016

Recognized as Councillor for Plant Protection Association of India, 2014-2016.

Was interviewed by *Bangalore Mirror* on "Biocontrol approaches for pest management using parasitoids and predators" and the article appeared in Bangalore Mirror "Scientists game insect parasite wasps to eliminate pests" – 19th September 2014.

Received best oral paper award: Ghosh, E., Ballal, C.R. and Roopa, G. 2015 Developmental thresholds for two potential egg parasitoids *Trichogramma chilonis* (Ishii) and *Trichogramma japonicum* (Ashmead). pp. 358 – 359, in IIMASAE held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015.

Recognized as guide for Doctoral Programme (Biotechnology) by Jain University

Co-chaired the session on Bio-suppression of pests of fruit and vegetable crops, polyhouse crop pests, storage pests and weeds during the AICRP-BC Group Meet held at OUA&T,

Bhubaneswar, 27th to 28th June, 2014.

Invited as a resource person to give a talk on "Biological control of insect pests and diseases for Plant Health Management" during the Refresher Course in Environmental Science organized by Academic Staff College, Kannur University; 6th December 2014.

Recognized to give a lead talk on the new pest, *Tuta absoluta* during the District Level Workshop on tomato cultivation & interaction session with farmers organized by College of Horticulture, Kolar; 12th March 2015.

Recognized to give a presentation on the invasive pest *Tuta absoluta* during the one day meet organized by Directorate of Plant Protection Quarantine and Storage, at NBAIR on 21st February, 2015.

Jalali S K
Declared Fellow of the Royal Entomological Society, London, October 2014.

Declared as Fellow of the Society for Biocontrol Advancement, Bangalore, October 2014.

Awarded 1st B. S. Bhumannavar award for Development and utilization of pesticide and abiotic stress tolerant natural enemies for crop pest management by Society for Biocontrol Advancement, Bangalore. As a team research award it was also conferred to Abraham Verghese, Venkatesan T, Murthy K S, Rangeshwaran R and Sivakumar G.

Recognized as Course Director for International Training Programme for 7 Iraqi delegates from 1st June to 15th June 2014, at NBAIR, Bangalore

Murthy K S
Declared Fellow of the Society for Biocontrol Advancement, Bangalore, October, 2014.

Recognized as Research Guide by the Department of Zoology, University of Mysore, Mysore

Recognized as External Examiner for Doctoral thesis in Agricultural Entomology, Telangana State Agricultural University, Hyderabad

Recognized as recognised as External Examiner for Doctoral thesis in Agricultural Entomology, submitted to Acharya N G Ranga Agricultural University, Hyderabad

Recognized as Nodal officer- HRD , NBAIR, Bengaluru

Mahesh S. Yandigeri
Awarded best poster - NikhitaPai, Sanjay Yalashetti, Mahesh S. Yandigeri, Mohan M. Sivakumar G. 2015, for the paper entitled "Diversity of bacterial communities in the midgut of silkworm *Bombyxmori*" presented during theInternational Symposium on New Perspectives in Modern Biotechnology, organized bySociety for Applied Biotechnology, 23-25 March, Puducherry, India.

Mohan M
Best poster presentation award- Mohan M, Sampathkumar M, Shanas S and Karthikeyan K, 2015, for the paper entitled "Bio-ecology of white stemborer, *Scirpophaga fusciflua* and its susceptibility to *Bt* toxins and strains", presented during the "National Meeting on New/Safer Molecules and Biocontrol Technologies for IPM in crops", Bengaluru, 23 Feb 2015.

Pratheepa M
Declared Fellow of the Society for Biocontrol Advancement, Bangalore, October, 2014.

Ramanujam B
Declared Fellow of the Society for Biocontrol Advancement, Bangalore, October, 2014.

Rangeshwaran R
Best poster presentation award - Rangeshwaran R, Frenita M. Lewis, Sivakumar G, Mohan M and Satendra Kumar, 2015, for the paper entitled "Cloning and expression of VIP3A gene for broad spectrum insecticidal activity" presented during the "National Meeting on New/Safer Molecules and Biocontrol Technologies for IPM in crops" Bengaluru, 23 Feb 2015.

Recognized as external examiner for Doctoral thesis in Microbiology, submitted to Kuvempu University, Shivamoga.

Declared Fellow of the Society for Biocontrol Advancement, Bangalore, and October, 2014.

Recognized as reviewer for the PLOS-ONE and Current Microbiology journals.

Shivalingaswamy T M
Invited to give lead lecture on "Pollinators" at the International Conference on IIMASAE held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015.

Shylesha A N
Honored for the work on invasive eucalyptus gall wasp with a certificate of excellence by the director NBAIR on 26th August 2014 during brain storming on insects in relation to quarantine and celebrations of success of classical biological control of eucalyptus gall wasp at NBAIR, Bengaluru.

Invited to deliver lead lecture on "Classical Biological Control" at the International Conference on IIMASAE held at Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai, Tamil Nadu from 27th January to 30th January, 2015.

Sivakumar G
Declared Fellow of the Society for Biocontrol Advancement, Bangalore, October, 2014.

Selected for Dr. Abdul Kalam Life Time Achievement National Award by the International Institute for Social and Economic Reforms (R), Dharwad, Karnataka.

Recognized as external examiner for thesis evaluation for Gandhi Rural Institute (Deemed University).

Recognized as a reviewer for the Journal of Experimental Biology and Agricultural Sciences.

Best poster presentation award -Surabhi Kumari, Sivakumar G, Rangeshwaran R, Ballal C R, Mahesh S. Yandigeri, M Mohan M, Raghavendra A and Abraham Verghese, 2015, for the paper entitled"Endosymbiotic bacteria, *Bacillus pumilus* and its role on fitness of *Amrasca biguttula biguttula* (Ishida) of cotton" presented during the "National Meeting on New/Safer Molecules and Biocontrol Technologies for IPM in crops", Bengaluru, 23, Feb 2015.

Sreerama Kumar P
Co-chaired Session on (Sustainable Agricultural Production and Agro-Ecosystems & Pest Management) at the World Biodiversity Congress 2014, Colombo, Sri Lanka.

Elected Nominated as Vice-President of the Society for Biocontrol Advancement.

Invited by Prof. Hiroshi Amano to be a speaker and an organiser of the "Symposium on Pathogens of Acari" at the "XIV International

Congress of Acarology (ICA)", Kyoto University, Kyoto, Japan, 14–18 July 2014.

Recognized as Ph.D. supervisor by Forest Research Institute (Deemed) University, Dehra Dun.

Recognised as M.Sc. (Ag.) advisor by Indira Gandhi KrishiVishwavidyalaya, Raipur.

Acted as Member of the Selection Committee for recruiting Senior Research Fellows by the Directorate of Plant Protection, Quarantine and Storage, Bengaluru, 03 September 2014.

Recognised as Ambassador for The Association of Applied Biologists, Warwick, United Kingdom.

Recognised as Endowment Awardee of the Society for Invertebrate Pathology, Knoxville, USA.

Acted as reviewer for several scientific journals, including World Journal of Agricultural Sciences, World Journal of Microbiology and International Journal of Plant Breeding and Crop Science, The Indian Journal of Agricultural Sciences, etc.

Subaharan K

Recognized as resource person for winter school and delivered a lecture on Chemo ecological approaches for management veterinary and agricultural pests at ICAR – National Centre for Integrated Pest Management, New Delhi on 13.3.2015.

Recognized as resource person for KVK officers training organized by ICAR – ZPD and ICAR – NCIPM on 11.9.2014 at ICAR – NBAIR Bengaluru.

Recognized as resource person for refresher course on Emerging pests and diseases of palms and cocoa at ICAR – CPCRI, Kasaragod on 22.05.2014

Best oral presentation for the invited lecture entitled "Behavioural manipulation methods in management of veterinary and agricultural pests" delivered in National Symposium on Entomology as a Science and IPM as a technology-the way forward held at College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh during November 13-15, 2014.

Best oral presentation for the paper titled Efficacy of Entomopathogenic nematodes in combination with imidacloprid against *leucopholis burmestrii* authored by Rajkumar, Jagdeesh Patil and Kesavan Subaharan in International Conference on Changing pest scenario of pest problems in Agri- Horti ecosystem and their management held from 27 - 29 November, 2014 at Udaipur.

Declared Fellow of Society for Biocontrol Advancement. Conferred during the Annual General Body Meeting of SBA held at Bengaluru on 23, February, 2015.

Best poster award for the paper titled "Cidal activity of Ajowan, *Trachyspermum ammi* essential oil and its component on housefly, *Musca domestica*" authored by M.Sowmya, Kesavan Subaharan and N.Bakthavatsalam presented in National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops, held at Bangalore on 23.02.2015 .

Best poster award for the paper titled "Behavioral responses of parasitoids of coconut black headed caterpillar to herbivore induced plant volatiles" authored by ADNT Kumara, Kesavan Subaharan and A.K.Chakravarthy presented in National Meeting on New/Safer Molecules and Biocontrol Technologies for

Integrated Pest Management in Crops, held at Bangalore on 23.02.2015 .

External examiner for Ph.D thesis by Ms. Kavitha in Agricultural Entomology at Tamil Nadu Agricultural University

External examiner for M.Sc thesis by Mr. Jeevan in Agricultural Entomology at Kerala Agricultural University.

External Examiner for M.Sc thesis by Mr. Ravikumar Patnala from PAJANCOA, Karikal.

Interview panel member for selection of Assistant Professor in Nanotechnology at University of Horticultural Sciences, Bagalkot on 20.03.2015.

Interview panel member for selection of Junior Research Fellow of Silk Board sponserd project on management of Uzi fly at ICAR – NBAIR.

Venkatesan T

Recognized as Co-supervisor for Guiding Ph.D student, Institute of Wood Science and Technology, Bengaluru registered with Forest Research Institute, Dehra Dun on 22nd September 2014.

Recognized as IRC external member for Directorate of Medicinal and Aromatic plants research, Anand during 10-11 Oct. 2014.

Guided Ph.D. student Ms. Hemalatha, B.N. registered with University of Mysore and awarded Ph.D degree on 10th Feb 2015.

AICRP / COORDINATION UNIT / NATIONAL CENTRES

Large scale demonstrations and field testing of biological control technologies developed at NBAII are undertaken by select ICAR institutes and State Agricultural Universities.

Headquarters

ICAR-National Bureau of Agriculturally Important Insects, Bangalore	Basic Research

State Agricultural University–based Centres

i.	Anand Agricultural University, Anand	Cotton, pulses, Oilseeds, vegetables, weeds
ii.	Assam Agricultural University, Jorhat	Sugarcane, pulses, rice, weeds
iii.	Dr. Y.S. Parmar University of Horticulture and Forestry, Solan	Fruits, vegetables, weeds
iv.	Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
v.	Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits
vi.	Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soyabean, Guava
vii.	Pandit Jayashankar Telangana State Agricultural University, Hyderabad	Cotton, pulses, oilseeds, sugarcane
viii.	Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, Rice, tomato, weeds
ix.	Sher-e-Kashmir University of Agricultural Science & Technology, Srinagar	Temperate fruits, vegetables
x.	Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses, Tomato
xi.	Central Agricultural University, Pasighat	Rice, vegetables
xii.	Maharana Pratap University of Agriculture Technology, Udaipur	Vegetables, whitegrubs, termites

xiii.	Orissa University of Agriculture & Technology, Bhubaneshwar	Rice, vegetables
xiv.	University of Agricultural Sciences (Raichur), Raichur	Oilseeds, pulses

ICAR Institute–based Centres

I.	ICAR - Central Institute of Subtropical Horticulture, Lucknow	Mango
II.	ICAR - Central Plantation Crops Research Institute, Kayangulam	Coconut
III.	ICAR - Central Tobacco Research Institute, Rajahmundry	Tobacco and soyabean
IV.	ICAR - Directorate of Rice Research, Hyderabad	Rice
V.	ICAR - Directorate of Seed Research, Mau	Pigeonpea, sorghum
VI.	ICAR - Indian Institute of Millet Research, Hyderabad	Sorghum
VII.	ICAR - Directorate of Soybean Research, Indore	Soyabean
VIII.	ICAR - Directorate of Weed Science Research, Jabalpur	*Chromolaena odorata*
IX.	ICAR - Indian Agricultural Research Institute, New Delhi	Basic Research
X.	ICAR - Indian Institute of Horticultural Research, Bangalore	Fruits and Vegetables
XI.	ICAR - Indian Institute of Sugarcane Research, Lucknow	Sugarcane
XII.	ICAR - Indian Institute of Vegetable Research, Varanasi	Natural enemies of vegetable Pests
XIII.	ICAR - National Centre for Integrated Pest Management, New Delhi	IPM of whitegrubs in coconut

PUBLICATIONS

Peer reviewed articles

ICAR - NBAIR

Abraham Verghese, Kesavan Subaharan, Ankita Gupta, 2014. Insects related to veterinary and fisheries sciences. *Current Science* **107**(8) 25 : 1226-1228.

Abraham Verghese, Shylesha, AN, Kesavan Subaharan, 2014. Biosecurity in Agriculture. *Current Science* **107** (9) 10 : 1370-1371.

Abraham Verghese, Kamala Jayanthi PD, Sreedevi K, Sudha Devi K, Viyolla Pinto, 2013. A quick and non-destructive population estimate for the weaverant *Oecophylla smaragdina* Fab.(Hymenoptera: Formicidae). *Current Science* **104** (5):1-6.

Abraham Verghese, Shivananda TS, Kamala Jayanthi PD, Sreedevi K, 2013. Frank Milburn Howlett (1877-1920): Discoverer of the pied piper'slure for the fruit flies (Tephritidae: Diptera). *Current Science* **105** (2): 260-262.

Ankita Gupta, Khot R, Chorge, 2014. A new species of *Parapanteles* Ashmead, 1900 (Hymenoptera : Braconidae: Microgastrinae) parasitic on *Charaxes athamas* (Drury) (Lepidoptera: Nymphalidae) in India. *Systematic Parasitology* **88** :273–279.

Ankita Gupta, José Fernández-Triana, 2014. Diversity, host association, and cocoon variability of reared Indian Microgastrinae (Hymenoptera: Braconidae) *Zootaxa* **3800** (1): 001–101.

Ankita Gupta, Achterberg CV, 2014. A new species of *Phanerotoma* Wesmael (Hymenoptera: Braconidae: Cheloninae) from the Andaman Islands, India. *Zootaxa* **3856** (4): 595–600.

Ankita Gupta, Churi PV, Sengupta A, Mhatre S, 2014. Lycaenidae parasitoids from peninsular India with description of four new species of microgastrine wasps (Hymenoptera: Braconidae) along with new insights on host relationships. *Zootaxa* **3827** (4): 439–470.

Ankita Gupta, Sureshan PM, 2014. A new pteromalid species of the genus *Anisopteromalus* Ruschka (Hymenoptera) from India. *Oriental Insects* **48** 1-2: 67-72.

Ankita Gupta,Poornima Kannan, 2014. First host record of the eulophid wasp *Tetrastichus bilgiricus* Narendran (Hymenoptera: Chalcidoidea) along with the first description of a male from India. *Journal of threatened taxa* **6** (12):6544-6548.

Anwar PT, Zeya SB, Veenakumari K, 2014. First record of *Stephanocampta* Mathot (Hymenoptera: Mymaridae) from India, with description of a new species. *Journal of Insect Systematics* **1** (2): 149-151.

Anwar PT, Zeya SB, Veenakumari K, 2014. Two new species of *Omyomymar* schuaff (Hymenoptera: Mymaridae) from India. *Journal of Insect Systematics* **1** (2): 139-144.

Archana M, D'Souza PE, Jalali SK, Renukaprasad C, Ojha R, 2015. DNA barcoding of commonly prevalent Culicoides midges in South India. *Indian Journal of Animal Sciences* **85** :37–39.

Arvind Kumar Yadav, Mahesh Yandigeri S, Shachi Vardhan, Sivakumar G, Rangeshwaran R, Tripathi CPM. 2014. *Streptomyces* sp. S160: A potential antagonist against chickpea charcoal root rot caused by *Macrophomina phaseolina* (Tassi) Goid, *Annals of Microbiology*, **64**

(3):1113–1122.

Babu RV, Vemuri S, Padmavathy C, Mohan M, Balachandran S, 2014. Toxicity of *Bacillus thuringiensis* crystal toxins to field populations of rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) and establishment of baseline susceptibility to Cry1Ab. *Journal of Agricultural Science and Technology* **A3** :617-621.

Babu RV, Vemuri S, Padmavathy C, Mohan M, Balachandran S, Ramesh B, 2014. Carboxylesterase and glutathione-S-transferase (GST's) induced resistance to *Bacillus thuringiensis* toxin Cry1Ab in rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) populations. *Journal of Agricultural Science and Technology* **A3** :53-59.

Chaubey BK, Srinivasa Murthy K, Jalali SK, Venkatesan T, 2014. Determination of host parasitoid ratio for Diamond backs moth *Plutella xylostella* (Linnaeus) and its parasitoid *Cotesia vestalis* Haliday. *International Journal of Current Research* **6** (11):42-45.

Chaubey BK, Srinivasa Murthy K, Jalali SK, Venkatesan T, 2014. Standardization of host –parasitoid ratio of *Plutella xylostella* and *Trichogramma bactrae* Nagaraja. *Journal of Biological Control* **28** (3): (Accepted)

David KJ, Shakti Kumar Singh, Ramani S, 2014. New species and records of Trypetinae (Diptera: Tephritidae) from India. *Zootaxa* **3795** (2): 126-134.

David KJ, Hancock DL, Ramani S, 2014. Two new species of *Acroceratitis* Hendel (Diptera: Tephritidae) and an updated key for the species from India. *Zootaxa* **3895** (3): 411-418.

David KJ, Shakti Kumar Singh, 2015. Two new species of *Euphranta* Loew (Diptera: Tephritidae: Trypetinae) and an updated key for the species from India. *Zootaxa* **3914** (1): 064–070.

Devi Thangam S, Selvakumar G, Abraham Verghese, Kamala Jayanthi PD, 2013. Natural mycosis of mango leaf hoppers (Cicadellidae: Hemiptera) by *Fusarium* sp. *Biocontrol Science and Technology* **DOI** :10.1080/09583157. 2013.

Devi Thangam S, Abraham Verghese, Dinesh MR, Vasugi C, Kamala Jayanthi PD, 2013.Germplasm evaluation of mango for preference of the mango hopper, *Idioscopus nitidulus* (Walker)(Hemiptera: Cicadellidae): The first step in understanding the host plant resistance. *Pest Management in Horticultural Ecosystems* **19** (1):10-16.

Dheemanth L, Srinivasa Murthy K, Chandish Ballal R, 2014. Molecular characterization of common predatory anthocorids. *Journal of Biological Control* **28** (4): (Accepted).

Guruprasad NM, Harish BM, Jalali SK, Puttaraju HP, 2014. *In-silico* modelling of *Wolbachia* and its potentials in combating mosquito borne diseases chikungunya and dengue. *International Journal of Mosquito Research* **1** : 61-68.

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Hayat M, Veenakumari K, Badruddin SMA, 2014. Description of a new species of *Aphelinus* Dalman (Hymenoptera: Calcidoidea: Aphelinidae) from India, with some records. *PROMMALIA* **II** :120-129.

Hayat M, Veenakumari K, 2014. Further records of Encyrtidae (Hymenoptera:

Chalcidoidea) from Andaman & Nicobar Islands, with description of a new species of *Ooencyrtus* Ashmead. *PROMMALIA* **II** :23-36.

Hayat M, Veenakumari K, 2013. Encyrtidae (Hymenoptera: Chalcidoidea) from Andaman& Nicobar Islands, with description of a new genus and two new species. *PROMMALIA* **I** :98-113.

Hayat M, Veenakumari K, 2014. Description of a new and record of two known species of *Rhopus* Foerster (Hymenoptera: Encyrtidae) from India. *Journal of Insect Systematics* **1** :27-30.

Hayat M, Veenakumari K, 2014. Record of the genus *Arrhenophagoidea* Girault (Hymenoptera: Chalcidoidea: Encyrtidae) from India, description of a new species from the Andaman Islands. *Journal of Threatened Taxa* **6** (5):5769-5773.

Hayat M, Veenakumari K, 2014. Records and descriptions of Encyrtidae (Hymenoptera: Chalcidoidea) from Southern India–1. *Journal of Insect Systematics* **1** :1-26.

Hayat M, Veenakumari K, Badruddin SM, Ahmad SK, Khan MT, 2014. Additions to the Aphelinidae of India (Hymenoptera: Chalcidoidea) – 5. Records and descriptions of some species. *Journal of Insect Systematics* **1** (2):116–134.

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Hema Bisht, Bhagat Deepa, Bhatnagar MK, 2014. Metabolic profiling of tomatoes with pest infestation using GC-MS and NMR spectroscopy. *International Journal of Pharmacognosy and Phytochemical Research* **6** (3):550-556.

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Honnur Basha and Ramanujam B, 2014. Growth promoting potential of native *Bacillus megaterium* strain EXB-53 in some vegetable crops in commercial nursery. *Journal of Pure and Applied Microbiology* **8** (5): 3653-3665.

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Kamala Jayanthi PD, Rajinikanth P, Ravishankar KV, Sangeetha P, Abraham Verghese, Lokeshwari D, 2013. Influence of cGMP on feeding potential of predatory coccinellid, *Cryptolaemus montrouzieri* Mulsant and isolation of partial foraging gene. *Journal of Insect Behaviour* 10.1007/s10905-013-9433-1.

Kamala Jayanthi Pagadala Damodaram, Vivek Kempraj, Ravindra Mahadappa Aurade, Sowmya Bandhisara Rajasekhar, Ravindra Kothapalli Venkataramanappa, Bakthavatsalam Nandagopal & Abraham Verghese, 2014. Centuries of domestication has not impaired oviposition site-selection function in the silkmoth, *Bombyx mori*. *Nature Scientific Reports* . 4-7472/DOI 10.1038/srep07472

Kharbanda N, Jalali SK, Ojha R, Bhatnagar RK, 2015. Temporal expression profiling of novel *Spodoptera litura* nucleopoly hedrovirus encoded microRNAs upon infection of Sf21 cell line. *Journal of General Virology* **96** :688–700.

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Mohan M, Rangeswaran R, Sivakumar G, Verghese A, 2014. Relative toxicity of subspecies of *Bacillus thuringiensis* against lepidopterous insect pests of agricultural importance. *Journal of Biological Control* **28** (4):119-125.

Nagesh M, Saleem Javeed, Ramanujam B, Rangeswaran R, 2013. Suitability of soil types for *Paecilomyces lilacinus* and *Pochonia chlamydosporia* and their performance against root-knot nematode, *Meloidogyne incognita* on *Lycopersicon esculentum* in glass house. *Indian Journal of Agricultural Sciences* **83** (8): 828-833.

Neelam Sheoran, Agisha Valiy Nadakkakathb, Vibhuti Munjala, Aditi Kundu, Kesavan Subaharan, Vibina Venugopal, Suseelabhai Rajamma, Santhosh J. Eapen, Aundy Kumar. 2015. Genetic analysis of plant endophytic *Pseudomonas putida* BP25 and chemo-profiling of its antimicrobial volatile organic compounds. *Microbiological Research* **173** :66–78.

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Patil J, Gaur HS, 2014. Effect of root-knot nematode, *Meloidogyne graminicola*, on the quality and vigour of rice seed. *Nematology* **16** :555-564.

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(Coleoptera, Coccinellidae) and notes on nomenclature of *Platynaspis kapuri* Chakraborty & Biswas. *Biodiversity Data Journal* **2** :e1096.

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ONGOING RESEARCH PROJECTS

DIVISION OF INSECT SYSTEMATICS

Sl. No.	Title of the Project	Period	PI	Co-PIs
	INSTITUTE PROJECTS			
1	Biosystematics of Trichogrammatidea (Hymenoptera)	01.04.2013 to 31.05.2017	Dr. Prashanth Mohanraj	Dr. S. K. Jalali Dr. K. Veenakumari
2	Biosystematics of oophagous parasitoids with special reference to Platygastroidea (Hymenoptera)	01.04.2008 to 31.03.2018	Dr. K. Veenakumari	Dr. Prashanth Mohanraj
3	Digitization of type specimens in NBAII reference collection	01.04.2013 to 31.03.2015	Dr. J. Poorani	-
4	Biosystematics of aphids, coccids and diversity of their natural enemies	01.04.2009 to 31.03.2016	Dr. Sunil Joshi	-
5	Mechanism of insecticide resistance in *Leucinodes orbonalis*	01.10.2012 to 31.03.2016	Dr. M. Mohan	Dr. T. Venkatesan Dr. R. Rangeshwaran Dr. Mahesh Yandigeri
6	Biosystematics and Diversity of Agriculturally Important Cerambycidae	01.10.2013 to 31.03.2017	Dr. M. Mohan	Dr. J. Poorani
7	Biodiversity of economically important Indian microorganisms (Braconidae) supported by molecular phylogenetic studies	21.09.2010 to 21.09.2015	Dr. Ankita Gupta	Dr. S. K. Jalali Dr. T. Venkatesan
8	Biosystematics and Diversity of Entomogeneous Nematodes in India	01.04.2012 to 31.03.2015	Dr. Jagadish Patil	Dr. M. Nagesh
9	Taxonomic studies on fruit flies (Diptera: Tephretidae) of India	01.04.2012 to 31.03.2017	Mr. K. J. David	**Study leave**
10	Taxonomic studies on Pentatomidae (Hemiptera: Pentatomoidea) of India with special reference to Pentatominae	01.04.2012 to 31.03.2017	Ms. Salini, S.	
	LATERALLY FUNDED PROJECTS			
1	**ICAR:** Network project on Insect biosystematics	09.04.2012 to 31.03.2015	Dr. J. Poorani	
2	**ORP:** ORP on Management of Sucking Pests of Horticultural Crops - Taxonomy of Aphids and Coccids	04.01.2012 to 31.03.2017	Dr. Sunil Joshi	
3	**DST:** Diversity and distribution entomopathogenic nematodes in coconut and arecanut ecosystems	16.05.2014 to 15.05.2017	Dr. Jagadeesh Patil	

DIVISION OF MOLECULAR ENTOMOLOGY

Sl. No.	Title of the Project	Period	PI	Co-PIs
INSTITUTE PROJECTS				
1	Molecular characterization and DNA barcoding of some agriculturally important insect pests	01.04.2013 to 30.09.2018	Dr. S. K. Jalali	Dr. J. Poorani Dr. T. Venkatesan Dr. M. Mohan Dr. Kesavan Subaharan
2	Genetic diversity, biology and utilization of entomopathogenic nematodes (EPN) against cryptic pests	01.04.2012 to 10.11.2014	Dr. M. Nagesh	Dr. A. N. Shylesha Dr. Jagadish Patil
3	Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators	01.06.2013 to 31.05.2018	Dr. T. Venkatesan	Dr. S. K. Jalali Dr. Ankita Gupta Dr. Prashanth Mohanraj Dr. K. Veenakumari Dr. Sunil Joshi Dr. Chandish R. Ballal
4	Molecular characterization and DNA barcoding of subterranean insect diversity	01.04.2014 to 31.03.2019	Dr. K. Srinivasa Murthy	Dr. T. Venkatesan Dr. K. Veenakumari Ms. Gandhi Gracy Dr. Prashanth Mohanraj Dr. A. N. Shylesha
5	Mapping of the cry gene diversity in hot and humid regions of India	01.04.2011 to 31.03.2015	Dr. R. Rangeshwaran	Dr. S. K. Jalali Dr. G. Sivakumar
6	Culturable and unculturable microflora associated with soil insects and other arthropods	01.04.2013 to 31.03.2016	Dr. R. Rangeshwaran	Dr. A. N. Shylesha Dr. G. Sivakumar Dr. M. Mohan
7	Role of microbial flora of aphids in insecticide resistance	01.10.2012 to 31.03.2016	Dr. Mahesh Yendigeri	Dr. M. Mohan Dr. Sunil Joshi Dr. G. Sivakumar
8	Development of computational tool for prediction of insecticide resistance gene in agriculturally important insects	01.04.2012 to 31.03.2015	Dr. M. Pratheepa	Dr. S. K. Jalali Dr. T. Venkatesan Dr. K. S. Murthy
9	Distribution of abiotic stress tolerant genes / alleles across insect orders	01.04.2014 to 31.03.2017	Dr. M. Pratheepa	Dr. K. Srinivasa Murthy Dr. S. K. Jalali Dr. T. Venkatesan
10	Taxonomy and diversity of Indian Sphecidae	01.09.2014 to 31.03.2020	Dr. R. Gandhi Gracy	Dr. M. Pratheepa

LATERALLY FUNDED PROJECTS				
1	**NAIP:** Effect of abiotic stresses on the natural enemies of crop pests: *Trichogramma*, *Chrysoperla*, *Trichoderma* and *Pseudomonas*, and mechanism of tolerance to these stresses – Comp. 4	19.07.2008 to 30.06.2014	Dr. S. K. Jalali	Dr. J. Poorani Dr. T. Venkatesan Dr. K. S. Murthy Dr. R. Rangeshwaran
2	**NFBSFARA:** Identification of nucleopolyhedrovirus (NPV) encoded protein and small RNAs and the feasibility of their expression in plant to control *Helicoverpa*	01.01.2011 to 31.12.2015	Dr. S. K. Jalali	Dr. T. M. Shivalingaswamy
3	**NAIP:** Establishment of National Agricultural Bioinformatics Grid – Component 1	31.03.2010 to 30.06.2014	Dr. M. Nagesh	Dr. S. K. Jalali Dr. T. Venkatesan Dr. M. Pratheepa
4	**ICAR:** Intellectual property management & transfer/ commercialization of Agricultural Technology Scheme	06.06.2008 to 31.03.2015	Dr. T. Venkatesan	
5	**ORP-SP:** ICAR-Outreach Programme on Management of Sucking Pests in Horticultural Crops	02.01.2015 to 31.03.2017	Dr. T. Venkatesan	
6	**AMMAS:** Culturable and unculturable microbial diversity of aphids and their role in insecticide resistance and other fitness attributes	01.04.2014 to 31.03.2017	Dr. Mahesh Yandigeri	Dr. G. Sivakumar Dr. R. Rangeshwaran Dr. M. Mohan
7	**CRP on Bioinformatics – ICAR:** Centre for Agricultural Bioinformatics (Network Project on Insect Bioinformatics)	01.01.2015 to 31.03.2017	Dr. T. Venkatesan	

DIVISION OF INSECT ECOLOGY

Sl. No.	Title of the Project	Period	PI	Co-PIs
INSTITUTE PROJECTS				
1	Documentation, production and utilisation of predatory anthocorids and mites	24.03.2012 to 31.03.2017	Dr. Chandish R. Ballal	Dr. P. Sreerama Kumar Dr. S. K. Jalali
2	Semiochemicals for the management of coleopteran pests	01.09.2010 to 31.03.2015	Dr. N. Bakthavatsalam	Dr. Deepa Bhagat Dr. T. M. S. Swamy
3	Influence of infochemical diversity on the behavioural ecology of some agriculturally important insects	01.04.2013 to 31.03.2017	Dr. N. Bakthavatsalam	Dr. Abraham Verghese
4	Climate change effect on the diversity and bioecology of some important sucking pests	01.04.2014 to 31.03.2019	Dr. N. Bakthavatsalam	Dr. P. Sreeramakumar
5	Introduction and studies on natural enemies of some new exotic insect pests and weeds	27.08.2010 to 31.03.2016	Dr. A. N. Shylesha	Dr. Abraham Verghese
6	Exploitation of *Beauveria bassiana* for the management of maize stem borer (*Chilo partellus*) through endophytic establishment	01.04.2014 to 31.03.2017	Dr. B. Ramanujam	Dr. A. N. Shylesha Dr. R. Rangeshwaran
7	Pollinator diversity with special reference to non-*Apis* species	01.04.2012 to 31.03.2015	Dr. T. M. Shivalingaswamy	Dr. A. N. Shylesha
8	Insect vector components influencing phytoplasma diseases	01.01.2012 to 31.03.2015	Dr. P. Sreeramakumar	Dr. K. Srinivasa Murthy
9	Documenting agriculturally important mites and establishing an authentic collection	01.04.2014 to 31.03.2019	Dr. P. Sreerama Kumar	Dr. Chandish R. Ballal
10	Microflora associated with insecticides resistance in cotton leaf hoppers (*Amrasca biguttula biguttula*)	01.04.2012 to 31.03.2015	Dr. G. Sivakumar	Dr. R. Rangeshwaran Dr. T. Venkatesan Dr. Mahesh Yandigeri
11	Chemical characterization and ethology of economically important dipteran pests of veterinary and fisheries	09.10.2014 to 09.10.2017	Dr. Kesavan Subaharan	Dr. N. Bakthavatsalam Dr. K. J. David
12	Synthesis of Nanomaterials to act as sensor for semiochemicals in pest management	01.07.2013 to 31.07.2017	Dr. Deepa Bhagat	Prof. S. Bhattacharya, IISc, Bangalore Prof. R. Pratap, IISc, Bangalore Prof. N. Bhat Engineer Amit K Gupta, IIT, Mumbai Engineer N. S. Kale, IIT, Kanpur

LATERALLY FUNDED PROJECTS				
1	**DBT:** Studies on extending the shelf life and improving the delivery methods of trichogrammatid egg parasitoids for promoting their commercial mass production in India	01.07.2013 to 31.07.2016	Dr. Chandish R. Ballal	Dr. S. Sitanantham Dr. S. K. Jalali
2	**CST:** Studies on pest status and ecofriendly management of thrips (*Pseudodendrothrips mori*) (Thysanoptera: Thripidae) on Mulberry in Tamil Nadu	09.10.2014 to 31.10.2016	Dr. Chandish R. Ballal (Co-CPI)	
3	**ICAR-CABI**: The study of biological control of invasive plant species & Indian natural enemies	01.07.2014 to 31.07.2016	Dr. Chandish R. Ballal	
4	**CRP:** Consortium Research Platform (CRP) on Borer in Network Mode	01.04.2014 to 31.03.2017	Dr. N. Bakthavatsalam	
5	**CSB**: Investigation on semiochemicals of the silkworm uzifly *Exorista bombycis*	01.01.2015 to 31.12.2016	Dr. N. Bakthavatsalam	
6	**DBT:** Plant-derived botanicals from herbs/shrubs of Indo-Burma biodiversity hotspot for control of stored grain insect pests	20.03.2015 to 31.03.2018	Dr. N. Bakthavatsalam	
7	**AMAAS:** Development of formulations of *Beauveria bassiana, Metarhizium anisopliae* and *Lecanicillium* spp. for management of certain sucking pests in vegetable crops.	01.04.2014 to 31.03.2017	Dr. B. Ramanujam	
8	**DBT**: Controlled release dispensers for delivery of semiochemicals	25.11.2014 to 24.11.2017	Dr. K. Subaharan	
9	**DBT**: Nanoparticles for enhancing shelf life/storage and field application of semiochemicals	05.07.2010 to 09.07.2015	Dr. Deepa Bhagat	
10	**CRP**: CRP on Nanotechnology project	18.11.2014 to 31.03.2017	Dr. Deepa Bhagat	
11	**IISc**: Characterization, functionalisation and assembly of nanosensors and their applications	03.08.2012 to 31.08.2015	Dr. Deepa Bhagat	Dr. N. Bakthavatsalam

ACTIVITIES OF ITMU

Technologies Commercialized (2014- 2015)

S.No	2014- 2015
1	Multiple insecticide tolerant strain of egg parasitoid *Trichogramma chilonis*
2	Novel insecticidal WP formulations of *Heterorhabditis indica* strain NBAII Hi1 for the biological control of white grubs and other soil insect pests
3	Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide & methods thereof for scale -up production & down-stream processing for biological control of plant parasitic nematodes
4	Liquid formulation of *Bacillus thuringiensis* (NBAII-Bt1)
5	Powder based formulation (WP) of *Bacillus megaterium* (NBAII 63)as growth promoter (Phosphate solubilizer) & management of bacterial wilt disease
6	Bioformulation of salinity tolerant *Trichoderma harzianum* with biocontrol potential
7	Bioformulation of carbendazim tolerant *Trichoderma harzianum* with biocontrol potential
8	Promising plant growth promoting strain of *Bacillus megaterium* for vegetable crops

NBAIR has transferred the following technologies to industries (2014- 2015)

1. Agri Bio Care, Kottayam, Kerala

a. Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis*

b. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests

c. Promising plant growth promoting strain of *Bacillus megaterium* for vegetable crops

d. Liquid formulation of *Bacillus thuringiensis*

e. Powder based formulation of *Bacillus megaterium* as growth promoter

2. Dr. Abdul Rauf Agri-Research Foundation, Sirsi

a. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests

3. Ponolab, Bangalore

a. Bio formulation of salinity tolerant *Trichoderma harzianum* with biocontrol potential

b. Bioformulation of carbendazim tolerant *Trichoderma harzianum* with biocontrol potential

c. Powder based formulation of *Bacillus megaterium* as growth promoter

d. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests

e. Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes

Transfer of technologies to Agri Bio Care, Kottayam – Kerala

Transfer of technologies to Dr. Abdul Rauf Agri-Research Foundation, Sirsi

Transfer of technologies to Ponolab, Bangalore

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MEETINGS AND DECISIONS

Institute Research Council

The Institute Research Council meeting of the NBAIR, Bengaluru was held from 21-23rd April, 2014, 30th May, 2014 and 21st October, 2014 under the Chairmanship of Dr. Abraham Verghese, Director, NBAIR, Bengaluru. All projects were discussed and the following recommendation made.

1. Scientists should collect diverse insects from diverse habitats and different agro-climatic regions like, Andaman and Nicobar Islands, NEH region, Sub-Himalayan and coastal areas during their respective trips and hand them over to respective scientists.
2. Scientists who have undergone overseas training should also take up work on similar line.
3. All Heads to ensure that IRC comments are included by the scientists in RPP II before sending it to PME Cell.
4. The scientists should submit the soft copy of RPP-III at the end of the project and where ever commercialization is possible include RPP-IV on or before 31.05.2014.
5. In Dr. Joshi's project, name of Dr. Ballal as Co-PI may be deleted. Dr. Joshi's name may be deleted from Dr. Ballal's project as both of them are working on different aspects.
6. One of the parasitic Hymenoptera experts at NBAIR may be included as Co-PI in the project in place of Dr. J. Poorani as she is not working on Hymenoptera.
7. Dr. P. Sreerama Kumar's name to be included in Dr. Ballal's project as Co-PI in place of Dr. Joshi. Similarly Dr. Ballal to be included as Co-PI in new project proposal of Dr. Sreerama Kumar on mites.
8. Technical bulletin on production of brown lacewing.
9. Technical folder on mass production of Anthocoridae.
10. Folder on biological control of eucalyptus gall wasp.
11. Catalogue on insects in NBAIR collection may be taken up on priority.
12. IRC approved the inclusion of Dr. K. Subaharan as Co-PI in the project entitled "Semiochemicals for the management of coleopteran pests" (Dr. N. Bakthavatsalam as PI).

Research Advisory Committee

The 19th meeting of the Research Advisory Committee (RAC) was held on 1st April, 2015 at NBAIR, Bengaluru. The meeting was chaired by Dr. C. A. Viraktamath and attended by the members Dr. M. Venkat Rajam, Dr. Abraham Verghese and Dr. S. K. Jalali (Member-Secretary). The Heads of the three Divisions presented the salient achievements made in the various research projects during 2014-15. The Chairman and members of the RAC were appreciative of the progress made in the research projects during 2014-15. The recommendations are as below.

RAC recommendations

1. A core committee to be formed to alert and plan methods of management of invasive insects.
2. In the case *Trichogramma*, apart from SEM studies of male genitalia, SEM studies on additional characters such as antennae, mesosoma, etc. to be explored for species characterisation.
3. Research attempts should be made to find a solution for long term permanent preservation of mites either through permanent slides in Canada balsam or through dry / wet preservation and in combination with SEM images.
4. Initiate biosystematics work on thrips especially in the light of report of *Frankliniella occidentalis* to be strength
5. Work on *Tuta absoluta* needs to be intensified including the work on microbials like entomopathogenic fungi.
6. Attempt to be made to standardize the procedure for characterization of termites from museum specimens of UAS.
7. Some novel / potent Cry genes to be provided for transformation work.

PARTICIPATION OF SCIENTISTS IN CONFERENCES, MEETINGS, WORKSHOPS, SYMPOSIA, ETC., IN INDIA AND ABROAD

Abraham Verghese	▪ IXthInternational Symposium on Fruit Flies, from 12-16 May, 2014, Bangkok ▪ World Biodiversity Congress (WBC-2014) held at Colombo, Sri Lanka, from 24th to 27th November, 2014
Chandish R. Ballal	▪ Meeting organized by Department of Horticulture for the release of a scientific technical manual in Mannada on “Mass production of biocontrol agents for the management of insect pests” jointly prepared by NBAIR and Department of Horticulture on 24th April, 2014:. ▪ National Workshop on importation of bio-agents at DPPQ&S Faridabad and presented a brief on the issue faced with respect to importation regulations for macrobials, 16th July, 2014. ▪ Refresher Course in Environmental Science organized by Academic Staff College, Kannur University as a resource person, 6th December, 2014:. ▪ District Level Workshop on tomato cultivation & interaction session with farmers organized by College of Horticulture, Kolar, 12th March, 2015: ▪ Project meeting with RSRS, Salem and Erode, Central Silk Board, 20th October, 2014. ▪ Meeting at State Bio-diversity Board, Malleswaram on BDA Rules and Regulations and access to benefit sharing, 11th December, 2014.
Abraham Verghese, Chandish R. Ballal, K. Subharan, S. K. Jalali, N. Bakthavatsalam, A. N. Shylesha, M. Mohan,	▪ One day review meet organized by Directorate of Plant Protection Quarantine and Storage & NBAIR, at NBAIR on the invasive pest *Tuta absoluta* 21st February, 2015.
Abraham Verghese, S. K. Jalali, T. Venkatesan, J. Poorani, K. S. Murthy, R. Rangeshwaran,	▪ NAIP Project Ending Workshop – Panel Discussion on Sustainability of Results and Way Forward. 26th June 2014 at NBAIR, Bangalore.
K.S.Murthy	▪ Interactive meet of the farmers, scientists from ICAR and University of Horticultural sciences for the management of root grubs at RARS, Sringeri on 22.9.2014. ▪ National Horticultural Meet on 14.3.2015, at Paiyur (DharmapuriDist) jointly organized by TNAU and IIHR. ▪ Workshop on Training needs Assessment for HRD Nodal Officers of ICAR at NAARM, Hyderabad on

	26th February 2015.
Chandish R Ballal, S. K. Jalali, T. Venkatesan, K. S. Murthy, M. Mohan	▪ VIIth International Workshop on Management of Diamond back moth and other crucifer pests. 23td March 2015. Jointly, organized by UAS, Bangalore, AVRDC, Taiwan and Cornell University, USA
Abraham Verghese, Chandish R. Ballal, P. Sreeramakumar	▪ World Biodiversity Congress 2014" organised by Global Scientific Research Foundation (Bengaluru) and Field Ornithology Group of Sri Lanka, in association with the University of Colombo (Sri Lanka) and Rajarata University of Sri Lanka, at Cinnamon Lakeside Colombo, Colombo, Sri Lanka, 24–27 November 2014.
All scientists	▪ "Brainstorming Session on Insects Related to Veterinary and Fisheries Sciences" NBAII, Bangalore, 02 August 2014.
All scientists	▪ "Brainstorming on Biosecurity Issues in Relation to Insects and Quarantine & Celebration of the Successof Biological Control of Eucalyptus Gall Wasp", NBAII, Bengaluru, 26 August 2014.
All scientists	▪ "National Meeting on New/Safer Molecules and Biocontrol Technologies for Integrated Pest Management in Crops", Karnataka Veterinary Council Auditorium, Bengaluru, 23 February 2015.
Abraham Verghese, PrashanthMohanRaj, S. K. Jalali, Chandish R. Ballal, B. Ramanujam, T. Venkatesan	▪ XXIII Biocontrol Workers' Group Meeting of the AICRP on Biological Control of Crop Pests, Diseases and Weeds" organised by NBAII at Bhubaneshwar, 27 to 28 June, 2014: held at OUA&T, Bhubaneswar
T. M. Shivalingaswamy	▪ National meet on the role of pollinators in IPM at KVK, Puducherry on 9.9.2014 organized by NCIPM New Delhi
N. Bakthavatsalam, T. M. Shivalingaswamy, A. N. Shylesha, K. Subaharan	▪ International Conference on Innovative Insect Management Approaches for Sustainable Agro Eco System on 28.01.2015 at Agricultural College and Research Institute, Madurai, Tamil Nadu Agricultural University
T. M. Shivalingaswamy, A N Shylesha, M Nagesh	▪ Farmers training cum demonstartion programme of EPN in areca nut orchards meet at Heggodu, Shimoga on 10.6.2014
G. Sivakumar	▪ Meeting on "Intellectual property rights and Biodiversity" held at Fortune Hotel South Park, Trivandrum on 30th Sep. 2014, Thiruvananthapuram ▪ "AgriIP2014", Annual Meeting – Cum –Workshop at IIHR, Bengaluru on 9&10 October 2014. National Farmers Meet held on 14.03.2015 at Regional Research Station, Paiyur, Tamil Nadu Agricultural University, Tamil Nadu
Mahesh S. Yandigeri	▪ CPE sponsored one day Seminar on "Emerging trends in Microbiology:Issues and Challenges" on 31st March, 2015 organised at Sahyadri Science College,

	Shivamoga, Karnataka.
R. Rangeshwaran	- Workshop on "Open access to Agricultural Knowledge for Inclusive Growth and Development" from 29.10.14 to 30.10.14 at NAARM Hyderabad
T. Venkatesan	- "Short term Workshop on Molecular Phylogenetics" at Centre for Ecological Sciences, IISc, Bengaluru during August 1- 5, 2014. - NAIP Agri Innovation Conclave held at NASC, New Delhi during 18-19th May 2014. - Workshop on Impact of Capacity Building Programs under NAIP, held at AP Shinde Symposium Hall, NASC, New Delhi during June 6-7th 2014. - Meeting on "Documentation of tradable bio-resources in various districts across Karnataka" at Karnataka State Forest Industry Corporation, Bengaluru on 4th December 2014.
T. Venkatesan, G. Sivakumar	- One day seminar on Intellectual Property Rights (IPR) & Biodiversity, organized by Andhra Pradesh Technology Development and Promotion Centre (APTDC) and Confederation of Indian Industry (CII) in partnership with US patent office Global Intellectual Property Academy (USPTO-GIPA) and Kerala State Biodiversity Board at Hotel Fortune, The South Park, Trivandrum on 30th September 2014.
Subharan K	- National Conference on Entomology as a Science and IPM as a technology held at Central Agricultural University Campus of Pasighat, Arunachal Pradesh 16.11.2014. - Attended the industry scientist interface meet on 30.01.15 at ICAR – CPCRI Kasaragod. Participated in the meet and presented the inventions on nanomatrix for delivery of pheromones. - National Conference on Sustainability of coconut, arecanut and cocoa farming Technological Advances and Way forward., CPCRI, Kasaragod, August 22-23, 2014, p 94. - Participated in Kisan Mela organized at University of Agricultural & Horticultural Sciences, Shimoga between 18 – 20 .10.2014

TRAININGS CONDUCTED 2014-2015

S.No	Programme	Duration	Co-ordinator / Resource persons
1	Bio-intensive integrated pest management of crop pests and diseases	1-6-2014 to 15.6.2014 (15 days)	Dr.S.K.Jalali and other Scientists
2	International Training on Biosystematics of Potato aphid	3.6.2014 to 5.6.2014 (3 days)	Dr. Sunil Joshi Dr. Ankita Gupta
3	B.Tech (Biotechnology) IV year students,	June to August 2014 (3 months)	Dr. T.Venkatesan Dr. R.Rangeshwaran Dr. K.S.Murthy Dr. G.Sivakumar Dr.M.Mohan Dr.Mahesh Yendegari
4	Pest Management in coconut, arecanut, cocoa and cashew	11.9.2014 (one day)	Dr. Kesavan Subaharan
5	Mass production of *Trichogramma*	2.2.2015– 4.2.2015 (3 days)	Dr.S.K.Jalali Dr.Chandish Ballal Dr. Y.Lalitha
6	Charcaterisation of microflora associated with various ant species	6.2.2015 (one day)	Dr . Rangeshwaran
7	Culturing *Galleria mellonella*	6.2.2015 (one day)	Dr. Jagadish Patil
8	Training on biocontrol products	5.3. 2015-10.3.2015 (5 days)	Dr. Chandish Ballal Dr.R.Rangeshwaran Dr. G.Siva kumar Dr.Jagadish Patil Dr.A.N.Shylesha N.Bhaktavatasalam Dr.B. Ramanujam

DISTINGUISHED VISITORS

1. Dr. C. A. Viraktamath, Chairman RAC of this Bureau and former Professor, Division of Entomology, UAS, Bangalore chaired the meeting of the Research Advisory Committee on 01/04/2015.
2. Dr. M. Venkatrajam, Member RAC of this Bureau attended the meeting of the Research Advisory Committee on 01/04/2015.
3. Dr. S. Ayyappan, Secretary (DARE) & Director General (ICAR), New Delhi visited Insectarium at NBAIR visited the NBAIR and interacted with the scientists on 18/04/2014.
4. Dr. S. Ayyappan, Secretary (DARE) & Director General (ICAR), New Delhi inaugurated Society of Biocontrol office and visited the laboratories at NBAIR on 19/04/2014 and interacted with the scientists.
5. Padma Bhushan Dr. Madappa Mahadevappa, former Chairman of Agricultural Scientists Recruitment Board and Vice-Chancellor at University of Agricultural Sciences, Dharwad visited the NBAIR and interacted with the scientists on22/05/2014.
6. Dr. S. P. Singh, Founder PDBC and Dr. V. V. Ramamurthy, Two Eminent Scientists visited the NBAIR and interacted with the scientists on 21/06/2014.
7. Dr. Swapan Kumar Datta, Deputy Director General (Crop Science), ICAR, New Delhi inaugurated the newly added mite repository at NBAIR and interacted with the scientiststs on 17/07/ 2014.
8. Dr. C. Chattopadhyay, Director, NCIPM visited the laboratories at NBAIR on 23/07/2014.
9. Dr. Rob and Mx. Kate, CABI, London visited the NBAIR and interacted with the scientists on 13/08/2014.
10. Dr. S. Ayyappan, Secretary (DARE) & Director General (ICAR), New Delhichaired a meeting on "Insects Related to Veterinary and Fisheries Sciences" at NBAIR, Bangalore on 2nd August, 2014. Dr.C. Vasudevappa, Vice Chancellor, UAHS, Shimoga, Dr.S.Yathiraj, Dean, Veterinary College, Bangalore, Dr.C. A. Viraktamath, Chairman, RAC, NBAIR, Dr. H. Rahman, Director, NIVEDI, Dr. R.Venkataramanan, Joint Director, IVRI and Dr. J. K. Jena, Director, NBFGR, Lucknow were present during the inauguration and later visited 'Insectarium' on 02/08/2014.
11. Dr K.Satya Gopal, IAS, DG, NIPHM, Hyderabad chaired a Brain storming on Bio-Security issues in relation to insect and quarantine and celebrations on classical biological control of eucalyptus gall wasp, held at NBAIR Research Farm, Attur, Yelahanka campus on 26.08.14.
12. Dr. S.N. Sushil, Plant Protection Advisor-Govt. Of India, New Delhi co-chaired a Brain storming on Bio-Security issues in relation to insect and quarantine and celebrations on classical biological control of eucalyptus gall wasp, held at NBAIR on 26.08.14.
13. Shri T.P. Ananthakrishnan, Deputy Superintendent of Police, Vigilance & Anti-Corruption Wing, Central Bureau of Investigation, Bangalore visited at NBAIR and delivered a lecture to the staff during celebration of "Vigilance Awareness Week" (27 October 2014 to 1 November 2014) on 27/10/2014.
14. Dr. B.R. Subba Rao, formely Commonwealth Institute of Entomology (CIE), London, visited the NBAIR and interacted with the scientists on 04/11/2014.
15. Dr. S. Ayyappan, Secretary (DARE) & Director General (ICAR), New Delhi inaugurated three laboratories at NBAIR Research Farm.
16. Shri R. Rajagopal, Additional Secretary (DARE) & Secretary (ICAR) New Delhivisited the NBAIR and interacted with the scientists on 17/01/2015.
17. Dr. Praveen Karanth, Associate Professor, Centre for Ecological Sciences, Indian Institute of Science, Bangalore visited the NBAIR and delivered a lecture 'Evolution in action: From Darwin's finches to Indian taxa' in commemoration of International Darwin Day on 12/02/ 2015.

CHAPTER 18

PERSONNEL

Sl. No.	Name	Designation
Scientists		
1	Dr. Abraham Verghese	Director
2	Dr. PrashanthMohanraj	Head, Division of Insect Systematics
3	Dr. (Ms.) Chandish R. Ballal	Head, Division of Insect Ecology
4	Dr. S. K. Jalali	Head, Division of Molecular Entomology
5	Dr. N. Bakthavatsalam	Principal Scientist (Agri.Ento.)
6	Dr. B. Ramanujam	Principal Scientist (Pathology)
7	Dr. (Ms.) K. VeenaKumari	Principal Scientist (Agri.Ento.)
8	Dr. A. N. Shylesha	Principal Scientist (Entomology)
9	Dr. T. Venkatesan	Principal Scientist (Agri.Ento.)
10	Dr. T. M. Shivalingaswamy	Principal Scientist (Agri. Ento.)
11	Dr. P. Sreerama Kumar	Principal Scientist (Plant Pathology)
12	Dr. K. Srinivasa Murthy	Principal Scientist (Agri.Ento.)
13	Dr. Sunil Joshi	Principal Scientist (Agri. Ento.)
14	Dr. R. Rangeshwaran	Principal Scientist (Agri. Microbiology)
15	Dr. G. Sivakumar	Senior Scientist (Microbiology)
16	Dr.MaheshYandigeri	Senior Scientist (Microbiology)
17	Dr. M. Mohan	Senior Scientist (Agri. Ento.)
18	Dr. Kesavan Subaharan	Senior Scientist (Entomology)
19	Dr.(Ms.) DeepaBhagat	Senior Scientist (Organic Chemistry)
20	Dr. (Ms.). M. Pratheepa	Senior Scientist, (Computer Application)

21	Dr. Jagadeesh Patil	Scientist (Nematology)
22	Ms. R. Gandhi Gracy	Scientist (Agri. Ento.)
23	Mr. K. J. David	Scientist (Agri. Ento.)
24	Ms. S. Salini	Scientist (Agri. Ento.)
25	Dr. Ankita Gupta	Scientist (Agri. Ento.)
26.	Ms. RichaVarsheny	Scientist (Agri. Ento.)
27.	Ms. Rachana R R	Scientist (Agri. Ento.)
Technicians		
1	Ms. Shashikala S. Kadam	Chief Technical Officer
2	Dr. (Ms.) Y. Lalitha	Assistant Chief Technical Officer
3	Mr. B. K. Chaubey	Assistant Chief Technical Officer
4	Mr. Satendra Kumar	Assistant Chief Technical Officer
5	Mr. P. K. Sonkusare	Sr. Technical Officer
6	Ms. B. L. Lakshmi	Sr. Technical Officer
7	Ms. L. Lakshmi	Sr. Technical Officer
8	Mr. H. Jayaram	Senior Technical Officer
9	Mr. S. Venkatachalam	Technical Officer
10	Ms. S. K. Rajeshwari	Technical Officer
11	Mr. P. Raveendran	Technical Officer
12	Ms. R. Rajeshwari	Sr. Technical Assistant (Laboratory Technician)
13	Mr. P. Ramakrishna	Technical Assistant (Laboratory Technician)

14	Dr. A. Raghavendra	Technical Assistant (Laboratory Technician)
15	Mr. M. Chandrappa	Technical Assistant (Driver)
16	Mr.R. Narayanappa	Technical Assistant (Generator Operator)
17	Mr. P. Madanathan	Technical Assistant (Driver)
18.	Mr. Umesh Kumar Sanjeev	Technical Assistant (Laboratory)
Administrative		
1	Smt. S. Rama	Administrative Officer
2	Mr. T. A. Vishwanath	Finance and Accounts Officer
3	Mr. Ajit Desai	Assistant Administrative Officer
4	Mr. K. N. Visweswara	Private Secretary
5	Mr. M. Eswar Reddy	Assistant
6	Ms. Dipanwita Deb	Assistant
7.	Mr. M. Narayanaswamy	Assistant
8	Ms.S. Kaveriamma	Personal Assistant
9	Ms. M. S. Uma	Junior Stenographer
10	Ms. NaziyaAnjum	Upper Division Clerk
11	Ms. Anitha. P.	Lower Division Clerk
Supporting		
1	Mr.Ramakrishnaiah	Mali
2	Mr. C. Anjenappa	Messenger
3	Mr. V. Anjenappa	SS Gr.I
4	Mr. Pamulu Nagiah	Safaiwala

INFRASTRUCTURE DEVELOPED

Dr. Swapan Kumar Datta, DDG (Crop Science) inaugurated the 'Mite Repository' at NBAIR on 17th July, 2014

Dr. S. Ayyapan, Secretary DARE and DG, ICAR inaugurated the Veterinary & Fisheries Arthropod Laboratory at the Yelhanka Campus of NBAIR on 10th January, 2015

Honourable Union Minister for Agriculture Shri. Radha Mohan Singh inaugurated the newly established'Insect Photo Gallery' at NBAIR on 2nd April 2015

EMPOWERMENT OF WOMEN

Sushmita, the differently abled, eldest daughter of Nanjundaswamy and Mamtha lives in the village of Madla, Mandya district. During 2012 their sugarcane crop was severely infested by the early shoot borer. Scientists from NBAIR successfully managed this pest with periodic releases of the biological control agent, *Trichogramma chilonis* multiplied en masse on the eggs of the eri silk moth. Impressed with the results Nanjundaswamy opted to produce this effective bioagentin his house by utilizing the NBAIR technology. Sushmita took the lead. Under her care eri silk moth based tricho cards were produced and used on the farm. Her innovative and creative mind found other uses for the by-products of this technology. Aesthetically conceptualized 'book marks' and 'welcome boards' were designed by her from the shelled cocoons of the eri silk moth. This is an added source of income.

As a part of Human Resource Development at ICAR-NBAIR Yelahanka campus, eight graduate girl students from College of Agriculture, Hasan were trained in different areas of Entomology including Biotechnology for 90 days from December 2014 to March 2015. Director NBAIR addressed the students at the Valedictory session and motivated the students to undertake further research on similar lines.

EXHIBITIONS CONDUCTED/PARTICIPATED

The NBAIR participated in the following exhibitions/melas to showcase research technologies developed at the institute.

1. **Krishi Mela at GKVK from 19.11.2014 to 21.11.2015.**
2. **Krishi Mela at Horticultural University, Shimoga from 18th to 20th October, 2014.**
3. **NBAIR arranged an exhibition at Zonal Project Directorate, Bangalore on 09.01.2015 for visit of Honorable Union Agricultural Minister.**
4. **On the occasion of '86th ICAR Foundation Day' dated 16.07.2014 an exhibition at NBAIR campus was arranged wherein children from various schools and farmers from nearby villages actively participated.**
5. **Provided material for an exhibition organized for 'National Farmers' Meet for Horticultural Crops' at Paiyur on 14.03.2015.**

86th ICAR Foundation Day on 16.07.2014, at NBAIR, Bangalore

An exhibition at Zonal Project Directorate, Bangalore on 09.01.2015

KrishiMela at GKVK from 19/11/2014 to 21.11.2015

KrishiMela at Horticultural University, Shimoga from 18th to 20th October, 2014

Annual Performance Evaluation Report of RFD for 2013-2014

S.No	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value**					Consolidated Achievements	Raw score	Weighted Score	Percent achievements against Target values of 90% Col.*	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%					
1	**Augmentation of genetic resources of agriculturally important insects*.**	**48**	[1.1]. Collection and Characterization of agriculturally important insects	[1.1.1] Insect collections made	Num	**20**	850	765	680	595	510	**837**	**98.4**	**19.68**	**109.41**	
				[1.1.2] Insect specimens identified	No,	**18**	11000	9900	8800	7700	6600	**14470 $**	**100**	**18**	**146.16**	**$**
				[1.1.3] GenBank accessions, gene sequences & Barcodes developed	No.	**10**	555	500	450	400	350	**577**	**100**	**10**	**115.4**	
2	**Conservation, evaluation, utilization and supply of agriculturally important insects.**	**30**	[2.1] Ex situ conservation	[2.1.1] Insect species conserved	No.	**12**	500	450	400	350	300	**517**	**100**	**12**	**114.88**	
			2.2] Evaluation of Bioagents	[2.2.1] Evaluation experiments conducted	No.	**10**	150	135	120	105	90	**158**	**100**	**10**	**117.03**	
			2.3] Supply	[2.3.1] Insect species supplied	No.	**8**	550	495	440	385	330	**539**	**98**	**7.84**	**108.88**	
3	**Capacity building and dissemination of technology**	**10**	[3.1] Impartation of trainingon Insects & dissemination of technology	[3.1.1] Trainings conducted/organised	No.	**10**	15	13	11	10	9	**27#**	**100**	**10**	**207.69**	**#**

$ More number of collections was made in greater frequency due to invasive threats

More number of trainings were conducted based on the demand for the management of pests of coconut, invasive pests and mass rearing techniques

Continued

S.No	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria value					Consolidated Achievements	Raw score	Weighted Score	Percent achievements against Target values of 90% Col.*	Reasons for shortfalls or excessive achievements, if applicable
							Excellent 100%	Very Good 90%	Good 80%	Fair 70%	Poor 60%					
	Efficient functioning of RFD	12	[4.1] Timely Submission of draft RFD (2014-15) for Approval	[4.1.1] On-time submission	Date	2	March 23 2014	March 26 2014	March 27 2014	March 28 2014	March 29 2014	0	0	0	0	
			[4.2] Timely submission of RFD results (2013-14)	[4.2.1] On -time submission	Date	1	May 1 2014	May 2 2014	May 3 2014	May 4 2014	May 5 2014	0	0	0	0	
	Administrative Reforms		[4.3] Implement ISO 9001	[4.3.1] Prepare an ISO 9001 action plan	Date	1	June 4 2014	June 5 2014	June 6 2014	June 7 2013	June 8 2014	0	0	0	0	Action plan initiated
				[4.3.2] Implementation of ISO 9001 action plan	Date	2	100	95	95	85	80	0	0	0	0	Implementation would take another six months
			[4.4] Implement mitigating strategies for reducing potential risk of corruption	[4.4.1] % implementation	%	2	100	95	90	85	80	100	100	2	100	
	Improving internal efficiency /responsiveness .service delivery of Ministry Department		[4.5] Implementation of Sevottam	[4.5.1] Independent Audit of Implementation of Citizens Charter	%	2	100	95	90	85	80	100	100	2	100	
				[4.5.2] Independent Audit of Implementation of Public Grievance redressal system)	%	2	100	95	90	85	80	100	100	2	100	

* Per cent of Achievable Targets = Consolidated Achievements /Targets under 90% Column * 100

Total composite score : 91.52

Rating : Very Good

Procedure for computing the Weighted and Composite Scores

1. Weighted Score of a Success Indicator = Weight of the corresponding Success Indicator x Raw Score / 100
2. Total Composite Score = Sum of Weighted Scores of a ll the Success Indicators
3. Raw score for achievement = Obtained by comparing achievement with agreed target values
   Example : Values between 80% (Good) and 70% (Fair), the raw score is 75%.

Departmental rating	Value of Composite score
Excellent	100-96%
Very Good	95-86%
Good	85-76%
Fair	75-66%
Poor	65% and below

Annual Report
2014-15

वार्षिक प्रतिवेदन
2014-15

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CONTENTS

PREFACE

Insects appeared on earth about 400 Mya. Since then they have dominated almost all ecosystems on our planet. One of the factors that has contributed to their astonishing success has been their small size. It is therefore significant that this year saw the NBAIR discovering *Kikiki huna,* an egg parasitoid*,* the smallest flying insect on earth. This rare insect is not known from most parts of the world. It is just one of the treasures unearthed by the NBAIR during the last year. Taxonomists from the Bureau did extensive surveys in Sikkim, Arunachal Pradesh, Nagaland and Assam for their unique insect fauna and many taxa not known to occur there have been discovered and documented. The main taxa being studied are Platygastroidea, Trichogrammatidae, Microgastrinae, Mymaridae, Aphelinidae, Pteromalidae, Encyrtidae, Sphecidae, Aphididae, Coccoidea, Cerambycidae and Coccinellidae. Many new species have been collected, described and added to the National Insect Repository at NBAIR. The barcoding of Indian insects in the repository and from collections made from across the country is also in progress. A vast collection of entomogenous nematodes occurring in India has been made and their taxonomy is being worked out. Notably the characterization of *Oscheius* sp. which attacks the pupae of dipterans is a significant achievement. The mite repository too is being built up with additions from various parts of the country. In recognition of its excellence in insect systematics by ICAR the Bureau has from this year been entrusted with coordinating the Network Project on Insect Biosystematics.

Studies to enable the utilization of new natural enemies like predatory anthocorids are being pursued with encouraging results. Work on new pheromones and other semiochemicals and the application of nanotechnology in pest management are being investigated for incorporation in pest management programmes in the country. Insects of importance in the veterinary and fisheries sectors are being collected and documented. Their cuticular hydrocarbons are being studied for the development of novel management techniques. In view of their importance and long period of neglect in our country a brainstorming session was organized on the 2nd of August, 2014.

Invasive species pose a constant threat to agriculture. Invasives that have already entered our country like the papaya mealybug and the eucalyptus gall wasp, both of which have been successfully managed are being constantly monitored to initiate timely action when required to avoid future outbreaks. Taxonomic support has been provided to the national Quarantine service to identify insects gaining entry into the country. Information on the threats posed by the intercepted insects to Indian Agriculture is being regularly updated. A one day brainstorming meet was held on 26th August, 2014 to discuss and sort out issues in the area of biosecurity.

Websites hosted by the Bureau on various insect taxa are being constantly updated and expanded.

Entomopathogens (bacteria, fungi and viruses) are being collected, studied and documented. The possibility of utilizing them as biocontrol agents is being explored. Several of them are to be commercialized.

The All India Coordinated Research Project on Biocontrol with over 25 centres spread across the country are field testing the efficacy of bioagents as well as the biological control technologies developed at the NBAIR. To support this programme and to meet the requirements of bioagents for farmers, entrepreneurs and SAUs, this Bureau maintains a vast array of over 100 insects and 300 insect related resources for use in biocontrol and research programmes. These are supplied on demand to the end users across the country.

To create awareness and to impart the necessary knowledge and skills in the field of biological control the Bureau imparts need based specialized training to farmers, scientists and students.

As the tropics harbour many more species than the temperate regions of the world the task of documenting and evaluating the biological control potential of insects in our agroecosystems is enormous. The small number of taxonomists and biocontrol specialists currently working here can only scratch the surface. The presence of additional, appropriately trained manpower only can achieve the desired goal.

June, 2015

Abraham Verghese
Director

EXECUTIVE SUMMARY

The National Bureau of Agricultural Insect Resources is the only institution in the country recognized as a National Repository for agriculturally important insects, spiders and mites. The Bureau is committed to the collection, cataloguing and conservation of insects and other related organisms including mites, spiders, nematodes and microbes associated with arthropods in the agro ecosystems of our country. All research work in the Bureau is undertaken by the three Divisions of Insect Systematics, Molecular Entomology and Insect Ecology. Basic research is mainly undertaken at NBAIR. Additionally all work on biological control is formulated and coordinated by the Bureau by networking a number of institutions in the country under the All India Coordinated Research Project (AICRP) on Biological Control of Crop Pests. Summarized below are the results of the research undertaken during 2014 – 2015 in the three Divisions of the Bureau as well as the AICRP on Biological Control of Crop Pests.

INSECT SYSTEMATICS

Surveys

Expeditions were undertaken for insects, other arthropods and associated organisms in 12 states in the country, *viz*.: Arunachal Pradesh, Sikkim, Nagaland and Assam in Northeast India; Uttar Pradesh, Uttara khand, Himachal Pradesh and Punjab in North India; Tamil Nadu, Kerala and Karnataka in South India and Gujarat in West India.

Digitization of type specimens in NBAII collections

A total of 184 types including 121 holotypes, 60 paratypes, one cotype and two allotypes were digitized and the information hosted on the NBAIR website.

Biosystematics of Trichogrammatidae

Prestwichia, Chaetogramma, Burksiella, Lathromeris, Lathromeromyia, Pseudoligosita, Paracentrobia, Aphelinoidea, Mirufens and *Tumidiclava* were added to the collections of the Bureau for the first time. *Mymaromma ignatii,* a new species of *Mymarommatoidea* was described from S. India. This is the first record of a mymarommatoid from India.

Biosystematics of oophagous parastioids with special reference to Platygastroidea

A new genus *Chakra,* with type species *Chakra sarvatra* was described from Andaman Islands. Twelve new species of Platygastroidea were described as new to science. Five new species of *Phanuromyia, viz Phanuromyia andamanensis, P. kapilae, P. koenigi, P. nabakovi* and *P. jarawa* were described. Two new species of *Amitus* and two new species of *Synopeas* viz. *Amitus kiefferi, Amitus sikkimensis, Synopeas dohertyi* and *Synopeas aitkeni* were described. *Trichacoides ranganabettensis, Platygaster neostriatitergitis* and *Neotrimorus ferrari* were also described as new species. *Protelenomus flavicornis* Kieffer and *Amitus aleurolobi* Mani were redescribed.

Biodiversity of economically important Indian Microgastrinae (Braconidae)

Seven new Indian species of parasitic wasps are described. *Anisopteromalus indicus* was reared from a lymantriid associated with sugarcane from southern India. A new species *Phanerotoma andamanensis* was described from the Andaman Islands, India.

A new species of gregarious endoparasitoid, *Parapanteles athamasae* (Hymenoptera: Braconidae), parasitising caterpillars of *Charaxes athamas* (Drury)

(Lepidoptera: Nymphalidae) on the host plant *Senegalia catechu* (=*Acacia catechu*) (L.f.) was described from Maharashtra, India. The sexually dimorphic male of *Tetrastichus bilgiricus* was described from parasitized pupae of *Euthalia aconthea meridionalis*.

A monograph with rearing records of microgastrine wasps (Hymenoptera: Braconidae) covering 16 States and one Union Territory (Andaman & Nicobar islands) was published.

Biodiversity of aphids, coccids and their natural enemies (Hemiptera)

The families Margarodidae and Kuwaniidae as well as 23 species of aphids not represented in the NBAIR collection were collected and deposited in the museum. The aphids *Liosomaphis ornata*, *Sitobion asirum*, *Uroleucon sonchellum, Pseudoregma montana*, *Hyperomyzus pallidus;* the mealybugs *Trionymus bruneiensis* and *Pseudococcus calceolariae* and a diaspidiid *Chionaspis salicis* were collected from India for the first time.

Biosystematics and diversity of Cerambycidae

Thirteen species of cerambycids were identified from the collections made during the year of which *Xystrocera globosa* (Cerambycinae: Xystrocerini) was reared from trunks of silver oak.

Taxonomy and diversity of Indian Sphecidae

Nine genera were identified from the collections made during the year. *C. (Carinostigmus) griphus* Korembein is a new record for India.

Network Project on Insect Biosystematics

A new species of Coccinellidae *Calvia explanata* was described from Nepal and northeastern India. *Micraspis pusillus* was described from northeastern India. *Platynaspis flavoguttata* (Gorham), a rare species from Karnataka was redescribed and the male genitalia were illustrated for the first time.

The genus *Kikiki*, the smallest genus of flying insects was collected from Arunachal Pradesh and Tamil Nadu. *Anagyrus amnestos* (Encyrtidae), a potential parasitoid of the invasive Madeira mealybug, was found to have established well in and around Bangalore.

MOLECULAR ENTOMOLOGY

Molecular characterization and DNA barcoding of some agriculturally important insect pests

More than 1000 insect specimens belonging to different orders were collected from 10 different states. Specimens were kept in -70°C as well as in 95% alcohol. Specimens were identified by Co-PIs and were also provided from some AICRP centres, UAS-GKVK, KVAFSU, Bangalore, Silk Board, etc. One hundred and one insect species were molecularly characterized. These consisted of 71 species and 30 populations and belonged to Coleoptera (14), Diptera (12), Hemiptera (33), Hymenoptera (1), Lepidoptera (37 including populations) and Orthoptera (4).

Protocol for museum specimens up to 8 years old was standardized for both mini-barcode (≤ 130 bp) and also *Cox1* 658 bp. Two insects, *Cosmopsaltria* sp. (8 years old) and *Anoplocnemis phasianus* (5 years old) characterized and the sequences submitted to GenBank (KM459444, KM459441). Mini barcodes (≤ 130 bp) for five insects (up to 8 years old) were developed.

Genetic variation studies of *Plutella xylostella*

Genetic variation among different Indian populations of cabbage diamondback moth (*Plutella xylostella*; Lepidoptera: Plutellidae) based on mitochondrial DNA was determined. The populations collected from thirteen states, spanning a geographic area of ~ 12250000 km^2, were sequenced. Sequence analysis of the 658bp *mtCOX1* gene from 13 populations resulted in 9 haplotypes, of which 13 clustered to form a haplotype group. Among these populations, 11 polymorphic sites were observed, of which 5 were transitional and 6 were of transversional substitution.

Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators

Molecular characterization using cytochrome oxidase 1 gene (CO1) was done for the following parasitoids namely the encyrtids *Aenasius advena (KJ850498), Blepyrus insularis (KJ850500), Neastymachus axillaris (KM095502);* the aphelinid *Myiocnema comperei (KJ955498);* the eulophid *Diglyphus isaea (KM016074);* the braconids *Aphidius ervi (KM054518), Aphidius colemani (KM054519) Cotesia* sp. *(KM875666), Glyptapanteles* sp. (Bidar) *(KM887912), Glyptapanteles* sp. (Valparai) *(KM887913), Apanteles phycodis (KP055616), Bracon greeni (KP055617), Micropilitis macullipennis (KP759288);* the vespid *Ropalidia* sp. *(KM054517);* the scelionids *Macrotelia* sp. *(KM095503), Idris* sp. *(KP271246);* the ichneumonid *Pristomerus sulci (KM875667)* and the chalcidid *Brachymeria tachardiae (KP055618).* Molecular characterization of trichogrammatids belonging to 21 species was characterized using CO-1 and ITS-2 regions and a phylogenetic tree was constructed.

Molecular characterization and DNA barcoding of subterranean insects

Collection and identification of scarabaeid beetles and termites

Scarabaeid beetles and termites were collected from different geographical locations in the country. The beetle and termite specimens collected from different geographical locations in India were preserved in 70% absolute alcohol. The adult beetles were morphologically identified based on the types of antennae, mandibles, maxillae, presence and absence of stridulatory organs and tarsal claws, while the grubs were identified based on the anal slit, raster pattern , spiracles and legs. The termites were identified based on the morphology of the soldier caste *viz*., length of the antennae, shape of the mandibles, relative position of mandibular tooth, shape and size of the head, labrum, fontanelle and shape of postmentum and pronotum.

Important scarabaeid beetles identified included *Protaetia* sp., *Anomola* sp., *Heterorrhina* sp., *Apogonia* sp., *Schizonycha* sp., *Alissonotum* sp. and *Anomola singularis.* Termites identified were *Odentotermes longignathus, Microtermes obesi, Euhamitermes hamatus, Nasutitermes octopilis, Nasutitermes exitiosus, Macrognathotermes serrator, Odontermes mathurai, Neotermes koshunensis, Odontotermes gurdaspurensis, Microtermes mycophagus, Odontotermes mathuri* and *Odontermes obesus.*

Mapping of the cry gene diversity in hot and humid regions of India

A total of 80 isolates of *Bacillus thuringiensis* were purified from soil and insect cadaver samples of Almora region. Forty of these isolates were screened for cry gene diversity using degenerate primers. All of them harboured *cry*1 and *cry*2 genes.

The vip3a gene was amplified using PCR and the 2.3Kb product was sequenced and confirmed. PCR amplicon (~2.3Kb) was successfully cloned into a cloning vector (pUC29) at NdeI and XhoI restriction sites. Sub-cloning of sequence confirmed vip3a gene in pET21a was confirmed by PCR amplification. The VIP3A protein was purified from the *pET21a-Vip3a* clone by IPTG induction for 4 and 16h and the induced protein collected at 4h exhibited LC_{50} value of 1.9 µg/ml against *Plutella xylostella.* Induced protein collected at 16h exhibited an LC_{50} value of 0.423 µg/ml. Bioassay against *Spodoptera litura* showed that at 72h the protein collected at 4h of induction with IPTG exhibited an LC_{50} value of 12.35 µg/ml and at 96h the LC_{50} value was calculated as 6.87 µg/ml. The protein collected at 16h of induction incited LC_{50} value of 4.87 µg/ml at 72h and the LC_{50} was 2.68 µg/ml at 96h.

Studies on microflora associated with soil insects and other arthropods

From *Protaetia aurichalcea* 30 culturable microbes were identified, *Bacillus amyloliquefaciens, B. subtilis B. cereus, B. pumilus, Flavobacterium* sp. and *Pseudoxanthomonas* sp. were characterized as positive for cellulose, lignin or pectin degradation. The larvae of *Hermetia illucens* also harboured 30 culturable microbes and *Brevibacterium epidermidis, B. cereus, Bacillus* sp., *B.flexus* and *Proteus mirabilis* were characterized as positive for cellulose, lignin or pectin degradation. The gut of coconut beetle *Oryctes rhinoceros* showed presence of 38 culturable microbes. *Bacillus cereus, Bacillus* sp., *B. amyloliquefaciens, B. pumilus, B. megaterium, B. subtilis, B. altitudinis, B. marisflavi, B. bombysepticus, B. tequilensis, Microbacterium testaceum* and *Lysinibacillus sphaericus* were characterized as positive for cellulose, lignin or pectin degradation.

Studies on role of microbial flora of aphids in insecticide resistance

A total of 29 isolates were obtained from two aphid species of Bangalore, Kolar and Dharwad. Phylogenetic affiliation and molecular identification of microflora indicated that many bacteria were new reports from the current studies, which include *Bacillus aryabhattai, B. firmus, B. cereus,* and *Stenotrophomonas maltophilia.* Bacillus was the dominant genus found invariably in all aphid species.

Bioassay for red gram aphid *Aphis craccivora* to imidacloprid 17.8% SL insecticide revealed that Dharwad population was 9.7 times more resistant to imidacloprid than the Bangalore population. Bioassay for *Brevicoryne brassicae* to imidacloprid 17.8% insecticide revealed that Dharwad population was five times more resistant to imidacloprid.

Database on genetic resources

Molecular data on insecticide resistance genes like Cytochrome P450, Acetylcholinesterase and knock down are essential for important pests. Hence, Insecticide Resistant Gene Database (IRGD) has been developed and this database can be viewed at http://www.cib.res.in/irgd. Presently, IRGD contains 365 sequences for the pests *Helicoverpa armigera, Bemisia tabaci, Acrythosiphon pisum* and *Aphis gossypii* with key features like Search, View options etc. and this database will be updated regularly.

INSECT ECOLOGY

Diversity of Indian Anthocoridae

Orius minutus was collected from Pasighat. *Physopleurella pessoni* and *Rajburicoris stysi* from Palani hills are new records for India. Three more *Xylocoris* spp. were documented: *Xylocoris* (*Proxylocoris*) *afer* which was collected from dry fruits of *Ficus* and *Lagerstromia; Xylocoris* (*Proxylocoris*) *confuses* and *Xylocoris* (*Arrostelus*) *ampoli* from maize ecosystem. All the three are new records for India.

Egg characters used for differentiating *Cardiastethus exiguus* from *Cardiastethus affinis*

Cardiastethus exiguus and *C. affinis*, which are predators of coconut black-headed caterpillar, were differentiated based on egg characters. Eggs of *C. exiguus* are longer than that of *C. affinis*. The surface of *C. exiguus* eggs has a speckled appearance and the central region of the operculum has distinct hexagonal cells, unlike *C. affinis*.

Evaluation of *Amphiareus constrictus* against brown planthopper

Amphiareus constrictus was evaluated in cages against BPH infesting paddy. The pre-counts of adult and nymphal hoppers per tiller in control were 6.2 and 8.4, respectively, while in the treatment cages they were 14.5 and 12.3, respectively. After five releases, counts in treatment cages were 1.8 and 1.4, respectively, while in control, values were 6.3 and 3.3, respectively. This indicates that *A. constrictus* could be a potential predator of BPH.

Natural predation of *Aleurothrixus trachoides* on capsicum

Natural predation of *Aleurotrachelus trachoides* (solanum whitefly) by the coccinellid *Axinoscymnus puttarudriahi* was observed on capsicum.

Studies on the new invasive pest *Tuta absoluta*

Tuta absoluta infestation was observed to be severe in Karnataka and Tamil Nadu. Its natural enemies *Nesidiocoris tenuis, Trichogramma achaeae, Neochrysocharis formosa, Habrobracon* sp. and *Goniozus* sp. were recorded. *Trichogramma achaeae, T. pretiosum* and *T. bactrae* could parasitise the eggs of *T. absoluta.*

Parasitism of eggs of banana skipper *Erionota thrax* by *Trichogramma chilonis*

Trichogramma chilonis could parasitise 10.5% eggs of *Erionota thrax,* but the parasitoid adults could not emerge from the parasitized eggs.

Studies on parasitoids of litchi stink bug *Tessaratoma javanica*

Eggs of eri silkworm (ESW) can be stored in the deep freeze for 2 to 6 days and used for rearing *Anastatus acherontiae* and *A. bangaloriensis*; per cent parasitism values recorded being 41.4 to 63.3% and 39.3 to 55% respectively. Biological parameters of *A. bangaloriensis* were recorded: mean adult longevity 9.8 days; mean developmental period 17.3 days; mean per cent parasitism 19.9; mean total fecundity 38.9 and mean per cent female progeny 20.5. ESW eggs parasitized by *A. acherontiae* were stored for 7, 15 and 21 days and the per cent adult emergence recorded was 85.7, 72.5 and 63.8, respectively.

Charging of *Corcyra* boxes with lower dosage of eggs to improve production efficiency

The fecundity of *C. cephalonica* emerging from boxes charged with a lower dosage of 0.125 cc per box was 467 in comparison with the fecundity of adults emerging from the boxes with higher dosage (0.5 cc per box), recorded as 279.

Live insect germplasm maintenance and supply

In the Live Insect Repository, a total of 139 live insect cultures were maintained, 1148 consignments of live insect cultures were supplied and a revenue of Rs 5,50,931 generated.

Screening of *Beauveria bassiana* isolates against maize stem borer, *Chilo partellus* (Laboratory bioassay)

Bioassay studies were conducted with 87 isolates of *B. bassiana* against second instar larvae of *Chilo partellus.* Among the 87 isolates tested, five isolates (Bb-7, 14, 19, 23 and 45) resulted in significantly higher mortality (86.4.-100%). Among these five isolates significantly higher mycosis (84.4-97.8%) was shown by Bb-14, 23 & 45. Dose and time mortality studies indicated that Bb-45 showed the lowest LC_{50} (5.02 $x10^4$ conidia ml^{-1}) and LT_{50} (136.25 hr) values with Bb-45.

Establishment of *Beauveria bassiana* as endophyte in maize

Pot culture studies were conducted with six promising isolates of *B. bassiana* (Bb-5a, 7, 14, 19, 23 & 45) to test their ability to establish as endophytes in maize through seed treatment/foliar spray on two susceptible varieties of maize viz., COH(M)10) and Bio9681.In foliar application, colonization of Bb-45 isolate was observed in the leaf tissues up to 60 days after treatment (DAT), whereas Bb-23 isolate colonized the leaf tissues up to 30 DAT and Bb-14 isolate till 15 DAT of the maize variety-COH(M)10. In case of Bio-9681 maize variety, colonization of Bb-19 isolate was observed in stem and root tissues for a period of 30 days after treatment and in leaf tissues only for 15 DAT.

In a field trial with three isolates of *B. bassiana* (Bb-14, 23 & 45) foliar application ($1x10^8$spores/ml)/ at 30 days of crop age showed that Bb-14 and Bb-45 colonized stem and leaf tissues for a period of 15days after treatment. In crown application method, Bb-23 and Bb-45 isolates colonized leaf tissues for a period of 15 days after treatment.

Monitoring of papaya mealybug and its natural enemies on papaya and other alternate hosts

Based on the survey conducted in different parts of the state and also the feedback from various AICRP (BC) centers revealed that the papaya mealybug, *Paracoccus marginatus* did not attain pest status in any of the commonly occurring crops. Infestation in papaya and mulberry was surveyed in the districts of Bangalore, Kanakapura, Mysore, Maddur, Hassan, Tumkur, Mandya, Chamarajnagar, Ramanagar, Kollegal, Kolar and Chikballapur area. The occurrence of papaya mealybug was nil in the surveyed areas

Erythrina gall wasp management

Erythrina gall wasp *Quadrastichus erythrinae* was found in low populations in Kolar, Mandya and Ramnagar districts. *Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae.*

Establishment of *Cecidochares connexa* gall fly

Chromolaena weed biocontrol agent *C. connexa* released at different places has established upto 15 galls per 5 minutes search in 450 m around the released spot.

Host range of invasive Jack Beardsley mealybug (*Pseudococcus jackbeardsleyi*)

Survey for invasive insects in South India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu and Karnataka. In the recent survey it was found to be severe on cocoa. *Nephus regularis* was found to be a major predator on eggs of *P. jackbeardsleyi.*

New invasive and host extensions

Tuta absoluta was recorded in Karnataka, Tamilnadu and Gujarat. Western flower thrips, *Frankliniella occidentalis,* was reported from Bangalore by ZSI. Banana skipper *Erionota thrax,* bruchid on seeds of *Hibiscus subdariffa* and *Pseudococcus jackbeardsleyi* were recorded on cocoa; *Phenacoccus madeirensis* was recorded on cashew, root mealybug on pepper (*Formicococcus polysperes*) are some of the new invasives or new host records for the year.

Monitoring upsurge of banana leaf skipper *Erionota thrax*

Banana skipper is on the upsurge in homesteads and a few orchards in Karnataka and is severe in Kerala and parts of Tamil Nadu. Incidence of up to 20-27% is recorded in Kerala.

PEQ testing of exotic bioagents

The two bioagents *Neoseiulus californicus* and *Orius laevigatus* were imported by Koppert Biological Systems on 27 May 2014.

INIS Marketing Services imported *Amblyseius swirskii* and post entry safety tests were conducted for this mite.

The exotic predatory mite *Amblyseius swirskii* (KM035534) was identified and was true to type. No feeding injury by *Amblyseius swirskii* was observed on test insects.

New invasive bruchid on *Hibiscus subdariffa* seeds

Seeds of *Hibiscus subdariffa* (Gongura) purchased from the local market were found infested with *Althaeus,* an invasive bruchid species.

Pollinators of cucurbits

Cucurbits were monitored for flower visitors and 17 different species of bees were collected from different flowers.

Documentation of pollinator diversity with focus on non-*Apis* species

The pollinator garden was extended with 47 species of diverse plant families. Over 100 specimens of bees belonging to Apidae, Megachilidae, Anthophoridae, Halictidae were collected on different host plants.

Insecticide resistance in *Amrasca biguttula biguttula*

The relative resistance of *Amrasca biguttula biguttula* population collected from cotton fields of Dharmapuri was higher (LC_{50} 1121.2 ppm) as compared to the population collected from Baita village, Bangalore (LC_{50} 823.6 ppm) based on 48 h bioassay data. The gut bacteria *Bacillus pumilus, Stenotrophomona smatophilia, Enterobacter cloacae***,** *Filobasidium floriforme, Bacillus subtilis, Staphylococcus aureus, Bacillus cereus* grew well in all the concentrations of acephate insecticide. Esterase, an important enzyme involved in insecticide degradation, was detected in *Bacillus pumilus* culture.

Endosymbionts of *Amrasca biguttula biguttula* inhibiting insect pathogens

The bacteria *E. cloacae, B. pumilus* and *Filobasidium floriformie* inhibited the entomopathogens *Beauveria bassiana* and *Paecilomyces fumosoroseus. Microbacterium imperiale* inhibited another entompathogen *Verticillium lecanii. Bacillus pumilus* exhibited maximum inhibition (3.5cm) against *Paecilomyces fumosoroseus. Microbacterium imperiale* exhibited maximum inhibition (3.3cm) against *Verticillium lecanii. Enterobacter cloacae* exhibited maximum inhibition (3.4cm) against *Beauveria bassiana.*

Synthesis of nanomaterials to act as sensor for semiochemicals in pest management

A sensor for pheromones was developed. The invention provides a pheromone detector for the early detection of pheromones in the field. The functionalized devices detect the pheromones at an early stage of pest infestation in a rapid and energy efficient way. The concentration of pheromone released by insects per acre per hour is estimated to deploy pheromone detectors to cover nearly one acre of the field to detect the incidence of pest infestation.

Chemical characterization and ethology of economically important dipteran pests of domestic animals and fish

Dipteran pests (*Musca domestica*, *Chrysomya megacephala*, *Sarcophaga dux*, *Stomoxys calcitrans* and *Tabanus* sp.) of importance to veterinary and fisheries sciences were collected. The cuticular hydrocarbon (CHC) profile of adult *M. domestica* had nine compounds, among which octadecanol and cycloeicosene were present at over 10%. Alphadodecane, tridecane and butylphenol were present at rates ranging from 5-9%. On the efficacy of essential oils that were evaluated against housefly imago, ajowan oil was effective over citridora oil. In fumigant toxicity test ajowan oil, caused LD_{50} at 5.98 µg/cm^3 as against citridora oil that required 10.12 µg/cm^3.

Documentation of leafhoppers and other hemipterans

A total of 960 leafhoppers were captured from various plant species at the NBAIR Research Farm, Yelahanka, Bengaluru, for identification, documentation and use in various studies during 2014-15.

Optimising a large-scale rearing methodology for *Hishimonus phycitis*

A large-scale rearing methodology for *Hishimonus phycitis* has been optimised to produce and maintain over 2000 adults at any given time on 200 brinjal (MEBH-11) plants in a single bay of the greenhouse. In a 24”x18” x18” rearing cage with four brinjal plants, not less than 100 adults could be maintained continuously with plant replacement once a month.

Field experiments on the natural incidence of insect vectors and phyllody in sesame

In the first experiment, phyllody incidence was only 6.9% on 13 August 2014, but shot up to 16% in 40 days. Throughout the crop period, *H. phycitis* (11.9 & 16.9 adults/ infected plant in August & September, respectively) dominated over *O. albicinctus* (4.6 & 7.0 adults/ infected plant in August and September, respectively). In the second trial, phyllody incidence was a meager 6.6%. *H. phycitis* was the dominant vector.

Monitoring the incidence of viruliferous leafhoppers through transmission studies

Viruliferous *H. phycitis* and *Orosius albicinctus* were monitored by first attracting the populations to a sesame crop sown in June 2014. In the greenhouse, directly field-collected *H. phycitis* induced symptoms in 65% brinjal plants, irrespective of the crop from which the insects originated. On the other hand, *O. albicinctus* could transmit the pathogen to only sesame at 50%. Ten other genera of leafhoppers were found to be aviruliferous when caged on periwinkle.

Molecular confirmation of vector-transmitted phytoplasma in symptomatic plant species

Primary PCR followed by nested PCR indicated the association of the same phytoplasma with symptomatic plant species, thus confirming that *H. phycitis* transmitted the same organism to sesame, brinjal and sunn hemp from periwinkle. The pathogen was found to be closest to periwinkle phyllody r RNA gene.

Establishment of a Mite Repository

A mite repository has been established at NBAIR. The facility became operational on 17 July 2014. During the period mite collections came from 39 places in 18 districts across 10 states. Totally, 172 plant species with possible mite infestation were collected for processing. Thirty-four hosts other than plants were also collected for separating mites.

Phytophagous mites belonging to suborder Prostigmata (Supercohorts Eleutherengonides and Eupodides) were predominantly found during the collections. They were collected with prior information about their damage potential on economically important plant species. In January-March 2015 alone, more than 100 specimens of phytophagous mites were mounted in Hoyer's medium and preserved. Specimens belonged to Tetranychidae, Tenuipalpidae, Tarsonemidae and Eriophyoidea.

In general, Phytoseiidae dominated all other predators on various plant species. Predatory mites belonging to the families Ascidae, Melicharidae and Blattisocidae were separated out and genus-level identifications were done. Under order Trombidiformes, predatory mites belonging to the families Bdellidae, Cheyletidae, Cunaxidae, Stigmaeidae and Tydeidae were collected, mounted and preserved.

Identifying year-round plant hosts of predatory mites

Out of 88 plant species, a few were identified as potential year-round hosts of predatory mites. For example, *Solanum virginianum* generally harboured species of *Amblyseius*, *Phytoseius* and *Stigmaeus*. Across plant species, the phytoseiids *Amblyseius*, *Euseius*, *Neoseiulus*, *Phytoseius*, *Typhlodromalus* and *Typhlodromips* were the most dominant associates.

Semiochemicals for the management of coleopteran pests

Lepidiota mansueta grubs were highly pestiferous causing damage to sugarcane, potato and other important crops. Through electrophysiological studies, it was found that prothoracic gland secretions could play the role of aggregation pheromone. The male pheromone from the prothoracic glands of the root grub, *L. mansueta* was analyzed through GCMS and GCEAD.

निष्पादित सारांश

राष्ट्रीय कृषि कीट संसाधन ब्यूरो, देश का मात्र एक ऐसा संस्थान है जिसको कृषि महत्त्वपूर्ण कीटों, मकड़ियों और माइट्स की देश भर की राष्ट्रीय धरोहर संजोने के रूप में मान्यता प्राप्त है। यह ब्यूरो, हमारे देश की कृषि पारिस्थितिकी तन्त्र में आर्थ्रोपोड्स के साथ संबंधित कीटों, मकड़ियों यहाँ तक कि सूत्रकृमियों और सूक्ष्म जीवों के संग्रहण, सूचीबद्धीकरण और संरक्षण करने के लिए प्रतिबद्ध है। ब्यूरो, के सभी अनुसंधान कार्य तीन, प्रभागों - कीट प्रणालियाँ, आण्विक कीट विज्ञान और कीट पारिस्थितिकीय विभागों द्वारा किया जाता है। मौलिक अनुसंधान, रा. कृ. की. सं. ब्यू., बैंगलोर पर किया जाता है। इसके साथ-साथ जैविक नियंत्रण संबंधित सभी शोध कार्य फसल कीटों के जैविक नियंत्रण पर अखिल भारतीय समन्वित अनुसंधान परियोजना (ए आई सी आर पी) के अन्तर्गत देश में कई संस्थानों किए जाते हैं। वर्ष 2014-15 के दौरान ब्यूरो में, उपरोक्त तीन विभागों के साथ-साथ फसल कीटों के जैविक नियंत्रण पर अ. भा. स. अनु. परि. (ए आई सी आर पी) पर किए गए शोध परिणामों को नीचे संक्षेप में उद्धृत किया गया है।

कीट प्रणालियाँ विभाग

सर्वेक्षण

देश के 12 राज्यों नामतः भारत के पूर्वोत्तर में अरूणाचल प्रदेश, सिक्किम, नागालेण्ड और असम; उत्तर भारत के उत्तर प्रदेश, उत्तराखण्ड, हिमाचल प्रदेश और पंजाब; दक्षिण भारत के तमिलनाडु, केरल और कर्नाटक तथा पश्चिमी भारत के गुजरात राज्यों से कीटों, अन्य आर्थ्रोपोड्स और संबंधित जीवों के सर्वेक्षण का कार्य किया गया।

रा. कृ. की. सं. ब्यू. के संग्रहण प्रतिदर्शों के प्रकार का डिजिटलीकरण

121 होलोटाईप, 60 पेराटाईप, 1 कोटाईप और 2 ऐलोटाईप सहित कुल 184 प्रकारो को संपूर्ण किया तथा रा. कृ. की. सं. ब्यू. की वेबसाईट पर लगाया गया।

ट्रायकोग्रामेटिडे की जैव प्रणालियाँ

प्रेस्टविकीआ, काण्टोग्रामा, बुर्कसीएल्ला, लेथरोमेरीस, लेथरोमेरोमायईआ, न्यूडोलीगोसिटा, पैरेलेन्ट्रौबिआ, एफेलीनाव्हीआ, मोरयूकेन्स और *टयूसीडीक्लेवा* को पहली बार ब्यूरो के संग्रहण में शामिल किया गया। *मायमेरोमाटॉयडिआ* की एक नई प्रजाति *मायमेरोमा इग्नाटी* को दक्षिण भारत में पहली बार अभिलेखित किया गया।

प्लेटीगेस्ट्रायडीआ के विशेष संदर्भ में ऊफेगस परजीवी कीटों की जैव प्रणाली

अंडमान द्वीप समूह से एक नए वंश *चकरा* की प्रजाति *चकरा सर्वत्रा* वर्णित की गई। विज्ञान के लिए प्लेटीगेस्ट्रायडीआ की 12 नई प्रजातियों को नए रूप में वर्णित किया गया। फेनुरोम्यईआ की पाँच नई प्रजातियों अर्थात फे. *अन्डमानएन्सिस* प्र. पा., फे. *केपीलिए* प्र. पा., फे. *कोएनीगी* प्र. पा., फे. *नबाकोवी* प्र. पा. और फे. *जरावा* प्र. पा. वर्णित की गई। *एमाइटस* की दो नई प्रजातीयाँ अर्थात ए. *कीएफेरी* प्र. पा. और ए. *सिक्किमएन्सिस* प्र. पा. तथा *सायनोपीआज* की दो नई प्रजातियाँ अर्थात *सा. डोहेर्टाई* प्र. पा. और सा. *ऐटकेनी* वर्णित की गई। *ट्राइकेकॉयडस रन्नानबेटेन्सिस* प्र. पा., *प्लेटीगेस्टर नीओस्ट्रीएटीटेलीटिस* प्र. पा. और *नीओट्रीमोरस फेरारी* प्र. पा. वर्णित की गई।

प्रोटेलीनोमस फ्लेविकोर्निस कैफर और *एसाइटस एल्यूरोलॉबी* मणि को पुनः वर्णित किया गया।

आर्थिकरूप से महत्वपूर्ण भारतीय माइक्रोगेस्ट्रिने (ब्रेकोनिडे) (अंकिता गुप्ता) की जैव विविधता

परजीवी कीट वैस्प की सात नई भारतीय प्रजाति वर्णित की गई। दक्षिण भारत में गन्ने से संबंधित लाईमेन्ट्रिडि से *ऐनीसोप्टेरोमेलस इन्डिकस* गुप्ता और सुरेशन को पाला गया। *फेनेरोटोमा अण्डमानेन्सिस* गुप्ता और वेन एक्टिवर्ग को भारत के अण्डमान द्वीप से नई प्रजाति के रूप में वर्णित किया गया। भारतवर्ष में महाराष्ट्र राज्य से, *सेनेगलीया केटेचु (=एकेशिआ केटेचु)* पोषक पौधे की सूँड़ी *केरेक्सस अथामास* को परजीवित करने वाली एक नई प्रजाति का अन्तः परजीवी कीट *पेरापेन्टेलस अथामासे* वर्णित किया गया। *यूथेलिआ अकोन्थिआ मेरीडीओनेलिस* के परजीवित प्यूपों से द्विप्रारूपीय लिंगीय नर परजीवी कीट *टेट्रास्टिकस बिलगीरीकस* वर्णित किए गए।

16 राज्यों और केन्द्र शासित प्रदेश (अंडमान निकोबार और निकोबार द्वीप समूह) में उपस्थित एक माइक्रोगेस्ट्राईन वेस्प (हायमेनोप्टेराः ब्रेकोनिडे) को पालने के अभिलेखन को मोनोग्राफ के रूप में प्रकाशित किया गया।

माहु और कोक्सिड्स की जैव विविधता तथा उनके प्राकृतिक शत्रु कीट

मारगेरोडिडे और क्वार्नीडे के साथ-साथ माहु की 23 प्रजातियों को रा. कृ. की. सं. ब्यू. के कीट संग्राहलय में पहली बार संग्रहित किया गया। माहु की *लायोसोमेफिस ओरनाटा, साइटटोबिओन एर्सारम, यूरोल्यूकोन सोनकीलम, स्यूडोरीगमा मोन्टाना, हाईपरोमायजल पेर्लाडस*; मिलोबग की *ट्रायोनीमस ब्रुनीएन्सिस* और *स्युडोकोकल केल्सिओलेरिए* तथा एक डायस्पेडिड *चिओनेस्पिस सेलिसिस* को भारत में सर्वप्रथम एकत्र किया गया।

कृषि महत्वपूर्ण सीरेमबायसीडे की जैव प्रणाली और विविधता

वर्ष के दौरान सीरेमबायसीड के संग्रहण में से तेरह प्रजातियों की पहचान की गई *जाइल्ट्रोसीरा ग्लोबोसा* को सिल्वर ओक वृक्ष के तने पर पाला गया।

भारतीय स्फेसीडे का वर्गीकरण और विविधता

वर्ष के दौरान संग्रहण से नौ वंशों की पहचान की गई। भारत वर्ष में, *ज्यूस्टिम्सस सी. (केरीनोस्टिम्सस) ग्राइप्स* को पहली बार अभिलेखित किया गया।

कीट जैव प्रणाली की नेटवर्क परियोजना

नेपाल और उत्तर पूर्वी भारत वर्ष से कोक्सीनेलीडे की एक नई प्रजाति *केल्चिआ एक्सप्लेनेटा* वर्णित की गई। उत्तर पूर्वी भारत वर्ष से *माइक्रेस्पिस प्यूसिलस* वर्णित की गई। *प्लेटीनेस्पिल फ्लेवोगुटेटा* नामक एक दुर्लभ प्रजाति को कर्नाटक राज्य से पुनः वर्णित किया गया और पहली बार इस कीट के नर जननांग के चित्र लिए गए।

उड़ने वाले कीटों के न्यूनतम वंश वाले वंश *किकीकी* को अरुणाचल प्रदेश और तमिलानाडु राज्यों से एकत्र किया गया। आक्रमक मेडेईरा मिलीबग के एक संभाव्य परजीवी कीट के रूप में *एनागायरस एम्नेस्टस* रमेश कुमार और साथी. को बेंगलोर के आसपास स्थापित होते पाया गया।

आण्विक कीट विज्ञान विभाग

कृषि महत्वपूर्ण कीटों के डी. एन. ए. बारकोडिगं और आण्विक लक्षण वर्णन

विभिन्न गणों से संबंधित 1000 से अधिक कीट प्रतिदर्शों को 10 विभिन्न राज्यों से एकत्र किया गया।

प्रतिदर्शों को -70° से.ग्रे. के साथ-साथ 95% एल्कोहल मिश्रण में भी रखा गया। अ. भा. स. अनु. परि. के अनेक केन्द्रों, यू.ए.एस. - जी.के.वी.के., के. वी. ए. एफ. एस. यू. बेंगलोर, सिल्क बोर्ड आदि से प्राप्त प्रतिदर्शों की पहचान की गई। 101 कीट प्रजातियों की आण्विक विशेषता तैयार की गई। इनके अन्तर्गत 30 कीट संख्या और 71 प्रजातियाँ जो कि कोलीओप्टेरा (14), डिप्टेरा (12), हेमिप्टेरा (33), हायमेनोप्टेरा (1), लेपिडोप्टेरा (कीट सँख्या सहित 37) तथा आर्थोप्टेरा (4) से संबंधित थे।

दोनों मिनी बारकोड (≤130 बी पी व कोक्स। 658 बी पी) के 8 वर्ष पुराने प्रतिदर्शों का संग्रहालय में प्रोटोकोल का मानकीकरण किया गया। *कोसमोप्सेल्ट्रिआ* स्पे. (8 वर्ष पुराना) और दूसरे कीट *एनोप्लोक्नेमिस फेजीएनस* (5 वर्ष पुराना) दोनों कीटों की विशेषता सीक्वेन्स (क्रमशः के एम 459444 और के एम 459441) जीन बैंक में शामिल करने के लिए भेजी गई। पाँच कीटों (8 साल पुराने) के मिनी बारकोड (≤130 बीपी) विकसित किए गए।

प्लूटेल्ला जाइलोस्टेल्ला की आनुवांशिक विविधता का अध्ययन

माइट्रोकॉन्ड्रियल डी एन ए के आधार पर पातागोभी की डायमण्ड बैक मौथ (*प्लूटेल्ला जाइलोस्टेल्ला*) के विभिन्न भारतीय सँख्याओं के बीच आनुवांशिक विभिन्नता को निर्धारित किया गया। कीट सँख्याओं को ~12250000 किमी^{2} के भौगोलिक क्षेत्र में फैले तेरह राज्यों से एकत्र किया गया और सीक्वेन्स तैयार किया गया। तेरह कीट सँख्याओं के 658 बी पी एम टी कोक्स I जीन के सीक्वेन्स विश्लेषण में 9 होलोटाईप, 5 कीट सँख्याओं में होलोटाईप समुह से 13 गुच्छ के रूप में परिणाम प्राप्त हुए। इन कीट सँख्याओं में से 11 पोलीमार्फिक स्थितित पाए गए जिनमें से 5 ट्रान्सिशनल और 6 ट्रान्सवर्सिनल प्रतिस्थापन पाए गए।

कृषि महत्वपूर्ण परजीवी और परभक्षी कीटों की आण्विक लक्षण और डी एन ए बारकोडिंग

साइटोक्रोम आक्सीडेज 1 जीन (को 1) का उपयोग करने पर एनसीर्टिड, *एनासिअस एडवीना* (के जे 850498), *ब्लेपायरस इन्सुलेरिस* (के जे 850500), *नीआस्टिमेकस एक्जिलेरिस* नामक परजीवी कीट; एफेलीनिड, *मायोक्निमा कम्पेरी* (के जे 955498); यूलोफिड, *डिगलीफस आईसेईआ* (के एम 016074); ब्रेकोनिड, *एफीडिअस एर्वी* (के एम 054518), *एफीडिअस कोलेमणि* (के एम 054519), *कोटेशिआ* स्पे. (के एम 875666), *ग्लायप्टेपेन्टेलस* स्पे. (बीदर) (के एम 887912), *ग्लायप्टेपेन्टेलस* (बालपराई) (के एम 887913), *एपेन्टेलस फाईकोडिस* (के पी 055616), *ब्रेकोन ग्रीनी* (के पी 055617), *माइक्रोपिलीटीस मेक्यूलीपेनिस* (के पी 759288); बेस्पिड, *रेपालिडिआ* स्पे. (के एम 0545517); सीलोनिड, *मेक्रोटेलिआ* स्पे. (के एम 095503), *इदरीस* स्पे. (के पी 271246); इक्निय़मोनिड *प्रिस्टोमेरस सुल्की* (के एम 875667); केल्सिडिड, *ब्रेकीमेरीआ टेकेरीडे* (के पी 055618) का आण्विक लक्षण तैयार किया गया। को-1 और आई टी एस रीजनस का प्रयोग करने पर 21 प्रजातियों के अन्तर्गत आने वाले ट्राईकोग्रामेटिड्स का आण्विक लक्षण तैयार किया गया।

भूमिगत कीटों के आण्विक लक्षण और डी एन ए बारकोडिंग तैयार करना

स्क्रेबीड बीटल और दीमक का संग्रहण और उनकी पहचान

देश के विभिन्न भौगोलिक स्थानों से स्क्रेबीड बीटलों और दीमकों को एकत्र किया गया। भारत वर्ष के विभिन्न भौगोलिक स्थानों से एकत्र किए गए प्रतिदर्शों को 70% अल्कोहल में संरक्षित किया गया। प्रौढ़ बीटल की पहचान उनके एंटीने, मेन्डिबल्स, मेक्सिले की उपस्थिति और

अनुपस्थिति और स्ट्रीडयूलेटरी अंगों और टार्सल पंजों के आधार पर जबकि ब्रव की पहचान गुदा कटाव, रेखापुंज पद्धति, स्पाइरेकल्स और पैरों के आधार पर प्रारूपीय पहचान की गई। दीमक कीट सिपाही की आकृति और आकार जैसे कि श्रृंगिकाओं की लम्बाई, मेन्डिबीलस का आकार, मेन्डिबल दाँत की आपेक्षिक स्थिति, सिर, लेब्रम, फोन्टेनेले का आकार और आकृति तथा पोस्टमेन्टम और प्रोनोटम के आधार पर दीमकों की पहचान की गई।

स्क्रेबीड बीटलों में, *प्रोटेशिआ* स्पे., *एनोमोला* स्पे., *हेटेरोरहाईना* स्पे., *ऐपोगोनिआ* स्पे., *स्किजोनिका* स्पे., *एलॉसोनोटम* स्पे. और *एनोमोला सिन्गुलेरिस* प्रमुख रूप से पहचान की गई। दीमकों में, *ओडॅन्टोटर्मस लोन्गिग्नेथस, माइक्रोटर्मस ओबेसी, यूहेमीटर्मस हेमेटस, नेसुटीटर्मस आक्टोपिलीस, ने. एक्जिटीओसस, मेक्रोग्नेथोटर्मस ईरिटर, ओडोन्टर्मस मधुराई, नीओटर्मस कोसुमेन्सिस, ओडोन्टोटर्मस गुल्दासपुरेन्सिस, माइक्रोटर्मस माइकोफेगस, ओडोन्टोटर्मस मधुराई* और *ओडोन्टोटर्मस ओबेलस* के रूप में पहचान की गई।

भारत वर्ष में गर्म और आर्द्र क्षेत्रों में क्राय जीन विविधता की मैपिंग

बेसीलस थ्यूरिन्जिएन्सिस के कुल 80 पृथक्करणों को अल्मोड़ा क्षेत्र की मृदा और मृत कीटों के नमूनों से शुद्ध किया गया। डीजनेरेट प्राइमर के प्रयोग से क्राय जीन विविधता के लिए 40 प्रथक्करणों का अनुवीक्ष्ण किया गया। सभी में क्राय 1 और क्राय 2 जीन पाए गए।

वी आई पी 3 ए जीन, पी सी आर के उपयोग करते हुए परिलक्षित किए गए और 2.3 के बी उत्पाद अनुक्रम (सीक्वेन्स) और उनकी पुष्टि की गई। एन डी ई 1 और एक्स एच ओ 1 प्रतिबंध साइट पर एक क्लोनिंग वेक्टर (पी यू सी 29) में पी सी आर एम्पलिकन (~2.3 के बी) के द्वारा साफलतापूर्वक किया गया। पी सी आर एम्पलिफिकेशन के द्वारा पी ई टी 21 ए में वी आई पी 3ए जीन उप-क्लोनिंग के अनुक्रम की पुष्टि की गई। *प्लूटेल्ला जाइलोस्टेल्ला* के प्रति एल $सी_{50}$ मात्रा 1.9 माइक्रोग्राम/मिली. 4 घन्टे पर दर्शाने वाले को आई पी टी जी इन्डकशन को 4 और 16 घन्टों वाले पी ई टी 21 ए वी आई पी 3 ए को शुद्ध करके शुद्ध वी आई पी 3 ए प्रोटीन प्राप्त किया गया। 16 घन्टे प्रदर्शित करने वाले एल $सी_{50}$ मात्रा के प्रोटीन 0.423 माइक्रोग्राम/मिली को निवेशित किया गया। *स्पोडोप्टेरा लिटच्यूरा* के प्रति जैव विश्लेषण में प्रदर्शित हुआ कि 4 घन्टे में आई पी टी जी के साथ 72 घन्टे मे यह एल $सी_{50}$ मात्रा 6.87 माइक्रोग्राम/मिली की गणना पाई गई। 16 घन्टे के निवेशन पर प्राप्त प्रोटीन की एल $सी_{50}$ मात्रा 72 घन्टे पर 4.87 माइक्रोग्राम/मिली और 97 घन्टे पर 2.68 माइक्रोग्राम/मिली. पाई गई।

मृदा कीटों और अन्य आर्थ्रोपोड्स के साथ जुडे सूक्ष्म जीवों का अध्ययन

सेलुलोज, लिग्निन या पेक्टिन को सडाने वाले 30 संवर्धन योग्य सूक्ष्म जीवों में *बेसीलस एमायलोलिक्यूफेसीस, बे. सबटिलीस, बे. सेरीअस, बे. प्यूमिलस, फ्लेवोबेक्टेरिअम* स्पे. और *स्यूडोक्सेन्थोमोनाज* स्पे. को *प्रोटेसिआ आरोकेलसाअिा* से पहचान की गई। सेलुलोज, लिग्निन या पेक्टिन को सडाने वाले 30 संवर्धन योगय सूक्ष्म जीवों में *ब्रेवीबेक्टेरिअम एपिडर्मिडिस, बे. सेरीअस, बेसीलस* स्पे. *बे. फ्लेक्सस* और *प्रोटीअस माइरेबिलीस* को *हरमेसिआ इलुसेन्स* के लारवों में पाया गया। नारियल की बीटल *ओरीक्टस रहाईनोसेरस* की गट में सेलुलोज, लिग्निन या पेक्टिन को सडाने वाले 38 संवर्धन योग्य सूक्ष्म जीवो *बेसीलस सेरीअस,*

CHAPTER 2

बेसीलस स्पे., *बे. एमायलोलिक्विफेसीएन्स, बे. प्युमिलस, बे. मेगाटेरिअम, बे. सबटिलिस, बे. एल्टिटयूडिनिस, बे. मेरिसफ्लेवी, बे. बाम्बीसेप्टिकस, बे. टेक्यूईलेन्सिस, माइक्रोबेक्टेरिअम टेस्टेसिअम* और *लायसिनीबेसीलस स्फेरिकस* को सकारात्मक पाया गया।

कीटनाशक प्रतिरोध में माहु से जुडे सूक्ष्म जीवों की भूमिका पर अध्ययन

बेंगलोर, कोलार और धारवाड से एकत्रित माहु की दो प्रजातियों से कुल 29 पृथक्करण प्राप्त किए गए। फायलोजिनेटिक एफिलिएशन और आण्विक पहचान के अन्तर्गत पाया कि मौजुदा अध्ययन में अनेक नए जीवाणु पहली बार पाए गए जैसे कि *बेसीलस आर्यभट्टाई, बे. फर्मस, बे. सेरीअस* और *स्टेनोट्रोफोमोनाज* माल्टोफिलिआ उनमें शामिल हैं। माहु की सभी प्रजातियों में *बेसीलस* सदैव ही प्रमुख जीन पाया गया।

अरहर के माहु *एफिस क्रेक्सीवोरा* में ईमिडेक्लोप्रिड 17.8% रासायनिक प्रयोग का जैव विश्लेषण दर्शाता है कि धारवाड की कीटसंख्या ईमिडेक्लोप्रिड के प्रति बेंगलोर की कीट संख्या की अपेक्षा 9.7 गुणा अधिक प्रतिरोधी पाई गई। *ब्रेवीकोरीने ब्रेसीके* पर ईमिडेक्लोप्रिड 17.8% रासायनिक कीटनाशक के जैवविश्लेषण में धारवाड की कीट सँख्या ईमिडेक्लोप्रिड के प्रति पाँच गुणा अधिक प्रतिरोधी पाई गई।

आनुवंशिक संसाधनों का डाटाबेस

प्रमख कीटों के आवश्यक कीटनाशक प्रातीरोधी जीन जैसे कि साईटोक्रोम पी 450, एसीटील्कोलीनीस्टिरेज और दस्तक का आण्विक आँकडे तैयार किए गए। इसलिए, कीटनाशक प्रतिरोधी जीन डाटाबेस (आई आर जी डी) विकसित किया गया और इस डाटाबेस को http://www/cib.res.in/irgd पर देखा जा सकता है। वर्तमान में, आई आर जी डी पर *हेलीकोवर्पा आर्मिजेरा, बेमीसीआ टेबेसी, एक्रीथोसीफोन पाइसम* और *एफिस गोसीपी* कीटों की 365 अनुक्रमों के साथ उनके प्रमुख भाग जैसे खोजना, दृष्टि विकल्प आदि उपलब्ध है और इस डाटाबेस को नियमित रूप से अपडेट किया जाएगा।

कीट पारिस्थितिकी विभाग

भारतीय एन्थोकोरिडे की विविधता

ओरीयस माइनुटस को पार्सीघाट से एकत्र किया गया। *फायजोप्लेवुरेला पेसोनाई* और *राजव्यूरीकोरिस स्टाईसी* को पलानी पहाडियों पर भारत वर्ष में नए रूप में आभिलेखित किया गया। *जाइलोकोरिस (प्रोक्सीलोकोरिस) आफर* जिसे कि *फायकस* और *लेजरस्ट्रोमिआ* के सूखे फलों से *जाइलोकोरिस (प्रोक्सीलोकोरिस) कन्फयूसेस* और *जाइलोकोरिस (एरोस्टेलस) एम्पोलाई* को मक्का पारिस्थितिकी तन्त्र से एकत्र करके *जाइलोकोरिस स्पे.* की अन्य तीन प्रजोतियों का अभिलेखन किया। भारतवर्ष में सभी तीनों एक नये रूप में अभिलेखित की गई।

कार्डिआस्टेथस एक्जिगुअस एवं *का. एफिनिस विभिन्नता* के लिए अंडों के लक्षण का प्रयोग

नारियल के काले सिर वाली सूँडी के परभक्षी कीटों, *का. एक्जिगुअस* एवं *का. एफिनिस* में अन्तर जानने के लिए उनके अण्डों के लक्षणों के आधार पर किया गया। *का. एक्जिगअस* के अण्डे *का. एफिनिस* के अण्डों से लम्बे होते हैं। *का. एक्जिगअस* के अण्डे धब्बेदारनुमा और उनका मध्य भाग ओपरकुलम षटकोर्णाय कोशिका वाले होते हैं।

भूरे पादप फुदकों के प्रति *एम्फिरीअस कान्सट्रिकटस* का मूल्यांकन

पिंजडे में भूरे पादप फुदकों से ग्रसित धान में, *ए. कान्सट्रिक्टस* का मूल्यांकन किया गया। उपचारित पिंजडों

में प्रौढ़ और निम्फ फुदकों की सँख्या क्रमशः 14.5 और 12.3 जबकि अनोपचारित पिंजडों में यह सँख्या प्रति टिलर क्रमशः 6.2 और 8.4 थी। पाँच बार ए. *कान्सट्रिक्टस* पिंजडों में छोडने के बाद उपचारित पिंजडो में यह संख्या क्रमशः 1.8 और 1.4 जबकि अनोपचारित पिंजडों में क्रमशः 6.3 और 3.3 पाई गई। इस अध्ययन से ज्ञात होता है कि भूरे पादप फुदकों के प्रति ए. *कान्सट्रिक्टस* एक संभाव्य परभक्षी कीट है।

शिमला मिर्च पर *एलीयूरोथ्रिक्सस ट्रेकॉयडस* का प्राकृतिक भक्षण

कोक्सीनेलीड *एक्सिनोस्किमनस पुट्टारुद्रीआहा* को, शिमला मिर्च पर ए. *ट्रेकॉयडस* (सोलेनम सफेद मक्खी) का प्राकृतिक भक्षण करते हुए पाया गया।

नए आक्रामक कीट *टयूटा एब्सोलूटा* पर अध्ययन

कर्नाटक और तमिलनाडु राज्यों मे ट. *एब्सोलूटा* का प्रकोप अत्यधिक पाया गया। इस कीट के प्राकृतिक शत्रु कीटों में, *नेसीडिओकोरिस टेनुईस, ट्राइकोग्रामा अकीए, नीओक्रायसोकारिस फोर्मोसा, हेबरोब्रेकोन* स्पे. और *गोनियोजस* स्पे. मुख्य रूप से अभिलेखित किए गए। ट. *एब्सोलूटा* के अण्डों को *ट्रायकोग्रामा अकीए, ट्रा. प्रेटीओजम* और *ट्रा. बेक्टरे* परजीवित करते हैं।

ट्रायकोग्रामा किलोनिस द्वारा केले के स्किपर *एरीओनोटा थ्रेक्स* के अंडों का परजीवीकरण

ट्रा. किलोनिस द्वारा ए. *थ्रेक्स* के 10.5% अण्डे परजीवित पाए गए किन्तु परजीवित अण्डों से परजीवी कीट के प्रौढ़ नहीं निकल पाये।

लीची स्टिन्क बग *टेसारेटोमा जवेनिका* के परजीवी कीटों का अध्ययन

ऐरी रेशम कीट के अंडे 2 से 6 दिनों के लिए रेफरीजरेटर में रखे जा सकते हैं और *एनास्टेटस एकेरोन्टिए* और ए. *बेंगलोरिएन्सिस* को पालने के प्रयोग करते हैं; परजीवीकरण प्रतिशत क्रमशः 41.4 से 63.3 और 39.3 से 55% तक अभिलेखित किया गया। ए. *बेंगलोरिएन्सिस* का जैविक मापन अध्ययन किया गया; प्रौढ़ काल माध्य 0.3 दिन; वृद्धि काल माध्य 17.3 दिन; परजीवीकरण प्रतिशत माध्य 19.9; कुल जनन क्षमता माध्य 38.9 और मादा जनन सनति क्षमता प्रतिशत माध्य 20.5 पाया गया। ए. *एकेरोन्सि* द्वारा परजीवित ऐरी सिल्क वर्म के अण्डों को 7, 15 और 21 दिनों तक संग्रहित किया और उन अण्डों से प्रौढ़ कीट निकलने की प्रतिशतता क्रमशः 85.7, 72.5 और 63.8 अभिलेखित की गई।

उत्पादन क्षमता बढाने के लिए *कोरसेरा* बॉक्स को अण्डों की न्यूनतम मात्रा का निवेशन

जिन बाक्सों में *कोरसेरा* अण्डों की न्यूनतम (0.125 सी सी बॉक्स) मात्रा में डाले गये थे उनसे 467 जबकि अधिकतम मात्रा (0.5 सी सी बॉक्स) में डाले गये थे उनसे *कोरसेरा सॅफेलोनिका* के प्रौढ़ कीट केवल 279 ही पाये गये।

जीवित कीट जर्मप्लाज्म का रखरखाव और आपूर्ति

जीवित कीट भंडार में, 139 जीवित कीट संवर्धनों का रखरखाव किया गया, 1148 जीवित कीट संवर्धनों को भेजकर कुल 5,50,931 रुपयों का राजस्व उत्पन्न किया गया।

CHAPTER 2

मक्का के तना बेधक कीट, *काईलो पारटेलस* (प्रयोगशाला जैव विश्लेषण) के प्रति *ब्यूवेरिआ बेसीआना* पृथक्ककरणों का अनुवीक्षण

काईलो पारटेलस के दूसरे निरुपीय लारवों के प्रति *ब्यू. बेसीआना* के 87 पृथक्ककरणों के जैव विश्लेषण अध्ययन किया गया। परीक्षण किये गए 87 पृथक्ककरणों में से, पाँच पृथक्कणों (बी बी – 7, 14, 19, 23 और 45) ने महत्वपूर्ण से अत्यधिक घातकता (86.4 – 100%) दिखाई। इन पाँच पृथक्ककरणों में से बी बी 14, 23 और 45 पृथक्ककरणों ने महत्वपूर्ण रूप से अत्यधिक माइकोसिस (84.4 – 97.8%) प्रदर्शित किया। मात्रा और समय मृत्यु दर अध्ययन मे ज्ञात हुआ कि बी बी 45 की न्यूनतम एल सी$_{50}$ (5.02 x 10^{4} कोनिडिआ मिली$^{-1}$) प्रदर्शित किया और एल टी$_{50}$ (136.25 घन्टे) मात्रा बी बी – 45 पृथक्ककरण में पाई गई।

मक्का में एन्डोफाईट के रूप में *ब्यूवेरिआ बेसीआना* की स्थापना

मक्का को दो सुग्राह्य किस्मों नामतः सी ओ एच (एम 10) और बायो 9681 पर बीजोपचार/पत्ती पर छिड़काव के माध्यम से मक्का में एन्डोफाईटस के रूप में स्थापित करने के लिए *ब्यू. बेसीआना* के छः उत्कृष्ट पृथक्ककरणों (बी बी – 5ए, 7, 14, 19, 23 और 45) को जाँच क्षमता परीक्षण किया गया। मक्का को सी ओ एच (एम 10) पर्ण छिड़काव में बी बी 45 पृथक्ककरण की कॉलोनियाँ पर्ण ऊतकों में उपचार के 60 दिनों के बाद तक, जबकि बी बी – 23 पृथक्करण की कालोनियाँ पर्णऊतकों में उपचार के 30 दिनों के बाद तक और बी बी – 14 पृथक्ककरण की कालोनियाँ पर्णऊतकों में उपचार के 15 दिनों के बाद तक देखी गई। मक्का की बायो – 9681 किस्म में, तने और जड ऊतकों में उपचार के 30 दिनो बाद तक और पर्ण ऊतकों में केवल उपचार के 15 दिन बाद तक देखी गई।

क्षेत्रीय परीक्षण में *ब्यू. बेसीआना* के तीन पृथक्ककरणों (बी बी – 14, 23 और 45) के जाँच परीक्षण में 30 दिन की फसल पर पर्ण छिड़काव (1 x 10^{8} बीजाणु/मिली) पर देखा गया कि बी बी – 14 और बी बी 45 की कालोनियाँ तने और पर्ण ऊतकों में उपचार के 15 दिनों तक पाया जाता है। क्राऊन प्रयोग विधि में बी बी – 23 और बी बी 45 पृथक्ककरणों की कालोनियाँ उपचार के 15 दिनों के बाद तक दिखाई पड़ती हैं।

पपीते के मिलीबग और उनके प्राकृतिक शत्रु कीटों का पपीते और उसके विकल्प परपोषी पौधों पर अनुवीक्षण

राज्य के विभिन्न भागों में किए गए सर्वेक्षणों और आ. भा. स अनु परि (जै नि) केन्द्रों के द्वारा प्राप्त जानकारी से ज्ञात हुआ कि इन क्षेत्रों की फसलों में पपीता मिलीबग *पेराकोकस मार्जिनेटस* एक पीडक स्थिति तक नहीं पँहुचा है। बेंगलोर, कनकपुरा, मैसुर, मद्दुर, हासन, तुमकुर, माण्डया, चामराजनगर, रामनगर, कोल्लेगल, कोलार और चिकबल्लापुर शहरों के क्षेत्रों में पपीते और शहतुत की फसल पर ग्रसन का सर्वेक्षण किया गया। सर्वेक्षण किए गए क्षेत्रों में पपीते के मिलीबग नही पाया गया।

एरीथ्रिना गॉल वैस्प का प्रबन्धन

कोलार, माण्डया और रामनगर जिलों में, एरीथ्रिना गॉल वैस्प, *क्वाड्रास्टिकस एरीथ्रिने* की सँख्या न्यूनतम पाई गयी। *क्वा. एरीथ्रिने* के परजीवी कीट के रूप में *एरोस्टोसॉटस गाला* को मुख्यतः पाया गया।

सेसीडोकेरस कोनेक्सा गॉल मक्खी की स्थापना

क्रोमोलीना खरपतवार का जैविक नियंत्रण कारक *से. कोनेक्सा* को विभिन्न स्थानों पर छोडा गया, जो कि छोडे

गए स्थान के 450 मीटर दायरे में 15 गॉल प्रति 5 मिनट के अनुसार क्षेत्र में स्थापित पाए गए।

आक्रामक कीट जैक बेयर्डस्ले मिलीबग (*स्यूडोकोकस जैकबेयर्डस्ले*) के परपोषी पौधे

दक्षिण भारत में आक्रामक कीट सर्वेक्षण में, तमिलनाडु और कर्नाटक राज्यों में *स्यू. जैकबेयर्डस्ले* पाया गया। हाल में किए गये सर्वेक्षण में कोको फसल पर अत्यधिक ग्रसन पाया गया। *स्यू. जैकबेयर्डस्ले* के अण्डों के परजीवी कीट के रूप में *नीफस रेगुलेरिस* को प्रमुख परभक्षी कीट पाया गया।

नए आक्रामक परभक्षी कीट और विस्तारण

टयूटा एब्सोल्यूटा को कर्नाटक, तमिलनाडु और गुजरात में पाया गया। वेस्टर्न फ्लॉवर थ्रिप्स *फ्रैंकलिनिएल्ला ऑक्सीडेन्टेलिस* को जुलोजिकल सर्वे ऑफ इन्डिया द्वारा बेंगलोर में रिपोर्ट किया गया। *हिबिस्कस सब्देरिफा* के बीजों पर केले के स्किपर *एरीओनोटा थ्रैक्स* ब्रुकीड पाया गया, कोको पर *स्यूडोकोकस जैकबेयर्डस्ले* अभिलेखित किए गए, काजू पर *फीनेकोकस सेर्डीरिन्सिस* अभिलेखित किए गए, काली मिर्च में जड के मिलीबग *फोर्मिकोकस पोलीस्पेरेस* अभिलेखित किए गए।

केले के पर्ण स्किपर *एरीओनोटा थ्रेकस* का अनुवीक्षण

कर्नाटक के कुछ उद्यानों में केले के स्किपर अभी बढ़ रहा है और केरल तथा तामिलनाडु के भागों में ग्रसन अत्यधिक पाई गई। केरल राज्य में ग्रसन 20-27% अभिलेखित किया गया।

विदेशी जैव कारकों का पी ई क्यू परीक्षण

दो जैवकारकों *नीओसीउलस केलीफोर्निकस* और *ओरिअस लेवीगेटल* को निष्क्रिय सामग्री के साथ 27 मई 2014 को कापर्ट जैवनियंत्रण प्रणाली से आयात किया गया।

आयातित *एम्बलायसीयस स्वीरस्की* की आई एन आई एस विपणन और सुरक्षा के परीक्षण सेवायें

विदेशी परभक्षी माईट *ए. स्वीरस्की* (के एम 035534) की पहचान की गई और टाईप को सही पाया गया। परीक्षण कीटों पर *ए. स्वीरस्की* द्वारा भक्षण के चिन्ह दिखाई नही दिए।

हिबिस्कस सब्दारिफा बीजों पर नए आक्रामक ब्रुकीड कीट

हिबिस्कस सब्दारिफा (गोंगुरा) के बीजों को बाजार से खरीदने पर पाया कि वे आक्रामक ब्रुकीड *एल्थेईअस प्रजाति* से ग्रसित थे।

कुकुरबिट्स के परागणकर्ता कीट

कद्दू वर्गीय (कुकुरबिट्स कुल) के फूलों पर आने वाले कीटों के निरीक्षाण में विभिन्न फूलों से मधुमक्खी की 17 विभिन्न प्रजातियाँ एकत्र की गईं।

भारत में गैर *एपिस* प्रजातियों के संदर्भ में, विभिन्न कृषि जलवायु क्षेत्रों में परागणकर्ता कीटों की विविधता का प्रलेखन

परागणकर्ता कीट उद्यान के एक नए भाग में 47 प्रजातियों के भिन्न-भिन्न कुलों के पौधे लगाए गए। विभिन्न पोषक पौधों से एपिडे, मेगोचिलीडे, एन्थोफोरिडे, हेलिक्टिडे कुलों से संबंध रखने वाली मधुमक्खियों के 100 से भी अधिक प्रतिदर्श एकत्र किए गए।

CHAPTER 2

CHAPTER 2

अमरास्का बिगुटुल्ला बिगुटुल्ला में कीटनाशक सहिष्णुता

धर्मपुरी में कपास के क्षेत्रों से एकत्र *अमरास्का बिगुटुल्ला बिगुटुल्ला* कीटों में आपेक्षिक सहिष्णुता 48 घन्टों के जैवविश्लेष्ण के आधार (एल सी$_{50}$ 1121.2 पी पी एम) जबकि बैंगलोर के बेटा गाँव से एकत्र कीट संख्या में कम (एल सी$_{50}$ 823.6 पी पी एम) पाई गई। कीटनाशी एसीफेट के सभी सान्द्रणों में कीट की गट में उपस्थित *बेसीलस प्यूमिलस, स्टेनोट्रोफोमोनाज मेटोफिलिआ, एन्टेरोबेक्टर क्लोएसे, फाईलोबेसीडिअम फ्लोरिफोर्मे, बेसीलस सबटीलिस, स्टेफायलोकोकस आरीअस* और *बेसीलस सेरीअस* जीवाणु अच्छे से वृद्धि करते पाए गए। *बे. प्यूमिलस* संवर्धन में, कीटनाशी को विच्छेदित करने वाला एक प्रमुख एन्जाईम, एस्टीरेज पाया गया।

अमरास्का बिगुटुल्ला बिगुटुल्ला में कीट रोगाणु रोधी अन्तःसहजीवी

कीटरोगाण्विक *ब्यूबेरीआ बेसीआना* और *पेसीलोमायसस फ्यूमोसोरोसीअस* के वृद्धि रोधी के रूप में *ए. क्लोएसे, बे. प्यूमिलस* और *फायलोबेसीडिअम फ्लोरिफोर्मे* जीवाणु पाए गए। एक अन्य कीटरोगाण्विक *वर्टिसीलियम लेकेनाई* वृद्धि रोधी के रूप में, *माइक्रोबेक्टेरिअम इम्पेरीले* पाया गया। *पेसीलोमायसस फ्यूमोसोरोसीअस* के प्रति अत्यधिक (3.5 सेमी) वृद्धि रोधी के रूप में *बेसीलस प्यूमिलस* प्रदर्शित करता है। *वर्टिसीलियम लेकेनाई* के प्रति अत्यधिक (3.3 सेमी.) वृद्धि रोधिता *माइक्रोबेक्टेरिअम इम्पेरीले* प्रदर्शित करता है। *ब्यूबेरीआ बेसीआना* के प्रति *एन्टेरोबेक्टर क्लोएसी* प्रदर्शित करता है।

कीट प्रबन्धन में अर्द्वरासायनिकों के रूप में नैनो उत्पाद संश्लेषण

फेरोमोन के लिए एक संवेदक विकसित किया गया। क्षेत्र में फेरोमोन का जल्दी पता लगाने के लिए फेरोमोन आविष्कारक खोजा गया। क्रियाशील उपकरण फिरोमोन की खोज के आधार पर तुरंत और दक्षता पूर्ण रूप से कीटों के ग्रसन को प्रारंभिक दशाओं में ढूँढा जा सकता है। कीटों द्वारा एक घन्टे में प्रति एकड़ फेरोमोन छोड़ने की सांद्रता का अनुमान लगाकर फेरोमोन ढूँढने वाले उपकरण लगभग एक एकड़ क्षेत्रफल में कीट ग्रसन को नियंत्रित कर सकते हैं।

पशुचिकित्सा और मात्सियकी के आर्थिक प्रमुख डिप्टेरन कीट रासायनिक लक्षण वर्णन और आचार विज्ञान

डिप्पटेरा कुल के (*मस्का डोमेस्टिका, क्रायसोम्या मेगासीफेले, सर्कोफेगा डक्स, स्टोमोक्सिस केल्सिट्रेन्स* और *टेबेनस स्पे.*) नामक पशुचिकित्सा और मात्यसिकी प्रमुख कीटों का संग्रहण किया गया। *म. डोमेस्टिका* के प्रौढ़ कीट का क्युटिकल हायड्रोकार्बन (सी एच सी) प्रोफाईल नौ यौगिकों से बना है जिसमें 10% से अधिक आक्टाडेकेनोल और साईक्लोएईकोसेन उपस्थित पाए गए। एल्काडोडीकेन, ट्राईडीकेन और ब्यूटीलफीनोल की बिस्तार दर 5-9% तक पाई गई। घरेलू मक्खी के प्रति आवश्यक तेलों के दक्षता अध्ययन में ईमेजो, अजोवान तेलों को सीट्राईडोरा तेल से अधिक प्रभावी पाया गया। धूमित विषैलेपन जाँच परीक्षण में अजोवान तेल के द्वारा एल डी$_{50}$ 5.98 माइक्रोग्राम/सेमी^{3} जबकि सीट्राईडोरा तेल में 10.12 माइक्रोग्राम/सेमी^{3} आवश्यक पाया गया।

पणुफुदकों और अन्य हेमीप्टेरन्स गणों का प्रलेखन

वर्ष 2014-15 के दौरान कीटों की पहचान, प्रलेखन और अनेक उपयोगी अध्ययनों के माध्यम से रा. कृ. की. सं. ब्यू, यलहंका, बैंगलोर में पौधों की अनेक प्रजातियों से कुल 960 पर्णफुदके पकड़े गए।

हिस्हिमोनस फायसिटिज के वृहतस्तर पर पालने के लिए उत्कृष्ट विधि का विकास

ग्रीन हाऊस में बैंगन (एम ई बी एच - 11 किस्म) के 200 पौधों पर *हि. फायसिटिज* के 2000 प्रौढ़ कीट को किसी भी समय पर रखरखाव एवं उत्पादन करके *हि. फायसिटिज* के बहोत्पादन के लिए उत्कृष्ट विधि का विकास किया । एक 24" x 18" x 18" आकार के पिंजडे में बैंगन के चार पौधों को प्रति माह अन्य दुसरे पौधों के साथ बदलते रहने पर 100 से अधिक प्रौढ़ कीटों को निरंतर रखरखाव किया गया।

तिल की फसल पर कीट रोगवाहकों और फायलोडी के प्राकृतिक ग्रसन के क्षेत्रीय परीक्षण

प्रथम परीक्षण में 13 अगस्त, 2014 को फायलोडी का केवल 6.9% ग्रसन पाया गया, किन्तु 40 दिनों के अन्दर ही यह ग्रसन बढ़कर 16% तक पहुंच गया। फसल काल में, *ओ. एल्बिसिन्कटस* द्वारा फसल में कम (अगस्त और सितम्बर माह के दैरान क्रमश. 4.6 और 7.0 प्रौढ़ कीट/ग्रसित पौधा) जबकि *हि. फायसिटिज* कीटसँख्या अत्यधिक (अगस्त और सितम्बर माह के दौरान क्रमशः 11.9 और 16.9 प्रौढ़/ग्रसित पौधा) पाई गई। दुसरे जाँच परीक्षण में, फायलोडी द्वारा 6.6% ग्रसन पाया गया। *हि. फायसिटिज* को प्रमुख वाहक पाया गया।

ट्रान्समिशन अध्ययन के माध्यम से विषाणुवीय पर्णफुदकों के ग्रसन की निगरानी

जून 2014 में बोई गई तिल की फसल में विषाणुवीय कीट *हि. फायसिटिज* और *ओरोसीअस एल्बिसिन्कटस* की कीट सँख्या को सर्वप्रथम आकर्षित होते पाया गया। सीधे क्षेत्र से एकत्र *हि. फायसिटिज* को ग्रीन हाऊस में बैंगन की फसल पर निवेशित करने पर 65% पौधों पर उनके लक्षण पाए जो कि परिणाम उनके समान पाए गए, जिस असली क्षेत्र या फसल से इनको एकत्र किया गया था। वहीं दुसरी तरफ, *ओ. एल्बिसिन्कटस* तिल की 50% फसल में रोगाणु वाहित कर पाया। पिंजडों में सदाबहार पौधों की दशाओं में पर्णफुदकों के 10 अन्य वंशों को विषाणुवीय पाया गया।

रोगसूचक पादप प्रजातियों में वेक्टर-वाहक फायटोप्लाज्मा की आण्विक पुष्टि

पी सी आर प्राइमर तदोपरान्त नेस्टेड पी सी आर के माध्यम से ज्ञात हुआ कि सदाबहार पौधों से तिल, बैंगन और सनई के पौधों पर *हि. फायसिटिज* कीट वही एक प्रकार के जीव वाहित करने के लिए वही एक प्रकार का प्रोटोप्लाजमा समूह रोगसूचक पादप प्रजातियों तक पँहुचाता है। इस रोगाणु को सदाबहार फायलोडी आर आर एन ए जीन के बहुत नजदीकी पाया गया।

माईट भंडारण की स्थापना

रा. कृ. की. सं. ब्यू में एक विशेष माईट भण्डारण की स्थापना की गई। 17 जुलाई 2014 से यह इकाई प्रारम्भ हुई। इस काल के दौरान 10 राज्यों से 18 शहरों के 39 माईट एकत्र की गई। प्रसंस्करण के लिए संभावित माईट ग्रसन के कुल 172 पादप प्रजातियों को एकत्र किया गया। पौधों के अलावा अन्य चौंतीस पोषक भी माईटों को अलग करने के लिए एकत्र किया गया।

माईट एकत्र करने के दौरान उपकुल प्रोस्टिग्माटा के अन्तर्गत आने वाली पादपभक्षी माईट प्रमुखतः पाए गए। प्रजातियों, आर्थिक रूप से महत्वपूर्ण पादप को संभाव्य क्षति पहुँचाने से पहले ही जानकारी प्राप्त करके इनको एकत्र किया गया। केवल जनवरी-मार्च 2015 के समय में ही फायटोफेगस माईट के 100 से अधिक प्रतिदर्शों को हायर्स माध्यम में रंजित कर संरक्षित किया गया।

INTRODUCTION

The National Bureau of Agriculturally Important Insects, established in the year 2009, was rechristened the National Bureau of Agricultural Insect Resources on 9th October, 2014. This change was effected to focus awareness on insects as a natural resource in our agricultural landscapes. Thus far insects had been paid scant attention in agriculture except as pestiferous species that had to be eliminated.

Insects not only constitute the bulk of living organisms in our world but also render a host of ecosystem services like pollination, natural pest control, recycling of organic matter and so on unbeknownst to most of us. Not confined to any one ecosystem they move between them forming the glue –in Daniel Janzen's apt terminology – that holds all ecosystems together. Consequently while the mandate of the NBAIR mainly focuses on the study of insects in agricultural ecosystems, insects everywhere within the confines our national boundary are subjects for study. It is only with the knowledge of the insect fauna in agricultural and adjacent ecosystems that we can formulate management strategies to ensure the productivity and sustainability of our agricultural systems.

This shifting perspective on insects in agriculture has been mirrored in the evolution of this Bureau. When the possibility of using insects instead of harmful chemicals for the management of insect pests in agriculture was realised the Indian Council of Agricultural Research (ICAR) initiated the All India Coordinated Research Project (AICRP) on Biological Control of Crop Pests and Weeds in 1977. Though initially funded by the Department of Science and Technology, Government of India the ICAR began extending full financial support to the programme from 1979. To further strengthen research on biological control the centre was upgraded to the Project Directorate of Biological Control on 19th October, 1993. With the growing realization that effective biological control was predicated on sound taxonomic and ecological knowledge the National Bureau of Agriculturally Important Insects was created on 29th June, 2009. The NBAIR was subsequently established to document the vast insect resources to enable studies on their multifarious roles in the agroecosystems of our country.

MANDATE

ICAR - NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
To act as a nodal agency for collection, characterization, documentation, conservation, exchange and utilization of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture.
AICRP ON BIOLOGICAL CONTROL OF CROP PESTS
Promotion of biological control as a component of integrated pest and disease management in agricultural and horticultural crops for sustainable crop production. Demonstration of usefulness of biocontrol in IPM in farmers' fields.

Notable achievements of the past

Basic and Strategic Research for Biological Control

- An expanding image gallery of agriculturally important insects is hosted on NBAIR's website with hundreds of species of insects and over 3000 photographs.The USDA and Colorado State University feature this on their site 'ID Source' along with another website 'Featured Insects'.
- Fact sheets, diagnostics and illustrations on Indian Mymaridae and Pteromalidae have been developed and hosted on the NBAIR website.
- Insects in agroecosystems ' is hosted on

the NBAIR website (URL:http://www.nbair.res.in / insectpests / index.php). It includes pests of crops and other common insects from Indian agroecosystems. About a thousand species with 3500 colur photographs are for viewing and study on the site).

- Websites on Indian Coccinellidae and Aphids of Karnataka have been constructed and hosted on the NBAIR website.

- A website featuring biocontrol introductions to India (http://www.nbair.res.in/ Inroductions / Insects/index.htm) has also been hosted on the NBAIR website.

- 106 types belonging to Thysanoptera, Hymenoptera, Coleoptera and Diptera including 50 primary types in the NBAIR collections have been documented and 15 of these were digitized.

- Nine new species of Platygastroidea were described and the phoretic *Sceliocerdo viatrix* was redescribed. For the first time a parasitic wasp (*Ooencrtus parasiticus*) was reported attacking the genus *Bibasis* (Lepidoptera: Hesperiidae). Twelve species of aphids and coccids were recorded for the first time from India. SEM studies of two species of *Trichogramma* were completed. Four new species of Mymaridae were described.

- *Anagyrus amnestos*, a potential parasitoid of the invasive Madeira mealybug was described.

- Bar codes of 25 species of insect natural enemies including parasitoids, anthocorid predators, coccinelld predators, pollinators and a weed killer were developed. In addition bar codes were also developed for a total of 149 species belonging to 9 orders of insects.

- *Paracoccus marginatus* was successfully managed by the exotic parasitoid *Acerophagus papayae*. *Leptocybe invasa* was managed by the parasitoid *Quadrastichus mendeli*.

- Anthocorid predators collected on different host plants were studied for their feeding potential and amenability for culturing indoors in the search for effective agents for use in biocontrol programmes.

- *Cecidochares connexa* released for the management of *Chromolaena odorata* continues to be present in its areas of release.

- A pollinator garden has been developed that has been attracting a large number of bees (belonging to the families Apidae, Megachilidae, Anthophoridae and Halictidae), a host of dipterans and lepidopterans.

- *Liriomyza trifolii* was found to occur at significantly higher levels when carbon dioxide and temperatures were higher.

- A cost effective mass production protocol was developed for *Pseudococcus jackbeardsleyi*.

- Chitosan- alginate nanoparticles were

found to be safe to *Chrysoperla zastrowi sillemi*.

- A collection of insects of importance in veterinary and fisheries sciences has been initiated.

Applied Research (Biological Control)

- The papaya mealybug, eucalyptus gall wasp and the sugarcane woolly aphid were successfully managed by release and management of natural enemies.

- A cost-effective WP/EC based *Trichoderma* (Th-14) formulation and an efficient delivery system were developed. Rice brown spot disease severity was found to be significantly reduced by *Trichoderma* isolates TCMS 5 and TCMS 14a.

- *Metarhizium anisopliae* @$2x10^8$ spores / ml was found to cause mycosis in rice bugs. In sugarcane eight releases of *Trichogramma chilonis* (TTS) @50,000 / ha reduced the incidence of early shoot borer and twelve releases of *T. chilonis* @50,000 / ha reduced incidence of stalk borer.

- In soyabean SlNPV sprays @250 LE / ha ($1.5 . 10^{12}$ POBs) thrice was effective in suppressing *Spodoptera litura*. Biosuppression of the safflower aphid *Uroleucon composite* can be achieved with two sprays of *Verticillium lecanii* 1.0 % WP in non-spiny safflower.

- In brinjal, shoot and fruit borer incidence can be significantly reduced with two sprays of NSKE and six releases of *T. chilonis; Brumus suturoides* @ 1500/ha, *Scymnus* @1500/ha and *Cryptolaemus* @1500/ha significantly reduced mealybug populations.

- The BIPM module developed against *Aleurodicus dispersus* on cassava was superior to farmers' practice in managing this pest.

- *Neoseiulus longispinosus* @ 1:10 predator:prey ratio in carnation in polyhouses resulted in 91.2 % reduction of phytophagous mites and was on par with fenazaquin (0.0025%) which caused 92.1 % reduction in the mite population.

- *Blaptostethus pallescens* @30 nymphs/ m row along with chemical control (Omite 300 ml / acre) was effective in managing *T.urticae* on okra in polyhouses.

- *Xylocoris flavipes* nymphs (30 nymphs / kg of rice) performed better than those of *Blaptostethus pallescens* in minimizing *Corcyra* moth populations in rice in storage.

Organizational set-up

Research at NBAIR is undertaken in the three Divisions of Insect Systematics, Molecular Entomology and Insect Ecology. Research on microbial biocontrol is addressed under the coordination cell of the AICRP on Biocontrol (Fig.1).