Annual Report
2018-19
वार्षिक प्रतिवेदन
२०१८-१९

ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
Bengaluru, India

राष्ट्रीय कृषि कीट संसाधन ब्यूरो
बेंगलूरु, भारत

Honourable Union Minister of Agriculture & Farmers' Welfare, Mr Radha Mohan Singh, chairing a meeting at ICAR–NBAIR on 30 June 2018

Dr T. Mohapatra, Secretary, DARE & Director-General, ICAR, and other dignitaries during the inauguration of the *First International Conference on Biological Control: Approaches and Applications* in Bengaluru on 27 September 2018

Dr T. Mohapatra, Secretary, DARE & Director-General, ICAR, addressing the gathering during the inauguration of the *First International Conference on Biological Control: Approaches and Applications* in Bengaluru on 27 September 2018

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The newly opened National Insect Museum at ICAR–NBAIR
(Courtesy: Sandesh M. Gawas & Sunil Joshi)

PREFACE

ICAR–NBAIR Annual Report 2018-19, besides documenting numerical and factual information, aims to provide a real portrait of NBAIR, focusing on its contributions in the last one year towards diversity-documentation of agriculturally important insects and protocols developed for non-chemical modes of pest management. It has emerged that the period from April 2018 to March 2019 was a very eventful phase for NBAIR, which was also marked as the Silver Jubilee Year for the organisation. While the curtain raiser was an 'Awareness Programme on Insect Diversity', which was inaugurated by the former Directors of NBAIR, Dr R.J. Rabindra, Dr N.K. Krishna Kumar and Dr Abraham Verghese, along with quiz and elocution competitions on 'Insect Diversity' for school students, the curtain closer was the grand inauguration of the ICAR–NBAIR National Insect Museum on 10 March 2019 by Dr Trilochan Mohapatra, Secretary, DARE and Director General, ICAR.

During 2018-19, the three Divisions of NBAIR — Germplasm Collection and Characterisation (GCC), Genomic Resources (GR) and Germplasm Conservation and Utilisation (GCU) — focussed on the committed mandates of the Bureau. During 2018-19, a total of 19,189 specimens and 13 types were added to the NBAIR Museum, thus bringing the total number to 1,89,959 specimens and 326 types, respectively. The 11 databases developed on insect genetic resources meant for farmers, public, researchers and students are being widely accessed nationally and internationally, and a database on NBA Voucher Specimens was hosted on NBAIR website. The identification services provided by the NBAIR taxonomists is worth more than ₹ 1 crore per year (calculated based on the charges levied for identification services by the Natural History Museum, London). During the period under report, 204 identification services were provided through which 601 species were identified. The GR Division characterised 172 insects and 70 barcodes were generated during the year. The GCU Division focused on reaching out to the farmers with novel, farmer-friendly non-chemical pest management technologies. Holding the largest 'Live Insect and Insect Derived Resources Repository' with 129 live insect germplasms and 721 microbial isolates, NBAIR supplied 1,157 lakh live insects in 1,449 shipments and made 44 shipments of microbials, thus relentlessly serving researchers and the farming community. Awareness on non-chemical modes of pest management was created either by directly interacting with the farmers in the 35 adopted villages or by licensing the NBAIR technologies to commercial entrepreneurs.

Last year, 13 NBAIR technologies were licensed to 10 licensees including commercial entrepreneurs and government organisations. Training programmes were organised for 220 trainees, besides exposure visits for students from various colleges and universities. We are all set to register two of the potential microbial isolates of NBAIR, Ma4 and BtG4, so that farmers can have access to these for targeting notorious pests like root grubs and pests of pulse crops.

Scientific excellence was recognised at the national level through 30 awards bestowed on the NBAIR researchers. Our scientists published 127 research publications, including research papers in peer-reviewed journals, technical bulletins and book chapters. Networking was done at national and international levels to strengthen our research programmes. National and international conferences were held focusing on themes related to biological control for pest and disease management, conservation strategies for management of invasives and chemo-ecological methods for pest management. The most notable one was the 'International Conference on Biological Control (ICBC 2018)' held during 27–29 September 2018. Whatever we achieved was through the joint efforts of 32 scientists, 14 technical staff, 9 administrative staff, 2 supporting staff and around 89 temporary staff.

India has adopted Aichi Target 9 as its National Biodiversity Target 4, i.e. to identify invasive alien species and their pathways of introduction, and to develop strategies to manage prioritised invasive alien species by 2020. It is important to now discuss the challenges posed by invasive species to conservation and well-being in India, take stock of the status of invasive species management, policy and practice and provide suggestions citing global best practices. During 2018-19, NBAIR focussed on two notorious invasive insect pests – the rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus*, and the fall armyworm (FAW), *Spodoptera frugiperda*. NBAIR scientists were successful in not only identifying the RSW, but also in identifying its natural enemies and suggesting the management of RSW through conservation strategies for the indigenous parasitoid *Encarsia guadeloupae* and the application of a biopesticide *Isaria fumosorosea*.

In India, occurrence of FAW was first reported by NBAIR as a PEST ALERT on its website on July 2018. The pest identification was done based on molecular characterisation. A search for indigenous natural enemies followed, which resulted in a report of an indigenous natural enemy complex comprising of egg parasitoids, viz. *Telenomus* sp. and *Trichogramma* sp.; egg larval parasitoid, *Chelonus* sp.; gregarious larval parasitoid *Glyptapanteles creatonoti*; solitary larval parasitoid, *Campoletis chlorideae*; a solitary indeterminate ichneumonid larval–pupal parasitoid and a larval–pupal pteromalid parasitoid, *Trichomalopsis* sp. Several predators were found associated with the pest, viz. earwig, *Forficula* sp., predatory bugs *Andrallus spinidens* and *Eocanthecona furcellata.* Epizootics of the entomopathogenic fungus *Metarhizium* (*Nomuraea*) *rileyi* was also recorded in Chikkaballapura, Shivamogga and Bengaluru causing considerable mortality of the pest in the larval stage. Through very intensive search in several infested fields, virus-infected FAW larvae were also collected.

As FAW started spreading across different states, NBAIR with its expertise in the field of biological control and armed with its large repository of bioagents, swung into action on evaluating all the promising bioagents including egg parasitoids, entomofungal pathogens, *Bt,* NPV and entomopathogenic nematodes. The initial laboratory testing and small plot trials led to the identification of the bioagents, viz. egg parasitoids *Trichogramma pretiosum* and/or *Telenomus remus*, microbials *Metarhizium anisopliae* (NBAIR Ma-35), *Beauveria bassiana* (Bb-45), *Bacillus thuringiensis* (NBAIR Bt-25) and EPN (NBAII Hi-38 and NBAII Hi-101), which together could form integral part of a bio–intensive IPM module. These bioagents developed by NBAIR are now being widely tested and validated in different states under FAW attack through farmer field trials and also through the AICRP Biocontrol Centres and KVKs. The initial results are found to be highly promising, thus encouraging us to move ahead with the formalities of CIBRC registration for the promising NBAIR microbials.

It is important to emphasise that NBAIR holds the unique technology for wettable powder formulation of EPN and transferred the same to several commercial companies. This will ensure to some extent the availability of EPN formulations for farmers. Moreover, the fact that EPN are exempt from CIBRC registration should encourage more commercial entrepreneurs to take up EPN production and supply to needy farmers. Through a public–private partnership mode, NBAIR also developed a controlled-release dispenser for delivery of FAW pheromone. Field trials using the NBAIR controlled–release dispenser at different field locations indicated a significantly higher trap catch and persistence, in comparison to the widely used rubber septa leading to commercialisation of the technology. Thus, the overall aim is to manage FAW by any/all means. Taxonomic support for the identification of FAW was offered to neighbouring countries by NBAIR molecular taxonomists. Besides, the report presented by the NBAIR team on biocontrol options for FAW during the 'Regional Workshop on New Invasive Species Threats in South and South–East Asia' proved to be a road map for several other Asian countries, which are already under FAW attack and also those which are under potential threat.

In conclusion, I can say that it was a great year. We are satisfied with the growth of our organisation and we are looking forward enthusiastically to the year ahead for more events, more contributions and more opportunities to serve the farming community.

Bengaluru
31 May 2019

Chandish R. Ballal
Director

1. EXECUTIVE SUMMARY

The ICAR–National Bureau of Agricultural Insect Resources is the only institution under ICAR to be recognised as a 'Designated Repository' for agriculturally important insects, mites and spiders. This 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 various agroecosystems of our country. Research work in the bureau is undertaken in three divisions: Germplasm Collection and Characterisation; Genomic Resources and Germplasm Conservation and Utilisation. The work related to biological control is formulated and coordinated under the All-India Coordinated Research Project on Biological Control of Crop Pests. The results of the research for 2018-19 are summarised hereunder:

ICAR–National Bureau of Agricultural Insect Resources

Germplasm Collection and Characterisation

Extensive surveys across the country for insect collection yielded 50 species of Pentatomidae, representing 32 genera; 34 species of fruit flies belonging to 21 genera representing four subfamilies of Tephritidae; 20 species of weevils; 72 and 65 species of root grubs representing 19 and 17 genera of Scarabaeidae from the northeastern and southern India, respectively. Mite samples originated from 62 places in 16 districts across nine states. A total of 7,250 mites were sampled and processed. Over 1,325 permanent slides were prepared and preserved.

Several new species were described from Coleoptera, Diptera, Hymenoptera and Hemiptera. Nine new scarab species belonging to the tribe Sericini of Scarabaeidae of Coleoptera were discovered and described. One new weevil was described under the genus *Cratopus* from Jammu and Kashmir. Four new species of fruit flies were described, viz. *Bactrocera* (*Bactrocera*) *prabhui*, *Bactrocera* (*Parazeugodacus*) *conica*, *Coelotrypes merremiae* and *Coelotrypes paralatilimbatus*. Five new species of Hymenoptera, viz. *Rhogadopsis gratia*, *Rhogadopsis macrusa*, *Klabonosa indica*, *Neastymachus notialis* and *Ooencyrtus xenasteiae*, were described. Revision of the genus *Acrozangis* from India was made with description of a new species, *Acrozangis dakshinae*, from southern India.

Several new records of scales, aphids, thrips, wasps, mites, spiders and nematodes for the country and various states were documented. Two soft scale insects, viz. *Platylecanium nepalense* and *Ceroplastes cirripediformis*, and one species of aphid, *Patchiella reaumuri* were recorded for the first time from India. *Maacoccus bicruciatus* and *Discochiton paucipedis* were recorded for the first time from Karnataka. Twenty-six species, 18 genera and two subfamilies, Stenogastrinae and Vespinae, of family Vespidae were documented as new state distribution records. Two terebrantian thrips species, *Asprothrips bimaculatus* and *Pseudodendrothrips darci*, were recorded for the first time from India. The genera *Neocentrobiella*, *Megaphragma, Paracentrobia*, *Tumidiclava* and *Aphelinoidea* of Hymenoptera were collected from Assam for the first time. *Megaphragma* was also recorded for the first time from Gujarat. *Amblyseius tamatavensis*, a phytoseiid mite of commercial value, was discovered in several regions. The crab spider, *Thomisus spectabilis*, was reported as new distribution record for Gujarat. Entomopathogenic nematode *Oscheius rugaoensis* was reported for the first time from India.

Systematic studies of tribe Dacini in India was done using morphological characters and elucidated the synapomorphies of *Bactrocera*, *Dacus* and *Zeugodacus*. Revision of the genus *Acrozangis* belonging to Pentatomidae and redescriptions of the pentatomid bugs *Eocanthecona concinna* and *Eocanthecona furcellata* were carried out. Larval and adult taxonomic studies of phytophagous Scarabaeidae were carried out. Checklist was prepared for the genera *Dermatodes*, *Achaenomus* and *Hyperomias* of Curculionidae. Identification keys were prepared to distinguish nine genera of predatory thrips belonging to three families collected from northeastern India. *Dahlia rosea* was reported as a new host for the invasive thrips species *Thrips parvispinus* from Puttur, Karnataka. The salticid spider, *Madhyattus jabalpurensis*, collected from the sugarcane ecosystem in Punjab was redescribed.

The natural enemy complex of the invasive pest *Spodoptera frugiperda*, the fall armyworm, was reported for the first time from India with the parasitoids identified as *Glyptapanteles creatonoti*, *Campoletis chlorideae*, *Phanerotoma* sp., *Chelonus* sp. and *Trichomalopsis* sp. The pest was recorded

as the first host record for *G. creatonoti* across the globe. A parasitoid, *Trichogramma* sp., was collected from the eggs of *S. frugiperda* infesting maize. The pentatomid bug *Eocanthecona concinna* was identified as a promising biocontrol agent for lepidopteran pest management in tea plantations. The entomopathogenic nematode *Heterorhabditis indica* NBAIIH38 was identified as a promising biocontrol agent against the white grub *Holotrichia serrata*.

A total of 129 isolates/species of *Steinernema*, *Heterorhabditis* and *Oscheius* nematodes were maintained on wax moth larvae. Nine *Steinernema pakistanense* isolates and one *Heterorhabditis indica* isolate were identified and added to NBAIR's EPN repository. Fifty-six species of spiders representing 15 families collected from different agroecosystems were added to the NBAIR's Araneae collection. One thysanopteran genus, *Asprothrips*, and two species, *Asprothrips bimaculatus* and *Pseudodendrothrips darci*, were newly added to the reference collection.

A total of 81 identification services were provided and 203 species of coccids and scales were identified for different SAUs and ICAR institutions. Around 37 identification services of Coleoptera group were provided, wherein 64 species were identified.

A website for the fauna of Pentatomidae of India was created and maintained on the institute website. A new online open access database on "List of NBA Voucher Specimens in ICAR– NBAIR Repository" was prepared, developed and uploaded on the institute website with 10 factsheets.

Around 350 sphecid wasps were collected from different states of India and 200 specimens from 18 genera were identified, and added to the collections. Molecular characterisation was completed and DNA barcodes were generated for around 25 wasps belonging to 10 genera, where the species level identity was established.

Genomic Resources

Molecular characterisation and DNA barcoding of insect pests, parasitoids, predators and pollinators were completed for 70 insects and accession numbers were obtained from GenBank, NCBI, which included 25 populations of the fall armyworm and 33 insect pests attacking medicinal plants and veterinary animals.

The population genetic diversity of 20 populations of the pink stem borer, *Sesamia inferens*, were studied using SSR primers. Clustering and principal component analysis suggested a low level of inter-population gene flow.

Delivery of entomopathogenic nematodes to whorls using WP formulations reduced the population of *S. frugiperda* to the tune of 60–72% in maize, and was also found to have improved plant growth, yield and harvest index when compared with that of emamectin benzoate and chlorpyriphos sprays, both in kharif and rabi seasons.

The *Bacillus thuringiensis* isolate NBAIR-BT25 was characterised as a new strain to combat the invasive pest *S. frugiperda*. It showed an LC_{50} of 44.7 *µg/ml.* Field trials showed 69–81% pest reduction. A novel *Bt* fermentation medium supporting significantly high protein production was developed.

Two *Bacillus* spp., with plant growth-promoting properties, were isolated for further screening for nematicidal and insecticidal activities.

Bioassays were carried out with the *Bt* toxins Cry1Ac and Cry2Ab for field and laboratory susceptible populations of the pink bollworm, *Pectinophora gossypiella*. The LC_{50} values for Cry1Ac and Cry2Ab for the field population from Jolarpettai, Tamil Nadu, were compared with the corresponding LC_{50} values for the laboratory susceptible population and the resistance ratios were calculated to be 6.11 and 1.96 for Cry1Ac and Cry2Ab, respectively.

The activity of carboxyl esterases was estimated and Jolarpettai population recorded the maximum enzyme activity of 4.4940 µmoles of enzyme/mg of protein/minute. This was 2.22 times of that of the enzyme activity in the laboratory susceptible population. Staining of non-specific esterases of different pink bollworm populations depicted two esterase bands for all the field populations, whereas in the laboratory susceptible population, there was only one esterase band.

Black soldier fly (BSF), a detritivorous insect, was collected, identified and evaluated for bioconversion of farm wastes. Microflora from the fly were isolated, molecularly identified, and biochemically characterised for enzymes. The compost generated through BSF was found to be as nutrient rich as vermicompost and farmyard manure. It yielded superior results in the establishment of nurseries of chilli, capsicum, brinjal and tomato. The technology of mass culturing of BSF was commercialised.

A mobile application in Kannada was created for information on the non-chemical management of coconut pests. This mobile app helps the farmers to learn about and adopt non-chemical methods of controlling coconut pests.

Gene sequences related to insecticidal resistance in storage pests were retrieved from public domain and structure prediction was carried out for the resistant gene *Cytochrome P450* for *Tribolium castaneum* through the softwares such as UniProt and SWISS-MODEL.

Germplasm Conservation and Utilisation

Surveys were conducted in several districts of Karnataka to record the incidence of *S. frugiperda* on maize. The incidence ranged from 9.0–62.5%. Entomofungal pathogens and nucleopolyhedroviruses were evaluated against *S. frugiperda.* IPM field trials using parasitiods, predators, *Bt*, pheromone traps and *Beauveria bassiana* (Bb-45) and *Metarhizium anisopliae* (NBAIR-Ma-35) were carried out against *S. frugiperda* in a 30-day-old maize crop.

A push–pull strategy of growing the fodder legume *Desmodium gangeticum* (as an intercrop to repel adult moths from oviposition) and Napier grass (as a border crop to attract adult moth for oviposition) was evaluated for the management of fall armyworm in maize.

Two fungal pathogens, *Beauveria bassiana* (Bb-5a & Bb-45 isolates) and *Metarhizium anisopliae* (Ma-4 & Ma-35 isolates), were established as endophytes in cabbage leaf, stem and root tissues through seed treatment, root inoculation and foliar application methods. All the four isolates showed varied colonisation and persistence in root, stem and leaf bits of cabbage during 15–60 days after treatment (DAT) in different methods of inoculation. Among the four isolates tested, Ma-35 showed persistence in cabbage leaf tissues till 60 DAT in all the three methods tested.

Spodoptera frugiperda nucleopolyhedrovirus (*Sf*NPV) was isolated and characterised. Electron microscopy studies indicated that the tetrahedral occlusion bodies measured 1.64 µm. In bioassay studies, larval mortality was observed at low doses of *Sf*NPV with the LC_{50} of 1×10^6 OBs/ml against second instar larvae of *S. frugiperda*. In a field experiment on jute, 68.9, 78.6 and 93.2% reduction in larval population of *S. obliqua*, respectively, at 3, 4, 7 days after spray, was obtained with *So*NPV. *Spodoptera mauritia* NPV (*Sm*NPV) and *Helicoverpa armigera* NPV (*Ha*NPV) were found effective in reducing the population of rice armyworm and chickpea podborer under field conditions.

Small-scale rearing methods for *Amblyseius largoensis*, *Paraphytoseius orientalis* and *Scapulaseius suknaensis* were developed.

Nanoemulsions of sweet basil oil were thermodynamically stable. They did not have phase separation and turbidity. The droplets exhibited a size range of 30–50 nm on day one. A gradual increase in the droplet size was observed after 30 days and it was 200 nm after 60 days. The nanoemulsion at 1:1 ratio with Tween 80 was found to be toxic to housefly, mosquito and phorid fly larvae.

Three low cost sensors (patent applied) were developed for onsite qualitative and quantitative identification of NPVs of *Helicoverpa armigera*, *Spodoptera litura* and *Spilosoma obliqua*. These reusable sensors help in rapid assessment of the efficacy of these viruses. A new low-cost, portable sensor was developed for detecting oxalate and urea which has applications in the area of insect pest population dynamics.

Whiteflies such as *Bemisia tabaci*, *Aleurodicus rugioperculatus*, *A. dispersus*, *Aleurotrachelus trachoides, Paraleyrodes bondari, P. minei, Pealius nagarcoilensis* and *A. atratus* were identified through morphological as well as molecular characterisation. Natural parasitism of *Encarsia guadeloupae* against rugose spiralling whitefly on coconut and other crops was quantified through a regular monitoring programme.

Biology and feeding potential of *Dortus primarius* and *Termatophylum orientale* were studied on *Corcyra cephalonica* eggs. *Blaptostethus pallescens* and *Cardiastethus affinis* exhibited type III response at 15 °C and type II response at 20 and 28 °C. *Montandoniola indica* exhibited type II response at 15 and 20 °C, while at 28 °C, it showed type III response.

Plant growth-promoting rhizobacteria (PGPR) *Pseudomonas fluorescens* strain NBAIR-PFDWD was effectively used to manage the sucking pest *Scirtothrips dorsalis* on capsicum under polyhouse and field conditions with significant increase in yield when compared with untreated control plants.

The role of native bees in pollination and yield of yardlong bean and cucumber was studied under field conditions. Bee pollination significantly enhanced the yields in both the crops.

The nesting sites of the native ground nesting bee, *Hoplonomia westwoodi*, were augmented in new sites by splitting the nest with viable broods and seeding in new sites for its propagation. Active nesting activity was recorded in newly seeded sites.

Amur carp fish, *Cyprinus carpio*, fed with BSF meal (70% BSF meal + 30% fish meal) was recorded to have statistically significant growth parameters when compared with commercial fish meal. Broiler chicken fed with BSF meal (5% substitution in broiler diet) was recorded to have significantly higher body weight and feed intake in comparison with control meal.

All-India Coordinated Research Project on Biological Control of Crop Pests

Biodiversity of biocontrol agents from various agroecological zones

Spiders belonging to Araneidae, Lycosidae, Oxyopidae Tetragnathidae, Thomisidae, Salticidae, Attidae and Linyphidae were abundant in Gujarat and Assam. Out of the 20 natural enemies recorded on apple, predators were the most abundant followed by parasitoids. The parasitoids, *Aphelinus mali*, *Encarsia perniciosi* and *Aphytis proclia* were also found to cause significant parasitisation of woolly apple aphid. Coccinellids, *Cotesia glomerata*, *Campoletis chloridae*, *Diplazon* sp. and *Trathla* sp. recorded on various crops in Himachal Pradesh. Sorghum stem borer was found to be parasitised (25%) by *Cotesia flavipes*. The egg parasitoid, *Trichogrammatoidea simmondsi*, larval parasitoid, *Neotrichoporoides nyemitawus* and pupal parasitoid, *Spalangia endius* were found to cause 18, 21 and 13% parasitisation in shoot flies infesting millets in Telangana.

Surveillance for invasive alien pests

The new alien pest fall armyworm (FAW), *Spodoptera frugiperda*, was reported from Gujarat, Rajasthan, Maharashtra, West Bengal, Karnataka, Kerala, Telangana, Andhra Pradesh and Tamil Nadu on maize. During rabi, 10–60% damage of *S. frugiperda* was recorded in Telangana across different millets. Papaya mealybug incidence was observed in Tamil Nadu, Gujarat, Assam and Maharashtra.

Surveys conducted in the coastal districts of Karnataka and Goa recorded moderate to severe incidence of the rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus*, on coconut. *Encarsia guadeloupae* was found to cause higher rates of parasitisation of RSW (24–62%) in Karnataka and Andhra Pradesh. In Nalbari and Kamrup districts of Assam, the natural parasitisation was 82.1%. Other invasive whiteflies such as Bondar's nesting whitefly, *Paraleyrodes bondari*, and *P. minei* were also recorded to the extent of 15–28% on coconut in Karnataka and Kerala.

Biological control of sugarcane pests

Plants treated with the entomopathogenic nematode *Heterorhabditis indica* recorded maximum reduction (81.2%) in damage due to white grub in Andhra Pradesh.

Biological control of cotton pests

Spray of *Lecanicillum lecanii* (1×10^8 conidia/g) @ 5 g/litre recorded the lowest population of sucking pests in Maharashtra. In Fazilka district of Punjab, the mean parasitisation by *Encarsia* sp. was 45.9%.

Biological control of rice pests

Significantly higher yield in basmati rice was recorded in BIPM plots (31.25 q/ha) compared with control plots (29.75 q/ha) in Punjab. Lowest population of planthoppers was recorded in the BIPM plots. Percent damage by leaf folder and stem borer was found to be lowest in the plots treated with the entomopathogenic nematode, *Steinernema carpocapsae* in Andhra Pradesh.

Biological control of maize pests

Release of *Trichogramma chilonis* (1,00,000/ha) resulted in significant reduction in the damage caused by borers *Chilo partellus* and *Sesamia inferens*. Chemical control recorded the highest number of dead larvae of *Spodoptera frugiperda* per plot followed by *T. pretiosum* plus *Metarhizium anisopliae* (NBAIR Ma-35) and *T. pretiosum* plus *Bt* (2%) in Andhra Pradesh.

Biological control of pests of pulses

Spray of NBAII-BTG4 formulation recorded the higher grain yield of 625 kg/ha with a C:B ratio of 2.13 in pigeonpea. Both *Hear*NPV NBAIR and *Hear*NPV UAS-R (2 ml/litre) were on par with regard to reducing the pod damage in chickpea.

Biological control of pests of tropical fruit crops

Spraying of the AAU-A strain of *M. anisopliae* reduced the incidence of leafhoppers on mango. CISH formulation of *Beauveria bassiana* effectively reduced the damage by leaf webber in mango. In guava, Neem cake (50 g/2 kg soil) and CISH-Biopesticide (50 g/ 2 kg soil) significantly reduced the infestation of root-knot nematode.

Biological control of pests of temperate fruit crops

IPM module consisting of release of *Trichogramma cacoeciae* (2.5 lakh/ha) four times along with trunk banding, disposal of infested fruits, pheromone traps and a spray of NBAIR strain of *H. pakistanensis* significantly reduced the damage of apple codling moth. The mortality of apple root grubs was highest in plants treated with *M. anisopliae* in Himachal Pradesh.

Biological control of pests of plantation crops

Spray of the entomopathogenic fungus *Isaria fumosorosea* (NBAIR Pfu-5) recorded significant reduction in the live colonies of whiteflies on coconut in Kerala.

Biological control of pests of vegetable crops

Tomato

Lowest fruit damage by *Tuta absoluta* and *Helicoverpa armigera* was recorded in BIPM plots in Gujarat and Tamil Nadu. Lowest population of sucking pests was recorded in BIPM plots in Uttar Pradesh.

Brinjal

Damage by shoot and fruit borer was recorded to be the lowest in BIPM plots (11.4 and 13.2%) compared with control plots in Gujarat. Fruit damage and C:B ratio in BIPM plots were 14.6% and 1:3.58, respectively in Tamil Nadu. In Odisha, highest yield (9.5 t/ha) and C:B ratio (1:1.54) were recorded in BIPM plots.

Okra

Release of *T. chilonis* (@ 50,000/ha) six times at weekly intervals followed by *Bt* (@ 1 kg/ha) recorded maximum reduction in fruit damage (83.4%) by fruit borer.

Cabbage

BIPM package significantly reduced the population of diamond backmoth with highest yield (44.3 t/ha) and C:B ratio (3.53) in Tamil Nadu.

Biological control of pests of oilseed crops

The mean population of aphids recorded in the treatment *L. lecanii* (NBAIR strain) @ 5 g/litre (10.2 per 10-cm apical twig) was at par with *L. lecanii* (AAU-J strain) and *B. bassiana* (11.2 and 11.7 per 10-cm of apical twig).

Biological control of polyhouse and flower crop pests

In Punjab, spray of *L. lecanii* significantly reduced the damage by aphids (76.4%). Release of *Chrysoperla zastrowi sillemi* at the rate of 4 larvae per plant resulted in the maximum reduction (55.8%) in aphid population on capsicum in Himachal Pradesh. Significant reduction in bud borer damage in jasmine was recorded in the plots sprayed with *B. bassiana* (NBAIR formulation) at the rate of 5 g/ litre of water along with six releases of *T. chilonis* and *C. zastrowi sillemi* at 7-day intervals in Tamil Nadu.

Biological control of plant diseases

In chickpea, mixed formulation (Th14 + Psf173) of microbials has shown better performance over individual isolates with respect to its effect on seed germination and plant growth. In rice, the isolates Psf-173, PBAT-3, Th14, TCMS 36 and NBAIR-2 were better than other bioagents.

Tribal Sub-Plan programme (TSP)

Tribal farmers were trained on ecofriendly management of various pests in Gujarat, Andhra Pradesh, Tamil Nadu, Himachal Pradesh, Chhattisgarh, West Bengal and in the northeastern region. Field demonstrations, awareness-cum-training programmes and farmers' meetings were also held in various places to popularise biological control. Inputs were also supplied to the trained farmers.

2. कार्यकारी सारांष

भा.कृ.अनु.प.–राश्ट्रीय कृशि कीट संसाधन ब्यूरो ही देष का एकमात्र संस्थान है, जिसको कृशि-क्षेत्र में महत्वपूर्ण कीटों, कुटकियों और मकड़ियों के 'अधिकृत संग्रह स्थल' के रूप में मान्यता प्राप्त है। यह ब्यूरो देष की विभिन्न कृशि पारिस्थितिकी में कीटों और कुटकियों, मकड़ियों, सूत्रकृमियों और आथ्रोपोड से संबंधित सूक्ष्माणुओं सहित अन्य संबंधित जीवों के संग्रहण, सूचीकरण और संरक्षण के लिए समर्पित है। ब्यूरो का अनुसंधान कार्य तीन प्रभागों द्वारा किया जाता है, जैसे जननद्रव्य संग्रहण एवं लक्षणीकरण प्रभाग, जीनोमिक संसाधन प्रभाग तथा जननद्रव्य संरक्षण एवं उपयोग प्रभाग। जैविक नियंत्रण से संबंधित कार्य अखिल भारतीय समन्वित फसल कीट जैविक नियंत्रण परियोजना के तहत् निर्धारित और समन्वित किया जाता है। अनुसंधान के परिणाम निम्नलिखित हैं:

भा.कृ.अनु.प.–राश्ट्रीय कृशि कीट संसाधन ब्यूरो

जननद्रव्य का संग्रहण एवं लक्षणीकरण

कीटों को संग्रहीत करने के लिए देषभर में किए गए गहन सर्वेक्षण के फलस्वरूप 32 वंष के पेन्टाटोमिडे की 50 जातियाँ; टेफ्राइटिडे के चार उप-परिवारों के 21 वंष की फल मक्खियों की 34 जातियाँ; घुनों की 20 जातियाँ; स्केरेबीडे के 19 एवं 17 वंष के जड़-मत्कुणों की 72 एवं 65 जातियाँ क्रमषः उत्तरपूर्वी और दक्षिण भारत से संग्रहीत की गईं। कुटकियों के नमूने नौ राज्यों के 16 जिलों के 62 स्थानों से प्राप्त हुए। कुल 7,250 कुटकियों को प्रतिचयनित एवं संसाधित किया गया। एक हज़ार तीन सौ पच्चीस स्थाई स्लाइड तैयार किए गए और संरक्षित किए गए।

कोलियोप्टेरा, डाइप्टेरा, हाइमेनोप्टेरा एवं हेमीप्टेरा से कई नई जातियों का वर्णन किया गया। कोलियोप्टेरा के स्केरेबिडे के सेरिसीनी जाति की नौ नई जातियों की खोज एवं इनका वर्णन किया गया। जम्मू एवं कष्मीर से क्रेटोपस वंष से एक नए घुन का वर्णन किया गया। फल मक्खियों की चार जातियों का वर्णन किया गया, जैसे बैक्ट्रोसेरा (बैक्ट्रोसेरा) प्रभुई, बैक्ट्रोसेरा (पेरास्यूगोडेकस)कोनिका, कोलोट्राइप्स मेर्रीमी और कोलोट्राइप्स परालेटिलिम्बेटस। हाइमेनोप्टेरा की पाँच नई जातियों, जैसे रोगेडोप्सिस ग्रेषिया, रोगेडोप्सिस मेक्रूसा, क्लेबोनोसा इंडिका, नीस्टाइमेकस नोषियालिस और ओएनसिरटस सेनास्टी का वर्णन किया गया। भारत से एक्रोज़ेंगिस वंष का संषोधन दक्षिण भारत से एक्रोज़ेंगिस दक्षिणे नामक नई जाति के साथ वर्णन से किया गया।

देष के लिए और विभिन्न राज्यों के लिए षल्क, ऐफिड, थ्रिप्स, बर्ट, कुटकियों, मकड़ियों और सूत्रकृमियों के संबंध में नए अभिलेख तैयार किए गए। दो मृदु षल्क कीट, जैसे प्लेटिलेसेनियम नेपालेन्स और सेरोप्लास्टेस सिर्रिपेडिफोर्मिस, और ऐफिड की एक जाति, पेचील्ला रियुमुरी भारत में पहली बार दिखाई दिए। मैकोकस बाइक्रूषिएटस और डाइसकोचिटन पॉसिपेडिस कर्नाटक में पहली बार दिखाई दिए। छब्बीस जातियों, 18 वंषों और दो उप-परिवारों, वेसिपिडे परिवार के स्टेनोगेस्ट्राइन एवं वेसिपिने का प्रलेखन नए राज्य वितरण अभिलेख के रूप में किया गया। दो टेरेब्रेनषियन थ्रिप्स जातियाँ, एस्प्रोथ्रिप्स बाइमेकुलेटस एवं स्यूडोडेन्ड्रोथ्रिप्स डार्सी पहली बार भारत में दिखाई दिए। हाइमेनोप्टेरा के नियोसेन्ट्रोबील्ला, मेग्राफ्राग्मा, पेरासेन्ट्राबिया, टुमिडाइक्लावा और ऐफीलिनोइडी वंषों को पहली बार असम से संग्रहीत किया गया।मेगाफ्राग्मा पहली बार गुजरात में देखा गया। एब्लाइसियस टमाटावेनसिस, जो व्यावसायिक मूल्य का एक फाइटोसीड कुटकी है, कई क्षेत्रों में पाई गई। केकड़ा मकड़ी, तोमियस स्पेक्टाबिलिस, गुजरात में नए वितरण अभिलेख के रूप में दर्ज हुआ। कीटरोगवाहक सूत्रकृमि ओषियस रुगाओएनसिस पहली बार भारत में दिखाई दी।

आकारकीय लक्षण का उपयोग करते हुए भारत में डेकिनी जाति का व्यवस्थित अध्ययन किया गया और बेक्ट्रोसेरा, डेकस और स्यूगोडेकस के साइनापोमोर्फी की व्याख्या की गई। पेन्टाटोमिडे के एक्रोज़ेंगिस वंष का संषोधन और पेंटाटोमिड मत्कुण, इयोकेन्थेकोना कोनकिन्ना एवं इयोकेन्थेकोना फर्सेलेटा का पुनःविवरण किए गए। फाइटोफेगस स्केरेबिडे के डिंभक एवं वयस्क अध्ययन किया गया। कुरकुलियोनिडे के डेर्मेटोड, एकीनोमस ओर हाइपेरोमियास वंष की सूची तैयार की गई। उत्तरपूर्वी भारत से संग्रहीत तीन परिवारों के परभक्षी थ्रिप्सों के नौ वंषों के अंतर समझाने के लिए पहचान कुंजियाँ तैयार की गईं। कर्नाटक के पुत्तूर से आक्रामक थिप्स जातियों, थ्रिप्स पर्वीस्पाइनस, के लिए नए परपोशी के रूप में डेहलिया रोसी दर्ज की गई। पंजाब के गन्ना पारिस्थितिकी से संग्रहीत साल्टीसिड मकड़ी, माध्याट्टस जबलपुरेनसिस का पुनःवर्णन किया गया।

आक्रामक कीट, स्पोडोप्टेरा फ्रुजिपेर्डा, चने की सूंडी, की प्राकृतिक षत्रु-जटिलता पहली बार भारत में पाई गई और परजीवियों की पहचान ग्लाइप्टापेन्टील्स क्रियाटोनोटी, कैम्पोलेटिस क्लोरिडे, फेनेरोटोमा जाति, केलोनस जाति और ट्राइकोमेलोप्सिस जाति के रूप में की

गई। यह कीट विष्वभर में जी. क्रियाटोनी के पहली परपोशी के रूप में दर्ज हुआ। मक्के पर संक्रमित करने वाले एस. फ्रुजिपेर्डा के अंडों से ट्राइकोग्राम्मा परजीवी एकत्रित की गई। पेंटाटोमिड मत्कुण इयोकेन्थेकोना कोनकिन्ना की पहचान चाय के बागानों में लेपिडोप्टेरन कीट प्रबंधन के लिए उन्नत जैविक कारक के रूप में की गई। सफ़ेद मत्कुण होलोट्राइकिया सेर्राटा की अपेक्षा कीटरोगवाहक सूत्रकृमि हीटरोहेबडिटिस इंडिका एनबीएआईआईएच38 की पहचान उन्नत जैविक कारक के रूप में की गई।

मोम कीट के डिंभक पर स्टीनर्नेमा, हीटरोरहेब्डिटिस और ओषियस सूत्रकृमियों के कुल 129 पृथक्कृतों/जातियों का अनुरक्षण किया गया। नौ स्टीनेर्निमा पाकिस्तानेन्स पृथक्कृतों और एक हीटरोरहेब्डिटिस इंडिका पृथक्कृत की पहचान की गई तथा एनबीएआईआर के ईपीएन संग्रह में जोड़ा गया। विभिन्न कृशि-पारिस्थितिकी तंत्र से संग्रहीत 15 परिवारों की 56 मकड़ियों को एनबीएआईआर के ऐरेनी संग्रह में जोड़ा गया। एम थाइसेनोप्टेरेन वंष, एस्प्रोथ्रिप्स, और दो जातियाँ, एस्प्रोथ्रिप्स बाइमेक्युलेटस एवं स्यूडोडेन्ड्रोथ्रिप्स डार्सी, हाल ही में संदर्भ संग्रह में जोड़ी गई।

कुल 81 पहचान सेवाएँ दी गईं और विभिन्न राज्य कृशि विष्वविद्यालय एवं भा.कृ.अनु.प. संस्थानों के लिए कोक्सिड और षल्क की 203 जातियों की पहचान की गई। कोलियोप्टेरा समूह की लगभग 37 पहचान सेवाएँ प्रदान की गईं; जिनमें से 64 जातियों की पहचान की गई।

भारत के पेन्टाटामिडे वर्ग की एक वेबसाइट तैयार की गई, जिसको संस्थान की वेबसाइट पर अनुरक्षित किया जा रहा है। ''भा.कृ.अनु.प.–एनबीएआईआर संग्रहस्थल में एनबीए वाउचर नमूने की सूची'' का ऑनलाइन ऑपन एक्सेस डाटाबेस विकसित किया गया और उसे 10 तथ्यपत्रकों के साथ में संस्थान की वेबसाइट पर अपलोड किया गया।

भारत के विभिन्न राज्यों से लगभग 350 स्फेसिड वेस्प संग्रहीत किए गए और 18 वंषों के 200 नमूनों की पहचान की गई और संग्रहों में जोड़ा गया। ऐसे 10 वंषों के 25 वेस्पों का आणविक लक्षणीकरण पूर्ण किया गया और डीएनए बारकोड तैयार किए गए, जहाँ जाति स्तरीय पहचान स्थापित हुआ।

जीनोमिक संसाधन

कीटों व नाषीजीवों, परजीवियों, परभक्षियों और परागदों सहित सत्तर कीटों का आणविक लक्षणीकरण एवं डीएनए बारकोडीकरण किया गया तथा जीन बैंक, एनसीबीआई से एक्सेषन संख्या प्राप्त की गई, जिसमें 25 चने की सूँडी कीट और औशधीय पौधों एवं पषुओं का आक्रमण करने वाले 33 कीट व नाषीकीट षामिल हैं।

एसएसआर प्राइमरों का उपयोग करते हुए गुलाबी तना छेदक, सेसेमिया इनफेरेन्स, की 20 जातियों की आनुवंषिक विविधता का अध्ययन किया गया। क्लस्टरिंग और मुख्य घटक विष्लेशण ने अंतर-जातीय जीन बहाव निम्न स्तर का बताया।

खरीफ़ और रबी के मौसमों में इमामेक्टिन बेन्जोएट एवं कलोरपाइरिफॉस छिड़कावों की तुलना में डब्ल्युपी मिश्रणों का उपयोग करते हुए पत्तियों के वृत्ताकार गुच्छों पर कीटरोगवाहक सूत्रकृमियों के वितरण ने मक्के में एस. फ्रुजिपेर्डा की संख्या 62–72% तक कम किया और यह पौध-वृद्धि, उपज एवं तुड़ाई सूचक में सुधार करते पाया गया।

बेसिलस थूरिंजिएनसिस पृथक्कृत एनबीएआईआर-बीटी25 का लक्षणीकरण आक्रामक कीट, एस. फ्रुजिपेर्डा के प्रतिरोध के नए वंष के रूप में किया गया। इसने 44.7 माइक्रोग्राम/मि.ली का एलसी50 दर्षाया। प्रक्षेत्र परीक्षणों ने 69–81% नाषीजीवों की कमी दिखाई। काफी अधिक उच्च प्रोटीन-उत्पादन के लिए मददगार एक नवीन बीटी किण्वन माध्यम का विकास किया गया।

गुलाबी बॉल कीट, पेक्टिनोफोरा गोस्सिपील्ला, की प्रक्षेत्र एवं प्रयोगषाला-संवेदनषील जातियों के लिए बीटी विशालु क्राई1एसी और क्राई2एबी के साथ जैव-विष्लेशण किया गया। जोलारपेट्टई, तमिलनाडू के क्राई1एसी और क्राई2एबी की प्रक्षेत्र जाति के एलसी50 मूल्य की तुलना प्रयोगषाला-संवेदनषील जाति के तद्विशय एलसी50 मूल्य के साथ की गई और प्रतिरोध अनुपात क्राई1एसी एवं क्राई2एबी के लिए क्रमषः 6.11 एवं 1.96 पाया गया।

कार्बोक्सिल एस्टेरेस की क्रियाषीलता का आकलन किया गया और जोलारपेट्टई जाति में 4.4940 माइक्रोमोल एन्ज़ाइम/मि.ग्रा. प्रोटीन/मिनट की अधिकतम एन्ज़ाइम क्रियाषीलता दर्ज हुई। यह प्रयोगषाला-संवेदनषील जाति की एन्ज़ाइम क्रियाषीलता से 2.22 गुना अधिक थी। विभिन्न गुलाबी बॉल कीट जातियों के गैर-विषिश्ट एस्टेरेस के अभिरंजन से सभी प्रक्षेत्र जातियों में दो एस्टेरेस बेण्ड दर्षाए गए, जबकि प्रयोगषाला-संवेदनषील जाति में केवल एक ही एस्टेरेस बेण्ड था।

ब्लैक सोलजर मक्खी (बीएसएफ), जो एक अपरदाहारी कीट है, का संग्रहण व पहचान की गई और प्रक्षेत्र अपषिश्टों के जैव-परिवर्तन के लिए मूल्यांकन किया गया। मक्खियों से सूक्ष्मवनस्पति जात का पृथक्करण, आणविक पहचान और एन्ज़ाइम हेतु जैवरासायनिक

लक्षणीकरण किया गया। बीएसएफ के माध्यम से तैयार कम्पोस्ट केंचुआ खाद एवं गोबर की खाद के जैसे पोशक तत्व संपन्न पाया गया। मिर्ची, षिमला मिर्च, बैंगन और टमाटर की नर्सरी की स्थापना के लिए यह बहुत ही मददगार साबित हुआ। बीएसएफ के बृहत् संवर्धन की तकनीकी का व्यावसायीकरण किया गया।

नारियल के नाषीजीवों के गैर-रासायनिक प्रबंधन की जानकारी देने के लिए कन्नडा में एक मोबाइल एप्प विकसित किया गया। इस एप्प से किसानों को नारियल के नाषीजीवों के नियंत्रण की गैर-रासायनिक विधियों के बारे में जानने और उन्हें अपनाने में मदद मिलेगी।

संचयी नाषीजीवों में कीटनाषी-प्रतिरोध के संबंध में जीन अनुक्रमों को पब्लिक डोमेन से पुनः प्राप्त किया गया और यूनीप्रोट एवं स्विस-मॉडल जैसे सोफ्टवेयरों के माध्यम से ट्राइबोलियम कैस्टेनियम हेतु प्रतिरोधी जीन साइटोक्रोम पी 450 का संरचना-अनुमान किया गया।

जननद्रव्य संरक्षण एवं उपयोग

मक्के पर एस. फ्रुजिपेर्डा के प्रकोप को दर्ज करने के लिए कर्नाटक के कई जिलों में सर्वेक्षण किए गए। प्रकोप का स्तर 9.0–62.5% के बीच था। एस. फ्रुजिपेर्डा के विरुद्ध कीट-कवकीय रोगवाहकों और न्यूक्लियोपॉलीहेड्रो विशाणुओं का मूल्यांकन किया गया। तीस दिवसीय मक्के की फसल मेंएस. फ्रुजिपेर्डा के विरुद्ध परजीवियों, परभक्षियों, बीटी, फेरोमोन जालों और ब्युवेरिया बेस्सियाना (बीबी-45) और मेटाराइज़ियम एनीसोप्लिए (एनबीमआईआर-एमए-35) का उपयोग करते हुए प्रक्षेत्र में समेकित कीट प्रबंधन परीक्षण किया गया।

मक्के के सैनिक षलभ (चने की सूँडी) के प्रबंधन के लिए फलीदार चारा फसल डेस्मोडियम गांजेटिकम (वयस्क कीटों को अंडनिक्षेपण से विकर्शित करने के लिए अंतरवर्ती फसल के रूप में) और नेपियर घास (वयस्क कीटों को अंडनिक्षेपण के लिए आकर्शित करने हेतु सीमावर्ती फसल के रूप में) उगाने की कर्शापकर्श नीति का मूल्यांकन किया गया।

दो फफूँद रोगवाहक, ब्युबेरिया बेस्सियाना (बीबी-5ए और बीबी-45 पृथक्कृत) और मेटाराइज़ियम एनीसोप्लिए (एमए-4 और एमए-35 पृथक्कृत) बीजोपचार, जड़-संचारण और पर्ण-प्रयोग की विधियों के माध्यम से पत्तागोभी के पत्ते, तने और जड़-कोषिकाओं में अंतपादप के रूप में स्थापित किए गए। सभी चारों पृथक्कृतों ने संचारण की विभिन्न विधियों में उपचार के बाद के 15–60 दिनों के दौरान पत्तागोभी की जड़, तने और पत्तों के टुकड़ों में अलग-अलग आबादी और सातत्य दिखाए। परीक्षण किए गए चार पृथक्कृतों में से एमए-35 ने परीक्षण की सभी तीनों विधियों में उपचार के 60 दिनों तक पत्तागोभी के पर्ण-ऊतकों में सातत्य दिखाया।

स्पोडोप्टेरा फ्रुजिपेर्डा न्यूक्लियोपॉलीहेड्रो विशाणुओं (एसएफएनपीवी) का पृथक्करण और लक्षणीकरण किया गया। इलेक्ट्रॉन सूक्ष्मदर्षी अध्ययन से पता चला कि चतुश्फलकीय बाधक काया 1.64 माइक्रोमोल थी। जैवविष्लेशण अध्ययन में लार्वा की मृत्यु-दर स्पोडोप्टेरा फ्रुजिपेर्डा के द्वितीयक इन्स्टर लार्वे की तुलना में एलसी50 सहित एसएफएनपीवी की कम मात्रा में पाई गई। पटसन पर प्रक्षेत्र परीक्षण में एसओ एनपीवी के प्रयोग से स्पोडोप्टेरा ओब्लिक्वा की डिंभकों की संख्या में छिड़काव के 3,4,7 दिनों के बाद क्रमषः 68.9, 78.6 और 93.2% की कमी पाई गई। स्पोडोप्टेरा मौरीषिया एनपीवी (एसएमएनपीवी) एवं हेलिकोवर्पा आर्मीगेरा एनपीवी (एचए एनपीवी) प्रक्षेत्र परिस्थितियों में चावल की सूँडी कीट और चने के फली बेधक की संख्या कम करने में प्रभावी पाए गए।

एम्ब्लीसियस लार्गोएनसिस, पैराफाइटोसियस ओरिएन्टालिस और स्केपुलेषियस सुखनेनेसिस के लघु-स्तर पर पालने की विधियाँ विकसित की गईं।

मीठी तुलसी तेल के नैनोएमल्षन ऊश्मगतिषीलता की दृश्टि से स्थिर थे। उनमें चरण-अलगाव और मैलापन नहीं थे। छोटी बूँद पहले दिन में 30–50 नैनो मीटर के बीच थी। तीस दिन बाद बूँद के आकार में धीमी वृद्धि दिखाई दी और 60 दिन बाद यह 200 नैनो मीटर था। ट्वीन 80 के साथ में नैनोएमल्षन का 1:1 अनुपात मक्खी, मच्छर और फोरिड मक्खी के डिंभक के लिए ज़हरीला पाया गया।

हेलिकोवर्पा आर्मीगेरा, स्पोडोप्टेरा लिट्युरा और स्पाइलोसोमा ओब्लिक्वा के एनपीवी की स्वस्थाने गुणात्मक एवं मात्रात्मक पहचान के लिए तीन सस्ते सेंसरों (पेटेन्ट के लिए आवेदन दिया गया) का विकास किया गया। ये पुनरुपयोगी सेंसर इन विशाणुओं की प्रभावकारिता के त्वरित मूल्यांकन के लिए मदद करते हैं। ऑक्सलेट और यूरिया का पता लगाने के लिए एक नया सस्ता पोर्टेबिल सेंसर का विकास किया गया, जिसका कीट व नाषीजीवों की गतिषीलता के क्षेत्र में प्रयोग किया जा सकता है।

आकारकीय एवं आणविक लक्षणीकरण के माध्यम से बेमीसिया टबाषी, एल्युरोडिकस रुगियोपर्कुलेटस, ए. डिस्पर्सेस, एल्युरोट्रेकीलस ट्रेकोइडस, पैरालीरोड्स बोण्डारी, पी. मिनेई, पीलियस नागरकोइलेनसिस और ए. एट्राटस जैसी सफ़ेद मक्खियों की पहचान

की गई। नियमित निगरानी कार्यक्रम के माध्यम से नारियल एवं अन्य फसलों पर रूगोस चक्करदार सफ़ेद मक्खी के विरुद्ध एनकार्सिया ग्वाडिलूप की प्राकृतिक परजीविता की मात्रा निर्धारित की गई।

कोर्साइरा सेफालोनिका के अण्डों पर डोर्टस प्राइमेरियस और टर्मेटोफाइलम ओरिएनटेल की जैविकी एवं भक्षण-क्षमता का अध्ययन किया गया। ब्लेप्टोस्टेथस पेल्लेसीन्स और कार्डियास्टेथस एफ्फिनिस ने 15° से. पर टाइप प्प्प् और 20° से. एवं 28° से. पर टाइप प्प् अनुक्रिया दर्षाई। मोंटान्डोनियोला इंडिका ने 15 एवं 20° से. पर टाइप प्प् अनुक्रिया और 28° से. पर टाइप प्प्प् अनुक्रिया दर्षाई।

पॉलीहाउस और प्रक्षेत्र परिस्थितियों में षिमला मिर्च पर चूशक कीट स्किर्टोथ्रिप्स डोर्सालिस के प्रबंधन के लिए पौध-वृद्धि-प्रोत्साहक राइज़ोबैक्टीरिया (पीजीपीआर) स्यूडोमोनास फ्लूरसेंस वंष एनबीएआईआर-पीएफडीडब्ल्युडी का प्रभावी उपयोग किया गया, जिससे अनुपचारित पौधों की तुलना में उपज में काफ़ी बढ़ोत्तरी हुई।

प्रक्षेत्र परिस्थितियों में परागण में देषी मधुमक्खियों की भूमिका और लंबी लोबिया एवं खीरे की उपज का अध्ययन किया गया। दोनों फसलों में मधुमक्खी के परागण से उपज में काफ़ी बढ़ोत्तरी हुई।

भू-पोटा बनाने वाली देषी मधुमक्खी, होप्लोनोमिया वेस्टवूडी, के प्रवर्धन के लिए जननक्षम बच्चों और नए स्थानों पर बीज बोते हुए पोटे को विभाजित कर भू-पोटा-स्थलों को बढ़ाया गया। नव बीज बोए स्थलों में सक्रिय घोंसला बनाने की क्रिया दर्ज की गई।

अमूर कार्प मछली, साइप्रिनस कार्पियो, जिसको बीएसएफ आहार (70% बीएसएफ आहार + 30% मत्स्य-चूर्ण) दिया गया, में व्यावसायिक मत्स्य-चूर्ण की तुलना में सांख्यिकीय दृश्टि से महत्वपूर्ण वृद्धि प्राचल दर्ज किया गया। बीएसएफ आहार (ब्रॉइलर आहार में 5ः प्रतिस्थापन) दी गई ब्रॉइलर मुर्गी में सामान्य आहार की तुलना में अधिक षरीर भार एवं आहार-ग्रहण दर्ज किए गए।

अखिल भारतीय समन्वित फसल कीट जैवनियंत्रण परियोजना

विभिन्न कृशि-जलवायु क्षेत्रों में जैवनियंत्रण कारकों की जैवविविधता

गुजरात एवं असम में अरनीडे, लाइकोसिडे, ऑक्सियोपिडे टेट्राग्नाजीपक्म, थॉमिसिडे, साल्टिसिडे, आइडे और लिलिफिडे जाति की मकड़ियाँ प्रचुर मात्रा में थीं। सेब पर दर्ज 20 प्राकृतिक दुष्मनों में से परभक्षियाँ बहुत अधिक थीं, जिनके बाद परजीवियाँ। परजीवियाँ, एफीलिनस माली, एनकार्सिया पर्नीसियोसी और एफाइटिस प्रोक्लिया भी ऊनी सेब ऐफिड की काफ़ी परजीविता के कारक होती पाई गईं। हिमाचल प्रदेष में कई फसलों पर कोक्सिनेल्लिड्स, कोटेषिया ग्लोमेरेटा, कैम्पोलेटिस क्लोरिडे, डाइप्लेज़ोन स्पीषीज और ट्राथला स्पीषीज़ पाई गई। ज्वार का तना बेधक कोटीषिया फ्लेविप्स द्वारा परजीवी बनाते (25%) पाया गया। तेलंगाना में अण्ड परजीवी ट्राइकोग्राम्माटोइडी सिम्मोन्डसी, डिंभक परजीवी नियोट्रिकोपोरोइड्स निएमिटावस और प्यूपा परजीवी स्पलांगिया एन्डियस प्ररोह मक्खियों से प्रकोपित ज्वार में 18, 21 और 13% परजीवीकारक होते पाए गए।

आक्रामक विदेषी कीटों की निगरानी

गुजरात, राजस्थान, महाराश्ट्र, पष्चिम बंगाल, कर्नाटक, केरल, तेलंगाना, आंध्र प्रदेष और तमिल नाडू में मक्के पर नई विदेषी कीट सैनिक षलभ (चने की सूँडी कीट) (एफएडब्ल्यु), स्पोडोप्टेरा फ्रुजिपेर्डा दर्ज हुआ। तेलंगाना में विभिन्न ज्चार फसलों में रबी के दौरान एस. फ्रुजिपेर्डा से 10–60% नुकसान दर्ज हुआ। तमिलनाडू, गुजरात, असम और महाराश्ट्र में पपीते के चूर्ण कीट का प्रकोप देखा गया।

कर्नाटक एवं गोवा के तटीय जिलों में किए गए सर्वेक्षण से नारियल पर रूगोस चक्करदार सफ़ेद मक्खी (आरएसडब्ल्यु), एल्यूरोडिकस रुगियोपर्कुलेटस, का प्रकोप दर्ज हुआ। कर्नाटक और आंध्र प्रदेष में एनकार्सिया ग्वाडिलूप आरएसडब्ल्यु के अधिक परजीविता दर (24–62%) का कारण बना। असम के नलबारी एवं कामरूप जिलों में प्राकृतिक परजीविता 82.1% थी। कर्नाटक और केरल में अन्य आक्रामक सफ़ेद मक्खियाँ, जैसे बोण्डर्स नेस्टिंग सफ़ेद मक्खी, पेरालीरोड्स बोण्डारी, और पी. मिनीई 15–28% तक पाई गईं।

गन्ने के कीटों का जैविक नियंत्रण

आंध्र प्रदेष में कीटरोगवाहक सूत्रकृमि, हीट्रोरहेबडिटिस इंडिका से उपचारित पौधों में सफ़ेद कीटडिंभ के द्वारा नुकसान सबसे कम (81.2%) था।

कपास के पौधों का जैविक नियंत्रण

महाराश्ट्र में लेकानिसिल्लम लेकानी (1 × 108 कोनीडिया/ग्रा.) के 5 ग्रा./ली. की दर से छिड़काव करने से चूशक कीटों की संख्या सबसे कम पाई गई। पंजाब के फ़ज़िल्का जिले में एनकार्सिया स्पीषीज़ द्वारा औसत परजीविता 45.9% थी।

धान के कीटों का जैविक नियंत्रण

पंजाब में बसमती चावल में अनुपचारित खेतों (29.75 क्विं./हे.) की तुलना में बीआईपीएम खेतों (31.25 क्विं./हे.) में काफ़ी अधिक उपज पाई गई। पौध फुदकों की कम संख्या बीआईपीएम खेतों में देखी गई। आंध्र प्रदेष में कीटरोगवाहक सूत्रकृमि, स्टीनेर्नेमा कार्पोकैप्सी से उपचारित खेतों में पत्ती मोड़क और तना बेधक से होने वाला नुक़सान का प्रतिषत सबसे कम पाया गया।

मक्के के कीटों का जैविक नियंत्रण

ट्राइकोग्राम्मा किलोनिस को 1,00,000 प्रति हेक्टेयर की दर से छोड़ने से किलो पार्टेल्लस और सेसेमिया इनफेरेन्स जैसे बेधकों से होने वाला नुक़सान काफ़ी कम हुआ। आंध्र प्रदेष में रासायनिक नियंत्रण से प्रति खेत में स्पोडोप्टेरा फ्रुजिपेर्डा के मृत डिंभकों की संख्या अधिक पाई गई, जिसके बाद टी. प्रिटियोसम + मेटाराइज़ियम एनीसोप्लिए (एनबीएआईआर एमए-35) और टी. प्रिटियोसम + बीटी (2%) का स्थान था।

दलहनों के कीटों का जैविक नियंत्रण

एनबीएआईआई-बीटीजी4 के छिड़काव से मटर में 2.13 के लागतःलाभ अनुपात के साथ 625 कि.ग्रा./हे. की अधिक उपज दर्ज की गई। हियर एनपीवी एनबीएआईआर और हियर एनपीवी यूएएस-आर (2 मि.ली./ली.) चने में फली के नुकसान को कम करने की दृश्टि से बराबर थे।

उष्ण क्षेत्रीय फल फसलों के कीटों का जैविक नियंत्रण

मेटाराइजियम एनीसोप्ली के एएयु-ए वंष के छिड़काव से आम पर पर्ण फुदकों का प्रकाप कम हुआ। सीआईएसएच के ब्युवेरिया बेस्सियाना के मिश्रण ने आम में पर्ण जालकों से होने वाले नुकसान को प्रभावी रूप से कम किया। नीम की खली (50 ग्रा./2 कि.ग्रा. मिट्टी) और सीआईएसएच-जैव-कीटनाषक (50 ग्रा./2 कि.ग्रा. मिट्टी) ने अमरूद में जड़-गाँठ सूत्रकृमि के संक्रमण का काफ़ी कम किया।

षीतोश्ण फल फसलों के कीटों का जैविक नियंत्रण

धड़ पर पट्टी बाँधना, संक्रमित फलों को नश्ट करना, फेरोमोन जाल और एच. पाकिस्तानेनसिस के एनबीएआईआर वंष से छिड़काव के साथ में टी. केकोषी का 2.5 लाख/हे. की दर से चार बार विमोचन सम्मिलित समेकित कीट प्रबंधन विधि से सेब पर कोडलिंग कीट से होने वाले नुकसान को काफ़ी कम किया। हिमाचल प्रदेष में एम. एनीसोप्ली से उपचारित पौधों में सेब के जड़-कीटों की मृत्यु-दर अधिकतम थी।

रोपण फसलों के कीटों का जैविक नियंत्रण

केरल में कीटरोगवाहक फफूँद इसारिया फ्युमोसोरोसी (एनबीएआईआर पीएफयु-5) के छिड़काव से सफ़ेद मक्खियों की सजीव समूहों में काफ़ी कमी देखी गई।

सब्जियों के कीटों का जैविक नियंत्रण

टमाटर

गुजरात एवं तमिलनाडू में जैवगहन कीट प्रबंधन अपनाए गए खेतों में टूटा एब्सोल्यूटा और एच. आर्मीजेरा द्वारा फलों का नुकसान सबसे कम पाया गया। उत्तर प्रदेष के जैवगहन कीट प्रबंधन खेत में चूशक कीटों की संख्या सबसे कम पाई गई।

बैंगन

गुजरात में जैवगहन कीट प्रबंधन खेतों में (11.4 एवं 13.2%) अनुपचारित खेतों की तुलना में प्ररोह एवं फल बेधकों द्वारा नुकसान सबसे कम था। तमिलनाडू में जैवगहन कीट प्रबंधन खतों में फल की ख़राबी और लागतःलाभ अनुपात क्रमषः 14.6ः और 1ः3.58 थे। ओडिषा में जैवगहन कीट प्रबंधन खेतों में अधिकतम उपज (9.5 टन/हे.) और लागतःलाभ अनुपात (1ः1.54) पाया गया।

भिण्डी

ट्राइकोग्राम्मा किलोनिस को साप्ताहिक अंतराल में 50,000/हे. की दर से छह बार छोड़ने के बाद बीटी (1 कि.ग्रा./हे.) के विमोचन से फल बेधक से फल पर होने वाली क्षति काफी कम (83.4ः) हुई।

पत्तागोभी

जैवग्रहन कीट प्रबंधन विधि ने तमिलनाडू में हीरक पृश्ठ षलभ की संख्या काफ़ी कम की और अधिक उपज (44.3 टनध्हे.) और लागतःलाभ अनुपात (3.53) भी दी।

तिलहन फसलों के कीटों का जैविक नियंत्रण

ऐफिडों की औसत संख्या एल. लेकानी (एनबीएआईआर वंष) के 5 ग्रा./ली. (10.2 प्रति 10-से.मी. षिखर की टहनी) के उपचार में दर्ज की गई, जो एल. लेकानी (एएयू-जे वंष) और ब्युवेरिया बेस्सियाना (11.2 एवं 11.7 प्रति 10-से.मी. षिखर की टहनी) के बराबर थी।

पॉली हाउस की फसलों और पुश्प फसलों के कीटों का जैविक नियंत्रण

पंजाब में एल. लेकानी के छिड़काव से ऐफिडों से होने वाला नुकसान काफ़ी कम (76.4ः) हुआ। हिमाचल प्रदेष में 4 डिंभक प्रति पौधे की

दर से क्राइसोपर्ला ज़ेस्ट्रोवी सिल्लेमी को छोड़ने से षिमला मिर्च पर ऐफिड की संख्या काफ़ी कम (55.8%) हुई। तमिलनाडू में 5 ग्रा./ली. पानी की दर से ब्युवेरिया बेस्सियाना के छिड़काव के साथ में साप्ताहिक अंतराल में ट्राइकोग्राम्मा किलोनिस और क्राइसोपर्ला ज़ेस्ट्रोवी सिल्लेमी को छह बार छोड़ने से चमेली में कली-छेदक से होने वाला नुकसान काफ़ी कम हुआ।

पौध रोगों का जैविक नियंत्रण

मटर में बीजों के अंकुरण और पौध-वृद्धि के संबंध में एक-एक पृथक्कृत की अपेक्षा मिश्रित घोल (टीएच14 + पीएसएफ173) ने बेहतर परिणाम दिए। धान में पीएसएफ-173, पीबीएटी-3, टीएच14, टीसीएमएस 36 और एनबीएआईआर-2 अन्य जैवकारकों की अपेक्षा बेहतर थे।

जनजातीय उपयोजना कार्यक्रम (टीएसपी)

गुजरात, आंध्र प्रदेष, तमिल नाडू, हिमाचल प्रदेष, छत्तीसगढ़, पष्चिम बंगाल और उत्तरपूर्वी क्षेत्र के किसानों को विभिन्न कीटों के परिस्थिति-अनुकूल प्रबंधन पर प्रषिक्षण दिया गया। जैविक नियंत्रण को लोकप्रिय करने के उद्देष्य से कई स्थानों पर प्रक्षेत्र प्रदर्षन, जागरूकता व प्रषिक्षण कार्यक्रम और कृशक-बैठकें आयाजित की गई। प्रषिक्षित किसानों को उत्पादक-सामग्रियाँ भी दी गई।

3. INTRODUCTION

The National Bureau of Agricultural Insect Resources (NBAIR) came into existence on 9 October 2014. 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. Not confined to any one — in Daniel Janzen's apt terminology — that holds all ecosystems together. Consequently it is not ony insects in agricultural ecosystems, insects everywhere within the confines our national boundary that 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, 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 19 October 1993. With the growing realisation that effective biological control was predicated on sound taxonomic and ecological knowledge the National Bureau of Agriculturally Important Insects was created on 29 June 2009.

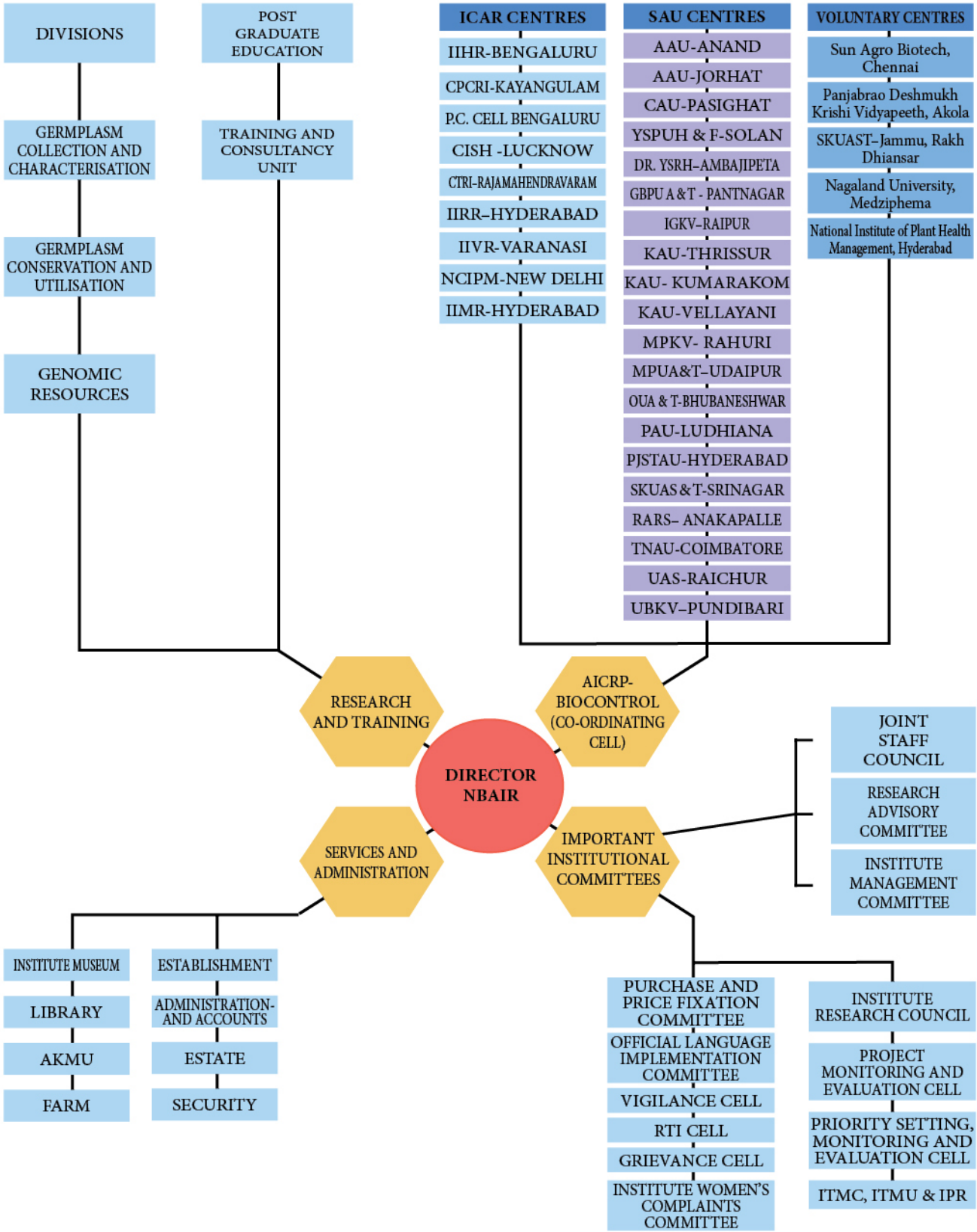
Our repository was recognised by the Ministry of Environment & Forests (presently MoEF&CC) in 2012 as the designated National Repository for preservation of insects, spiders and mites. The NBAIR repository holds nearly 1,89,959 specimens, and more 326 types. This is the only national bureau under the National Agricultural Research System (NARS) that acts as the nodal agency for collection, characterisation, documentation, conservation, exchange, research and utilisation of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture. Most of the specimens in the collection are Indian, but there is a unique representation of exotic beetles, wasps, flies and moths from various countries, including Australia, Argentina, the West Indies, Japan and USA. The museum is also unique in having one of India's largest collections of economically important taxa, including various biological control agents, viz. parasitic Hymenoptera (parasitoids), Coleoptera (Coccinellidae), along with major collections of groups with members which are pests, viz. Coleoptera, Hemiptera, Diptera, Lepidoptera and Orthoptera. Besides holding the world's smallest insect, Kikiki huna, in its collection, our museum also holds many undescribed species, and some species found in no other collections in the world. Online web diagnostic portals/web pages are prepared and maintained by the museum researchers under the NBAIR domain. Presently there are 10 major databases on the NBAIR website.

ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
To act as a nodal agency for collection, characterisation, documentation, conservation, exchange, research and utilisation of agriculturaly important insect resources (inculding mites, spiders and related arthropods) for sustainable agriculture. Capacity building, dissemination of technologies and forging linkages with stakeholders. On-farm validation of biocontrol strategies, forging linkages with commodity-based crop research institutes, AICRP / AINP and capacity building.
AICRP ON BIOLOGICAL CONTROL OF CROP PESTS
Promotion of biological control as a component of integrated pest and disease management in agriculture and horticultural crops for sustainable crop production. Demonstration of usefulness of biocontrol in IPM in farmers' fields.

Organisational set-up

Research is undertaken in the Divisions of Germplasm Collection and Characterisation, Genomic Resources and Germplasm Conservation and Utilisation. Research on microbial biocontrol is addressed under the AICRP on Biocontrol. The organogram is given on page 13.

Organogram


DIVISIONS
GERMPLASM COLLECTION AND CHARACTERISATION
GERMPLASM CONSERVATION AND UTILISATION
GENOMIC RESOURCES
POST GRADUATE EDUCATION
TRAINING AND CONSULTANCY UNIT
ICAR CENTRES
IIHR-BENGALURU
CPCRI-KAYANGULAM
P.C. CELL BENGALURU
CISH -LUCKNOW
CTRI-RAJAMAHENDRAVARAM
IIRR–HYDERABAD
IIVR-VARANASI
NCIPM-NEW DELHI
IIMR-HYDERABAD
SAU CENTRES
AAU-ANAND
AAU-JORHAT
CAU-PASIGHAT
YSPUH & F-SOLAN
DR. YSRH–AMBAJIPETA
GBPU A &T - PANTNAGAR
IGKV–RAIPUR
KAU-THRISSUR
KAU- KUMARAKOM
KAU-VELLAYANI
MPKV- RAHURI
MPUA&T–UDAIPUR
OUA & T-BHUBANESHWAR
PAU-LUDHIANA
PJSTAU-HYDERABAD
SKUAS & T-SRINAGAR
RARS– ANAKAPALLE
TNAU-COIMBATORE
UAS-RAICHUR
UBKV–PUNDIBARI
VOLUNTARY CENTRES
Sun Agro Biotech, Chennai
Panjabrao Deshmukh Krishi Vidyapeeth, Akola
SKUAST–Jammu, Rakh Dhiansar
Nagaland University, Medziphema
National Institute of Plant Health Management, Hyderabad
RESEARCH AND TRAINING
AICRP-BIOCONTROL (CO-ORDINATING CELL)
DIRECTOR NBAIR
SERVICES AND ADMINISTRATION
IMPORTANT INSTITUTIONAL COMMITTEES
JOINT STAFF COUNCIL
RESEARCH ADVISORY COMMITTEE
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Significant achievements

Basic research

- Five new species of Scelionidae, viz. *Oethecoctonus suryaseni, Pardoteleia flava, Microthoron bloomsdalensis, M. shompen* and *Nyleta onge* were described. Four new species of parasitic Hymenoptera, viz. *Crinibracon chromusae, Tanaostigma indica, Cotesia trabalae* and *Agiommatus thyrsisae,* were described. *Pulvinaria urbicola,* a soft scale, was redescribed.
- Morphology, host records and molecular phylogenetic analyses were integrated to generate boundaries between species / species group of the genus *Glyptapanteles*.
- *Megaphragma* and *Neocentrobiella,* belonging to Trichogrammatidae were collected for the first time in Maharashtra and Kerala.
- *Polistes* (*Polistella*) *dawnae* (Hymenoptera: Vespidae : Polistinae) was recorded for the first time from Arunachal Pradesh.
- A new terebrantian thrips species, *Thrips laurencei,* from flowers of *Hydrangea macrophylla* was described.
- *Heterorhabditis pakistanense* and *Steinernema huense* were reported for the first time from India.
- *Anagyrus amnestos,* a potential parasitoid of the invasive Madeira mealybug was described.
- Two aphids, *Tuberaphis xinglongensis* and *Lepidosaphes laterochitinosa,* were recorded for the first time from India.
- The natalicoline bug, *Empysarus depressus*, was recorded for the first time from Maharashtra and Karnataka.
- A checklist for Indian species of longhorn beetles was prepared which consisted of 1,555 longborn beetles classified under 72 tribes, 447 genera and seven subfamilies fof Cerambycidae, Vesperidae and Disteniidae.
- The transcriptome of susceptible and resistant strains of *Plutella xylostella* was sequenced. *P. xylostella*-ryanodine receptor protein modelling was done by molecular modelling method and prediction of molecular mechanism of diamides resistance in Px-PyR was achieved computationally.
- Molecular characterisation revealed the dual specificity of the indigenous *Bacillus thuringiensis* isolate NBAIRBtAN4, toxic to both lepidopteran and coleopteran insect pest. It carried the coleopteran specific *cry8* gene and lepidopteran specific *cry1* and *cry2* genes.
- Strain NBAIR-BTAN4 of *Bacillus thuringiensis* was characterised as a novel isolate capable of expressing crystal proteins toxic to both lepidopteran and coleopteran pests.

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.
- An alcohol-free formulation of 'Cuelure' trapped higher number of flies over the 'Cuelure' loaded in plywood pieces. A modified sticky trap with methyl eugenol was developed with good catches of *Bactrocera dorsalis*. A new formulation containing δ- octalactone along with other blends of volatiles was developed for attracting the mango frit fly, *Bactrocera dorsalis*. A new bisexual trap was developed to attract females of *Bactrocera dorsalis*.
- For the first time, mitochondrial genomes of *Heterorhabditis indica* and *H. bacteriophora* were sequenced.
- *Cecidochares connexa* released for the management of *Chromolaena odorata* continues to be present in its areas of release.
- 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.
- An interactive mobile app on non-chemical methods for management of arthropod and other pests of coconut was developed.
- The essential oil of sweet basil, eucalyptus and clove oil were characterised for chemical composition and insecticidal activity against housefly, *Musca domestica*. Clove oil was more toxic than basil and eucalyptus oil. A combination of essential oils (lemon grass, eucalyptus and Ocimum) was found to be toxic to the housefly.

- *Bacillus thuringiensis* var. *israeliensis* (VLC1) causing cent per cent mortality of mosquito larvae at the lowest dosage (1 ppm) was isolated and characterised. Two pupal parasitoids, *Nasonia vitripennis* and *Spalangia* sp., were identified and their mass production protocols were standardised.
- Soil application of *Heterorhabditis indica* (or *Steinernema* sp.), *Metarhizium anisopliae* (or *Beauveria bassiana*) in sugarcane after the onset of monsoon rains was found to be effective in reducing white grub damage, which resulted in higher yield compared with phorate treatment.
- Infestation of rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus* was found to have declined from 60.5% to 15.8% egg spirals per leaflet/leaf. *Encarsia guadeloupae* was the only major natural enemy encountered on the RSW, causing 82.6% parastism.
- In brinjal, shoot and fruit borer incidence could be significantly reduced with two sprays of NSKE and six releases of *T.chilonis. Brumus suturoides* @ 1,500/ha, *Scymnus* @ 1,500/ha and *Cryptolaemus* @ 1,500/ha significantly reduced mealybug populations.
- Type II functional response was observed in all stages of *Geocoris orchropterus* and *Helicoverpa armigera* eggs.
- *Termatophylum orientale* was reported for the first time from India.
- Bioecology of black soldier fly was studied by rearing it on various substrates. A mass rearing protocol for the insect was standardised using kitchen/ farm wastes, and a patentable technology was developed.

FINANCIAL STATEMENT (2018-19)

ICAR–National Bureau of Agricultural Insect Resources

Head	Amount (₹ in lakhs)
Pay & allowance	1,302.57
TA	29.89
Other charges, including equipment and office buildings	453.00
Information technology	3.93
Works and petty works	24.00
HRD	2.74
Pension	320.80
Loan	0.00
Total	**2,136.93**

All-India Coordinated Research Project on Biological Control of Crop Pests

Name of the centre	Salary	TA	RC	TSP	Total (₹ in lakhs)
AAU, Anand	19.32	6.00	20.62	8.41	**54.35**
AAU, Jorhat	29.55	4.50	11.00	5.42	**50.47**
RARS, Anakapalle	13.25	5.40	9.80	3.42	**31.87**
PJTSAU, Hyderabad	25.41	1.95	3.92	0.00	**31.28**
Dr YSPUH&F, Solan	30.37	2.25	4.00	1.17	**37.79**
GBPUAT, Pantnagar	9.18	4.05	10.70	10.17	**34.10**
KAU, Thrissur	9.18	4.05	8.10	0.00	**21.33**
MPKV, Pune	10.38	5.40	25.83	0.00	**41.61**
PAU, Ludhiana	26.58	4.50	18.72	0.00	**49.80**
SKUAST, Srinagar	28.54	4.50	9.00	8.27	**50.31**
TNAU, Coimbatore	13.79	4.05	13.96	3.17	**34.97**
MPUAT, Udaipur	0.00	1.00	2.00	0.00	**3.00**
OUAT, Bhubaneswar	0.00	1.00	2.34	0.00	**3.34**
CAU, Pasighat	0.00	1.00	8.54	6.13	**15.67**
CAU, Directorate of Extension Education	0.00	0.00	38.03	0.00	**38.03**
UAS, Raichur	0.00	5.00	10.00	0.00	**15.00**
ICAR–CPCRI, Kayankulam	0.00	1.50	3.00	0.00	**4.50**
ICAR–IIHR, Bengaluru	0.00	1.50	3.00	0.00	**4.50**
ICAR–CISH, Lucknow	0.00	1.00	2.00	0.00	**3.00**
ICAR–CTRI, Rajamahendravaram	0.00	0.75	1.50	0.00	**2.25**
ICAR–IIRR, Hyderabad	0.00	1.00	2.00	0.00	**3.00**
ICAR–IIMR, Hyderabad	0.00	1.00	2.00	0.00	**3.00**
ICAR–IIVR, Varanasi	0.00	1.50	3.00	0.00	**4.50**
ICAR–NCIPM, New Delhi	0.00	1.00	1.25	0.00	**2.25**
IGKV, Raipur	0.00	1.50	3.00	5.17	**9.67**
KAU, Kumarakom	0.00	1.50	3.00	0.00	**4.50**
KAU, Vellayani	0.00	1.50	3.00	0.00	**4.50**
Dr YSRHU, Ambajipeta	0.00	1.50	3.00	0.00	**4.50**
UBKV, Pundibari	0.00	1.00	2.00	10.67	**13.67**
P.C. Cell, Bengaluru	0.00	0.00	106.54	0.00	**106.54**
Total	**215.55**	**70.90**	**334.85**	**62.00**	**683.30**

4. RESEARCH ACHIEVEMENTS

ICAR–National Bureau of Agricultural Insect Resources

Division of Germplasm Collection and Characterisation

Surveys and explorations

Surveys for collection of aphids and coccids were conducted in Gujarat, Diu island, Chettalli, New Delhi, Calicut and rural Bengaluru. Also, surveys were carried out in nearby areas of Bengaluru viz. Doddaballapur, Nandi hills, Kanakapura, Kunigal, GKVK and Attur and collected the scales, aphids and mealybugs infesting different crop plants, which were observed for parasitoid emergence and later used for preservation and slide preparation. Similarly extensive surveys were conducted in Karnataka (Bagalkot, Belgaum, Bellary, Bengaluru, Chikkaballapur, Chikkamagaluru, Chitradurga, Davanagere, Dharwad, Haveri, Kolar, Raichur, Shivamogga, Tumakuru and Vijayapura) for collection of thrips.

Surveys for collection of adult beetles of Scarabaeidae and Cerambycidae through light traps and manual scouting were carried out in Northeast, viz. Assam, Mizoram and Nagaland, and South India viz. Andhra Pradesh, Tamil Nadu, Karnataka and Kerala (Fig. 1-3). The collections of Scarabaeidae yielded 72 species under 19 genera from Northeastern region and 65 species under 17 genera from South India, where 49 species under 14 genera belonged to Melolonthinae, 30 species under four genera belonged to Rutelinae and five species under four genera belonged to Dynastinae. The Cerambycidae collections resulted in 27 species representing 25 genera. A total of 405 weevil specimens were collected from different locations of the country, of which 20 species were identified.

A total of 972 specimens of Pentatomidae and 1000 specimens of Tephritidae were collected from various regions of Karnataka, Kerala, Sikkim, Rajasthan and Tamil Nadu. Collections yielded 50 species of Pentatomidae belonging to 32 genera and 34 species of Tephritidae belonging to 21 genera.

Around 350 sphecid wasps were collected, processed and mounted from six different states viz. Karnataka, Tamil Nadu, Kerala, Odisha, Gujarat and Sikkim.

Fig. 1. Installation of light trap in sugarcane field

Fig. 2. Light trap

Fig. 3. Manual scouting for collection of beetles

Two hundred and fifty spider specimens were collected from surveys undertaken in five states representing different agri–horti ecosystems like rice, red gram, maize, coconut, tobacco, mango etc. One hundred and fifty specimens were identified upto generic level. Analysis of the guild structure revealed

nine feeding guilds, viz. orb-weavers, ground runners, stalkers, burrowers, ambushers, foliage runners, space web builders, sheet web builders and tangle web builders. Orb-weavers, belonging to the families Tetragnathidae and Araneidae constituted the dominant guild representing 24% of the total species sampled.

Surveys were carried out for the collection of trichogrammatid species in Kerala, Assam, Karnataka and Gujarat and ten genera, viz. *Chaetogramma, Chaetosticha, Lathromeroidea Megaphragma, Neocentrobiella*, *Oligosita, Paracentrobia, Trichogramma*, *Trichogrammatoidea,* and *Tumidiclava* were collected.

Mite samples originated from 62 places in 16 districts across nine states, viz. Assam, Gujarat, Karnataka, Kerala, Maharashtra, Meghalaya, Tamil Nadu, Tripura and West Bengal. Approximately, 7,250 mites were sampled and processed during the year, which was an increase of 17.9% over the previous year. Over 1,325 permanent slides were prepared.

Approximately, 75% of all the processed mites belonged to Parasitiformes (Mesostigmata) and the rest belonged to Acariformes [Trombidiformes (20%) and Sarcoptiformes (5%)].

Description of new species

Several new species were described from Coleoptera, Diptera, Hymenoptera and Hemiptera. Nine new scarab species belonging to the tribe Sericini of Scarabaeidae of Coleoptera were discovered and described from Indian subcontinent. One new weevil species was described under genus *Cratopus* from Jammu and Kashmir. Four new species of fruit flies were described from India namely *Bactrocera* (*Bactrocera*) *prabhui* (Fig. 4), *Bactrocera* (*Parazeugodacus*) *conica* (Fig. 5), *Coelotrypes merremiae* (Fig. 6) and *Coelotrypes paralatilimbatus* (Fig. 7). Both species of *Bactrocera* are examples of cryptic species. *Bactrocera prabhui* closely allied to *B. caryeae* and *B. conica*, a closest relative of *B. bipustulata*.

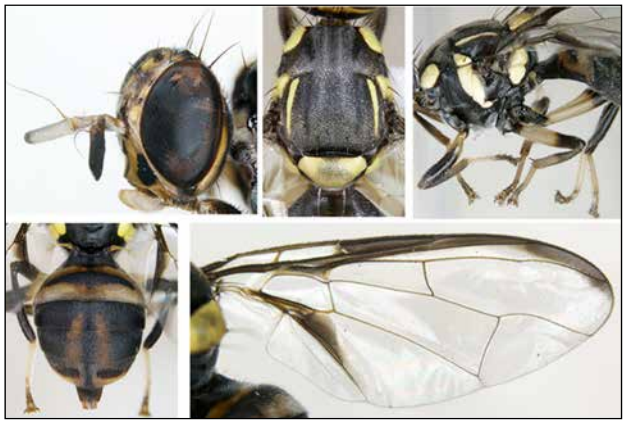


Fig. 4. *Bactrocera prabhui*

Fig. 5. *Bactrocera conica*

Fig. 6. *Coelotrypes merremiae*

Fig. 7. *Coelotrypes paralatilimbatus*

Two new braconid species, *Rhogadopsis gratia* (Fig. 8) and *R. macrusa* (Fig. 9) parasitic on *Merochlorops* in *Hedychium gardnerianum* stems; *Klabonosa indica* (Fig. 10) reared from eggs of *Endochus* sp; *Neastymachus notialis* (Fig. 11) and *Ooencyrtus xenasteiae* (Fig. 12), reared from the pupae of a *Xenasteia* sp., a sooty mould scavenger found

associated with the invasive rugose spiralling whitefly, *Aleurodicus rugioperculatus* were described. Revision of the genus *Acrozangis* from India was made with description of a new species, *Acrozangis dakshinae* (Fig. 13) from southern India.

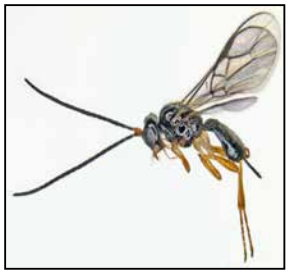


Fig. 8. *Rhogadopsis gratia*

Fig. 9. *Rhogadopsis macrusa*

Fig. 10. *Klabonosa indica*

Fig. 11. *Neastymachus notialis*

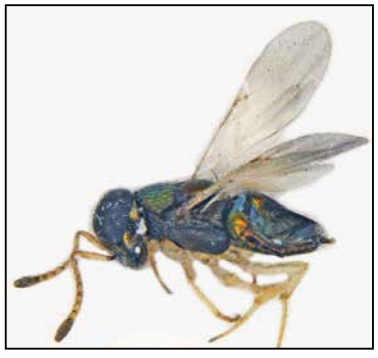


Fig. 12. *Ooencyrtus xenasteiae*

Fig. 13. *Acrozangis dakshinae*

Several phytoseiid mites collected this year were found to be hitherto undescribed species. New *Okiseius* spp. were collected in the northeastern states. A new species close to *Euseius ahaioensis* was added to the collection. For the first time in India, *Amblyseius tamatavensis*, a phytoseiid of commercial value, was discovered.

Euseius alstoniae and *E. finlandicus*, which are commonly found on a wide range of plants in Bengaluru, showed peculiar attributes in their ability to feed, develop, reproduce and survive on plants. *In situ* observations and experiments indicated that not only adults but deutonymphs of these two phytoseiids can also feed on *Magnolia champaca* and *Spathodea campanulata*. In the laboratory, the two plant-fed *Euseius* spp. could not consume the acarid *Tyrophagus putrescentiae* or the tetranychid *Tetranychus urticae*.

For the first time, an undescribed species of *Neocypholaelaps* (Mesostigmata: Ameroseiidae), with typical sabre-like setae, was discovered.

Predatory mites in the family Stigmaeidae were found on various plant species throughout the year. *Agistemus* sp.nr. *hystrix*/*macrommatus* and some *Zetzellia* spp. were added to the repository.

Several specimens of Bdellidae, including an undescribed species of *Spinibdella* (Fig. 14) collected on China aster, were added to the repository. Interestingly, no fully named species of *Spinibdella* is known from India.

Specimens of Erythraeidae, including *Abrolophus* sp.nr. *delhiensis* and *Leptus* sp.nr. *giganticus*, were added to the repository.

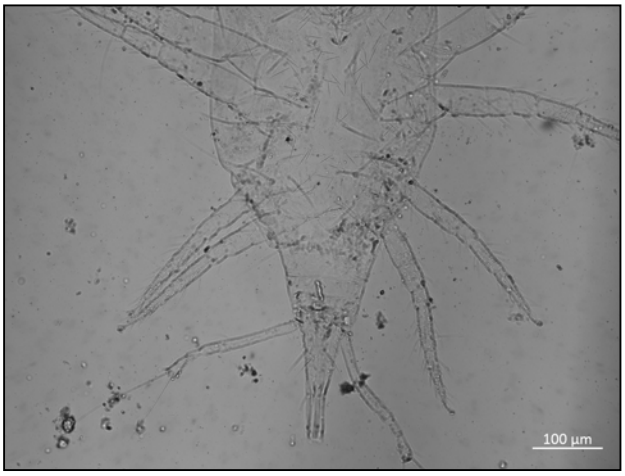


Fig 14. *Spinibdella* sp.

New distributional records

Several new records of scales, aphids, thrips, wasps for the country and various states were documented. Coccids, *Macoccus bicruciatus* (Fig. 15) and *Discochiton paucipedis* (Fig. 16) were recorded for the first time from Karnataka. *Maacocccus bicruciatus* was recorded on *Schefflera* and *D. paucipedis* was recorded on *Areca catechu*. Both of these are new host plant records for these species. Two soft scale insects viz. *Platylecanium nepalense* (Fig. 17) and *Ceroplastes cirripediformis* (Fig. 18) and one species of aphid viz. *Patchiella reaumuri* were recorded for the first time from India. *Patchiella reaumuri* was found to be emerging as serious pest of *Colocasia esculenta* in Meghalaya both in the field and storage. *Platylecanium nepalense* was recorded on an unidentified ornamental palm and *C. cirripediformis* was collected on 16 host plants.

Fig. 15. *Maacoccus bicruciatus*

Fig. 16. *Discochiton paucipedis*

Fig. 17. *Platylecanium nepalense*

Fig. 18. *Ceroplastes cirripediformis*

The scarab beetle, *Maladera bhutanensis* collected from Kolasib, Mizoram was recorded as the first report to India and several sericine beetles of family Scarabaeidae were recorded as first records to states like Nagaland (9 species), Mizoram (11 species), Kerala (2 species) and Karnataka (2 species).

Twenty–six species, 18 genera, and two subfamilies, Stenogastrinae and Vespinae of family Vespidae were documented as new state distribution records. The

genera *Neocentrobiella, Megaphragma, Paracentrobia*, *Tumidiclava* and *Aphelinoidea* of Hymenoptera were collected from Assam for the first time. *Megaphragma* was also recorded for first time from Gujarat. The sphecid, *Carinostigmus griphus* (Fig. 19) was reported for the first time in India.

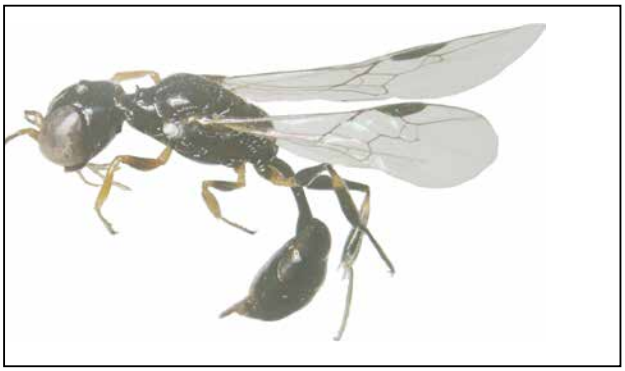


Fig. 19. *Carinostigmus griphus*

Two terebrantian thrips species, *Asprothrips bimaculatus* (Fig. 20) and *Pseudodendrothrips darci* (Fig. 21) were recorded for the first time from India. *Dahlia rosea* was reported as a new host for invasive thrips species, *Thrips parvispinus* (Fig. 22) from Puttur, Karnataka.

Fig. 20. *Asprothrips bimaculatus*

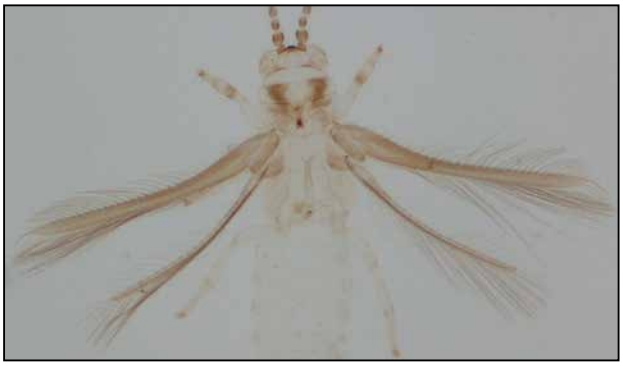


Fig. 21. *Pseudodendrothrips darci*

Fig. 22. *Thrips parvispinus*

The crab spider, *Thomisus spectabilis* was reported as new distributional record to Gujarat.

A total of 22 soil samples were collected randomly from sugarcane and turmeric growing regions of Hosur, Tamil Nadu. *Oscheius rugaoensis* NBAIRO27 was isolated from Hosur, Tamil Nadu. A soil sample was drawn from sugarcane rhizosphere of Hosur, Tamil Nadu and a positive sample was anticipated with *Oscheius* sp. nematode. Based on morphological and morphometrical studies (Fig. 23), the EPN, *Oscheius* sp. was identified and designated as *O. rugaoensis* NBAIRO27. Further identity was confirmed with molecular characterization using the ITS-rDNA region. To our knowledge, this is the first report of *O. rugaoensis* from India and this nematode can be used for the management of white grubs occurring in sugarcane fields.

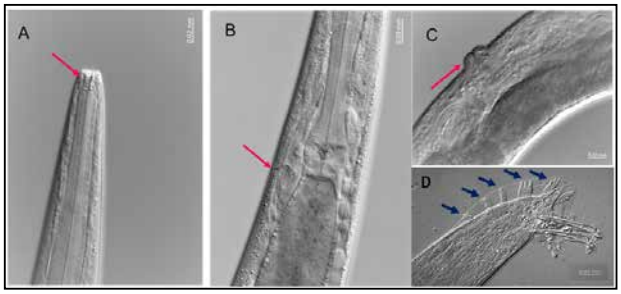


Fig. 23. Light microscope photographs of first-generation *Oscheius rugaoensis* NBAIRO27: (A) Anterior region of a male showing highly cuticularised cheilorhabdions; (B) Female with well circularised excretory pore (arrow); (C) Vulva patterns of *Oscheius rugaoensis,* slightly protruding vulva; (D) Male tails with bursal papillae bursal arrangement 1+1+1+3+3.

Taxonomic redescriptions and phylogenetic studies

A neotype is designated for *Acrozangis semiprasina* (Fig. 24). *Cuspicona antica* was transferred from *Cuspicona* to *Acrozangis* and made a new combination as *A. antica* (Fig. 25). The original specimen of *C. antica* by Vollenhoven, 1868 was designated as a lectotype. *Acrozangis antica* was transferred from the tribe Rhynchocorini to tribe Nezarini.

Redescriptions of pentatomid bugs, *Eocanthecona concinna* (Fig. 26) and *E. furcellata* were made for the first time based on male and female genitalia, prepared a key to the included species and documented the biology of this species under laboratory conditions.

Fig. 24. *Acrozangis semiprasina*

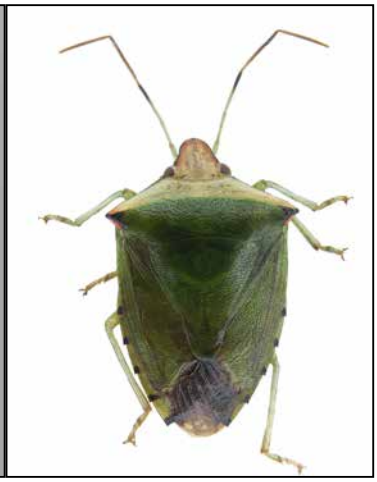


Fig. 25. *Acrozangis antica*

Fig. 26. *Eocanthecona concinna*

Species of fruit fly, *Coelotrypes* belonging to Tephritidae were found infesting flowers of plants of the family Convolvulaceae. Facial mask, cephalopharyngeal skeleton, spiracular morphology, anal lobe and creeping welt of larvae of *C. merremiae* (Fig. 27) and *C. luteifasciatus* (Fig. 28) were studied for the first time using scanning electron and light microscopy. Phylogenetic analysis of 62 species of fruit flies belonging to the tribe Dacini based on 51 morphological characters was attempted which revealed the monophyly of the tribe Dacini and genera *Bactrocera*, *Dacus* and *Zeugodacus*. Morphological characters supporting the monophyly of the aforementioned taxa were also elucidated for the first time (Fig. 29). This type of study is first of its kind for fruit flies in India and is concordance with results of phylogenetic analysis using molecular markers. Apart from these, diagnostic keys to all genera of tribe Dacini, all oriental species of *Coelotrypes* were also prepared and published.

Fig. 27. Pseuocephalon of third instar larva of *Coelotrypes merremiae*

Fig. 28. Pseudocephalon of third instar larva of *Coelotrypes luteifasciatus*

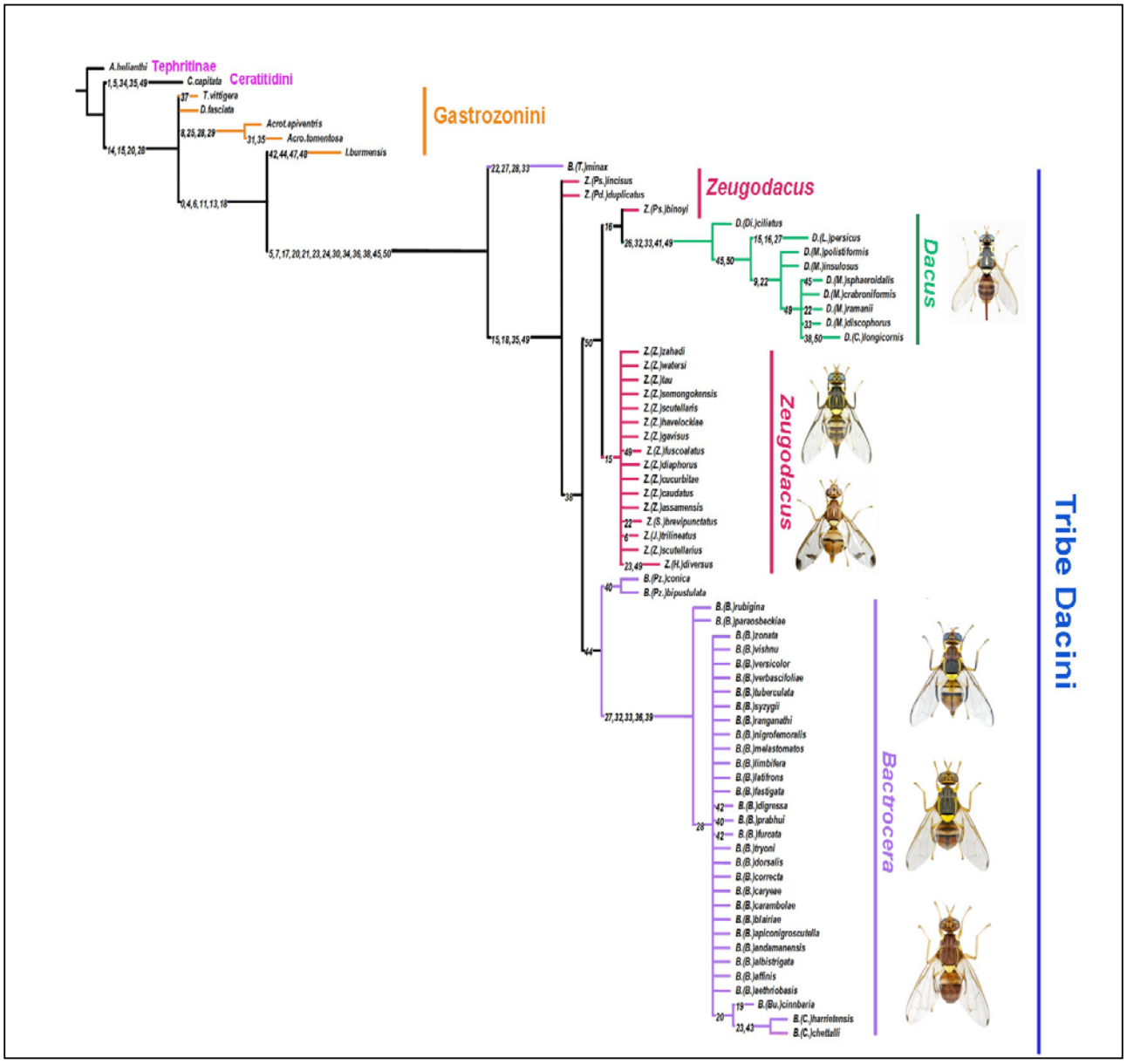


Fig. 29. Strict consensus cladogram of tribe Dacini with mapped synapomorphies

The salticid spider, *Madhyattus jabalpurensis* collected from sugarcane ecosystem in Punjab was re-described.

Scanning electron microscopy studies

Egg morphology and chorion ultrastructures of three species of *Anomala,* viz. *Anomala elata* (Fig. 30), *A. communis* (Fig. 31), *Anomala* sp., and two melolonthine species viz. *Schizonycha ruficollis* and *Sophrops* sp. belonging to Scarabaeidae were carried out through SEM studies. The larval morphological characters of *Anomala elata* and *A. communis* were documented. Adult morphological characters of three major species of Melolonthinae, viz. *Leucopholis lepidophora, L. burmeisteri* and *L. coneophora* and three major species of Rutelinae viz. *Anomala varivestis, A. biharensis* and *A. communis* were studied.

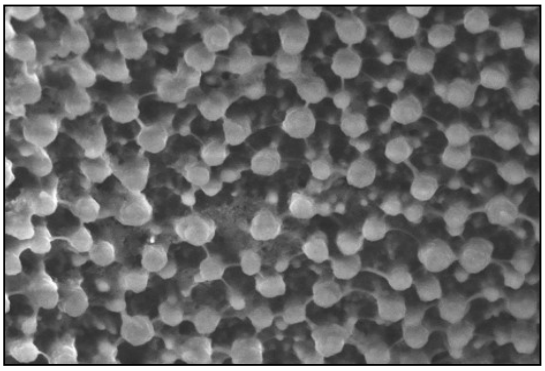


Fig. 30. Chorion ultrastructure of *Anomala elata*

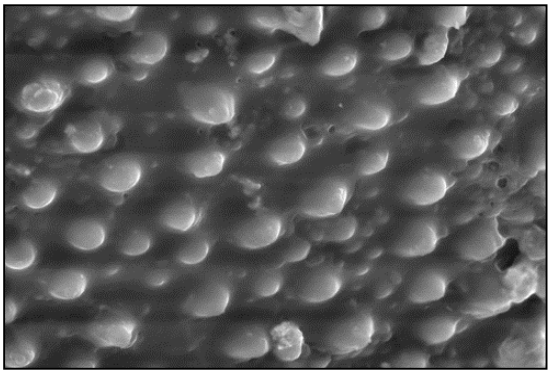


Fig. 31. Chorion ultrastructure of *Anomala communis*

Augmentation of NBAIR collection

One Thysanoptera genus (*Asprothrips*) and two species (*Asprothrips bimaculatus* and *Pseudodendrothrips darci*) were newly added to NBAIR reference collection. A total of 129 isolates of *Steinernema*, *Heterorhabditis* and *Oscheius* nematodes are being maintained on wax moth larvae. Nine *Steinernema pakistanense* isolates and one *Heterorhabditis indica* isolate were identified and added to NBAIR–EPN repository. Fifty–six species of spiders representing fifteen families including two new families collected from different agro–ecosystems were added to the NBAIR Araneae collection.

Development of diagnostics keys/tools/websites/checklists

New online database on "List of NBA voucher specimens in ICAR–NBAIR repository" (Fig 32) was prepared and uploaded in the institute website with 10 factsheets.

Fig. 32. Database on voucher specimens

A website for the fauna of Pentatomidae of India was created and maintained in the institute website (www.nbair.res.in/pentatomidae).

Digitization and database preparation was carried out for 1,385 specimens of Cerambycidae, 5085 specimens of Scarabaeidae and 87 specimens of Tephritidae as a part of cataloguing.

Identification keys to distinguish nine genera of predatory thrips belonging to three families from North East India were prepared. *Aduncothrips*, *Aeolothrips*, *Aleurodothrips*, *Androthrips*, *Franklinothrips*, *Indothrips*, *Mymarothrips*, *Karnyothrips*, *Scolothrips* were the genera included in the key. Identification keys were also made to distinguish three species of *Androthrips,* viz. *Androthrips flavipes*, *A. flabitibia* and *A. ramachandrai*.

Identification key based on the features of the male chelicera to few Indian Tetragnathids are provided.

A checklist was prepared for the genera, *Dermatodes*, *Achaenomus* and *Hyperomias* of Curculionidae.

Division of Genomic Resources

Molecular characterisation of insects

Different parasitoids, predators and other insects were collected from various crops in Karnataka, Andhra Pradesh, Maharashtra, Telangana, Gujarat and South Andaman and were used for DNA barcoding studies. Molecular characterisation and DNA barcodes were generated for 70 agriculturally important insect pests, parasitoids, predators, pollinators including invasive *S. frugiperda* based on *COI* gene (Tables 1 & 2). Twenty four populations of *S. frugiperda* collected from Gujarat, Karnataka, Telangana, Andaman and Nicobar, Andhra Pradesh and Maharashtra were identified using *COI* gene and deposited in NCBI and accession numbers were obtained. The Chikkaballapura population showed 100 % resemblance with the sequences submitted from Canada (GenBank: GU095403.1) and Costa Rica (GenBank JQ547900.1) (Fig. 33).

Whitefly occurring on banana and coconut in Assam was identified as invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* using molecular studies (*COI* gene). Veterinary pests like *Hyalomma* sp. (MH923577), *Haemaphysalis* sp. (MH937512), *Rhipicephalus microplus* (MH918000), *Rhipicephalus* sp.(TK-4) (MK123947) and *Hyalomma excavatum* (MK005261) were characterised. The following tephritids, *Platensina acrostacta* (MH748566), *Spathulina acroleuca* (MH748567) and *Dacus* (*Didacus*) *ciliatus* (MH733833) were characterised. Stored grain pests like *Corcyra cephalonica* (MK377173) and *Sitotroga cerealella* (MK377174), staphylinid beetle, *Paederus fuscipes* (MH916764) and different populations of *Bemisia tabaci* were characterised (MH807440, MH823740,MH891617, MK123947, MK568467, MK568468 and (MK497172).

Thirty three insect pests attacking medicinal plants were characterised using CO1 gene and the following insects were identified. *Spilarctia obliqua* (MK491177), *Pyrausta panopealis* (MK559412), *Apis florea* (MK491178), *Ceratina binghami* (MK559415), *Leptocentrus* sp (MK491176), *Olene mendosa* (MK455104), *Catopsilia pyranthe* (MK531549), *Aleurodicus dispersus* (MK491179), *Spodoptera litura* (MK491175), *Giaura punctata* (MK482339) and *Apocryptophagus* sp (MK569694) and DNA barcodes were generated for the same.

Around 200 specimens belonged to 18 genera, viz. *Stigmus*, *Carinostigmus*, *Sphex*, *Bembix*, *Bembicinus*, *Chalybion*, *Sceliphron*, *Chlorion*, *Psen*, *Lara*, *Liris*, *Tzustigmus*, *Carbro*, *Diodontus*, *Ammophila*, *Cerceris*, *Tachysphex* and *Gorytes* were identified using morphological characters. Molecular characterization and DNA barcodes were generated for around 25 wasps belonging to 10 genera, where the species level identity was established.

Table 1: Molecular characterisation of different populations of *Spodoptera frugiperda*

Name of the species with location	Accession no.
Spodoptera frugiperda Anakapalle (Visakhapatnam)	MH822831
Spodoptera frugiperda Bellur	MH881532
Spodoptera frugiperda Chikkaballapura	MH704433
Spodoptera frugiperda Chikkaballapura	MK079565
Spodoptera frugiperda Chinthapalle (Visakhapatnam)	MH822832
Spodoptera frugiperda Dharwad	MH822830
Spodoptera frugiperda Dharwad	MK318531
Spodoptera frugiperda Doddaballapura	MK041922
Spodoptera frugiperda Gujarat	MK279399
Spodoptera frugiperda Gujarat	MK303391
Spodoptera frugiperda Hassan	MH881533
Spodoptera frugiperda Hassan	MK327538
Spodoptera frugiperda Khammam	MH822835
Spodoptera frugiperda Latur	MK285364
Spodoptera frugiperda Nagarkurnool	MH881528
Spodoptera frugiperda Nelivada (Visakhapatnam)	MH822834
Spodoptera frugiperda Pedabathepalle (Visakhapatnam)	MH822833
Spodoptera frugiperda Pune	MH899609
Spodoptera frugiperda Rajendranagar, Hyderabad	MH881530
Spodoptera frugiperda Shimoga	MH881531
Spodoptera frugiperda Siddipet	MH881529
Spodoptera frugiperda Tirupati	MH899610
Spodoptera frugiperda Vijayawada	MH899611

***Spodoptera frugiperda* sequence (Chikaballapur) with GenBank Accession No. MH704433**

AACATTATATTTTATTTTTGGAATTTGAGCAGGAATAGTAGGTACTTCTTTAAGTTTA
TTAATTCGAGCTGAATTAGGAACTCCAGGATCTTTAATTGGAGATGATCAAATTTAT
AATACTATTGTAACAGCCCATGCTTTTATTATAATTTTTTTTTATAGTTATACCAATTA
TAATTGGAGGATTTGGAAATTGACTTGTACCTTTAATATTAGGAGCTCCTGATATAG
CTTTCCCACGTATAAATAATATAAGTTTTTGACTTTTACCCCCATCTTTAACTTTATTA
ATTTCTAGTAGCATTGTAGAAAATGGAGCAGGAACTGGATGAACAGTTTACCCCCCC
CTCTCCTCTAATATTGCTCATGGTGGTAGTTCAGTAGATTTAGCTATTTTCTCACTTC
ATTTAGCTGGAATTTCATCTATTTTAGGAGCTATTAACTTTATTACCACTATTATTAA
TATACGATTAAATAATTTATCATTTGATCAAATACCTTTATTTATTTGAGCTGTAGGTA
TTACCGCATTTTTATTATTATTATCTTTACCTGTTTTAGCTGGAGCTATTACTATATT
ACTTACTGATCGAAATCTAAATACATCATTTTTCGATCCTGCAGGAGGAGGTGATCC
TATTCTTTATCAACATTTATTT

BOLD-ID: AGIMP054-18

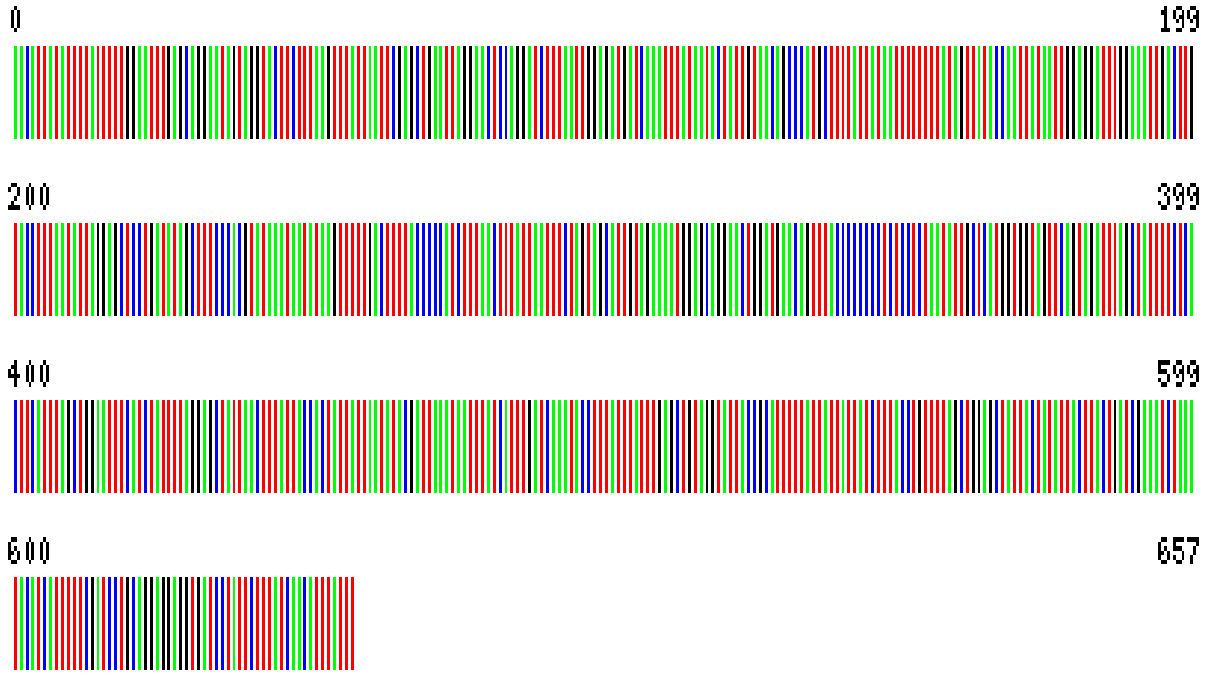
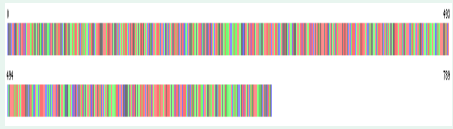
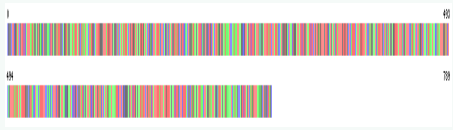
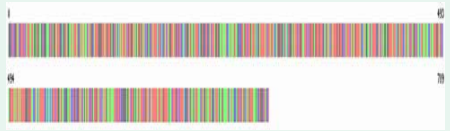
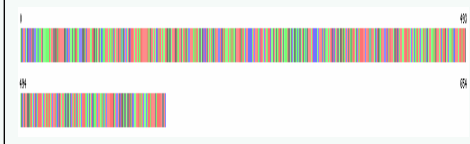
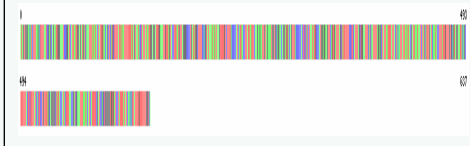


Fig. 33. Barcode image of *Spodoptera frugiperda*

Table 2: DNA barcodes generated for economically important insects

S.No.	Species	GenBank acc. no	DNA barcode	Image
1	*Aleurodicus dispersus*	MK491179		
2	*Aparteles* sp.	MH279888		
3	*Bemisia tabaci* (WF-52)	MH823740		
4	*Bemisia tabaci* (WF-54)	MH891617		
5	*Bemisia tabaci*	MH807440		
6	*Dacus ciliatus*	MH74866		
7	*Eocanthecona furcellata*	MH795079		
8	*Haemaphysalis* sp.	MH937512		

9	*Hyalomma excavatum*	MK005261		
10	*Hyalomma* sp.	MH923577		
11	*Leptocentrus* sp.	MK491176		
12	*Mythimna separata*	MH252215		
13	*Platensina acrostacta*	MH748566		
14	*Rhipicephalus microplus*	MH918000		
15	*Spathulina acroleuca*	MH748567		
16	*Spilarctia obliqua*	MK491177		
17	*Spodoptera frugiperda*	MK279399		

Studies on population genetic diversity in pink stem borer

The genetic variability of 20 populations of *Sesamia inferens* was investigated by PCR analysis of DNA using 47 SSRs, from that only 6 SSRs produced scorable polymorphic markers in each DNA sample and remaining 41 SSRs were found to produce a single monomorphic band in DNA of all population

samples. The primer SI SSR37 was found to be highly informative to differentiate the host associated populations with a polymorphism information content value of 0.81. The result of UPGMA dendrogram and Principal Component Analysis by using Jaccards Similarity Coefficient data, different populations of *S. inferens* were clustered according to host (Fig. 34). These results suggest a low level of inter-population gene flow in pairwise populations from sorghum, sugarcane, maize and rice fields in India. Such levels of differentiation among populations may indicate only a moderate dispersal capacity of *S. inferens*, even when no remarkable geographic barriers exist.

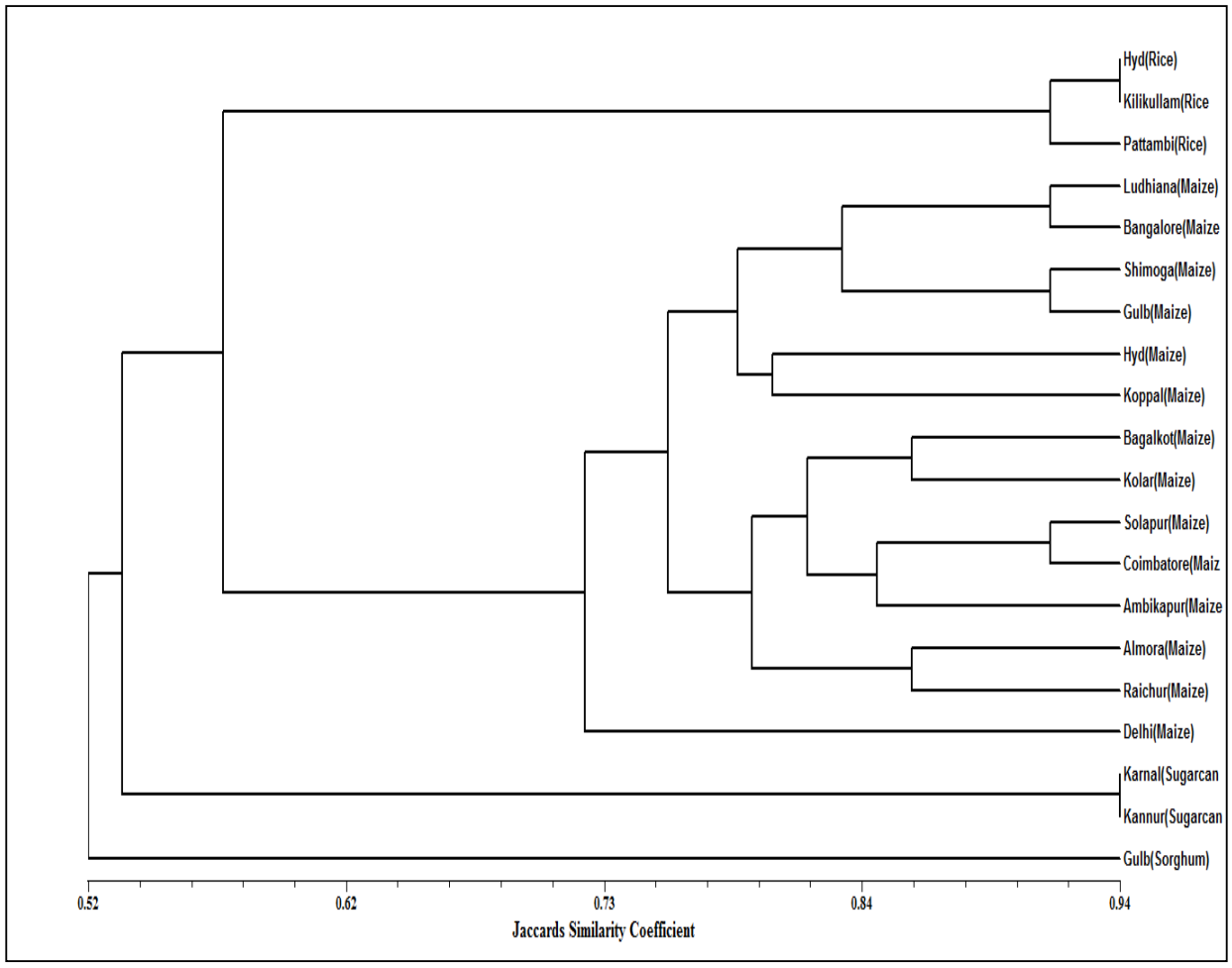


Fig. 34 . Dendrogram from Jacards Coefficient matrices of pairwise similarity in SSR analysis between twenty populations of *S. inferens* using the un-weighted pair-group method analysis, UPGMA

Gene expression analysis in brinjal shoot and fruit borer

Taking advantage of the whole genome sequence information, the present study investigated the level of insecticide and the expression pattern of individual carboxylesterase (CE) and glutathione S-transferases (GST) genes in various field collected populations of brinjal shoot and fruit borer, *Leucinodes orbonalis*. Dose-mortality bioassays revealed a very high level of resistance development against fenvalerate (48.20 to 160.00 folds), phosalone (94.00 to 534.60 folds), emamectin benzoate (7.20 to 55.00 folds), thiodicarb (9.64 to 22.70 folds), flubendiamide (187.40 to 303.00 folds) and chlorantraniliprole (1.60 to 8.60 folds) in field populations as compared to the laboratory-reared susceptible iso-female colony (Lo-

S). Over-production of detoxification enzymes, viz. carboxylesterases (CE) and glutathione S-transferases (GST) were evident upon enzyme assays. Mining of the draft genome of *L. orbonalis* yielded large number of genes potentially belonging to the CE and GST gene families with known history of insecticide resistance in other insects. Subsequent RT-qPCR studies on relative contribution of individual genes revealed significant over-expression of numerous GSTs (Fig. 35) in field populations, indicating co-evolution of multiple modes of insecticide resistance. The genomic information will facilitate development of novel resistance management strategies against this pest.

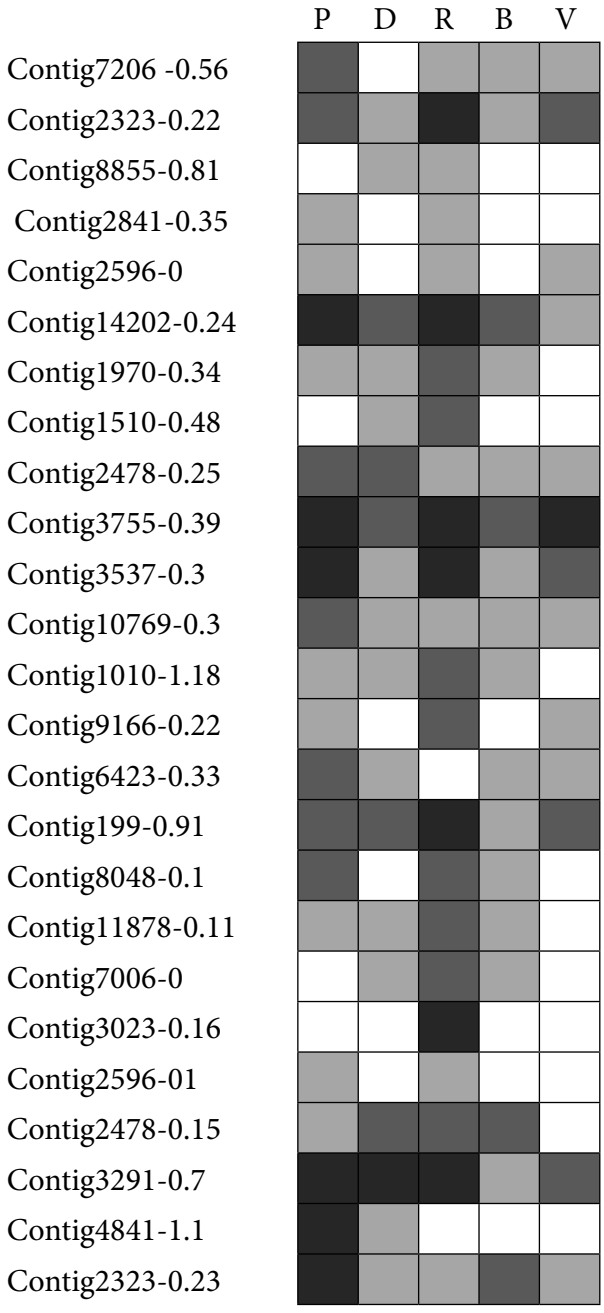


Fig. 35. Expression profiles (fold changes over Lo-S population) of glutathione-S-transferase genes across field collected *Leucinodes orbonalis* populations (P-Pune; D-Dharmapuri; R-Raichur; B-Bhubaneswar; V-Varanasi). The fold changes are indicated in different shades which indicate significant difference as per Mann-Whiteney U-test *P*-value<0.05

The qualitative differences in carboxylesterase isozymes were visualised under native PAGE after incubation of the gels in the α-napthyl acetate as substrate. Among the four major esterase activity bands (E_1 to E_4), the high molecular weight E_1 and E_2 bands were totally absent in Lo-S and Pune populations and faint in case of Varanasi population. However, the E_1 band was very prominent and intense in other field populations indicating its nature of over-production (Fig. 36).

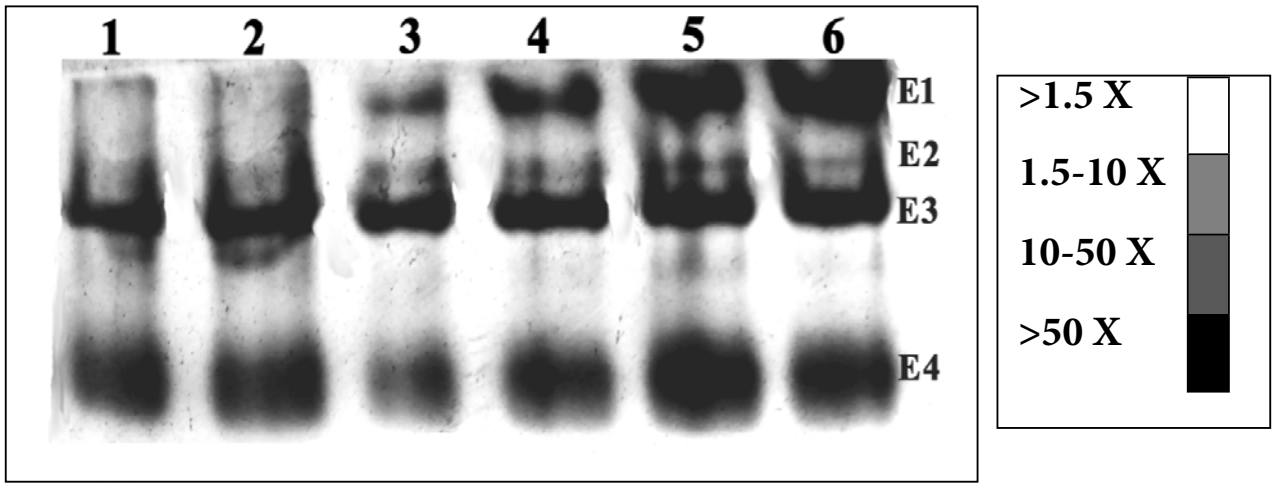


Fig. 36. Native PAGE analysis of esterase isozyme of *Leucinodes orbonalis* (1. Lo-S, 2. Pune, 3. Varanasi, 4. Raichur, 5. Bhubaneswar, 6. Dharmapuri)

Studies on insecticide and Bt resistance in pink bollworm, *Pectinophora gossypiella*

Bioassays were carried out with *Bt* toxins, Cry1Ac and Cry2Ab for Jolarpet population. The LC_{50} values for Cry1Ac and Cry2Ab for the field population from Jolarpet were recorded to be 14.61 and 18.98 ppm respectively. These were compared with the corresponding LC_{50} values for the laboratory susceptible population (2.39 ppm and 9.67 ppm respectively) and the resistance ratios were calculated to be 6.11 and 1.96 for Cry1Ac and Cry2Ab respectively. Bioassays were also carried out in pink bollworm populations with Cypermethrin and Fipronil. The LC_{50} values of Vadodara and Bharuch populations for Cypermethrin were 7.725 ppm and 10.377 ppm respectively. The LC_{50} value of Jolarpet population for Fipronil was recorded to be 2.759 ppm.

The midgut of the fourth instar larvae of pink bollworm from different populations were dissected out and stored in Phosphate buffer in -20 °C. Protein estimation was done for these samples using Bradford's method. Formation of protein-dye complex which has an absorbance maximum at 595 nm was estimated using Uv-Vis spectrophotometer. The protein content estimated in µg/µl for different populations varied from 2.3809 µg/µl to 7.7143 µg/µl.

The activity of carboxyl esterases was estimated by microplate assay using α-naphthyl acetate as substrate and Fast Blue BB salt as staining solution. The formation of α-naphthol was monitored at 590 nm. Jolarpet population recorded the maximum enzyme activity of 4.4940 µmoles of enzyme/mg of protein/min. This was 2.22 times of that of the enzyme activity in the laboratory susceptible population which was 2.0282 µmoles of enzyme/mg of protein/min. Staining of non-specific esterases of different pink bollworm populations were done on native PAGE (Fig. 37). Staining of the gel was done using α-naphthyl acetate as substrate and Fast Blue BB salt as staining solution. The results depicted two esterase bands for all the field populations whereas in the laboratory susceptible population, there was only one esterase band.

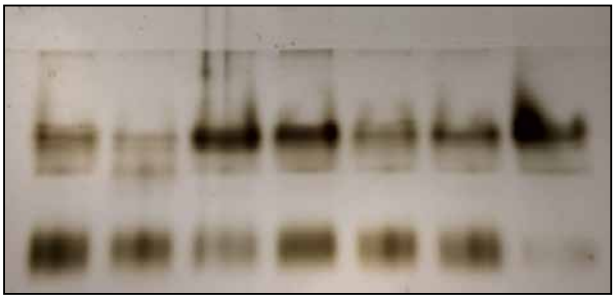


Fig. 37. Staining of non-specific esterases of different populations of *Pectinophora gossypiella* (Lane 1: Botad; Lane 2: Jolarpet; Lane 3: Vadodara; Lane 4: Bhavnagar; Lane 5: Surat; Lane 6: Bharuch; Lane 7: Susceptible strain)

Molecular docking studies of insecticide resistance gene of storage pests: *Tribolium castaneum* and *Callosobruchus maculatus*

The gene sequences related to insecticidal resistance in storage pests were retrieved from public domain and structure prediction was carried out for the resistant gene Cytochrome P450 for the organism, *Tribolium castaneum* by using the softwares, Uniprot and Swiss Model.

Studies on induction of hormones and its effect on biology of pink mealybug

Bioassays and life-table analysis were done for field populations of *Maconellicoccus hirsutus* using sublethel doses of agrochemicals viz. Gibberellic acid (500 ppm and 250 ppm), Buprofezin (1 ml/l, 1.5 ml/l) and Imidacloprid (0.25 ml/l, 0.5 ml/l). Results indicated that GA at sublethal dose (500 ppm) have increased the fecundity (283.6/female) and shortened the longevity of the nymphs (21.03 days), whereas the insecticides were reported to have shortened the nymphal period (18.6 and 19.2 days) when compared to that of the control (23.6 days).

Division of Germplasm Conservation and Utilisation

Studies on invasive fall armyworm (FAW), *Spodoptera frugiperda*

Incidence of *Spodoptera frugiperda*

Based on the surveys conducted from July to August 2018 by NBAIR team, *Spodoptera frugiperda* was recorded from many locations in Karnataka on maize crop. Surveys were conducted in several districts of Karnataka comprising of Chikkaballapur, Hassan, Shivamogga, Davanagere and Chitradurga, Raichur and Dharwad to record the incidence of *S. frugiperda,* where the maize crops were in the age of 15–60 days. The incidence ranged from 9.0 to 62.5% at various locations. Maximum incidence was recorded in Hassan district followed by Chikkaballapur, Davanagere, Shivamogga and Chitradurga. During the field survey, the larvae were found to be infected with the entomopathogenic fungus, *Nomuraea rileyi*.

Mass production of *S. frugiperda*

Potato was used for mass production of FAW. Rearing on wet potato resulted in increased size of larvae but recorded death rate up to 10 percent. Dry potato was found to be the best suited for mass production. Rearing on castor leaf yielded good population but heavy cannibalism was noticed. Diet supplemented with maize leaf powder with yeast powder yielded good rate of survival and observed no cannibalism.

Parasitoid complex obtained from *S. frugiperda*

The natural enemy complex of FAW, including *Glyptapanteles creatonoti*, *Campoletis chlorideae*, *Phanerotoma* sp., *Chelonus* sp. and *Trichomalopsis* sp. was reported first time from India. *Spodoptera frugiperda* is the first host record for *G. creatonoti* across the globe. *G. creatonoti*, being a well established parasitoid of various noctuids in India and Malaysia, was capable of parasitizing *S. frugiperda*. Besides these, severak predators like earwig, *Forficula* sp, predatory bugs like *Andrallus spinidens* and *Eocanthecona furcellata* were identified. In addition to this, one dipteran parasitoid, *Pseudgourax* sp. was also recorded on the egg mass of fall armyworm. The maggots were found feeding on the eggs thereby showing a potential for the management of FAW.

Characterisation of viruses against *S. frugiperda*

Surveys were made at maize and sugarcane fields of Chikkaballapura, Pugalur, Coimbatore and Jolarpettai to collect the diseased larvae of *S. frugiperda,* showing characteristic viral infection symptoms (Fig. 38). Observation of discharged body fluid of diseased larvae under a phase-contrast microscope revealed occlusion bodies (OBs) of nucleopolyhedrovirus (Fig. 39). Under SEM, the OBs of *Spodoptera frugiperda* NPV appeared tetrahedral in shape. TEM of the OBs revealed the tetrahedral shape with size of polyhedra to be 1.64 µm (Fig. 40). Bioassay studies revealed that larval mortality was observed at low doses of Spfr with the LC_{50} of 1×10^6

OBs/ml against second instar larvae of *S. frugiperda*. The 95 % fiducial limits ranged from 1.216 to 3.457. The LC_{50} values observed for second instar larvae was 2.17 POBs/mm^2 for Spfr. Field evaluation of *S. frugiperda* NPV is in progress.

Fig. 38. Diseased larvae of *Spodoptera frugiperda* showing characteristic viral infection symptoms

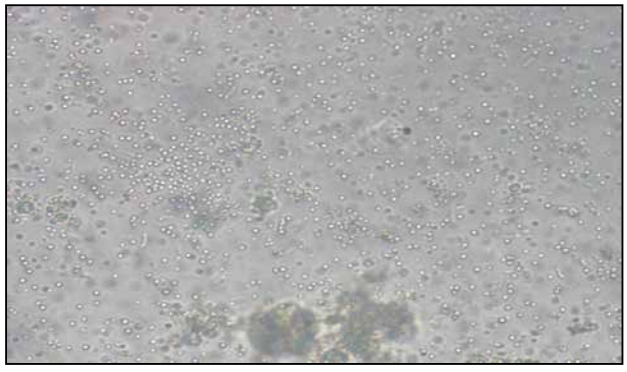


Fig. 39. Light micrograph of body fluid obtained from diseased larvae of *Spodoptera frugiperda* showing the occlusion bodies of *Spfr*NPV

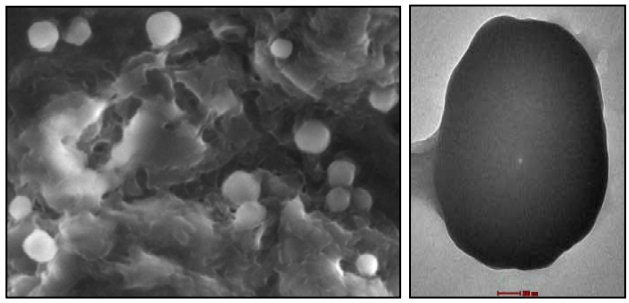


Fig. 40. Scanning (a) and transmission (b) electron micrographs of tetrahedral occlusion bodies of *S. frugiperda* NPV extracted from infected larvae of *S. frugiperda*

Evaluation of entomopathogenic fungi against *S. frugiperda*

Ten entomofungal strains were evaluated against second instar larvae of *S. frugiperda* in laboratory bioassays. Among the ten EPF isolates tested, *Metarhizium anisopliae* NBAIR-Ma-35 caused 67.8% mortality followed by *Beauveria bassiana* NBAIR-Bb-45 with 64.3% and Bb-11 with 57.1% mortality. Rest of the isolates showed 10.7-28.6% mortality (Table 3).

Field evaluation with *B. bassiana* (NBAIR Bb-45) and *M. anisopliae* (NBAIR Ma-35) were carried out in 45 days old crop against *S. frugiperda* in maize during rabi season (September-December 2018) in Thondebavi, Dodaballapura and results showed 66 and 56% of pest reduction, respectively. Similar experiments conducted against *S. frugiperda* in maize during rabi season (November 2018 to February 2019) in NBAIR Yelahanka Attur Farm showed 79 and 80% of pest reduction, respectively (Table 4-6).

Table 3. Screening of entomofungal strains against fall army worm

Isolate	% Mortality
Bb-5a	28.6^{b}
Bb-11	57.1^{a}
Bb-45	64.3^{a}
Ma-4	21.4^{bc}
Ma-11	10.7^{bc}
Ma-14	21.4^{bc}
Ma-15	17.8^{bc}
Ma-35	67.8^{a}
Nr-1	14.3^{bc}
Nr Sf-1	21.4^{bc}
Control	6.67^{c}
CD@1%	**3.447**

Table 4. Field evaluation of entomopathogenic fungi against FAW in maize at Attur farm

Isolate	Pre count	No. of larvae / plant (after 3 sprays)	% decrease over control	% leaves infested	No. of plants infested/ 10 plants	Average yield/10 plants (kg)
Bb-45	2.17	0.31[a]	79.0	10.40[a]	2.19[a]	4.53[a]
Ma-35	2.20	0.30[a]	80.0	8.93[a]	2.62[a]	4.97[a]
Control	2.80	1.10[b]	-	77.14[b]	7.24[b]	1.72[b]
CD@5%	NS	0.145	-	5.88	0.93	0.798

Table 5. Field evaluation of entomopathogenic fungi against FAW in maize in Dodaballapura

Isolate	Pre count	No. of larvae / plant (3 sprays)	% decrease over control	% leaves infested	No. of plants infested/ 10 plants	Average cob yield/10 plants (kg)
Bb-45	2.14	0.67[a]	55.92	22.96[a]	3.14[a]	3.51[a]
Ma-35	2.00	0.52[a]	65.79	23.66[a]	2.71[a]	3.83[a]
Control	2.43	1.52[b]	-	72.35[b]	8.43[b]	1.54[b]
CD@ 5%	NS	0.210	-	5.94	0.93	0.402

Table 6. Field evaluation of entomopathogenic fungi against FAW in maize in Gowribidanur district

Isolate	Pre count	No. of larvae / plant (3 sprays)	% decrease over control	% leaves infested	No. of plants infested/ 10 plants
Bb-45	3.17	0.39[a]	79.58	13.77[a]	2.24[a]
Ma-35	3.43	0.58[a]	69.63	12.50[a]	2.33[a]
Control	3.21	1.91[b]	-	70.24[b]	6.62[b]
CD@5%	NS	0.101	-	7.898	0.847

Bioefficacy and field efficacy of WP formulation of EPN species on the management of fall army worm (FAW) in *kharif* and *rabi* maize

Prophylactic application of WP formulation of *H. indica* @ 6 kg/ha at 15 and 45 days after emergence reduced FAW infestation by 65-72% during kharif and 58-64% during rabi, while 45-65% reduction was observed in emamectin benzoate treated field. Yields per plant were on par. Due to plant mortality and stand/m^2, significant differences in productivity were observed in treated and untreated. We report that EPN can be a tangible component in integrated management of FAW in maize.

Evaluation of *Bacillus thuringiensis* strain against *S. frugiperda*

The *Bacillus thuringiensis* strain NBAIR-BT25 was characterised as a new isolate to combat the invasive pest, *S. frugiperda*. It showed an LC_{50} of 44.7 µg/ml (Table 7). Liquid formulation was

developed for field evaluation and a field trial was carried out in maize field at farmers' fields in Doddaballapur, Karnataka and Hindupur, Andhra Pradesh. Observations showed that there was 69.4% and 70% reduction in pest damage, respectively after two sprays of NBAIR-BT25. The strain was also evaluated in NBAIR research farm in maize and found that NBAIR-BT25 incited 81% decrease in pest population based on larval mortality. NBAIR-BT25 was supplied to 9 KVK and 3 AICRP centers for limited evaluation.

Table 7. *In vitro* bioassay of NBAIR *Bacillus thuringiensis* isolates against *Spodoptera frugiperda*

Treatment	Time (h)	LC_{50} (µg/ml)	Fiducial limits		Slope ± SE	Chi square	*P*
			Lower	Upper			
NBAIR-BT25	96	44.718	34.691	56.915	2.618 ± 0.389	4.294	0.001
NBAIR-BT1	96	57.299	43.341	76.933	2.146 ± 0.342	0.366	0.001
NBAIR-BT4	96	94.955	69.956	143.322	1.926 ± 0.345	0.443	0.001
NBAIR-BT5	96	211.571	140.262	501.689	1.889 ± 0.436	0.782	0.001
NBAIR-BT6	96	114.209	77.459	216.169	1.496 ± 0.316	0.060	0.001

Development of efficient fermentation medium and formulations of *Bacillus thuringiensis*

A strategy was developed to test the use of molasses as carbon supplement in growth medium along with addition of different flours. Protein content was significantly high in all the flour amended media tested and maximum protein content was 13.4 µg/ml.

Push–pull strategy for the management of *S. frugiperda*

A push–pull strategy consisting of growing fodder legume, *Desmodium gangeticum* (as an intercrop to repel adult moths from oviposition) and Napier grass (as border crop to attract adult moth for oviposition) was evaluated for fall armyworm management. The number of egg patches per 5 plants and number of live larvae per plant were significantly higher in the border crop (napier grass) and sole crop of maize when compared to maize intercropped with *D. gangeticum*.

Integrated management of *S. frugiperda*

IPM field trials using parasitiods, predators, *Bt,* pheromone traps and *B. bassiana* (NBAIR Bb-45) and *M. anisopliae* (ICAR–NBAIR Ma-35) were carried out in 30 days old crop against *S. frugiperda* in maize during rabi season (December 2018-March 2019) in Obuli village, Gauribidanur and results showed 79 and 70% of pest reduction, respectively.

An IPM trial was conducted to manage fall armyworm at Manchanahalli, Gauribidnaur, Karnataka covering 1.5 acre area (Figs 41-45). In IPM field, percent decrease in egg mass was 98 percent at 80 DAT whereas in the field with farmers' practice, it was 8.5 percent. Similarly larval population also decreased by 79.16 percent in IPM field compared to that of farmers' practice, where 12.5 percent reduction was observed. Every week more than 20 adults were caught in pheromone traps. In IPM field, per cent parasitism by *Trichogramma* spp. varied from 8.19-18.25 percent. Per cent parasitism was higher for *Trichogramma* sp. compared to *T. remus*.

Fig. 41. Egg patch on plant

Fig. 42. Fall armyworm moth

Fig. 43. Fungus-infected larvae

Fig. 44. IPM field: before release of bioagents

Fig. 45. IPM field: after release of bioagents

Studies and evaluation of entomopathogens against various insect pests

Evaluation of enotmofungal pathogens

All four isolates, viz., Bb5a, Bb45, Ma4 and Ma35 of *Beauveria* and *Metarhizium* showed varied colonisation and persistence in root, stem and leaf bits of cabbage during 15-60 DAT in different methods of inoculation. In seed treatment, all four isolates showed colonisation in leaf, stem and root parts for upto 30 DAT. Ma-35 isolate showed colonisation and persistence in leaf bits upto 60 DAT (Table 8).

In root inoculation method, all isolates except Bb-5a showed colonisation in leaf and stem parts upto 15 DAT. Ma-35 isolate showed colonisation and persistence in root, stem and leaf bits upto 60 DAT (Table 9).

In foliar application technique, all four isolates showed colonisation and persistence in stem and leaf tissues upto 15 DAT. Bb-45, Ma-4 and Ma-35 isolates showed colonisation and persistence for upto 60 DAT in leaf tissues whereas Bb-5a showed colonisation upto 15 DAT (Table 10).

The genomic DNA extracted from *B. bassiana* and *M. anisopliae* treated root, stem and leaf bits showed amplification at 450bp with *B. bassiana* and *M. anisopliae* specific primers. The genomic DNA extracted from untreated tissues (control) failed to amplify any PCR product of cabbage plant (Figs 46-48).

Scanning Electron Microscope (SEM) studies with EPF treated 5-day old leaf samples indicated conidial attachment and germination of all four isolates on cabbage leaf surface. Germ tubes were gradually elongated and penetrated into the epidermal cell layer. No conidia were found on untreated leaf surface (Fig. 49).

Transmission Electron Microscope (TEM) with EPF treated 15-day old leaf samples indicated presence of spore-like structures of all isolates inside the parenchymatic and mesophyll cells. No such structures were found in the untreated leaf.

Table 8. Colonisation and persistence of *B. bassiana* and *M. anisopliae* isolates in cabbage by seed treatment method

Isolate	Colonisation (%)											
	Root				Stem				Leaf			
	Days after treatment				Days after treatment				Days after treatment			
	15	30	45	60	15	30	45	60	15	30	45	60
Bb5a	33.3	8.3	-	-	8.3	8.3	-	-	12.5	12.5	-	-
Bb45	12.5	8.3	-	-	20.83	4.17	-	-	8.3	8.3	-	-
Ma4	29.17	25.0	-	-	-	20.83	12.5	-	-	25.0	-	-
Ma35	33.3	16.7	-	-	41.7	4.17	-	-	20.83	4.17	8.3	12.5
Control	-	-	-	-	-	-	-	-	-	-	-	-

Table 9. Colonisation and persistence of *B. bassiana* and *M. anisopliae* isolates in cabbage by root inoculation method

Isolate	Colonisation (%)											
	Root				Stem				Leaf			
	Days after treatment				Days after treatment				Days after treatment			
	15	30	45	60	15	30	45	60	15	30	45	60
Bb5a	-	-	-	-	0.00	-	-	-	-	-	-	-
Bb45	-	-	-	-	20.83	-	-	-	4.17	-	-	-
Ma4	8.30	20.83	25.0	-	25.00	4.17	-	-	25.00	-	-	-
Ma35	-	-	16.7	74.17	33.30	37.50	4.17	33.3	25.00	8.30	8.3	12.5
Control	-	-	-	-	-	-	-	-	-	-	-	-

Table 10. Colonisation and persistence of *Beauveria bassiana* and *Metarhizium anisopliae* isolates in cabbage by foliar application method

Isolate	Colonisation (%)											
	Root				Stem				Leaf			
	Days after treatment				Days after treatment				Days after treatment			
	15	30	45	60	15	30	45	60	15	30	45	60
Bb5a	-	-	-	-	20.8	-	-	-	12.5	-	-	-
Bb45	-	-	-	-	66.7	8.3	4.16	-	33.3	8.3	8.3	4.17
Ma4	-	-	-	-	33.3	12.5	16.7	20.83	16.7	16.7	12.5	12.5
Ma35	-	-	-	-	66.7	8.3	-	-	62.5	16.7	8.3	8.3
Control	-	-	-	-	-	-	-	-	-	-	-	-

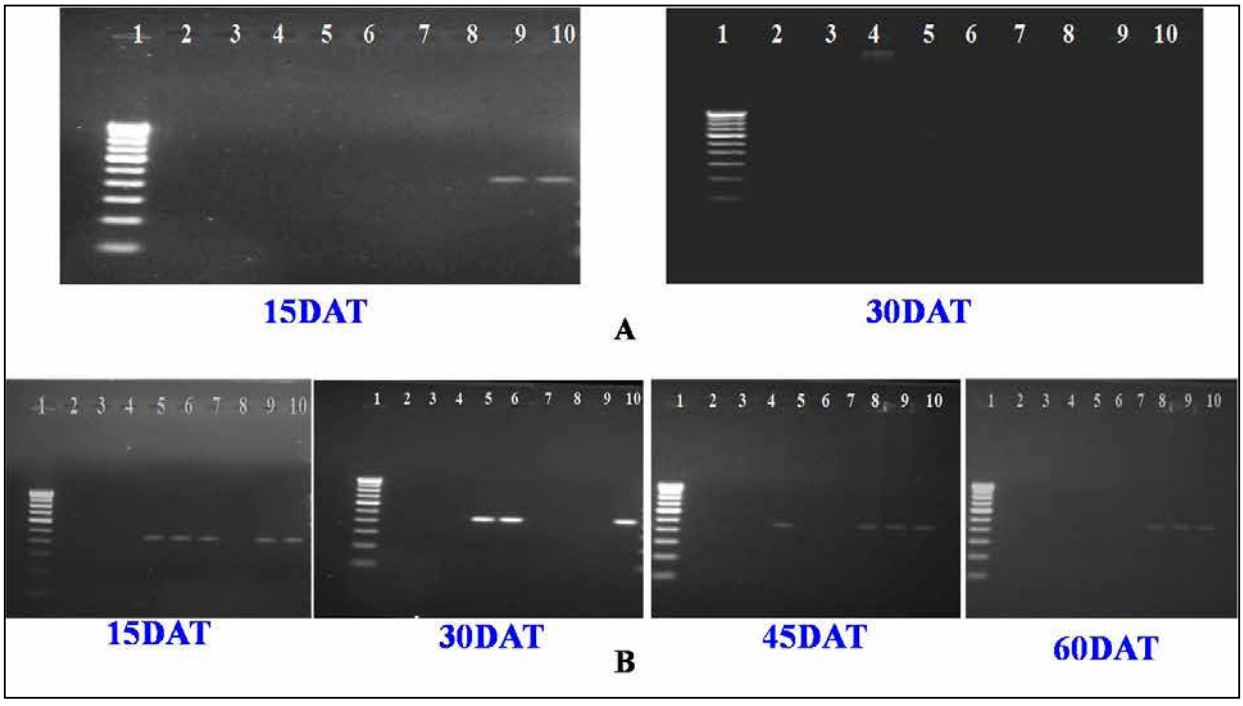


Fig. 46. A. PCR amplification of *Beauveria bassiana*-specific primer from seed treated and untreated cabbage plant parts at different intervals. Lane 1-10: 1-100bp ladder, 2-Control root, 3-Control stem, 4-Control leaf, 5-Bb-5a root, 6-Bb-5a stem, 7-Bb-5a leaf, 8-Bb-45 root, 9-Bb-45 stem, 10-Bb-45 leaf; B. PCR amplification of *Metarhizium anisopliae*-specific primer from seed-treated and untreated cabbage plant parts at different intervals. Lane 1-10; 1-100bp ladder, 2-Control root, 3-Control stem, 4-Control leaf, 5-Ma-4 root, 6-Ma-4 stem, 7-Ma-4 leaf, 8- Ma-35 root, 9-Ma-35 stem, 10-Bb-35 leaf

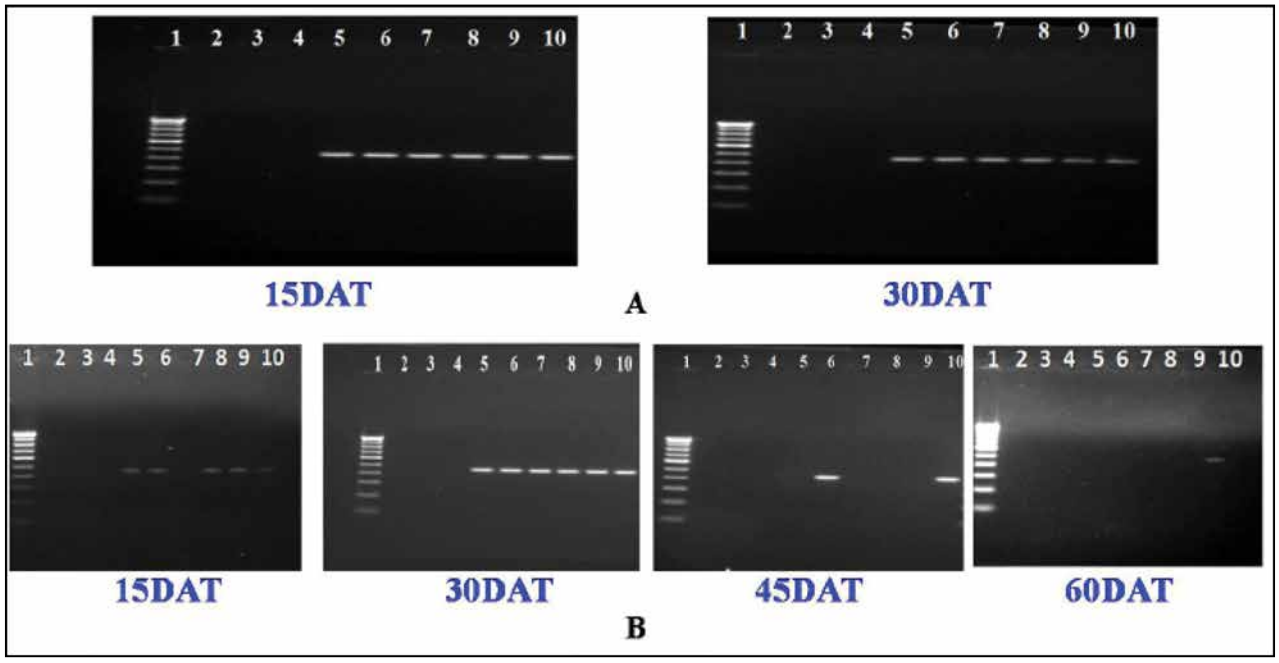


Fig. 47. A. PCR amplification of *Beauveria bassiana* specific primer from root inoculation treated and untreated cabbage plant parts at different intervals. Lane 1-10: *B. bassiana* 1-100bp ladder, 2-Control root, 3-Control stem, 4-Control leaf, 5- Bb-5a root, 6-Bb-5a stem, 7-Bb-5a leaf, 8- Bb-45 root, 9-Bb-45 stem, 10-Bb-45 leaf; B. PCR amplification of *Metarhizium anisopliae* specific primer from root inoculation treated and untreated cabbage plant parts at different intervals. Lane 1-10: *M. anisopliae* 1-100bp ladder, 2-Control root, 3-Control stem, 4- Control leaf, 5- Ma-4 root, 6-Ma-4 stem, 7-Ma-4 leaf, 8- Ma-35 root, 9-Ma-35 stem, 10-Bb-35 leaf

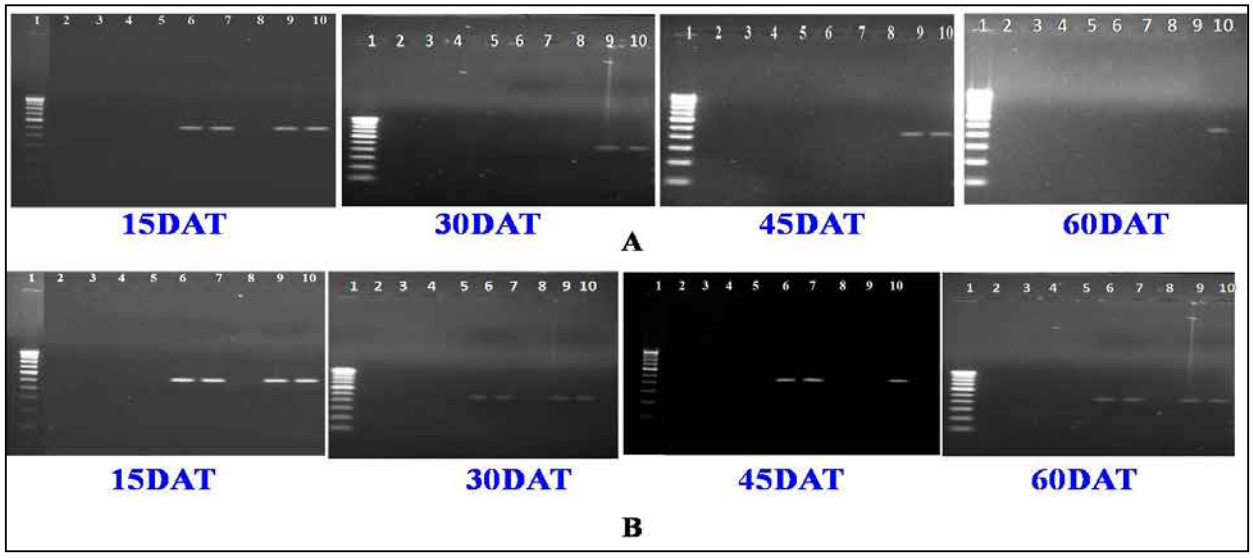


Fig. 48. A. PCR amplification of *Beauveria bassiana* specific primer from foliar application treated and untreated cabbage plant parts at different intervals. Lane 1-10: *B. bassiana* 1-100bp ladder, 2-Control root, 3-Control stem, 4-Control leaf, 5- Bb-5a root, 6-Bb-5a stem, 7-Bb-5a leaf, 8- Bb-45 root, 9-Bb-45 stem, 10-Bb-45 leaf; B. PCR amplification of *Metarhizium anisopliae* specific primer from foliar application treated and untreated cabbage plant parts at different intervals. Lane 1-10: *M. anisopliae* 1-100bp ladder, 2-Control root, 3-Control stem, 4- Control leaf, 5- Ma-4 root, 6-Ma-4 stem, 7-Ma-4 leaf, 8- Ma-35 root, 9-Ma-35 stem, 10-Bb-35 leaf

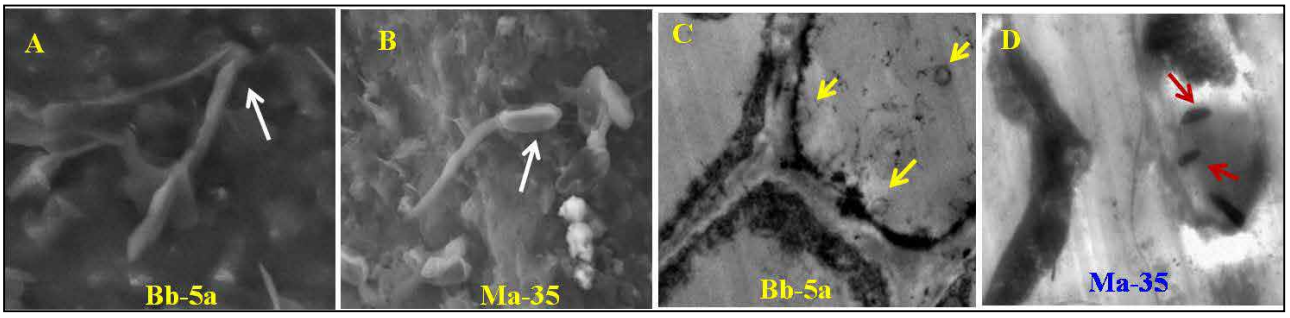


Fig. 49. SEM: A and B-Spore germination and penetration on cabbage leaf; TEM: C and D-conidia inside the parenchymatic and mesophyll cells of cabbage leaf

Evaluation of *Spilosoma obliqua* NPV

Field evaluation of *Spilosoma obliqua* nucleopolyhedrovirus (SpobNPV) against jute hairy caterpillar, *Spilosoma obliqua* in jute revealed 68.92%, 78.59% and 93.16% reduction in larval population of *S. obliqua,* respectively at 3, 4, 7 days after spray of SpobNPV (1.5×10^{12} POBs/ha @ 2ml/L). Spraying of *Bacillus thuringiensis* var. *kurstaki* @ 2ml/l showed 51.36%, 70.91% and 80.71% reduction in the larval numbers respectively at 3, 4, 7 days after spray (Table 11).

Table 11. Field evaluation of *Spilosoma obliqua* nucleopolyhedrovirus (SpobNPV) on jute

Treatment	Pre-treatment	Larvae/ 25 plants days after spray			Reduction in larval population (%)		
		3 DAS	4 DAS	7 DAS	3 DAS	4 DAS	7 DAS
SpobNPV (1.5×10^{12} POBs/ha)@ 2ml/l	36.25	13.10^{a}	9.75^{b}	1.21^{ab}	68.92	78.59	93.16
Bacillus thuringiensis (2ml/l)	35.50	20.50^{c}	13.25^{b}	3.15^{b}	51.36	70.91	80.71
Profenophos 50 E.C.@2ml/l	38.00	9.55^{a}	4.55^{a}	0.95^{a}	77.34	90.01	96.14
Control	37.00	42.15^{d}	45.55^{c}	19.45^{c}	0.00	0.00	0.00
CD (P=0.05)		5.12	4.12	1.31	-	-	-

Application of *Spodoptera mauritia* nucleopolyhedrovirus (SpmaNPV) under field conditions at the rate of 1×10^{7} POBs/ml was found effective in reducing the rice armyworm larvae from 36.45 to 1.33 followed by the concentration 1×10^{6} POBs/ml which reduced it from 40.25 to 3.15. Chlorpyriphos reduced the larval numbers from 37 to 0.75.

Rearing of mites

Small-scale rearing methods for *Amblyseius largoensis*, *Paraphytoseius orientalis* and *Scapulaseius suknaensis* were developed.

Evaluation of entomopathogens against mites

Metarhizium anisopliae isolate IF(Gm)90 was found to be pathogenic to a range of phytophagous mites. It was able to cause 90% mortality within 7 days.

Evaluation of *Pseudomonas fluorescens* strain NBAIR-PFDWD for the management of sucking pest *Scirtothrips dorsalis* in *Capsicum annuum*

Ecologically important group of PGPR pseudomonads competitively colonises plant roots, suppresses diverse plant pests and pathogens and further enhance plant growth. This particular group of fluorescent pseudomonads produces a cocktail of exoproducts with broad-spectrum toxicity mainly 2,4-diacetylphloroglucinol (DAPG),

pyoluteorin (PLT), pyrrolnitrin (PRN), phenazines (PCN), hydrogen cyanide (HCN), lipopeptides and exoproteases against various pests. *Pseudomonas fluorescens* strain NBAIR-PFDWD was very effective in the management of *S. dorsalis* under protective cultivation of export quality *C. annuum* (Fig. 50) during the month of September 2018. Lesser population (<4%) of *S. dorsalis* for a period of four months was recorded in one acre protected cultivation of *C. annuum*.

Fig. 50. *Pseudomonas fluorescens* strain NBAIR-PFDWD for the management of *S. dorsalis* in *C. annuum* under protected cultivation

Under open field condition, *P. fluorescens* strain NBAIR-PFDWD was very effective in management of *S. dorsalis* at NBAIR, Yelahanka campus. Among the different treatments, imidacloprid was very effective followed by NBAIR-PFDWD strain and consortia of NBAIR-PFDWD and CHA0 strains. Two sprays of *P. fluorescens* given @ 2% effectively controlled the population of *S. dorsalis* under field conditions.

Plant growth promotion of *Capsicum annuum* under field conditions

The direct action of PGPR through the production or alteration of phytohormone concentrations, nitrogen fixation, solubilisation of phosphate minerals or other soil nutrients, sulfur oxidation, increased root permeability, and production of siderophores is a reported phenomenon. In our study, PGPR *P. fluorescens* enhanced the vegetative growth of *C. annuum* with increased yield when compared to that of chemical check and untreated control. Growth parameters like shoot length, number of fruits per plant, fruit length, weight of fruits per plot, shoot dry weight and root dry weight were significantly enhanced in NBAIR-PFDWD strain treated plants (Fig. 51) compared to that of chemical check and untreated control.

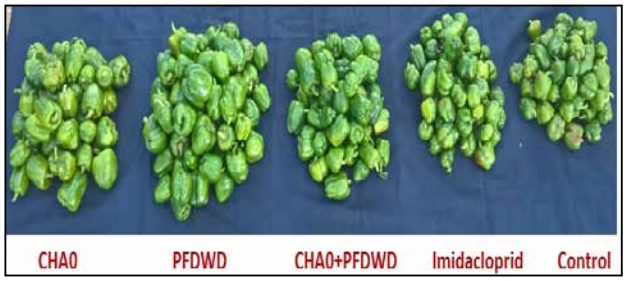


Fig. 51. Representative image to show the growth promotion activity of PGPR in *Capsicum annuum* under field conditions

Characterisation of sweet basil (*Ocimum basilicum*) oil

Sweet basil oil was characterised by gas chromatography. Among the compounds in basil oil, methyl chavicol was 80.3%. This was followed by linalool, which constituted 10.76 per cent. Methyl chavicol though present at higher concentration cannot be used for pest management, as it is carcinogenic.

Nanoemulsion of basil oil

Nanoemulsions of sweet basil oil prepared were thermodynamically stable without phase separation and turbidity. Characterisation was done adopting free thaw test and droplet size and polydispersity index after 60 days of storage. The droplet size was 70 nm for sweet basil oil (Fig.52). Transmission Electron Microscopy revealed that sweet basil oil-Tween 80 (1:1) droplets exhibited size range between 30 nm and 50 nm on first day. There was a gradual increase in the droplet size after 30 days and it was 200 nm after 60 days

Efficacy of nanoemulsion on housefly and mosquito

Nanoemusion at (1:1) ratio with Tween 80 was found to be toxic to housefly, mosquito and phorid fly larvae. Nano size particles had a better surface area and hence were more toxic to the target pest than bulk emulsion that had the droplets of micron size and which were prone to quick agglutination as compared to nanoemulsion. There was no heavy flocculation even after 60 days of storage. House fly larvae when exposed to basil oil showed shrinkage of the integument, causing mortality of the larvae (Fig.53). Similar effects were observed when mosquito larvae were exposed to basil oil (Table 12-13).

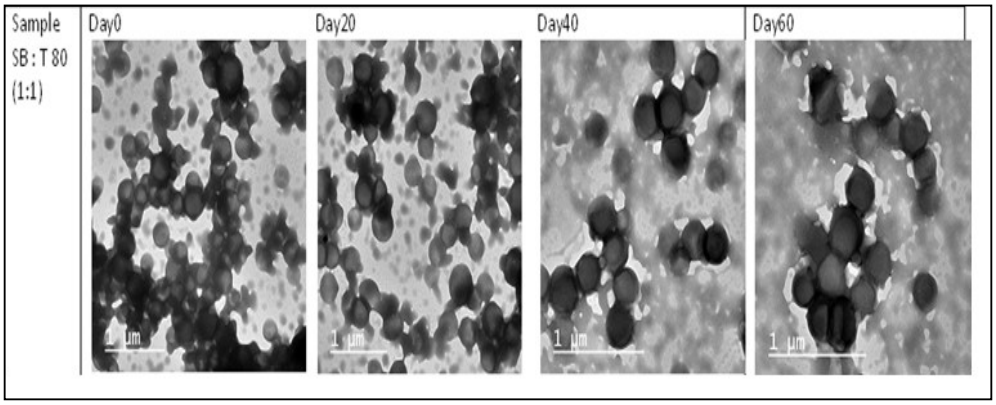


Fig. 52. TEM image of sweet basil oil – Tween 80 nanoemulsions

Table 12. Toxicity of sweet basil oil on larvae of house fly, *Musca domestica*

Treatment	LD_{50} (ppm)	95% CI	Chi-square
Sweet basil oil NE	5.34	4.34-6.83	12.16
Sweet basil oil BE	8.23	6.68-10.18	8.16

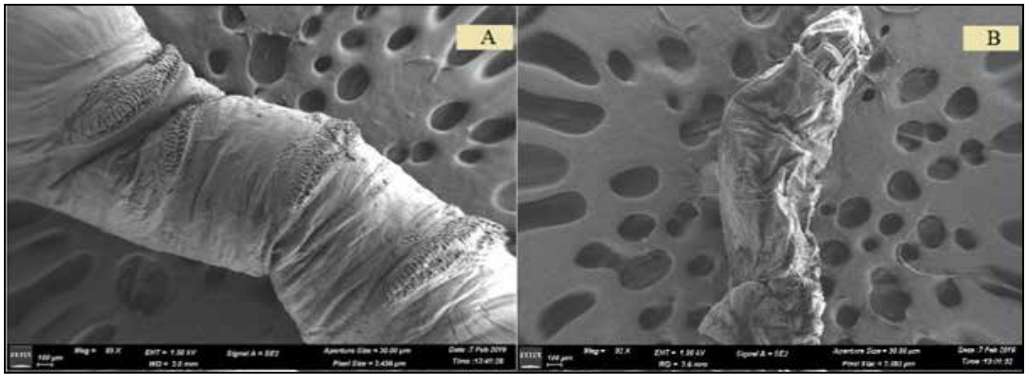


Fig. 53. SEM micrograph of housefly larvae

(A) Control (B) larva treated with *Ocimum basilicum*

Table 13. Toxicity of sweet basil oil on larvae of mosquito, *Aedes aegypti*

Treatment	LC_{50} (ppm)	95% CI	Chi-square
Sweet basil oil NE	52.87	47.58-57.62	30.72
Sweet basil oil BE	200.85	192.35-210.65	27.34

Pheromone nanogel technology

Pheromone slow-release formulations (adsorbed on nanogels) are practical, thermostable, low-cost, environment-friendly and they dramatically extend the field-life of pheromones and was proven effective in disrupting the lifecycle of harmful crop pests. The invented pheromone sensors can detect minute quantities of pheromones and are stable during the extreme weather conditions that occur in India. Many organogelators are already developed for the management of *Bactrocera dorsalis*, *Holotrichia consanguinea*, *Rhizophagus ferrugineus*, *Pollenia* spp., *Coccotrypes*

distinctus, *Xylosandrus crassiusculus* and *Dryoxylon onoharaensum*, *Xyleborinus saxeseni*, *Xyleborus ferrugineus* and *Xylosandrus compactus*. The management of *Bactrocera dorsalis* in guava through pheromone loaded organogels was attempted. The present finding is potentially useful in preparing new nanogel formulations with other pests with suitable Low Molecular-weight Mass Gelators (LMMGs) and the appropriate pheromones. This may be applicable for kairomones for the attraction of predators and parasitoids. The results of findings suggested that pheromone loaded nanogels could be used to manage wood borers. Sensors for biopesticides for *Helicoverpa armigera* NPV, *Spodoptera litura* NPV and *Spilosoma obliqua* NPV were also developed.

Method and device for rapid detection of *Hear* NPV

The device has a probe (made of a substrate embedded with a carbazole derivative), that works via an UV source and an analyser for the rapid detection of *Hear*NPV. A method for synthesizing a compound specific for rapid detection of *Hear*NPV was developed.

A kit for specific detection for SpliNPV

The probe is made of a substrate embedded with the synthesised compound. The probe employs an UV source and a reference chart. The probe displays fluorescence on the shining of the UV source. The reference chart lists colors corresponding to various concentrations of SpliNPV.

Rapid on-field detection of *Spilosoma obliqua* nucleopolyhedrovirus

The device detects *Spilosoma obliqua* nucleo-polyhedrovirus (*Spob*NPV) concentration in commercially available biopesticides. Portable reusable probes measure the insecticidal efficacy of *Spob*NPV by quantifying the number of occlusion bodies present. Through the on-site detection of *Spob*NPV in commercial formulations using the probe and the device, this paper-based sensor eliminates the need for technicians for detecting *Spob*NPV, thereby empowering farmers with low cost technology.

Surveillance of whiteflies

Twenty field surveys were undertaken across India to collect whiteflies covering five states and two union territories and processed for morphological and molecular based identification.

The major species of whiteflies collected were *Aleurodicus dispersus*, *Aleurodicus rugioperculatus* followed by *Bemisia tabaci*, *Paraleyrodes bondari* and *P. minei*. Surveys conducted in cotton growing areas in Tamil Nadu, Karnataka, Delhi, Goa, Kerala, Chhattisgarh, Andhra Pradesh and on vegetables, cassava, cosmos, jasmine, marigold revealed presence of *Bemisia tabaci*. Furthermore, sequence analyses using mitochondrial cyctochrome oxidase I confirmed the presence of two putative species Asia 1 and Asia II. This whiteflies believed to have survived in vegetables especially brinjal which was cultivated throughout the year. Asia-I populations are more prevalent in Tamil Nadu, Karnataka, Andhra Pradesh, Kerala, Chhattisgarh and Asia-II-1 in Haryana, Rajasthan and Punjab. New host plants of rugose spiralling whitefly such as Amla, maize, *Ficus*, *Combretum*, *Ravenala, Magnolia*, arjun tree, castor, hibiscus and citrus were recorded. Though natural parasitism by *E. guadeloupae* was very high (64-82%), the pest continued to spread to newer areas and create havoc because of inadequate natural enemies. A potential isolate of *Isaria fumosorosea* was evaluated against RSW under laboratory as well as field conditions with an overall reduction about 58-64% of whitefly colonies (Fig. 54). Biology of rugose spiralling whitefly was studied on *Canna indica* and banana to determine ideal stage to rear the parasitoid and it was observed that second instar of RSW was the ideal life stage to obtain maximum parasitism of *E. guadeloupae*.

Fig. 54. Rugose spiralling whitefly colonies infected by *Isaria fumosorosea*

Mass production and formulation of *Isaria fumosorosea* against coconut rugose spiralling whitefly, *Aleurodicus rugioperculatus*

Different liquid culture media like, potato dextrose broth (PDB), molasses yeast extract broth (MYB), jaggery yeast extract broth (JYB) and Sabourauds dextrose yeast extract broth (SDYB) in shaker cultures and a solid substrate, rice were evaluated for growth and sporulation of *I. fumosorosea* to standardise mass production technology.

Among different media, highest colony forming units (CFU) were observed on rice grains (2×10^{13} CFU/g), followed by SDYB (2×10^{10} CFU/ml), JYB (8.5×10^{8} CFU/ml), PDB (8×10^{8} CFU/ml) and MYB (4×10^{8} CFU/ml). Talc formulation prepared from SDYB showed CFU of 5×10^{10}/g. Development of formulations of *I. fumosorosea* for shelf-life studies was also attempted.

Studies on the predatory mirids *Dortus primarius* and *Termatophylum orientale*

Biology, morphology and feeding potential of predatory mirid, *Dortus primarius* (Miridae: Deraeocorinae) were studied for the first time in the laboratory (at 26±2 °C and 65±2% RH) on UV irradiated *Corcyra cephalonica* eggs. A total of five instars were observed, with nymphal duration of 17.2 days. Mean fecundity was 127.6 eggs per female. Female longevity was higher than male. One nymph could consume a total of 363 *C. cephalonica* eggs in its life span. Adult male and female fed on a total of 713 and 1014.75 eggs, respectively (Fig. 55).

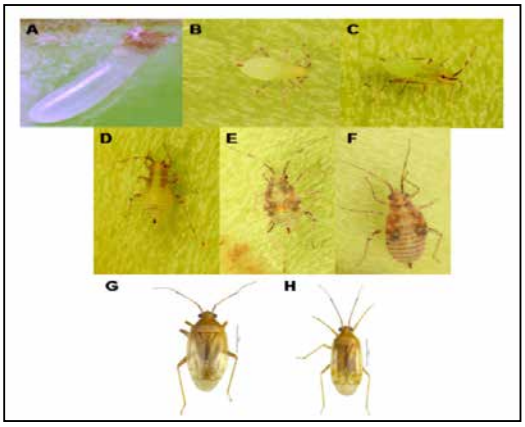


Fig. 55. Different life stages of *Dortus primarius*: A: egg; B-F: nymphal instars; G: female; H: male

Biology of *Termatophylum orientale* on *Corcyra cephalonica*

Termatophylum orientale laid 45-50 eggs singly or in group of 3 and 4 eggs embedded on the side of bean pod. Nymphs started emerging after 3 to 5 days and underwent five instars in 16 to 21 days (Fig. 56). Mating occured after 1-2 days of emergence. Female continued to lay eggs till its death. Adult longevity was 15-20 days. Male emerged earlier than female. Sex ratio was 1.25:1.00 (female: male) indicating balanced sex ratio in the laboratory and hence revealing the amenablity for mass production in insectaries.

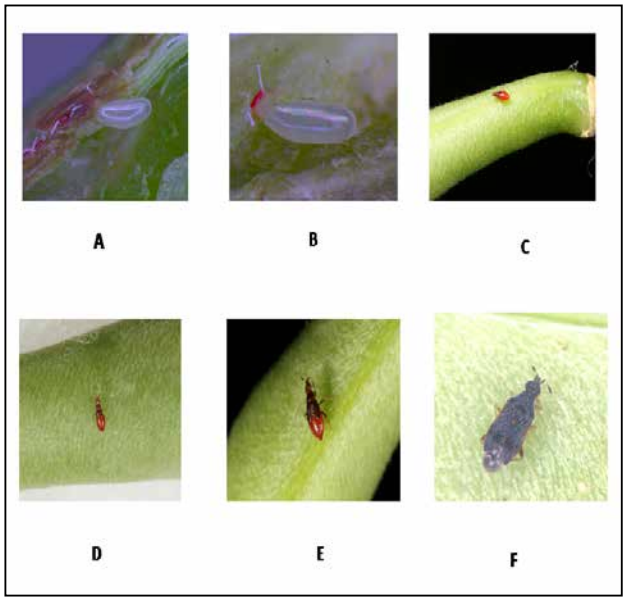


Fig. 56: Different stages of *Termatophylum orientale*

A) Eggs laid in row with operculum exposed B) larger view of egg C) first instar D) second instar E) third instar F) adult

Biological control of thrips

The functional response of three anthocorid bugs, *Blaptostethus pallescens, Cardiastethus affinis* and *Montandoniola indica* was assessed on the nymphs of *Frankliniella schultzei* at three constant temperatures (15, 20 and 28° C). *Blaptostethus pallescens* and *C. affinis* exhibited type III response at 15° C and type II response at 20 and 28° C. *Montandoniola indica* exhibited type II response at 15 and 20° C while at 28°C, it showed type III response. The present study indicated that *M. indica* and *B. pallescens* could be used in augmentative biological control programme for thrips.

Biointensive pest management module in rice

BIPM modules in rice at Rajabahar, Titabar and Jorhat districts of Assam resulted 6.27 and 5.69 per cent dead hearts at 45 and 60 DAT, respectively compared to that of farmer's practice (5.9 and 3.28 per cent). Similarly, leaf folder damage in BIPM field was 5.92 and 2.8 per cent at 45 and 60 DAT, respectively as compared to 5.75 and 3.23 per cent in farmer's practice field. Per cent white earhead (2.74) was significantly low (F=3.73, P=0.05) in BIPM field when compared to farmer's practice (3.78). Grain yield in BIPM field (49.98 q/ha) (F=104.66, P<0.0001) was significantly better as compared to 45.18 q/ha in farmer's practice.

Evaluation of pentatomid bug against tea looper

Feeding efficacy of different instars of pentatomid bug, *Eocanthecona concinna* was evaluated on third instar tea looper, *Biston suppressaria.* The results suggested that *E. concinna* was a promising candidate for biological control of looper pests in tea plantations.

Parasitisation efficiency of trichogrammatids

Trichogramma sp. was collected from the naturally parasitised eggs of fall armyworm, *S. frugiperda* infesting maize and was evaluated for its parasitisation efficiency along with other species, *Trichogramma pretiosum, T. chilonis* and *Trichogrammatoidea armigera* against fall armyworm, *S. frugiperda*. The rate of parasitism by *T. pretiosum, Trichogramma* sp., *T. chilonis* and *T. armigera* was 49.20, 46.49, 42.86 and 17.32%, respectively. The natural parasitism of *Trichogramma* sp. on the eggs of *Euthalia aconthea* varied from 30.77 to 47.37% in mango. *Trichogramma* sp. reared on the *Corcyra cephalonica* in laboratory for five generations was evaluated for parasitisation efficiency. The parasitisation rate for 1^{st}–5^{th} generations were 14.45, 14.80, 23.80, 26.20 and 14.20 with an adult emergence of 47.98, 31.17, 15.46, 8.70 and 0.00%, respectively. The percent parasitism of the eggs of *Tuta absoluta* by *T. achaeae* varied from 19.05 to 61.54% after ten releases in tomato under field conditions.

Field efficacy of EPN formulations for the management of grubs in sugarcane and turmeric

Formulations of *H. indica, S. carpocapsae* and *S. abbasi* at 2.0×10^9 and two doses (July and August) reduced field populations of white grubs in turmeric (Maharashtra), sugarcane (Karnataka, Maharashtra), groundnut (Rajasthan) in farmers' fields by 48-56% and improved plant recovery.

Biology and functional variability among populations of *Heterorhabditis* and *Steinernema* sp.

Biology and life tables of *Heterorhabditis indica, H bacteriophora*, *Steinernema abbasi* and *S. carpocapsae* were determined in fall army worm (FAW), tomato pin worm (*Tuta absoluta*), *Spodoptera exigua*, pink bollworm, and coleopteran grubs. Functional variability, in terms of infectivity and fecundity, of four populations of *Heterorhabditis* and *Steinernema* was recorded against fall army worm, tomato pin worm and pink boll worm at three temperature sets. Ovicidal activity was recorded with *Heterorhabditis indica* and *H. bacteriophora* against several coleopteran and lepidopteran species, and factors favouring ovicidal activity were examined.

Evaluation of entomopathogenic nematodes against white grub, *Holotrichia serrata*

Evaluation of two species of entomopathogenic nematodes (EPN), *Heterorhabditis indica* NBAIRH38 and *Steinernema abbasi* NBAIISa01 WP formulation in sugarcane fields for management of white grub, *Holotrichia serrata* in Vijayapura and/or Bagalakot districts of Karnataka along with a commonly used insecticide (chlorpyrifos) revealed that the percentage reduction in *H. serrata* grub population was significantly higher with *H. indica* at a dose of 2.5×10^9 IJ ha^{-1} than *S. abbasi* and chlorpyrifos application (Fig. 57). Overall, these experiments suggested that *H. indica* is a promising biocontrol agent against *H. serrata*.

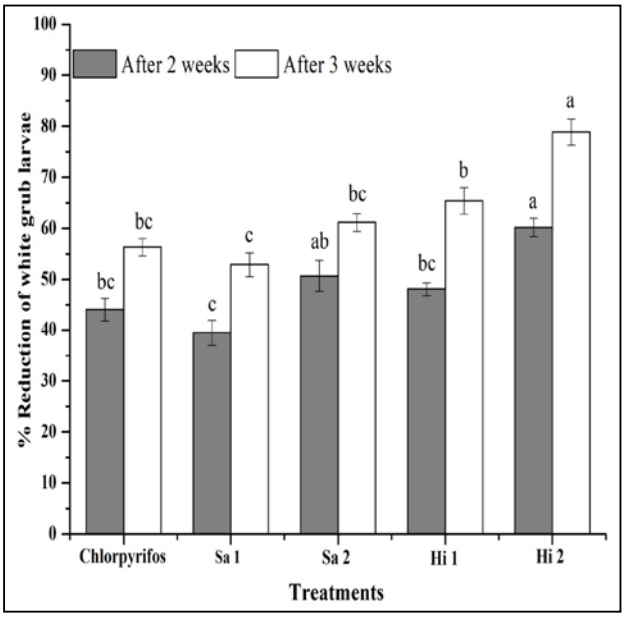


Fig 57. Percentage reduction of second instar grubs of *Holotrichia serrata,* at 2 and 3 weeks after different treatments in farmer's field at Vijayapura, Karnataka, India. Different letters on the top of error indicate statistically different values for different nematode concentrations at ($P < 0.05$) using Tukey's test. Bars = standard error. Sa, *Steinernema abbasi*; Hi, *Heterorhabditis indica*; 1 = 1.25 × 10^9 IJ ha^{-1}, 2 = 2.5 × 10^9 IJ ha^{-1}. Chlorpyrifos was used at the rate of 4,500 ml ha^{-1} as drench application

Semiochemicals for the management of mango fruit fly

Methyl eugenol is a known parapheromone attracting the males of *Bactrocera dorsalis*, however there is no effective female attractant as of now. Hence, studies were carried out to identify potential female attractants. The GCMS analysis of guava fruits revealed the presence of several volatile compounds. Different combinations of volatile mixtures were prepared and evaluated for the attraction of adult females of *B. dorsalis,* among which, one combination attracted high number of males and to a lesser extent females (Fig. 58). The studies were in progress to refine the combination further for exploration of its potential catch.

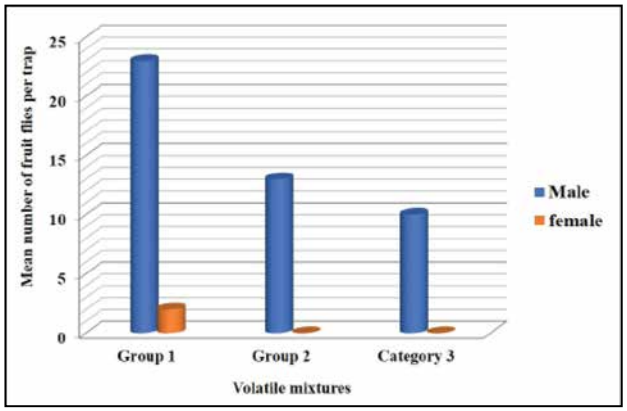


Fig. 58. Mean catches of fruit flies in different combinations of volatiles

Colour traps for *Amrasca devastans* in brinjal

The colour preference of hopper, *A. devastans* in brinjal crop was tested using different colour traps. Among the different colour traps, orange colour was found to be the most preferred colour by *A. devastans* (Fig. 59).

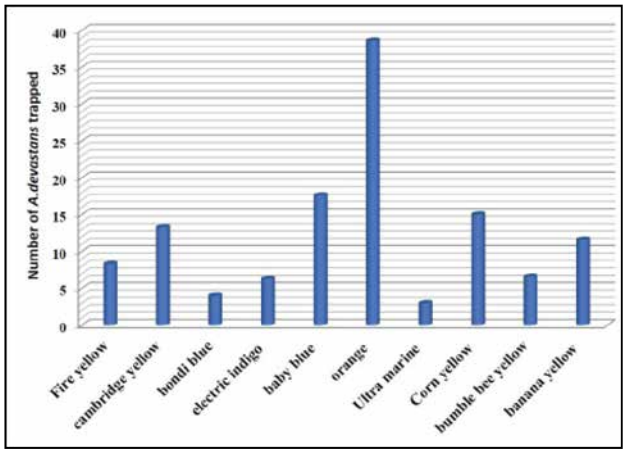


Fig. 59. Evaluation of colour traps for *A. devastans*

Studies on gall insect pests and their management

The behaviour of gall insect, *Asphondylia pongamiae* infesting *Pongamia pinnata* was studied. Pink flowers attracted large number of gall flies when compared to white flowers. Gall damage was observed till adult emergence in pink flowers whereas white flowers recorded less than 5% of galls. Removal of galls helped to reduce the gall incidence in the area.

Terminal bud gall of jamun was found to be severe on local jamun trees where all terminal shoot/buds got converted to galls arresting the growth of the shoot. Gall maker, *Betousa stytophora* was recorded to cause stem gall in Aonla. Activity was observed during

October-May, while peak activity was found to be during February-March.

Bee pollination studies

The role of native bees in pollination and yield of yard long bean and cucumber was studied under field conditions. The major bees visiting and pollinating the flowers of yard long bean were *Apis cerana, A dorsata, A. florea, Ceratina binghami* and *Megachile* sp. (Table 14) The mean pod weight was found to be higher in the bee pollinated plant (27.67 g/pod) when compared to that of self pollinated flowers (25g/pod) (Fig. 60) in yard long bean. In comparison of cross and self pollination in cucumber, self pollination led to no fruiting while cross pollinated flowers produced fruits (131g/fruit) (Fig. 61).

Table 14. Diversity of flower visitors in yard long bean

Bee species	Shannon Weiner Index	Margalef Richness index	Berger Parker Dominance Index	Evenness Index
Apis cerana	1.54	1.38	0.33	0.93
A. dorsata	1.50	1.29	0.36	0.90
A. florea	1.54	1.21	0.33	0.93
Ceratina binghami	1.51	1.28	0.35	0.90
Megachile sp.	1.53	1.23	0.37	0.92

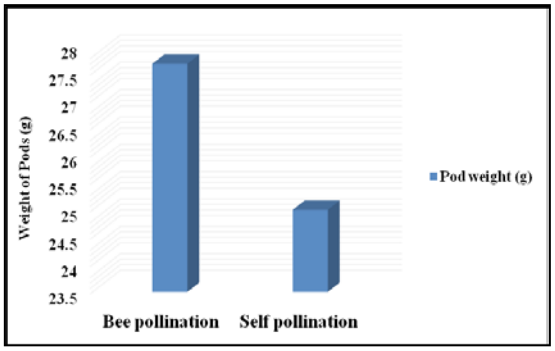


Fig. 60. Pod weight (g) in Yard long bean

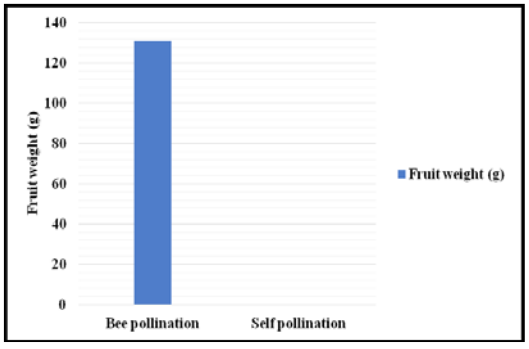


Fig. 61. Fruit weight (g) in Cucumber

Augmentation of nesting sites of native bee, *Hoplonomia westwoodi*

The nesting sites of ground nesting bee, *Hoplonomia westwoodi* were augmented by splitting the nest aggregations with viable broods and the split nest were seeded in new sites to observe the nest propagation. Active nesting activity was noticed in the newly seeded sites during the monsoon period with first adult emergence during the month of May. There was a steady increase in adult bee nesting activity in the newly seeded site (8.50 adult bees/turret) when compared to the mother site (2.72 adult bees/turret).

Biology of sphecid wasps

A study was conducted to study the biology, prey composition and nesting behavior of the sphecids, viz. *Sceliphron* sp., *Carinostigmus griphus* and *Carinostigmus costatus* A total of 32 naturally constructed nests were collected to study the biology of *Sceliphron* sp., whereas for the *Carinostigmus* species, provisions were provided to construct the nest using *Caesalpinia pulcherrima* tender wood cut. Later the accepted twigs were used for studying the

biology. The life cycle parameters of *Sceliphron* sp., *Carinostigmus griphus* and *C. costatus* were 37.3±2.3, 27.2±1.2 and 26.3±2.0 respectively.

Black soldier fly (BSF) feeding trials in fish and poultry

Fish meal substituted with BSF meal (70%) recorded the least feed conversion ratio (FCR) in Amur carp (*Cyprinus carpio*) when compared to commercial fish meal. The per cent weight gain, survival rate and specific growth rate of fishes fed with 70% fish meal replaced with BSF meal was statistically on par with commercial fish meal.

Feeding trials in broiler chicken fed with BSF meal (5% substitution in broiler diet), recorded significantly higher body weight gain and feed intake when compared to that of control meal. The feed conversion ratio recorded in broilers fed with BSF and control meal was statistically on par with each other.

Studies on black soldier fly (BSF) compost

The black soldier fly (BSF) compost is equally nutrient rich as compared to vermicompost and farm yard manure. Black soldier fly compost was evaluated for nursery establishment and yielded better results for chilli, capsicum, brinjal and tomato in terms of root length, shoot length and germination percentage (Table. 15-16 & Fig. 62). Compost evaluation for shelf-life with respect to nutrients like N, P and K; C:N ratio and micronutrient status was undertaken on monthly basis and results of four months shelf-life studies indicated no significant changes in nutrient composition.

Different oviposition structures for BSF were evaluated and found that adult females prefer natural substrates like unpolished wood stacks followed by corrugated carton stacks, whereas, polished wood stacks, laminate sheet stacks and plastic sheet stacks were not preferred and showed zero oviposition.

Five microflora from matured black soldier fly (BSF) compost were isolated and were purified using microbiological methods. Further these microflora were tested for enzymatic hydrolysis substrates like gelatin, starch and lipids. Among the microflora, two microbes were found to be positive for hydrolysis of all the three substrates tested. Antibiotic sensitivity test was carried out for microflora by measurement of sensitivity radius (cm) and found that two microbes possessed resistance to seven antibiotics tested and sensitivity to ampicillin-G alone. Testing this trait was important along with hydrolysis of substrates in order to find out the best strain for decomposition of organic matter by competing with native microflora. The four microflora were identified based on sequencing of 16S rDNA as *Bacillus oleronius*, *B. licheniformis*, *Pseudomonas aeruginosa* and *Serratia marcescens*.

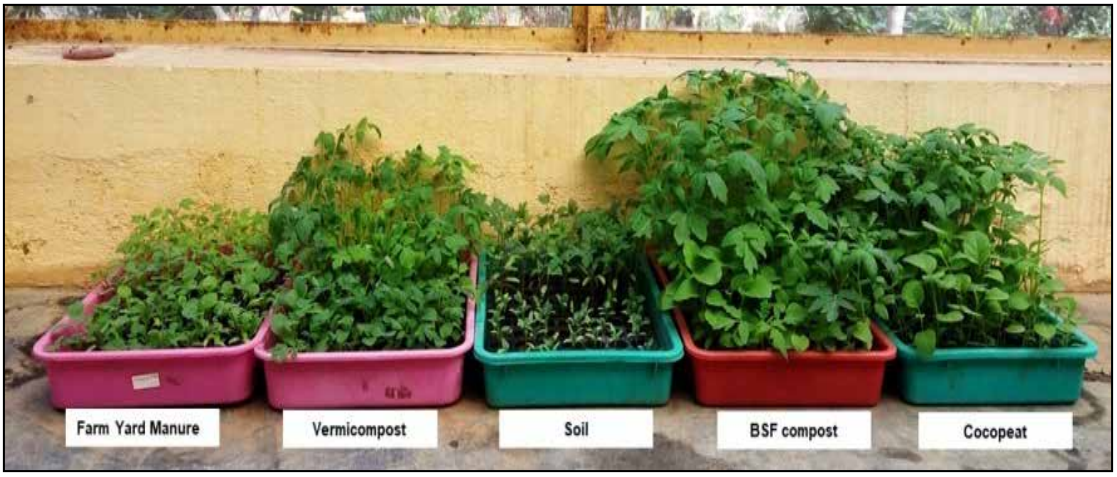


Fig. 62. Evaluation of different composts and substrates for nursery establishment of tomato and brinjal

Table 15. Effect of different composts on germination percentage of capsicum, tomato, brinjal and chilli seedlings in nursery

Treatment	Seed germination (%)			
	Capsicum	Tomato	Brinjal	Chilli
BSF compost	93	96	94	97
Farmyard manure	85	88	92	96
Vermicompost	81	71	95	97
Soil	28	55	89	88
Cocopeat	58	60	92	98

Table 16. Effect of different composts on growth parameters of capsicum, tomato, brinjal and chilli seedlings in nursery

Treatment	Capsicum		Tomato		Brinjal		Chilli	
	Root length	Shoot length	Root length	Shoot length	Root length	Shoot length	Root length	Shoot length
BSF compost	11.0 a	10.5 a	6.0 a	17.0 a	5.0 b	11.5 a	5.8 a	9.5 a
Farmyard manure	3.6 d	5.5 c	3.2 b	8.0 e	3.5 c	6.0 d	3.1 b	4.5 c
Vermicompost	4.3 c	4.8 d	4.1 b	15.6 b	3.0 d	7.0 c	4.0 b	3.8 d
Soil	4.4 c	4.7 d	1.5 c	9.0 d	7.0 a	4.0 e	1.8 c	3.7 d
Cocopeat	6.3 b	9.0 b	3.6 b	10.0 c	5.0 b	11.0 b	3.6 b	8.0 b
SEM±	0.11	0.14	0.28	0.15	0.11	0.12	0.27	0.13
CV(%)	3.3	3.6	3.3	2.2	2.3	3.4	3.3	3.4

The assays were in 3 replicates and each treatment was conducted with 35 plants. Mean values followed by a different letter in the same column are significantly different (P=0.05) by Duncan's multiple range test SEM± standard error of means, CV Co-efficient of variance

Development of mobile apps for non-chemical methods for the management of important crop pests

A Mobile Application was created for the management of coconut pests by using non-chemical methods in Kannada version. It contains the information about the coconut pests, rhinoceros beetle (*Oryctes rhinoceros*), red palm weevil (*Rhynchophorus ferrugineus*), black headed caterpillar (*Opisina arenosella*), coconut eriophyid mite (*Aceria guerreronis*), white grub (*Leucopholis coneophora*) and rodents (Palm civet) and its biological control measures. This mobile app will help the farmers to apply non-chemical methods for the control of coconut pests.

All-India Coordinated Research Project on Biological Control of Crop Pests

Biodiversity of biocontrol agents from various agro-ecological zones

A total of 22 spider specimens belonging to three families, viz. Araneidae, Tetragnathidae and Thomisidae were collected from paddy ecosystem (AAU-A). One hundred and twelve spiders from seven different families (Tetragnathidae, Lycosidae, Oxyopidae, Araneidae, Salticidae, Attidae and Linyphidae) were collected from different rice fields. The predominant spiders were *Lycosa pseudoannulata* and *Oxyopes javanus* (AAU-J).

Out of the 20 natural enemies recorded on apple, predators were the most abundant followed by parasitoids. Per cent parasitism by *Aphelinus mali*

on woolly apple aphid was found to be the highest (34–80%) in unmanaged orchards. Parasitism by *Encarsia perniciosi* and *Aphytis proclia* ranged from 14–29% in similar orchards (SKAUST). Besides coccinellids, other natural enemies like *Cotesia glomerata* parasitising *Pieris brassicae* in cauliflower, *Campoletis chloridae* parasitising *Helicoverpa armigera* in tomato, *Diplazon* sp. parasitising syrphid flies, *Trathla* sp. parasitising brinjal shoot and fruit borer were also collected from Nauni (YSPUHF).

Parasitism by *Trichogramma* sp. was observed in cotton, maize, soybean, pigeonpea, sugarcane, tomato and brinjal in Pune region. *Chrysoperla zastrowi sillemi* was observed in cotton, maize, bean, sorghum, okra and brinjal, while *Mallada boninensis* was recorded on cotton, beans, mango, papaya and ornamental plants. *Cryptolaemus* adults were recovered from custard apple and papaya orchards, cotton and ornamental hibiscus (MPKV).

The activity of the egg parasitoid *Trichogramma* sp. parasitising fruit borer of tomato, okra and shoot and fruit borer of brinjal, bud borer of jasmine and diamondback moth in cabbage was observed (TNAU). About 25% parasitisation by *Cotesia flavipes* was observed in *Chilo partellus* infesting sorghum. The egg parasitoid, *Trichogrammatoidea simmondsi*, larval parasitoid, *Neotrichoporoides nyemitawus* and pupal parasitoid, *Spalangia endius* were found to cause 18, 21 and 13 per cent parasitisation in shoot flies infesting millets (IIMR).

Surveillance for alien invasive pests

The alien invasive pests, viz. *Brontispa longissima, Aleurodicus dugesii, Phenacoccus manihoti, Phenacoccus madeirensis* were not recorded in any of the centres during 2018-19. However, *Tuta absoluta* was observed in Tamil Nadu, Himachal Pradesh and Uttar Pradesh. In Maharashtra, the mealybug species *Pseudococcus jackbeardsleyi* and *Paracoccus marginatus* were recorded on custard apple and papaya, respectively, in Pune region. Papaya mealybug incidence was observed in Tamil Nadu, Gujarat, Assam and Maharashtra. The new alien pest fall armyworm (FAW), *Spodoptera frugiperda*, was reported from Gujarat, Rajasthan, Maharashtra, West Bengal, Karnataka, Kerala, Telangana, Andhra Pradesh and Tamil Nadu. Surveys for the incidence of *S. frugiperda* were carried out during kharif in Telangana (Mahboobnagar) and Maharashtra (Parbhani, Rahuri and Akola) where the pest incidence was observed at low levels (< 5.0%) in sorghum. There was incidence in Hisar, Udaipur, Ludhiana, Indore and Surat. During rabi (Septempter–December), medium to severe damage (10–60%) was observed across the millets. On an average, 1–2 larvae per whorl were found in sorghum and pearl millet.

Surveillance of rugose spiralling whitefly and other whiteflies in coconut and assessing the population of natural biocontrol agents

NBAIR: The rugose spiralling whitefly (RSW), *Aleurodicus rugioperculatus*, continued to spread to newer areas along the coastal tracts in Karnataka. The incidence was even more serious in Goa. Parasitism by *Encarsia guadeloupae* was recorded to the extent of 24–62%. Besides RSW, other invasive whiteflies such as Bondar's nesting whitefly, *Paraleyrodes bondari*, and *P. minei* were also recoded to the extent of 15–28% on coconut. The intensity and severity of this whitefly on coconut and arecanut is about 10–80% of leaflets per frond per palm and observed in few isolated gardens across two districts.

CPCRI: A new distribution record of RSW was confirmed from Nalbari and Kamrup districts of Assam infesting coconut, arecanut, ornamental yellow palm, banana and crotons during August 2018. Observations revealed 82.1% natural parasitism by *E. guadeloupae* in RSW samples collected from Nalbari and Kamrup districts of Assam. Two species of new invasive nesting whiteflies were reported to be infesting coconut leaves in Kerala.

ANGRAU: In February 2019, RSW was noticed on coconut in Srikakulam, Vizianagaram, Visakhapatnam districts of Andhra Pradesh.

Biological suppression of sugarcane pests

In sugarcane, the entomopathogenic nematode *Heterorhabditis indica* recorded the maximum reduction in plant damage (81.2%) followed by *Metarhizium anisopliae* (78.8%), in comparison with chlorantraniliprole 18.5 SC (54.2%) and untreated control (ANGRAU).

The plant damage due to white grubs was lowest (7.5%) in *Metarhizium anisopliae* (NBAIR Ma

4)-treated plots which was statistically superior over rest of the treatments (UAS-R).

Biological suppression of cotton pests

Fewest rosette flowers (0.03 per 5 plants) per plot were recorded in biocontrol field followed by that of insecticidal treatment, both being at a par with each other and significantly superior over untreated control (PDKV).

Amongst the biopesticides, *Lecanicillum lecanii* (1×10^8 conidia/g) @ 5 g/litre recorded the lowest population of sucking pests (MPKV, Pune). The population of whitefly remained low to moderate except at few locations in Khuiyan Sarvar block of Fazilka. The mean parasitisation of the whitefly by *Encarsia* sp. in different cotton-growing areas of Punjab was around 5% (PAU).

Mean per cent parasitisation of whitefly nymphs by *Encarsia* sp. was recorded as maximum in Fazilka (45.9%) district of Punjab (NCIPM).

Biological suppression of rice pests

The percent damage caused by leaf folder and stem borer was recorded to be the lowest in plots treated with *Steinernema carpocapsae* followed by those treated with *Bacillus thuringiensis* (ANGRAU, Anakapalle). The population of planthoppers in BIPM and control plots was 2.88 and 4.21 per hill resulting in a reduction of 31.7% over control. Basmati yield was 31.25 q/ha in BIPM as compared with 29.75 q/ha in untreated control with an increase of 5.04% (PAU). *Lecanicillium saksenae* @ 10^7 conidia/ml was the most effective treatment, closely followed by NBAIR isolate Bb5 @ 10^8 spores/ml (KAU, Vellayani).

Biological suppression of cereal pests

Release of *Trichogramma chilonis* @ 1,00,000/ha at 15, 22 and 29 days at 7–10 day interval after seedling emergence resulted in complete reduction of *Chilo partellus* damage, 35.5% reduction in *Sesamia inferens* damage and 49.2% reduction in *Spodoptera frugiperda* damage. The number of dead larvae of *S. frugiperda* per plot 30 DAS was the highest in chemical control (48.0) followed by *Trichogramma pretiosum* + *Metarhizium anisopliae* NBAIR Ma-35 (23.0) and *T. pretiosum* + NBAIR Bt 2% (22.0) (ANGRAU).

Biological suppression of pests of pulses

In pigeonpea, NBAII-BTG4 formulation and chemical sprays recorded higher grain yield of 625 and 590 kg/ha respectively, than control (415 kg/ha). The CB ratio was maximum (2.13) in NBAII BtG4 treatment (TNAU). *Hear*NPV NBAIR @ 2 ml/l recorded 7.78% pod damage in chickpea, which was at par with *Hear*NPV UASR @ 2 ml/l, which recorded 8.16% pod damage (UAS-R).

Biological suppression of pests of tropical fruit crops

Significant reduction in the number of hoppers was recorded in mango trees treated with AAU-A strains of *Metarhizium anispoliae* (0.63/tree) and *Beauveria bassiana* (0.75 hoppers/tree) (DRYSRUH). In mango, low incidence of leaf webber was recorded in *B. bassiana* (CISH formulation), which was on par with *M. anisopliae* (NBAIR-Ma-4). Neem cake @ 50 g/ 2 kg soil and CISH-Biopesticide @ 50 g/ 2 kg soil were the best treatments which significantly reduced root-knot index in guava (CISH).

Biological suppression of pests of temperate fruit crops

Release of *T. cacoeciae* @ 2.5 lakh/ha (4 releases/season) along with trunk banding, disposal of infested fruits, pheromone traps and a spray of NBAIR strain of *Heterorhabditis pakistanensis* significantly reduced (52.3%) the fruit damage by codling moth in apple (SKAUST). *Metarhizium anisopliae* treatment resulted in 67.8–78.4% mortality of the apple root borer grubs in different orchards, while in chlorpyriphos (0.06%) treated plants, the grub mortality was 76.4–88.6% (YSPUHF).

Biological suppression of pests in plantation crops

The reduction in the live colonies of whiteflies was 78.8% and 75% at 3 and 7 days after treatment, respectively, with the entomopathogenic fungus *Isaria fumosorosea* (NBAIR Pfu-5) (KAU- Kumarakom).

Biological suppression of pests in vegetables

Tomato: BIPM package was found to be as effective as chemical control against *H. armigera*. Chemical control module recorded the highest yield (16.43 t/ha) which was at par with the yield recorded in BIPM package(16.25 t/ha) (AAU-A). At 105 DAT, the fruit damage caused by *T. absoluta* and *H. armigera* was significantly less in BIPM plots when compared to chemical treatment (TNAU). BIPM module recorded the lowest population of whiteflies(0.27), aphid(0.20), leafhopper(0.23) and leaf miner(0.97) populations per leaf followed by chemical module (IIVR).

Brinjal: The incidence of shoot and fruit borer infestation in BIPM plot was 11.4 and 13.2%, as against 18.7 and 23.9% in untreated control plots, respectively (AAU-J). The fruit damage in brinjal was significantly lower (10.5%) in plots sprayed with pesticides followed by 14.6% fruit damage in BIPM plots. The cost benefit ratio realised in BIPM was 1:3.58 against 1:4.57 in insecticides treated plots (TNAU). Highest yield (9.5 t/ha) and C:B ratio (1:1.54) was recorded in BIPM plots followed by chemical control (OUAT).

Okra: Among the different biocontrol treatments, maximum reduction in fruit damage (83.4%) due to *Earias vittella* was recorded in *T. chilonis* @ 50,000/ha, six releases at weekly intervals followed by *Bt* @ 1 kg/ha (70.8%). Among different biocontrol agents tested, significantly lowest number of *E. vittella* larvae/plant was recorded in *B. thuringiensis* @ 5 g/litre (0.99) which was followed by *T. chilonis* @ 50,000/ha (1.06 larvae/plant), NSKE 5% suspension (1.09 larvae/plant) and *B. bassiana* @ 5 g/litre (1.10 larvae/plant) (AAU-A).

Cabbage: The efficacy of BIPM practices was significantly superior in reducing the population of diamondback moth. The highest yield of 44.3 t/ha was recorded in BIPM plot which was on par with chemical treatment (43.2 t/ha). The CB ratio was 3.53 in BIPM plot while it was 2.84 in chemical treatment (TNAU).

Biological suppression of oilseed crop pests

The mean population of aphids recorded in the treatment *L. lecanii* (NBAIR strain) @ 5 g/litre (10.2 per 10-cm apical twig) was significantly at par with *L. lecanii* (AAU-J strain) and *Beauveria bassiana* (11.2 and 11.7 per 10-cm of apical twig). The yield recorded in both the treatments were at par with each other (7.2 and 7.2 q/ha) (AAU-J).

Biological suppression of polyhouse and flower crop pests

Aphid population in capsicum was significantly brought down by *L. lecanii* (76.4%) followed by *M. anisopliae* (68.5%), *B. bassiana* (56.3%) and azadirachtin 1,500 ppm @ 2 ml/litre (17.5%) (PAU). Similarly, release of *Chrysoperla zastrowi sillemi* @ 4 larvae/plant resulted in the maximum reduction (55.8%) in aphid population over control in capsicum which was on par with *L. lecanii* (50.3%) and azadirachtin (49.8%) (YSPUHF).

Application of *Beauveria bassiana* (NBAIR formulation) at 5 g/ litre of water along with six releases of *Trichogramma chilonis* and *Chrysoperla* at 7-day intervals from bud initiation stage was superior in checking the bud borer with minimum bud damage of 21.7% followed by azadirachtin 1,500 ppm @ 2ml/litre (25.4%) (TNAU).

Biological suppression of plant diseases

In chickpea, mixed formulation (Th14 + Psf173) has shown better performance over individual isolates with respect to its effect on seed germination and plant growth. Among all the isolates, Psf-173, PBAT-3, Th14, TCMS 36 and NBAIR-2 were comparatively better than other bioagents in reducing diseases and in increasing yield in rice (GBPUA&T).

Tribal Sub-Plan programme (TSP)

AAU-A: Two hundred tribal farmers were selected from Dediyapada, Sagbara and Tilakwada talukas of

Narmada district. The area covered was about 1 acre per farmer. Training and demonstration programmes were organised.

AAU-J: Two hundred tribal farmers were selected from four districts and biocontrol inputs were distributed to them. Trainings were provided on management of insect pest of rice and vegetables. Eco-friendly ways of management of insect pests were emphasised along with the proper use of biopesticides.

ANGRAU: Demonstrations, awareness-cum-training programmes and farmers' meetings were organised in 11 villages in Araku valley and Chinthapalli areas of Visakhapatnam district, covering 143 acres of paddy, rajmah and ginger crops. Altogether, 330 farmers benefitted from the programme. The centre imparted training on importance and mass production of parasitoids (*Trichogramma* sp.), botanicals (neem oil, neem cake), microbials (*Trichoderma, Pseudomonas, Metarhizium*) and biofertilisers (*Azospirillum, Phosphobacterium*, potassium-solubulising bacteria, VAM) benefitting 142 tribal farmers.

TNAU: Trainings on production of biocontrol agents and biointensive pest management were conducted to benefit 100 tribal farmers from Coimbatore, Erode and Tirupur districts.

YSPUHF: One hundred farmers of Khani and Holi villages of Chamba district of Himachal Pradesh beneffited from the trainings and demonstrations. These farmers were exposed to the use of biopesticides for pest management for the first time. In peas, beans, cauliflower and cabbage, there was a reduction of two sprays of chemical pesticides. In the case of apple, farmers saved about Rs 15,000 per hectare by avoiding chemical treatment for the control of root borer.

CAU: A training programme on integrated pest management in horticultural crops was conducted for tribal farmers and bio-inputs were supplied.

IGKV: Field demonstrations on the use of parasitoids and predators were conducted at six villages, Lamker, Pallichakwa, Badechakwa, Nadisagar, Tahkapal and Tandpal located in Bastar plateau zone of Chhattisgarh. Around 150 tribal farmers and farm women participated in the programme.

UBKV: An awareness-cum-training programme on the use of biocontrol agent for management of pests and diseases of different crops was conducted for the first time to benefit tribal farmers. Around 160 tribal farmers from Cooch Behar and Dakshin Dinajpur districts of West Bengal participated in the programme. Microbial biocontrol agents were given to the trained tribal farmers for field demonstration against diseases of crops. Pheromone traps were distributed among trained tribal farmers for management of cucurbit fruit fly.

5. GENBANK / BOLD ACCESSIONS

ORGANISM	ACCESSION NUMBER
HEMIPTERA (COI)	
Aleurodicus dispersus	MK491179
Bemisia tabaci	MH807440
Bemisia tabaci	MH823740
Bemisia tabaci	MH891617
Bemisia tabaci	MK123947
Bemisia tabaci	MK568467
Bemisia tabaci	MK568468
Eocanthecona furcellata	MH795079
Halyomorpha picus	MK559394
Leptocentrus sp.	MK491176
Placosternum sp.	MK110508
Plautia crossota	MK559393
DIPTERA (COI)	
Dacus (*Didacus*) *ciliatus*	MH733833
Diarrhegma modestum	MK559395
Hermetia illucens	MG682545
Hermetia illucens	MG733996
Platensina acrostacta	MH748566
Spathulina acroleuca	MH748567
LEPIDOPTERA (COI)	
Catopsilia pyranthe	MK531549
Corcyra cephalonica	MK377173
Giaura punctata	MK482339
Mythimna separata	MH252215
Olene mendosa	MK455104
Pyrausta panopealis	MK559412
Sitotroga cerealella	MK377174
Spilarctia obliqua	MK491177
Spodoptera frugiperda Anakapalle	MH822831
Spodoptera frugiperda Bellur	MH881532
Spodoptera frugiperda Chikkaballapura	MH704433
Spodoptera frugiperda Chikkaballapura	MK079565
Spodoptera frugiperda Chinthapalle	MH822832
Spodoptera frugiperda Dharwad	MH822830
Spodoptera frugiperda Dharwad	MK318531

ORGANISM	ACCESSION NUMBER
Spodoptera frugiperda Doddaballapura	MK041922
Spodoptera frugiperda Gujarat	MK279399
Spodoptera frugiperda Gujarat	MK303391
Spodoptera frugiperda Hassan	MH881533
Spodoptera frugiperda Hassan	MK327538
Spodoptera frugiperda Khammam	MH822835
Spodoptera frugiperda Latur	MK285364
Spodoptera frugiperda Nagarkurnool	MH881528
Spodoptera frugiperda Nelivada	MH822834
Spodoptera frugiperda Pedabathepalle	MH822833
Spodoptera frugiperda Pune	MH899609
Spodoptera frugiperda Rajendranagar, Hyderabad	MH881530
Spodoptera frugiperda Shimoga	MH881531
Spodoptera frugiperda Siddipet	MH881529
Spodoptera frugiperda Tirupati	MH899610
Spodoptera frugiperda Vijayawada	MH899611
Spodoptera litura	MK491175
COLEOPTERA (COI)	
Paederus fuscipes	MH916764
Protaetia aurichalcea	MH045571
HYMENOPTERA (COI)	
Ammophila attripes (F)	MK898951
Ammophila attripes (M)	MK898952
Ampulex compressa	MK898945
Apanteles sp.	MH279888
Apis florea	MK491178
Apocryptophagus sp.	MK569694
Astata sp.	KR878917
Bembix sp.	KR791175
Carinostigmus griphus	KT070202
Ceratina binghami	MK559415
Chalybion bengalense	MK898946
Crabro sp.	KR879299
Liris haemorrhoidalis	MH609275
Liris sp.1	MK898947
Liris sp.2	MK898948
Liris subfaciatus	MK898949
Liris subfaciatus	MH609996

ORGANISM	ACCESSION NUMBER
Podalonia sp.	KY829639
Sceliphrion coromandelicum	MK922295
Sceliphrion madarspatanum	MK934129
Sphex argentatus	MK940485
Sphex ichneumoneus	KM568635
Sphex sericeus	KX017525
Tachysphex sp.	MK898950
Trirogma caerulea	MH610448
Trypoxylon sp.	MK947367
IXODIDA (COI)	
Haemaphysalis sp.	MH937512
Hyalomma excavatum	MK005261
Hyalomma sp.	MH923577
Rhipicephalus microplus	MH918000
Rhipicephalus sp.	MK123947
MICROBIAL 16S rRNA SEQUENCES (INSECT-ASSOCIATED)	
Gut microflora of *Protaetia aurichalcea*	
Bacillus amyloliquefaciens strain P5	MK346849
Bacillus aryabhattai strain P6	MK346850
Bacillus cereus strain P10	MK346853
Citrobacter freundii strain P4	MK346848
Enterococcus hirae strain P9	MK346852
Paracoccus sp. strain P8	MK346851
Staphylococcus sciuri strain P1	MK346846
Staphylococcus sp. strain P3	MK346847
Gut microflora of *Spodoptera litura*	
Bacillus clausii strain SL4-4	MK312486
Bacillus licheniformis strain SL1-3	MK312475
Bacillus licheniformis strain SL3-1	MK312480
Bacillus megaterium strain SL1-4	MK312476
Bacillus oceanisediminis strain SL3-2	MK312481
Bacillus oleronius strain SL1-2	MK312474
Bacillus sp. (in: Bacteria) strain SL2-3	MK312479
Bacillus subtilis strain SL1-1	MK312473
Bacillus toyonensis strain SL4-3	MK312485
Enterococcus faecium strain SL4-2	MK312484
Enterococcus mundtii strain SL2-1	MK312477

ORGANISM	ACCESSION NUMBER
Enterococcus mundtii strain SL3-4	MK312483
Enterococcus sp. strain SL3-3	MK312482
Kocuria rhizophila strain SL4-6	MK312487
Pseudoclavibacter faecalis strain SL2-2	MK312478
Stenotrophomonas nitritireducens strain SL4-7	MK312488
NUCLEOPOLYHEDROVIRUSES	
Helicoverpa armigera NPV	MK288144
Spilosoma obliqua NPV	MK288145
Spodoptera litura NPV	KY549343
ENTOMOPATHOGENIC NEMATODES	
Heterorhabditis bacteriophora NBAII 505gl	MH104864
Heterorhabditis bacteriophora NBAII Hb105	MH119604
Heterorhabditis indica NBAII Hi101	MH119603
Steinernema abbasi NBAII Sa04	MG970364
Steinernema carpocapsae NBAII Sc05	MG875343
Steinernema carpocapsae NBAII112	BankIt 2096502
Steinernema carpocapsae NBAII Ssp 112	MH104863
Steinernema pakistanense AAU-A	MK491792
Steinernema pakistanense AAU-B	MK491793
Steinernema pakistanense AAU-C	MK491794
Steinernema pakistanense AAU-D	MK491795
Steinernema pakistanense AAU-E	MK491796
Steinernema pakistanense AAU-F	MK491797
Steinernema pakistanense AAU-G	MK491798
Steinernema siamkayai NBAIRS92	MH208855
Steinernema siamkayai NBAIRS93	MH208856

6. IDENTIFICATION SERVICES

Hymenoptera (Dr Ankita Gupta)

Identification services were provided to 18 researchers/ universities/ institutes. Over 900 specimens were mounted and identified.

Hymenoptera: Apidae, Halictidae (Dr U. Amala)

Identified 45 bee specimens belonging to 7 species for a Ph.D. scholar from Bangalore University.

Hymenoptera: Trichogrammatidae (Dr Navik Omprakash Samodhi)

Identification services were provided to Acharya N.G. Ranga Agricultural University, Hyderabad; Indira Gandhi Krishi Vishwavidyalaya, Raipur; University of Calicut, Calicut; and ICAR¬–National Institute of Biotic Stress Management, Raipur.

Hemiptera: Aphididae, Coccidae, Diaspididae and Pseudococcidae (Dr Sunil Joshi)

A total of 81 identification services were provided to different State Agricultural Universities and ICAR institutions. For these identification services, around 409 specimens were processed and 203 species were identified.

Hemiptera: Aleyrodidae (Dr K. Selvaraj)

About 26 whitefly specimens which were received from several institutes, viz. ICAR–Central Coastal Agricultural Research Institute, Goa; ICAR–Central Plantation Crops Research Institute, Kasaragod; ICAR–Indian Institute of Pulses Research, Kanpur; ICAR–Research Complex for North Eastern Hill Region, Manipur Centre; Horticultural Research Station of Assam Agricultural University, Kahikuchi, Assam; Kerala Agricultural University, Thrissur; University of Agriculture and Horticultural Sciences, Shivamogga and BASF, Pune were identified.

Hemiptera: Pentatomidae (Dr S. Salini)

Nine identification services were provided. 62 specimens under 18 species of Pentatomidae / related groups were identified for various researchers (India: Karnataka; Abroad: Indonesia).

Coleoptera: Cerambycidae (Dr M. Mohan)

Four identification services were provided. 29 specimens from Kerala Agricultural University, Thrissur; 21 specimens from College of Horticulture, Tamil Nadu Agricultural University, Periyakulam; 11 specimens from University of Agricultural Sciences, GKVK, Bengaluru; and 7 specimens from Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Thiruvananthapuram were identified.

Coleoptera: Scarabaeidae, Cerambycidae, Curculionidae, Buprestidae (Dr K. Sreedevi)

Around 557 insect specimens belonging to Coleoptera were examined for identification services and 64 species belonging to 11 families were identified.

Coleoptera: Curculionidae (Dr G. Mahendiran)

Twelve identification services were provided for different State Agricultural Universities and ICAR institutions.

Diptera: Tephritidae, Drosophilidae, Calliphoridae, Phoridae, Lonchaiedae and Sarcophagidae (Dr K.J. David)

14 identification services were provided for various ICAR institutes, State Agricultural Universities and private firms. 63 species of dipterans belonging to various families were identified.

Thysanoptera (Ms R.R. Rachana)

Provided 28 thysanopteran identification services to various ICAR institutes, State Agricultural Universities and private organisations, viz. ICAR–Central Institute for Cotton Research, Nagpur; ICAR–Indian Institute of Oilseeds Research, Hyderabad; ICAR–National Research Centre for Banana, Thiruchirapalli; Cotton Research Station, Nanded; Institute of Wood Science and Technology, Bengaluru; Acharya N.G. Ranga Agricultural University, Hyderabad; College of Agriculture, Bijapur; College of Horticulture, Kerala Agricultural University, Thrissur; University of Agricultural Sciences, GKVK, Bengaluru; University of Agricultural and Horticultural Sciences, Shivamogga; University of Agricultural Sciences,

Dharwad; University of Agricultural Sciences, Raichur; Krishi Vigyan Kendra, Brahmavar, Udupi; BASF Pvt Ltd. and Vaahai Agri Clinic, Dindigul.

Araneae (Dr M. Sampath Kumar)

Provided identification services to various ICAR institutes and State Agricultural Universities, viz. ICAR–Central Tobacco Research Institute, Rajahmundry; ICAR–Indian Institute of Rice Research, Hyderabad; Anand Agricultural University, Anand; Assam Agricultural University, Jorhat; College of Agriculture, Bapatla, Acharya N.G. Ranga Agricultural University, Hyderabad; College of Horticulture, Mudigere, University of Agricultural and Horticultural Sciences, Shivamogga; Kerala Agricultural University, Thrissur; Odisha University of Agriculture and Technology, Bhubaneswar; Punjab Agricultural University, Ludhiana; University of Agricultural Sciences, Dharwad and University of Horticultural Sciences, Bagalkot. Identified 180 specimens belonging to 60 species.

Entomopathogenic Fungi (Dr B. Ramanujam)

Identification of the entomopathogenic fungus, Aschersonia aleyrodis was done for All India Coordinated Research Project on Fruits, Punjab Agricultural University, Ludhiana. Identified the entomopathogenic fungus, *Simplicillium cylindrosporum* for ICAR–Central Plantation Crops Research Institute, Kasaragod. Identification of entomopathogenic fungus (*Nomuraea rileyi*) was done for National Institute of Plant Health Management, Hyderabad.

Nucleopolyhedrovirus (Dr G. Sivakumar)

Identification and confirmation of nucleopolyhedrovirus infecting brown-tail moth, *Euproctis chrysorrhoea* was done for Sher-e-Kashmir University of Agricultural Sciences & Technology, Srinagar.

Entomopathogenic Nematodes (Dr Jagadeesh Patil)

Identification services were provided to Anand Agricultural University, Anand and ICAR–Central Potato Research Station, Ooty. Identified 29 specimens belonging to 9 species of entomopathogenic nematodes.

Identification using DNA barcoding Technique (Dr T. Venkatesan)

Insect pests received from the following locations, viz. Plant Quarantine and Pest management Centre, Nepal; ICAR–Directorate of Medicinal and Aromatic Plants Research, Anand; ICAR–Research Complex for North Eastern Hill Region, Manipur Centre; Assam Agricultural University, Guwahati; Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola; Haryana Agricultural University, Hissar; Karnataka Veterinary, Animal and Fisheries Sciences University, Bengaluru; Krishi Vigyan Kendra, Navsari Agricultural University, Gujarat; Mumbai Veterinary College, Mumbai; Regional Agricultural Research Station, Anakapalle, Vishakapatnam; Central Integrated Pest Management Centre, Directorate of Plant Protection, Quarantine & Storage, Port Blair; Directorate of Plant Protection, Quarantine & Storage, Baroda and Cipla Inc., Goa were identified using DNA barcoding technique.

7. EXTENSION ACTIVITIES

I. Field demonstration of technologies

An interactive meeting was held in farmers' field in Gauribidanur, Chikkaballapura district of Karnataka. Scientists from NBAIR interacted with the farmers and answered their queries. Crop advisory services were rendered for efficient management of the fall armyworm in maize. Biocontrol inputs such as *Trichogramma*, *Telenomus, Beauveria bassiana, Metarhizium anisopliae* and *Bacillus thuringiensis* were supplied to the farmers and the methods of releasing the parasitoids were also demonstrated.

On 14 December 2018, a team of NBAIR scientists visited Balijapalli and Morumpalli villages in Hindupur district of Andhra Pradesh, where rabi maize was infested with FAW. *Spodoptera frugiperda* lures were supplied to 19 KVKs under ATARI Hyderabad for monitoring and mass trapping.

The team provided *Trichogramma pretiosum* cards, *Bacillus thuringiensis, Metarhizium anisopliae* and EPN formulations for the management of FAW. FAW pheromone was demonstrate to supplied the technology in West Bengal and Tripura as well.

A day-long workshop entitled "Foldscope for Farmers" was organised . The intent was to attest the utility of the Foldscope (a paper-based microscope) in advocating management practices against microscopic pests in organic farming.

Farmers meet cum demonstration on biological control agents for the management of Rergore Spirating Whikly on coconut and oil palm" was organised at Krishnagiri in, Tamil Nadu, Kalavalapalli, Gantavarigudem, Davarapalli, West Godavari, Madhavaraya Palem and East Godavari in Andhra Pradesh and Mangaluru, Karnataka.

Release of trichocards (*Trichogrammatoidea bactrae*) was demonstrated for the management of pink bollworm in cotton at Yavatmal, Maharashtra. Large scale field demonstration of technologies like WP formulation of *Heterorhabditis indica*, *H. pakistanense* and *Steinernema abbasi* were taken up for the management of white grubs in sugarcane, turmeric and ground nut and also for the management of apple codling moth, brinjal ash weevil, cabbage diamond back moth and rice army worm through various AICRP-BC centers. Farm waste management using black solider fly" was demonstrated to the organic growers at KVK, Doddaballapura, Bengaluru and in the farmers' field at Askihal, Raichur. Rhinoceros and red palm weevil traps were provided to install in farmers' garden in Mandya and Bellary. NBAIR scientists demonstrated the controlled release-rice yellow stem borer pheromone in farmers' field at RARS, Pattambi, Kerala.

Demonstration of farm waste management using black solider fly

Demonstration of release of trichocards

II. Awareness creation and empowerment of farmers

An interactive meeting on rugose spiralling whitefly (RSW), was organised with 40 farmers at Madhavarayudupalem and another awareness programme on RSW was organised by NBAIR in coordination with the Department of Horticulture, Government of Karnataka at Krishi Vigyan Kendra, Kankanady in Mangaluru, wherein awareness was created on the RSW incidence, its host plants, appropriate control measures, mass production of *Isaria fumosorosea*, its mode of action, preparation of spray fluid and application methods. As part of the silver jubilee celebrations of NBAIR, a field survey was conducted in West Godavari district of Andhra Pradesh on 4 July 2018 to determine the infestation of RSW on coconut and oil palm. The level of pest

incidence and occurrence of natural enemies were assessed by the survey team. Natural parasitism by *Encarsia guadeloupae* to the extent of 10-15% was observed.

NBAIR in collaboration with Acharya N.G. Ranga Agricultural University (ANGRAU) organised a tribal farmers' meet as part of its silver jubilee celebrations on 6 July 2018 at Pedalabudu in Araku Valley mandal and emphasized the importance of biological control in organic farming and encouraged the tribal farmers to use biocontrol agents in the fields extensively. *Trichogramma* and *Pseudomonas* were distributed to the tribal farmers. A farmers meeting was organised in cotton growing areas of Gadwal district, Telangana to create awareness on cotton pink bollworm management.

Hands-on training programme was organised to the farmers on the efficacy and mass production of *M. anisopliae* against white grub management in sugarcane and *Spodoptera litura* in soybean for two batches of farmers from Kolhapur, Maharashtra.

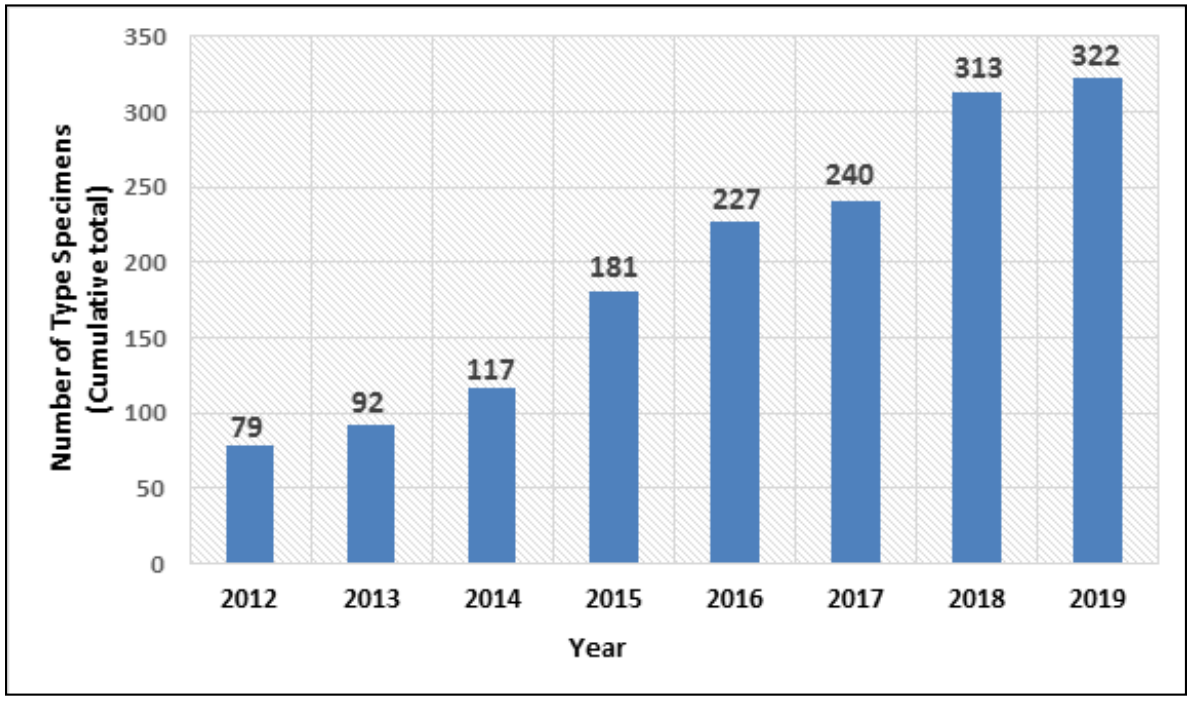
Tribal Sub Plan training cum input supply was organised to empower tribal beneficiaries in collaboration with Bhagavathula Charitable Trust, Vishakhapatnam, on 4 September and 5 May 2018, in Chinthapalli tribal area, Andhra Pradesh.

Several lectures were delivered to the farmers which included "Organic Cultivation of vegetables, fruits and other horticultural crops" in the Organic fair held at Thally, Tamil Nadu on 10 October 2018; "Management of coffee shot hole borer using symbionts" at coffee drip planters meet held at Sakleshpur on 21 January 2019; "Application of bio-fertilizers and bio-pesticides in coconut ecosystem" at KVK, Kandali, Hassan on 29 March 2019; "Application of insect viruses for the management of insect pests" at KVK, Doddaballapura on 20 March 2018 and "Organic pest management in cut flower cultivation" at Organic Farming Mela, Krishnagiri.

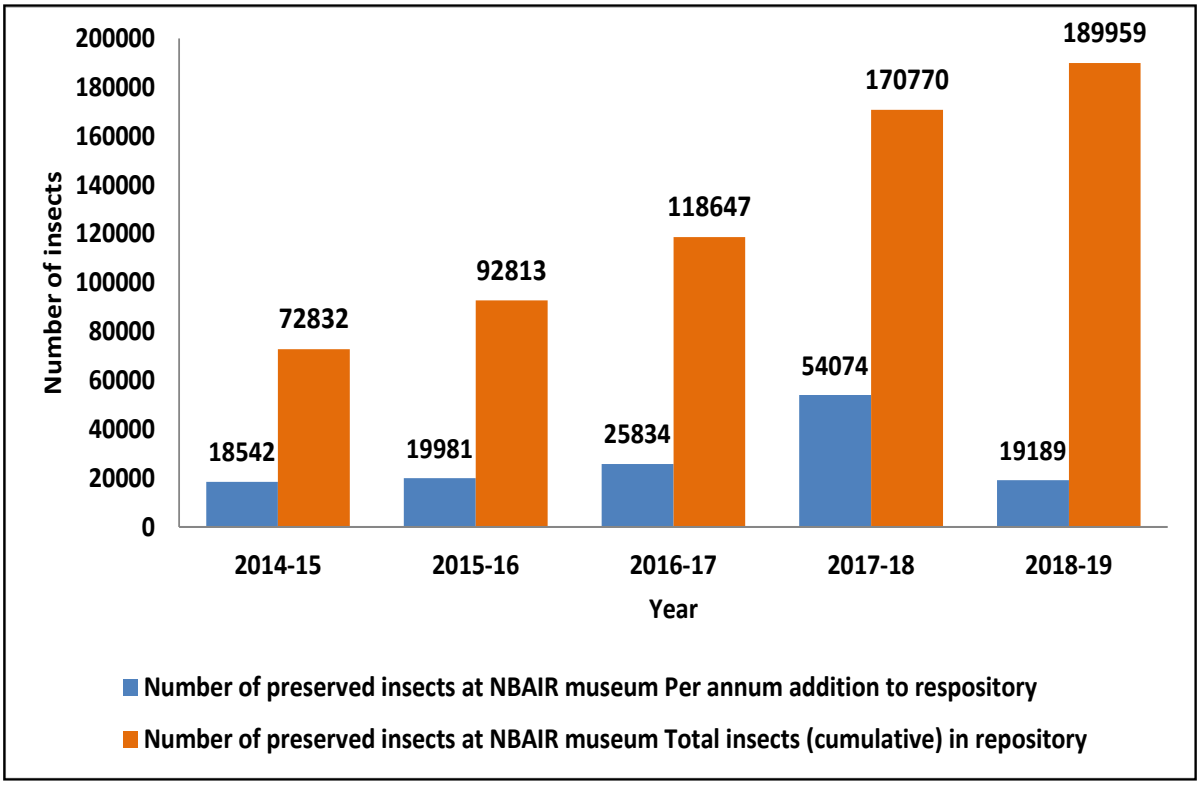
Media coverage of awareness programme in cotton fields in Gadwal district, Telangana

Distribution of biocontrol agents to the farmers and demonstration of field release of parasitoids

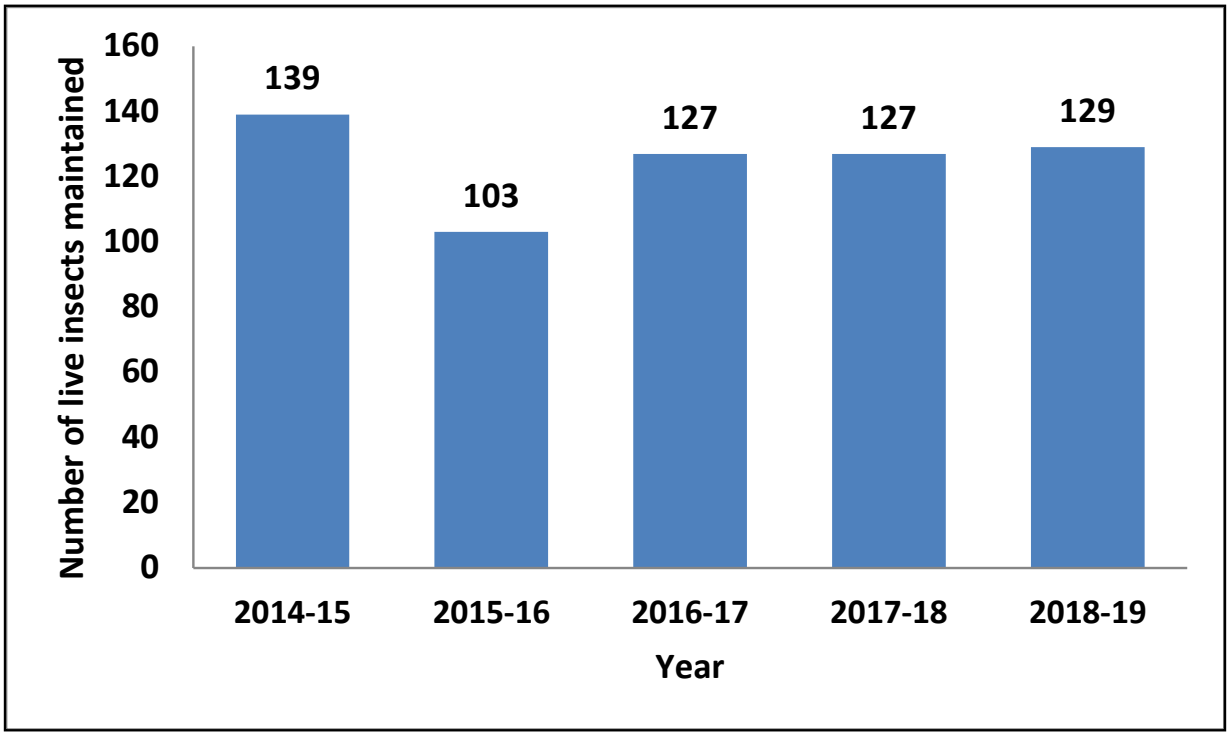
Farmers Meeting on Biological control of Crop Pests in Agricultural Research Station, Ambajipeta, Andhra Pradesh, 5 July 2018



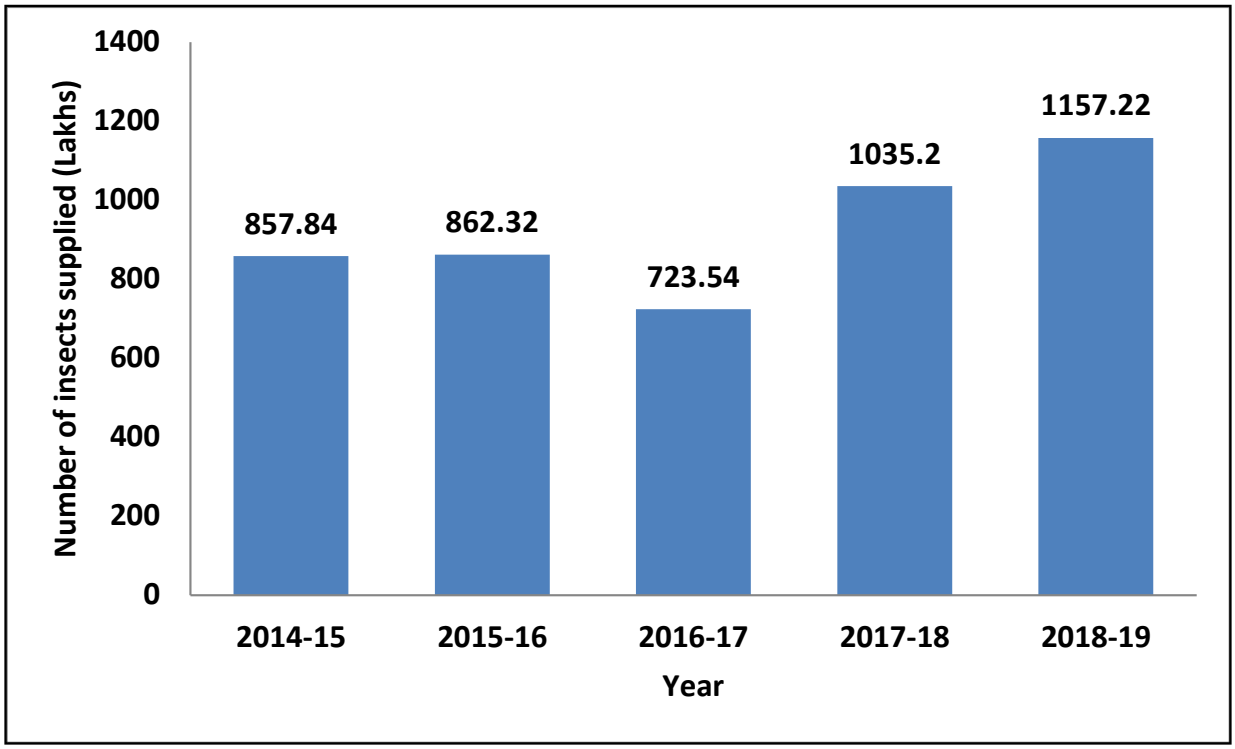
Number of type specimens of insects at ICAR–NBAIR museum



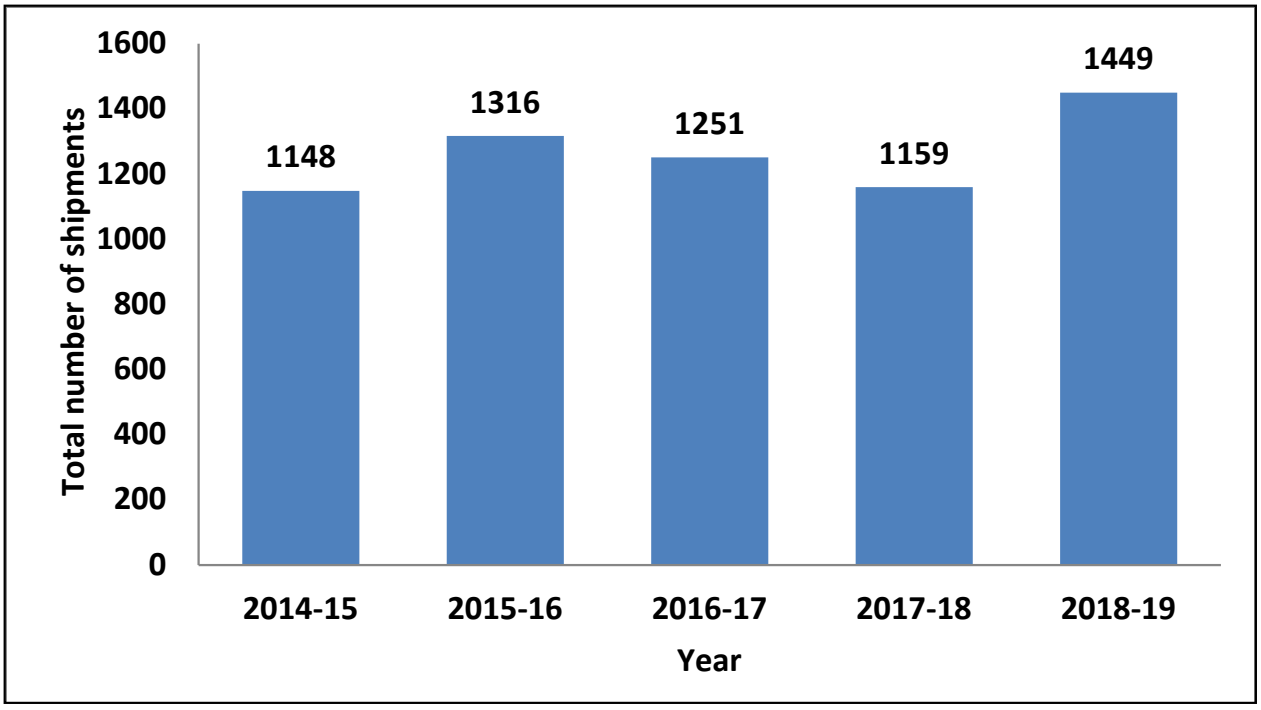
Number of preserved insects in the ICAR–NBAIR museum:
annual additions and cumulative figures



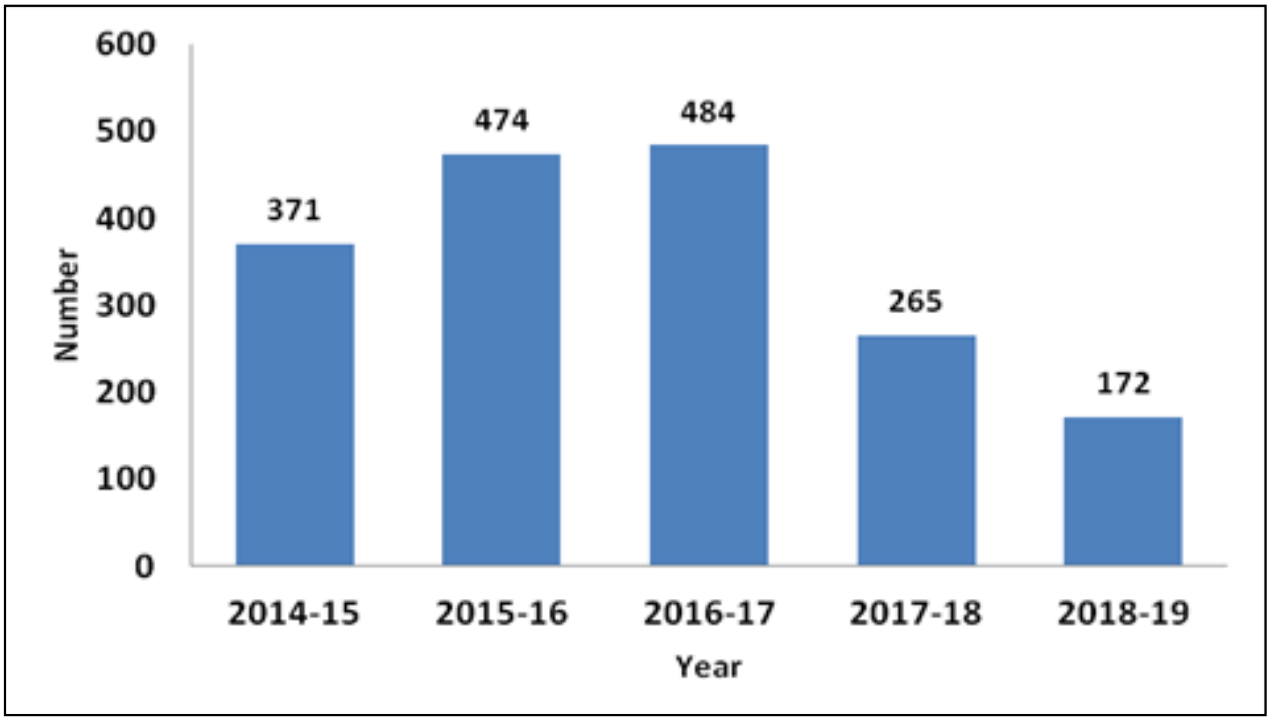
Number of insect live cultures maintained



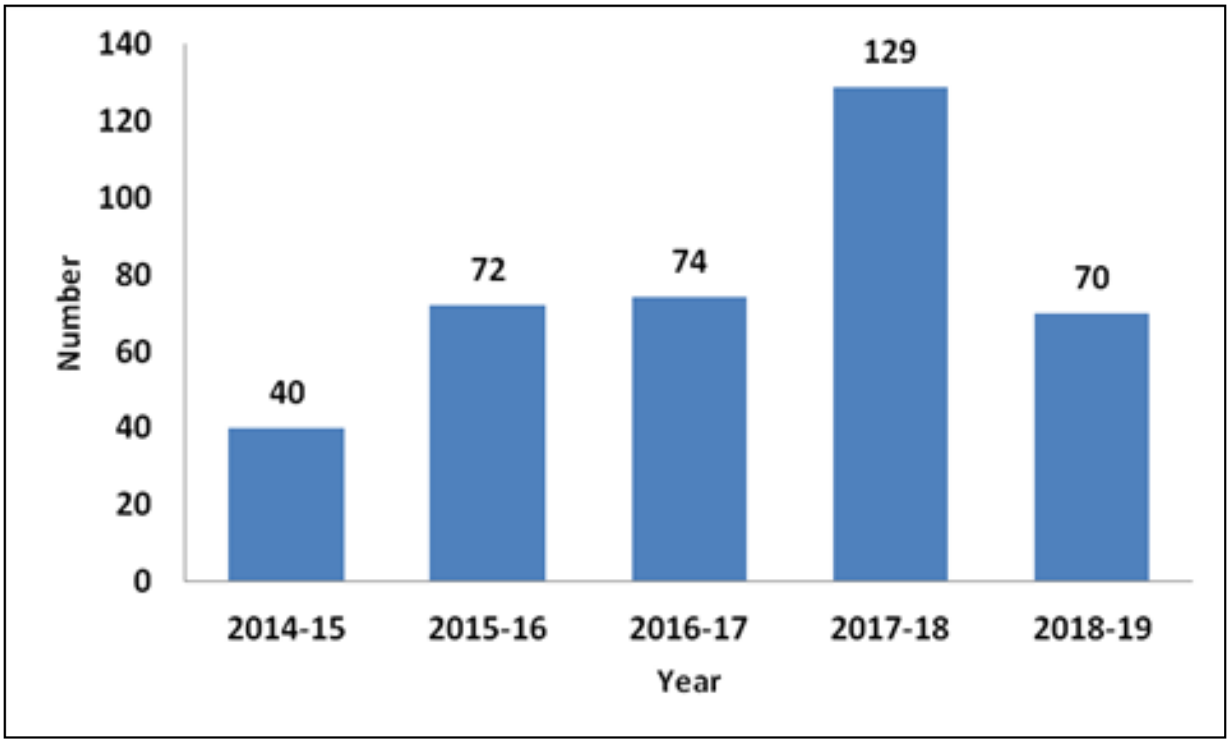
Total number of insects supplied during the last five years



Total number of shipments (host insects and natural enemies) supplied to different organisations



Number of insects and their resources molecularly characterised



Number of insect DNA barcodes developed

8. AWARDS AND RECOGNITIONS

Dr Chandish R. Ballal

Received Dr S. Pradhan Memorial Award and delivered memorial lecture at IARI New Delhi, 27 August 2018.

Awarded Dr. (Ms) Prem Dureja Endowment Award for the Biennium 2017-18, 20 February 2019.

RAC Chairperson, CSGRC, Hosur.

Member of National Advisory Committee of the "Fifth National Symposium of Society for Plant Protection and Environment (SPPE)".

Member, Expert Committee on Agro-biodiversity, National Biodiversity Authority.

Member, National Advisory Committee on Management of Genetic Resources.

Member, Core Expert Group to develop guidelines / eligibility conditions / parameters for identification of repositories.

Member, Panel Discussion on 'Career opportunities in Science' held on 28 May 2018.

Member, Research Coordinator Committee, Central Silk Board.

Member, Expert committee to evaluate the report on contained filed trial of genetically engineered silkworm conducted by DNA finger printing and diagnostics (CDFD), Hyderabad, India, 20 June 2018.

Member, Expert Committee for problems encountered on organic farming by the farmers of silkworm and for making strategies for sustainable agriculture in the state.

Received Life time Achievement Award from Doctor Krishi Evam Bagwari Vikas Sanstha, Lucknow, 28 November 2018.

Member, Advisory Committee of the National Seminar on "Recent trends on Microbial Technology" held at Govt. College of Arts, Science and Commerce, Quopem, Goa, 8–9 February 2019.

Member, Research Coordinator Committee, Central Silk Board.

Member of National Advisory Committee for the "National symposium on Entomology 2018. Advances and Challenges" held at Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, India, 5–7 December 2018.

Member expert Committee on Normally traded commodities nominated by NBA.

Member of National Advisory Committee of AZRA International Conference to be held at Raichur, 12–14 February 2020.

Dr B. Ramanujam

Chaired the Session on 'Coconut Disease management' at "National Level workshop on Plant Health Management of Coconut" held at NIPHM, Hyderabad, 14 March 2019.

Served as subject expert on plant pathology for selection of the post of Deputy Director (Plant Pathology) at NIPHM, Hyderabad, 29 December 2018.

Dr M. Nagesh

Received Letter of appreciation, plaque and felicitation from the sugarcane farmers, Sri Basaveshwara Cooperative Farming Society, Kalloli, Gokak, on 18 September 2018 for commercialising WP formulation of *Heterorhabditis indica* for ecologically safe and effective whitegrub management in sugarcane.

Received Certificate of Appreciation from International Seed Testing Association for training international workers on seed health, with respect to seed-borne nematodes of rice.

Dr Sunil Joshi

Best Oral Presentation Award for the paper entitled, 'An Indian perspective of the neglected players for the control of nasty sucking pests' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr T. Venkatesan

Elected as Fellow of Royal Entomological Society by Royal Entomological Society, London on 5 December 2018.

Best Oral Presentation Award for the paper entitled, 'Molecular characterization of *Microplitis*

maculipennis from India with notes on its generic placement' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Oral Presentation award for the paper entitled 'Management of Bt resistant pink bollworm, *Pectinophora gossypiella* (Saunders), in transgenic cotton by Cry 1 Ac-Vip 3 AcAa fusion protein: A molecular modelling study' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Guided Dr. Aditi Agrawal in the project entitled "Identification and characterization of baculovirus encloded miRNAs and evaluate their expression in plants to control *Helicoverpa armigera* under DST women scientist-A (WAS-A) Scheme.

Best Oral Presentation award for the research paper entitled 'Biological suppression of invasive rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin in coconut' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr P Sreerama Kumar

Received "International Travel Support" from the Science and Engineering Research Board, Department of Science and Technology, Government of India, to participate in the "XV International Congress of Acarology" held at Swandor Hotel Resorts, Topkapi Palace, Antalya, Turkey, 02–08 September 2018.

Received "Certificate of Appreciation" from Professor Dr Sebahat K. Ozman-Sullivan, President, XV ICA 2018, for chairing a session entitled "Section 1. Biological Control" on 06 September 2018 along with the other Chair, Dr Hans Klompen, at the "XV International Congress of Acarology" held at Swandor Hotel Resorts, Topkapi Palace, Antalya, Turkey, 02–08 September 2018.

Chaired a session entitled "Theme: Evaluation of Biological Control" on 27 September 2018 at the "Third International Workshop of the IOBC Global Working Group on Biological Control and Management of *Parthenium* Weed" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Poster Presentation Award for poster entitled 'Taking advantage of the Foldscope in biocontrol research and practice' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Became the Editor of "Society for Invertebrate Pathology (SIP) Newsletter" by the President of the SIP.

Continued as the Ambassador of the Association of Applied Biologists, Warwick, United Kingdom.

Acted as Guest Editor of the Special Issue (Volume 28, Number 10, Year 2018) of Biocontrol Science and Technology, titled "Biocontrol: Approaches and Applications", brought out on the occasion of the "First International Conference on Biological Control: Approaches and Applications", 27–29 September 2018, Bengaluru.

Acted as an Editorial Advisor to the Journal of Biological Control published by the Society for Biocontrol Advancement, Bengaluru.

Acted as the Organising Secretary (Publications) of the "First International Conference on Biological Control: Approaches and Applications" organised by the Society for Biocontrol Advancement and ICAR–National Bureau of Agricultural Insect Resources at Hotel Le Meridien, Bengaluru, 27–29 September 2018.

Acted as the Co-Convernor of the "Third International Workshop of the IOBC Global Working Group on Biological Control and Management of *Parthenium* Weed" held at Hotel Le Meridien, Bengaluru, 27–29 September 2018.

Acted as the Co-Convenor of the "Workshop of the IAPPS Working Group on *Tuta absoluta* – Biology, Ecology and Management' held at Hotel Le Meridien, Bengaluru, 28 September 2018.

Acted as a Member of the Advisory Committee, National Symposium on Cutting Edge Approaches for Sustainable Plant Disease Management and Ensuring Farmers' Profit, organised by the Indian Phytopathological Society (Southern Zone Chapter) and the ICAR–National Research Centre for Banana, at Tiruchirappalli, 21–23 December 2018.

Acted as an Examiner for evaluation of a Ph.D. thesis submitted to the Forest Research Institute Deemed to be University, Dehra Dun, in August 2018.

Nominated as a Member of the Committee to Evaluate Project Completion Reports, by the Director, Institute of Wood Science and Technology, Bengaluru, in June 2018.

Dr R. Rangeshwaran

Served as Chief Editor for the Journal of Biological Control and brought out 5 issues for 2 volumes of the Journal containing more than 50 articles.

Recognised as Ph.D. guide by Mysore University.

Recognised as Ph.D. guide by Jain University.

Dr K. Subaharan

Served as a resource person for CAFT in Department of Microbiology, Tamil Nadu Agricultural University. Delivered a lecture on Deciphering plant microbe interactions responsible for plant defense.

Delivered an invited lecture on 'Smell of food and love: Exploiting olfactory cues for pest management' in "National Symposium on Entomology 2018: Advances and Challenges, held at Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, India, 5–7 December 2018.

Received the DBT – Biotech Product Process Development and Commercialization Award 2018 with Prof. Eswaramoorthy, JNCASR and Dr. Gautam Kaul, ICAR–NDRI, 11 May 2018.

Received the T. N. Ananthakrishnan Senior Scientist Award 2016–2017 for contribution in the field of Entomology at the "National Symposium on Entomology 2018: Advances and Challenges" held at Hyderabad, India, 12 December 2018.

Best Poster Presentation Award for poster entitled 'Essential oil based nanoemulsion for housefly, *Musca domestica* management' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Delivered a talk on 'Controlled release dispenser for delivery of red palm weevil, Rhyncophorus ferrugineus pheromone' during "Nanobiotek 2018" held at All India Institute of Medical Sciences, 25–26 October 2018.

Delivered a talk on 'Insect olfaction' at Entomology Club of Agriculture College and Research Institute, TNAU, Madurai on 26.11.2018.

Delivered a talk on 'Controlled release matrix for delivery of South American tomato moth, *Tuta absoluta* pheromone' during the workshop of "IAPPS working group on *Tuta absoluta* - Biology, Ecology and Management" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Served as a panelist for International Consultative workshop on Disruptive translational research in nanobiotechnology: Advancing sustainable food systems and human health solutions organised by DBT– TERI and Deakin University, 13 March 2018.

Served as a Project Management Committee member of DBT - BIRAC funded projects. As PMC member, the projects funded under BIRAC were reviewed from time to time.

Invited as a speaker for plenary session during 'Integrated Pest Management Session' in Virtual symposium organised by Entomological Society of America, 17 April 2018.

Recognised as a Post Graduate Teacher at University of Agricultural Sciences, Raichur.

Served as Judge for screening Post Graduation research for 2018 held at University of Agricultural Sciences (B) during Science week during 28–30 May 2018.

External Examiner for evaluation of Ph.D thesis of Department of Entomology, Tamil Nadu Agricultural University, Coimbatore.

External Examiner for evaluation of M.Sc (Agri) thesis of Department of Entomology, Kerala Agricultural University, Thrissur.

External Examiner for evaluation of M.Sc (Agri) thesis of Department of Entomology, Pandit Jawaharlal College of Agriculture, Karaikal.

External Examiner for evaluation of M.Sc (Agri) thesis of Department of Entomology, Faculty of Agriculture, Annamalai University.

Served as advisory committee member for Mr. Girish, Ph.D. Scholar, UAS Raichur, 13 May 2018.

Served as Evaluator for DBT – BIPP project proposal on 5 January 2019.

Section Editor for Economic Entomology in Indian Journal of Entomology.

Editorial Board member of Journal of Biological Control.

Served as Observer for ARS and NET 2018 exams conducted during 9 to 10 April 2018 and facilitated in conduct of online examination.

Invited for setting question paper of Pondicherry University on 27 December 2018 for Insect Physiology and Storage Entomology.

Delivered an invited lecture on 'Exploiting olfactory cues for pest management' at "Phytopherocon 2019" held at Department of Entomology, Annamalai University, 3 January 2019.

Conferred Fellow of Indian Society for Plantation Crops for outstanding research in Plantation Crops, 6 March 2019.

Dr G. Sivakumar

Best Oral Presentation award for the paper entitled 'Characterization and Evaluation of nucleopolyhedroviruses against lepidopteran pests of crops' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Oral Presentation award for the paper entitled 'Exploitation of mutualistic fungal symbiont *Fusarium ambroseum* for the suppression of tea shot hole borer, *Euwallacea fornicatus*' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Visited as an Expert Scientist for reviewing the Research Project on Integrated Disease Management practices funded under the Karnataka Water Development Project, Watershed Development Department, Karnataka at Watershed Development Department, Bengaluru on 31 December 2018.

Recognised as External examiner for Ph.D Thesis evaluation of Jawaharlal Nehru Technological University, Hyderabad

Organizing Secretary for the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Recognised as a Lead Speaker and delivered a talk on the 'Management of Tea Shot Hole Borer Euwallacea fornicatus through its fungal symbiont Fusarium ambrosium' at the "National Agri- Business Entrepreneurship Conclave" held at ICAR Research Complex for NEH region, Umiam, Meghalaya, 9–11 February 2019.

Recognised as a Reviewer of Journal of Plant Interaction.

Dr M. Mohan

Best Oral Presentation award for the paper entitled, 'Controlled release matrix for delivery of South American tomato moth, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) pheromone' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr Mahesh Yandigeri

Recognised as Post Graduate teacher for Veterinary Microbiology at Karnataka Veterinary Animal & Fisheries Sciences University, Bidar, Karnataka.

Dr A. Kandan

Best Poster Presentation award for the poster entitled '*Pseudomonas fluorescens* as a biological control agent against *Plutella xylostella* in Cabbage' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr Deepa Bhagat

Reviewer for Biotechnology Industry Research Assistance Council, BIRAC (A Government of India Enterprise) for screening/scrutinising Projects.

Scientific Advisor in a BIRAC BIG-14 proposal from a freelancer researcher, Ms. Nandamuri Sri Lakshmi Bhavani, Vijayawada, on "Plant Hack-Micro Embedded System for Soil Less Agriculture".

Editorial Board of International Journal of Global Advanced Materials and Nanotechnology.

Dr Ankita Gupta

Best Oral Presentation award for the paper entitled 'An Indian perspective of the neglected players for the control of nasty sucking pests' at the "First

International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Oral Presentation award for the paper entitled 'Morphological and molecular characterization of *Microlpitis maculipennis* Szepligeti (Hymenoptera: Braconidae) from India with notes on its generic placement' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Served as Organizing Secretary Liaison for "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Served as Moderator for the Session I 'Biodiversity, Biosecurity and conservation strategies' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Selected as NKN champion for presentation at IIT Delhi through video conferencing facility at NIC Bangalore, 20 June 2018.

Trained an international PhD student, Mr Mohammad Zargar from 25 July 2018 to 27 March 2019 at ICAR–NBAIR, Bengaluru.

Nominated as expert to attend "National workshop on recent trends in Taxonomy" held at Jodhpur, 10 to 11 January 2019 and served as evaluator of poster session on 11 January 2019.

Reviewed project as expert under Core Research Grants scheme of Science and Engineering Research Board (SERB).

Selected as subject expert under taxonomy for Editorial advisory board of Entomological Society of India, IARI.

Dr Jagadeesh Patil

Received Prof. T. N. Ananthakrishnan Young Scientist award from Prof. T. N. Ananthakrishnan foundation, Chennai for outstanding contribution in the field of entomopathogenic nematodes at the "National Symposium on Entomology 2018: Advances and Challenges" held at Hyderabad, India, 10–12 December 2018.

Best Oral Presentation award for the paper entitled 'Compatibility and efficacy of entomopathogenic nematode-insecticide combinations against *Holotrichia consanguinea* Blanch. (Coleoptera: Scarabaeidae)' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best poster presentation for the poster entitled 'First report of *Steinernema cholashanense* (Rhabditidae: Steinernematidae) from India and its biocontrol potential against potato pests' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Poster Presentation award for the poster entitled 'Integrating biocontrol agents with farmers practices for the management of diamond back moth, *Plutella xylostella* in cabbage' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr Gandhi Gracy

Advisory council member for one PhD student from Department of Entomology, GKVK, UAS (B).

Co-Major Advisor for one MSc student from Department of Entomology, IGKV, Raipur.

Subject Editor- Journal of Biological Control

Dr S. Salini

Received "International Travel Support" from the Science and Engineering Research Board, Department of Science and Technology, Government of India, to participate in the "VI Quadrennial Meeting of International Heteropterists' Society" held at La Plata, Argentina, 03–07 December 2018.

Served as Moderator for the technical session on 'Biological control of invasive pests and weeds' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Invited as Resource Person to deliver lecture on 'Methods of insect collection, processing and curation and Identification keys' during the workshop on "Insect Taxonomy and Field Sampling Skills" held at Calicut University, Kerala, 25–28 March 2019.

Dr K.J. David

Received "Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agriculture and Allied Sciences-2017 for Crop Protection" at NASC Complex, New Delhi, 16 July 2018.

Best Oral Presentation award for paper entitled 'A Systematic account of weed infesting fruit flies in India' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Invited as Resource Person to deliver lecture on 'Schools of taxonomy' during five days training program on "DNA Barcoding and Bioinformatics Applications in Entomology" at ICAR–NBAIR Bengaluru from 25 February to 3 March 2019.

Invited as Resource Person to deliver lectures on 'Introduction to insect taxonomy and classification, Digitization of insect specimens and Preparation of taxonomic illustrations and Principles of Nomenclature' during the workshop on "Insect Taxonomy and Field Sampling Skills" held at Calicut University, Kerala, 25–28 March 2019.

Dr M. Sampath Kumar

Guided Mr H.P. Lava Kumar BLH5018, IV B. Tech (Biotechnology), UAS, Bengaluru, COA, Hassan student for completing his three months internship programme entitled 'Survey, collection, and gut content analysis of Spiders' from 4 December 2018 to 22 March 2019 at ICAR–NBAIR Bengaluru.

Served as Organising Secretary/Treasurer of "First International Conference on Biological Control: Approaches and Applications" held in Bengaluru from 27–29 September 2018.

Organized Six trainings (as Programme Coordinator) which include three farmer trainings, one short course to NEH officials, one training to NIPHM- PGDPHM course and one training on skill training programme sponsored by ASCI.

Rapporteur for Technical session at the Group meeting of All India Co-ordinated Research Project on Biological Control of Crop Pests held at KAU Thrissur, 17–18 May 2018.

Rapporteur for Technical session on 'Biotechnological Approaches in Biological Control' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr K. Selvaraj

Received 'Young Scientist Award with certificate and cash prize' at the "National Symposium on Entomology 2018: Advances and Challenges Entomological society of India" from Plant Protection Society of India held at Professor Jayashankar Telangana State Agricultural University, Hyderabad, India, 10–12 December, 2018.

Best Oral Presentation award for paper entitled 'Biological suppression of invasive rugose spiraling whitefly *Aleurodicus rugioperculatus* Martin in coconut' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Poster Presentation for poster entitled on 'Isaria fumosorosea Wise: A potential biocontrol agent for management of *Aleurodicus rugioperculatus* Martin in coconut and oil palm' at the "Sixth Biopesticides International Conference (BIOCICON 2019)" held at Chhattisgarh Council of Science and Technology & Amity University, Raipur, India, 06–08 March 2019.

Received Young Disseminator Award (Eco-friendly pest management awards) at "Sixth Biopesticides International Conference (BIOCICON 2019)" held at Chhattisgarh Council of Science and Technology & Amity University, Raipur, India, 06–08 March 2019.

Dr U. Amala

Received Kanwar Virender Singh Memorial Best Publication Award in Fruit Science for the publication entitled "Comparative biology and fertility parameters of two spotted spider mite, *Tetranychus urticae* Koch on different grapevine varieties" from Society for Advancement of Human and Nature, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan.

Received Fellow award from Society for Biocontrol Advancement, Bengaluru.

External Examiner for evaluation of Ph.D thesis of Department of Entomology, Tamil Nadu Agricultural University, Coimbatore.

Served as Moderator for the technical session on 'Production and Utilization of Macrobials for Insect Pest Management' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Dr. Richa Varshney

Received title of "Krishi Vigyan Gaurav (2018)" for the hindi article "*Trichogramma*: Fasal keet ke ando ka parjivi" in Bhartiya Krishi Anusandhan Patrika.

Best Oral Presentation Award for the paper entitled, '*Geocoris ochropterus* Fieber: a potential predator' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Rapporteur for Technical session at the Group meeting of All India Co-ordinated Research Project on Biological Control of Crop Pests held at KAU Thrissur, 17–18 May 2018.

Rapporteur for Technical session on 'Production and Utilization of Microbials for Insect Pest and Disease Management' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Ms R.R Rachana

Recognised as an honorary member of the editorial board of the IJBST (International Journal of BioSciences and Technology) group of journals.

Dr Veeresh Kumar

Awarded "Fulbright-Nehru Post-Doctoral Fellow" from United States-India Educational Foundation (USIEF) during 2019-20.

Dr R.S. Ramya

Best Poster Presentation award for the poster entitled 'Arthropod diversity in rose, jasmine and cock's comb ecosystem' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Best Poster Presentation award for the poster entitled 'Integrating biocontrol agents with farmers' practices for the management of diamondback moth, *Plutella xylostella* (Linnaeus), in cabbage' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Moderator in the Technical session on 'Biological Control Compatible Approaches' at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

Invited as Resource Person to deliver lecture on 'Application of insect genomics in pest management strategies' during the training on "DNA-barcoding and bioinformatics applications in Entomology" at ICAR–NBAIR, Bengaluru, 25 February to 3 March 2019.

Invited as Resource Person to deliver lecture on 'Insect collection, processing and mounting techniques' during the training on "DNA-barcoding and bioinformatics applications in Entomology" at ICAR–NBAIR, Bengaluru, 25 February to 3 March 2019.

Dr Navik Omprakash Samodhi

Best Poster Presentation award for paper entitled "Integrating biocontrol agents with farmers practice for the management of diamondback moth, *Plutella xylostella* (Linnaeus) in cabbage" at the "First International Conference on Biological Control: Approaches and Applications" held at Hotel Le Meridien, Bengaluru, India, 27–29 September 2018.

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Dr Chandish R. Ballal receiving Dr (Ms) Prem Dureja Endowment Award for the biennium 2017-18

Dr Chandish R. Ballal receiving Dr S. Pradhan Memorial Award

Dr K. Subaharan and team receiving the DBT – Biotech Product Process Development and Commercialisation Award 2018

9. AICRP COORDINATION UNIT AND CENTRES

The biocontrol technologies developed at NBAIR are field tested, validated and demonstrated on a large scale under the All-India Coordinated Research Project on Biological Control of Crops Pests by selected ICAR institutes and State Agricultural Universities.

Coordination Unit

• ICAR–National Bureau of Agricultural Insect Resources, Bengaluru	Basic research

State Agricultural University-based centres

• Acharya N.G. Ranga Agricultural University, Guntur	Sugarcane, maize
• Anand Agricultural University, Anand	Cotton, pulses, oilseeds, vegetables, weeds
• Assam Agricultural University, Jorhat	Sugarcane, pulses, rice, weeds
• Central Agricultural University, Pasighat	Rice, vegetables
• Dr Y.S. Parmar University of Horticulture & Forestry, Solan	Fruits, vegetables, weeds
• Gobind Ballabh Pant University of Agriculture and Technology, Pantnagar	Plant disease antagonists
• Kerala Agricultural University, Thrissur	Rice, coconut, weeds, fruits
• Maharana Pratap University of Agriculture & Technology, Udaipur	Maize, vegetables
• Mahatma Phule Krishi Vidyapeeth, Pune	Sugarcane, cotton, soybean, guava
• Orissa University of Agriculture & Technology, Bhubaneswar	Rice, vegetables
• Pandit Jayashankar Telangana State Agricultural University, Hyderabad	Cotton, pulses, oilseeds, sugarcane
• Punjab Agricultural University, Ludhiana	Sugarcane, cotton, oilseeds, rice, tomato, weeds
• Sher-e-Kashmir University of Agriculture Science & Technology, Srinagar	Temperate fruits, vegetables
• Tamil Nadu Agricultural University, Coimbatore	Sugarcane, cotton, pulses, tomato, papaya, cassava
• University of Agricultural Sciences, Raichur	Oilseeds, pulses, millets, cotton
• Indira Gandhi Krishi Viswavidhyalaya, Raipur	Rice, pulses, vegetables
• KAU–Regional Agricultural Research Station, Kumarakom	Rice, plantation crops, vegetables
• Kerala Agricultural University, Vellayani	Rice, papaya, cassava
• Uttar Banga Krishi Vishwavidyalaya, Pundibari	Rice, maize, vegetables, pulses

ICAR Institute-based centres

• ICAR–Central Plantation Crops Research Institute, Kayamkulam	Coconut, areca nut
• ICAR–Indian Institute of Horticulture Research, Bengaluru	Fruits and vegetables
• ICAR–Indian Institute of Rice Research, Hyderabad	Rice
• ICAR–Indian Institute of Vegetable Research, Varanasi	Vegetables
• ICAR–National Centre for Integrated Pest Management, New Delhi	Biocontrol in IPM
• ICAR–Central Institute for Subtropical Horticulture, Lucknow	Tropical fruits

- ICAR–Central Tobacco Research Institute, Rajamahendravaram — Tobacco
- ICAR–Indian Institute of Millet Research, Hyderabad — Maize, sorghum and other millets

Voluntary centres

- Dr Y.S.R. Horticultural University, Ambajipeta
- Sun Agro Biotech, Chennai
- Panjabrao Deshmukh Krishi Vidyapeeth, Akola
- SKUAST–Jammu, Rakh Dhiansar
- Nagaland University, Medziphema
- National Institute of Plant Health Management, Hyderabad

10. ONGOING RESEARCH PROJECTS

A. Institute Projects for 2018-19

DIVISION OF GERMPLASM COLLECTION AND CHARACTERISATION

I. Biosystematics of agriculturally important insects and associated fauna

1. Taxonomy of Pseudococcidae, Coccidae and Diaspididae (Hemiptera Coccoidea) (01.04.2017 to 31.03.2022) – Dr Sunil Joshi
2. Biosystematics studies on Scarabaeidae and Cerambycidae of Coleoptera (22.06.2017 to 31.03.2022) – Dr K. Sreedevi
3. Taxonomic studies on Indian Curculionidae (Coleoptera) with emphasis on Entiminae (01.07.2016 to 31.03.2021) – Dr G. Mahendiran
4. Taxonomy and biocontrol potential of entomopathogenic nematodes in Deccan Plateau of India (01.04.2017 to 31.03.2022) – Dr Jagadeesh Patil
5. Taxonomic studies on fruit flies (Diptera: Tephritidae) of India (01.04.2012 to 31.03.2020) – Dr K. J. David
6. Taxonomic studies on Pentatomidae (Hemiptera: Pentatomoidea) of India with special reference to Pentatominae (14.03.2012 to 31.03.2020) – Dr S. Salini
7. Taxonomy, diversity and host-parasitoid association of Ichneumonoidea: Braconidae with special reference to Braconinae, Doryctinae & Microgastrinae (09.05.2016 to 31.03.2021) – Dr Ankita Gupta
8. Digitization of type specimens and cataloguing of voucher specimens in ICAR–NBAIR reference collections. (01.04.2018 to 31.03.2021) – Dr Ankita Gupta
9. Taxonomy of Indian spiders (Araneae) with reference to agro ecosystem (01.07.2016 to 31.03.2020) – Dr M. Sampath Kumar
10. Taxonomy and diversity of Indian Thysanoptera with special reference to Terebrantia (01.10.2015 to 31.03.2021) – Ms. R. R. Rachana
11. Taxonomy of Indian Trichogrammatidae (Chalcidoidea: Hymenoptera) and evaluation of potential species (01.09.2016 to 31.03.2022) – Dr Navik Omprakash Samodhi

DIVISION OF GENOMIC RESOURCES

II. Molecular characterization, genomics and bioinformatics of agriculturally important insects, entomopathogenic nematodes and associated microorganisms

12. Studies on molecular and functional diversity of EPN-EPB-insect tritrophism and their utilization against soil pests (08.07.2016 to 31.03.2021) – Dr M. Nagesh
13. Molecular characterization and DNA barcoding of agriculturally important parasitoids and predators (01.06.2013 to 31.05.2020) – Dr T. Venkatesan
14. Molecular characterization and DNA barcoding of subterranean insects (01.04.2014 to 31.03.2019) – Dr K. Srinivasa Murthy
15. *Bacillus thuringiensis* – Fermentation and formulation strategies for enhanced toxicity against insect pests (01.04.2017 to 31.03.2020) – Dr R. Rangeshwaran

16. Population genetic diversity in selected insect borers of economic importance (01.04.2018 to 31.03.2022) – Dr M. Mohan

17. Development of Mobile Apps for Non-chemical methods for important crop pests (01.04.2017 to 31.03.2020) – Dr M. Pratheepa

18. Molecular docking studies of insecticide resistance genes of storage pests: *Tribolium castaneum* (Herbst) and *Callosobruchus maculatus* (Fabricius) (01.04.2017 to 31.03.2020) – Dr M. Pratheepa

19. Studies of detritivorous insects and associated microorganisms for their scope in farm waste management (01.10.2016 to 31.03.2020) – Dr Mahesh S. Yandigeri

20. Taxonomy and diversity of Sphecidae (01.09.2014 to 31.03.2020) – Dr R. Gandhi Gracy

21. Exploration of induced Hormesis for the possible role in enhanced efficacy of biocontrol agent (01.09.2017 to 31.03.2020) – Dr R. Gandhi Gracy

22. Studies on insecticide and Bt resistance in pink bollworm, *Pectinophora gossypiella* (Saunders) (01.09.2016 to 31.03.2020) – Dr R. S. Ramya

DIVISION OF GERMPLASM CONSERVATION AND UTILISATION

III. Biodiversity conservation, behavioural studies and maintenance and utilisation of arthropod germplasm

23. Behavioural manipulation techniques for the management of some important insect pests using olfactory and visual cues (01.07.2017 to 31.07.2021) – Dr N. Bakthavatsalam

24. Climate change effect on the diversity and bioecology of some important sucking pests (01.04.2014 to 31.03.2021) – Dr N. Bakthavatsalam

25. Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamond backmoth (*Plutella xylostella* (L.)) (01.04.2017 to 31.03.2020) – Dr B. Ramanujam

26. Gall formers of important crops and their management (01.04.2017 to 31.03.2021) – Dr A. N. Shylesha

27. Effect of pollinator friendly crop plants in enhancing pollination and yield in selected crops (01.04.2017 to 31.03.2020) – Dr T. M. Shivalingaswamy

28. Documenting agriculturally important mites and establishing an authentic collection (01.04.2014 to 31.03.2019) – Dr P. Sreerama Kumar

29. Chemical characterization and ethology of economically important dipteran pests of veterinary and fisheries (09.10.2014 to 31.03.2019) – Dr Kesavan Subaharan

30. Characterization of viruses with special reference to Lepidoptera & Coleoptera (24.11.2015 to 31.03.2021) – Dr G. Sivakumar

31. Nanotechnology Applications in pest management (01.04.2018 to 31.03.2023) – Dr Deepa Bhagat

32. Studies on tospovirus-thrips interactions and ecofriendly management of the vector (01.08.2017 to 31.03.2020) – Dr A. Kandan

33. Studies on whiteflies and associated natural enemies for their management (19.09.2016 to 31.03.2021) – Dr K. Selvaraj

34. Habitat manipulation as a tool to conserve beneficial insects (15.07.2016 to 31.03.2021) – Dr U. Amala

35. Studies on exploitation of insects as food and feed (01.01.2017 to 31.03.2019) – Dr U. Amala

36. Diversity and predator-prey interactions in predatory mirids geocorids, anthocorids and mites (1.10.2015 to 31.03.2019) – Dr Richa Varshney

B. List of Externally Funded Projects 2018-19

DIVISION OF GERMPLASM COLLECTION AND CHARACTERISATION

1. DBT: Multifaceted exploration of edible molluscs of North East India (18.07.2018 to 17.07.2021) – Dr K. Sreedevi

2. DST: Biogeography, systematics and molecular characterization of white grub fauna (Coleoptera: Scarabaeidae) of South India (19.11.2018 to 18.11.2021) – Dr K. Sreedevi

3. CABI: Insect biodiversity documentation in Sikkim region including research into the potential for biological control of *Hedychium* species using Indian natural enemies (2018 to 2020) – Dr Chandish R. Ballal

4. Bioversity International: Biodiversity of insect pests and natural enemies in organically grown land races of rice at Chengalpattu, Tamil Nadu (01.03.2019 to 01.03.2022.) – Dr M. Sampath Kumar

5. DST: Systematic studies on fruit flies of subfamily Tephritinae (Diptera: Tephritidae) from south India with special reference to Western Ghats (30.03.2019 to 29.03.2022) – Dr K.J. David

DIVISION OF GENOMIC RESOURCES

6. NICRA: Development of IPM strategies to combat whitefly and other emerging pests in cotton (2016-2020) – Dr T. Venkatesan

7. AMAAS: Exploitation of endosymbionts of insect pests for pest management (01.04.2017 to 31.03.2020) – Dr Mahesh S. Yandigeri

8. ICAR–CRP on Genomic platforms (01.04.2015 to 31.03.2020) – Dr M. Mohan

9. DST: Studies on pollination dynamics, pod yield and oil content in *Pongamia pinnata* (26.02.2018 to 31.02.2021) – Dr Veeresh Kumar

10. Network project on Agricultural bioinformatics and computational biology (31.03.2014 to 31.03.2020) – Dr T. Venkatesan

11. Tropical Nanosciences Pvt Ltd: Evaluation of bio-efficacy of TagNOK, a microbial formulation against Fall armyworm *Spodoptera frugiperda* in Maize (Zea mays) (10.11.18 to 09.11.19) – Dr M. Mohan

DIVISION OF GERMPLASM CONSERVATION AND UTILISATION

12. AMAAS: Exploitation of endophytism of entomopathogenic fungi for insect pest management in groundnut, soybean, pigeonpea and chickpea (01.04.2014 to 31.03.2020) –Dr B. Ramanujam

13. DBT: Wide use of the Foldscope as a research tool (11.05.2018 to 10.09.2019) – Dr P. Sreerama Kumar

14. CDB: Biological control of invasive rugose spiralling whitefly *Aleurodicus rugioperculatus* using *Encarsia guadeloupae* in coconut (04.08.2017 to 31.08.2019) – Dr K. Selvaraj

15. KCPM: Characterisation and application of virulent strains of Nucleopolyhedrosis viruses (NPV) *Bacillus thuringiensis* (Bt) and Entomopathogenic nematodes (EPN) for the management of rice armyworm *Spodoptera mauritia* (10.10.2017 to 09.10.2019) – Dr G. Sivakumar

16. NTRF: Feasibility of suppression of tea shot Hole Borer *Euwallacea fornicatus* through its mutualistic *Fusarium* sp. (01.01.2016 to 31.03.2019) – Dr G. Sivakumar

17. DBT: Developing a nanomatrix for delivery of pheromone synergists of house fly, *Musca domestica* L. (01.03.2018 to 01.03.2021) – Dr K. Subaharan

18. ATGC: Pheromone formulations for mating disruption in some important agricultural insect pests (01.04.2016 to 16.07.2018) – Dr N. Bakthavatsalam

19. CABI : Emergency response to address fall armyworm (*Spodoptera frugiperda*) in India through deployment of proven IPM technologies for its management (2018-2020) – Dr A. N. Shylesha

20. DST : Signalling mechanisam in the tri-trophic interaction between Brasicacious plants and their insect pest and parasitoid of the pest (14.11.2018 to 31.03.2021) – Dr N. Bakthavatsalam

11. ACTIVITIES OF ITMU

Technologies developed

1. Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis.*
2. High temperature tolerant strain of egg parasitoid, *Trichogramma chilonis.*
3. Pesticide tolerant strain of aphid lion, *Chrysoperla zastrowi sillemi*, an important predator of sucking pests.
4. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests.
5. Novel WP formulation of *Pochonia chlamydosporia* as bio-nematicide against plant parasitic nematodes.
6. Liquid formulation of *Bacillus thuringiensis.*
7. Powder based formulation of *Pseudomonas fluorescens*, a DAPG producing abiotic stress tolerant isolate for rain fed and stressed agricultural soil.
8. Closed system for mass production of predatory mites.
9. A dispenser for the monitoring of eucalyptus gall wasp.
10. Bio formulation of salinity tolerant *Trichoderma harzianum* with biocontrol potential.
11. Bio formulation of carbendazim tolerant *Trichoderma harzianum* with biocontrol potential.
12. Powder based formulation of *Bacillus megaterium* as growth promoter.
13. A plant volatile based attractant for enhanced attraction of fruit fly.
14. A simple technique of rearing brinjal shoot and fruit borer, *Leucinodes orbonalis.*
15. Protocol for designing lure for impregnating parapheromone 4[4-acetoxy) phenyl-butanone to attract male flies of *Bactrocera* spp. attacking cucurbit crops for mass trapping and monitoring its population thereof.
16. Control release dispensers for semiochemicals.
17. Mass production of *Trichogramma chilonis* & *T. embryophagum* using Eri silkworm eggs.
18. A Herbal based Repellant for Termites on woody trees-REPTER.
19. Herbal swabber for the management of white stem borer, *Xylotrechus quadripes* in Coffee (organic and non-pesticidal). B. Booster for boosting plant health in coffee (not for certified organic coffee).
20. Adsorption and delivery of molecules using Nanoporous materials.
21. Shatpada Dorsa-Delta an efficient trap for Mango fruit fly.
22. A Technique for rearing of Housefly parasitoid, *Spalangia*.
23. A Technique for rearing of Housefly parasitoid, *Nasonia vitripennis* (Pteromalidae).
24. Waste to wealth: Technology on Black Soldier Fly mediated bioconversion of farm and kitchen wastes.
25. Insect repellent formulation and methods thereof.
26. Novel device for field release of parasitoids.

Technologies commercialised

1. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests.
2. Waste to wealth: technology on black soldier fly mediated bioconversion of farm and kitchen wastes.
3. A technique for rearing of housefly parasitoid, *Nasonia vitripennis.*

4. A technique for rearing of housefly parasitoid, *Spalangia sp.*
5. Adsorption and delivery of molecules using nanoporous materials.
6. Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis.*
7. Powder based formulation of *Pseudomonas fluroscens*, a DAPG producing abiotic stress tolerant isolate for rain fed and stressed agricultural soil.
8. Powder based formulation of *Bacillus megaterium* as growth promoter.
9. Closed system for mass production of predatory mites.

Achievements of ITMU under National Agriculture Innovation Fund Project

- Total number of technologies available at NBAIR: 26
- Number of technologies commercialised: 09
- Number of licensees that purchased technologies from NBAIR: 13
- Number of patents granted:01

Patents granted

1. 'Amorphous formulation of entomopathogenic nematodes as biopesticide', (Patent No. 295748), granted on 22 May 2018. (Primary innovator: M. Nagesh).

Revenue generated during 2018-19

The total revenue generated was **₹38,56,819/-** through following activities.

Details	Revenue generated (₹)
Commercialisation of technologies	16,25,000
Sale of macrobials	8,60,869
Sale of microbials	4,09,030
Contract research	8,52,000
Training	1,07,790
Sale of publications	2,130
Total	38, 56, 819

MOU being exchanged between NBAIR and Mahatma Phule Krishi Vidyapeeth, Rahuri

MOU being exchanged between NBAIR and Global Blooms, Bengaluru

MOU being exchanged between NBAIR and Sri Bhagyalakshmi Farms, Kolur, Tavarekere (Hobli)

MOU being exchanged between ICAR–NBAIR and Amunra Holidays & Resorts Pvt. Ltd., New Delhi

MOU being exchanged between ICAR–NBAIR and Darshana Horticulture LLP, NASIK

MOU being exchanged between ICAR–NBAIR and KCPM, Alapuzha

12. PUBLICATIONS

Peer-reviewed articles

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14. MEETINGS AND DECISIONS

XXII Research Advisory Committee Meeting

The XXII Meeting of the Research Advisory Committee of the ICAR–National Bureau of Agricultural Insect Resources was held on 18 June 2018 in the conference hall of the NBAIR.

The following members of the RAC attended the meeting.

Dr S. N. Puri	Chairman
Dr P. K. Chakrabarty	Member
Dr Chandish R. Ballal	Member
Dr V. V. Ramamurthy	Member
Dr Joseph Bhagyaraj	Member
Dr Suresh Nair	Member
Dr S. Lingappa	Member
Dr Suraj Singh Rajput	Member

General Comments

Dr Chandish R. Ballal, Director of ICAR–NBAIR welcomed the Chairman and members of the RAC and highlighted the achievements made by the institute including the research outputs, publications, commercialization and revenue generated.

1. Looking at the work pressure and the research activities of the Bureau, the RAC recommended to maintain the Cadre Strength and in addition sanction of additional manpower support by ICAR.
2. Folders and Pamphlets have to be prepared on the biocontrol success stories.
3. Identify and adopt small village holdings, exclusively for biocontrol trials and create wider awareness on the importance of Biological Control Programmes must be formed to boost the confidence of the farmers about the biocontrol technology.
4. A request can be sent to DST and DBT, for the deposition of reference collection of insects at ICAR–NBAIR, which were collected through their funded projects.
5. Apart from direct revenue, an initiative has to be made to document the indirect revenue earned through the use of biocontrol.
6. Interactions among the scientists across the Divisions to be strengthened.
7. Scientists from ICAR–NBAIR, ICAR–NBAIM, ICAR–NCIPM, ICAR–NIBSM and AICRP-BC centres should interact with each other and plan for network programmes on pest management.
8. The museum under development requires lot of support not only in terms of supplemented infrastructure but also essential cooperation from AICRP centres for augmenting the material for display. Efforts and actions will be required for achieving these.
9. The RAC appreciated the all round development of the research activities of NBAIR including well acclaimed publications and the filing/accomplishment of patents by the Institute. At least few of these can be developed as success stories and circulated / used as publicity material.
10. Field trials on biological control to be conducted at Uttarakhand State for the management of *Tuta absoluta*.
11. Field trials to be conducted for the Litchi stinkbug bicontrol programme, under AICRP-Biocontrol.

The following comments / suggestions were given by the RAC:

I. Division of Germplasm Collection and Characterization

Dr Sunil Joshi presented the report on the projects handled in the division.

1. UAS-Dharwad can be contacted officially and can be requested to deposit the bee specimens collected (as part of the DST project) in the ICAR–NBAIR Museum for wider usage.
2. An internal committee can be formed to fix the charges for taxonomic identification services provided by the Bureau.
3. Exploratory survey and documentation to be made for the spider taxonomy and their utilization.

4. Taxonomist should give importance for the potential use of identified species in all biocontrol programmes.

II. Division of Genomic Resources

Dr S. K. Jalali presented the research achievements of the division.

1. Whitefly biotype to be validated through proper molecular study and integrated with the insecticide resistance data.
2. Studies to be conducted on the insecticide resistance mechanism of pink bollworm.
3. Molecular basis for tritrophic interactions in EPN needs to be addressed.
4. Microbial communities associated with BSF responsible for decomposition of organic matter are to be documented.

III. Division of Insect Germplasm Conservation and Utilization

Dr N. Bakthavatsalam presented the research achievements of the division.

1. Study to be initiated to identify alternate host for the mass multiplication of litchi stink bug biocontrol agent.
2. Citrus mite problem to be addressed.
3. Database with distribution map and a forewarning system can be prepared for the potential invasive pests.
4. Study to be initiated for the effective management of stored grain pests, especially the pulse beetles which pose a major problem in storage.
5. Collaborative work can be initiated with AICRP-Honeybee, giving importance to identification and conservation of alternative pollinators.
6. A database on the firms which produce and supply the biocontrol agents to be created to cater the need of the farmers as well as entrepreneurs.
7. Study to be conducted in collaboration with AICRP-Soil arthropods to find out the alternative pheromones or generic pheromones for the effective management of white grub *Lepidiota mansueta*, a serious pest in Majili island.

IV. Institute Technology Management Unit

Dr T. Venkatesan, Officer i/c presented the report.

Recommendations

1. Two booklets to be prepared about the biocontrol technologies, for the ICAR–TC interface meet for Kharif and Rabi seasons, respectively.

XXXVIII Institute Research Council Meeting

The XXXVIII Institute Research Council Meeting of the ICAR–NBAIR, Bengaluru was held during 24–26 July 2018, under the Chairmanship of Dr Chandish R. Ballal, Director, ICAR–NBAIR.

General Comments

- It is was unanimously decided that, Dr Mohan, Principal Scientist will be transferred to Division of Genomic Resources and Dr K. Selvaraj, Scientist will be transferred to Division of Germplasm Conservation and Utilization, considering their nature of research. (Action: Dr M. Mohan and Dr K. Selvaraj)
- All the scientists are requested to send the information on awards received, their publications and field demonstrations and trainings conducted if any to PME (Action: all the Scientists).
- The Nodal officers for "ICAR–NBAIR-SBC Aadhar Based Attendance" are Dr Navik Omprakash Samodhi for ICAR–NBAIR Hebbal Campus and Dr K. Selvaraj for ICAR–NBAIR, Yelahanka Campus respectively (Action : Dr Navik Omprakash Samodhi and Dr K. Selvaraj).
- Scientists are requested to share their open access publication for the Data Knowledge Portal (Action: All HODs and Scientists).
- Scientists are requested to send their insect collection information in a prescribed

format to Dr G. Mahendiran (Action all the taxonomists).

- Institute citation index need to be calculated for ICAR–NBAIR. In this regard ICAR–IIHR can be contacted for the clarification (Action: Dr R. Rangeshwaran and Dr M. Pratheepa).
- Contingency from EFC can be used for the generation of toxicological Data (Action: Dr B. Ramanujam).
- In all the field demonstrations/trainings conducted, the ICAR–NBAIR Silver jubilee logo needs to be included (Action : AICRP-BC cell and all scientists).
- General collections by all scientists to be pooled at monthly intervals and to be made available to other taxonomists for sorting their groups and thus to enrich the museum collections.
- Scientists are encouraged to apply for ICAR team awards.

XXXIX Institute Research Council Meeting

The XXXIX Institute Research Council Meeting of the ICAR–NBAIR, Bengaluru was held on 3 October 2018, under the Chairmanship of Dr Chandish R. Ballal, Director, ICAR–NBAIR.

General Comments

- A brainstorming session on Nanotechnology/ Nanosensors/Nanoformulations to be organised to review the work of Dr Deepa Bhagat and Dr K. Subaharan.
- A subject expert (Nanotechnology) shall be identified and invited for the review. (Actions: Dr N. Bakthavatsalam, Principal Scientist & HOD).

XXII meeting of the Research Advisory Committee of the ICAR–National Bureau of Agricultural Insect Resources was held on 18 June, 2018 at NBAIR, Bengaluru.

15. PARTICIPATION OF SCIENTISTS IN MEETINGS

Abroad

Dr Chandish R. Ballal	Regional Workshop on Fall Army Worm, Kathmandu, Nepal, 21 November 2018. Consultative Meeting on Fall Army Worm in Asia, Bangkok, Thailand, 20–22 March 2019.
Dr P. Sreerama Kumar	XV International Congress of Acarology, Antalya, Turkey, 02–08 September 2018.
Dr S. Salini	VI Quadrennial Meeting of International Heteropterists' Society (IHS), Museum of La Plata, Paseo del Bosque, Argentina, 03–07 December 2018.

India

Dr Chandish R. Ballal Dr S.K. Jalali Dr N. Bakthavatsalam	First International Conference on Biological Control: Approaches and Applications, organised by the Society for Biocontrol Advancement Bengaluru, at Hotel Le Meridien, Bengaluru 27–29 September 2018
Dr B. Ramanujam Dr A.N. Shylesha Dr Sunil Joshi Dr T. Venkatesan Dr T.M. Shivalingaswamy	Third International Workshop of the IOBC Global Working Group on Biological Control and Management of Parthenium Weed, organised by the Society for Biocontrol Advancement, at Hotel Le Meridien, Bengaluru, 27–29 September 2018.
Dr K. Srinivasamurthy Dr P. Sreerama Kumar Dr R. Rangeshwaran Dr K. Subaharan Dr M. Mohan Dr G. Sivakumar Dr M. Pratheepa Dr A. Kandan Dr Mahesh Yandigeri Dr K. Sreedevi Dr R. Gandhi Gracy Dr K.J. David Dr S. Salini Dr G. Mahendiran Dr Ankita Gupta Dr Jagadeesh Patil Dr M. Sampath Kumar Dr K. Selvaraj Dr U. Amala Dr Richa Varshney Ms R.R. Rachana Dr R.S. Ramya Dr Navik Omprakash Samodhi	Workshop of the IAPPS Working Group on *Tuta absoluta*-Biology, Ecology and Management, organised by the Society for Biocontrol Advancement, at Hotel Le Meridien, Bengaluru, 28 September 2018.

Dr Chandish R. Ballal Dr K. Sreedevi Dr R.S. Ramya	42nd Annual Conference of Ethological Society of India and National Symposium on Animal Behaviour, Biodiversity and Human Future, University of Calicut, Kerala, 04–06 December 2018.
Dr Chandish R. Ballal Dr K. Subaharan Dr Jagadeesh Patil Dr K. Selvaraj	National Symposium on Entomology 2018: Advances and Challenges, Professor Jayashankar Telangana State Agricultural University, Hyderabad, 10–12 December 2018.
Dr Chandish R. Ballal	Invited to deliver 10th Dr S. Pradhan Memorial Lecture, Indian Agricultural Research Institute, New Delhi, 24 August 2018.
	National Symposium on New Dimensions in Plant Protection-A Step Towards Food and Nutritional Security and Environmental Safety, Odisha University of Agriculture and Technology, Bhubaneswar, 27 October 2018.
	8th Indian Horticulture Congress 2018, Indira Gandhi Krishi Vishwavidyalaya, Raipur, 29 October-2 November 2018.
	Harvest Festival organised by Department of Agriculture, Kerala; Kerala Agricultural University, Thrissur; and Keezhpadam Patashekaram, Alathur, Palakkad, Kerala, 27 February 2019.
	Meeting of All India Network Project on Soil Arthropods, University of Agricultural Sciences, GKVK, Bengaluru, 01 March 2019. Workshop on ABD index and Ecosystem Services, 26 March 2019.
Dr B. Ramanujam	Institute Management Committee (IMC) Meetings, ICAR–National Bureau of Agriculturally Important Microorganisms, Mau.
	Research Advisory Committee (RAC) Meetings, Institute of Wood Science and Technology, Bengaluru.
Dr M. Nagesh	Screening and Selection Committee Meeting for finalizing Dr KKM and Nagamma Dattatreya Rao Desai Prize Award for Best Agricultural Research for the year 2017–18, University of Agricultural Sciences, GKVK, Bengaluru, 29 September 2018.
	Workshop for Vigilance Officers of ICAR, ICAR–National Academy of Agricultural Research Management, Hyderabad, 31 October-01 November 2018.
	DPC Committee Meeting, ICAR–National Research Centre for Banana, Tiruchirapalli.
Dr Sunil Joshi	Workshop on Sustainability of Indian Agriculture: Biodiversity, Environmental and Climate Change Perspective, NASC complex, New Delhi, 26 November 2018.
	Workshop on Taxonomy, Biodiversity and Conservation, Loyola College, Chennai, 11–12 February 2019.
Dr T. Venkatesan	Meeting with CABI Scientists, 12 April 2018.
	International Day for Biological Diversity, Professor Jayashankar Telangana State Agricultural University, Hyderabad, 4 May 2018.

	DST Sponsored Stakeholders Discussion on Scientific Research Infrastructure Sharing Management and Networks (SRIMAN) Policy, National Centre for Biological Sciences, Bengaluru, 10 January 2019.
	Progress Review Meeting of Crop and Horticultural Sciences of Network Projects on Agricultural Bioinformatics and Computational Biology under CABin Scheme, New Delhi, 16–17 January 2019.
Dr T.M. Shivalingaswamy	Invited Lecture to participants of UGC Refresher Course in Life Sciences, Department of Botany, Bangalore University, 09 March 2019.
Dr P. Sreerama Kumar	Foldscope Orientation Workshop, conducted by the Department of Biotechnology in collaboration with Foldscope Instruments and Prakash Lab (Stanford, USA), at the International Centre for Genetic Engineering and Biotechnology, New Delhi, 17 April 2018.
	Workshop on Utility of the Foldscope in Crop Protection: Assessment-cum-Training Workshop for Farmers, conducted by NBAIR in collaboration with the College of Agriculture, Lembucherra, Tripura, at Shivnagar ADC village, Sumili Agri Sector, Mandwi, Tripura, 27 May 2018.
	Meeting for Evaluation of Project Completion Reports, Institute of Wood Science and Technology, Bengaluru, 19 June 2018.
	Workshop on Utility of the Foldscope in Crop Protection: Assessment-cum-Training Workshop for Farmers, Haristhala, Chikkaballapura district, Karnataka, 28 August 2018.
	Workshop on Utility of the Foldscope in Crop Protection: Assessment-cum-Training Workshop for Farmers, Channapatna, Ramanagara district, Karnataka, 30 October 2018.
	Workshop on Use of Foldscope, jointly conducted by the College of Agriculture, Tripura; Division of Educational Kits, National Council of Educational Research and Training, New Delhi; and NBAIR, at the College of Agriculture, Lembucherra, Agartala, 13 November 2018.
	XV Group Meeting of the All-India Network Project on Agricultural Acarology, Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, 10–12 December 2018.
	Demonstration-cum-Training Workshop for Farmers on Utility of the Foldscope in Agriculture, organised jointly by NBAIR; ICAR Research Complex for North Eastern Hill Region, Umiam; and the National Centre for Cell Science-National Centre for Microbial Resources, Pune, at Mynsain village, Ri Bhoi district, Meghalaya, 29 January 2019.
	Demonstration-cum-Awareness Workshop: Utility of the Foldscope in Education and Research, jointly organised by NBAIR and ICAR Research Complex for North Eastern Hill Region, Umiam, at the College of Horticulture, University of Horticultural Sciences-Bagalkot, Bengaluru, 22 February 2019.

	Demonstration Workshop on Utility of the Foldscope in Education and Research, jointly organised by NBAIR and ICAR Research Complex for North Eastern Hill Region, Umiam, at BGS Science Academy and Research Center, Agalagurki, Chikkaballapura, Karnataka, 28 February 2019.
Dr R. Rangeshwaran	Invited Lecture in Training Programme on Production and Utilization of Biocontrol Agents-A way Forward for Sustainable Agriculture, jointly organised by University of Agricultural Sciences, Raichur and NBAIR, at Biocontrol Unit, Main Agricultural Research Station, University of Agricultural Sciences, Raichur, 11–21 February 2019.
	Management Development Programme for HRD Nodal Officers of ICAR for Effective Implementation of Training Functions, ICAR–National Academy of Agricultural Research Management, Hyderabad, 14–16 March 2019.
Dr K. Subaharan	Workshop on Nanomedicine: Challenges and Barriers in Translation, organised by Indian Society of Nanomedicine, at Indian Institute of Technology, New Delhi, 16 April 2018.
	DST-TRC Annual Review Meeting, Jawaharlal Nehru Centre for Advanced Scientific Research (JNCASR), Bengaluru, 29 June 2018.
	TRAC-DBT Workshop for Translational Research Projects, All India Institute for Medical Sciences, New Delhi, 04 July 2018.
	National Consultation Meeting on Agriculture Startup for Smart Agriculture, ICAR–National Institute of Animal Nutrition and Physiology, Bengaluru, 11 October 2018.
Dr M. Mohan	Invited Lecture in ICAR Sponsored Training Programme on Recent Advances in Development of Bioformulations, UHS, Bagalkot, Mysore, 07 September 2018.
	Invited Lecture in CAFT Advanced Training Programme on Facets in Biopesticide and Botanical Formulation Production, TNAU, Coimbatore, 30 November 2018. XXX ARC Meeting of Indian Cardamom Research Institute, Myladumpara, 04–05 February 2019.
Dr G. Sivakumar	Coffee Drip Planters Meeting, Shalespur, 21 January 2019.
Dr M. Pratheepa	National Workshop on e-Crop, an IoT solution in Agriculture, ICAR–Central Tuber Crops Research Institute, Thiruvananthapuram, 05–07 September 2018.
	KRISHI workshop, NASC Complex, New Delhi, 04–05 December 2018.
	Interactive Meeting-cum-Workshop of Scientists in IT/Computer Application of ICAR Research Institutes, NASC Complex, New Delhi, 06 March 2019.
Dr Mahesh Yandigeri	Interactive Meeting and Farm Demonstration of Black Soldier Fly Rearing Technology Using Farm Wastes, Farmers' field, Askihal, Raichur, 28 December 2018.
Dr Jagadeesh Patil	QRT Meeting of All India Coordinated Research Project on Biological Control of Crop Pests, Dr Y.S. Parmar University of Horticulture and Forestry, Solan, 22 June 2018.

	QRT Meeting of All India Coordinated Research Project on Biological Control of Crop Pests, Assam Agricultural University, Jorhat, 21 August 2018.
	Training of Trainers Program on Organic Grower, organised by Agricultural Skill Council of India, at University of Agricultural Sciences, GKVK, Bengaluru, 24–26 November 2018.
Dr M. Sampath Kumar	Brain Storming Session of Ecosystem Services and ABD Index, University of Agricultural Sciences, GKVK, Bengaluru, 13 November 2018.
	ISWS Golden Jubilee International Conference on Weeds and Society: Challenges and Opportunities, ICAR–Directorate of Weed Research, Jabalpur, 21–24 November 2018.
Dr K. Selvaraj	6th Annual Review Workshop on National Innovations on Climate Resilient Agriculture (NICRA), NASC complex, New Delhi, 07–08 August 2018.
	Eri Krishi Vigyan Mela, Eri p2 Basic Seed farm, Hosur, 14 February 2019. State Level Seminar on Tomato, Dharmapuri, 01 March 2019.
	Sixth Biopesticide International Conference, Amity University, Raipur, 06–08 March 2019.
Dr U. Amala	Project Meeting organised by Bioversity International, ICAR–National Bureau of Fish Genetic Resources, Lucknow, 30 June 2018.
	Partners Meet for Bioversity International Funded Project, ICAR–National Academy of Agricultural Research Management, Hyderabad, 25 July 2018.
Dr Navik Omprakash Samodhi	Special Joint Survey on Armyworm and *Spodoptera frugiperda* in Maize Crop, NBAIR and CIPMC, Bengaluru, 01–03 August 2018.
Dr B. Ramanujam Dr T. Venkatesan Dr K. Subaharan Dr K. Selvaraj	National Workshop on Plant Health Management of Coconut: Challenges and Future Opportunities, National Institute for Plant Health Management, Hyderabad, 14–15 March 2019.
Dr Sunil Joshi Dr T. Venkatesan Dr T.M. Shivalingaswamy Dr K. Subaharan Dr M. Mohan Dr K.J. David Dr S. Salini Dr K. Selvaraj Dr Ankita Gupta Ms R.R. Rachana Dr R.S. Ramya	Seminar on Celebrating Indian Insect Diversity, University of Agricultural Sciences, GKVK, Bengaluru, 31 January 2019.
Dr Sunil Joshi Dr R. Gandhi Gracy Dr K.J. David Dr S. Salini	Workshop on Insect Taxonomy and Field Sampling Skills, University of Calicut, 25–28 March 2019.

Dr T. Venkatesan Dr Jagadeesh Patil Dr M. Sampath Kumar Dr Navik Omprakash Samodhi	XXVII Annual Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests, Kerala Agricultural University, Thrissur, 17–18 May 2018.
Dr T. Venkatesan Dr M. Mohan Dr R. Gandhi Gracy Dr R.S. Ramya	CABin Review Meeting, NBAIR, Bengaluru, 13 November 2018.
Dr T. Venkatesan Dr Navik Omprakash Samodhi	Consultative Group Meeting with the Staff of State Biocontrol Laboratory Department of Agriculture, Mannuthy, Kerala, at NBAIR, Bengaluru, 19 December 2018.
Dr T. Venkatesan Dr K. Selvaraj	XIII National Innovations on Climate Resilient Agriculture (NICRA) Expert Committee Meeting-2019, IIHR, Bengaluru, 06–07 February 2019.
Dr T. Venkatesan Dr G. Sivakumar	National Agri-Business Entrepreneurship Conclave, ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, 09–11 February 2019.
Dr T. M. Shivalingaswamy Dr U. Amala Dr Veeresh Kumar	2nd Bangalore Meeting on Asian Bees, National Centre for Biological Sciences, Bengaluru, 01–02 March 2019.

16. TRAININGS CONDUCTED

S.No.	Trainee(s) / Trainee(s) from	Particulars of the training programme	Date(s)	Coordinator(s) / Resource person(s)	No of participants
1.	Ms. Gurmeet Kaur, Ph.D student, Department of Zoology, Pune University	Training on "Isolation, identification, mass production, formulation of entomofungal pathogens and laboratory bioassay against tomato pinworm, *Tuta absoluta*"	01 April 2018–31 March 2019	Dr B. Ramanujam	1
2.	Ms. Sumalatha, SRF	Training on "Slide making of whiteflies"	13 April 2018	Dr Ankita Gupta	1
3.	Mr Aneeldev Dashavant, MSc student, UAS Dharwad	Training on "Braconid identification"	23 April 2018	Dr Ankita Gupta	1
4.	Students of MSc (Ag) Entomology, BCKV, Nadia, West Bengal	Training on "Isolation, culturing, identification, bioassay, mass production, formulation & utilisation of entomofungal pathogens for crop pest management"	22 May 2018	Dr B. Ramanujam	4
5.	International Ph.D student, Mr Mohammed Zargar, Tarbiat Modares University, Iran	Training on "Taxonomy and biodiversity of Microgastrinae subfamily (Hymenoptera: Braconidae) in Khuzestan province of Iran"	25 July 2018 27 March 2019	Dr Ankita Gupta	1
6.	Farmers of Karnataka Grape Export Group (KGEG), Vijayapura	Training on "Biological control of pests and diseases in grapes"	18 August 2018	Dr M. Sampath Kumar Dr Richa Varshney Dr A. Kandan	16
7.	Ms. Kousalya Devi, N., B. Tech (Biotechnology) student, Tamil Nadu Agricultural University	Three months internship programme for the Project work entitled "Genetic diversity of pink bollworm (*Pectinophora gossypiella*) populations"	September 2018-December 2018	Dr R.S. Ramya	1
8.	Farmers from Maharashtra	Training on "Biological control of white grub in sugarcane and cutworm management in vegetables (in association with ATMA, Kolhapur)"-Batch I	05–07 September 2018	Dr M. Sampath Kumar Dr Jagadeesh Patil Dr B. Ramanujam	46

S.No.	Trainee(s) / Trainee(s) from	Particulars of the training programme	Date(s)	Coordinator(s) / Resource person(s)	No of participants
9.	M/s. Nirmal seeds, Pachora, M/s. Dhanwantari, Pune, College of Agriculture, Kolhapur, MPKV and M/s. Advance Crop Care, M.P.	Training on "EPN production, down-stream processing and formulations"	October 2018 (4 days), March 2019 (4 days)	Dr M. Nagesh	16
10.	ICAR institutes and SAUs	Capacity building programme on "Green technologies for utilisation of entomopathogenic nematodes for sustainable soil insect pest management in crop situations"	03–06 October 2018	Dr M. Nagesh Dr Jagadeesh Patil Dr Mahesh Yandigeri	1
11.	ADA, Department of Agriculture, Government of Goa	Training on "Isolation, culturing, identification, bioassay, mass production, formulation & utilisation of entomofungal pathogens for crop pest management"	04–05 October 2018	Dr B. Ramanujam	1
12.	M.Sc / Ph.D (Entomology) students, UAS, Raichur, Karnataka	Training on "Mass rearing of *Helicoverpa armigera* by artificial diet, rearing of *Corcyra cephalonica* and *Trichogramma* sp. mass production"	29 October 2018	Dr Richa Varshney Dr Y. Lalitha	2
13.	M.Sc (Entomology) student, BHU, Varanasi	Training on "Mass production of macrobials and microbials including EPN"	04–15 November 2018	Dr A.N. Shylesha Dr M. Sampath Kumar Dr R. Rangeshwaran	1
14.	ICAR scientist probationer, Mr Satyapriya Singh, ICAR–REC, NEH, Umiam	Professional attachment training	12 November 2018- 12 February 2019	Dr M. Mohan	1
15.	ICAR scientist probationer, Dr P.N. Guru, ICAR–CIPHET, Ludhiana	Professional attachment training on "Studies of phosphine resistance in red flour beetle, *Tribolium castaneum* (Herbst), a major stored grain pest"	12 November 2018- 12 February 2019	Dr R.S. Ramya	1
16.	Dr Karthikeyan, RARS Pattambi, Kerala	Training on "Chemical ecological methods covering electrophysiological and chromatographic techniques"	13–15 November 2018	Dr K. Subaharan	1

S.No.	Trainee(s) / Trainee(s) from	Particulars of the training programme	Date(s)	Coordinator(s) / Resource person(s)	No of participants
17.	International trainees	Training on "Seed health methods using PCR, ELISA, dilution plating and indexing methods"	20–23 November 2018	Dr M. Nagesh	30
18.	ICAR scientist probationer, Mr N.N. Rajgopal, ICAR–IINRG, Jharkhand	Professional attachment training on "Taxonomic studies of Lac insects (Kerriidae: Coccoidea)"	20 November 2018- 20 February 2019	Dr Sunil Joshi	1
19.	ICAR scientist probationer, Mr K.T. Shiva Kumara, ICAR–DMAPR, Gujarat	Professional attachment training on "Barcoding of insect species associated with medicinal and aromatic plants"	01 December 2018- 28 February 2019	Dr T. Venkatesan	1
20.	KVK technical officers/scientists from North Eastern Hill Region	Training on "Biological control for pest management for North Eastern Hill Region personnel"	03–07 December 2018	Dr M. Sampath Kumar Dr U. Amala Dr Richa Varshney Dr Omprakash Navik Dr B. Ramanujam Dr T. Venkatesan Dr R. Rangeshwaran Dr Ankita Gupta	15
21.	Ms Deena Lyrisha Aranha, College of Agriculture, Hassan	Three months internship programme for the Project work entitled "Species diversity of Vespidae (Insecta: Hymenoptera) from Karnataka, India"	04 December 2018–22 March 2019	Dr Ankita Gupta	1
22.	Mr. H.P. Lava Kumar, B.Tech (Biotechnology) student, College of Agriculture, Hassan	Three months internship programme for the Project work entitled "Survey, collection, and gut content analysis of spiders"	04 December 2018–22 March 2019	Dr M. Sampath Kumar	1
23.	Plant protection scientists of Karnataka KVKs	Training on "Various technologies of ICAR–NBAIR"	5 December 2018	Dr T. Venkatesan	30
24.	ADAs and agricultural officers from Hindupur, Andhra Pradesh	Training on "Mass production, formulation & utilisation of entomofungal pathogens for fall army worm management"	21 December 2018	Dr B. Ramanujam	5
25.	Lab assistants, HRS, Ambajipetta, Andhra Pradesh	Training on "Mass production of macrobials and microbials"	08–09 January 2019	Dr B. Ramanujam Dr Richa Varshney Dr Y. Lalitha Dr R. Rangeshwaran	2

S.No.	Trainee(s) / Trainee(s) from	Particulars of the training programme	Date(s)	Coordinator(s) / Resource person(s)	No of participants
26.	Mrs Prita Ghosh and Mr Manjunath Ph.D students, Department of Entomology, GKVK, Bengaluru	Training on "Thrips mounting and taxonomy"	08–10 January 2019	Ms R.R. Rachana	2
27.	Agricultural officers, Kerala Centre for Pest Management, Moncompu, Kerala	Training on "Identification, characterization and mass production of *Bacillus megaterium*"	21 January-22 January 2019	Dr G. Sivakumar	3
28.	Coconut farmers from West Godavari, Andhra Pradesh	Training on "Mass production of *Isaria* fungus and mass rearing technique for *Encarsia guadeloupe* for the management of coconut RSW"	22–23 January 2019	Dr B. Ramanujam Dr K. Selvaraj	8
29.	Farmers from Rajahmundry, Andhra Pradesh	Training on "Mass production, formulation & utilisation of *Isaria fumosorosea* for rugose white fly management in coconut"	22–23 January 2019	Dr B. Ramanujam	48
30.	Farmers from Maharashtra	Training on "Biological control of white grub in sugarcane and cutworm management in vegetables (in association with ATMA, Kolhapur)"- Batch II	28–30 January 2019	Dr M. Sampath Kumar Dr Jagadeesh Patil Dr B. Ramanujam	50
31.	NIPHM- PGDPHM course	Training on "Mass production of macrobials and microbials"	04–07 February 2019	Dr M. Sampath Kumar Dr B. Ramanujam Dr R. Rangeshwaran	18
32.	M/s. Coromandel International Limited	Training on "Mass rearing of *Helicoverpa armigera* and DBM"	05–07 February 2019	Dr Richa Varshney Dr Y. Lalitha	1
33.	Ph.D student, Dept. of Botany, Savitribai Phule Pune University, Pune	Training on "Mass rearing of DBM"	07–08 February 2019	Dr Richa Varshney Dr Y. Lalitha	1
34.	Unemployed rural youths /farmers	ASCI training for "Organic growers" in collaboration with KVK, Dodaballapura	19 February –21 March 2019	Dr Jagadeesh Patil Dr B. Mahendiran Dr Omprakash Navik	20

S.No.	Trainee(s) / Trainee(s) from	Particulars of the training programme	Date(s)	Coordinator(s) / Resource person(s)	No of participants
35.	ICAR institutes, Central Silk Board and SAUs	Capacity building programme on "DNA barcoding and bioinformatics applications in entomology"	25 February -03 March 2019	Dr T. Venkatesan Dr R. Gandhi Gracy Dr M. Mohan Dr R.S. Ramya	10
36.	Farmers from Dharmapuri, Salem and Vellore	Training on "Biocontrol agents and biopesticides"	27 February 2019	Dr T. Venkatesan	115
37.	Unemployed rural youths /farmers	ASCI training on "Friends of coconut tree" in collaboration with KVK, Hassan	05–29 March 2019	Dr K. Selvaraj Dr Jagadeesh Patil Dr M. Sampath Kumar Dr U. Amala	25
38.	M/s. Deejay Coconut Farm Pvt. Limited	Training on "Mass production of *Isaria* fungus for the management of coconut RSW"	06 March 2019	Dr B. Ramanujam	2
39.	Assistant Professors from various universities across India, students and research scholars of University of Calicut	Workshop on "Insect taxonomy and field sampling skills"	25–28 March 2019	Dr Sunil Joshi Dr R. Gandhi Gracy Dr K.J. David Dr S. Salini	40

Training on "Biological control for pest management for North Eastern Hill region" during 03–07 December 2018 at NBAIR, Bengaluru

Capacity building programme on "DNA barcoding and bioinformatics applications in Entomology" during 25 February – 03 March 2019 at NBAIR, Bengaluru

17. DISTINGUISHED VISITORS

- Dr Ulrich Kuhlmann, Executive Director, Global Operations, CABI, Switzerland, 12 April 2018.
- Dr Richard Shaw, Country Director, CABI, Bakeham Lane, Egham, UK, 12 April 2018.
- Dr Simon Attwood, Bioversity International, Rome, 5 May 2018.
- Dr Daniel McGonigle, Bioversity International, Rome, 5 May 2018.
- Dr T.V.R.S. Sharma, Governing Board Member, ICAR Society, 13 June 2018.
- Dr P.K. Chakrabarty, ADG (PP & B), ICAR, New Delhi, 18 June 2018, 01 & 10 March 2019.
- Dr S.N. Puri, Chairman, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 18 June 2018.
- Dr V.V. Ramamurthy, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 18 June 2018.
- Dr D. Joseph Bagyaraj, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 18 June 2018.
- Dr Suresh Nair, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 18 June 2018.
- Dr S. Lingappa, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru, 18 June 2018.
- Dr Suraj Singh Rajput, Member, Research Advisory Committee, ICAR–NBAIR, Bengaluru ,18 June 2018.
- Mr Radha Mohan Singh, Union Minister of Agriculture and Farmers' Welfare, Govt of India, New Delhi, 30 June 2018.
- Dr Sujaya Rao, Professor, University of Minesota, 12 July 2018.
- Dr Suresh K. Malhotra, Agriculture Commissioner, Government of India, New Delhi, 13 July 2018.
- Dr A.K. Vasisht, ADG (PIM), ICAR, Krishi Bhawan, New Delhi, 08 September 2018.
- Dr Anand Kumar Singh, Deputy Director General (Horticulture & Crop Sciences), Visited NBAIR, 22 January 2019.
- Dr Trilochan Mohapatra, Secretary, DARE & Director-General, ICAR, New Delhi, 10 March 2019.

Honourable Union Minster of Agriculture & Farmers' Welfare visited ICAR–NBAIR on 30 June 2018

Deputy Director-General (Horticulture & Crop Sciences), Dr A.K. Singh visited ICAR–NBAIR on 22 January 2019

18. MERA GAON MERA GAURAV

Seven teams of scientists/technical officers have adopted a total of 18 villages in Karnataka and Tamil Nadu. The teams visited their respective villages every month and conducted 37 farmer-centric activities including demonstrations, provided technical guidance and information to the farmers. Farmers' '*Goshthies*' were also conducted on a regular basis to sensitise the farmers about the importance of natural enemies of insect pests.

As part of MGMG, Dr A.N. Shylesha and his team demonstrated the management of papaya mealybug, fall army worm in maize, root grub in sugarcane and mulberry and village level bio-agents multiplications. Three interactive meetings were organised with the famers of Saudenahalli, Madla, Honnenahalli, and Srirampura villages. Other teams have demonstrated different technologies to the farmers such as, coccinellids for the control of pink mealy bug and striped mealy bug on various agriculturally crops; mass production of *Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium lecanii* using locally available substrates and utilisation for the pest and disease management and off season monitoring of *Tuta absoluta* and its management in tomato.

Awareness on use of biological agents for the management of field crop was provided to farmers. Dr Jagadeesh Patil and his team demonstrated the EPN technology for the management of white grubs and *Spodoptera litura* in grapes in Talahalli and Yalavahalli. Another MGMG group headed by Dr N. Bakthavatsalam, created awareness in Ramgiri, Jangamakote and Krishnagiri regarding the use of pheromone technology in pest management. Awareness program was organised on the management of pests and diseases of coconut at Mungilpudhur village at Krishnagiri, Tamil Nadu. Repeated visits were made to farmers' fields in the adopted villages, Dodballapura and nearby areas and the farmers were enlightened about the biocontrol methods of pest management in tomato. Exhibition of live biocontrol agents and microbial, biopesticide formulations were organised at farmers meet held at various places in Tamil Nadu and Karnataka.

Rugose spiralling whitefly is an invasive insect spreading across India. Hence, several awareness cum demonstrations were conducted on management of coconut rugose spiralling whitefly using *Encarsia* parasitoids and *Isaria fumosorosea.* Mass production of parasitoids and *Isaria fumosorosea* were demonstrated. Linkages were developed through Govt. sponsored schemes like Coconut Development Board and KVKs in organizing rugose white fly awareness cum demonstrations to the farmers.

Under MGMG, 320 trichocards, 2,870 numbers of *Cryptolaemus montrouzieri*, 45,630 numbers of chrysopids, 5,160 numbers of *Goniozus nephantidis*, 635 *Nephus* spp. and 25 numbers *Zygogrammbicolorata* were supplied to 155 farmers for the management of insect pests. The tricho-cards of species, *Trichogramma chilonis* and *T. achaeae* were distributed in Hosuru and Irigenahalli, Chikkaballapura for the management of cabbage and tomato pests, respectively. Ms B.R. Lalitha from Therubedhi village in Kanakapura taluk, Ramanagara district, Karnataka, received the IARI Innovative Farmer Award at Pusa Krishi Vigyan Mela organised by ICAR–IARI during 5–7 March 2019.

Treatment of fall armyworm-affected fields with biocontrol agents

Demonstration of release of parasitoids

Ms B.R. Lalitha receiving IARI Innovative Farmer Award

Institute's team-wise progress (summary)

Team	No. of scientists involved	No. of villages covered	No. of field activities conducted	No. of messages/ advisory sent	Farmers involved (No.)
1	5	5	4	52	77
2	5	5	6	13	56
3	5	5	8	43	104
4	5	5	5	24	54
5	5	5	4	16	58
6	5	5	5	34	75
Total	**30**	**30**	**32**	**182**	**424**

Activities organised by ICAR -NBAIR under MGMG

Name of activity	No. of activities conducted	No. of farmers participated & benefitted
Visit to village by teams	17	354
Interface meeting/ *Goshthies*	6	450
Training organized	5	45
Demonstrations conducted	8	300
Mobile based advisories (No. of messages)	358	358
Literature support provided (No.)	156	156
Awareness created (No.)	28	1,500
Total	**578**	**3,163**

19. EXHIBITIONS

NBAIR participated in the following exhibitions to showcase various research technologies developed at the institute:

1. 'International Day for Biodiversity (IBD) 2018' "Celebrating 25 years of action on biodiversity" organised at Prof. Jayashankar Telangana State Agricultural University (PJTSAU) Auditorium, Hyderabad on 22 May 2018.
2. 'Krishi Mela', organised at GKVK Campus, UAS, Bengaluru on 15–18 November 2018.
3. 'National Horticultural Fair 2019' organised at ICAR–IIHR Bengaluru on 23–25 January 2019.
4. 'Pusa Krishi Vigyan Mela 2019' organised at ICAR–IARI, New Delhi on 5–7 March 2019.

DDG (Crop Science), ICAR, at the ICAR–NBAIR stall at Pusa Krishi Vigyan Mela

Visitors at the ICAR–NBAIR exhibition stall

20. PERSONNEL

S.No.	Name	Designation
Director		
1.	Dr Chandish R. Ballal	Director
Scientists		
Division of Germplasm Collection and Characterisation		
2.	Dr Sunil Joshi	Principal Scientist (Agricultural Entomology) & Head (In-Charge), Division of Germplasm Collection and Characterisation
3.	Dr K. Veenakumari	Principal Scientist (Agricultural Entomology) (Superannuated on 31.01.2019)
4.	Dr K. Sreedevi	Senior Scientist (Agricultural Entomology)
5.	Dr K.J. David	Scientist (Agricultural Entomology)
6.	Dr S. Salini	Scientist (Agricultural Entomology)
7.	Dr G. Mahendiran	Scientist (Agricultural Entomology)
8.	Dr Ankita Gupta	Scientist (Agricultural Entomology)
9.	Dr Jagadeesh Patil	Scientist (Nematology)
10.	Dr M. Sampath Kumar	Scientist (Agricultural Entomology)
11.	Ms R.R. Rachana	Scientist (Agricultural Entomology) (On study leave from 04.09.2017)
12.	Dr Navik Omprakash Samodhi	Scientist (Agricultural Entomology)
Division of Genomic Resources		
13.	Dr S.K. Jalali	Principal Scientist (Agricultural Entomology) & Head, Division of Genomic Resources (Superannuated on 31.10.2018)
14.	Dr M. Nagesh	Principal Scientist (Nematology) & Head (In-Charge) Division of Genomic Resources
15.	Dr T. Venkatesan	Principal Scientist (Agricultural Entomology)
16.	Dr K. Srinivasa Murthy	Principal Scientist (Agricultural Entomology)
17.	Dr R. Rangeshwaran	Principal Scientist (Microbiology)
18.	Dr M. Mohan	Principal Scientist (Agricultural Entomology)
19.	Dr M. Pratheepa	Principal Scientist (Computer Applications)
20.	Dr Mahesh Yandigeri	Senior Scientist (Microbiology)
21.	Dr R. Gandhi Gracy	Senior Scientist (Agricultural Entomology)
22.	Dr R.S. Ramya	Scientist (Agricultural Entomology)

S.No.	Name	Designation
23.	Dr Veeresh Kumar	Scientist (Agricultural Entomology) (Joined NBAIR on 13.02.2019)
Division of Germplasm Conservation and Utilisation		
24.	Dr N. Bakthavatsalam	Principal Scientist (Agricultural Entomology) & Head (In-Charge), Division of Germplasm Conservation and Utilisation
25.	Dr B. Ramanujam	Principal Scientist (Plant Pathology)
26.	Dr A.N. Shylesha	Principal Scientist (Agricultural Entomology)
27.	Dr T.M. Shivalingaswamy	Principal Scientist (Agricultural Entomology)
28.	Dr P. Sreerama Kumar	Principal Scientist (Plant Pathology)
29.	Dr Kesavan Subaharan	Principal Scientist (Agricultural Entomology)
30.	Dr G. Sivakumar	Principal Scientist (Microbiology)
31.	Dr Deepa Bhagat	Principal Scientist (Organic Chemistry)
32.	Dr A. Kandan	Principal Scientist (Plant Pathology)
33.	Dr K. Selvaraj	Scientist (Agricultural Entomology)
34.	Dr U. Amala	Scientist (Agricultural Entomology)
35.	Dr Richa Varshney	Scientist (Agricultural Entomology)
Technical Officers/Assistants		
36.	Ms Shashikala S. Kadam	Chief Technical Officer (Superannuated on 31.05.2018)
37.	Dr Y. Lalitha	Chief Technical Officer
38.	Dr B.K. Chaubey	Chief Technical Officer
39.	Mr Satandra Kumar	Chief Technical Officer
40.	Mr P.K. Sonkusare	Senior Technical Officer (T6)
41.	Ms L. Lakshmi	Senior Technical Officer (T6)
42.	Mr H. Jayaram	Senior Technical Officer (T6)
43.	Ms S.K. Rajeshwari	Senior Technical Officer (T6)
44.	Mr P. Raveendran	Technical Officer (T5)
45.	Dr A. Raghavendra	Technical Assistant (Laboratory Technician)
46.	Mr Umesh Kumar Sanjeev	Technical Assistant (Laboratory Technician)
47.	Mr R. Maruthi Mehanth	Technical Assistant (Laboratory Technician) (Joined NBAIR on 19.09.2018)
48.	Mr K.M. Venugopala	Technical Assistant (Laboratory Technician) (Joined NBAIR on 28.09.2018)
49.	Mr M. Chandrappa	Technical Assistant (Driver)

S.No.	Name	Designation
50.	Mr R. Narayanappa	Technical Assistant (Generator Operator)
51.	Mr P. Madanathan	Technical Assistant (Driver)
Administrative Staff		
52.	Mr Alok Kumar	Administrative Officer
53.	Mr T.A. Viswanath	Finance & Accounts Officer (Superannuated on 31.05.2018)
54.	Mr B.L. Ramachandrappa	Finance & Accounts Officer (Joined NBAIR on 23.05.2018; Superannuated on 28.02.2019)
56.	Mr K.N. Visveswara	Private Secretary to Director
57.	Mr Ajit Desai	Assistant Administrative Officer
58.	Ms S. Kaveriamma	Personal Assistant
59.	Mr M. Eswar Reddy	Assistant (On deputation to ICAR–NBSS&LUP from 25.06.2018)
60.	Ms Dipanwita Deb	Assistant
61.	Ms M.S. Uma	Junior Stenographer
62.	Ms Nazia Anjum	Upper Division Clerk
63.	Ms P. Anitha	Lower Division Clerk
Supporting Staff		
64.	Mr Ramakrishnaiah	Skilled Supporting Staff
65.	Mr P. Nagaiah	Skilled Supporting Staff

Dr K.J. David receiving the *Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2017* in Crop Protection category

Inauguration of the National Insect Museum by
Dr T. Mohapatra, Secretary, DARE & Director-General, ICAR, on 10 March 2019

Dr T. Mohapatra, Secretary, DARE & Director-General, ICAR, addressing the gathering during the inaugural function of the National Insect Museum on 10 March 2019

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ICAR–National Bureau of Agricultural Insect Resources

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