Annual Report
2017-18
वार्षिक प्रतिवेदन
२०१७-१८

ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
Bengaluru, India
राष्ट्रीय कृषि कीट संसाधन ब्यूरो
बेंगलूरु, भारत

Mr Chhabilendra Roul, Additional Secretary, DARE & Secretary, ICAR, at NBAIR on 24 August 2017

Dr S. Salini receiving the *Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2016* in Crop Protection category

Drs N. Bakthavatsalam and K. Subaharan receiving the DBT Biotechnology Industry Research Assistance Council's *BioInnovations Award 2016* with ATGC Biotech, Hyderabad

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PREFACE

The biotic relationship between insects and humans can be categorised into three: parasitism, commensalism or mutualism. Depending on the category, we decide to take action to either combat or encourage insects. Hence, it is extremely important to understand the role of insects as our friends or foes during specific situations.

This year witnessed several atrocities caused by insects. In Ganjam district in Odisha, out of 2.16 lakh hectares of paddy cultivated, 13,009 hectares were destroyed by brown planthopper. The centuries-old facade of the beautiful monument Taj Mahal is under attack from another foe: the excessively defecating species of a chironomid bug, *Goeldichironomus*, which is reported to be breeding in the polluted water of the Yamuna. The invasive rugose spiralling whitefly (RSW) damaged several coconut plantations in Tamil Nadu, Kerala, Karnataka, Andhra Pradesh and Goa. The pink bollworm has developed resistance to *Bt* cotton and caused extensive damage in Gujarat, Maharashtra, Tamil Nadu and Karnataka. Nalbari, Bongaigaon, Allengmora and Dergaon taluks of Jorhat district witnessed severe swarming caterpillar infestation in paddy.

Thus, it is evident that insects have innumerable negative impacts on humans; however, their positive contributions can never be ignored. It is an impossible task to precisely quantify the ecosystem services provided by insects, which may actually outweigh the harm (unfortunately this can be precisely quantified) they cause. While pollination is the most significant function of insects, they also impact several other areas of life, including production of various substances, biological control, culture, medicine, research and soil health. Insects reach their greatest diversity in the tropics. Though man has already identified more species than all other animals combined, there are yet millions of unidentified insect species.

NBAIR holds the responsibility of collecting, characterising, documenting, conserving, exchanging, conducting research and utilising insect genetic resources, including insect-derived resources. During 2017-18, a total of 54,074 insect specimens and 73 types were added to the NBAIR Museum, thus bringing the total number to 1,70,770 and 313, respectively. The type holdings in the Museum are documented in the database "Type Specimens in ICAR–NBAIR Collections", which is hosted on the NBAIR website. Two new websites that aid as identification guides for soft scales and longhorn beetles have also been developed. NBAIR taxonomists provided identification service to more than 200 organisations by processing 11,318 specimens and identifying 721 species. In order to strengthen the documentation, molecular characterisation was done for 308 insects and 273 DNA barcodes, five whole-genome sequences and five transcriptomes were generated. Subsequent to morphological identification, further genetic group determination of the whitefly, *Bemisia tabaci*, was carried out and the presence of two putative groups, i.e., Asia 1 and Asia II-1 has been confirmed. Strain NBAIR-BTAN4 of *Bacillus thuringiensi*s was characterised as a novel isolate capable of expressing crystal proteins toxic to both lepidopteran and coleopteran pests. Six mitochondrial genomes of entomopathogenic nematodes (EPNs) were sequenced and deposited with NCBI.

We also focussed on identifying, conserving and utilising insect resources. New parasites and predators were identified, and those potential ones amenable to rearing are maintained in the NBAIR Live Insect Repository. Viruses were isolated from notorious pests, viz. *Mythimna separata, Euproctis chrysorrhoea*, *Chilo infuscatellus, Chilo sacchariphagus indicus, Helicoverpa armigera* and *Spodoptera obliqua*. Conservation of the two species of wasps, *Encarsia guadeloupae* and *Encarsia dispersa*, which parasitise the RSW, led to the reduction in population of this pest in Tamil Nadu, Andhra Pradesh and Kerala. The subterranean nesting behaviour of the native buzz pollinating bee, *Hoplonomia westwoodi*, was studied to conserve the bees using artificial trap nests. A *Bt* fermentation medium amended with molasses and soy flour was standardised for fermentation of NBAIR-BTG4 and NBAIR-BTAN4 as an innovative technology. Research on utilisation of insects as fish feed has yielded remarkable results. Tilapia (*Oreochromis niloticus*) fish fed with the formulated diet of prepupae of black soldier fly, *Hermetia illucens*, recorded significantly higher food conversion ratio, per cent weight gain and survival rate. Translation of research results to technologies has been the main thrust, and two patents were granted for NBAIR technologies.

Through the AICRP coordinating centres, EPNs, fungal pathogens, *Bt* and macrobials were evaluated on various crops in different agro-ecological zones and their potential was established. The centres also assisted NBAIR in the surveillance and monitoring of invasive alien pests, including the recent entrants, viz. *Tuta absoluta*, *Paracoccus marginatus*, *Pseudococcus jackbeardsleyi* and *Aleurodicus rugioperculatus*. Research on biological control has received support through the SFC approval for strengthening the AICRP biocontrol project with 13 additional contingency centres, which would be taking up new programmes during 2018-19 and 2019-20.

NBAIR, with its strong team of taxonomists, molecular entomologists and ecologists, is networking and striking a balance between research on basic and applied aspects, with an ultimate aim to provide sustainable and pesticide-free solutions for the Indian farmer.

Bengaluru
31 May 2018

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. The Bureau is committed to the collection, cataloguing and conservation of insects and other related organisms including mites, spiders, nematodes and microbes associated with arthropods in 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 (AICRP) on Biological Control of Crop Pests. The results of the research are summarised below.

ICAR–National Bureau of Agricultural Insect Resources

Germplasm collection and characterisation

Systematic surveys and explorations were carried out covering 14 states, viz. Andhra Pradesh, Arunachal Pradesh, Assam, Goa, Himachal Pradesh, Karnataka, Kerala, Maharashtra, Odisha, Punjab, Tamil Nadu, Telangana, Uttarakhand and Uttar Pradesh to collect insect specimens.

Collections included 3,000 specimens of Bethylidae, Braconidae and Pteromalidae, and 1,200 specimens of Sphecidae of Hymenoptera; 547 specimens of Scarabaeidae and 297 specimens of Curculionidae of Coleoptera; 2,500 specimens of Tephritidae of Diptera; 726 specimens of Pentatomidae of Hemiptera and 300 specimens of Araneae.

The collected specimens yielded more than 100 species of Hymenoptera, 94 species of phytophagous Scarabaeidae and 48 species of Curculionidae under Coleoptera; 43 species of Tephritidae (Diptera) and 49 species of Pentatomidae (Hemiptera). Around 402 slides of mealybugs, scales and aphids were prepared out of 1,788 specimens collected across the country.

In total, two new genera and 82 new species were described from different groups; two new genera and 67 new species from superfamily Platygastroidea, three new species of parasitic wasps belonging to Braconidae, Pteromalidae and Bethylidae of Hymenoptera; eight new white grub species belonging to tribe Sericini of Melolonthinae (Coleoptera: Scarabaeidae), two new fruit fly species (Diptera: Tephritidae), a new aphid species (Hemiptera: Aphididae) and a thrips species (Thysanoptera: Thripidae) were described and illustrated.

Redescriptions were carried out for 58 species of *Leptacis* and two species of *Stigmina* of Hymenoptera, 40 sericine species of Coleoptera, 47 species of Tephritidae of Diptera and 14 species of Pentatomidae of Hemiptera. The salticid spider, *Madhyattus jabalpurensis*, collected from sugarcane ecosystem was redescribed. Hitherto unknown female of *Aelurillus kronestedti* was recorded for the first time in India and described.

Thirteen taxa were recorded for the first time from India along with 45 new distributional records and 12 new host plant/host insect associations. Two genera of Platygastroidea, viz. *Phlebiaporus, Sacespalus,* a species of *Mantibaria, M. mantis,* five species of platygasterids, *Leptacis ocellaris*, *L. pederseni*, *L. philippinensis*, *L. pteridis* and *L. semifusca* were reported for the first time from the Indian subcontinent. *Megaprosternum* (Bethylidae: Scleroderminae) was newly recorded from the Oriental region, and *M. cleonarovorum* was described and illustrated from southern India as a gregarious larval ectoparasitoid of *Cleonaria bicolor* (Coleoptera: Cerambycidae) on the host plant *Ixora coccinea.*

Polistes (*Polistella*) *dawnae* (Hymenoptera: Vespidae: Polistinae) was recorded for the first time from Arunachal Pradesh. *Cotesia ruficrus* (Hymenoptera: Braconidae: Microgastrinae) on rice green semilooper, *Naranga aenescens*, was the first record. Also, for the first time *Ooencyrtus* sp. (Hymenoptera: Encyrtidae) was recorded from the genus *Xenasteia* as its solitary parasitoid. Simultaneously, two hyperparasitoids, viz. *Trichomalopsis apanteloctena* (Pteromalidae) and an indetermined ichneumonid were also recorded.

Megaphragma and *Neocentrobiella*, belonging to Trichogrammatidae were collected for the first time in Maharashtra and Kerala, respectively. Also, *Trichogramma achaeae* was collected for the first time in Himachal Pradesh.

Ash weevils, *Myllocerus cardoni* from Pasighat, Arunachal Pradesh, *M. transmarinus* and *Tanymecus feae* from Udaipur, Rajasthan were the new distributional records. New distributional records for 13 sericine species (Coleoptera: Scarabaeidae: Melolonthinae: Sericini) from different parts of India were documented.

For the first time, the family Xenasteiidae (Diptera: Brachycera: Cyclorrhapha) was recorded from mainland India. Four fruit fly species, viz. *Bactrocera aethriobasis*, *B. rubigina*, *B. syzygii* and *B. tuberculata*, and two species of thrips, viz. *Caliothrips punctipennis* and *Plesiothrips perplexus* were reported for the first time from India. *Pulvinaria indica* and *Contigapis coimbatorensis* from Maharashtra, *Lopholeucaspis japonica* from Gujarat were recorded for the first time.

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. The ant-mimicking spider, *Castianeira furva*, was reported for the first time from Assam and an entomopathogenic nematode, *Steinernema cholashanense* was reported for the first time from India.

A total of 1,526 species of Coleoptera, Hemiptera, Hymenoptera and Thysanoptera, and 94 species of Araneae were added to the existing 1,70,770 specimens in NBAIR reference collection. Out of the 6,150 mites sampled and processed, 1,125 temporary mounts and 1,250 permanent slides were prepared. At least four potentially new phytoseiid species (*Euseius* sp.nr. *bhadrakaliensis*, *Neoseiulus* sp.nr. *baraki*, *Neoseiulus* sp.nr. *reticulatus*, *Okiseius* sp.nr. *himalayana*) were collected on various plant species.

Two new websites on 'Common soft scales of India' and 'Bee fauna of India' were developed and hosted on NBAIR website. A checklist of longhorn beetles belonging to Cerambycidae, Disteniidae and Vesperidae was prepared. A catalogue of Indian Sphecidae was prepared. Diagnostic keys for tribe Dacini of Tephritidae and thrips species of Thripidae were developed and published.

More than 300 identification services were provided where 721 species were identified for various state agricultural universities and ICAR institutions. Eight training programmes were conducted on identification of various groups of insects and nematodes.

In addition, parasitisation efficiency of trichogrammatids and other parasitic wasps was documented. Scanning electron microscopy studies on egg chorion structures and lamellar antennal sensillae of predominant scarab species were conducted and described.

Genomic resources

Sixty-two insect species belonging to five orders (Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera) and an acarine species were molecularly characterised. Three hundred barcodes were generated during the period.

De novo whole-genome sequencing of *Leucinodes orbonalis* was completed through Illumina paired-end and mate pair libraries by PacBio RS II system and P6C4 chemistry. The final genome size of *L. orbonalis* upon hybrid assembly was found to be 826 Mb with an N50 value of 108 kb. The genome was submitted to GenBank (PQWD00000000) as the first draft insect genome from India.

Rugose spiralling whitefly, *Aleurodicus rugioperculatus*, collected on coconut and banana in Karnataka, was molecularly characterised. The level of incidence, genetic groups and natural enemy complex of *Bemisia tabaci* was monitored by taking up intensive surveys in cotton-growing areas in Andhra Pradesh, Haryana, Karnataka, Punjab, Rajasthan and Tamil Nadu. All the collected samples were subjected to sequence analyses using mitochondrial cyctochrome oxidase I (COI) which confirmed the presence of two putative species, Asia I and Asia II.

Different populations of the brown planthopper, *Nilaparvata lugens*, which were collected on paddy in Madhya Pradesh were characterised using COI gene. DNA barcoding using partial gene amplification of COI gene has been done for nine species of thrips, viz. *Microcephalothrips abdominalis*, *Scirtothrips dorsalis*, *Thrips florum*, *Thrips orientalis*, *Haplothrips* sp. and *Thrips* sp. The sequences were submitted to GenBank.

Subterranean insect pests like scarabaeid beetles, termites and collembolans collected from different geographic locations were identified morphologically and were characterised using molecular tools based on ITS and/or COI genes. GenBank accession numbers were acquired and barcodes and Barcode Index Numbers (BINs) were obtained by submitting the sequences of identified species to BOLD Systems v3. Maximum likelihood method based on the Tamura-Nei model was used to construct phylogenetic trees. Gamma distribution shape parameters and substitution rates were used in phylogenetic analysis. Museum specimens of termites dating back to 2010/2013, obtained from the Department of Entomology, University of Agricultural Sciences and the Institute of Wood Science and Technology, both in Bengaluru, were characterised and identified through a modified procedure of DNA isolation.

Ninety agriculturally important parasitoids, predators

and other insects were molecularly characterised and DNA barcodes were generated based on COI and ITS2 genes.

Parapanteles spp. collected from different places in the country were characterised using COI gene and GenBank accession numbers were obtained for the same. Nine populations of chrysopids collected from different states were identified as *Chrysoperla zastrowi sillemi* using COI gene and ITS2 region. Molecular characterisation was done for *Habrobracon hebetor* collected in Coimbatore, *Megachile anthracina* in Bengaluru and *Paragus serratus* in Mandya using COI gene. Sphecid wasps were molecularly characterised and DNA barcodes were developed for species level identification.

In surveys conducted in Gujarat, Maharashtra, Telangana and Tamil Nadu to assess the severity of pink bollworm, *Pectinophora gossypiella*, on cotton, the locule damage was observed to range between 44% and 64%. Amod, Bharuch (Gujarat) and Rahuri, Ahmednagar (Maharashtra) recorded the highest incidence in terms of number of larvae per boll, while Jolarpet, Vellore (Tamil Nadu) recorded the least. The incidence in terms of number of exit holes per boll ranged between 1.11 and 1.83. In bioassays conducted with two *Bt* toxins, Cry1Ac and Cry2Ab, against the pest population collected from Jolarpet, it was observed that the resistance ratio for Cry1Ac was 6.19 and that for Cry2Ab was 1.96 in comparison with the laboratory susceptible population.

Strain NBAIR-BTAN4 of *Bacillus thuringiensi*s was characterised as a novel isolate capable of expressing crystal proteins toxic to both lepidopteran and coleopteran pests. Sequence studies showed that it expresses Cry2Ab, Cry1Ac, Cry1Ia and Cry2Aa apart from 20 other toxin proteins. The strain was evaluated against the lepidopteran pests *Helicoverpa armigera* and *Plutella xylostella* and the LC_{50} was calculated as 414 and 545 ng/ml, respectively. In *Holotrichia serrata*, it caused 50% mortality in 15 days of treatment. A *Bt* fermentation medium amended with molasses and soy flour was standardised for fermentation of NBAIR-BTG4 and NBAIR-BTAN4 as an innovative technology.

Two detritivorous insects, black soldier fly (*Hermetia illucens*) and scarab beetle (*Protaetia* sp.), were collected and identified using COI gene and GenBank accession numbers were obtained. A total of 15 bacteria, mostly *Bacillus* spp., were isolated from *H. illucens* larvae, identified using 16S rDNA sequencing and GenBank accession numbers were obtained.

An interactive mobile app on non-chemical methods for management of arthropod and other pests of coconut was developed. It gives biocontrol measures for rhinoceros beetle, red palm weevil, black-headed caterpillar, eriophyid mite, white grub and rodents (palm civet and rat). This comes in handy as a ready reckoner with photographs and videos about coconut pests and their natural enemies.

Six mitochondrial genomes of EPN were sequenced and deposited to NCBI. GenBank accession numbers were obtained for *Steinernema carpocapsae* NBAII Sc05 (MG875343), *Steinernema abbasi* NBAII Sa04 (MG970364), *Heterorhabditis bacteriophora* NBAII as (MH104864) and *Heterorhabditis indica* NBAII (MH119603).

Germplasm conservation and utilisation

Fergusonina syzygii was found to cause galls in *Syzygium cumini*. These galls were found to be fed upon by a hairy caterpillar. Stem gall fly infesting little gourd was identified. A parasitoid, *Inostemma indicum* parasitising the gall fly infesting little gourd was redescribed.

Type II functional response was observed in all stages of *Geocoris ochropterus* to *Helicoverpa armigera* eggs. *Termatophylum orientale* was reported for the first time from India.

The major flower visitors of field bean included *Xylocopa pubescens, X. fenestrata*, *Amegilla zonata*, *Hoplonomia westwoodi* and *Ceratina binghami*. Pollination by native bees increased the number of pods set per inflorescence and pod weight compared with wind pollinated flowers.

Subterranean nesting behaviour of the native buzz pollinating bee, *Hoplonomia westwoodi* was studied to conserve the bees using artificial trap nests.

Genetically improved farmed tilapia fish (*Oreochromis niloticus*) fed with the formulated diet of prepupae of black soldier fly, *Hermetia illucens*, recorded significantly high food conversion ratio, per cent weight gain and survival rate.

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.

Nanoemulsion of ajowan and thymol exhibited the highest level of repellence of houseflies. *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, *Nasoniavitripennis* and *Spalangia* sp., were identified and their mass production protocols were standardised.

Probes were synthesised for rapid detection of *Hear*NPV, *Spli*NPV (*Spodoptera litura*) and *Spob*NPV. Quantitative estimations of endogenous oxalate were achieved in more than 25 different agricultural crops using a rhodamine-based *in situ*-formed metal complex. A low cost urea sensor with hydrogen bonding facilitated quenching of molecular emission was developed. A pheromone detector for early detection of pheromones was invented which could measure pheromone mass as low as attograms.

In studies on nuclear polyhedrosis viruses, *Mythimna separata* NPV (*Myse*NPV) and *Euproctis chrysorrhoea* NPV (*Euch*NPV) were isolated from diseased larvae of their respective hosts, i.e. rice armyworm and apple brown-tail moth. Under scanning electron microscope, occlusion bodies of both viruses appeared as irregular and tetrahedral in shape. Granuloviruses (GVs) were isolated from diseased larvae of *Chilo infescatellus* (early shoot borer) and *C. sacchariphagus indicus* (internode borer), the pests of sugarcane. Granulosis viruses of sugarcane borers were granular in shape, measuring 259 × 249 nm. Both *Hear*NPV and *Spob*NPV performed better under field conditions and were found effective in reducing pod borer and Bihar hairy caterpillar on chickpea and jute, respectively.

Isolates of *Beauveria bassiana* (NBAIR-Bb-5a) and *Metarhizium anisopliae* (NBAIR-Ma-4 and NBAIR-Ma-35) caused 77–89% mortality of the diamondback moth, *Plutella xylostella*, in laboratory bioassays. Protocols for endophytic establishment of promising entomopathogenic fungal isolates like NBAIR-Bb5a, NBAIR-Bb-45, NBAIR-Ma-4 and NBAIR-Ma-35 in cabbage leaves through foliar spray of oil formulations were standardised. The endophytic isolates showed 70–77% mortality of *P. xylostella* larvae 15 days after treatment and 14–55% mortality 30 days after treatment in leaf bioassay tests.

Groundnut bud necrosis virus was isolated from tomato, detected using RT-PCR and maintained on cowpea cv C-152. The plant growth-promoting rhizobacterium *Pseudomonas fluorescens* NBAIR-PfDWD was effectively used to manage *Frankliniella schultzei*.

For the first time in India, plant-feeding phytoseiid mites were investigated. Mass production protocols were developed and standardised for *Tyrophagus putrescentiae*, the mould mite or copra mite, and for a *Lardoglyphus* sp. The phytoseiid mite, *Neoseiulus indicus*, was successfully used against the phalaenopsis mite, *Tenuipalpus pacificus*, an invasive pest of orchids.

Surveys for whiteflies were carried out in different agricultural, horticultural and landscape-based ecosystems in seven states to understand the species diversity and dominance. Most of the specimens were morphologically identified as *Bemisia tabaci, Aleurodicus rugioperculatus, A. dispersus* and *Aleurotrachelus trachoides.* Infestation of *A. 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% parasitism in December 2017.

In vitro studies with entomopathogenic nematodes (EPNs) indicated that bacterial symbionts, age of juveniles, foraging habit, insect host, insect eggs and viability of insect eggs and larvae were functional factors for infectivity. Field trial indicated that mulching had an additive effect in controlling the damage due to ash weevil grubs and cumulative effect in enhancing the yield by 16–20% over control. Field studies to evaluate the efficacy of EPN species and to determine their respective LD_{50} values against white grubs in turmeric, soybean and groundnut indicated that *Heterorhabditis indica* performed better than *H. bacteriophora* and *S. abbasi*. Their LD_{50} values for field efficacy in terms of dose per ha ranged between 1.5 and 2.5 billion IJs/ha. Integrated approach of dislodging mustard sawfly larvae and application of EPN formulations at 10^5 IJs per m^2 reduced infestation of mustard sawfly in radish.

Heterorhabditis indica (@ 3.5 x 10^5 IJ/palm) was found to cause significant per cent mortality of larvae of white grub, *Leucopholis lepidophora* infesting arecanut. A long-term storage method of placing the infective juveniles in a mixture sterilised sandy soil and coir pith (2:1) was developed.

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

Biodiversity of biocontrol agents in various agro-ecological zones

Spiders were abundant on cotton, with *Neoscona theisi* as the most predominant species (72.1%) followed by *Tetragnatha javana* (14.3%) in Anand. In rice, coccinellids were abundant, with *Micraspis discolor* as the most predominant species.

Predators like *Coccinella undecimpunctata*, *Priscibrumus uropygialis, Chilocorus infernalis*, *C. septempunctata*, *Scymnus* sp. and *Chrysoperla zastrowi sillemi* were recorded on apple. Natural parasitisation of apple San Jose scale to the extent of 16–20% by *Encarsia perniciosi* and *Aphytis proclia* was recorded. *Coccinella undecimpunctata* recorded for the first time on apricot in Kargil.

Parasitoids of coccinellid insects like *Dinocalpus coccinellae* and *Pediobius foveolatus* parasitising *Coccinella septempunctata* and *Megalocaria dilatata* were recorded in Nauni. Natural enemies like *Nesidiocoris tenuis, Neochrysocharis formosa, Diglyphus* sp. and *Quadrastichus plaquoi* were recorded from *Tuta absoluta,* greenhouse whitefly, serpentine leaf miner and phytophagous mites infesting vegetables.

Parasitisation of rugose spiralling whitefly by *E. guadeloupae* was observed on coconut. Predators like *Cryptolaemus montrouzieri*, *C.z. sillemi* and *Mallada* sp. were recorded on sucking insects infesting tapioca, papaya, brinjal, okra, curry leaf and coconut. *Dipha aphidivora* and *Micromus igorotus* were found associated with the sugarcane woolly aphid in Tamil Nadu.

Surveillance for invasive alien pests

Incidence of *T. absoluta* and *Paracoccus marginatus* was observed in Gujarat. *T. absoluta* was observed in Himachal Pradesh. Two mealybugs, *Pseudococcus jackbeardsleyi* and *P. marginatus*, were recorded on custard apple and papaya, respectively, in Pune region. Lower to higher incidence of papaya mealybug was noticed in Tamil Nadu. Widespread occurrence of the papaya mealybug parasitoid, *Acerophagus papayae*, was noticed in most of the districts in Tamil Nadu. Other natural predators such as *Cryptolaemus montrouzieri*, *Spalgius epius* and *Mallada igorotus* were also noted.

Surveillance for rugose whitefly and its natural enemies on coconut

Rugose spiralling whitefly (RSW) was observed on coconut and oil palm in East Godavari, West Godavari and Srikakulam districts of Andhra Pradesh. The preferred hosts were coconut, oil palm and custard apple.

Less than 25% incidence of RSW was observed in newer areas like Dindigul, Thanjavur, Pudukottai and Tiruvarur districts of Tamil Nadu. Natural enemies like *Encarsia* sp., *C. z. sillemi, Mallada* sp. and *Cryptolaemus montrouzieri* were observed on infested leaflets in Tamil Nadu.

Parasitisation by *E. guadeloupae* was found to be 10–54% during 2017 with the highest parasitisation recorded during December (93.3%) and January (92%) in Kerala.

RSW was noticed to have spread in Kerala (Palakkad, Malappuram, Thrissur, Idukki, Kozhikode, Kannur, Ernakulam, Kasaragod, Pathanamthitta, Alappuzha, Kollam and Thiruvananthapuram), Tamil Nadu (Pollachi, Pattukottai, Tiruppur, Thanjavur, Theni, Marthandam), Andhra Pradesh (Kadiyam, East Godavari – Damalacheruvu, Pottilanka, West Godavari – Kalavalapalli, Chikkala and Kakinada), Karnataka (Udupi, Mulki, Sullia, Mangaluru, Dharwad) and Goa (Colva beach) with over 20 adult whiteflies per infested leaflet.

Pest outbreaks

During November 2017, severe pink bollworm damage was recorded at several places in Anand district of Gujarat.

Nalbari, Bongaigaon, Allengmora and Dergaon taluks of Jorhat district in Assam witnessed severe swarming caterpillar damage during August–September 2017. Severe diamondback moth incidence on cabbage was reported at Allengmora and Teok Boloma villages of Jorhat district during March 2018.

Severe early shoot borer incidence (> 50 %) was observed in the sugarcane ratoon crop during July 2017 at Ravikamatam, Narsipatnam, Kotavuratla, Devarapalli and Chodavaram mandals in Visakhapatnam district of Andhra Pradesh.

Severe infestation of leaf folder and yellow stem borer (35–40%) was observed in rice during August 2017 and February 2018 in Ramnagar in Uttarakhand.

Coconut plantations at several villages in Kadiyam and Chagallu mandals in Andhra Pradesh were severely infested with RSW. High infestation of RSW was observed also in oil palm plantations during December 2017.

Severe incidence of brown planthopper at Akalapur in Sorada block of Ganjam district in Odisha was reported during July and October 2017.

Tuta absoluta was reported for the first time in Punjab from Patiala and Ludhiana districts in in July 2017.

Severe incidence of diamondback moth on cabbage was reported in Bogam in Budgam district of Jammu and Kashmir during July–October 2017.

Severe infestation of RSW was observed in Pollachi taluk of Coimbatore district and Udumalpet taluk of Tiruppur district between June and October 2017.

During November 2017, severe pink bollworm incidence was observed on cotton at several villages in Raichur, Jewargi and Kalaburagi areas in Karnataka.

Biological control of plant diseases

Three bioagents, viz. PBAT-3, Psf-2 and Th-14 were found effective in reducing sheath blight and brown spot, which resulted in increased yield in rice. Minimum incidence of brown spot was recorded with NBAIR-2 (47.5%) isolate, which was on a par with that of Psf-2 (50.9%) and NBAIR-1 (50.9%). Maximum seed germination was recorded in chickpea (cv. PG-186) treated with NBAIR-1-Th.

Biological control of sugarcane pests

Plants treated with *Heterorhabditis indica* recorded the least plant damage by white grubs (79.9%) with 39.1% yield increase over the untreated control in sugarcane.

Biological control of cotton pests

Spraying of *Lecanicillum lecanii* (10^8 conidia/g) at the rate of 5 g/litre thrice resulted in the lowest population of aphids (6.68), leafhoppers (2.48), thrips (2.82) and whiteflies (1.81) compared with the untreated control. Yield of cotton sprayed with *L. lecanii* (17.85 q/ha) was statistically on a par with chemical control using 0.05% of dimethoate (18.50 q/ha) in Maharashtra.

Biological control of rice pests

Leaf folder and stem borer damage was recorded to be lowest in plants treated with *Beauveria bassiana* (78.5%) and *Metarhizium anisopliae* (39%), respectively. Biointensive pest management (BIPM) practices recorded the lowest population of hoppers (89.8%) and highest yield.

Biological control of maize pests

Release of *Trichogramma chilonis* reduced the percentage of dead hearts in maize. The BIPM module consisting of release of *T. chilonis* recorded the lower leaf injury rating, lower percentage of dead hearts and higher yield (21.5 q/ha) in comparison with farmers' practice (18.5 q/ha) in Udaipur.

Biological control of pests of pulses

Spray of NBAII-BTG4 at the rate of 2% significantly reduced the larval population with minimum pod damage (10.2%) by *Maruca vitrata* and *Exelastis atomosa* and was found on a par with the chemical control, flubendiamide (8.4%).

Biological control of pests of tropical fruit crops

Spraying of *Metarhizium anisopliae* (0.5 %) at the rate of 5 g/litre and *Beauveria bassiana* ITCC 6063 at the rate of 20 g/litre recorded significant reduction in the damage by hoppers and webber (*Orthaga* sp.) on mango. Zero incidence of papaya mealybug was observed within three months of release of *A. papayae*, but the pest flared up after March in the unreleased plots of papaya.

Biological control of pests of temperate fruit crops

A module consisting of release of *T. cacoeciae* at the rate of 2.5 lakh/ha (4 releases/season), trunk banding, pheromone trapping, disposal of infested fruits and spraying of *Heterorhabditis pakistanensis* (NBAIR) resulted in 48.2% reduction in damage by the codling moth, *Cydia pomonella* on apple. *M. anisopliae* treatment resulted in 71.1–82.2% mortality of root grubs in apple in Solan.

Biological control of pests of plantation crops

Liquid formulation of coleopteran-specific *Bacillus thuringiensis* BTAN4 has found to have caused maximum mortality (36%) in the grubs of coconut red palm weevil 10 days after treatment. Liquid formulations of 4Aa1 and BTAN4 recorded a maximum of 30% and 14% mortality of rhinoceros grubs, respectively, at 10 days after treatment.

Biological control of pests of vegetables

Tomato

Fruit damage by *H. armigera* (5.2%) and *T. absoluta* (5.3%) was found to be the lowest in the BIPM plots than in the control plot in Tamil Nadu. Per leaf, the lowest numbers of whitefly (0.27), aphid (0.20), leafhopper (0.23) and leaf miner (0.97) were recorded in the BIPM plot in Varanasi. The larval population was significantly low (2.2 larvae/10 plants) in the BIPM plot in Maharashtra.

Brinjal

Both shoot damage (3.6%) and the number of damaged fruits (0.46/plant) were found to be significantly lower in the BIPM plot with the benefit-cost ratio (BCR) of 1:7.6 in Tamil Nadu. Lower fruit damage (44.9%), higher yield (13.8 t/ha) and higher BCR (1:2.3) were obtained through the BIPM package. The fruit damage, yield and BCR in farmers' practice were 52.7%, 12.6 t/ha and 1:0.8, respectively in Odisha.

Okra

Three releases of *Trichogramma* at the rate of 50,000/ha significantly reduced the fruit damage by the spotted bollworm, *Earias vitella*, with a yield of 9.7t/ha which was found on a par with that of chemical control in

Tamil Nadu. Spraying of *Bt* at the rate of 1 kg/ha reduced shoot infestation by *E. vitella* to 6.3% and fruit damage to 11.6% in Maharashtra.

Cabbage

The larval population of *Plutella xylostella* was found to be significantly lower in BIPM plots (0.84 larvae/plant) after three rounds of spray of *Bt* (NBAII BtG4) than that of chemical control plot (2.26 larvae/plant) and control plot (8.88 larvae/plant) in Tamil Nadu. The mean number of holes on cabbage leaves (2.21 holes/plant) was significantly lower in biocontrol-based management practices with head damage of 7% compared with that of farmers' practices (32.2%) in Bengaluru.

Biological control of oilseed crop pests

Lecanicillium lecanii (10^8 spores/g) applied at the rate of 2.5 kg/ha was found to be significantly superior in reducing the aphid population of mustard in Odisha.

Biological control of polyhouse crop pests

Beauveria bassiana 1% (10^8 spores/ml and 10^9 spores/ml) and *Lecanicillium lecanii* 1% (10^8 spores/ml and 10^9 spores/ml) were effective in reducing aphid population in Kumarakom.

2. निष्पादित सारांश

भा.कृ.अनु.प.–राष्ट्रीय कृषि कीट संसाधन ब्यूरो ही देश का एकमात्र संस्थान है, जिसको कृषि क्षेत्र में महत्वपूर्ण कीटों, कुटकियों और मकड़ियों के 'अधिकृत संग्रह स्थल' के रूप में मान्यता प्राप्त है। यह ब्यूरो देश की विभिन्न कृषि पारिस्थितिकी में कीटों और कुटकियों, मकड़ियों, सूत्रकृमियों और आर्थ्रोपोड 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.–राष्ट्रीय कृषि कीट संसाधन ब्यूरो

जननद्रव्य का संग्रहण एवं लक्षणीकरण

कीटों के नमूनों को एकत्रित करने के लिए 14 राज्यों, जैसे आंध्र प्रदेश, अरुणाचल प्रदेश, आसम, गोवा, हिमाचल प्रदेश, कर्नाटक, केरल, महाराष्ट्र, ओडिशा, तमिलनाडू, तेलंगाना, उत्तराखण्ड और उत्तर प्रदेश में व्यवस्थित सर्वेक्षण एवं खोज किया गया।

संग्रहों में बीथाइलिडे, ब्रेकोनिडे और प्टेरोमेलिडे के 3,000 नमूने और हाइमनोप्टेरा के स्फेसिडे के 1,200 नमूने; स्कैराबिडे के 547 नमूने और कोलियोप्टेरा के कुरुकुलिनिडे के 297 नमूने; डिप्टेरा के टेफ्राइटिडे के 2,500 नमूने; हेमीप्टेरा के पेन्टाटोमिडे के 726 नमूने और एरानी के 300 नमूने शामिल हैं।

संग्रहीत नमूनों में से हाइमनोप्टेरा की 100 जातियाँ, फाइटोफेगस स्केराबिडे की 94 जातियाँ और कोलियोप्टेरा के कुरकुलियोनिडे की जातियाँ; टेफ्राइटिडे (डिप्टेरा) की 43 जातियाँ और पेंटाटोमिडे (हेमिप्टेरा) की 49 जातियाँ प्राप्त हुईं। देश भर से एकत्रित 1,788 नमूनों में से चूर्णी कीटों, शल्कों और ऐफिडों के 402 स्लाइड तैयार किए गए।

कुल मिलाकर, विभिन्न समूहों से दो नई पीढ़ी और 82 नई जातियों का वर्णन किया गया; सुपर परिवार प्लैटीगेस्ट्रॉइडीया से 67 नई जातियों, ब्रेकोनिडे, प्टेरोमालिडे एवं हाइमेनोप्टेरा के बीथाइलिडे से संबंधित परजीवी वास्प की तीन नई जातियो; मेलोलोन्थिने के सेरीकीनी (कोलियोप्टेरा : स्कैराबिडे) वंश से संबंधित सफेद डिंभक की आठ नई जातियाँ, दो नई फलमक्खी जातियाँ (डिप्टेरा:टेफ्राइटिडे), एक नई ऐफिड जाति (हेमिप्टेरा:ऐफिडिडे) और एक थ्रिप्स जाति (थाइसेनोप्टेरा : थ्रिपिडे) का सचित्र वर्णन किया गया।

लेप्टासिस की 58 जातियों और हाइमेनोप्टेरा के *स्टिगमिना* की दो जातियों, कोलियोप्टेरा की 40 सेरीसाइन जातियों, डिप्टेरा के टेफ्राइटिडे के 47 जातियों और हेमिप्टेरा के पेन्टाटोमिडे की 14 जातियों के संबंध में पुनःवर्णन किया गया। गन्ने की पारिस्थितिकी से एकत्रित साल्टिसिड मकड़ी, *माध्याट्टस जबलपूरेंसिस* का पुनःवर्णन किया गया। अब तक अज्ञात *एल्यूरिल्लस क्रोनस्टेड्टी* की मादा भारत में पहली बार पाई गई और इसका वर्णन किया गया।

भारत में पहली बार 45 नवविवरणात्मक अभिलेखों और 12 नए परपोषी पौधों/परपोषी–कीट सहयोग हेतु 13 टैक्सा का उल्लेख किया गया। प्लैटीगेस्ट्रोइडी के दो वंश, जैसे *फ्लीबियापोरस, सेस्पेलस, मेन्टीबेरिया* की एक जाति, *एम. मेन्टिस,* प्लेटीगेस्टेराइड की पाँच जातियाँ, जैसे *लेप्टेसिस ओसेल्लारिस, एल. पेडरसेनी, एल. फिलीप्पिनेनसिस, एल. प्टेराइडिस* और *एल. सेमीफ्युस्का* भारतीय उपमहाद्वीप में पहली बार पाई गईं। *मेगाप्रोस्टेरनम* (बीथाइलिडेःस्क्लेरोडर्मिने) पूर्वी क्षेत्रों में नया पाया गया और दक्षिण भारत से परपोषी पौधे, *इक्सोरा कोक्कीनिया* पर *क्लियोनेरिया बायकलर* (कोलियोप्टेरा : सेराम्बाइसिडे) के झुण्ड में रहनेवाले डिंभक एक्टोपेरासिटोइड के रूप में *एम. क्लियोनेरोवोरम* का सचित्र वर्णन किया गया।

पोलिस्टेस (पोलिस्टेल्ला) डॉनी (हाइमेनोप्टेरा : वेस्पिडे : पोलिस्टिने) पहली बार अरुणाचल प्रदेश में पाया गया। पहली बार *कोटेसिया रूफिक्रस* (हाइमेनोप्टेरा : ब्रेकोनिडे : माइक्रोगेस्ट्रिने) राइस ग्रीन सेमीलूपर, *नारंगा एनेसेन्स,* पर *कोटेसिया रूफिक्रस* (हाइमेनोप्टेरा : ब्रेकोनिडे : माइक्रोगेस्ट्रिने) पाया गया। इसके साथ ही साथ *ज़नेस्टिया* वंश से पहली बार इसकी एक ही परजीवी के रूप में *ऊनसिर्टस* जाति (हाइमेनोप्टेरा : एनकाइर्टिडे) पाई गई। इसी समय दो हाइपर परजीवी, *ट्राइकोमेलोप्सिस एपेन्टेलोक्टेना* (प्टेरोमेलिडे) और एक अनिर्धारित इचन्यूमोनिड भी पाए गए।

पहली बार *ट्राइकोग्राम्माटिडे* से संबंधित *मेगाफ्रेमा* और *नियोसेन्ट्रोबिल्ला* को क्रमशः महाराष्ट्र और केरल से संग्रहीत किया गया। साथ ही, पहली बार *ट्राइकोग्राम्मा एची* को हिमाचल प्रदेश से संग्रहीत किया गया।

पासीघाट, अरुणाचल प्रदेश से धूसर घुन, *माइलोसेरस कार्डोनी,* उदयपुर, राजस्थान से *एम. ट्रेंसमेरिनस* और *टेनाइमेकस फेई* नवीन विवरणात्मक अभिलेख थे। भारत के विभिन्न भागों से 13 सेरीसाइन जातियों (कोलियोप्टेरा : स्कैरेबिडे : मेलोलोन्थिने : सेरीसिनी) के लिए नवीन विवरणात्मक अभिलेखों का प्रलेखन किया गया।

पहली बार, भारत में सेनेस्टिडे (डिप्टेरा : ब्रेकाइसेरा : साइक्लोरहापा) परिवार दिखाई दिया। चार फलमक्खी जातियाँ, *बेक्ट्रोसेरा ईथ्रियोबेसिस, बी. रूबीगिना, बी. सिज़ाइजी* और *बी. ट्युबरकुलेटा* और थ्रिप्स की दो जातियाँ, *केलियोथ्रिप्स पंक्टीपेन्निस* और *प्लेसियोथ्रिप्स पर्प्लेक्सस* भारत में पहली बार देखा गया। पहली बार महाराष्ट्र में, *पलविनेरिया इंडिका* और *कोण्टिगोपिस कोयम्बटोरियेनसिस,* गुजरात में *जेपोनिका लोफोल्यूकेस्पिस* में देखा गया।

दो ऐफिड, *ट्यूबेराफिस सिंग्लोजेनसिस* और *लेपिडोसाफेस लेटेरोकाइटिनोसा* पहली बार पाए गए। नेटालिकोलाइन कीट, *एम्पाइसेरस डिप्रेसस,* पहली बार महाराष्ट्र और कर्नाटक में पाया गया। चींटी के नकल उतारनेवाली मकड़ी, *कैस्टियानीरा फर्वा,* पहली बार असम में पाई गई और कीट–रोगवाहक सूत्रकृमि, *स्टीनेरनेमा कोलाशेनेन्स,* भारत में पहली बार देखा गया।

कोलियोप्टेरा, हेमिप्टेरा, हाइमेनोप्टेरा और थाइसेनोप्टेरा की 1,526 जातियों और अरनी की 94 जातियों को इस ब्यूरो के मौजूदा 1,70,770 नमूनों के संग्रह में शामिल किया गया। नमूने बनाए और प्रसस्कृत 6,150 कुटकियों में से 1,125 अस्थाई माउण्ट और 1,250 स्थाई स्लाइड तैयार किए गए। विभिन्न पौध जातियों के कम से कम चार संभवतः नई फाइटोसीड जातियों (*यूशियस* स्पी. एनआर *भद्रकालियन्स, नियोशियलस* स्पी. एन.आर. *बरकी, नियोशियलस* स्पी.एनआर. *रेटिकुलेटस, ओकीशियस* स्पी. एन.आर. *हिमालयाना*) का संग्रहण किया गया।

'भारत के सामान्य मुदु स्केल' और 'भारत के मधुमक्खी जीव' विषयक दो नए वेबसाइटों का विकास किया गया और ब्यूरो की वेबसाइट पर शामिल किया गया है। सेराम्बाइसिडे, डाइस्टिनीडे और वेस्पेरिडे से संबंध रखने वो लंबी तुरही वाले भृंगों की सूची तैयार की गई। भारतीय स्फेसिडे की सूची तैयार की गई। टेफ्राइटिडे के डेसीनी तथा थ्रिपिडे की थ्रिप्स जातियों के संबंध में निदानकारी कुंजी का विकास किया गया और इसे सार्वजनिक किया गया।

तीन सौ से अधिक पहचान सेवाएँ प्रदान की गईं, जिनमें विभिन्न कृषि विश्वविद्यालयों और भारतीय कृषि अनुसंधान परिषद के संस्थान के लिए 721 जातियों की पहचान की गई। कीटों व सूत्रकृमियों के विभिन्न समूहों की पहचान के लिए आठ प्रशिक्षण कार्यक्रम आयोजित किए गए।

इसके अतिरिक्त ट्राइकोग्राम्माटिड्स और अन्य परजीवी वास्पों की परजीवीकरण दक्षता का प्रलेखन किया गया। प्रचुर गुबरैले भृंग जातियों के अंड जरायु संरचनाओं और परतदार स्पर्श–विषयक सेनसिल्ले पर स्कैनिंग इलेक्ट्रॉन माइक्रोस्कोपी अध्ययन एवं वर्णन किया गया।

जीनोमिक संसाधन

पाँच क्रमों (कोलियोप्टेरा, डिप्टेरा, हेमिप्टेरा, हाइमेनोप्टेरा और लेपिडोप्टेरा) के 62 कीट–जातियों और एक एकाराइन जाति का आणविक लक्षणीकरण किया गया। इस अवधि के दौरान 300 बारकोड तैयार किए गए।

पैकबायो आरएस 2 प्रणाली एवं पी6सी4 रासायन विज्ञान के द्वारा इल्यूमिना जोड़ीदार–अग्र और जोड़–संग्रहों को बाँधने के माध्यम से *ल्यूसिनोड़स ओर्बोनालिस* के *डी नोवो* संपूर्ण जीनोम अनुक्रमण पूर्ण किया गया। संकर समूह पर *ल्यूसिनोड़स ओर्बोनालिस* का अंतिम जीनोम आकार 108 के.बी. के एन 50 मूल्य सहित 826 एमबी पाया गया। इस जीनोम को भारत से पहली बार पाए गए कीट जीनोम के रूप में जीन बैंक (पीक्युडब्ल्युडी000000000) के लिए प्रस्तुत किया गया।

कर्नाटक से नारियल एवं केले से संग्रहीत रूगोस घुर्णी सफ़ेद मक्खी, *एल्यूरोडिकस रूगियोपर्कुलेटस,* का आणविक लक्षणीकरण किया गया। आंध्र प्रदेश, हरियाणा, कर्नाटक, पंजाब, राजस्थान एवं तमिलनाडू के कपास उगाने वाले क्षेत्रों में *बेमीसिया टबाशी* के संक्रमण का स्तर, आनुवंशिक समूह और प्राकृतिक शुत्रता की निगरानी गहन सर्वेक्षण के द्वारा किया गया। माइटोकोण्ड्रियल साइटोक्रोम ओक्सिडेस 1 (सीओ1) का उपयोग करते हुए संग्रहीत सभी नमूनों अनुक्रमण विश्लेषण किया गया, जिसने दो ख्यात जातियों, एशिया 1 एवं एशिया 2, की उपस्थिति की पुष्टि की।

भूरे पादप फुदक, *नीलपर्वत ल्यूगेन्स,* की विभिन्न जातियों, जिनको मध्य प्रदेश के धान के खेत से एकत्रित किया गया था, का लक्षणीकरण सीओ 1 जीन का उपयोग करते हुए किया गया। सीओ 1 जीन के आंशिक जीन परिवर्धन का उपयोग करते हुए थ्रिप्स के नौ जातियों, जैसे *माइक्रोसेफेलोथ्रिप्स एबडोमिनालिस, स्किर्टोथ्रिप्स डोर्सालिस, थ्रिप्स फ्लोरम, थ्रिप्स ओरिएन्टालिस, हेप्लोथ्रिप्स* जाति एवं *थ्रिप्स* जाति का डीएनए बारकोडीकरण किया गया। इन अनुक्रमों को जीन बैंक में प्रस्तुत किया गया था।

विभिन्न भौगोलिक स्थानों से संग्रहीत स्कैराबिड भृंग, दीमक और कोलेम्बोलन जैसे भूमिगत कीटों का आकारकीय पहचान की गई और आईटीएस एवं/या सीओ1 जीनों के आधार पर आणविक साधनों का उपयोग करते हुए इनका लक्षणीकरण किया गया। पहचान की गई जातियों के अनुक्रमों को बीओएलडी प्रणाली वी3 को प्रस्तुत करते हुए जीन बैंक प्राप्ति संख्या और बारकोड एवं बारकोड सूचक संख्या प्राप्त की गई। जातिवृत्त बनाने के लिए टमूरा–नी मॉडल पर आधारित अधिकतम संभावना विधि का उपयोग किया गया। जातिवृत्तीय विश्लेषण में गाम्मा वितरण आकार मानक और प्रतिस्थापन दर का

उपयोग किया गया। कृषि विश्वविद्यालय के कीट विज्ञान विभाग, बेंगलूरू और काष्ट विज्ञान एवं प्रौद्योगिकी संस्थान, बेंगलूरू से दीमकों पुराने यानी 2010/2013 के संग्रहालय नमूने प्राप्त किए गए और डीएनए पृथक्करण की संशोधित प्रक्रिया के माध्यम से इनका लक्षणीकरण और इनकी पहचान की गई।

कृषि संबंधी महत्वपूर्ण 90 परजीवियों, परभक्षियों और अन्य कीटों का आणविक लक्षणीकरण किया गया और सीओ1 एवं आईटीएस2 जीनों के आधार पर डीएनए बारकोड तैयार किए गए।

सीओ1 जीन का उपयोग करते हुए देश के विभिन्न भागों से संग्रहीत *पैरापेंटीलस* जाति का लक्षणीकरण किया गया तथा इससे जीन बैंक एक्सेशन संख्या भी प्राप्त की गई। सीओ1 जीन और आईटीएस2 जीनों का उपयोग करते हुए विभिन्न राज्यों से संग्रहीत नौ क्राइसोपिडों की पहचान *क्राइसोपर्ला ज़ेस्ट्रोवी सिल्लेमी* के रूप में की गई। सीओ1 जीन का उपयोग करते हुए कोयम्बतूर से संग्रहीत *हेब्रोब्रेकन हेबेटर,* बेंगलूरू से संग्रहीत *मेगाकाइल एंथ्रेकीना* और माण्डया से संग्रहीत *परागस सेर्रेटस* का आणविक लक्षणीकरण किया गया। स्फेसिड वास्पों का आणविक लक्षणीकरण किया गया और जाति–स्तरीय पहचान के लिए डीएनए बारकोड विकसित किए गए।

कपास पर गुलाबी गोलक कीट, *पेक्टिनोफोरा गोसिपीला,* की तीव्र संक्रमण के मूल्यांकन के लिए गुजरात, महाराष्ट्र, तेलंगाना और तमिलनाडू में किए गए सर्वेक्षणों में कोष्ठक की हानि 44 से 64 प्रतिशत के बीच पाई गई। अमोद, भरूच (गुजरात) एवं राहुरी, अहमदनगर (महाराष्ट्र) में प्रति गोलक में डिंबकों की संख्या के संबंध में प्रकोप अधिक पाया गया, जबकि जोलारपेट, वेल्लूर (तमिलनाडू) में सबसे कम पाया गया। निकास छेदों की सख्या के संबंध में प्रकोप 1.11 एवं 1.83 के बीच था। जोलारपेट से संग्रहीत कीटों के प्रति क्राइ1एसी एवं क्राइ2एबी बीटी टॉक्सिनों से किए गए जैव आमापन में यह पाया गया कि प्रयोगशाला–संवेदनशील कीटों की तुलना में क्राई1एसी एवं क्राई2एबी के लिए प्रतिरोध–अनुपात क्रमशः 6.19 एवं 1.96 था।

बेसिलस थूरिंजिएनसिस के एनबीएआईआर–बीटीएएन4 वंश का एक नवीन पृथक्कृत के रूप में लक्षणीकरण किया गया, जो लेपिडोप्टेरान एवं कोलियोप्टेरान कीटों के प्रति क्रिस्टल प्रोटीन विष अभिव्यक्ति के लिए सक्षम है। अनुक्रम अध्ययन ने दर्शाया कि अन्य 20 विषैले प्रोटीन के अतिरिक्त यह क्राई2एबी, क्राई1एसी, क्राई1आईए और क्राई2एए को अभिव्यक्त किया। लेपिडोप्टेरान कीटों, जैसे *हेलिकोवर्पा आर्मीजेरा* एवं *होलोट्रिकिया सेर्राटा* के प्रति इस वंश का मूल्यांकन किया गया और एलसी$_{50}$ की गणना क्रमशः 414 एवं 545 एनजी/मि.ली. के रूप में की गई। *होलोट्रिकिया सेर्राटा* में 15 दिनों के उपचार में मृत्यु–दर 50% हुई। नवाचारी प्रौद्योगिकी के रूप में एनबीएआईआर–बीटीजी4 और एनबीएआईआर–बीटीएएन4 के किण्वन के लिए गुड़ आपैर सोया आटा से संवर्धित बीटी किण्वित माध्यम का मानकीकरण किया गया।

सीओ1 जीन का उपयोग करते हुए दो अपरदाहारी कीटों, जैसे ब्लैक सोलजर मक्खी (*हर्मीशिया इल्यूसेन्स*) और गुबरैला भृंग (*प्रोटेशिया* जाति), का संग्रहण किया गया और इनकी पहचान की गई तथा जीन बैंक एक्सेशन संख्या प्राप्त की गई। *एच. इल्यूसेन्स* डिम्बक से 15 जीवाणु, अधिकतर *बैसिलस* जाति, का पृथक्करण किया गया तथा 16 एसआरडीएनए अनुक्रमण का उपयोग करते हुए इनकी पहचान की गई और जीन बैंक एक्सेशन संख्या प्राप्त की गई।

आर्थोपोड और नारियल के अन्य कीटों के प्रबंधन के लिए गैर–रासायनिक विधि पर एक मोबाइल एप्प विकसित किया गया। यह गैंडा भृंग, रेड पाल्म घुन, काले सिर वाली इल्ली, इरियोफाइड कुटकी, सफ़ेद ग्रब और रोडेन्ट (पाल्म सिवेट एवं चूहा) का जैविक नियंत्रण उपाय देता है। यह नारियल के कीडों और उनकी नैसर्गिक शत्रुओं के बारे में छायाचित्र एवं वीडियो प्रदान करते हुए सुविधाजनक और रेडी रेकनर है।

ईपीएन के 6 माइटोकोण्ड्रियाई जीनोम का अनुक्रमण किया गया और इसे एनसीबीआई में जमा किया गया। *स्टीनेरनीमा कार्पोकैप्सी* एनबीएआईआई एससी05 (एमजी875343), *स्टीनरनीमा अब्बासी* एनबीएआईआई एसए04 (एमजी970364), *हीटरोरहेबिडिटिस बैक्टीरियोफोरा* एनबीएआईआई (एमएच104864) एवं *हीटरोरहेबिडिटिस इंडिका* एनबीएआईआई (एमएच119603) की जीन बैंक एक्सेशन संख्या प्राप्त किया गया।

जननद्रव्य संरक्षण एवं उपयोग

फर्युसोनिया सिसीजी सिज़ियम क्युमिनी में गॉल बनने के कारक के रूप में पाया गया। इन गॉलों को रोयेंदार इल्ली द्वारा खाते पाया गया। कुंदरू को प्रकोपित करने वाले छोटी गॉल मक्खी की पहचान की गई। एक परजीवी, *इनोस्टेम्मा इंडिकम,* जो कुदरू को प्रकोपित करने वाली गॉल मक्खी का परजीवीकरण करता है, का पुनःवर्णन किया गया।

गियोकोरिस ओक्रोप्टेरस से लेकर *हेलिकोवर्पा आर्मीजेरा* अंडों के सभी चरणों में टाईप 2 कार्यात्मक अनुक्रिया पाई गई। *टर्मेटोफाइलम ओरिएन्टेल* भारत में पहली बार पाई गई।

बीन के प्रमुख पुष्प–आगंतुकों में, *साइलोकोपा प्यूबसेन्स, साइलोकोपा फेनेस्ट्रेटा, अमीजेल्ला ज़ोनाटा, हॉप्लोनोमिया वेस्टवुडी* और *सेराटीना बिंघामी* शामिल थे। हवा से परागणित फूलों की तुलना में स्थानीय मक्खियों द्वारा परागण से प्रति पुष्पक्रम में फलियों की संख्या और फली–वज़न बढ़ गई।

कृत्रिम जालों का उपयोग करते हुए भृंगों के संरक्षण के लिए स्थानीय गुंजन करने वाले परागक भृंग, *हॉप्लोनोमिया वेस्टवूडी,* के भूमिगत जाल बनाने का अध्ययन किया गया।

आनुवंशिक रूप से सुधारी गई तलापिया मछली (*ओरियोक्रोमिस निलोटिकस*) को ब्लैक सोलजर मक्खी, *हर्मेशिया इल्यूसेन्स,* के प्रीप्यूपा के सवंर्धित आहार खिलायी गई, जिससे अधिक आहार–संरक्षण अनुपात, प्रतिशत वज़न लाभ और बचाव–दर पाया गया।

विभिन्न अवस्तरों पर पालते हुए ब्लैक सोलजर मक्खी की जैवपारिस्थितिकी का अध्ययन किया गया। रसोई/प्रक्षेत्र अपशिष्टों का उपयोग करते हुए इस कीट के प्रति एक बृहत् पालन प्रोटोकॉल का मानीकरण किया गया और एक पेंटेंट–योग्य प्रौद्योगिकी का विकास किया गया।

अजवाइन और थाइमॉल के नैनोइमल्शन ने घर–मक्खियों के विकषर्ण का अधिकतम स्तर दिखाया। *बैसिलस थूरिंजिएनसिस* जाति *इज़राएलियेनसिस* (वीएलसी1), जो सबसे कम मात्रा (1 पीपीएम) में भी मच्छर के लार्वे के शतप्रतिशत मृत्यू–दर का कारक होता है, का पृथक्करण एवं लक्षणीकरण किया गया। दो कोषस्थ कीट परजीवियों, *नेसोनियाविट्रिपेन्निस* और *स्पेलेंजिया* जाति की पहचान की गई और उनके बृहत् उत्पादन प्रोटोकॉल का मानकीकरण किया गया।

हियर एनपीवी, *स्पिल* एनपीवी *(स्पोडोप्टेरा लिट्युरा) एवं स्पोब* एनपीवी की त्वरित पहचान के लिए जाँचों को संश्लेषित किया गया। रोडामाइन आधारित स्वस्थाने धातु मिश्रण का उपयोग करते हुए 25 से अधिक कृषि फसलों में अंतर्जात ऑक्सलेट के परिमाणात्मक अनुमान प्राप्त किए गए। आणविक उत्सर्जन को दबाने की हाइड्रोजन–बंधन सुविधा सहित कम लागत का युरिया सेंसर का विकास किया गया। फेरोमोनों की जल्दी पहचान के लिए एक फेरोमोन डिटेक्टर का आविष्कार किया गया, जिससे फेरोमोन की संख्या को एटोग्राम तक माप सका।

नाभिकीय पॉलीहेड्रोसिस विषाणुओं के अध्ययन में *माइथिम्ना सेपेरेटा* एनपीवी और *यूप्रोक्टिस क्राइसोरिया* एनपीवी उनसे संबंधित परपोषियों, राइस आर्मी कीट एवं एप्पल ब्राउण–टेल मॉथ, के रोगग्रस्त लार्वा से को पृथक्कृत किया गया। इलेक्ट्रॉन माइक्रोस्कोपा स्कैनिंग के तहत्, दोनों विषाणुओं के अंतर्रोध अनियमित एवं चतुष्फलकीय आकार में दिखाई दिए। गन्ने के कीटों, जैसे *काइलो इनफेस्केटेल्लस* (अगेती प्ररोह छेदक) और *काइलो सेक्करइफेगस इंडिकस* (अंतरगाँठीय छेदक) के रोगग्रस्त लार्वा से कणिका विषाणुओं का पृथक्करण किया गया था। गन्ने के कणिका विषाणु दाने के आकार में थे और ये 259 x 249 मि.मी. के थे। हियर एनपीवी और स्पोब एनपीवी का निष्पादन प्रक्षेत्र परिस्थितियों में बेहतर था और ये चना और पटसन में क्रमशः फली छेदक एवं बिहार रोयेंदार इल्ली को कम करने में प्रभावी पाए गए।

प्रयोशाला जैवआमापन में *ब्युबेरिया बेसियाना* (एनबीएआईआर–बीबी–5ए) और *मेटाराइज़ियम एनीसोप्ली* (एनबीएआईआर– एमए–4 एवं एनबीएआईआर–एमए–35) के पृथक्कृतों के कारण हीरकपृष्ठ शलभ, *प्ल्यूटेल्ला साइलोस्टेल्ला,* की मृत्यु–दर 7–89% हुई। तेल मिश्रणों के पर्णीय छिड़काव के माध्यम से पत्ता गोभी की पत्तियों में उन्नत कीटरोगवाहक फफूँद पृथक्कृतों, जैसे एनबीएआईआर–बीबी5ए, एनबीएआईआर–बीबी–45, एनबीएआईआर–एमए–4 और एनबीएआईआर–एमए–35 के अंतपादपीय स्थापना के प्रोटोकॉल का मानकीकरण किया गया। पर्ण जैवआमापन में अंतपादपीय पृथक्कृतों ने उपचार के 15 दिन बाद *प्ल्युटेल्ला ज़ाइलोस्टेल्ला* के लार्वा की 70–77 प्रतिशत मृत्युदर दर्शाया और उपचार के 30 दिन बाद 14–55 प्रतिशत मृत्यु–दर दर्शाया।

टमाटर से पृथक्कृत मूँगफली कलिका परिगलन विषाणु की आरटी–पीसीआर का उपयोग करते हुए पहचान की गई और लोबिया प्रजाति सी–152 पर इसको अनुरक्षित किया गया। *फ्रेंकलीनील्ला शूल्टज़ी* के प्रबंधन के लिए पादप–वृद्धि–प्रोत्साहक राइज़ोबैक्टीरियम *स्यूडोमोनास फ्लूरसेंस* एनबीएआईआर–पीएफडीडब्ल्युडी का प्रभावी उपयोग किया गया।

भारत में पहली बार पौधों को खाने वाली फाइटोसीड कुटकियों की खोज की गई। मोल्ड कुटकी या गरी कुटकी, *टाइरोफेगस प्यूट्रेसेनशिया* और *लैड्रोग्लाइफस* जाति के बृहत् उत्पादन प्रोटोकॉल का विकास एवं मानकीकरण किया गया। फाइटोसीड कुटकी, *नियोसियुलस इंडिकस* का उपयोग फेलेनोप्सिस कुटकी, *टेनूईपाल्पस पैसिफिकस,* जो ऑर्किड का एक आक्रामक कीट है, के प्रति सफलतापूर्वक किया गया।

सात राज्यों में कृषि, बागवानी एवं भू–दृश्य आधारित पारिस्थितिकी में स्पीशीज–विविधता और प्रचुरता को समझने के लिए सफेद मक्खियों का सर्वेक्षण किया गया। *बेमीशिया टबाशी, एल्यूरोडिकस रूगियोपर्कुलेटस, ए. डिस्पर्सस* और *एल्यूरोट्रेकिलस ट्रेकोइड्स* जैसे अधिकांश नमूनों की आकारकीय पहचान की गई। *ए. रूगियोपर्कुलेटस* का संक्रमण 60.5% से 15.8% अंड

चक्कर प्रति पत्रक/पत्ता तक कम होते पाया गया। *एनकार्सिया ग्वाडेलूपे* ही आरएसडब्ल्यु पर पाया गया अकेला प्रमुख नैसर्गिक शत्रु था, जिससे दिसंबर 2017 में 82.6% परजीविता हुई।

कीटरोगवाहक सूत्रकृमियों के साथ में किए गए प्रयोगशाला अध्ययनों ने संकेत दिया कि जीवाणु सहजीवी, अल्पवयस्क की आयु, चारा खोजने की प्रवृत्ति, कीट परपोषी, कीट अंडे और कीटों के अंडों और लार्वा की जीवन–क्षमता संक्रमण के कार्यात्मक कारक थे। प्रक्षेत्र परीक्षण से पता चला कि पलवार का धूसर घुन कीटों के कारण होने वाले नुकसान के नियंत्रण में और अनुपचारित की अपेक्षा 16–20% पैदावार में बढ़ोत्तरी में संचित एवं अतिरिक्त प्रभाव था। ईपीएन जातियों की प्रभावकारिता के मूल्यांकन और हल्दी, सोयाबीन और मूँगफली में सफ़ेद कीटों के प्रति उनके संबंधित एलडी$_{50}$ मूल्यों के निर्धारण के लिए किए गए प्रक्षेत्र परीक्षणों से पता चला कि *हीटरोहेबडिटिस इंडिका* का निष्पादन *एच. बैक्टीरियोफोरा* एवं *एस. टबाशी* से अच्छा रहा। मात्रा प्रति हेक्टेयर के रूप में प्रक्षेत्र प्रभावकारिता के लिए उनके एलडी$_{50}$ मूल्य 1. 5 एवं 2.5 बिलियन आईजे/हे. बीच था। सरसों की मक्खी के लार्वे को हटाने के लिए किए गए समेकित पद्धति और 10^5 आईजे प्रति मी.^{2} की दर से ईपीएन मिश्रणों के प्रयोग ने मूली में सरसों की मक्खी के प्रकोप को कम किया।

हीटरोहेबडिटिस इंडिका (3.5 x 10^5 आईजे/पेड़) सुपारी को प्रकोपित करने वाले सफेद कीट के लार्वा, *ल्यूकोफोलिस लेपिडोफोरा* की मृत्यु–दर का कारण बनते पाए गए। निर्जीवीकृत रेतीली मिट्टी और नारियल के मज्जे (2:1) में संक्रमित अल्पवयस्क कीटों को रखने के लिए एक दीर्घकाली भण्डारण विधि का विकास किया गया।

अखिल भारतीय समन्वित फसल कीट जैवनियंत्रण परियोजना

विभिन्न कृषि–जलवायु क्षेत्रों में जैवनियंत्रण कारकों की जैवविविधता

आनंद में कपास पर मकड़ियाँ प्रचुर मात्रा में थीं, जिनमें *नियोस्कोना थीसी* अत्यधिक प्रचुर (72.1%) जाति थी, जिसके बाद *टेट्रागनाथा जवाना* (14.3%)। धान में कोक्किनेल्लिडिस प्रचुर जाति थी, जिसमें *माइक्रापिस डिसकलर* अत्यधिक प्रचुर जाति थी।

सेब पर *कोक्किनेल्ला अंडेसिमपंक्टेटा, प्रिसिब्रमस यूरोपिजियालिस, काइलोकोरस इनफेरनालिस, सी. सेप्टेमपंक्टेटा, साइम्नस* जातियाँ और *क्राइसोपर्ला ज़ेस्ट्रोवी सिल्लेमी* जैसे परभक्षियाँ पाई गईं। *एनकार्सिया पर्निसियोसी* और *एफाइटिस प्रोक्लिया* द्वारा सेब सेन जॉस का नैसर्गिक परजीविता 16–20% तक पाई गई। कार्गिल में अखरोट पर पहली बार *कोक्कीनेल्ला अंडेसिमपंक्टेटा* पाया गया।

नॉनी में कोक्कीनेल्लिड की परजीवियों, जैसे *डायनोकाल्पस कोक्कीनेल्ला* और *पेडियोबायस फेवियोलेटस* द्वारा *कोक्कीनेल्ला सेप्टमपंक्टेटा* और *मेगेलोकेरिया डायलेटेटा* की परजीवीकरण पाया गया। *टूटा एब्सोल्यूटा,* हरित गृह सफ़ेद मक्खी, सर्पिल पर्ण फुदक और फाइटोफेगस कुटकियों द्वारा प्रकोपित सब्जियों से *नेसीडायोकोरिस टेनूइस, नियोक्राइसोकेरिस फोर्मोसा, डाइग्लिफस* जाति और *क्वाड्रेस्टिकस प्लक्वोइ* जैसे नैसर्गिक शत्रु पाए गए।

नारियल पर *ई. ग्वाडेलूप* द्वारा रूगोस चक्करदार सफ़ेद मक्खी की परजीविता पाई गई। परभक्षियों, जैसे *क्रिप्टोलेमस मोन्ट्रौज़ीरी, सी.जेड. सिल्लमी* और *मल्लडा* जाति जैसी परभक्षियाँ रतालू, पपीता, बैंगन, भिण्डी, कड़ी पत्ता और नारियल को प्रकोपित चूषक कीटों पर पाई गईं। तमिलनाडु में *डाइफा एफिडिवोरा* और *माइक्रोमस आइगोरोटस* गन्ने के ऊनी ऐफिड के सहयोगी के रूप में पाए गए।

आक्रामक विदेशी कीटों की निगरानी

गुजरात में *टूटा एब्सोल्यूटा* और *पैराकोक्कस मार्जिनेटस* का प्रकोप देखा गया। *टूटा एब्सोल्यूटा* हिमाचल प्रदेश में पाया गया। पुणे क्षेत्र में सीताफल और पपीते पर क्रमशः दो चूर्णी कीट, *स्यूडोकोक्कस जैकबर्ड़सलीई* और *पी. मार्जिनेटस* पाए गए। तमिलनाडु में पपीते के चूर्णी कीट का प्रकोप निम्न से उच्च स्तर तक देखा गया। तमिलनाडु के अधिकांश जिलों में पपीते के चूर्णी कीट व्यापक फैलाव देखा गया। *क्रिप्टोलीमस मोन्ट्रौज़ीरी, स्पेलजियस एपियस* और *मल्लडा आइगोरोटस* जैसे नैसर्गिक परभक्षियाँ भी पाई गईं।

नारियल पर रूगोस सफेद मक्खी और इसके नैसर्गिक शत्रुओं की निगरानी

आंध्र प्रदेश के पूर्वी गोदावरी, पश्चिमी गोदावरी और श्रीकाकुलम जिलों में नारियल और तेलताड़ पर रूगोस चक्करदार सफ़ेद मक्खी देखी गई। इनकी पसंदीदा परपोषी नारियल, तेलताड़ और सीता फल हैं।

तमिलनाडु के डिण्डिगुल, तंजावूर, पुदुकोट्टई और तिरुवारूर जिलों जैसे नए क्षेत्रों में रूगोस चक्करदार सफ़ेद मक्खी का प्रको 25% से कम देखा गया। तमिलनाडु में संक्रमित पत्रकों पर नैसर्गिक शत्रुओं, जैसे *एनकार्सिया* जाति, *सी.जेड. सिल्लेमी, मल्लडा* जाति और *क्रिप्टोलीमस मोन्ट्रौज़ीरी* देखी गई।

केरल में 2017 के दौरान *ई. ग्वाडेलोप* द्वारा परजीविता 10–54% के बीच पाई गई और सबसे अधिक परजीविता दिसंबर (93.3%) और जनवरी (92%) में देखी गई।

केरल (पालक्काड, मलप्पुरम, तृश्शूर, इडुक्की, कोषिक्कोड, कण्णूर, एरणाकुलम, कासरगोड, पत्तनमतिट्टा, आलप्पुषा, कोल्लम और तिरुवनंतपुरम), तमिलनाडू (पोल्लाची, पट्टुकोट्टाई, तिरुपूर, तंजावूर, तेनी, मारताण्डम), आंध्र प्रदेश (काडियम, पूर्वी गोदावरी – डमलचेरुवु, पोट्टिलेंका, पश्चिमी गोदावरी – कालवलपल्ली, चिक्कला और काकिनडा), कर्नाटक (उडुप्पि, मुलकी, सुल्लिया, मंगलूरू और धारवाड) तथा गोवा (कोलवा समुद्र तट) में संक्रमित प्रति पौधे पर 20 से अधिक वयस्कों सहित सफ़ेदमक्खियों का फैलाव देखा गया।

कीटों का प्रकोप

गुजरात के आणंद जिले के कई स्थानों पर नवंबर 2017 के दौरान गुलाबी गोलक कीटों द्वारा गंभीर नुकसान देखा गया।

असम के जोरहट जिले के नलबारी, बोंगईगाँव, अल्लेंगमोरा और डेरागाँव तहसीलों में अगस्त–सितंबर 2017 के दौरान रेंगनेवाली इल्ली का तीव्र प्रकोप देखा गया। मार्च 2018 में जोरहट जिले के अल्लेंगमोरा और तेवक बोलोमा गाँवों में पत्ता गोभी पर हीरक पृष्ठ शलभ का गंभीर प्रकोप देखा गया।

आंध्र प्रदेश के विशाखापट्टणम जिले के रविकामठम, नरसीपट्टणम, कोटावुरटला, देवरपल्ली और चोडावरम मंडलों में जुलाई 2017 के दौरान गंभीर अगेती प्ररोह छेदक प्रकोप (> 50%) देखा गया।

उत्तराखण्ड के रामनगर में अगस्त 2017 एवं फरवरी 2018 के दौरान धान में पत्ती मोड़क और पीला तना छेदक का गंभी प्रकोप (35–40%) देखा गया।

आंध्र प्रदेश के कडियम और चगलू मंडलों के कई गाँवों के नारियल के बागानों में रूगोस चक्करदार सफ़ेदमक्खी का गंभीर प्रकोप देखा गया। दिसंबर 2017 के दौरान तेलताड़ पर रूगोस चक्करदार सफ़ेदमक्खी का अधिक प्रकोप देखा गया।

ओडिशा के गंजम जिले के सोराडा खंड के अकलापुर में जुलाई एवं अक्तूबर 2017 के दौरान भूरे पादप फुदक का तीव्र प्रकोप देखा गया।

पंजाब में पटियाला और लुधियान जिलों में पहली बार जुलाई 2017 के दौरान *टूटा एब्सोल्यूटा* देखा गया।

जम्मू एवं कश्मीर के बुडगाम जिले के बोगम में जुलाई–अक्तूबर 2017 के दौरान पत्तागोभी पर हीरक पृष्ठ शलभ का तीव्र प्रकोप देखा गया।

कोयम्बत्तूर के पोल्लाची तहसील और तिरुपूर जिले के उदुमलपेट तहसील में जून एवं अक्तूबर 2017 के बीच रूगोस चक्करदार सफ़ेदमक्खी का तीव्र प्रकोप देखा गया।

कर्नाटक के रायचूर, जेवरगी एवं कलबुरगी क्षेत्रों में नवंबर 2017 के दौरान कपास पर गुलाबी गोलक कीट का गंभीर प्रकोप देखा गया।

पौध–रोगों का जैविक नियंत्रण

तीन जैवकारक, जैसे पीबीएटी–3, पीएसएसफ–2 और टीएच–14, धान में आच्छद अंगमारी और भूरे धब्बे कम करने में प्रभावी पाए गए, जिससे पैदावार में बढ़ोत्तरी हुई। भूरे धब्बे का सबसे कम प्रभाव एनबीएआईआर–2 (47.5%) पृथक्कृत में पाया गया, जो पीएसएफ–2 (50.9%) और एनबीएआईआर–1(50.9%) के बराबर था। एनबीएआईआर–1टीएच से उपचारित चने (पीजी–186 किस्म) में अधिकतम बीज–अंकुरण पाया गया।

गन्ने के कीटों का जैविक नियंत्रण

गन्ने में अनुपचारित की तुलना में *हीट्रोरहेबडिटिस इंडिका* से उपचारित पौधों में सफ़ेद कीटडिंभ के द्वारा नुकसान सबसे कम (79.9%) था और पैदावार में 39.1% की बढ़ोत्तरी देखी गई।

कपास के पौधों का जैविक नियंत्रण

लेकानिसिल्लम लेकानी (10^8 कोनीडिया/ग्रा.) के 5 ग्रा./ली. की दर से तीन बार छिड़काव करने से अनुपचारित की तुलना में ऐफिड (6.68), पर्ण फुदक (2.48), थ्रिप्स (2.82) और सफ़ेद मक्खी (1.81) की संख्या सबसे कम हुई। महाराष्ट्र में *लेकानिसिल्लम लेकानी* से छिड़काव किए गए कपास की उपज (17.85 क्वि./हे.) सांख्यिकीय दृष्टि से डायमेथोएट 0.05% के उपयोग द्वारा किए गए रासायनिक उपचार (18.50 क्विं./हे.) के बराबर थी।

धान के कीटों का जैविक नियंत्रण

ब्युवेरिया बैसियाना (78.5%) और *मेटाराइज़ियम एनीसोप्ली* (39%) से उपचारित पौधों में क्रमशः पत्ती मोड़क और तना छेदक द्वारा नुकसान सबसे कम था। जैवगहन कीट प्रबंधन पद्धतियों से फुदकों संख्या सबसे कम (89.8%) हुई और अधिक उपज प्राप्त हुई।

मक्के के कीटों का जैविक नियंत्रण

ट्राइकोग्राम्मा किलोनिस को छोड़ने से मक्के में मध्य भाग के अनुपयोगी होने का प्रतिशत कम हुआ। उदयपुर में किसानों की पद्धति (18.5 क्विं./हे.) की तुलना में

जैवगहन कीट प्रबंधन मॉड्यूल, जिसमें *ट्राइकोग्राम्मा किलोनिस* को छोड़ना शामिल है, से पर्ण–क्षति और अनुपयोगी मध्य भाग का प्रतिशत कम हुआ और अधिक पैदावार (21.5 क्विं./हे.) प्राप्त हुई।

दलहनों के कीटों का जैविक नियंत्रण

एनबीएआईआई–बीटीजी4 के 2% की दर से छिड़काव से लार्वा की संख्या कम हुई और *मरूका विट्रेटा* एवं *एक्सेलेस्टिस एटोमोसा* द्वारा होने वाल फली–नुकसान भी कम हुआ तथा यह रासायनिक उपचार, फ्लूबेनडायामाइड (8.4%) के बराबर पाया गया।

उष्ण क्षेत्रीय फल फसलों के कीटों का जैविक नियंत्रण

मेटाराइजियम एनीसोप्ली (0.5%) के 5 ग्रा./ली. और *ब्युबेरिया बेसियाना* आईटीसीसी 6063 के 20 ग्रा./ली. के छिड़काव से आम पर फुदकों और जालकों (*ओर्थागा* जाति) के द्वारा होने वाला नुकसान काफी कम हुआ। *ए. पपाई* को छोड़ने से लेकर तीन महीने तक पपीता चूर्णी कीट का कोई प्रकोप नहीं देखा गया, लेकिन *ए. पपाई* को न छोड़े खेतों में मार्च के बाद कीटों संख्या काफ़ी बढ़ी।

शीतोष्ण फल फसलों के कीटों का जैविक नियंत्रण

टी. केकोशी का 2.5 लाख/हे. की दर से विमोचन (4 विमोचन/मौसम), धड़ पर पट्टी बाँधना, फेरोमोन जाल, संक्रमित फलों को नष्ट करना और *हीट्रोहैबडिटिस पाकिस्तानेनसिस* (एनबीएआईआर) सम्मिलित मॉड्यूल से सेब पर कोडलिंग कीट, *साइडिया पोमोनेल्ला* से होने वाले नुकसान में 48.2% कमी आई। सोलन में सेब पर *एम. एनीसोप्ली* उपचार से जड़ कीटों की मृत्यु–दर 71.7–82.2% हुई।

रोपण फसलों के कीटों का जैविक नियंत्रण

कोलियोप्टेरान–विशेषक *बेसिलस थूरिंजिएनसिस* बीटीएएन4 के द्रव मिश्रण के प्रयोग से उपचार के दस दिन बाद नारियल के लाल घुनों की मृत्यु–दर (36%) अधि हुई। द्रव मिश्रण, 4एए1 और बीटीएएन4 के प्रयोग से गेंडा कीटों की मृत्यु–दर उपचार के 10 दिन बाद क्रमशः 30% और 14% अधिक हुई।

सब्जियों के कीटों का जैविक नियंत्रण

टमाटर

तमिलनाडू में अनुपचारति खेत की अपेक्षा जैवगहन कीट प्रबंधन अपनाए गए खेतों में *एच. आर्मीजेरा* (5.2%) और *टूटा एब्सोल्यूटा* (5.3%) द्वारा फलों का नुकसान सबसे कम पाया गया। वाराणसी में जैवगहन कीट प्रबंधन खेत में प्रति पत्ते में सफ़ेद मक्खी (0.27), ऐफिड (0.20), पर्ण फुदक (0.23) और पर्ण–सुरंगक (0.97) की संख्या सबसे कम पाई गई। महाराष्ट्र के जैवगहन कीट प्रबंधन खेत में लार्वा की संख्या काफी कम (2.2 लार्वा/10 पौधे) थी।

बैंगन

तमिलनाडू में जैवगहन कीट प्रबंधन खेत में प्ररोह–नुकसान (3.6%) और ख़राब फलों की संख्या (0.46/पौधा) काफी कम पाई गई और लाभ–लागत अनुपात 1:7.6 थी। जैवगहन कीट प्रबंधन पद्धति से फलों का नुकसान में कमी (44.9%), अधिक उपज (13.8 टन/हे.) और अधिक लाभ–लागत अनुपात (1:2.3) प्राप्त हुआ। ओडिशा में किसानों की पद्धति में फल का नुकसान, उपज और लाभ–लागत अनुपात क्रमशः 52.7%, 12.6 टन/हे. और 1:0.8 थे।

भिण्डी

तमिलनाडू में *ट्राइकोग्राम्मा* की 50,000/हे. की दर से तीन बार छोड़ने से धब्बेदार गोलक कीट, *एरियास विटेल्ला* द्वारा फल पर होने वाली क्षति काफी कम हुई और उपज 9.7 टन प्राप्त हुई, जो रासायनिक उपचार के बराबर थी। महाराष्ट्र में 1 कि.ग्रा./हे. की दर से बीटी का छिड़काव करने से *ई. विटेल्ला* द्वारा होने वाला प्ररोह–संक्रमण (6.3%) और फल–नुकसान (11.6%) कम हुआ।

पत्तागोभी

तमिलनाडू में बीटी (एनबीएआईआई बीटीजी4) के तीन बार के छिड़काव के बाद रासायनिक उपचार किए गए खेत (2.26 लार्वा/पौधा) और अनुपचारित खेत (8.88 लार्वा/पौधा) की तुलना में जैवगहन कीट प्रबंधन खेत में *प्लूटेल्ला साइलोस्टेल्ला* का लार्वा काफी कम (0.84 लार्वा/पौधा) था। बैंगलूरु में जैवनियंत्रण आधारित प्रबंधन पद्धतियों में पत्तागोभी के पत्तों के छेदों की संख्या काफी कम थी और 7% के शीर्ष भाग के नुकसान की किसानों की पद्धति (32.2%) से तुलना की गई।

तिलहन फसलों के कीटों का जैविक नियंत्रण

ओडिशा में 2.5 कि.ग्रा./हे. की दर से प्रयोग किया गया *लेकानिसिलियम लेकानी* (10^8 बीजाणु/ग्रा.) सरसों के ऐफिडों की संख्या काफी कम करते पाया गया।

पॉली हाउस फसलों के कीटों का जैविक नियंत्रण

कुमरकम में *ब्युवेरिया बेसियाना* 1% (10^8 बीजाणु/मि.ली. और 10^9 बीजाणु/मि.ली.) तथा *लेकानिसिलियम लेकानी* 1% (10^8 बीजाणु/मि.ली. और (10^9 बीजाणु/मि.ली.) ऐफिडों को कम करने के लिए प्रभावी थे।

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 ecosystem they move between them forming the glue — in Daniel Janzen's apt terminology — that holds all ecosystems together. Consequently it is not only 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. NBAIR was subsequently established to document the vast insect resources to enable studies on their multifarious roles in the agroecosystems of our country.

Organisational set-up

Research is undertaken in the Divisions of Germplasm Collection and Characterisation, Division of Genomic Resources and Division of Germplasm Conservation and Utilisation. Research on microbial biocontrol is addressed under the AICRP on Biocontrol. The organogram is given on page 16.

Mandate

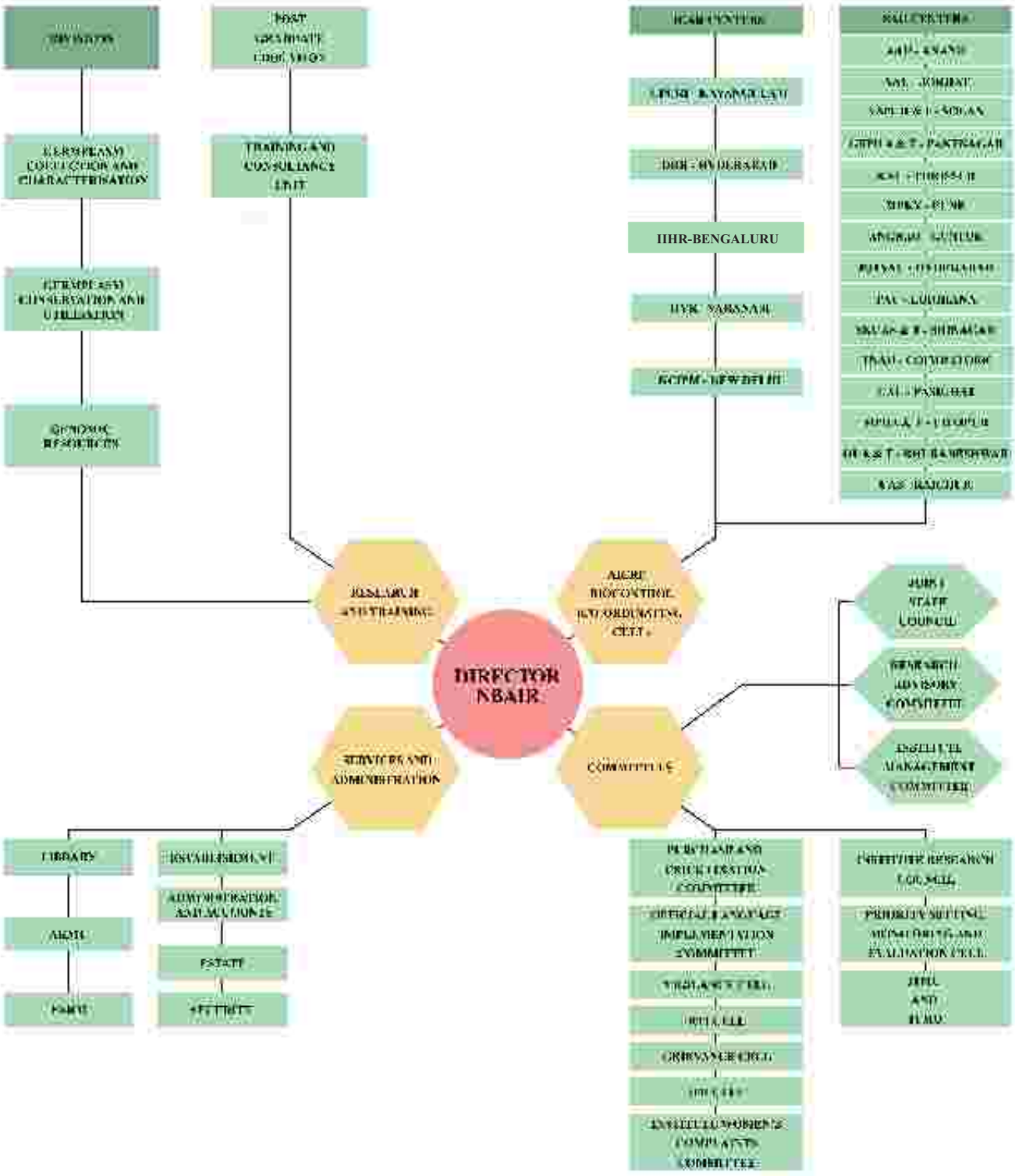
ICAR–NATIONAL BUREAU OF AGRICULTURAL INSECT RESOURCES
To act as a nodal agency for collection, characterisation, documentation, conservation, exchange, research and utilisation of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture. 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 agricultural and horticultural crops for sustainable crop production. Demonstration of usefulness of biocontrol in IPM in farmers' fields.

Notable achievements of the past

Basic research

* Insects in Indian agroecosystems is hosted on the NBAIR website (www.nbair.res.in/insectpests/index.php). It includes pests of crops and other common insects from Indian agroecosystems. About a thousand species with 6,247 colour photographs are for viewing and study on the site.
* An ever-expanding image gallery of agriculturally important insects is hosted on NBAIR's website with hundreds of species of insects and over 10,000 images. The USDA and Colorado State University feature this on their site 'ID source' along with another website 'Featured Insects'. This has 410 species and 2,322 images as of now.
* Factsheets, diagnostics and illustrations on Indian Mymaridae, Chalcididae, Aphelinidae and Pteromalidae have been developed and hosted on the NBAIR website.
* Webpage on Aphids of Karnataka has been constructed and hosted on the NBAIR website.

Organogram



* A website featuring biocontrol introductions to India (www.nbair.res.in/introductions/insects/index.htm) has also been hosted on the NBAIR website.
* *Anagyrus amnestos*, a potential parasitoid of the invasive Madeira mealybug was described.
* Twelve new species of Platygasteroidea were described.
* 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.
* A new species of Pentatomidae, *Brachycoris tralucidus* is described from India. Three new species of fruit flies were described: *Bactrocera* (*Calodacus*) *chettalli*, *B.* (*C.*) *harrietensis* infesting fruits of *Spondias pinnata* (Anacardiaceae) and *Gastrozona nigrifemur* infesting sprouts of *Dendrocalamus strictus* (Poaceae).
* A new terebrantian thrips species, *Thrips laurencei*, from flowers of *Hydrangea macrophylla* was described.
* A checklist for Indian species of longhorn beetles was prepared which consisted of 1,555 longhorn beetles classified under 72 tribes,447 genera and seven subfamilies of Cerambycidae, Vesperidae and Disteniidae.
* *Heterorhabditis pakistanense* and *Steinernema huense* were reported for the first time from India.
* Morphology, host records and molecular phylogenetic analyses were integrated to generate boundaries between species/species groups of the genus *Glyptapanteles*.
* The identity of the insect from insect fragments found in a pharmaceutical package was established by employing mitochondrial cytochrome oxidase subunit 1 gene. The insect was found to be *Pollenia rudis* (Fabricius 1794) (Diptera: Calliphoridae).
* Insecticide resistance gene database (IRGD) for key pests has been developed in MySQL as back end and PHP as front-end. It contains 851 sequences for different pests.
* A rapid and accurate identification of the new invasive rugose spiralling whitefly, *Aleurodicus rugioperculatus* and its indigenous aphelinid parasitoid, *Encarsia guadeloupae*, was done using *COI* gene. Molecular analysis of 31 populations of whitefly, *Bemisia tabaci* using ITS2 and COI regions revealed the presence of two putative genetic groups Asia1 and AsiaII1.
* Barcoding of 13 species of *Parapanteles* was examined utilising a wingless gene region (*wg*) as a marker for molecular systematics.
* De-novo whole genome sequencing of brinjal shoot and fruit borer, *Leucinodes orbonalis*, has been done through Illumina paired end and mate pair libraries by HiSeq 2500 IT upgrade system and Pac-Bio 20KB CCS library by RSII system and P6C4 chemistry.
* The transcriptome of susceptible and resistant strains of the diamondback moth, *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-RyR was achieved computationally.
* Molecular characterisation revealed the dual specificity of the indigenous *Bacillus thuringiensis* isolate NBAIRBtAN4, toxic to both lepidopteran and coleopteran insect pests. It carried the coleopteran specific *cry8* gene and lepidopteran specific *cry1* and *cry2* genes.
* For the first time, mitochondrial genomes of *Heterorhabditis indica* and *H. bacteriophora* were sequenced.
* *Paracoccus marginatus* was successfully managed by the exotic parasitoid *Acerophagus papayae*. *Leptocybe invasa* was managed by the parasitoid *Quadrastichus mendeli*.
* Anthocorid predators collected on different host plants were studied for their feeding potential and amenability for culturing indoors in the search for effective agents for use in biocontrol programmes.
* *Cecidochares connexa* released for the management of *Chromolaena odorata* continues to be present in its areas of release.
* A pollinator garden has been developed that has been attracting a large number of bees (belonging to the families Apidae, Megachilidae. Anthophoridae and Halictidae), a host of dipterans and lepidopterans.

* *Liriomyza trifolii* was found to occur at significantly higher levels when carbon dioxide and temperatures were higher.
* A cost-effective mass production protocol was developed for *Pseudococcus jackbeardsleyi*.
* Chitosan–aliginate nanoparticles were found to be safe to *Chrysoperla zastrowi sillemi*.
* 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 housefly.
* An alcohol-free formulation of 'Cuelure' trapped higher number of flies over the 'Cuelure' loaded in plywood pieces. A modified stick 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 fruit fly, *Bactrocera dorsalis*. A new bisexual trap was developed to attract females of *Bactrocera dorsalis*.
* The invasion and infestation of *Aleurodicus rugioperculatus* was reported for the first time from India. It is the first invasion report from the Oriental region.

Applied research (Biological control)

* The papaya mealybug, eucalyptus gall wasp and the sugarcane woolly aphid were successfully managed by release and management of natural enemies.
* A cost-effective WP/EC based *Trichoderma* (Th-14) formulation and an efficient delivery system were developed. Rice brown spot disease severity was found to be significantly reduced by *Trichoderma* isolates TCMS 5 and TCMS 14a.
* *Metarhizium anisopliae* @ 2 x 10 spores/ml was found to cause mycosis in rice bugs. In sugarcane, eight releases of *Trichogramma chilonis* @ 50,000/ha reduced the incidence of early shoot borer and twelve releases of *T. chilonis* @ 50,000/ha reduced incidence of stalk borer.
* In soyabean, *Spli*NPV sprays @ 250 LE/ha (1.5 x 10^{12} POBs) thrice were effective in suppressing *Spodoptera litura*. Biosuppression of the safflower aphid, *Uroleucon compositae*, could be achieved with two sprays of *Lecanicillium lecanii* 1% WP in non-spiny safflower.
* 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.
* The BIPM module developed against *Aleurodicus dispersus* on cassava was superior to farmers practice in managing this pest.
* *Neoseiulus longispinosus* @ 1:10 predator:prey ratio in carnation in polyhouses resulted in 91.2% reduction of phytophagous mites and was on par with fenazaquin (0.0025%) which caused 92.1% reduction in the mite population.
* *Blaptostethus pallescens* @ 30 nymphs/m row along with chemical control (Omite 300 ml/acre) was effective in managing *T. urticae* on okra in polyhouses.
* *Xylocoris flavipes* nymphs (30 nymphs/kg of rice) performed better than those of *Blaptostethus pallescens* in minimising Corcyra moth populations in rice in storage.
* 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.
* Field release of *Trichogramma chilonis* at the rate of 75,000 and 1,00,000 parasitoids/ha at 15 days after seedling emergence, three times at weekly intervals was found effective in reducing damage by stem borer damage in maize.
* Investigations confirmed the superiority of *Trichogramma cacoeciae* over *T. embryophagum* with increased reduction in fruit damage against codling moth.
* *Metarhizium anisopliae* (2×10^8 cfu) application followed by Bt spray (1 kg/ha) proved to be the best treatment in reducing sucking and fruit borer pests in okra.
* Against the rose aphid, *Macrosiphum rosaeiformis*, azadirachtin (3 ml/litre), *Hippodamyia variegata* (10 beetles/plant) and *Lecanicillium lecanii* (5 g/litre of 10^8 conidia/g) were equally effective, resulting in 50.8 to 69.1% reduction in the aphid population over control.

FINANCIAL STATEMENT (2017-18)

ICAR–National Bureau of Agricultural Insect Resources

(₹ in lakhs)

Head	Amount
Pay & allowances	920.12
T.A.	17.00
Other charges including equipment, office buildings	411.47
Information technology	0.00
Works/petty works	18.00
HRD	2.43
Pension	62.78
Loan	0.00
Total	**1,431.80**

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

(₹ in lakhs)

Name of the centre	Pay	TA	RC	TSP	Total
AAU, Anand	48.00	0.56	3.51	5.50	57.57
AAU, Jorhat	35.00	0.50	1.39	2.00	38.89
RARS, Anakapalle	21.50	0.53	0.87	0.50	23.40
PJTSAU, Telangana	27.03	0.20	0.62	0.00	27.85
YSPUHF, Solan	44.00	0.50	1.65	0.50	46.65
GBPUAT, Pantnagar	20.00	0.79	1.02	0.00	21.81
KAU, Thrissur	36.00	0.87	1.75	0.00	38.62
MPKV, Pune	38.00	0.50	1.75	0.00	40.25
PAU, Ludhiana	67.73	1.20	3.14	0.00	72.07
SKUAST, Srinagar	35.23	0.37	1.25	0.00	36.85
TNAU, Coimbatore	36.51	0.57	2.05	0.00	39.13
MPUAT, Udaipur	0.00	0.22	0.99	0.00	1.21
OUAT, Bhubaneswar	0.00	0.75	1.22	0.00	1.97
CAU, Pasighat	0.00	0.30	1.33	0.00	1.63
UAS, Raichur	0.00	0.25	0.81	0.00	1.06
P.C. Cell, Bengaluru	0.00	0.00	13.78	0.00	13.78
Total	**409.00**	**8.11**	**37.13**	**8.50**	**462.74**

4. RESEARCH ACHIEVEMENTS

ICAR–National Bureau of Agricultural Insect Resources

Division of Germplasm Collection and Characterisation

Surveys and explorations

Hymenoptera

Surveys for the collection of trichogrammatids were carried out in Karnataka, Kerala, Tamil Nadu, Himachal Pradesh, Punjab, Telangana and Maharashtra. Eight genera of trichogrammatids, viz. *Chaetostricha*, *Chaetogramma*, *Megaphragma*, *Neocentrobiella*, *Oligosita*, *Paracentrobia*, *Trichogramma* and *Trichogrammatoidea* were collected. *Trichogramma achaeae*, *T. chilonis*, *T. pretiosum* and *Trichogrammatoidea armigera* were collected, reared and identified from different host eggs, while *T. hebbalensis* was collected through sweep net.

Nearly 100 survey trips were made in Himachal Pradesh (Palampur, Bajaura, Katrain, Kullu and Manali), Goa, Karnataka and Arunachal Pradesh for collections of parasitised hosts (followed by laboratory rearing). Hymenopteran parasitoids were collected from different crops and different regions of India using yellow pan trap, malaise trap and sweep net. Around 100 species were identified from 3,000 specimens, which were bred, curated, identified and preserved. Around 1,200 specimens of Sphecidae were collected from five states, viz. Karnataka, Tamil Nadu, Odisha, Assam and Arunachal Pradesh, which were sorted, processed and labeled.

Coleoptera

Explorations were carried out for white grub species diversity in Uttar Pradesh, Uttarakhand, Andhra Pradesh and Karnataka, and around 547 adult specimens of phytophagous scarab species were collected through light traps (Fig. 1) and manual scouting (Fig. 2).

Fig. 1. Light trap

Fig. 2. Manual scouting

The collected beetles (Fig. 3) were sorted and identified up to species level and the faunistic composition comprised of 94 species under 22 genera, of which 57 species under 14 genera, 32 species of four genera and five species under four genera belonged to Melolonthinae, Rutelinae and Dynastinae, respectively. A dynastine species, *Phyllognathus dionysius,* was observed in huge numbers and found as an emerging pest in most of the surveyed areas in sugarcane and groundnut crops.

Fig. 3. Scarab beetles

A total of 297 Curculionidae specimens were collected/received from 57 locations comprising of 19 states, which included approximately 48 species. All the collected specimens were carefully processed, labeled and preserved for further studies. Species belonging to subfamily Entiminae were identified based on the existing keys and nine species were identified up to genus level and the identity of 16 species was confirmed.

Diptera, Hemiptera and Thysanoptera

Nearly 2,500 specimens of fruit flies were collected from Assam, Arunachal Pradesh, Himachal Pradesh and Tamil Nadu. Around 43 species of fruit flies representing 17 genera and four subfamilies were collected and curated.

Around 37 survey trips were undertaken for collection of pentatomids from various regions like Kerala (Kollam), Tamil Nadu (Valparai and Coimbatore), Arunachal Pradesh (Pasighat) and Odisha apart from various other regions of Karnataka. Nearly 726 specimens collected were processed and identified 49 species of Pentatomidae.

Around 1,788 specimens of mealybugs, scales and aphids were processed following standard procedures and prepared 402 slides. Extensive surveys were carried out in Karnataka for collection of thrips and the collected specimens were sorted, processed and slide-mounted.

Araneae

Nearly 300 specimens of spiders belonging to different families were collected across various agro-ecosystems (rice, red gram, maize, sunflower, tea, litchi) from several surveys undertaken including northeast India like Pasighat (Arunachal Pradesh), Rani (Assam), which are known for unique spider fauna.

Acari

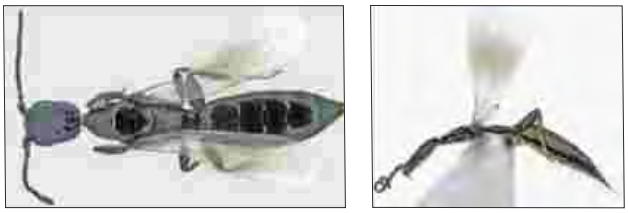
Around 6,150 mite samples were collected/received from 50 locations covering 15 districts across 11 states. Of these, 1,225 temporary mounts were made in various popular acarological media for preliminary identification of mites. Approximately, 80% of all the processed mites belonged to Parasitiformes (Mesostigmata) and the rest belonged to Acariformes [Trombidiformes (17%) and Sarcoptiformes (3%)].

Descriptions of new species

Hymenoptera

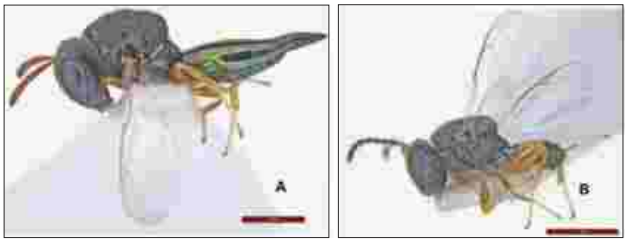
A new braconid species of *Acanthormius* (Hymenoptera: Braconidae) (Fig. 4) was described and illustrated as a gregarious larval parasitoid of undetermined bagworm moth caterpillar (Lepidoptera: Psychidae) from southern India. A new species, *Megaprosternum cleonarovorum* (Hymenoptera: Bethylidae) (Fig. 5) was described and illustrated. One new species of parasitic wasp, *Uniclypea similis* (Hymenoptera: Pteromalidae) (Fig. 6) reared from the leaf knots constructed by *Apoderus tranquebaricus* (Coleoptera: Attelabidae) on the host plant, *Grewia abutilifolia* was described.

Fig. 4. *Acanthormius indicus* female



Male Female

Fig. 5. *Megaprosternum cleonarovorum*



Female Male

Fig. 6. *Uniclypea similis*

Two new genera and 67 new species of Platygastroidea were described. Two new genera *Indiscelio* with *Indiscelio aulon* as type species and *Anokha* with *Anokha anoojii* as type species were erected.

Twenty species of *Cremastobaeus*, viz. *C. boolei*, *C. breviabdominus, C. cornutus*, *C. eila*, *C. foveatus*, *C. fuscus*, *C. longigaster*, *C. luteus*, C. *mahaviraii*, *C. nicobarensis*, *C. nigricephalus*, *C. nigrifemoralis*, *C. parallelogaster*, *C. robustus*, *C. suvarnadeha*, *C. tanugatra*, *C. valmikii*, *C. variegatus*, *C. varuna* and *C. yoganarasimha* were described.

Forty-two new *Leptacis* species, *L. belli*, *L. boseii*, *L. brevicorniculata*, *L. corbetti*, *L. deerghakanta*, *L. densipilis*,

L. dhura, *L. farmanii*, *L. ferrarii*, *L. flavicorniculata*, *L. gargiae*, *L. gaurasaktha*, *L. grossiclava*, *L. hayatii*, *L. insolita*, *L. kolhapurensis*, *L. laevifrons*, *L. lakshmiae*, *L. longicantha*, *L. mandakuta*, *L. maulikii*, *L. mechaka*, *L. naiduii*, *L. neelakesha*, *L. oculopilis*, *L. pithambara*, *L. ramanujanii*, *L. rayii*, *L. rekilii*, *L. rossii*, *L. salimalii*, *L. sarabhaii*, *L. shenbagam*, *L. spumida*, *L. stebbingii*, *L. tanvi*, *L. viralaroma*, *L. vittata*, *L. wallaceii*, *L. wheelerii*, *L. zenoi* and *L. zorbasii* were described.

Two new species of *Apteroscelio*, *A. aureus* and *A. shyamala* were described. A new sexually dimorphic species of *Telenomus chandishae* (Fig. 7) was also described. A neotype was designated for *Inostemma indicum*, a parasitoid of *Neolasioptera cephalandrae* (Diptera: Cecidomyiidae), causing galls on ivy gourd [*Coccinia grandis* (Cucurbitaceae)]. The male of the species was described for the first time (Fig. 8).

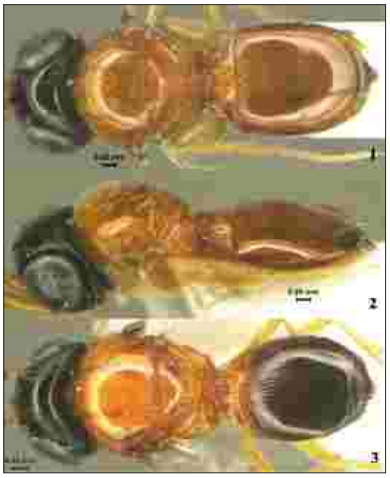


Fig. 7. *Telenomus chandishae*

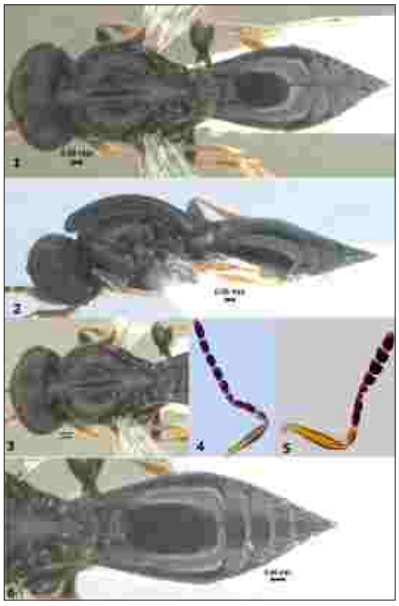


Fig. 8. *Inostemma indicum*

Coleoptera

Eight new white grub species, viz. *Maladera alloservitrita*, *M. kolasibensis*, *M. mizoramensis*, *Neoserica radhanagariensis*, *Serica* (s. str.) *basantapurensis*, *S.* (s. str.) *mahakaliensis*, *S.* (s. str.) *therathumensis*, *S.* (s. str.) *zianii* belonging to tribe Sericini (Scarabaeidae: Melolonthinae) were documented and described from the Indian subcontinent.

Diptera

Two new fruit fly species namely *Bactrocera* (*Bactrocera*) *furcata* and *Zeugodacus* (*Sinodacus*) *brevipunctatus* (Diptera: Tephritidae: Dacini) (Fig. 9) were described.

Fig. 9. *Zeugodacus brevipunctatus*

Hemiptera

A new species, *Kaochiaoja sikkimensis* (Hemiptera: Aphididae) (Fig. 10), was described from India. It was collected on *Phyllostachys* sp. (Poaceae) from Upper Tadong area of Gangtok, east Sikkim.

Fig. 10. *Kaochiaoja sikkimensis*

Thysanoptera

A new terebrantian thrips species, *Bregmatothrips ramani* (Fig. 11) (Thripidae), collected through yellow pan trap from Andaman islands was described.

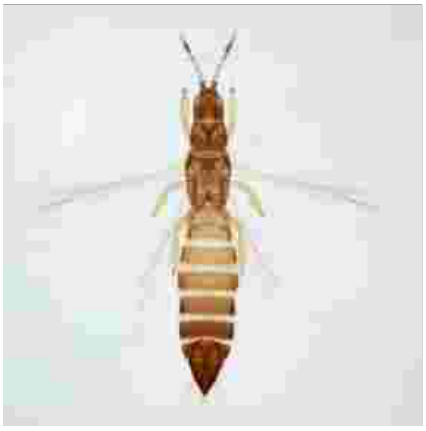


Fig. 11. *Bregmatothrips ramani*

Acari

A new species of *Lasioseius* (Blattisociidae) was collected from under the bark of the raintree (*Samanea saman*). Two new predators, viz. *Euseius* sp.nr. *bhadrakaliensis* and *Neoseiulus* sp.nr. *reticulatus*, were also collected.

Taxonomic redescriptions

Hymenoptera

Indian species of *Leptacis* was revised with the description of 58 species. *L. bengalensis*, *L. brachycerus*, *L. coorgensis*, *L. indica*, *L. keralensis*, *L. malabarensis*, *L. maldarensis*, *L. propodealis*, *L. thanensis*, *L. thrissurensis* and *L. yercaudensis*, previously reported from India were re-described. The name *L. coorgensis* was replaced by the junior synonym *L. propodealis*. All the 58 species were illustrated and a key was provided.

Five species of platygasterids, *Leptacis ocellaris*, *L. pederseni*, *L. philippinensis*, *L. pteridis* and *L. semifusca,* were redescribed.

Redescription of two Indian *Stigmina* species (Hymenoptera: Sphecidae) was done and key was generated for the identification of the species of the genus *Carinostigmus*. Male of *Carinostigmus aterrimus* was described for the first time (Fig. 12).

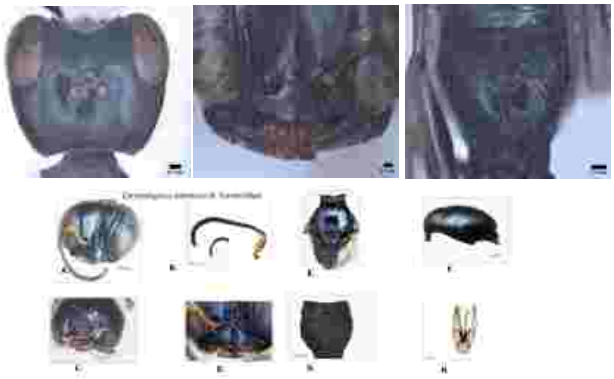


Fig. 12. *Carinostigmus aterrimus*

Coleoptera

Taxonomic studies were carried out on Tribe Sericini (Coleoptera: Scarabaeidae: Melolonthinae) of Indian subcontinent (India, Nepal, Bhutan, Pakistan and Sri Lanka), where 92 species under 14 genera were recorded from examined 421 specimens. Redescriptions were carried out for 40 sericine species of Indian fauna.

Checklist preparation on important genera of subfamily Entiminae of Curculionidae is in progress and existing checklist of *Geotragus*, *Leptomias* and *Ptochus* was updated.

Diptera

Studies were carried out on genera, *Dacus* and *Zeugodacus* of Tephritidae and post abdominal structures of males and/or females of 23 species of *Bactrocera*, 16 species of *Zeugodacus* and 8 species of *Dacus* from India were studied, which revealed similarities between *Dacus* and *Zeugodacus* at generic level and uniqueness of *Bactrocera*.

Hemiptera

The genus *Halys* (Hemiptera: Heteroptera: Pentatomidae: Pentatominae: Halyini) is redescribed and revised from India. Based on examination of specimens from various locations of India, the independent status of *H. serriger* from *Halys fabricii* could not be justified and hence the name *Halys fabricii* was considered as a new synonym of *H. serriger*.

Descriptions of majority of the pentatomid species were done. Fourteen species of Pentatomidae were identified, which were digitised along with illustration of both male and female genitalia. A few of the poorly described taxa, viz. *Eocanthecona concinna* (Fig. 13), *Empysarus depressus* (Fig. 14) and *Neojurtina typica* (Fig. 15) were redescribed. *Eocanthecona concinna* was recorded as an important predator of Lepidopteran pests in tea plantations of South India. As it is a poorly described taxon, redescription based on male and female genitalia was done for the first time from India.

Fig. 13. *Eocanthecona concinna*

Fig. 14. *Empysarus depressus*

Fig. 15. *Neojurtina typica*

Araneae

A study targeted at unfolding the taxonomic diversity of orb weaver, *Tetragnatha* in rice fields of IIRR (Rajendranagar), Nelaigudem, Telangana, revealed occurrence of seven tetragnathid species. The salticid spider, *Madhyattus jabalpurensis*, collected from sugarcane ecosystem was redescribed. The hitherto unknown female of *Aelurillus kronestedti* recorded from India was described.

New distributional records

Hymenoptera

Two genera of Platygastroidea, viz. *Phlebiaporus, Sacespalus* and a species of *Mantibaria, M. mantis* were reported for the first time from India. Five species of platygastrids, *Leptacis ocellaris*, *L. pederseni*, *L. philippinensis*, *L. pteridis* and *L. semifusca* were reported for the first time from the Indian subcontinent.

Megaprosternum (Bethylidae: Scleroderminae) was newly recorded from the Oriental region, and *M. cleonarovorum* was described and illustrated from southern India as a gregarious larval ectoparasitoid of *Cleonaria bicolor* (Coleoptera: Cerambycidae) on the host plant *Ixora coccinea* (Rubiacae). This is the firstever documentation of the biology of *Megaprosternum*.

The species *Polistes* (*Polistella*) *dawnae* (Hymenoptera: Vespidae: Polistinae) was recorded for the first time from Arunachal Pradesh. This discovery extends the distribution of the species to India, previously known from Dawna Hills (Myanmar), Northeastern Laos and Northern Vietnam.

Also, for the first time *Ooencyrtus* sp. (Hymenoptera: Encyrtidae) was recorded from the genus *Xenasteia* as its solitary parasitoid. This was the firstever report of parasitism associated with Xenasteiidae (Diptera: Brachycera: Cyclorrhapha).

Severe outbreak of rice green semilooper, *Naranga aenescens* (Lepidoptera: Noctuidae: Eustrotiinae), in West Bengal was documented along with the first record of its primary parasitoid *Cotesia ruficrus* (Hymenoptera: Braconidae: Microgastrinae). Simultaneously two hyperparasitoids, viz. *Trichomalopsis apanteloctena* (Pteromalidae) and indet. Ichneumonidae were also recorded.

The genera, *Megaphragma* and *Neocentrobiella*, belonging to Trichogrammatidae were collected for the first time from Maharashtra and Kerala, respectively. Also, *Trichogramma achaeae* was collected for the first time from Himachal Pradesh.

Coleoptera

New distributions were recorded for ash weevil, *Myllocerus cardoni*, from Pasighat, Arunachal Pradesh, and *M. transmarinus* and *Tanymecus feae* from Udaipur, Rajasthan. Six new host plants, viz. cherry, almond, peach, quince, kiwi and rose were recorded for *Myllocerus kashmirensis*. New distributional records for 13 sericine species (Coleoptera: Scarabaeidae: Melolonthinae: Sericini) from different parts of India were documented.

Diptera

Firstever record of family Xenasteiidae (Diptera: Brachycera: Cyclorrhapha) from mainland India was provided. Most of the previous records of this family are from coastal sites, as they have usually been found on islands in the Indian and Pacific Oceans. For the first time biology and life stages of *Xenasteia* were illustrated. *Xenasteia* members were found associated with an exotic rugose spiraling whitefly (RSW) colony of *Aleurodicus rugioperculatus* (Hemiptera: Aleyrodidae) in the coastal areas of Karnataka in southern India. However, no direct obligate association could be diagnosed.

Four species of *Bactrocera*, namely, *B. aethriobasis*, *B. tuberculata*, *B. rubigina* and *B. syzygii* (Fig. 16), were recorded for the first time from India. Of these two new records, *B. syzygii* was found infesting fruits of watery rose apple, *Syzygium samarangense*, whereas *B. tuberculata* recorded from Meghalaya is a pest of peach and mango in Thailand.

Fig. 16. *Bactrocera syzygii*

Thysanoptera

Thrips, *Caliothrips punctipennis* (Fig. 17), was reported for the first time from India. Occurrence of New World thrips genus, *Plesiothrips*, was reported from India with a note on *Plesiothrips perplexus* (Fig. 18).

Fig. 17. *Caliothrips punctipennis*

Fig. 18. *Plesiothrips perplexus*

Hemiptera

Pulvinaria indica (Fig. 19) on chilli roots and *Contigapis coimbatorensis* on *Tephrosia purpurea* were recorded for the first time from Maharashtra. *Lopholeucaspis japonica* (Fig. 20) on pomegranate from Gujarat was recorded. *Tuberaphis xinglongensis* and *Lepidosaphes laterochitinosa* (Fig. 21) were recorded on arecanut for the first time from India.

Fig. 19. *Pulvinaria indica*

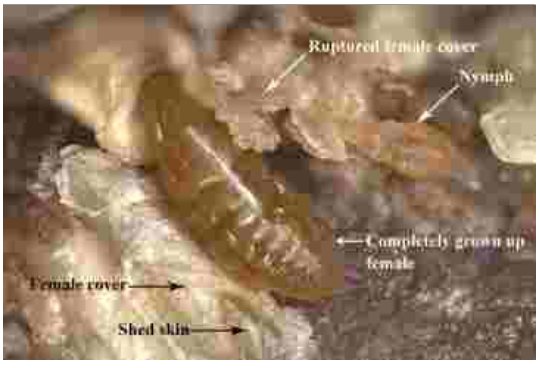


Fig. 20. *Lopholeucaspis japonica*

Fig. 21. *Lepidosaphes laterochitinosa*

The natalicoline bug, *Empysarus depressus* known from Kandy (Sri Lanka), Kodaikanal (Tamil Nadu) and Barkuda island (Odisha) was recorded for the first time from Pune (Maharashtra) and Bengaluru (Karnataka).

Araneae

The ant-mimicking spider belonging to Corinnidae, *Castianeira furva*, was reported from Assam in tea ecosystem.

Acari

Plant-feeding phytoseiid mites were documented for the first time in India. *Okiseius* sp. nr. *himalayana* was found on champak (*Magnolia champaca*) in Bengaluru. Another *Okiseius* sp. was collected from litchi leaves infested with the erineum mite (*Aceria litchii*) in Pasighat, Arunachal Pradesh. Predatory mite, *Neoseiulus* sp. nr. *baraki*, was found associated with the coconut mite (*Aceria guerreronis*) in Vellore district of Tamil Nadu. A possibly new anystid species was recorded for the first time on *Magnolia champaca*. The oriental spider mite, *Eutetranychus orientalis*, was reported for the first time on two new hosts.

Nematoda

An entomopathogenic nematode, *Steinernema cholashanense* (Rhabditida: Steinernematidae) (Fig. 22), isolated from potato rhizosphere in Udhagamandalam, Tamil Nadu, was identified through morphological and molecular studies and was reported for the first time from India.

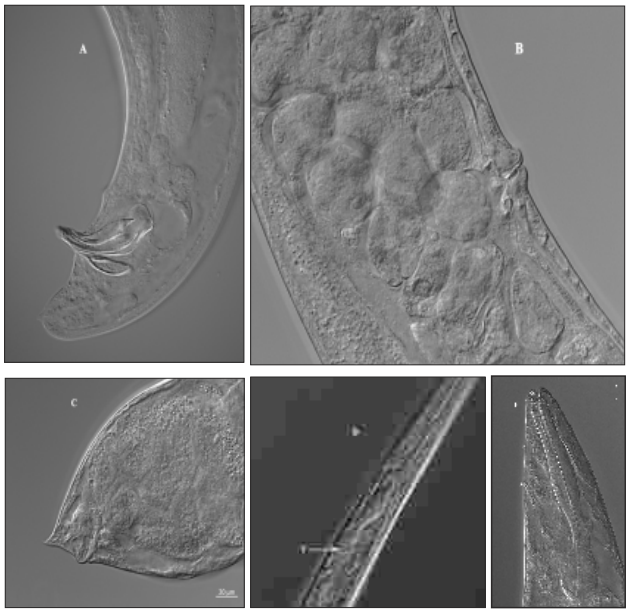


Fig. 22. *Steinernema cholashanense* (A) Posterior region of a male showing spicule, gubernaculum and mucron at tail tip. (B) Protruding vulva (C) Female tail with post-anal swelling. (D) Esophageal region of an infective juvenile showing basal bulb and bacterial vesicle (V). (E) Female with well circularised excretory pore (arrow).

Augmentation of NBAIR collection

Hymenoptera

Trichogrammatid species, viz. *Trichogramma achaeae*, *T. chilonis, T. pretiosum* and *Trichogrammatoidea armigera*, were reared for taxonomic studies and added to the live repository maintained in the insectary.

Coleoptera

Around 391 adult specimens of Scarabaeidae and Cerambycidae belonging to Coleoptera were added to NBAIR collections.

Thysanoptera

Three genera (*Bregmatothrips, Plesiothrips* and *Rhamphothrips*) and three species (*Bregmatothrips ramani*, *Plesiothrips perplexus* and *Rhamphothrips pardus*) were added to NBAIR reference collection.

Hemiptera

A total of 402 slides of mealybugs, scales and aphids were prepared by following standard procedures and by processing 1,788 specimens. Aphid species, viz. *Aphis glycines* and *Panaphis juglandis*; scale species, viz. *Metaceronema japonica*, *Parthenolecanium corni*, *Eulecanium tiliae*, *Coccus latioperculatum*, *Megapulvinaria burkilli* were added as new to the existing collection of NBAIR.

Nearly 726 specimens belonging to 49 species of Pentatomidae were added to the collection. Several specimens belonging to various families such as Coreidae, Dinidoridae, Fulgoridae, Largiidae, Plataspidae, Pyrrhocoridae, Reduviidae, Scutelleridae and Tessaratomidae were also added to the insect collection. *Madates limbata* (Pentatomidae: Strachiini) was also added to NBAIR collection.

Araneae

Thirteen families, 45 genera and 94 species of spiders like *Argiope pulchella, Argiope aemula, Cyclosa bifida* (Fig. 23), *Oxyopes shweta, Oxyopes birmanicus* (Fig. 24), *Telamonia dimidiata* (Fig. 25), *Hippasa agelenoides* (Fig. 26) from different agro-ecosystems were added to the NBAIR Araneae collection.

Fig. 23. *Cyclosa bifida*

Fig. 24. *Oxyopes birmanicus*

Fig. 25. *Telamonia dimidiata*

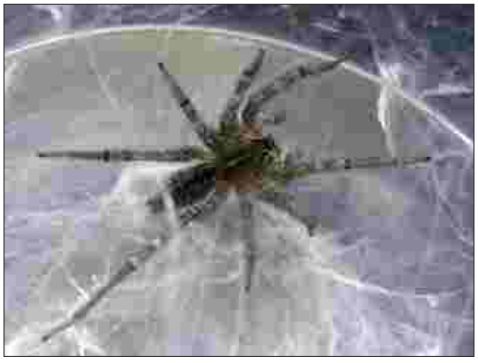


Fig. 26. *Hippasa agelenoides*

Acari

Over 100 specimens of Blattisociidae (Mesostigmata) were mounted and preserved. Three new predatory stigmaeids, including the one close to *Agistemus edulis*, and a phytoseiid, *Phytoseius roseus*, collected from fig leaves in Himachal Pradesh were added to the collection.

Development of diagnostic keys/tools/website

Hymenoptera

A new web portal, 'Bee fauna of India' which contains factsheets of 34 species of genus *Xylocopa*, was uploaded on NBAIR website (Fig. 27).

Fig. 27. Bee fauna of India

Catalogue of Indian Sphecidae was prepared by abstracting the available literature and web resources.

Coleoptera

A checklist of longhorn beetles (Coleoptera: Cerambycidae) within the present geographical frontier of India was prepared along with a distribution record from different states of India and the subcontinent. As per the current checklist prepared, there are 1,558 species, classified under 72 tribes, 447 genera and nine subfamilies of Cerambycidae as well as Vesperidae and Disteniidae were reported. Among all the Indian longhorn beetles tribes, Pteropliini, Lamiini Latreille, Clytini and Saperdini have the maximum species abundance of 184, 170, 166 and 143, respectively.

The number of species recorded under each subfamilies from India are: Lamiinae: 1,108 species, Cerambycinae: 349 species, Prioninae: 57 species, Lepturinae: 20 species, Disteniidae: 9 species, Spondylidinae: 6 species, Dorcasominae: 4 species, Necydalinae: 3 species and Vesperidae: 3 species. The subfamily wise distribution of genera in India is: Lamiinae (275); Cerambycinae (109); Prioninae (29); Lepturinae (18); Disteniinae (Disteniidae) (6); Spondylidinae (4); Dorcasominae (3); Philinae (Vesperidae) (2) and Necydalinae (1). The subfamilies Necydalinae, Philinae (Vesperidae) are the smallest, while the Lamiinae is the largest sub-family in terms of number of species. The subfamily Lamiinae is accounted for 70.8% of all known species of longhorns from India followed by Cerambycinae (22.5%) and Prioninae (3.9%). Other subfamilies are together represented by 2.8%. Out of 1551 Indian longhorn species, the region wise distribution are: 592 from north eastern states, 272 from north India, 431 from south India, 47 from central India, 48 from west India, 348 from east India, 18 from north west India, 57 from India orientalis and 121 from Indian islands. The maximum

numbers of species were recorded from north east India (38.1%).

Hemiptera

A website was developed on 'Common soft scales of India'. This website has detailed information about classification and morphology of soft scales. Checklist was furnished with references on 70 soft scales which have been recorded from India. It has factsheet on 32 species of soft scale insects which are commonly found in India and most of them are economically important. There is description of these characters along with high resolution microphotographs of live as well as mounted scale insect. There are in all 760 photographs.

Diptera and Thysanoptera

Keys to 12 subgenera of tribe Dacini and 37 species of *Bactrocera* (*Bactrocera*) were published.

A diagnostic key was developed to distinguish thrips species, *Bregmatothrips ramani*, *B. willcocksi* and *B. furcatus*.

Parasitisation efficiency of trichogrammitids and other parasitic wasps:

The parasitizing efficiency of trichogrammatids was tested against the *Tuta absoluta* infesting tomato. The highest per cent parasitism was recorded by *Trichogramma achaeae* followed by *Trichogrammatoidea bactrae* under laboratory conditions. In cage studies, *T. achaeae* showed 55.1% parasitism to the eggs *T. absoluta* than other species of trichogrammatids. Among the screened exotic species of trichogrammatids, *T. evanescens* (arrhenotokous, France) could parasitise 55% eggs of *T. absoluta*.

In laboratory condition, *Trichogrammatoidea bactrae* and *Trichogramma chilonis* were evaluated against the pink bollworm *Pectinophora gossypiella*. The per cent egg parasitism and adult emergence by *T. bactrae* was 56.5% and 79.7% and while in *T. chilonis* it was 61.3% and 66.5%.

Two species of parasitic wasps were identified for the new invasive rugose spiralling whitefly (*Aleurodicus rugioperculatus*), viz. *Encarsia guadeloupae* and *E. dispersa*, which was found infesting coconut, banana and several ornamental plants in Tamil, Nadu, Andhra Pradesh and Kerala. During the survey, several natural enemies were also recorded and maximum parasitism was recorded with *E. guadeloupae*.

The parasitisation by *Cotesia ruficrus,* on rice green semilooper, *Naranga aenescens* varied from 3.20 to 5.45 larvae per hill with the peak in the first fortnight of August 2015. Percent parasitism of the larvae was as high as 94% recorded in the first fortnight of August with 77.5% as the mean.

Scanning electron microscopy studies

Egg morphology and chorion ultrastructures of five species of *Anomala*, viz. *Anomala dorsalis* (Fig. 28), *A. varicolor* (Fig. 29), *A. ruficapilla* (Fig. 30) and *A. varivestis* (Fig. 31), were studied through scanning electron microscopy and documented species-delineating characters.

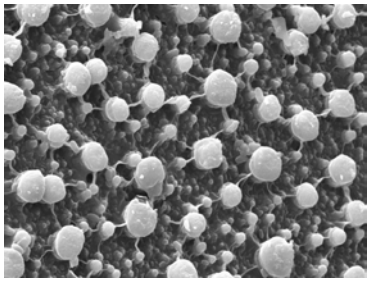


Fig. 28. *Anomala dorsalis*

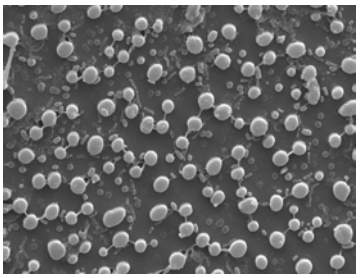


Fig. 29. *Anomala varicolor*

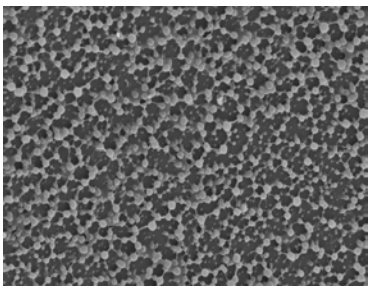


Fig. 30. *Anomala ruficapilla*

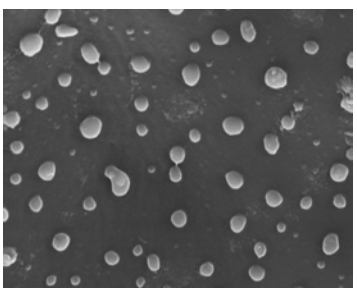


Fig. 31. *Anomala varivestis*

Antennal sensillae (Fig. 32) in lamellar segments (Fig. 33) of three species of *Holotrichia*, viz. *H. serrata, H. nagpurensis* and *H. consanguinea* (Scarabaeidae: Melolonthinae) were studied through scanning electron microscopy to confirm the consistency in their diversity, distribution and density with respect to mechano receptors and chemoreceptors documented in previous year.

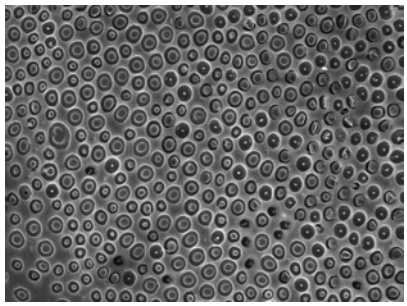


Fig. 32. Antennal sensillae

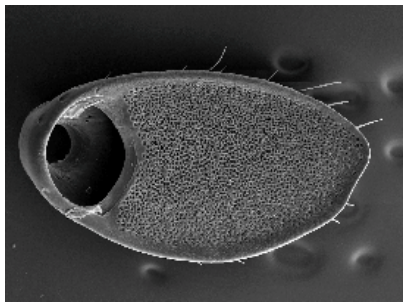


Fig. 33. Lamellar segment

Division of Genomic Resources

Molecular characterisation and DNA barcoding of agriculturally important insects

Pest insects

During the period, more than 500 insect specimens belonging to different groups were collected from all over the country. Molecular characterisation of 62 species belonging to 5 insect orders and an acarine species was done. These insects belonged to Coleoptera (8 species), Diptera (6 species), Hemiptera (23 species), Lepidoptera (14 species) and Hymenoptera (10 species/populations). Three hundred barcodes were obtained during the period.

Leucinodes orbonalis

De novo whole genome sequencing of *Leucinodes orbonalis* was completed through Illumina paired end and mate pair libraries by Pac-Bio RSII system and P6C4 chemistry. Final genome size of *L. orbonalis* upon hybrid assembly was found to be 826MB with an N50 value of 108KB. Genome was submitted to the NCBI-GenBank under accession number PQWD00000000, as the first draft insect genome from India.

Whiteflies

The invasive pest, rugose spiralling whitefly, *Aleurodicus rugioperculatus*, collected from Karnataka on banana crop was identified using COI gene. Molecular characterisation of the invasive pest RSW, *A. rugioperculatus* collected on coconut from Karnataka was done using COI gene. *Aleurodicus dispersus* and *Aleurotrachelus trachoides* were also identified using COI gene.

The level of incidence, genetic groups and natural enemy complex of *Bemisia tabaci* were monitored by taking up intensive surveys in cotton growing areas in Haryana, Rajasthan, Punjab, Tamil Nadu, Karnataka and Andhra Pradesh. All the collected samples were subjected to sequence analyses using mitochondrial cyctochrome oxidase I which confirmed the presence of two putative species, Asia I and Asia II. This whitefly is believed to have survived in vegetable especially brinjal which is cultivated throughout the year. Similarly, parasitoids such as *Eretmocerus* sp. on *B. tabaci* and *B. breyniae* and *Encarsia guadeloupae* and *E. dispersa* on *A. rugioperculatus* were also recorded.

Brown planthopper

Different populations of the brown planthopper, *Nilaparvata lugens*, were collected on paddy from Jabalpur, Satna, Panna, Sidhi and Balaghat in the state of Madhya Pradesh and were characterised using COI gene.

Thrips

Methodology for the isolation of genomic DNA from single thrips has been standardised by non-invasive method. DNA barcoding using partial gene amplification of COI gene has been done for six species of thrips viz. *Microcephalothrips abdominalis*, *Scirtothrips dorsalis*, *Thrips florum*, *T. orientalis*, *Haplothrips* sp. and *Thrips* sp. The sequences were submitted to GenBank database and accession numbers were obtained.

Subterranean insect pests

A total of 62 scarabaeid beetles were collected from eight states (Andhra Pradesh, Arunachal Pradesh, Karnataka, Kerala, Meghalaya, Odisha, Tamil Nadu and Uttar Pradesh). Termite collections were made from the states of Andhra Pradesh, Bihar, Kerala, Karnataka, Meghalaya, Mizoram and Odisha which amounted to a total of 69 termite populations. A total of 46 collembolans were collected from marshy places, soil

litter and decaying organic matter from states of Andhra Pradesh, Bihar, Karnataka, Tamil Nadu and Uttar Pradesh.

Scarabaeids and termites were characterised based on the COI gene whereas the collembolans were characterised based on the ITS2 region. The GenBank accession numbers were obtained for all the subterranean pests obtained from various locations. Barcodes and the Barcode Index Numbers (BINs) were obtained for all the species with GenBank accession numbers by submitting the sequences of identified species to BOLD systems V3. Maximum-likelihood method based on the Tamura-Nei model was used to construct the phylogenetic tree. The genetic relatedness between the isolates was analyzed. Constructed phylogenetic tree was visualised using tree viewer program. The gamma distribution shape parameters and substitution rates were used in phylogenetic analysis.

Museum specimens of termites dating back to 2010-2013 which were obtained from Department of Entomology, University of Agricultural Sciences, Bengaluru and Institute of Wood Science and Technology, Bengaluru, were characterised and identified through modified procedure of DNA isolation.

Parasitoids and predators

Molecular characterisation was carried out and DNA barcodes were generated for 90 agriculturally important parasitoids, predators and other insects based on COI gene and ITS-2. *Parapanteles* spp. collected from different places in the country were characterised using COI gene and GenBank accession numbers were obtained for the same. Nine populations of chrysopids collected from different states were identified as *Chrysoperla zastrowi sillemi* using COI gene and ITS-2 region. *Trichogramma* sp. collected on tomato crop from Coimbatore, Tamil Nadu is identified as *Trichogramma chilonis* using COI gene. Molecular characterisation of a braconid collected from Coimbatore was done using COI gene and it was identified as *Habrobracon hebetor*. Molecular characterisation of *Megachile anthracina* collected from Bengaluru was done using COI gene and a syrphid from Mandya has been identified as *Paragus serratus* based on COI gene. Molecular characterisation of sphecid wasps was completed and DNA barcodes were developed for the species level identification.

Monitoring of resistance in cotton pink bollworm, *Pectinophora gossypiella*

Surveys were carried out in four states viz. Gujarat, Maharashtra, Telangana and Tamil Nadu for the collection of pink bollworm, *Pectinophora gossypiella*. Pink bollworm damage assessment was done in all the districts surveyed in terms of locule damage, number of larvae/boll and number of exit holes/boll. The data was transformed accordingly and the statistical analysis was done using SAS software. The incidence in terms of % locule damage ranged between 44% and 64%. But there was no significant difference in the % locule damage between the districts surveyed. Amod, Bharuch (Gujarat) and Rahuri, Ahmednagar (Maharashtra) recorded the highest incidence in terms of number of larvae/boll, while Jolarpet, Vellore recorded the least. The incidence in terms of number of exit holes/boll ranged between 1.11 and 1.83. But there was no significant difference in the number of exit holes/boll between the districts surveyed. Bioassay was done with two *Bt* toxins, Cry1Ac and Cry2Ab in population collected from Jolarpet, Vellore, Tamil Nadu. The LC_{50} values were calculated and then compared with that of the laboratory susceptible population. It was observed that the resistance ratio for Cry1Ac was 6.19 and that for Cry2Ab was 1.96.

Bacillus thuringiensis formulations and their insecticidal activity

The *Bacillus thuringiensis* strain NBAIR-BTAN4 was characterised as a novel isolate capable of expressing crystal proteins toxic to both lepidopteran and coleopteran pests. Sequence studies showed that it expresses Cry1Ac, Cry2Ab, Cry1Ia and Cry2Aa toxins. It was also found to be expressing 20 other toxin proteins (Table 1). It was already characterised as toxic to coleopteran pests and during the period, it was evaluated against lepidopteran pests namely *Helicoverpa armigera* and *Plutella xylostella* and the LC_{50} values were calculated as 414 and 545 ng/ml, respectively. It was also tested against *Holotrichia serrata* and 50% mortality was observed in 15 days. It is developed as a technology for controlling both the group of pests.

As a part of the objective for developing efficient fermentation medium and formulations of *Bacillus thuringiensis*, a strategy was developed to test the use of molasses as carbon supplement in growth medium. Four different mediums were tested. Cell growth parameters showed that Medium-2 supported maximum cell growth of NBAIR-BTAN4 and HD-1 within 120h which showed log numbers of 11.04 and 10.7 (cfu/ml) respectively. However, when protein parameter was taken into account, maximum protein content of 13.6 mg/ml was obtained with Medium-3 for NBAIR-BTG4

Table 1. Insecticidal crystal genes identified in NBAIR-BTAN4		
1	Insecticidal crystal protein	CDS ID
2	Cry2Ab	AHMLFPGL_04725
3	Cry1Ac	AHMLFPGL_04730
4	Cry1Ia	AHMLFPGL_04731
5	Cry2Aa	AHMLFPGL_04738
Other toxins		
6	Death on curing protein Doc toxin	AHMLFPGL_06333
7	Lmo0066 homolog within ESAT-6 gene cluster similarity to ADP-ribosylating toxins	AHMLFPGL_06433
8	Non-hemolytic enterotoxin A	AHMLFPGL_02331
9	Non-hemolytic enterotoxin lytic component L1	AHMLFPGL_02332
10	Enterotoxin C	AHMLFPGL_02333
11	Holin toxin secretion/phage lysis	AHMLFPGL_02761
12	Toxic anion resistance protein TelA	AHMLFPGL_02849
13	Holin toxin secretion/phage lysis	AHMLFPGL_06548
14	Enterotoxin/cell-wall binding protein	AHMLFPGL_00021
15	Enterotoxin/cell-wall binding protein	AHMLFPGL_03700
16	Holin toxin secretion/phage lysis	AHMLFPGL_03846
17	Trifolitoxin immunity domain protein	AHMLFPGL_00639
18	Cytotoxin K	AHMLFPGL_00661
19	Enterotoxin/cell-wall binding protein	AHMLFPGL_04941
20	Putative toxin component near putative ESAT-related proteins repetitive	AHMLFPGL_01044
21	Zeta toxin	AHMLFPGL_05166
22	Mosquitocidal toxin protein	AHMLFPGL_05478
23	Programmed cell death toxin YdcE	AHMLFPGL_05630

followed by BTAN4 (12.4 mg/ml). Protein released was higher in Medium-3. Hence, Medium-3 has been chosen as the optimal medium for *Bt* fermentation and for further technology development.

Microflora associated with insects and their role in farm waste management

Detritivorous insects, black soldier fly (BSF), *Hermetia illucens* and scarab beetle, *Protaetia* sp., were collected and identified using molecular tools like mitochondrial gene cytochrome oxidase I (COI) gene and obtained GenBank accession numbers as MG682545 and MG733996 for *Hermetia illucens* and MH045571 for *Protaetia aurichalcea*. A total of 15 bacteria were isolated from the BSF larvae, identified using 16S rDNA sequencing and obtained GenBank accession numbers as Mg711836 to MG711849. Majority of microbial microflora from BSF larvae belonged to *Bacillus* sp.

Interactive mobile apps on non-chemical methods for insect pest management

A mobile application was created which includes information about the management of coconut pests using non-chemical methods. It contains the details about the coconut pests like 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, rat) and their biological control measures. This mobile app will help

the farmers to apply biological control measures and will also aid in their skill development in adopting non-chemical methods for the control of coconut pests. This can be a ready reckoner tool with photographs and videos about coconut pests and their natural enemies.

Molecular identification and mitochondrial genome sequencing of entomopathogenic nematodes (EPNs)

Six mitochondrial genomes of EPN were sequenced and deposited with NCBI (Table 2).

Table 2. GenBank/BOLD accessions and other details for mit DNA genomes of EPN species

Accession Number	Submission
MG875343	Complete sequence of mitochondrial genome of *Steinernema carpocapsae* NBAII Sc05 from India. Mandadi, N., Hendrickson, C. A., Handanahal, S. S., Dhingra, A., Patil, J., Jalali, S. K., Deshpande, U., Shrivastav, A. K. and Chilukoti, R.
MG970364	Complete mitochondrial genome sequence of *Steinernema abbasi* NBAII Sa04 from India. Mandadi, N., Hendrickson, C. A., Handanahal, S. S., Dhingra, A., Jalali, S. K., Deshpande, U. and Shrivastav, A.K.
BankIt2096502	Mitochondrial DNA genome sequence of *Steinernema carpocapsae* NBAII112 from India. Mandadi, N., Patil, J., Jalali, S. K., Deshpande, U. and Shrivastav, A. K.
MH104864	Mitochondrial DNA genome sequence of *Heterorhabditis bacteriophora* NBAII from India. Mandadi, N., Handanahal, S. S. and Deshpande, U.
MH119604	Mitochondrial DNA genome sequence of *Heterorhabditis bacteriophora* from India. Mandadi, N., Hendrickson, C. A., Handanahal, S. S., Pai, R. N., Deshpande, U. and Shrivastav, A. K.
MH119603	Mitochondrial DNA genome sequence of *Heterorhabditis indica* NBAII from India. Mandadi, N., Hussaini, S. S., Pai, R. N., Handanahal, S. S., Hendrickson, C. A., Dhingra, A. and Deshpande, U.

	H. indica	*H. bacteriophora*	*S. carpocapsae*	*Heterorhabditis* sp.
Length (bp)	15,633	13,925	13,624	13,918
Genes not found	atp8, trnG, trnk	atp8, trnK	-	atp8, trnK
Split/duplicate genes	atp6, NAD5, TRNn, rrnS	Nad4, trnN	-	Nad4l, trnN
Hi gene order list	atp6-1 trnPtrnV nad6 nad4l trnWtrnErrnS trnS2 -rrnStrnNtrnY nad1 atp6-0 trnN trnL2 trnS1 nad2 trnItrnRtrnQtrnF cob trnL1 cox3 trnT nad4 trnD nad5-0 nad5-1 cox1 trnMtrnC cox2 trnHrrnL nad3 trnA.			
SC gene order list	nad6 trnN nad4l trnWtrnErrnS trnS2 trnY nad1 atp6 trnN trnL2 trnS1 nad2 trnItrnRtrnQtrnF cob trnL1 cox3 trnT nad4 cox1 trnCtrnMtrnDtrnG cox2 trnHrrnL nad3 nad5 trnA.			
H. bacteriophora	trnPtrnV nad6 trnN nad4l trnWtrnErrnS trnS2 trnY nad1 atp6 trnN trnL2 trnS1 nad2 trnItrnRtrnQtrnF cob trnL1 cox3 trnT nad4-0 cox1 trnCtrnMtrnDtrnG cox2 trnH nad4-1 rrnL nad3 nad5 trnA.			
Heterorhabditis sp.	trnPtrnV nad6 trnN nad4l-0 trnWtrnErrnS trnS2 trnY nad1 atp6-0 trnN trnL2 trnS1 nad2 trnItrnRtrnQtrnF cob trnL1cox3 trnT nad4 cox1 trnCtrnMtrnDtrnG cox2 trnHrrnL nad3 nad5 nad4l-1 trnA.			

Division of Germplasm Conservation and Utilisation

Studies on gall-forming insects and their natural enemies

During the studies on the gall insects and their management, galls of *Syzygium cumini* had been identified as *Fergusonina syzygii* (Fegusoninidae). Stem galls of bitter gourd and little gourd were identified. Stem gall fly of little gourd was found to be parasitised by *Inostemma indicum* was redescribed and reported to be a major parasitoid of the gall fly. Teak velvet gall fly was collected and adults were sent for identification. Pongamia galls were collected and reared to adults and sent for identification. The emergence of gall fly coincided with flowering of the pongamia. Removal of galls of pongamia just after formation reduced incidence in trees by about 80%. Seven natural extracts of essential oils were tested as attractants for little gourd gall fly and none were found to be attractive to the fly. Azadirachtin and chlorpyriphos and Betacyfluthrin were found to be very effective in management of little gourd fly in farmers fields. *Syzygium* galls were found to be fed by hairy caterpillars and a weevil reducing the galls in the field. Bitter gourd stem galls were found to harbour more than 20 gall fly per gall and was very severe during the new flush period. Several natural extracts of essential oils were tested as attractant for bitter gourd gall fly but none were found to attract them.

Five trips were made to Dakshina Kannada, Udupi and Uttara Kannada districts and two trips in Ramanagara, Mandya, Mysuru districts in Karnataka for survey on incidence and infestation of rugose spiralling whitefly *Aleurodicus rugioperculatus* on coconut and other host plants during 2017-18. Surveys were carried out in Mangaluru, Udupi, Brahmavar, Kundapura, Hemmadi, Marvanthe, Byndoor, Shiroor, Bhatkal, Malavalli, Ramanagara, Channapatna, Madduru, KM Doddi, Lakshmipura, Bannur, Mysuru, Srirangapatna and Mandya. Incidence and infestation of rugose spiralling whitefly on coconut, banana, mango, Indian almond, cashew and many other ornamental plants was recorded to the extent of 20-80% on different host plants. Maximum incidence on coconut, banana, sapota, Indian almond and low to moderate on mango, cashew and few ornamental plants. The pest was found spreading at greater extent along the coastal belts and highways towards Goa.

Diversity and predator–prey interactions in predatory mirids and geocorids

All the immature stages of *Geocoris ochropterus* except first and second instars and adult exhibited a type II functional response to different densities of *Helicoverpa armigera* eggs. In choice experiments, both 5th instar nymph and adult of predator consumed 5.47 and 8.95% of *Trichogramma chilonis*-parasitised *Helicoverpa armigera* eggs compared to 69.04 and 88.57% unparasitised eggs, respectively. A similar trend was observed in no-choice experiments.

Termatophylum orientale (Heteroptera: Miridae: Deraeocorinae) was reported for the first time from India (Fig. 34). For the first time, rearing protocols and biology were studied for this mirid.

Fig. 34. Different life stages of *Termatophylum orientale*

Field evaluation of parasitoids against paddy

Six releases of *T. japonicum* resulted in 3.14 and 1.85% damage by stem borer in paddy compared with 10.84 and 16.00% damage in farmers' practice field at 45 and 65 DAT, respectively in Kotabagh, Uttarakhand (Fig. 35).

Fig. 35. Experimental plots in Kotabagh

Field evaluation of parasitoids against brinjal

Twelve releases of *Trichogramma chilonis* (HQS) @ 1,00,000/ release were made against fruit and shoot borer. The percent fruit damage (F= 112.29; df =1,119, P<0.0001) and shoot damage (F= 103.73; df= 1,119, P<0.0001) was significantly lower in the biocontrol field in comparison to farmer practices.

Effect of pollinator friendly crop plants in enhancing pollination and yield in selected crops

The role of native bees in pollination and yield of field bean was studied under field condition (Fig . 36). Major bees visited and pollinated the flowers of field bean (Fig 37) included *Xylocopa pubescens*, *X. fenestrata*, *Amegilla zonata*, *Hoplonomia westwoodi*, *Ceratina binghami* (Table 3). The mean number of pods set per plant was found to be higher in the bee pollinated plant (7.71 pods/ inflorescence) compared to wind pollinated flowers (5.33). Significant increase in pod weight was recorded in the bee pollinated flowers (73.20 g/20pods) compared to pods set from wind pollination (60.1 g/20 pods) (Table 4).

Fig. 36. Field beans experimental plot

Fig. 37. Different species of bees visiting field bean flowers

Table 4. Pollinator exclusion studies in field bean

Pollination in field bean	No of pods set/ inflorescence	Pod weight (20 pods) (g)
Bee pollination	7.71[a]	73.20[a]
Wind pollination (open)	5.33[b]	60.09[b]
CD (0.05%)	1.64	7.11
CV (%)	39.15	5.97

Studies on nesting biology of *Hoplonomia westwoodi*

Nesting biology of a potential buzz pollinating native bee, *H. westwoodi* (Halictidae: Nomiinae) (Fig. 38) was studied to conserve them using artificial soil trap nests. The bee constructed subterranean nests on a levelled soil surface with turrets and main shaft running to a depth of 70.1 cm (Fig. 39). The life cycle of the bee was completed in 41.80 days.

Influence of native bee *Amegilla violacea* on pollination and fruit set of brinjal

Native bee, *A. violacea* (Apidae: Anthophorinae) enhanced the pollination, fruit set and weight of brinjal under field conditions. The percent fruit set and mean

Table 3. Diversity of flower visitors in field bean

Species	Shannon index H'	Simpson index	Margalef's richness index D_{mg}	Evenness J'	Berger-Parker dominance
Megachile disjuncta	2.45	0.91	2.65	0.97	0.13
Apis dorsata	2.25	0.88	3.32	0.94	0.13
A. florea	2.24	0.87	3.50	0.79	0.15
Amegilla zonata	2.44	0.91	4.17	0.96	0.14
Xylocopa pubescens	2.39	0.89	4.06	0.92	0.20
Megachile lanata	2.32	0.85	2.82	0.85	0.24
Ceratina hieroglyphica	2.37	0.89	3.81	0.89	0.17
C. binghami	2.17	0.90	4.02	0.97	0.18

fruit weight was found to be the highest in the bee pollinated flowers (76.02%; 63.54g/fruit) compared to wind pollination (31.99%; 35.57g/fruit).

Fig. 38. Pollen-laden *Hoplonomia westwoodi* near nest entrance

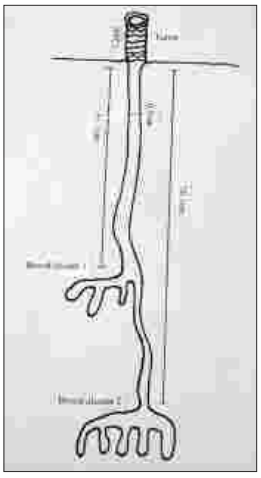


Fig. 39. Nest architecture of *H. westwoodi*

Studies on exploitation of insects as food and feed

An experiment was conducted to evaluate the effect of black soldier fly (BSF), *Hermetia illucens* over the growth performance of Tilapia (*Oreochromis niloticus*) (Fig. 40). Four treatments, viz. BSF prepupae, BSF prepupae (50%) + formulated BSF (50%), formulated BSF (Fig . 41) and fish meal (control) were used. The fishes readily accepted all the diets without any palatability issues. Fishes fed with BSF Prepupae recorded the highest food conversion ratio compared to control diet. Specific growth rate of the fishes fed with control diet (2.42±0.007) was statistically on par with the formulated BSF diet (2.39±0.009). Percentage weight gain was significantly the highest in fishes fed with control diet which was statistically on par with formulated BSF diet.

Fig. 40. Tilapia fishes feeding on BSF diet

Fig. 41. Formulated BSF feed

Chemical characterisation and ethology of economically important dipteran pests of veterinary and fisheries

Plant derived products for housefly management

Emulsions of essential oil (ajowan oil and thymol) prepared were thermodynamically stable and did not have phase separation and turbidity. They were characterised for free thaw test and droplet size and polydispersity index after 60 days of storage. The destabilisation (flocculation/Ostwald's ripening) of the droplets was significantly inhibited by the steric repulsion attributing to narrow size distribution of the droplets.

Transmission electron microscopy revealed that in the emulsion of ajowan–Tween 80 (1:1) the droplets exhibited size range between 20 nm to 50 nm on day one. There was a gradual increase in the droplet size that led to steady destabilisation of droplets through flocculation.

Among the combinations, emulsion of plant derived products comprising ajowan and thymol had significantly higher level of repellence of flies (12 – 25) whilst in control over 178 flies were obtained per trap. The efficacy of plant derived emulsions needed reapplication at 15 days interval.

Microbial bioagent for *Aedes aegypti*

A bacteria causing mortality to larvae of *Aedes aegypti* was isolated and characterised based on 16SrRNA and was identified as *Bacillus thurungiensis* var. *israeliensis* (VLC1) (Fig. 42). The Cry protein was isolated and the

total soluble protein is 13.88 µg/ml. The *Bt* strain VLC 1 caused 100 % mortality in 1 ppm of TSP as compared to VCRC strain that caused 40 % mortality at 2,500 ppm.

Fig. 42. *Bacillus thuringiensis* var. *israeliensis* VLC1

Pupal parasitoids of housefly

The process of mass rearing of housefly parasitoids, *Nasonia vitripennis* (Fig. 43) and *Spalangia* sp. was standardised (Fig. 44).

Fig. 43. *Nasonia vitripennis* parasitised pupae with exit hole

Fig. 44. *Spalangia* sp. parasitoid

Nanosensors for detection of entomopathogenic viruses

Probes for rapid detection of three biopesticides, namely, *Helicoverpa armigera* nucleopolyhedrosis virus, *Spodoptera litura* nucleopolyhedrosis virus and *Spilosoma obliqua* nucleopolyhedrosis virus were devised. The probe included a process of obtaining a bromide precursor in acetonitrile at a predefined temperature to obtain a piperazine derivative. Subsequent to obtaining the piperazine derivative, the piperazine reacted to obtain an intermediate aldehyde derivative. The aldehyde derivative was further refluxed to obtain a carbazole derivative. Further, the invention provides a method for obtaining a probe for rapid detection for biopesticides containing NPV. The invention also provides a device comprising a probe, a detection means and an analyzer for rapid detection of biopesticides containing NPV.

A 'cost-free' estimation of oxalate contents in different tropical leaves via simple 'catch-free' strategy was developed. Estimation of oxalate in human urine is particularly attractive as elevated oxalate level in urine is the indicative of renal failure, kidney stone formation and pancreatic insufficiency. Identification of high oxalate content in food items is also essential for preparation of ideal diet chart for patients having hyperoxaluria. A rhodamine-based in-situ formed metal complex has been utilised for 'naked-eye' detection of an antinutrient (oxalate) at the nanomolar concentration (~12.5 nM) in water (pH 7.4). Mechanistic investigations indicated that oxalate can turn the pink-colored solution colorless by dissociating the preformed metal (Cu^{2+}) complex. With these results, quantitative estimations of endogenous oxalate were achieved in more than twenty-five different agricultural crops. Finally, low-cost, portable paper strips were developed for rapid, on-site estimation of oxalate.

A urea sensor with hydrogen bonding facilitated quenching of molecular emission. A supramolecular host for urea sensor was developed which will help for the management of urea in various samples. Presently samples tested with the said urea sensor were milk, soil, fodder, human blood serum and human urine samples.

A pheromone detector for early detection of pheromones, which could detect pheromone mass as low as 5 femtograms was invented and successfully patented. This technology was further refined with synthesis of nanomaterials. Surface functionalisation for sensing of volatile organic compounds: a method for surface functionalisation of semiochemicals which was first reported by our group was utilised in other materials to increase sensitivity. In one new materials (Patent pending) to our surprise we found that detection limit increase from femtogram to attogram.

Characterisation of viruses with special reference to Lepidoptera and Coleoptera

Nucleopolyhedroviruses (NPVs) were isolated from diseased larva of *Mythimna separata* (rice armyworm) and *Euproctis chrysorrhoea* (apple brown tail moth) (Fig. 45). Granuloviruses (GVs) were isolated from diseased larvae of *Chilo infuscatellus* (early shoot borer) and *Chilo sacchariphagus indicus* (internode borer) (Fig. 46). The LC_{50} values observed for second instar larvae were 6.17 POBs/mm^2 and fourth instar larva were 11.62 POBs/mm^2 for *Euproctis chrysorrhoea* NPV (EuchNPV). Scanning electron micrographs of EuchNPV (Fig. 47) revealed the crystalline structures of variable shapes of occlusion bodies (OBs) with the size of 1.016 to1.596µm. Most of the OBs of EuchNPV were tetrahedral in shape and few OBs were in hexagonal in shape. TEM of the OBs revealed the tetrahedral shape. *Mythimna separata* NPV (Fig. 48) appeared in tetrahedral shape with size of 1.499 µm to 1.700 µm. Granulosis viruses of sugarcane internode and early shoot borers were granular in shape with the size of 259 × 249 nm. Ninety six percent reduction in Bihar hairy caterpillar larvae was observed when *Spilosoma obliqua* NPV was sprayed @ 1 × 10^7 POB/ml over jute plants as compared to Profenophos where 98 per cent reduction was recorded. Spraying of Hear NPV strains of both NBAIR and UASR strain @ 2 ml/l were found effective in reducing the chick pea pod borer larvae and increasing the yield. Minimum per cent damage of 10.62 per cent was noticed in the plot sprayed with HearNPV NBAIR and it was at par with Hear NPV UASR which recorded 11.38 per cent pod damage.

Fig. 45. Diseased larvae of *Euproctis chrysorrhoea*

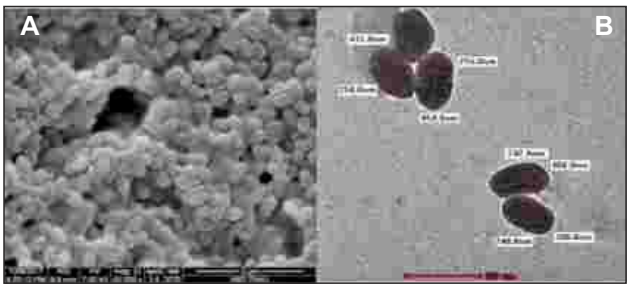


Fig. 46. Scanning (A) and transmission (B) electron micrographs of granular OBs GV extracted from the diseased larvae of sugarcane internode borer

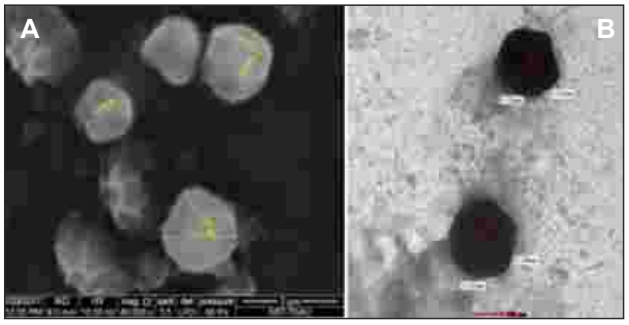


Fig. 47. Scanning (A) and transmission (B) electron micrographs of polyhedral OBs extracted from NPV infected larvae of *Euproctis chrysorrhoea*

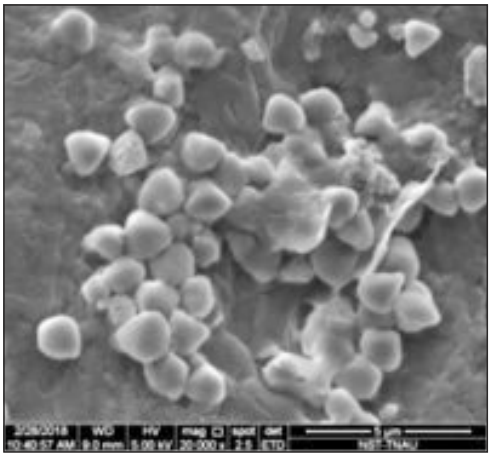


Fig. 48. Scanning electron micrograph of polyhedral OBs of NPV extracted from diseased larvae of *Mythimna separata*

Endophytic establishment of *Beauveria bassiana* and *Metarhizium anisopliae* in cabbage for management of diamond back moth

Screening of *B. bassiana* and *M. anisopliae* isolates against *Plutella xylostella* (laboratory bioassay)

Among the 20 isolates each of *B. bassiana* and *M. anisopliae* tested at 1x10^{7}spores/ml against second instar larvae of *P. xylostella*, ICAR-NBAIR-Bb-5a, Ma-4 and

Ma-35 showed significantly higher mortality (77.4, 81.4 and 88.9%, respectively) (Table 5).

Table 5. Effect of *B. bassiana* and *M. anisopliae* isolates on the larvae of *P. xylostella* in the laboratory bioassay

Isolate	Mortality (%)	Isolate	Mortality (%)
Bb-5a	77.36[a]	Ma-4	81.44[a]
Bb-10	36.07[b]	Ma-7	44.52[c]
Bb-17	43.56[b]	Ma-8	70.33[b]
Bb-18	36.07[b]	Ma-10	51.77[c]
Bb-21	39.90[b]	Ma-19	55.72[b]
Bb-22	39.82[b]	Ma-35	88.85[a]
Bb-24	43.56[b]	Ma-39	44.48[c]
Bb-26	39.82[b]	Ma-43	36.95[c]
Bb-27	32.37[b]	Ma-44	59.21[b]
Bb-28	17.31[c]	Ma-45	48.19[c]
Bb-29	43.56[b]	Ma-46	37.07[c]
Bb-30	47.35[b]	Ma-47	51.85[c]
Bb-40	32.33[b]	Ma-48	55.55[b]
Bb-43	25.47[c]	Ma-49	62.92[b]
Bb-45	51.14[b]	Ma-51	55.63[b]
Bb-51	39.78[b]	Ma-53	48.19[c]
Bb-55	47.35[b]	Ma-54	55.51[b]
Bb-57	51.10[b]	Ma-55	55.51[b]
Bb-60	47.44[b]	Ma-56a	40.86[c]
Bb-74	28.50[b]	Ma-57	55.51[b]
Control	11.33[c]	Control	10.00[d]

*Values in columns followed by a different letter are significantly different with each other according to LSD ($P < 0.01$).

Endophytic ability of *B. bassiana* and *M. anisopliae* isolates in leaf tissues of cabbage

A glasshouse experiment was conducted to study the endophytic ability of *B. bassiana* (Bb-5a & Bb-45) and *M. anisopliae* (Ma-4 & Ma-35)in cabbage leaves. Foliar application and seedling dip methods with oil formulations at the rate of $1x10^8$ spores/ml were tested on 30 days old seedlings. Confirmation of endophytic establishment was done using plating technique and PCR method 15, 30, 45 and 60 days after treatment (DAT).

Foliar application method: In old leaves, all four isolates showed colonisation upto 30 DAT. In young leaves, all four isolates showed colonisation during 30-60 DAT (Table 6 & Fig. 49). The results observed in plating technique and PCR studies (Fig. 50) were similar with regard to colonisation and persistence in cabbage leaves.

Table 6. Colonisation of *B. bassiana* and *M. anisopliae* in old and young leaf tissues

Isolate	Old leaf				Young leaf			
	Days after treatment				Days after treatment			
	15	30	45	60	15	30	45	60
Bb5a	-	+	-	-	-	-	+	-
Bb45	+	-	-	-	-	-	+	-
Ma4	+	+	-	-	-	+	+	+
Ma35	+	+	-	-	-	+	-	-
control	-	-	-	-	-	-	-	-

+ indicates colonisation; - indicates non-colonisation

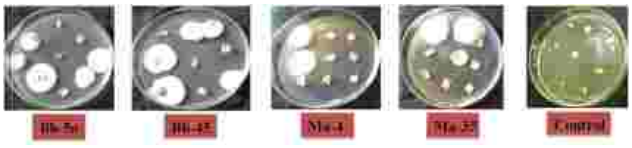


Fig. 49. Growth of *B. bassiana* and *M. anisopliae* from the treated leaf bits

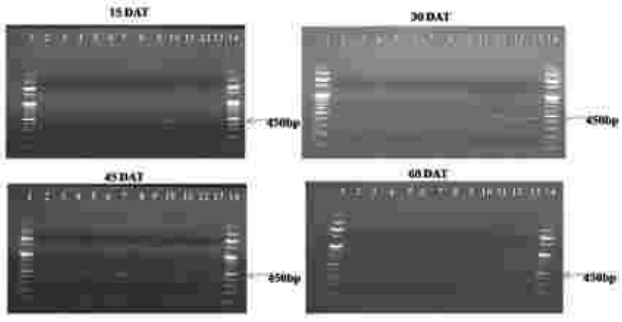


Fig. 50. PCR amplification of genomic DNA extracted from treated and untreated leaf tissues at different sampling periods

Lane 1 to 7: *B. bassiana* specific primer 1-control older leaf, 2-control young leaf, 3-Bb5a older leaf, 4-Bb5a young leaf, 5-Bb45 older leaf, 6-Bb45 young leaf

Lane 8 to 14: *M. anisopliae* specific primer 8-control older leaf, 9-control young leaf, 10-Ma4 older leaf, 11-Ma4 young leaf, 12-Ma35 older leaf, 13-Ma35 young leaf, 14-100bp ladder

Seedling dip method: No colonisation was observed in cabbage leaves.

Efficacy of endophytic *B. bassiana* and *M. anisopliae* strains against *P. xylostella*

Cabbage leaf samples treated with isolates of *B. bassiana* and *M. anisopliae* by foliar application method were collected at 15 and 30 DAT and were surface sterilised and fed to the second instar larvae of *P. xylostella*. The treated leaf samples collected after 15 DAT showed 70.0-76.7% mortality and 30 DAT showed 13.7-54.8% mortality (Table 7).

Table 7. Efficacy of endophytic *B. bassiana* and *M. anisopliae* isolates on *P. xylostella*

Isolate	1st bioassay (15 DAT) Mortality (%)	2nd bioassay (30 DAT) Mortality (%)
Bb-5a	76.67[a]	44.43[a]
Bb-45	76.67[a]	54.80[a]
Ma-4	70.00[a]	13.70[bc]
Ma-35	76.67[a]	37.40[ab]
Control	23.33[c]	3.33[c]

*Values in columns followed by the different letter are significantly different with each other according to LSD ($P < 0.01$)

Isolation, detection and maintenance of groundnut bud necrosis virus (GBNV)

GBNV is very important and most prolific tospovirus (Family: Bunyaviridae) affecting economically important solanaceous hosts such as cowpea, groundnut, mungbean, potato, soybean, tomato, chilli and potato. Virus bioassay was developed by sap transmission of GBNV from infected tomato leaf to cowpea cv C-152 under net house conditions. GBNV induced both local and systemic symptoms including chlorotic/necrotic spots and veinal necrosis on cowpea C-152 seedlings (Fig. 51). RT-PCR was used to detect the presence of GBNV based on primers on differential sequence from Gn/Gc genes located on mRNA. Approximately 950 bp amplified PCR product was purified, sequenced and confirmed the identity (99.6%) of GBNV (Fig. 52).

Fig. 51. Expression of GBNV symptoms on cowpea cv C-152 seedlings

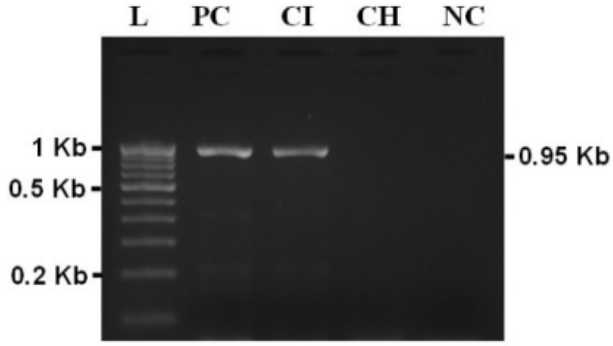


Fig. 52. Detection of GBNV using RT-PCR. Lane L-100bp DNA marker, Lane PC-psoitive control of GBNV; Lane CI- Cowpea infected with GBNV, Lane CH-copea healthy sample, Lane NC- Negative control

Exploitation of *Pseudomonas fluorescens* NBAIR-PfDWD for management of thrips

Pseudomonas fluorescens is well-known for plant-beneficial effects that improve crop health and agricultural production. It produces antifungal metabolites, antibiotics and insecticidal activity which suppress plant disease microbes and herbivores. Here, thrips which fed on *P. fluorescens* NBAIR-PfDWD treated leaves showed typical symptoms of body content oozing out with high mortality compared to untreated control (Fig. 53). High dosage @ 10^8 cfu/ml of *P. fluorescens* showed high mortality of thrips within 72 hrs, followed by medium (10^5 cfu/ml) and low dosage (10^2 cfu/ml) compared to untreated control (Fig. 54).

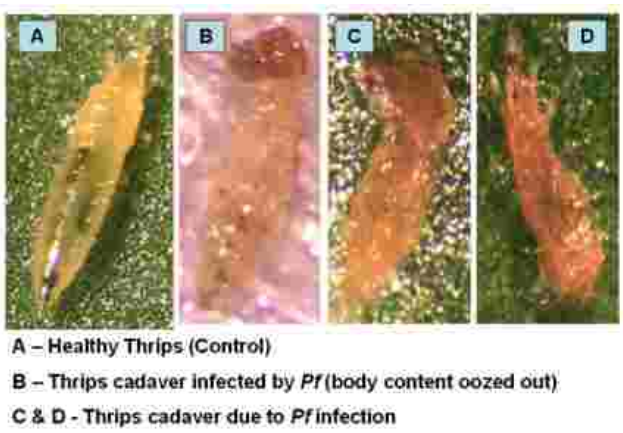


Fig. 53. Typical symptoms exhibited by thrips *F. schultzei* nymphs at 24 hours after ingestion of *P. fluorescens* strain PfDWD treated cowpea leaves

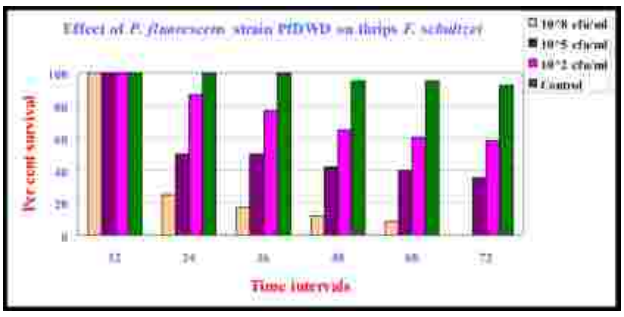


Fig. 54. Effect of *Pseudomonas fluorescens* strain PfDWD on *Franklieniella schultzei*

Degradation of farm waste using black soldier fly

Standardised the rearing technique and mass culturing of black soldier fly using kitchen waste and farm waste. Total life cycle of BSF in different substrates ranges from 36-52 days. Among all substrates, kitchen waste was most suitable for BSF rearing and developed technology of mass culturing of BSF. Recorded different parameters like prepupal weight, dry matter reduction (DMR), feed conversion ratio (FCR), bioconversion rate (BR) and residence time requirement (TR) on different substrates. The black soldier fly degraded compost was subjected for physico-chemical analysis and was found to be equivalent to vermicompost. Due to culturing of BSF, it was observed that 50-70% reduction of biomass of farm/kitchen wastes along with suppression of other insects and pathogenic microorganisms. In addition, the converted compost analyzed for their nutrient profile revealed N: 2-3%, P: 0.5-1.5% and K: 1-2%. The final degraded product (Fig. 55) possessed C:N ratio of 17:1 with pH 7.05 and electrical conductivity 1.36 dSm^{-1} which is suitable for utilisation as compost for crop nutrition.

Fig. 55. Compost generated from BSF rearing

Rearing method for scarabaeids

A simple technique of rearing the grubs of scarabaeids on bajra seedlings under laboratory conditions was developed (Fig . 56a, b).

Fig. 56a. Rearing of scarabaeids on bajra seedlings

Fig. 56b. Life stages of scarabaeid beetles

Mass production of mites

Six different mass production protocols were developed and standardised for *Tyrophagus putrescentiae*, the mould mite or copra mite. The mass produced mite was also successfully used as a feed for several phytoseiid mites in the laboratory. Four different mass production protocols were developed and standardised for a *Lardoglyphus* sp. (Fig . 57).

Fig. 57. *Lardoglyphus* sp

Biological control using mites

For the first time in India, biological control was attempted against the phalaenopsis mite, *Tenuipalpus pacificus*, an invasive pest of orchids. The phytoseiid mite, *Neoseiulus indicus*, which showed promise as a biocontrol agent in the laboratory, was used successfully against *T. pacificus* in a commercial polyhouse in Kanyakumari district of Tamil Nadu.

Survey of whiteflies and natural enemies

Survey of whiteflies was carried in coconut, brinjal, chilli, guava, custard apple, sapota, maize, mango, cashew, coconut, banana, oil palm, arjun tree, jamun, and many other ornamental and landscape plants in seven states. Among the specimens, most of them were morphologically identified as *Bemisia tabaci*, *Aleurodicus rugioperculatus*, *A. dispersus*, *Aleurotrachelus trachoides*. Further, they were characterised through molecular tool after sequencing. During the survey, many natural enemies including spider and parasitoids were collected in association with whiteflies which were identified and documented. The parasitisation on cotton ranged from 10-15% in few locations of Haryana and Punjab. Besides, whiteflies such as *Siphoninus phillyreae* in pomegranate, *Bemisia* sp. in custard apple, *Rusostigma euginae* in jamun, *A. trachoides* in tabacco, brinjal, chillies, capsicum, *Duranta,* and *Bemisia breyniae* in Indian gooseberry.

Biological suppression of invasive rugose spiralling whitefly on coconut

Population dynamics of *Aleurodicus rugioperculatus* and its parasitoid was studied in relationship to weather parameters from November 2016- December 2017 on coconut. Results revealed that the infestation of RSW was declined from 60.52 % egg spiral per leaflet/leaf in November 2016 to 15.80% egg spiral per leaflet/leaf in December 2017. Further, *E. guadeloupae* was the only major natural enemy encountered on the RSW causing 16.90% parasitism in December 2016, which had increased to 82.56% by December 2017. The density of the RSW was positively correlated with maximum temperature and negatively correlated with RH. The multiple regression analysis revealed that about 60.15% of the variation in the RSW population density could be due to natural parasitism. The parasitoid population was augmented by the re-distribution of *E. guadeloupae* to affected areas through field insectary technique. Further, strategies for the conservation and encouraging natural buildup of *E. guadeloupae* through providing reservoir plants/banker plants which protect them from pesticides, shelter and unfavorable weather factors were being developed. *Canna indica* is commonly known as Indian shot plant was found to be potent banker plant for conservation of the parasitoid, which may be planted in border as well as in between the coconut garden. Moreover, the parasitoid population has been enhanced due to various awareness programme on its conservation with the help of different stakeholders. Population of the parasitoid was also increased phenomenally over the period of time through breeding, favorable weather conditions and shifting from *A. dispersus* and perennial nature of palms.

Studies on tritrophism between EPN bacterium and insect hosts and their functional relationships

Methods were evolved and standardised to study the tritrophic relationships among EPN-bacterium-insect hosts under *in vitro* conditions (Fig. 58). Bacterial symbionts, age of the EPN juveniles, foraging habit, insect host, their eggs and viability of insect eggs and larvae influenced the rate and time of EPN infectivity. These studies help in determining suitable strain, dose and time of application.

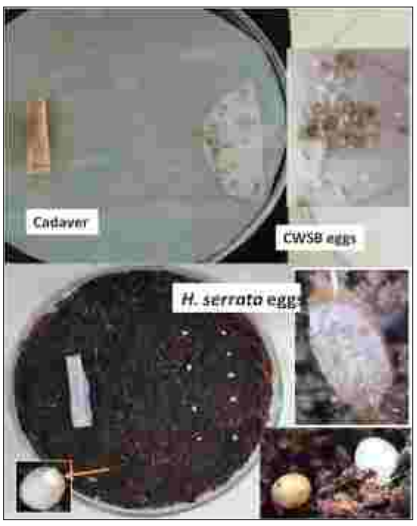


Fig. 58. *In vitro* technique for determining tritrophism and functional relationship of EPN-symbiotic bacteria-insect hosts (eggs and larvae)

In vitro studies on functional association of sympatric populations of EPN against insect pests

Preliminary studies indicated different combinations of sympatric populations of *H. indica, H. bacteriophora, S. carpocapsae* and *S. abbasi* had different mortality rates depending on insect species involved, amount of inoculum of each population and efficacy of bacterial symbiont in their guts (Fig . 59).

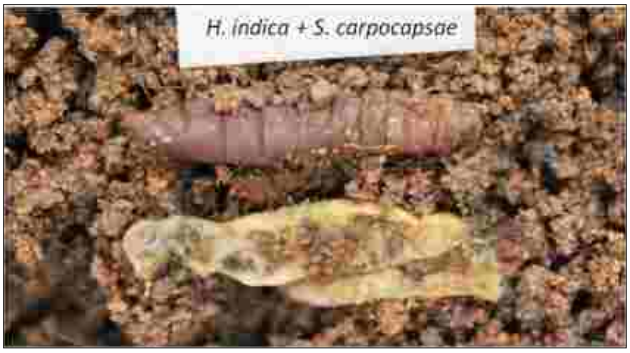


Fig. 59. Screening of functional association of sympatric populations of EPN against *Galleria mellonella* larvae

Effect of mulching on efficacy of EPN against ash weevil grubs in brinjal

Ash weevil in brinjal is a serious menace causing plant mortality and damage to the stems (Fig. 60) to the tune of 30-44%. Field trial indicated that mulching had an additive effect in controlling the damage due to ash weevil grubs (Figs. 61, 62) and cumulative effect in enhancing the yield by 16-20%.

Damaged **Healthy**

Fig. 60. Field symptoms of brinjal plants affected by grubs of ash weevil and healthy plants

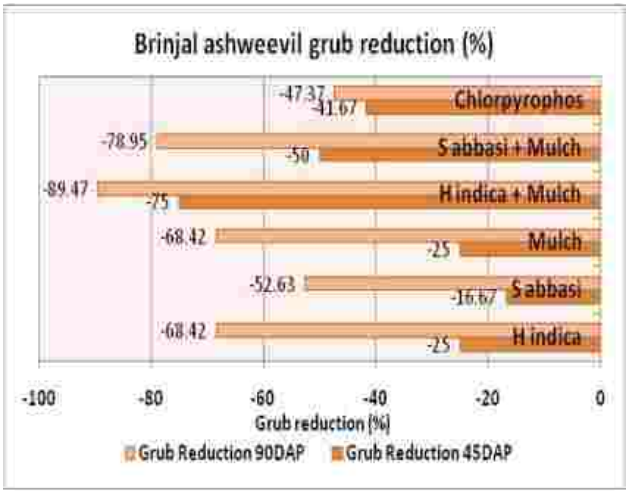


Fig. 61. Effect of mulching and EPN treatment on ash weevil grub populations in brinjal

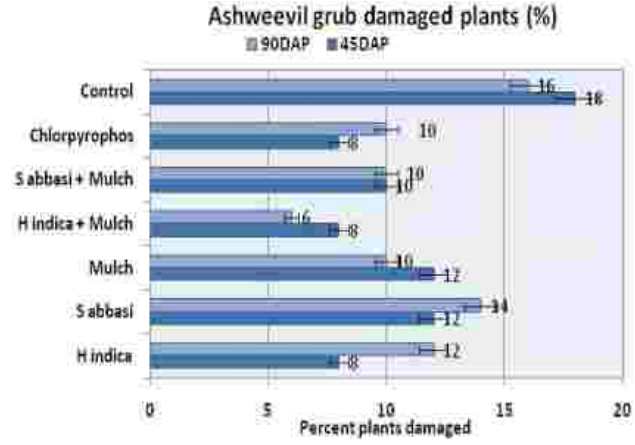


Fig. 62. Effect of mulching and treatment with EPN on plant damage due to ash weevil grubs

Field evaluation of EPN for the management of mustard saw fly in radish

Integrated approach of dislodging mustard sawfly larvae and application of EPN formulations at 10^5 IJs/m^2 reduced infestation of mustard sawfly in radish.

Field evaluation of EPN for management of whitegrubs in turmeric, soybean and groundnut

Field studies to evaluate the efficacy of EPN species (Table 8) and determine their respective LD values against whitegrubs in turmeric, soybean and groundnut, indicated that *H. indica* followed by *H. bacteriophora* and *S. abbasi* performed better and their LD_{50} values for field efficacy in terms of dose/ha ranged between 1.5 to 2.5 billion/ha.

Table 8. List of farmers supplied with EPN treatment in association with Khandelwal Biofertilisers, Ichalkunji.

S. No.	Name	Place	Crop
1	Khanjibhai Jivrajbhai Patel	Ghanteshvar, Rajkot Taluk	Groundnut
2	Bhupathbhai Luxmibhai Chavda	Kotharia Town, Rajkot Taluk	Groundnut
3	Bharat Bhimgonda Patil	Tilwani Village in Hatkanangle (Kolhapur) Maharashtra	Sugarcane
4	Rao Sahebba Busalingade	Chikodi Taluka Belgaum District, Karnataka	Sugarcane
5	Shri Kailash Uttamrao Patange	Kondur Village, Kalamnuri Taluk, Hingoli District	Turmeric
6	Shri Ramachandra Piraji Jadhave	Kondur Village, Kalamnuri Taluk, Hingoli District	Turmeric
7	Shri Shankar Rao Bhuthar	Sawangi Village, Kalamnuri Taluk, Hingoli District	Turmeric
8	Harshibhai Limba Bhairayani	Gatka village, Rajkot Taluk	Groundnut

Novel EPN delivery methods

Tree banding and fabric sachets was developed for EPN delivery systems (Fig. 63).

Fig. 63. Tree banding for EPN delivery

Field evaluation of insecticide tolerant strain of *Trichogramma chilonis*

A field trial carried out at Chikkballapur against diamondback moth, *Plutella xylostella*, incorporating multiple insecticide tolerant strain of *Trichogramma chilonis*, *Bt* with farmers' practice effectively controlled the pest and it could reduce pesticide application by 40% and revenue earned by farmer was to the tune of ₹ 1,00,000 from an acre plot.

Efficacy of entomopathogenic *Heterorhabditis* and *Steinernema* nematodes against the white grub, *Leucopholis lepidophora* (Coleoptera: Scarabaeidae)

The entomopathogenic nematodes (EPN), namely *Steinernema abbasi* and *Heterorhabditis indica* (Rhabditida: Steinernematidae and Heterorhabditidae) and a standard insecticide (Chlorpyrifos) were used manage the white grub *Leucopholis lepidophora* (Coleoptera: Scarabaeidae) in arecanut fields. Field experimental results indicated that second instar grubs were more susceptible to the nematode species tested than third instar grubs and that the efficacy of EPNs against *L. lepidophora* larvae varies with nematode species. In both the field experiments, *H. indica* (3.5×10^5 IJ/palm) showed a significantly higher percentage mortality rate of the white grub larvae compared to that of *S. abbasi* and chlorpyrifos treatments. Chlorpyrifos application, however, was more effective in reducing the grub population compared with *S. abbasi* (1.7×10^5 IJ/palm) (Fig. 64). *H. indica* has good potential as an alternative

management tool for the management of *L. lepidophora* in arecanut production.

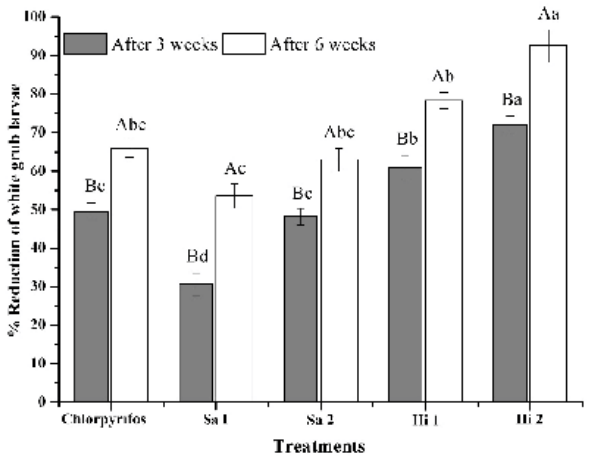


Fig. 64. Percentage reduction of *Leucopholis lepidophora* in arecanut fields with different treatments 3 and 6 weeks after application when grubs were mainly in the second instar stage. Bars with different uppercase letters on the top of error bars indicate significant differences among the same treatment on different days after applications and with different lowercase letters indicate significant differences for different treatments ($P < 0.05$, Tukey's test). Bars = standard error. Sa, *Steinernema abbasi*; Hi, *Heterorhabditis indica*; 1 = 1.7×10^5 IJ palm1, 2 = 3.5×10^5 IJ palm^{-1}. Chlorpyrifos was used at the rate of 5.6 ml palm^{-1} as a drench application.

Long term storage of entomopathogenic nematodes

An innovative technology was developed for the long term storage of entomopathogenic nematodes. Since the nematodes are soil dwelling organisms those can be stored for longer period by placing infective juveniles in a mixture of 2:1 of sterilised sandy soil and coir pith.

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

Biodiversity of biocontrol agents from various agro ecological zones

Forty-one spiders belonging to four families, viz. Araneidae, Oxyopidae, Tetragnathidae and Salticidae were collected from different ecosystems (AAU-A).

Chrysoperla sp. was found to be predominant species among different predators on cotton crop. Eleven species of spiders were recorded from the rice fields, among them *Neoscona theisi* was the predominant species (72.05%) at all the locations followed by *Tetragnatha javana* (14.29%). On cotton whitefly, mean per cent parasitism by *Encarsia* sp. was 5.20% (PAU).

Seventy-eight cocccinellid predators were recorded from rice fields, between them *Micraspis discolor* was the major predator. The combined per cent natural parasitism of rice stem borer egg mass by *Trichogramma* sp., *Telenomus* sp. and *Tetrastichus* sp. was 8.6%. The per cent parasitism by *Cotesia* sp. (leaf folder larvae) was 11.2% on cabbage and cauliflower (AAU-J).

Among all-natural enemies collected in apple, *Coccinella undecimpunctata*, *Priscibrumus uropygialis*, *Chilocorus infernalis*, *C. septempunctata*, *Scymnus* sp., *Chrysoperla zastrowi sillemi* were most frequently recorded on apple associated with different sucking pests. Among aphelinid parasitoids, *Encarsia perniciosi* and *Aphytis proclia* together parasitised 16.0 to 20.0 per cent San Jose scale in unmanaged orchards in Kashmir valley, whereas *C. undecimpunctata* was recorded for the first time from Kargil on apricot. The parasitism by *Aphelinus mali* on apple woolly aphid, *Eriosoma lanigerum* was to the tune of 75.0%. (SKAUST).

Dinocalpus coccinellae and *Pediobius foveolatus* were observed parasitizing pupae of *Coccinella septempunctata* and *Megalocaria dilatata* at Nauni. On cabbage and cauliflower, *Diadegma semiclausum* and *Diadromus collaris* were recorded parasitizing larvae and pupae of *Plutella xylostella*. *Orius* sp. and *Anthocoris* sp. were collected from peaches infested with leaf curl aphid and thrips. *Nesidiocoris tenuis*, *Neochrysocharis formosa*, *Diglyphus* sp., *Quadrastichus plaquoi* were collected from tomato, cucumber and beans infested with *Tuta absoluta*, greenhouse whitefly, serpentine leaf miner and phytophagous mites, respectively (YSPUHF).

Encarsia guadeloupae was recorded on rugose whitefly in coconut. The egg parasitoid, *Trichogramma* sp. was recorded on eggs from vegetables and flowers, whereas the predators, viz. *C. montrouzieri*, *Chrysoperla zastrowi sillemi* and *Mallada* sp. were recorded on mealybugs, scales, whiteflies, psyllids infesting the crops namely tapioca, papaya, brinjal, okra, curry leaf and coconut, respectively. The predators such as *Dipha aphidivora* and *Micromus igorotus* were recorded on sugarcane woolly aphid (TNAU).

Surveillance for invasive alien pests

The invasive alien pests, viz. *Brontispa longissima*, *Aleurodicus dugesii*, *Phenacoccus manihoti*, *Phenacoccus madeirensis* were not recorded in any of the centres during the year 2017-2018. However, *Tuta absoluta* and *Paracoccus marginatus* were observed in Gujarat, while in Himachal Pradesh, *T. absoluta* was observed. In Maharashtra, the mealybug species *Pseudococcus*

jackbeardsleyi and *Paracoccus marginatus* were recorded on custard apple and papaya, respectively, in Pune region. *Tuta absoluta* was recorded in Junnar tehsil of Pune district during April to May 2017 on tomato crop. The leaf damage percentage due to tomato pin worm was 3.13 per cent and fruit damage is ranged between 12–20%, with an average of 4.0% fruits/ plant. In Tamil Nadu, incidence of papaya mealybug varied from moderate to high during June to October. However, *Acerophagus papayae* has widely spread and established in most of the districts of Tamil Nadu. Natural predators like *Cryptolaemus montrouzieri*, *Spalgius epius* and *Mallada igorotus* were also observed.

Surveillance of rugose whitefly *Aleurodicus rugioperculatus* in coconut and assessing the population of natural bio control agents

The incidence of rugose white fly was observed on coconut and oil palm in the east & west Godavari and Srikakulam districts of Andhra Pradesh in 2017-18. Coconut, oil palm and seethaphal were most preferred host plants. The parasitisation by *Encarsia guadeloupae* was not observed in the white fly infested gardens and nurseries up to December 2017 (DRYSRHU).

In Tamil Nadu, the pest was reported from new areas like Dindigul, Tanjore, Pudukottai and Thiruvarur districts. The incidence was less than 25 per cent in new areas. Natural enemies like the parasitoid *Encarsia* sp. and predators, viz. *Chrysoperla zastrowi sillemi*, *Mallada* sp. and *Cryptolaemus montrouzieri* were observed in the infested leaflets., among them *Mallada* sp. was found actively predating on rugose whitefly (TNAU).

In Kerala, parasitism by *Encarsia guadeloupae* ranged from 10-54 per cent in September 2017, higher mean parasitism of 93.3 and 92.0% was recorded during December and January, respectively (KAU). The pest has now spread in all districts of Kerala (Palakkad, Malappuram, Thrissur, Idukki, Kozhikode, Kannur, Ernakulam, Kasaragod, Pathanamthitta, Alappuzha, Kollam and Thiruvananthapuram districts). In several infested coconut gardens of these places, the pest incidence exceeded 20 adult whiteflies per infested palm leaflet (CPCRI).

Pest outbreaks

Cotton sucking pest incidence at Puniyad village in Karjan taluk was severe during October 2017. Severe pink boll worm damage was recorded at several places in Anand district during November 2017 (AAU-A).

Severe incidence and damage of swarming caterpillar was observed in rice crop during August to September 2017 in the regions of Nalbari, Bongaigaon, Alengmora and Dergaon taluks of Jorhat district of Assam (AAU-J).

Severe early shoot borer infestation (≥50 %) was observed in the sugarcane ratoon crop during July 2017 at several villages such as Ravikamatam, Narsipatnam, Kotavuratla, Devarapalli and Chodavaram mandals in Visakhapatnam district (ANGRAU).

In Uttarakhand and UP, severe incidence of white rust disease was reported in mustard crop grown in Udham Singh Nagar district, during January 2018, while severe incidence of mango thrips (60-70%) was recorded in major mango growing belts of UP and Uttarakhand during March 2018 (GBPUAT).

In Andhra Pradesh, severe damage by rhinoceros beetle was observed in Ratnagiri, Tadikalapudi village of Pedavegi mandal of West Godavari and Vizianagaram districts. During December 2017-January 2018, coconut plantations at several villages at Kadiyam and Chagallu mandals were severely infested with RSW (DRYSRHU).

In Puri district, severe incidence of coconut black headed caterpillar, *Opisina arenosella* was reported in Handiali, Sahadevpur villages in Brahmagiri block during June 2017 (OUAT).

First record of South American tomato pinworm, *Tuta absoluta* in Punjab was reported from Patiala and Ludhiana districts in a survey undertaken at July 2017 (PAU).

In banana, severe infestation of burrowing nematode and moderate infestation of pseudostem and rhizome weevil was observed in Kottayam district during October 2017 (KAU, Kumarakom).

Severe incidence of diamond back moth on cabbage was reported in Bogam in Budgam district during July to October 2017 (SKAUST).

Severe infestation of rugose spiralling whitefly (RSW) was observed in the Pollachi taluk of Coimbatore district and Udumalpet taluk of Tiruppur district between June and October 2017 (TNAU).

Biological control of plant diseases

Among all the bioagents, PBAT-3, Psf-2 and Th-14 were comparatively better in reducing diseases (sheath blight and brown spot) and increasing yield in rice. Minimum brown spot disease severity was recorded with NBAIR-2 (47.5%), which was at par with Psf-2 (50.9%)

and NBAIR-1 (50.9%) but significantly better than other treatments and control (60.5%). In chickpea (variety PG-186), maximum per cent seed germination was observed in NBAIR-1-Th and carbendazim (69.8%). Minimum mature plant wilt was observed with BARC and PBAT-3 (4.7%) (GBPUAT).

Biological control of sugarcane pests

Per cent reduction in plant damage due to white grub was recorded significantly high in treatment with *Heterorhabditis indica* (79.9%) followed by *Metarhizium anisopliae* (67.7%) and chlorantraniliprole 18.5SC (72.9%) over untreated control. Higher yield increase was recorded in *H. Indica* (39.1%) compared to untreated control (ANGRAU).

Biological control of cotton pests

The lowest population of aphids (6.68), jassids (2.48), thrips (2.82) and white flies (1.81) were recorded in treatment where three sprays of *Lecanicillum lecanii* ($1x10^8$ conidia/g) @ 5 g/litre were given at fortnightly interval compared to the untreated control. The seed cotton yield of 17.85 q/ha recorded in *L. lecanii* treatment was on par with dimethoate (18.50 q/ha) (MPKV). Biointensive practice recorded 15.24, 26.32 and 22.86 PBW larvae, Good open balls (GOB) and bad open balls (BOB), respectively. While in farmers practice it was 12.28, 31.46, and 18.64 PBW larvae, GOB and BOB, respectively (UAS-R).

Biological control of rice pests

Per cent reduction in leaf folder damage was high in *Beauveria bassiana* (78.5%) and per cent reduction in stem borer damage was recorded high in *Metarhizium anisopliae* (39.0%) over untreated control. Grain yield recorded high in *Beauveria bassiana* (NBAIR strain) (5.7 t/ha) (ANGRAU).

Reduction in hopper population was high in BIPM plot (89.8%) and farmers practice plot (52.4%) over control plot. Grain yield recorded significantly high in BIPM practice.

Biological control of maize pests

At Anakapalle, low per cent dead heart (DH) due to maize stem borer, *Chilo partellus* was recorded in plots where *Trichogramma chilonis* was released (1.9% DH) and in chlorantraniliprole spraying (1.7% DH) (ANGRAU). At Udaipur, IPM module comprising use of releases of *T. chilonis* minimum leaf injury rating (LIR) and DH was recorded 1.8 and 2.0, respectively compared to farmers practice. Comparatively higher yield was recorded in IPM modules (21.5 q/ha) as compared to farmers practice (18.5 q/ha) (MPUAT).

Biological control of pests of pulses

Spray of Bt formulation, NBAII-BTG4 @ 2%, was found to be effective in reducing the larval population of *Maruca vitrata* and *Exelastis atomosa* in all stages, which was on par with the chemical flubendiamide (TNAU). Significantly less larval population was recorded in NBAIR BtG 4 treated field compared to farmers' practice. NBAIR BtG4 recorded 10.2% pod damage with grain yield of 8.75q/ha, while in farmers practice the per cent pod damage was 8.4%, with a grain yield of 9.50 q/ha (UAS-R).

Biological control of pests of tropical fruit crops

Mango: Significant reduction in the damage by the hoppers and webber (*Orthaga* sp.) was recorded at 3rd, 5th, 10th and 15th day after treatment of *Metarhizium anisopliae* @ 5 g/l, *Beauveria bassiana* ITCC 6063 @ 20 g /l where applied (KAU, Vellayani).

Papaya: With the release of *Acerophagus papayae*, the pest incidence became nil within three months, whereas in the unreleased field, the PMB incidence increased by March, 2018, the per cent incidence was 9.3% (TNAU).

Biological control of pests of temperate fruit crops

Apple: Release of *T. cacoeciae* @ 2.5 lakh/ha. (4 releases/ season) + Trunk banding + pheromone trapping + disposal of infested fruits + spray of *Heterorhabditis pakistanensis* (NBAIR) resulted in 48.2% reduction in damage of apple codling moth over control, which was much better than use of mating disruption pheromone alone and chemical control (SKUAST).

Metarhizium anisopliae treatment resulted in 71.1 to 82.2 per cent mortality of the apple root borer grubs in different orchards, which was close to chemical treatment (77.4 to 86.6%). It can, therefore, be concluded that *Metarhizium anisopliae* can be used as a substitute for chlorpyriphos for the control of apple root borer, *Dorysthenes hugelii* in apple (YSPUHF).

Biological control of pests in plantation crops

Coconut: Among three liquid formulations of coleopteran specific *Bacillus thuringiensis* (*Bt*), NBAIR formulation BtAN4, induced 8% mortality of grubs of red palm weevil at 48h after treatment and attained maximum of 36% at 10 days after treatment. Similarly, formulations like Bt4Aa1 and BtAN4 induced maximum of 30% and 14% mortality of rhinoceros grub 10 days after treatment (CPCRI).

Biological control of pests in vegetables

Tomato: At 105 DAT, the per cent fruit damage caused by *H. armigera* (5.2%) and *T. absoluta* (5.3%) was significantly lesser in BIPM plots, when compared to chemical treatment plot and control plots (TNAU). At Varanasi, BIPM had lowest whitefly (0.27), aphid (0.20), jassid (0.23) and leaf miner (0.97) populations per leaf followed by chemical module (IIVR). At Pune, BIPM treatment was found significantly superior over other treatments by recording minimum number of larval population of *H. armigera* (2.2 larvae/10 plants) with fruit damage on number basis (16.6%) and on weight basis (14.8%) (MPKV).

Brinjal: At Coimbatore, the per cent shoot damage and number of damaged fruits noted were significantly low (3.6 % and 0.46 no./plant) in BIPM plots as compared to farmers practice (and untreated check (19.8% and 3.25 no./plant). The cost benefit ratio realised in BIPM is 1: 7.64 (TNAU).

At Bhubaneshwar, lower fruit damage (44.9%), higher yield (13.8 t/ha) and higher B: C ratio (1: 2.34) was recorded in BIPM package. The fruit damage, yield and B: C ratio in farmers' practice were 52.7%, 12.63 t/ha and 1: 0.80, respectively (OUAT).

Okra: At Pune, three releases of *Trichogramma* @ 50000 /ha was able to control the damage by 100%, which was on par with flubendiamide treatment (2.7% damage) while realising the fruit yield of 9.7t/ha. The treatment with chlorpyriphos 0.04 per cent was at par with *B. thuringiensis* @ 1 kg/ha in respect of shoot infestation (6.3%) and fruit damage on number basis (11.6%) as well as weight basis (12.9%) (MPKV).

Cabbage: The efficacy of BIPM practices was significantly superior in reducing the population of DBM by recording 0.84 larvae/plant after six releases of MITS of *T. chilonis* and three rounds of spray of Bt (NBAII BtG4), while it was 2.26 and 8.88 larvae/plant in chemical treatment and control plot. The C: B ratio was 9.75 in BIPM plot and it was only 4.09 in chemical treatment (TNAU). The mean number of holes on cabbage leaves (2.21 holes/plant) were significantly ($P \leq 0.05$) lower in biocontrol based management practices. The percent head damage (7%) was recorded significantly lower in the biocontrol agent applied field in comparison to farmer practices (32.2%) (NBAIR).

Biological control of oilseed crop pests

Among the tested fungal bio-pesticides *Lecanicillium lecanii* @ 1 x 10^8 spores/g applied at a dose of 2.5 kg/ha was found significantly superior in reducing the aphid population and comparable to the commercial neem formulation, i.e. azadirachtin 1500 ppm @ 1l/ha (OUAT).

Biological control of polyhouse crop pests

Three sprays of *Beauveria bassiana* 1% (10^8 spores/ml and 10^9 spores/ml) and *Lecanicillium lecanii* 1% (10^8 spores/ml and 10^9 spores/ml) were effective in reducing aphid population (KAU Kumarakom).

Tribal Sub-Plan Programme (TSP)

AAU-A: Fifty tribal farmers (chick pea growers) were selected from Dahod district and distributed bio-inputs. Training and demonstration programmes were organised. There was a significant reduction (65-70%) in incidence of *Fusarium* wilt and *H. armigera* and 12-15% higher yield was recorded in the treated fields compared to untreated. Fifty tribal farmers (okra growers) were selected from Tapi district and distributed with bio-inputs. Training and demonstration programmes were organised on use of bio-inputs in cultivation of okra. Fields were visited to record the use of bio-inputs by the farmers and bio-efficacy of inputs distributed. Significant reduction (55-60%) in pest and disease was observed with 10-15% increase in the fruit yield.

ANGRAU: Awareness programmes on organic farming in paddy, rajmah, ginger and production of *Trichogramma chilonis* card using Eri silk worm eggs in tribal areas was conducted at Chittempadu, Koyyuru mandal; Asarada, GK veedhi mandal. Total of 74 tribal farmers of Chintapalli region, Visakhapatnam district, were benefitted through this programme. Imparted training to 29 tribal farmers of Chittempadu village, Koyyuru mandal, Chinthapalli division, on nutrient management and pest management in organic paddy cultivation with special emphasis on biological control. Thirty farmers from Asarada, GK veedhi mandal, Chinthapalli, were benefitted through training on nutrient management, pest management and post harvest practices in rajma. 15 tribal farmers from Asarada, GK veedhi mandal, Chinthapalli, were benefitted through exposure visit and training on trichocard production using Eri silkworm eggs and Corcyra eggs at AICRP on Biological control, RARS, Anakapalle.

YSPUHF: Demonstrations on the use of eco-friendly methods of pest management for apple and vegetable crop covering 100 ha benefiting 100 tribal farmers was conducted in Telangi and Sangla villages of district Kinnaur in Himachal Pradesh. The farmers were exposed to the use of bio-pesticides for the first time. The apple farmers saved about ₹14,000/ha as cost of insecticides for the management of root borer. The number of sprays was reduced by two in case of cauliflower.

5. GENBANK / BOLD ACCESSIONS

ORGANISM	ACCESSION NUMBER
ISOPTERA (COI)	
Hypotermes makhamensis	KY444138
Hypotermes makhamensis	KY614388
Hypotermes makhamensis	KY614389
Hypotermes xenotermitis	KY293420
Odontotermes escherichi	KY495154
Odontotermes escherichi	KY495155
Odontotermes feae	KY676779
Odontotermes feae	KY908402
Odontotermes formosanus	KY552744
Odontotermes longignathus	KY563711
Odontotermes longignathus	KY086467
Odontotermes longignathus	KY775488
Odontotermes longignathus	KY593992
Odontotermes longignathus	KY825250
Odontotermes longignathus	KY825249
Odontotermes longignathus	KY930907
Odontotermes mathuri	KY676778
Odontotermes obesus	KY474376
Odontotermes obesus	KY474377
Trinervitermes togoensis	KY569522
Trinervitermes togoensis	KY569523
HEMIPTERA (COI)	
Aleurodicus dispersus	MF149998
Aleurodicus dispersus	MF186939
Aleurodicus rugioperculatus	MF445090
Aleurodicus rugioperculatus	MF449463
Aleurodicus rugioperculatus	MF685246
Aleurotrachelus trachoides	MF149999
Aleurotrachelus trachoides	MF371113
Nilaparvata lugens	MG773575
Nilaparvata lugens	MG775040
Nilaparvata lugens	MG775041
Nilaparvata lugens	MG773576
THYSANOPTERA (COI)	
Haplothrips sp.	KY883612
Haplothrips sp.	KY883618
Microcephalothrips abdominalis	KY883619
Scirtothrips dorsalis	KY883613

ORGANISM	ACCESSION NUMBER
Thrips florum	KY883611
Thrips florum	KY883616
Thrips orientalis	KY883614
Thrips orientalis	KY883617
Thrips sp.	KY883615
NEUROPTERA (COI)	
Chrysoperla zastrowi sillemi	KY039159
Chrysoperla zastrowi sillemi	KY039160
Chrysoperla zastrowi sillemi	KY054900
Chrysoperla zastrowi sillemi	KY054901
Chrysoperla zastrowi sillemi	KY415602
Chrysoperla zastrowi sillemi	KY654081
Chrysoperla zastrowi sillemi	KY881717
Chrysoperla zastrowi sillemi	KY511707
DIPTERA (COI)	
Hermetia illucens	MG682545
Hermetia illucens	MG733996
Paragus serratus	MG194422
COLEOPTERA (COI)	
Anomala bengalensis	KY640304
Anomala ruficapilla	KY640303
Anomala ruficapilla	KU517668
Calcinemis obese	KU517665
Holotrichia longipennis	MG197995
Onthophagus nuchicornis	KU517667
Protaetia alboguttata	MG182151
Protaetia aurichalcea	MH045571
Protaetia brevitarsis	KM657486
HYMENOPTERA (SPHECIDAE) (COI)	
Carinostigmus sp.	KT070204
Carinostigmus sp.	KT070205
Isorophalum sp.	KU861378
Sphex sp.	KU902451
Sphex sp.	KU902452
Stigmus sp.	KT070206
Stigmus sp.	KT070202
Tzustigmus sp.	KT070203
Tzustigmus sp.	KX017525
OTHER HYMENOPTERA (COI)	
Megachile anthracina	MF351742
Parapanteles sp.	MH071685

ORGANISM	ACCESSION NUMBER
Parapanteles sp.	MH071686
Parapanteles sp.	MH071687
Parapanteles sp.	MH071688
Parapanteles sp.	MH071689
Parapanteles sp.	MH071690
Parapanteles sp.	MH071691
Parapanteles sp.	MH071692
Parapanteles sp.	MH071693
Parapanteles sp.	MH071694
Parapanteles sp.	MH071695
Parapanteles sp.	MH071696
Parapanteles sp.	MH071697
Parapanteles sp.	MH071698
Parapanteles sp.	MH071699
Parapanteles sp.	MH071700
Parapanteles sp.	MH071701
Parapanteles sp.	MH071702
Parapanteles sp.	MH071703
Parapanteles sp.	MH071704
Trichogramma chilonis	KY872646

MICROBIAL 16S rDNA SEQUENCES (INSECT-ASSOCIATED)

METAGENOMICS OF BLACK SOLDIER FLY *Hermetia illucens*

Bacillus aerius SF-6	MG711840
Bacillus amyloliquefaciens SF-10	MG711844
Bacillus amyloliquefaciens SF-12	MG711846
Bacillus anthracis SF-14	MG711848
Bacillus australimaris SF-4	MG711839
Bacillus cereus SF-11	MG711845
Bacillus pumilus SF-7	MG711841
Bacillus subtilis SF-2	MG711837
Bacillus subtilis SF-3	MG711838
Bacillus subtilis SF-15	MG711849
Bacillus velezensis SF-13	MG711847
Morganella morganii SF-1	MG711836
Morganella morganii SF-9	MG711843
Providencia sp. SF-8	MG711842

METAGENOMICS OF GREATER WAX MOTH *Galleria mellonella*

Bacillus cereus strain YPDF16	MH349088
Bacillus licheniformis strain NAF1	MH349084

ORGANISM	ACCESSION NUMBER
Bacillus sp. strain NAM	MH349083
Bacillus thuringiensis strain NAM6	MH349086
Enterococcus casseliflavus strain LBF11	MH349087
Enterococcus casseliflavus strain YPDM9	MH349081
Ochrobactrum haematophilum strain NAH9	MH349077
Ochrobactrum pseudogrignonense strain NAH7	MH349076
Pseudomonas putida strain LBF3	MH349082
Pseudomonas putida strain YPDH8	MH349080
Ralstonia sp. strain NAM5	MH349085
Ralstonia sp. strain YPDF19	MH349089
Staphylococcus lentus strain NAM3	MH349075
Staphylococcus lentus strain YPDM3	MH349078
Staphylococcus saprophyticus strain LBF1	MH349073
Staphylococcus sciuri strain LBM7	MH349074
Staphylococcus sciuri strain YPDM4	MH349079

PHYTOPLASMAS

Candidatus Phytoplasma asteris' isolate SW01, 16SrRNA	MG865435
Candidatus Phytoplasma asteris' isolate SW02, 16SrRNA	MG865436
Candidatus Phytoplasma asteris' isolate SW01, elongation factor Tu gene (*tuf*)	MG865439
Candidatus Phytoplasma asteris' isolate SW02, elongation factor Tu gene (*tuf*)	MG865440
Candidatus Phytoplasma asteris' isolate SW01, leucyl tRNA synthetase gene (*leuS*)	MG865437
Candidatus Phytoplasma asteris' isolate SW02, leucyl tRNA synthetase gene (*leuS*)	MG865438

MITOCHONDRIAL DNA GENOMES OF EPN SPECIES

Heterorhabditis bacteriophora	MH119604
Heterorhabditis bacteriophora NBAII	MH104864
Heterorhabditis indica NBAII	MH119603
Steinernema abbasi NBAII Sa04	MG970364
Steinernema carpocapsae NBAII112	BankIt 2096502
Steinernema carpocapsae NBAII Sc05	MG875343

6. IDENTIFICATION SERVICES

Hymenoptera: Apidae, Halictidae & Megachilidae (Dr Amala, U.)

Five identification services provided. Identified 42 specimens belonging to 16 species. University of Agricultural Sciences, Dharwad; Malabar Botanical Garden and Institute for Plant Sciences; Krishi Vigyan Kendra, Dibrugarh; Banaras Hindu University.

Parasitic Hymenoptera: Braconidae, Ichneumonidae, Dryinidae, Encyrtidae, Pteromalidae, Eulophidae, Chalcididae, Aphelinidae, Eucharitidae, Torymidae, and Platygastridae (Dr Ankita Gupta)

More than 25 identification services provided. Identified 760 specimens (460 dry mounted and >300 observed in alcohol) belonging to >50 taxa.

National: Banaras Hindu University, Varanasi; CSKHPKV, Palampur; Plant Quarantine Station, Bengaluru; Directorate of Research (RRS-TZ), Uttar Banga Krishi Viswavidyalaya; Indian Institute of Science, Education & Research (IISER), Mohali; ICAR-NBAIR; ICAR-Indian Institute of Maize Research, Hyderabad; Navsari Agricultural University, Gujarat; Directorate of Cashew Research, Puttur; University of Agricultural Sciences, Raichur; University of Agricultural Sciences (GKVK), Bengaluru; Kerala Agriculture University; University of Agricultural & Horticultural Sciences (UAHS), Shivamogga; Head Division of Entomology, UAS Dharwad and E.I.D. Parry (I) Ltd.

International: Northern Invasion Biology & Mgmt, CSIRO Health & Biosecurity, and USDA-ARS Australian Biological Control Laboratory, Brisbane and University of Zabol, Iran.

Hymenoptera: Trichogrammatidae (Dr Omprakash Navik)

Four identification services provided. PAU, Ludhiana; IGKV, Raipur; TNAU, Coimbatore and University of Calicut, Calicut.

Hymenoptera: Sphecidae (Dr R. Gandhi Gracy)

One identification service provided to Assam. Identified 17 specimens belonging to ten species.

Hymenoptera: Platygastroidea, Diapriidae and Stephanidae (Dr K. Veenakumari)

Identified 31 specimens belonging to 26 species. Pandit Jawaharlal Nehru College of Agriculture and Research Institute; AAU, Jorhat; ANGRAU and KV Patel college.

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

Seventy identification services were provided to different SAUs and ICAR institutions. For these identification services around 2030 specimens were processed and 246 species were identified.

Hemiptera: Aleyrodidae (Dr K. Selvaraj)

Two identification services provided (CIPMC and ICAR- IIHR). Identified 60 specimens belonging to three species.

Hemiptera: Petatomidae (Dr S. Salini)

Identified four species from KVK, Shivamogga; HRS, Ananthapuramu, and IWST, Bengaluru.

Coleoptera: 18 families (Dr K. Sreedevi)

Multiple requests entertained. Identified 513 specimens belonging to 47 species.

Coleoptera: Curculionidae (Dr G. Mahendiran)

Five identification services provided. Identified 34 specimens belonging to five species. JAU, Junagadh; AAU, Anand; RS-IARI, Wellington, Ooty; ICAR-CCARI, Goa and IWST, Bengaluru.

Coleoptera: Cerambycidae (Dr M. Mohan)

Three identification services provided. Identified 55 specimens belonging to 22 species. University of Agricultural Sciences, Dharwad; Manipur University and NAU, Navsari.

Diptera:Tephritidae, Tachinidae, Syrphidae, Cecidomyiidae, Agromyzidae, Phoridae, Platystomatidae, Muscidae and Chloropidae (Dr. K. J. David)

Twenty eight identification services to various ICAR institutes, Agricultural Universities & private firms. Identified 7078 specimens (observed 397 pinned specimens and 6681 in butter paper covers/alcohol) belonging to >84 taxa.

Thysanoptera (Ms. R.R. Rachana)

Identified 521 specimens belonging to 41 species. Sixteen identification services provided to BAU, Sabour; UAHS, Bagalkot; IIVR, Varanasi; UAS, Bengaluru; UAHS, Bagalkot; UAS, Dharwad; AAU, Assam; PAU, Punjab; UAHS, Bagalkot; BASF Pvt. Ltd and SKUAST, Kashmir.

EPNs (Dr Jagadeesh Patil)

Identified 18 specimens belonging to five species. ICAR-IIPR, Kanpur and ICAR-IIVR, Varanasi.

Araneae (Dr M. Sampath Kumar)

Identified 120 specimens belonging to 58 species. AICRP on Biocontrol- AAU, Jorhat; AICRP on Biocontrol- PAU, Ludhiana; AICRP on Biocontrol- KAU, Thrissur; AICRP on Biocontrol- IIRR, Hyderabad; AICRP on Biocontrol- AAU, Anand; UAS, Dharwad; TNAU, HC& RI (Women) Trichy; UAHS, Shimoga; UHS, Bagalkot; ANGRAU, COA, Bapatla; UAHS, Shimoga and COH, Mudigere.

7. EXTENSION ACTIVITIES

Field demonstration of technologies

Release of *Goniozus nephantidis* for the management of coconut black headed caterpillar (BHC) was demonstrated at Kanakapura district where coconut trees were severely affected by BHC. Similarly, release of trichocards in paddy field was demonstrated at Pathkot and Kotabagh in Uttarakhand in a farmers' meet which was organised by GBPUA & T, Pantnagar. Release of trichocards, *Bacillus thuringiensis* and entomopathogenic fungi were also demonstrated for the control of pests in brinjal and cabbage in Chikballapur in Karnataka. On-farm demonstrations were carried out on application of biocontrol agents like multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis* and *Bacillus thuringiensis* (NBAIR *Bt* G4) liquid formulation for the management of cabbage pests. Eleven field trials cum demonstrations were conducted on mating disruption technique in tomato against *Tuta absoluta* and in brinjal against *Leucinodes orbonalis* in Kolar district in Karnataka and Krishnagiri district in Tamil Nadu. A front-line demonstration was carried out at Mathur, Krishnagiri district with assistance from KVK, Krishnagiri on healer and sealer technique against stem borer of mango and male annihilation technique against mango fruit flies. The use of controlled release dispensers of coconut rhinoceros beetle and red palm weevil was demonstrated in coconut gardens of Krishnagiri district and red palm weevil and rhinoceros beetle lures were supplied to the farmers.

Farmers' meet at Kotabagh, Uttarakhand

Demonstration of technologies for trapping of red palm weevil using pheromone lures

Awareness creation and empowerment of farmers

World Soil Day was celebrated by NBAIR on 5 December 2017 at Anupanhalli in Karnataka and Krishnagiri in Tamil Nadu. A farmer meeting was organised and the benefits of soil health card were explained to them. The procedure for collecting the soil samples for analysis was demonstrated to the farmers. The importance of organic manure to enrich the soil condition was briefed and pamphlets on soil health were distributed among the farmers. A field day was organised under the leadership of the District Collector, Krishnagiri district, Tamil Nadu on the management of coconut pests on 27 December 2017. Farmers were sensitised about the various aspects of pest management in coconut in an event organised by Department of Horticulture, Government of Tamil Nadu at Arasampatti on 27 December 2017. A lecture was delivered on "Macrobial Mass production" for plant protection SMSs of KVKs in an event organised by NBAIR, Bengaluru on 5 February 2018. A field day cum awareness programme was organised on "Invasive rugose spiraling whitefly *Aleurodicus rugioperculatus*" at KVK, Kankanady, Mangalore on 5 February 2018. Farmers were apprised about the biocontrol approaches for the management of pests of horticultural crops at Shoolagiri Block, Krishnagiri district in an event organised by the Joint Director of Horticulture, Krishnagiri district, Tamil Nadu on 24 March 2018.

World Soil Day celebration in Krishnagiri

Empowerment of women farmers

NBAIR organised a training programme on "Production of *Trichoderma* by women farmers and Seed Savers of Self Help Groups (SHG)" in collaboration with Green Foundation at Harohally in Kulumedoddi village on 8 June 2017.The training was attended by

officials from state department of sericulture, members of Green Foundation and about 30 women farmers of six SHGs from Kulumedoddi, Nasarahalli, Bairegowdanadoddi, Bevinamaradoddi, Chikkaballi, Bowinahalli and Chikkamaralwadi villages. The importance of the antagonistic fungus *Trichoderma* in plant disease management, its production methods, utility, benefits and application procedures were highlighted. The practical procedures were demonstrated and the women farmers were involved in packing the material for autoclaving, preparation of mother culture and inoculation from slants into autoclaved grains and liquid broth. Different application methods like seed treatment, root-dip treatment, mixing of farmyard manure with *Trichoderma* talc formulation followed by soil application were also demonstrated to the participants. *Trichoderma* production on other media like vermicompost, silkworm waste and castor seed waste were also explained during the post-training interaction session. The participants were also given information on application and usage of *Pseudomonas fluorescens* and other biocontrol agents like trichogrammatids, bethylids, chrysopids and coccinellids. Cultures of *T. harzianum* and *P. fluorescens* were distributed to the participants.

Demonstration of production methods of *Trichoderma* to women farmers

Women farmers getting involved in various procedures of production methods of *Trichoderma*

"Mahila Kisan Diwas" was celebrated at NBAIR. Five women farmers from across Karnataka, namely, Ms. Munithayamma from Bommanahalli, Ms. Roopa from Kanathanahalli, Ms. Shanthamma from Kattigehalli, Ms. Mamatha from Mandya and Ms. Bharathi from Bettahalsur participated in the event. Demonstration cum training on farm-level production of *Trichoderma harzianum*, a widely used biocontrol agent, was imparted to the visiting farmers. The women farmers were felicitated by Dr Chandish R. Ballal, Director, NBAIR and each was provided with a pressure cooker and a pure culture of *T. harzianum* to enable them to commence production and use of the fungus on their farms. The function was covered by Doordarshan.

Celebration of Mahila Kisan Diwas in ICAR-NBAIR being covered by Doordarshan

8. AWARDS AND RECOGNITIONS

Dr Chandish R Ballal

Member of the committee for the selection of Associate/Assistant Professor (Entomology) of Banda University of Agriculture and Technology, Banda, Uttar Pradesh.

One of the special guests in the Sericulture Farmers' Workshop and Award Ceremony organised by Central Sericultural Research and Training Institute, Central Silk Board held on 6 March 2018 at Hassan.

Member, Scientific Advisory Committee, University of Agricultural Sciences, Bangalore to review periodically the programme and progress of KVK, Chintamani, Chikkaballapura District w.e.f. 4 April 2017 for a period of three years.

Member, National Advisory Committee on Management of Genetic Resources constituted by ICAR, New Delhi w.e.f. 5 May 2017 for a period of three years.

Member, Research Council of University of Horticultural Sciences, Bagalkot w.e.f. 16 June 2017 for a period of two years.

Selection committee member, Dr. Kalayya Krishnamurthy National Award for the Best Agricultural Research for the year 2016-17.

Member, Expert Committee on Agrobiodiversity constituted by National Biodiversity Authority, Chennai for a period of one year w.e.f. 1 January 2018.

Editorial Member, Entomon Journal.

Chaired a session on "Farmer interest Crops": Status and prospects during National consultation on Farmer organisations status and prospect held at ICAR-NIANP, Bengaluru on 25 July 2017.

Delivered a talk as a resource person on "Biocontrol agent - potential and quality control" during Agri clinics and Agri Business Centers (AC & ABC) training programme for agricultural graduates on 3 August 2018 at GPS Institute of Agricultural Management, Peenya, Bengaluru.

Organised the consultation workshop on facilitating the use of microbial pesticides in SAARC countries at ICAR-NBAIR, Bengaluru from 21 to 23 August 2017.

RAC Chairperson of CSGRC Hosur for the years 2017 to 2020.

Guest of Honour during International training programme on "Plant health management technologies and approaches" and delivered a guest lecture during the training programme held on 12 September 2017 at NIPHM, Hyderabad.

Participated in the Mahila Kisan Divas, trained and honoured women farmers and the program was telecasted in Doordarshan on 19 October 2017 and on 20 October 2017 in Chandana TV.

Member, Research Co-ordination Committee, Central Silk Board.

Chief guest for Inaugural Session of XXI National Training programme on "Agri update on vectors and vector borne diseases" at Veterinary college, Hebbal on 14 November 2017.

Chief guest for the Awareness workshop on the Biological Diversity Act -2002 and ABS provisions at Dr. R. D. Nanjaiah Hall, Veterinary College Bangalore on 15 December 2017.

Coorganised a session on "Organic Agriculture with Bio-intensive Pest Management as means to adapt/mitigate climate change" and delivered an invited talk on "Biointensive IPM in rice- success stories" during 9th International IPM Symposium "Improving Health, Environment and Global Sustainability" held at Baltimore, Maryland, USA from 19 to 22 March 2018.

Participated in the International Symposium on Biodiversity and Bio-banking (BIODIVERSE 2018) held from 27 to 29 January 2018 at IIT Guwahati and chaired a session on "Food and Agro-Biodiversity-I" on 28 January, 2018 and also presented a paper entitled Biodiversity and Biological Control during the symposium.

Participated in the International Conference on Biocontrol for Sustainable Insect Pest Management held from 29 to 31 January, 2018 at Agricultural College and Research Institute, Killikulam, Vallanadu, Tuticorin and delivered a lecture entitled "Biodiversity of natural enemies" on 30 January, 2018.

Dr N. Bakthavatsalam

Shared the DBT-BIRAC award 2017 as academic partner for pheromones for mating disruption.

Recognised for work on pheromone based attractant for trapping Uzi fly, *Exorista bombycis* by Central Silk Board at Hassan on 6 February 2018.

Acted as IMC member of ICAR-National Research Centre for Banana, Tiruchirappalli.

Acted as RAC member of Institute of Wood Science and Technology, Bengaluru.

Delivered an invited lecture on 'Insects as genetic resources and its utilisation' at Bangalore University on 7 March 2018.

Delivered an invited lecture on 'Classical, conservation and augmentative biological control' at Bangalore University on 7 March 2018.

Delivered an invited lecture on 'Ecofriendly management of insect pests using microbial, macrobial and biopesticides' at Bangalore University on 7 March 2018.

Delivered an invited lecture on 'Insects and society: benefits and conflicts' at Workshop cum training conducted by Academy of Sciences at Coonoor on 21 January 2018.

Delivered an invited lecture on 'Insects as model organisms for Zoological Research' at Workshop cum training conducted by Academy of Sciences at Coonoor on 21 January 2018

Delivered an invited lecture on 'Semiochemicals in Pest management' at the International Conference on Biocontrol and Sustainable Insect Pest Management at AC&RI, Killikulam on 30 January 2018

Delivered an invited lecture on 'Semiochemical interventions for the management of fruit flies' at Entomology Research Institute, Loyola College, Chennai on 1 February 2018

Delivered a lecture on 'Advanced methods in Chemoecological Research for pest management' at the Brainstorming session on Pheromones at ICAR-NBAIR on 18 August 2017

Delivered a talk on 'An innovative organic formulation for management of mango stem borer *Batocera rufomaculata* De Geer (Coleoptera: Cerambycidae)' at International conference on Advances in Horticultural Crops held at Bengaluru on 5 September 2017.

Dr. T. Venkatesan

Awarded the "Certificate of Merit and Appreciation for demonstrating and creating awareness on Ecofriendly Crop pests and Disease Management Techniques" at Krishnagiri, Tamil Nadu during the 69th Republic Day Celebrations on 26 January 2018 by the District Collector, Krishnagiri, Tamil Nadu.

Nominated as an external expert in the selection of Scientists C category at Central Sericulture Training Institute, Bangalore on 5 January 2018.

Deputed to attend Workshop on "Bio-suppression of Rugose Spiraling Whitefly, *Aleurodicus rugioperculatus* at ICAR-CPCRI, Kasaragod on 6 January 2018 to take stock of the situation of RSW and evolve strategies to combat the incursion quite effectively.

Nominated as expert to screen the abstracts on i) Production and utilisation of macrobials for insect pest management ii) Biotechnological Approaches in biocontrol at International Conference on Biological Control to be held at Bengaluru from 27 to 29 September 2018.

Recognised as Consulting Editor, Editorial Board for the Journal of Environmental Biology, Lucknow.

Recognised as referee to review the articles in journals viz. Journal of Asia Pacific Entomology, Journal of Biological Control, Indian Journal of Experimental Biology and Journal of Environmental Biology.

Dr P. Sreerama Kumar

Appointed as Associate Editor of SIP Newsletter by the President, Society for Invertebrate Pathology, USA, February 2018.

Selected for "Bharat Ratna Mother Teresa Gold Medal Award" by the Global Economic Progress and Research Association, November 2017.

Selected for "National Citizenship Gold Medal Award" by the Global Economic Progress and Research Association, March 2017.

Received a "Certificate of Appreciation" for the "Cleanest Laboratory of NBAIR (Hebbal Campus)" by the Swachh Bharat Abhiyan Committee on the occasion of Gandhi Jayanti on 2 October 2017.

Received the "Best Logo Award" for the logo designed for NBAIR's Silver Jubilee (1993–2018) Celebrations, which kick-started on 24 January 2018.

Acted as the Editor of the Special Issue of Biocontrol Science and Technology to be brought out during the First International Conference on Biological Control (ICBC2018), 27 to 29 September 2018, Bengaluru.

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

Acting as the Organising Secretary (Publications) of the "First International Conference on Biological Control" being conducted by the Society for Biocontrol Advancement and ICAR–NBAIR, Bengaluru from 27 to 29 September 2018.

Acting as the Local Coordinator for the "IOBC-Global Parthenium Working Group Workshop", which will be held alongside the "First International Conference on Biological Control" in Bengaluru from 27 to 29 September 2018.

Acting as the Local Coordinator for the "IAPPS *Tuta absoluta* Working Group Workshop", which will be held alongside the "First International Conference on Biological Control" in Bengaluru from 27 to 29 September 2018.

Acted as a Member (External Expert in Pathology/ Entomology) for selection of two Junior Research Fellows in an NMPB-funded project at the Institute of Wood Science and Technology on 3 August 2017.

Dr K. Subaharan

Team member of DBT BIRAC innovation award for 2017. The award was given for formulations of mating disruption techniques on 22 September 2017. The award was presented by Hon'ble Union Minister for Science & Technology and Earth Sciences, Dr. Harsh Vardhan in the presence of Mr. YS Chowdary, Hon'ble Minister of State (MoS), Science & Technology and Earth Sciences, Prof. Vijay Raghavan, Secretary, DBT and Chairman, BIRAC and Dr. Renu Swarup, Senior Advisor, DBT and Managing Director, BIRAC.

Received certificate of appreciation from Mr. Kathiravan, IAS, District Collector, Krishnagiri for developing and demonstrating ecofriendly pest management technologies. The award was given on 69th Republic day celebrations at Krishnagiri on 27 December 2017.

Served as central team member to assess the efficacy of mating disruption (MD) trails on cotton pink bollworm, *Pectinophora gossypiella*. Assessed the performance of the MD technology along with the central team members and submitted the report to Ministry of Agriculture, Govt. of India.

Chaired a session on Omics in Biodiversity during BIODIVERSE 2018 organised by Indian Institute of Technology, Guwahati on 28 January 2018.

Served in Project Management Committee (PMC) of DBT - BIRAC. As PMC member, reviewed the projects funded under BIRAC.

Invited as an expert for Ph.D Nanotechnology curricula development in Department of Nanotechnology at Tamil Nadu Agricultural University from 27 to 28 July 2017.

Editorial Board member of Journal of Biological Control.

Served as reviewer for Current Science and Arthropod plant interactions.

Technical reviewer of project proposals submitted to DBT BIRAC.

Served as a judge for evaluating the poster displayed in aquatic theme held during BIODIVERSE 2018 at Indian Institute of Technology, Guwahati on 29 January 2018.

Selection committee member for screening best Post Graduation research for the year 2014 – 15 at UAS (B) held on 7 June 2017 in line with Coleman Lecture series.

Served as Poster evaluation committee for the DST - SERB school on Chemical Ecology conducted at National Centre for Biological Sciences on 8 July 2017.

External examiner for evaluation of Ph.D thesis at Department of Entomology, Annamalai University, Annamalai Nagar, Tamil Nadu on 17 May 2017.

Served as panel member for screening the research work presentation by Ph.D scholars of University of Agricultural Sciences, Bengaluru in connection with Coleman Lecture series held on 15 June 2017.

External examiner for evaluation of M.Sc (Ag. Ento) thesis at Department of Entomology, Annamalai University, Annamalai Nagar, Tamil Nadu on 16 June 2017.

External examiner for conducting the viva voce examination of M.Sc (Ag. Ento) thesis at Department of Entomology, Annamalai University, Annamalai Nagar, Tamil Nadu on 22 July 2017.

Expert member for setting question paper for Ph.D qualifying examination at Pondicherry University.

External examiner for conducting the viva voce examination of Ph.D thesis at Department of Entomology, Annamalai University, Annamalai Nagar, Tamil Nadu on 9 February 2018.

External examiner for evaluation of M.Sc (Ag. Ento) thesis Pt. Jawaharlal Nehru College of Agriculture and Research Institute on 15 February 2018.

Dr K. Srinivasamurthy

External Examiner for Doctoral thesis, PJTSAU, Hyderabad and ANGRAU

External examiner for MSc thesis, University of Horticultural Sciences, Bagalkot

Member - DPC (Assessment committee for Scientists)

Member Secretary, Research Advisory committee of ICAR-NBAIR, Bengaluru.

Member Secretary, Institute Research Council of ICAR-NBAIR, Bengaluru.

Member Secretary, Quinquennial Review Team of ICAR-NBAIR, Bengaluru.

Dr M. Mohan

Patent No. 290170. An insect trapping device. Granted Indian Patent on 15 November 2017.

Patent filing No. 1627/DEL/2008. Process for mass production of *Bacillus thuringiensis* (*Bt*) biocide using Millet grain based agro-medium (Final hearing with patent attorney held on 9 February 2018 and the claims are in order for grant u/s 43 of the act and will be granted after NBA approval).

BIRAC - Bio innovations team award, 2017. DBT Biotechnology Industry Research Assistance Council (BIRAC), Department of Biotechnology, Govt. of India.

Best Research worker award for the year 2017-18, ICAR-NBAIR, Bengaluru.

Republic Day Award and Gold medal for meritorious service rendered in farmers welfare awarded by District Collector, Krishnagiri district (Government of Tamil Nadu).

Best poster award at National Conference on Organic Waste Management for Food and Environment Security at ICAR-IISS, Bhopal from 8 to 10 February 2018.

Dr G. Sivakumar

Awarded the "Certificate of Merit and Appreciation" by the Collector, Krishnagiri district, Tamil Nadu on 26 January 2018 for demonstrating and creating awareness on eco-friendly crop pests and diseases management techniques at Krishnagiri District, Tamil Nadu.

Awarded the CSIR foreign partial financial assistance to travel Malaysia to attend the international conference from 25 to 27 July 2017.

Dr Mahesh Yandigeri

Awarded 'Scientist of the Year' by Science & Technology Society for Integrated Rural Improvement (S&T SIRI) Thorrur, Warangal, Telangana in National Conference on Doubling Farmers Income for Sustainable and Harmonious Agriculture (DISHA-2017) at Sri Venkateshwara University, Tirupathi from 9 to 10 September, 2017.

Best poster award in National Conference on Organic waste management for food and Environment and Security at ICAR-Indian Institute of Soil Science and Indian Association of Soil Science, Bhopal on the poster entitled "Black soldier fly *Hermetia illucens* (L.) (Stratiomyidae: Diptera) for organic farm waste management" from 8 to 10 February 2018.

Dr A. Kandan

Appointed as Editorial Board Member of Journal of Food, Agriculture and Environment.

Appointed as Editorial Board Member of Agricultural Reviews.

Appointed as Editorial Board Member of Journal of Environmental Biology.

Appointed as Referee for a number of research papers of peer reviewed journals indexed in NAAS rating during the year (Journal of Biological Control, Journal of Environmental Biology, Journal of Oilseeds Research).

Dr Deepa Bhagat

Deepa Bhagat, Parikshit Moitra, Rudra Pratap and Santanu Bhattacharya. A walkaway discovery award received in 9th Bangalore Nano held at Grand Ashoka, Bengaluru from 7 to 8 December 2017.

The Executive committee of Biologix Research & Innovation Centre Pvt. Ltd (BRICPL) and Award jury committee of International Conference on Emerging trends in Allied and Applied Biotechnology (ICAABT)-2017, conferred BRICPL Science explorer award in ICAABT-2017 for contribution in the field of Agricultural Chemistry on 2 April 2017.

Dr K. Sreedevi

Awarded 'Edita David Memorial Award' by Applied Zoologists Research Association, Bhubaneswar at XVI International Conference on Applied Zoological Research for Sustainable Agriculture and Food Security held at Banaras Hindu University, Varanasi from 9 to 11 February 2018.

Awarded Fellowship from DFG, a German Research Foundation to work as Guest Researcher in Division of Arthropoda, Alexander Koenig Museum, Bonn, Germany for three months from 16 September to 15 December 2017.

Nominated as CEM member, International Union for Conservation of Nature and Natural Resources (IUCN) for three years (2017–2020)

Nominated as Executive Council Member, Ethological Society of India, Bengaluru (2017–2019)

Dr Ankita Gupta

Received UAS-Bengaluru (GKVK campus) PG guide recognition on 30 October 2017.

Manned exhibition stall of NBAIR and demonstrated

NBAIR biocontrol technologies in Krishi Mela on 18 November 2018 at GKVK, UAS, Bengaluru.

Dr Gandhi Gracy

Received 2nd Best Oral presentation award at "International Conference on Biodiversity-Strategies for Conservation and Sustainable Utilisation", 1 to 2 February 2018, Ethiraj College for Women, Chennai.

Recognised as PG Guide by University of Agricultural Sciences, GKVK, Bengaluru.

Serving as one of "Advisory Council Members" for a PhD student from Department of Entomology, GKVK, UAS(B), Bengaluru.

Serving as Subject Editor and Reviewer for the journal "Journal of Biological Control".

Dr S. Salini

Jawaharlal Nehru Award for P. G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences 2016 (for crop Protection).

Letter of appreciation from University of Agricultural Sciences, Bengaluru for getting the Jawaharlal Nehru Award for Outstanding Doctoral Thesis Research.

Dr M. Sampath Kumar

Best poster award (first prize) at Third National Conference on Frontiers in Ecobiological Sciences and its Applications (FESA 2018), Salem from 7 to 9 February 2018 (shared with Duraimurugan, P.)

Best poster award, National Conference on 'Organic waste management for food and environmental security', Bhopal from 8 to 10 February 2018 (shared with Mahesh, Y., Mahendiran, G., Sanjay, R. and Mohan. M)

Best poster award, National Conference on 'Technological Challenges in Social, Environmental and Agricultural Reforms', Hyderabad from 9 to 10 September 2017(shared with Duraimurugan, P.)

Treasurer, Society for Biocontrol advancement (SBA)

Rapporteur, Technical Session, XXVI AICRP-Biocontrol Workers' Group Meeting, Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan from 16 to 17 May 2017.

Dr K. Selvaraj

Awarded the "Certificate of Merit and Appreciation" by the Collector, Krishnagiri district, Tamil Nadu on 26 January 2018 for demonstrating and creating awareness on eco-friendly crop pests and diseases management techniques at Krishnagiri district, Tamil Nadu.

Dr Richa Varshney

Received Best oral presentation award at International conference of zoological Sciences (Symposium on molecular biology, cytogenetics and entomology) from 26 to 28 October 2017 at Punjabi University Patiala.

Rapporteur for one of the Technical session during the group meeting of All India Co-ordinated Research Project on Biological Control of Crop Pests from 16 to 17 May, 2017, at Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan.

Invited as resource person to deliver lecture on "Mass production and utilisation of insect hosts" for professors and scientists under capacity building programme organised by ICAR-NBAIR from 28 August to 1 September 2017 at NBAIR Bengaluru.

Invited as resource person to deliver lecture on "Advances in mass culturing and utilisation of insect hosts for large scale production of microbial Biopesticides" for professors and scientists under 21 days training programme on "Current techniques and advances in mass culturing of microbials for the production of biopesticides at ICAR-NBAIR, Bengaluru from 5 to 25 September 2017.

Invited as resource person to deliver lecture "Various biocontrol agents for insect pests" for scientists of Central Sericultural Germplasm Resources Centre, centre silk board on 27 January 2018 at Central Sericultural Germplasm Resources Centre, Hosur.

Invited as resource person to deliver lecture on "Mass production of macrobials" for plant protection SMSs of KVKs organised by ICAR-NBAIR, Bengaluru on 5 February 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, Hyderabad	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. Parmer University of Horticulture and 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	Vegetables, whitegrubs, termites
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
University of Agricultural Science, Raichur	Oilseeds, pulses

ICAR Institute-based centres

ICAR-Central Plantation Crops Research Institute, Kayangulam	Coconut
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

Voluntary centres

Dr YSR Horticultural University, Ambajipeta

Indira Gandhi Krishi Viswavidhyalaya, Raipur

KAU-Regional Agricultural Research Station, Kumarakom

College of Agriculture, Vellayani, Kerala Agricultural University

Uttar Banga Krishi Vishwavidyalaya, Pundibari

10. ONGOING RESEARCH PROJECTS

A. Institute projects for 2017-18

DIVISION OF GERMPLASM COLLECTION AND CHARACTERISATION

I. Biosystematics of agriculturally important insects and associated fauna

1. Biosystematics of Trichogrammatidae (Hymenoptera)
   (01.04.2013 to 30.09.2017) – Dr. Prashanth Mohanraj
2. Biosystematics of oophagous parasitoids with special reference to Platygastroidea (Hymenoptera) (01.09.2008 to 31.03.2018) – Dr. K. Veenakumari
3. Taxonomy of Pseudococcidae, Coccidae and Diaspididae (Hemiptera Coccoidea) (01.04.2017 to 31.03.2022) – Dr. Sunil Joshi
4. Biosystematics and diversity of agriculturally important Cerambycidae (01.10.2013 to 31.03.2018) – Dr. M. Mohan
5. Biosystematics studies on Scarabaeidae (Coleoptera) of India (22.06.2017 to 31.03.2022) – Dr. K. Sreedevi
6. Taxonomic studies on fruit flies (Diptera: Tephritidae) of India (01.04.2012 to 31.03.2020) – Dr. K. J. David
7. Taxonomic studies on Pentatomidae (Hemiptera: Pentatomoidea) of India with special reference to Pentatominae (14.03.2012 to 31.03.2020) – Dr. S. Salini
8. Taxonomic studies on Indian Curculionidae (Coleoptera) with emphasis on Entiminae (01.07.2016 to 31.03.2021) – Dr. G. Mahendiran
9. Digitisation of type specimens in NBAII reference collection (01.04.2013 to 31.03.2018) – Dr. Ankita Gupta
10. 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
11. Taxonomy and biocontrol potential of entomopathogenic nematodes in Deccan Plateau of India (01.04.2017 to 31.03.2022) – Dr. Jagadeesh Patil
12. Taxonomy of Indian spiders (Araneae) with reference to agro ecosystem (01.07.2016 to 31.03.2020) – Dr. M. Sampath Kumar
13. Taxonomy and diversity of Indian Thysanoptera with special reference to Terebrantia (01.10.2015 to 31.03.2021) – Ms. Rachana, R. R.
14. Taxonomy of Indian Trichogrammatidae (Chalcidoidea: Hymenoptera) and evaluation of potential species (01.09.2016 to 31.03.2022) – Dr. Navik Omprakash Samodhi

DIVISION OF GERMPLASM CONSERVATION AND UTILISATION

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

15. Climate change effect on the diversity and bioecology of some important sucking pests
    (01.04.2014 to 31.03.2019) – Dr. N. Bakthavatsalam
16. 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

17. 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
18. Gall formers of important crops and their management (01.04.2017 to 31.03.2021) – Dr. A. N. Shylesha
19. 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
20. Documenting agriculturally important mites and establishing an authentic collection (01.04.2014 to 31.03.2019) – Dr. P. Sreerama Kumar
21. Chemical characterisation and ethology of economically important dipteran pests of veterinary and fisheries (09.10.2014 to 31.03.2019) – Dr. Kesavan Subaharan
22. Characterisation of viruses with special reference to Lepidoptera & Coleoptera (24.11.2015 to 31.03.2021) – Dr. G. Sivakumar
23. Synthesis of nanomaterials to act as sensor for semiochemicals in pest management (01.07.2013 to 31.03.2018) – Dr. Deepa Bhagat
24. Studies on tospovirus-thrips interactions and ecofriendly management of the vector (01.08.2017 to 31.03.2020) – Dr. A. Kandan
25. Habitat manipulation as a tool to conserve beneficial insects (15.07.2016 to 31.03.2021) – Dr. Amala, U.
26. Studies on exploitation of insects as food and feed (01.01.2017 to 31.03.2019) – Dr. Amala, U.
27. Diversity and predator-prey interactions in predatory mirids and geocorids (01.10.2015 to 31.03.2019) – Dr. Richa Varshney.

DIVISION OF GENOMIC RESOURCES

III. Molecular characterisation, genomics and bioinformatics of agriculturally Important insects, entomopathogenic nematodes and associated microorganisms

28. Molecular characterisation and DNA barcoding of some agriculturally important insect pests (01.04.2013 to 30.09.2018) – Dr. S. K. Jalali
29. Studies on molecular and functional diversity of EPN-EPB-insect tritrophism and their utilisation against soil pests (08.07.2016 to 31.03.2019) – Dr. M. Nagesh
30. Molecular characterisation and DNA barcoding of agriculturally important parasitoids and predators (01.06.2013 to 31.05.2018) – Dr. T. Venkatesan
31. Molecular characterisation and DNA barcoding of subterranean insects (01.04.2014 to 31.03.2019) – Dr. K. Srinivasa Murthy
32. *Bacillus thuringiensis* – fermentation and formulation strategies for enhanced toxicity against insect pests (01.04.2017 to 31.03.2020) – Dr. R. Rangeshwaran
33. Development of interactive mobile Apps for non-chemical methods in insect pest management (01.04.2017 to 31.03.2020) – Dr. M. Pratheepa
34. Molecular docking studies of insecticide resistance gene of storage pests: *Tribolium castaneum* (Herbst) and *Callosobruchus maculatus* (Fabricius) (01.04.2017 to 31.03.2020) – Dr. M. Pratheepa
35. Role of microbial flora of aphids in insecticide resistance (01.10.2012 to 30.09.2017) – Dr. Mahesh Yandigeri
36. Studies of detritivorous insects and associated microorganisms for their scope in farm waste management (01.10.2016 to 31.03.2019) – Dr. Mahesh Yandigeri

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

38. Exploration of induced hormesis for the possible role in enhanced efficacy of biocontrol agent (01.09.2017 to 31.03.2019) – Dr. R. Gandhi Gracy

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

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

B. List of Externally Funded Projects 2017-18

DIVISION OF GERMPLASM COLLECTION AND CHARACTERISATION

1 DST: Diversity and distribution of entomopathogenic nematodes in coconut and arecanut ecosystems (16.05.2014 to 15.05.2017) – Dr. Jagadeesh Patil

DIVISION OF GERMPLASM CONSERVATION AND UTILISATION

2. ICAR-CABI: The study of biological control of invasive plant species and Indian natural enemies (01.07.2014 to 30.09.2017) – Dr. Chandish R. Ballal

3. CSRTI: Identification, characterisation, synthesis and field evaluation of sex pheromone of the mulberry leaf roller, *Diaphania pulverulentalis* (Lepidoptera: Pyralidae) (21.01.2016 to 20.01.2018) - Dr. N. Bakthavatsalam

4. DBT: Plant-derived botanicals from herbs/shrubs of Indo-Burma biodiversity hotspot for control of stored grain insect pests (20.03.2015 to 31.03.2018) – Dr. N. Bakthavatsalam

5. AMAAS: Development of formulations of *Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium* spp. for management of certain sucking pests in vegetable crops (01.04.2017 to 31.03.2020)

6. DBT: Controlled release dispensers for delivery of semiochemicals (25.11.2014 to 24.11.2017) – Dr. K. Subaharan

7. NTRF: Feasibility of suppression of Tea shot hole borer *Euwallacea fornicatus* through its mutualistic *Fusarium* spp. (01.01.2016 to 31.12.2018) – Dr. G. Sivakumar

8. KCPM: Characterisation and application of virulent strains of Nucleopolyhedrosis viruses (NPV) and *Bacillus thuringiensis* (*Bt*) and Entomopathogenic nematodes (EPN) for the management of rice armyworm *Spodoptera mauritia* (01.11.2017 to 31.10.2017) – Dr. G. Sivakumar

9. IISc: Characterisation, functionalisation and assembly of nanosensors and their applications as pheromone sensor for pest management (03.08.2012 to 30.06.2018) – Dr. Deepa Bhagat

DIVISION OF GENOMIC RESOURCES

10. CRP: Consortium Research Project (CRP) on Genomics (01.04.2015 to 31.03.2019) – Dr. S. K. Jalali

11. RASI: Baseline studies for cotton bollworms with *Bt* Cry1Fa1 (22.09.2016 to 21.09.2017) – Dr. S. K. Jalali

12. NICRA: Development of IPM strategies to combat whitefly and other emerging pests (04.08.2016 to 31.03.2019) – Dr. S. K. Jalali

13. ICAR: Intellectual property management and transfer/ commercialisation of Agricultural Technology Scheme (06.06.2008 to 30.09.2017) – Dr. T. Venkatesan

14. CRP on Bioinformatics – ICAR – Centre for Agricultural Bioinformatics (CABin) (01.01.2015 to 30.09.2017) – Dr. T. Venkatesan

15. NFSM: Establishment/strengthening of Bio-fertiliser/Bio-control production units in India (03.11.2016 to 31.03.2018) – Dr. R. Rangeshwaran

16. AMAAS: Exploitation of endosymbionts of insects pests for pest management (12.12.2017 to 31.03.2020) – Dr. Mahesh Yandigeri

17. DAC: Efficacy of phosphine fumigant against storage pests of pulses, wheat, rice and coffee beans; and residue analysis for quarantine and long term storage purpose (01.04.2017 to 31.03.2018) - Dr. Ramya, R. S.

18. CDB: Biological control of invasive rugose spiraling whitefly *Aleurodicus rugioperculatus* using *Encarsia guadeloupae* in coconut (04.08.2017 to 03.08.2019) – Dr. K. Selvaraj

11. ACTIVITIES OF ITMU

Technologies developed

1. Control release dispenser for delivery of semiochemicals
2. A technique for rearing of housefly parasitoid, *Spalangia* sp.
3. A technique for rearing of housefly parasitoid, *Nasonia vitripennis* (Pteromalidae)
4. Waste to wealth: technology on black soldier fly mediated bioconversion of farm and kitchen wastes
5. Insect repellent formulation and methods thereof
6. Novel device for field release of parasitoids

Technology transferred

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

Achievements of ITMU under National Agriculture Innovation Fund Project

1. Total number of technologies available at NBAIR: 27
2. Number of technologies commercialised: 1
3. Number of licensees that purchased technologies from NBAIR: 3
4. Number of technology brochures released: 6
5. Number of IP filed: 7
6. ITMU facilitated the contract research between NBAIR and Rasi Seeds India Private Limited, Salem and between NBAIR and ATGC Private Limited, Hyderabad

Patents filed

1. Protocol for alcohol-free plywood laced melon fly attractant. (Application No. 201641006014 A), dated 25 August 2017, (Primary innovator: N. Bakthavatsalam).
2. Dorsa delta- an insect attractant trap for mango fruit fly. (Application No. 201741045435), dated 18 December 2017, (Primary innovator: N. Bakthavatsalam).
3. Method for attracting both the sexes of *Bactrocera dorsalis* insect using delta trap. (Application No. 201741042209), dated 24 November 2017, (Primary innovator : N. Bakthavatsalam).
4. Herbal swabber for revival of coffee stem borer infested plants and process for preparation thereof. (Application No. 201641015523), dated 24 November 2017, (Primary innovator : N. Bakthavatsalam).
5. A reusable charge transfer based agrogel (Application No. PCT/IN2018/050292), (Innovators: Santanu Bhattacharya, Subham Bhattacharjee, Dipen Biswakarma, Deepa Bhagat).
6. Method and device for rapid detection of *Helicoverpa armigera* NPV. (Application No. 201741019790), (Innovators: Santanu Bhattacharya, Nilanjan Dey, Deepa Bhagat).
7. A kit for specific detection of *Spodoptera litura* NPV. (Application No. 20174104094), (Innovators: Santanu Bhattacharya, Nilanjan Dey, Dipen Biswakarma, Deepa Bhagat).

Patents granted

1. "Invert-emulsion formulation of a fungal antagonist for biological management of plant diseases", (Patent No. 292394), granted on 31 January 2018, (Primary innovator: S. Sriram).
2. "Amorphous formulation of *Pochonia chlamydosporia* as bionematicide and a method of preparing the same", (Patent No. 292859), granted on 13 February 2018, (Primary innovator: M. Nagesh).

Revenue generated during 2017-2018

Through technology commercialisation: ₹ 6,00,000

Through contract research: ₹ 1,50,000

Through sale of publications: ₹5,760

Through training: ₹1,01,955

Through sale of microbials: ₹ 3,03,940

Through sale of macrobials: ₹ 7,64,002

Total revenue generation: ₹ 19,25,657

MOU being exchanged between NBAIR and Natura Crop Care Center, Bengaluru

MOU being exchanged between NBAIR and Godavari Biofertiliser Industries, Nashik

MOU being exchanged between NBAIR and Khandelwal Biofertilisers and Herbochemical Industries, Belgaum

12. PUBLICATIONS

Peer-reviewed articles

Akbar, S.I., Dar, M.A., Mahendiran, G. & Wachkoo, A.A. 2017. The first record of pear psylla *Cacopsylla bidens* (Hemiptera: Psyllidae) from India along with notes on seasonal occurrence and some elements of its biology. *Oriental Insects*, DOI: 10.1080/00305316. 2017.1378598.

Akhtar, J., Singh, B., Kandan, A., Chand, D., Chaudhury, R. & Dubey, S.C. 2017. Survival of *Alternaria brassicicola* in cryo-preserved *Brassica* spp. seeds. *Indian Phytopathology*, 70(2): 256–257.

Akhtar, J., Singh, B., Kandan, A., Kumar, P., Maurya, A.K. & Dubey, S.C. 2017. Interception of pathogens during quarantine processing: an effort towards safe import of oilseed and vegetable *Brassicas* germplasm in India. *Journal of Oilseed Brassica*, 8(2): 120–130.

Akhtar, J., Singh, B., Kandan, A., Kumar, P., Maurya, A.K., Chand, D., Gupta, V. & Dubey, S.C. 2017. Status of seed-borne fungi in some indigenous medicinal and aromatic plants conserved in National Gene Bank, India. *Indian Phytopathology*, 70(2): 206–215.

Amala, U. & Shivalingaswamy, T.M. 2017. Role of native buzz pollinator bees in enhancing fruit and seed set in tomatoes under open field conditions. *Journal of Entomology and Zoology Studies*, 5(3): 1742–1744.

Amala, U. & Shivalingaswamy, T.M. 2018. Effect of intercrops and border crops on the diversity of parasitoids and predators in agroecosystem. *Egyptian Journal of Biological Pest Control*, 28:11.

Amala, U. & Shivalingaswamy, T.M. 2018. Trap-nest diameter preference of *Megachile lanata* (Hymenoptera: Megachilidae). *Journal of Entomological Science*, 53(1): 96–98.

Amala, U., Shivalingaswamy, T.M. & Kumar, V. 2017. An unusual nesting site by leaf cutter bee, *Megachile* (*Aethomegachile*) *laticeps* Smith. *Journal of Kansas Entomological Society*, 90(1): 77–81.

Ashika, T.R., Jalali, S.K., Ojha, R., Shivalingaswamy, T.M. & Bhatnagar, R. 2017. Whole genome sequence and comparative genomic sequence analysis of *Helicoverpa armigera* nucleopolyhedrovirus (*Hear*NPV-L1) isolated from India. *Virus Disease*, 28(1): 61–68.

Ashika, T.R., Ojha, R., Jalali, S.K. & Shivalingaswamy, T.M. 2017. Comparative study of hot-start PCR characterised species specific conserved gene regions of a biocontrol agent *Helicoverpa armigera* nucleopolyhedrovirus with its whole genome. *Journal of Entomology and Zoology Studies*, 5(4): 512–519.

Ashwini, M.S., Puttalakshmamma, G.C., Mamatha, G.S., Ojha, R., Chandranaik, B.M., Thimmareddy, P.M., D'souza, P.E., Jalali, S.K. & Venkatsan, T. 2017. Studies on morphology and molecular characterisation of oriental cat flea infesting small ruminants by barcoding. *Journal of Entomology and Zoology Studies*, 5(4): 301–305.

Ashwitha, K. & Rangeshwaran, R. 2018. Growth dynamics of *Pseudomonas putida* (Nbaii-Rpf9) under abiotic stress conditions. *International Journal of Microbiology Research*, 10(1):1005–1008.

Ballal, C.R., Gupta, T. & Joshi, S. 2017. Effect of constant temperature regimes on the biological parameters of an anthocorid predator, *Orius tantillus* (Motsch.). *Journal of Biological Control*, 31(3): 146–158.

Bara, N., Eshwarmoorthy, M., Subaharan, K. & Kaul, G. 2018. Mesoporous silica nanoparticle is comparatively safer than zinc oxide nanoparticle which can cause profound steroidogenic effects on pregnant mice and male offspring exposed *in utero*. *Toxicology and Industrial Health*, DOI: 10.1177/0748233718757641.

Bhattacharyya, N., Selvaraj K., Satpathy, S. & Gotyal, B.S. 2018. Biology and life table study of *Spilarctia obliqua* Walker (Arctiidae: Lepidoptera) on different host bast fibre crops. *Journal of Entomological Research*, 42(1): 97–102.

Dar, M.A., Akbar, S.A. & Mahendiran, G. 2017. Taxonomic note about Willow Ermine Moth *Yponomeuta rorrellus* Hübner (Lepidoptera: Yponomeutidae) from Ladakh division of Jammu & Kashmir, India. *Journal of Threatened Taxa*, 9(6): 10361–10364.

David, K.J., Hancock, D.L., Singh, S.K., Ramani, S., Behere, G.T. & Salini, S. 2017. New species, new records and updated subgeneric key of *Bactrocera* Macquart (Diptera: Tephritidae: Dacinae: Dacini) from India. *Zootaxa*, 4272(3): 386–400.

Deepthy, K.B., Joshi, S., Manoj, V.S. & Krishnaprasad, K.P. 2017. A new report of the myrmecophilous root mealy bug *Xenococcus annandalei* Silvestri (Rhizoecidae: Hemiptera)-a devastating pest. *Entomon*, 42(3): 185–192.

Devindrappa, Patil, J., Gowda, M.T. & Vijayakumar, R. 2017. Compatibility of *Steinernema carpocapsae* and *Heterorhabditis indica* with insecticides registered against

Helicoverpa armigera (Lepidoptera: Noctuidae). *Journal of Biological Control*, 31: 95–101.

Duraimurugan, P., Sampathkumar, M. & Srinivas, P.S. 2017. Field evaluation of synthetic kairomonal attractants against major lepidopteran pests of castor. *Journal of Environmental Biology*, 38: 1421–1427.

Gawas, S.M. & Gupta, A. 2017. First record of *Polistes* (*Polistella*) *dawnae* Dover and Rao (Hymenoptera: Vespidae) from India. *Journal of Biological Control*, 31(2): 79–81.

Ghosh, E. & Ballal, C.R. 2017. Diapause induction and termination in Indian strains of *Trichogramma chilonis* (Hymenoptera: Trichogrammatidae). *The Canadian Entomologist*, 149(5): 607–615.

Ghosh, E. & Ballal, C.R. 2017. Effect of age dependent cold storage of factitious host *Corcyra cephalonica* (Stainton) (Lepidoptera: Pyralidae) for their continuous production and *Trichogramma chilonis* (Ishii) (Hymenoptera: Trichogrammatidae) rearing. *Journal of Asia Pacific Entomology*, 20: 928–934.

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14. MEETINGS AND DECISIONS

XXI Research Advisory Committee Meeting

The 21st meeting of the Research Advisory Committee (RAC) of the National Bureau of Agricultural Insect Resources was held on 12 April 2017 in the conference hall of the NBAIR.

The following members of the RAC attended the meeting.

1.	Dr. S. N. Puri	Chairman
2.	Dr. P. K. Chakrabarty	Member
3.	Dr. Chandish R. Ballal	Member
4.	Dr. V. V. Ramamurthy	Member
5.	Dr. P. K. Mukherjee	Member
6.	Dr. Suresh Nair	Member
7.	Dr. S. Lingappa	Member
8.	Dr. Suraj Singh Rajput	Member
9.	Dr. A. N. Shylesha	Member Secretary

General Comments

1. The Network Project on Insect Systematics (NPIB), a flagship project of the ICAR, which was the only project of its kind in the country (networking taxonomists in ICAR institutes, SAUs and traditional universities) had the express objective of generating taxonomic capital of the insect resources of agricultural significance in the country (both emerging crop pests and their natural enemies) backed by a professional reference collection. This was abruptly wound up with effect from April 2017. The RAC strongly recommends the revival of the project to meet the needs of our agricultural community in the light of expanding trade in agricultural commodities leading to the entry of invasive alien species and the development of new pests in an era of climate change and GM crops. All these require strong taxonomic support, which the country is otherwise inadequately equipped.

   The exploratory surveys, collection and curation activities at NBAIR were strongly supported by the erstwhile NPIB project. Since the project has been closed, the above activities have been seriously affected. The revival of the project at NBAIR would strengthen exploratory surveys and thereby the National Repository Museum housed in this Bureau.

2. The research projects especially in the Division of Insect Ecology should clearly focus on solving the problems faced by farmers through reducing the cost of plant protection inputs and enhancing the production.

The following comments / suggestions were given by the RAC:

I. Division of Insect Biosystematics (New name proposed: Division of Insect Germplasm Exploration)

Dr. Prashanth Mohanraj presented the report on the systematics projects.

1. Integrate taxonomy for utilisation / bio prospecting of natural enemies amenable to mass rearing, to be developed as products in linkage with private entrepreneurs.
2. To explore the possibility of utilising newer natural enemies collected / discovered during insect surveys conducted through the AICRP network.

II. Division of Molecular Entomology (New name proposed: Division of Insect Genomics)

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

1. Besides COI gene, other markers such as ITS region may also be used to study the genetic variation among populations/species of insects.
2. Molecular docking studies may be initiated to design/suggest new insecticide molecules for insecticide resistant populations.
3. Efforts must be made to develop database for dissemination of information generated through molecular work for benefit of scientific community. The molecular databases should also include analysis tools.
4. All aspects of molecular work on insect pests must be extended to natural enemies also. Abiotic stress tolerant natural enemies should be developed considering likely impact of climate change.

III. Division of Insect Ecology (New name proposed: Division of Insect Germplasm Conservation and Utilisation)

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

1. Molecular characterisation for the different strains of *Metarhizium anisopliae* and *Beauveria bassiana* must be developed.
2. Data relating to economic impact i.e., area covered, number of farmers benefitted, etc. may be collected from the buyers who license NBAIR technologies, to help evaluate impact of such technologies.
3. Prioritisation of work and field oriented research for conservation of natural enemies in crops must be addressed.
4. To develop linkages with private entrepreneurs to ensure that potential bioagents are made available to the farmers easily.

XXXV Institute Research Council Meeting

Thirty fifth Institute Research Council Meeting of the ICAR-NBAIR, Bengaluru was held on 19-20 June, 2017 and 22-24 June, 2017, under the Chairmanship of Dr. Chandish R. Ballal, Director, ICAR-NBAIR.

General Comments

- Graphs on insect resources, collections, barcodes, etc. from respective divisions to be updated every year during April (Action all HODs and Dr. M. Pratheepa).
- Bt repository to be maintained at NBAIR (Action: Dr. R. Rangeshwaran).
- Quarantine activities (monitoring trips, status of invasives, input of biocontrol agents, etc) to be continued. The activities to be reported in IRC (Action: Dr. A. N. Shylesha, Dr. Sunil Joshi, Dr. Sreeram kumar and Dr. Sampath Kumar).
- Linkages must be developed with state departments / other organisations involved in quarantine to monitor pest outbreaks and invasives (Action: Dr. A. N. Shylesha).
- NPV isolates of insect pests to be deposited in the appropriate repository (Action: Dr. G. Sivakumar).
- Reporting of new species / invasives, quarantine interceptions to be informed to ICAR, DAC, DPPQ&S and others before the information is available on public domain (Dr. Sunil Joshi and Dr. A. N. Shylesha).
- Numbers of references collections, live insects, dead museum specimens, number of molecularly characterised, microbial and macrobials may be maintained and documented month wise (Action: All HODs).
- Dr. K. Veenakumari for Division of Insect Systematics, Dr. K. S. Murthy for Division of Molecular Entomology and Dr. Richa Varshney for Division of Insect Ecology will be the Nodal officers respectively for collecting the data and all scientists of the respective division should give the list on the above to the concerned Nodal Officer by first week of every month (Action: All Scientists)
- Identification services may be charged. A proposal can be put up for price fixation and the rates can be placed in NBAIR website (Action: All Scientists, Division of Insect Systematics).
- A mail to be sent to Dr. Salini to submit the RPP II for the project entitled "Taxonomic studies on pentatomidae (Hemiptera: pentatomoidea) of India with special reference to pentatominae" on or before 31.07.2017 (Action: PME Cell).
- Unidentified specimens may be identified atleast up to family level (Action: Dr. G. Mahendran)

XXXVI Institute Research Council Meeting

Thirty sixth Institute Research Council Meeting of the ICAR-NBAIR, Bengaluru was held on 4 August, 2017, under the Chairmanship of Dr. Chandish R. Ballal, Director, ICAR-NBAIR. The following scientists attended the meeting.

General Comments

- The project entitled "Chemical characterisation and ethology of economically important dipteran pests of veterinary and fisheries" has been extended up to 31.03.2019. (Attn: Dr. K. Subaharan).
- In view of Dr. Mohan working on biosystematics of Cerambycidae it was decided that Dr. K. Sreedevi may confine her studies to biosystematics of Scarabaeidae only. Accordingly her project title may be changed to "Biosystematics studies on Scarabaeidae (Coleoptera) of India"

XXXVII Institute Research Council Meeting

The Thirty seventh Institute Research Council Meeting of the ICAR-NBAIR, Bengaluru was held on 2 November, 2017, under the Chairmanship of Dr. Chandish R. Ballal, Director, ICAR-NBAIR. The following scientists attended the meeting.

General Comments

- There was a suggestion to create a core fund to meet Institutional the requirements during exigency. The fund can be created from out of the Institutional charges funds generated through commercialisation and sale of technologies. (Action: ITMU to discuss with IIHR ITMU cell to understand the modalities followed and All PIs of Lateral funded projects)

· The request for change in the title for the institute project "Biosystematics of Aphididae, Pseudococcidae, Coccidae, Diaspididae and biodiversity of their natural enemies" by Dr. Sunil Joshi was approved. The title is changed to "Taxonomy of Pseudococcidae, Coccidae and Diaspididae" The duration of the project was extended up to March 2022.

· The institute project entitled "Role of microbial flora of aphids in insecticide resistance" is closed on 30.09.2017. The final report (RPP III) and uploading in PIMS must be done. (Action: Dr. Mahesh Yandigeri)

Dr. Ganga Vishalakshi, Principal Scientist (Entomology), IIHR, Bengaluru, as collaborator in the project entitled "Studies on tospovirus-thrips interactions and ecofriendly management of the vector" by Dr. A. Kandan has been approved.

15. PARTICIPATION OF SCIENTISTS IN MEETINGS

Abroad

Dr Chandish R. Ballal Dr M. Nagesh	Ninth International IPM Symposium – Improving Health, Environment and Global Sustainability, Baltimore, Maryland, USA, 19–22 March 2018.
Dr Deepa Bhagat	International Conference on Emerging Trends in Integrated Pest and Disease Management for Quality Food Production, Kuching, Malaysia, 25–27 July 2017.
Dr K. Sreedevi	Deputation as Guest Researcher, Alexander Koenig Museum, Bonn, Germany, 16 September–15 December 2017. Immature Beetle Meeting 2017, Charles University, Prague, Czech Republic, 5–6 October 2017.

India

Dr Chandish R. Ballal	Seventh Meeting of Expert Committee on Agrobiodiversity, National Biodiversity Authority, Chennai, 9 May 2017. Eighth Meeting of Expert Committee on Agrobiodiversity, National Biodiversity Authority, Chennai, 1 August 2017. International Training Programme on Plant Health Management Technologies and Approaches, NIPHM, Hyderabad, 12 September 2017. SFC meeting for consideration of schemes of DARE/ICAR for the period (2017–2020), ICAR, Krishi Bhawan, New Delhi, 13 September 2017. AP AgTech Summit 2017: Progressive Farmer, Smart Farming, Visakhapatnam, 15 November 2017. Panjabrao Deshmukh Post Award Grant talk, KAU, Vellayani; KAU Thrissur; RARS, Kumarakom, 20–22 November 2017. International Conference on Biocontrol for Sustainable Insect Pest Management, Agricultural College and Research Institute, Killikulam, 29–31 January 2018. Sericulture Farmers' Workshop and Award Ceremony, Hassan, 6 March 2018.
Dr Chandish R. Ballal Dr B. Ramanujam Dr Jagadeesh Patil Dr M. Sampath Kumar Dr Richa Varshney	XXVI Annual Group Meeting of All India Coordinated Research Project on Biological Control of Crop Pests and Weeds, YSPUHF, Solan, 16–17 May 2017.
Dr Chandish R. Ballal Dr B. Ramanujam Dr M. Nagesh Dr K. Srinivasamurthy Dr R. Rangeshwaran Dr Mahesh Yandigeri Dr A. Kandan Dr Jagadeesh Patil Dr R.S. Ramya	SAARC Regional Consultation on Facilitating the Use of Microbial Pesticides in South Asia, ICAR–NBAIR, Bengaluru, 21–23 August 2017.

Dr Chandish R. Ballal Dr Ankita Gupta	Brainstorming Meeting on Strategies for Implementation of Delhi Declaration on Agrobiodiversity Management, NASC complex, New Delhi, 28 August 2017.
Dr Chandish R. Ballal Dr K. Subaharan	International Symposium on Biodiversity and Biobanking (BIODIVERSE 2018), IIT, Guwahati, 27–29 January 2018.
Dr Chandish R. Ballal Dr K. Srinivasamurthy	QRT Interface Meeting of ICAR–NBAIR and AICRP–BC, NASC Complex, New Delhi, 3 February 2018.
Dr Chandish R. Ballal Dr S.K. Jalali Dr A.N. Shylesha Dr T. Venkatesan Dr Ankita Gupta Dr K. Selvaraj	Awareness Programme on Invasive Rugose Spiralling Whitefly (*Aleurodicus rugioperculatus*), KVK, Mangaluru, 6 February 2018.
Dr B. Ramanujam	QRT Review Meeting of ICAR–NBAIM, Mau, TNAU, Coimbatore, 28–30 January 2018.
Dr M. Nagesh	IPS National Symposium of Indian Phytopathological Society (South zone), College of Horticulture, UHS Campus, Bengaluru, 12–13 September 2017.
Dr T. Venkatesan	Steering Committee Meeting for Network Project on Agricultural Bioinformatics and Computational Biology, ICAR–IASRI, New Delhi, 20 April 2017.
	Review Meeting on Progress of ZTMC (Zonal Technology Management Centre) Activities in ICAR Crop Institutes in the Southern Indian Zone, ICAR–IIMR, Hyderabad, 16 December 2017.
	Third National Conference on Frontiers in Ecobiological Sciences and its Applications, Periyar University, Salem, 8 January 2018.
Dr T.M. Shivalingaswamy	Zonal Action Plan Workshop of KVKs for 2018–19, Gonikoppal, Kodagu, 22–24 March 2018.
Dr K. Srinivasamurthy	Meeting on Empowering Women Farmers on Biological Control, Green Foundation, Kanakapura, Ramanagara, 8 June 2017.
Dr P. Sreerama Kumar	Selection Committee Meeting, Institute of Wood Science and Technology, Bengaluru, 3 August 2017.
Dr R. Rangeshwaran	National Science Academy Lecturer Workshop on Plant and Microbial Bio – Resources and their Conservation, Cauvery College for Women, Tiruchirappalli, 23–24 January 2018.
Dr K. Subaharan	Coleman Lecture Series, University of Agricultural Sciences, GKVK, Bengaluru, 8 July 2017.

	GPS Endowment Lecture on Translating the Chemical Language of Nature, GPS Institute of Agricultural Research Management, Bengaluru, 25 September 2017.
	NANOBIOTECK 2017 organised by Indian Society of Nanomedicine, and Department of Biotechnology, KTDC–Samudra, Thiruvananthapuram, 6 – 8 December 2017.
Dr M. Mohan	Training Workshop on Single Molecule Real Time (SMRT) Sequencing and Bioinformatics Analysis, ICAR–NBFGR, Lucknow, 25–26 July 2017.
	State Level Technical Committee Meeting on Issues Related to GM Crops, University of Agricultural Sciences, GKVK, Bengaluru, 27 March 2018.
Dr G. Sivakumar	Workshop on Plant Microbe Interactions for Sustainable Agriculture, Periyar University, Salem, 7–8 November 2017.
	Bengaluru Tech Summit, Bengaluru Palace, Bengaluru, 16–18 November 2017.
Dr Deepa Bhagat	AgriCon 2018, International Conference on Sustainability of Smallholder Agriculture in Developing Countries under Changing Climatic Scenario, CSAUAT, Kanpur, 14–17 February 2018.
Dr A. Kandan	Brainstorming Session on Thrips: Challenges and Management Options, NASC Complex, New Delhi, 22 September 2017.
Dr Mahesh Yandigeri	National Conference on Doubling Farmers Income for Sustainable and Harmonious Agriculture 'DISHA–2017', Sri Venkateswara University, Tirupati, 9–10 September 2017.
	Krishi Mela, University of Agricultural Sciences, GKVK, Bengaluru, 17 November 2017.
	National Conference on Organic Waste Management for Food and Environmental Security, ICAR–IISS, Bhopal, 8 – 10 February 2018.
	Farmers' Conclave, ICAR–NIANP, Adugodi, Bengaluru, 17 February 2018.
Dr K. Sreedevi	Review Meeting of All India Network Project on Soil Arthropod Pests, Durgapura, Jaipur, 5 February 2018.
	XVI AZRA International Conference on Applied Zoological Research for Sustainable Agriculture and Food Security, BHU, Varanasi, 9–11 February 2018.
Dr R. Gandhi Gracy	International Conference on Biodiversity – Strategies for Conservation and Sustainable Utilization, Ethiraj College for Women, Chennai, 1–2 February 2018.

Dr K.J . David	Workshop on Exchange/Transfer and Sharing of Knowledge/ Biological/Genetic Resources with Outside and Foreign Agencies, NASC Complex, New Delhi, 8 June 2017.
	Invited Lecture in Training Programme on Fruit Fly: Surveillance and Management, NIPHM, Hyderabad, 29 August 2017.
	Invited Lecture in Training Programme on Fruit Fly: Surveillance and Management, 27 February 2018, NIPHM, Hyderabad.
Dr Ankita Gupta	Meeting of Bureau Directors and Scientific Staff, ICAR–NBPGR, New Delhi, 29 August 2017.
	International Conference in Zoological Sciences and on Ants, Punjabi University, Patiala, 26–28 October 2017.
	National Conference on Status of Invasive Alien Species in India, Zoological Survey of India and Botanical Survey of India, Kolkata, 14–15 December 2017.
	First International Meeting on Asian Bees, NCBS, Bengaluru, 9–10 February 2018.
Dr M. Sampath Kumar	Third Meeting of the Expert Committee (EC) on Invasive Alien Species, National Biodiversity Authority, Chennai, 6–7 February 2018.
	Competency Enhancement Programme for Effective Implementation of Training Functions by HRD Nodal Officers of ICAR, ICAR–NAARM, Hyderabad, 15–17 February 2018.
Dr K. Selvaraj	Indo–US Symposium on Curbing Whitefly–Plant Virus Pandemics – the Departure from Pesticides to Genomic Solutions, PAU, Ludhiana, 4–5 December 2017.
	Workshop on Biosuppression of Rugose Spiralling Whitefly *Aleurodicus rugioperculatus* in Coconut, ICAR–CPCRI, Kasaragod, 6 January 2018.
Dr U. Amala	Eri Krishi Vigyan Mela, Eri Silkworm Seed Production Centre, Hosur, 7 March 2018.
Dr Richa Varshney	Stakeholder Workshop for Identification of Climate Hotspots in Karnataka, NABARD, Bengaluru, 29 January 2018.
Ms R.R. Rachana	Biosafety and Application of Nanotechnology in Agriculture and Allied Fields, UAS, Dharwad, 26–28 October 2017.
Dr R.S. Ramya	Workshop on Revisiting FOCARS: Reflections and Feedback of Trained Scientists, ICAR–NAARM, Hyderabad, 15–16 March 2018.

Dr M. Nagesh Dr K. Sreedevi	XIX Group Meeting of AINP on Soil Arthropod Pests, College of Forestry, UUHF, Ranichauri, 19–20 June 2017.
Dr M. Nagesh Dr M. Sampath Kumar Dr K. Selvaraj	National Consultation on Farmer Organizations: Status and Prospects, ICAR–NIANP, Adugodi, Bengaluru, 25–26 July 2017.
Dr T. Venkatesan Dr K. Subaharan Dr G. Sivakumar	Seminar and Field day on Management of Coconut Pests, Krishnagiri, 27 December 2017.
Dr T. Venkatesan Dr K. Subaharan Dr G. Sivakumar	Seminar on Organic Cultivation of Vegetables, Department of Horticulture (Government of Tamil Nadu), Krishnagiri, 24 March 2018.

Dr Chandish R. Ballal and Dr M. Nagesh attending the Ninth International IPM Symposium in Baltimore, Maryland, USA

Dr K. Sreedevi, deputed as Guest Researcher in Alexander Koenig Museum, Germany, interacting with Dr Dirk Ahren

Scientists of NBAIR attending the SAARC Regional Consultation on Facilitating the Use of Microbial Pesticides in South Asia

Dr K. Subaharan chairing a session on Omics in Biodiversity during BIODIVERSE 2018 held at IIT, Guwahati

Dr Chandish R. Ballal inaugurating the Awareness Programme on Invasive Rugose Spiralling Whitefly at KVK, Mangaluru

Dr Mahesh Yandigeri being awarded the *Scientist of the Year* by Science & Technology Society for Integrated Rural Improvement, Warangal, during National Conference on Doubling Farmers' Income for Sustainable and Harmonious Agriculture

Dr K. Sreedevi being awarded the *Edita David Memorial Award* by Applied Zoologists Research Association, Bhubaneswar, during XVI International Conference on Applied Zoological Research for Sustainable Agriculture and Food Security

16. TRAININGS CONDUCTED

S. No.	Trainee(s)/ trainee(s) from	Particulars of the programme	Date(s)	Coordinator(s)/resource person(s)	Number of participants
1.	SAARC countries	Regional consultation workshop on "Facilitating the use of microbial pesticides in South Asia" in collaboration with SAARC Agricultural Centre (SAC), Bangladesh, ICAR-NBAIR and CABI- South Asia	21–23 August, 2017	Dr Jagadeesh Patil	8
2.	ICAR institutes and SAUs	Capacity Building Programme on "Technologies for utilization of entomopathogenic nematodes for sustainable management of soil insect pests"2	8 August–5 September 2017	Dr M. Nagesh Dr Mahesh Yandigeri Dr Jagadeesh Patil	7
3.	ICAR institutes and SAUs	ICAR sponsored ten days short course on "Nanotechnological approaches in pest and disease management"	15–24 November 2017	Dr K. Subaharan	25
4.	ICAR institutes and SAUs	Capacity Building Programme on "Identification, mass production, and utilisation of parasitoids, predators and entomopathogens for sustainable insect pest management"	4–10 December 2017	Dr Ankita Gupta Dr Jagadeesh Patil Dr Richa Varshney	4
5.	REVA University	Training on "Chemoecological approaches" for M.Sc. students	5 October 2017–5 January 2018	Dr K. Subaharan	2
6.	ICAR institutes, SAUs and industries	One day workshop on "Advances in chemical ecology: way forward"	18 August 2017	Dr K. Subaharan	
7.	ICAR institutes and SAUs	ICAR sponsored 21days summer school training programme on "Current techniques and advances in mass culturing of microbials for the production of biopesticides"	5–25 September 2017	Dr G. Sivakumar Dr R. Gandhi Gracy Dr M. Mohan Dr Jagadeesh Patil	25
7.	KVKs of Karnataka	Orientation programme as part of HRD week (organised by ATARI, Bengaluru) for plant protection scientists	5 February 2018	Dr M. Sampath Kumar	35

9.	Ms G. Oviya, B.Tech. (Bio Tech) student, TNAU, Coimbatore	Project work entitled "Polymerase chain reaction-based detection of groundnut bud necrosis virus in cowpea"	October–December 2017	Dr A. Kandan	1
10.	Dr A.K. Rai, Rajendra Agricultural University, Samastipur, Pusa, Bihar	Training on "Diagnostic features of *Trichogramma*"	18–19 August 2017	Dr Omprakash Navik	1
11.	Ms Sonalika Kolhekar, M.Sc. (Ag.), IGKV, Raipur	Training on "Basics of preparing slides and taxonomy of parasitic Hymenoptera"	11–17 March 2017	Dr Ankita Gupta	1
12.	Ms G. Deepashalini and Ms S. Sarojini, M.Sc. students of University of Madras, Chennai	Training on "Diversity, life cycle, nesting biology, behaviour of vespids of different genera in urban Bengaluru"	8 May–8 July 2017	Dr Ankita Gupta	2
13.	Ms U.N. Anjani, B.Sc. (Ag.), UAS, Bengaluru	One-month internship on "Collection, preservation, curation and general identification"	10 August–15 September 2017	Dr Ankita Gupta	1
14.	Mr Kiran Narwade, Syngenta India Pvt. Ltd., Pune	Training on "Taxonomy of thrips"	5–6 April 2017	Ms R.R. Rachana	1
15.	Dr J. Stanley, Scientist, VPKAS, Almora and Mr. N.K.B. Patil, Scientist, ICAR–NRRI, Cuttack	Training on "Generation of phosphine and bioassay with phosphine" at ICAR–IARI, New Delhi	6–7 June 2017	Dr R.S. Ramya	2
16.	Anup Kumar Sharma, Subject Matter Specialist (Entomology), Assam Agricultural University	Training on Papaya mealybug (sponsored by ATARI, Shillong)	25 May–12 June 2017	Dr A.N. Shylesha	1

17.	Dr Sreeda Chalil, Industrial Biotechnology Lab, Department of Chemical Engineering, NITK, Surathkal	Training on *Galleria*	31 May 2017	Dr M. Nagesh	1
18.	Ms Pooja Dattatrey Kamble, Ms Megha Narsingh Shinde, Kaybee Exports, Mumbai	Training on "Rearing host insects and mass production of parasitoids/predators"	28–29 June 2017	Dr Richa Varshney Dr Y. Lalitha	2
19.	Ms. Smrita Pradhan, Department of Biotechnology, Sir MVSIT New Airport Road, Bengaluru	Training on "Mass production of entomopathogenic fungi and their utilisation"	3–4 July 2017	Dr B. Ramanujam	1
20.	Mr. Subrata Saren, Assistant Entomologist, Office of the Entomologist, Government of West Bengal	Training on "Mass production of papaya mealybug parasitoids"	5–7 July 2017	Dr A.N. Shylesha	3
21.	Mr T.V. Bhaskaran, ACTO, ICAR–CIFT Cochin	Training on "GCMS–EAG analysis"	3–12 August 2017	Dr N. Bakthavatsalam	1
22.	Ms Minakshi Pandey, GPS Institute of Agricultural Management, Bengaluru	Training on "Mass production of *Trichogramma* spp."	3 January 2018	Dr Richa Varshney Dr Y. Lalitha	1
23.	Mr Srikanth, GVK Biosciences, Hyderabad	Training on "Mass rearing of *Helicoverpa armigera*"	28 February –1 March 2018	Dr Richa Varshney Ms. Shashikala Kadam	1
24.	IGKV, Raipur	Training for M.Sc. students on "Mass production of *Cryptolaemus montrouzieri*"	30 October –3 November 2017	Dr Richa Varshney	1
24.	Providence College, Coonoor	Training for college students and teachers on "Insects as resources and chemoecology"	21–22 January 2018	Dr N. Bakthavatsalam	50

25.	Dr Amit Yadav, Scientist, National Centre for Microbial Resource, National Centre for Cell Science, Pune	Training on "Hemipteran vectors of phytoplasmas and the techniques involved in transmission assays"	1 February 2018	Dr P. Sreerama Kumar	1
26.	Training College, Bengaluru University	Training for teachers on "Chemoecology and Biocontrol"	7 March 2018	Dr N. Bakthavatsalam	30

17. DISTINGUISHED VISITORS

1. Dr Jitendra Kumar, Director, Institute of Pesticide Formulation Technology, Department of Chemicals and Petrochemicals, 1 July 2017.
2. Dr S. K. Malhotra, Agriculture Commissioner, Ministry of Agriculture & Farmers Welfare, New Delhi, 10 July 2017.
3. Dr S. K. Singh, Additional Secretary and Financial Advisor, Department of Agricultural Research and Education, New Delhi, 11 July 2017.
4. Dr W.A.R.T. Wickramarachchi, Senior Programme Specialist (Priority Setting & Programme Development) SAARC Agricultural Centre, Dhaka, Bangladesh, 23 August 2017.
5. Dr Ravi Khetarpal, Executive Secretary, Asia-Pacific Association of Agricultural Research Institutions, Bangkok, Thailand, 23 August 2017.
6. Dr Hussain Farah, Plant Protection Officer, Ministry of Fisheries and Agriculture, Maldives, 23 August 2017.
7. Dr Dinesh Babu Tiwari, Senior Plant Protection Officer, Plant Protection Directorate, Nepal, 23 August 2017.
8. Dr Amitava Das, Director, Plant Protection Division, Bangladesh, 23 August 2017.
9. Dr U. S. K. Abeysinghe, Office of the Registrar of Pesticides, Gatambe, Sri Lanka, 23 August 2017.
10. Dr Pema Tohgau, Plant Protection Officer, National Plant Protection Centre, Bhutan, 23 August 2017.
11. Dr Ghulam Mohammad Saedi, Pesticide Analysis Manager at PPAD, Afghanistan, 23 August 2017.
12. Mr Chhabilendra Roul, IAS, Additional Secretary, DARE & Secretary, ICAR, Ministry of Agriculture, Government of India, 24 August 2017.
13. Dr Kuldeep Singh, Director, ICAR–National Bureau of Plant Genetic Resources, New Delhi, 14 September 2017.
14. Dr R. J. Rabindra, Former Director, ICAR–NBAIR, 16 September 2017.
15. Dr M. Anandaraj, Former Director, ICAR–Indian Institute of Spices Research, Kozhikode, 16 September 2017.
16. Dr V. V. Ramamurthy, Former Professor, Division of Entomology, ICAR–Indian Agricultural Research Institute, New Delhi, 26 February 2018.
17. Dr S. Lingappa, Former Director of Research, University of Agricultural Sciences, Dharwad, 5 March 2018.

18. MERA GAON MERA GAURAV

Seven teams of scientists/technical officers have adopted a total of 35 villages in Karnataka and Tamil Nadu. The teams visited their respective villages every month and carried out farmer-centric activities, including demonstrations, providing technical guidance and information and supplying inputs to the needy farmers. Farmers' 'gosthis' were also conducted on a regular basis to sensitise the farmers about the importance of natural enemies and biological control.

As a part of MGMG, the Dodaballapura group consisting of Drs. Mahesh Yandigeri, M. Sampath Kumar, K. Selvaraj, M. Nagesh and Mr. B. K Chaubey facilitated and moderated an interactive session among the board members of Rajaghatta Horticulture Farmer Producer Company Limited, NABARD Chair, Farmers-First, ICAR-NIANP and ICAR-NBAIR. The agenda of the meeting was Farmers-First and increasing the farm income of this self-help group through identification of bottlenecks in realising the increased farm income and propose a way forward for the same. With similar doctrine, Prof. Dr. S. Ayyappan, the NABARD Chair and Dr. Latha Devi, Scientist, Farmers-First project, ICAR-NIANP have interacted and expressed their opinion. Dr. S. Ayyappan lauded the work done by FPO, Rajaghatta for the welfare of farmers. The major bottlenecks in realisation of farm income were identified as deficiencies in the marketing and community agriculture infrastructure (storage, transport, package). Dr. S. Ayyappan provided several steps as way forward for the group. He invited the board members of FPO and MGMG group of scientists to the '*National Consultation on Farmers Organisation: Status and Prospects*' to be held at ICAR-NIANP, Adugodi, Bengaluru for further interactions and deliberations.

814 trichocards, 65 cc *Corcyra* eggs, 8298 numbers of *Cryptolaemus montrouzieri*, 32430 numbers of chrysopids, 5750 numbers of *Goniozus nephantidis*, 50 numbers of *Zygogramma bicolorata* and 200 numbers of *Acerophagus papayae* were supplied to 161 farmers for the management of black headed caterpillar in coconut, rice pests and vegetable pests in Kunigal area.

Repeated visits were made to the farmers' fields in the adopted village, Rampura and the farmers were enlightened about the biological control methods of pest management. *Trichogramma chilonis* and chyrsopids were released for the management of mulberry pests and the same were distributed among the farmers for further management of pests.

Four lectures were delivered at district level farmers' seminar held on 5 December 2017, 16 December 2017, 27 December 2017 and 24 March 2018 at Hosur, Arasampatti, Shoolagiri and Thotibavi villages of Krishnagiri district in Tamil Nadu. Live biocontrol agents and microbial biopesticide formulations were exhibited and field demonstrations on pheromone technologies were also carried out at the farmers' meet.

Interaction with farmers about cotton bollworm management at Krishnagiri

Prof. Dr. S. Ayyappan, NABARD Chair, and Dr. Latha Devi, Scientist, Farmers-First project, ICAR-NIANP, along with MGMG team of NBAIR have interacted with FPO, Rajaghatta, Doddaballapur

19. EXHIBITIONS

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

1. 'Farmers' Conclave', organised at ICAR–National Institute of Animal Nutrition and Physiology, Adugodi, Bengaluru on 16–17 February 2018.
2. 'Krishi Mela' organised at GKVK Campus, University of Agricultural Sciences, Bengaluru on November 16–19, 2017.
3. 'National Horticultural Fair-2018' organised by ICAR–Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru on 15–17 March 2018.
4. Three exhibitions were organised during the farmers seminar held on 16 December 2017, 27 December 2017 and 24 March 2018 at Hosur, Arasampatti and Shoolagiri of Krishnagiri district of Tamil Nadu. The exhibitions were organized in association with Department of Horticulture, Govt. of Tamil Nadu.

Honourable Union Minister of Agriculture & Farmers Welfare visiting the NBAIR stall at Farmers' Conclave organised by ICAR–NIANP, Bengaluru

NBAIR stall at National Horticultural Fair-2018

NBAIR stall at Krishi Mela

20. PERSONNEL

S.No.	Name	Designation
Director		
1.	Dr Chandish R. Ballal	Director
Scientists		
Division of Germplasm Collection and Characterisation		
2.	Dr Prashanth Mohanraj	Principal Scientist (Agricultural Entomology) & Head, Division of Germplasm Collection and Characterisation (Superannuated on 30.09.2017)
3.	Dr Sunil Joshi	Principal Scientist (Agricultural Entomology) & Head (In-Charge), Division of Germplasm Collection and Characterisation
4.	Dr K. Veenakumari	Principal Scientist (Agricultural Entomology)
5.	Dr M. Mohan	Principal Scientist (Agricultural Entomology)
6.	Dr K. Sreedevi	Senior Scientist(Agricultural Entomology) (Joined NBAIR on 21.06.2017)
7.	Dr K.J. David	Scientist (Agricultural Entomology)
8.	Dr S. Salini	Scientist (Agricultural Entomology)
9.	Dr G. Mahendiran	Scientist (Agricultural Entomology)
10.	Dr Ankita Gupta	Scientist (Agricultural Entomology)
11.	Dr Jagadeesh Patil	Scientist (Nematology)
12.	Dr M. Sampath Kumar	Scientist (Agricultural Entomology)
13.	Ms R.R. Rachana	Scientist (Agricultural Entomology) (On study leave from 04.09.2017)
14.	Dr. Navik Omprakash Samodhi	Scientist (Agricultural Entomology)
Division of Germplasm Conservation and Utilisation		
15.	Dr N. Bakthavatsalam	Principal Scientist (Agricultural Entomology) & Head (In-Charge), Division of Germplasm Conservation and Utilisation
16.	Dr B. Ramanujam	Principal Scientist (Plant Pathology)
17.	Dr A.N. Shylesha	Principal Scientist (Agricultural Entomology)
18.	Dr T.M. Shivalingaswamy	Principal Scientist (Agricultural Entomology)
19.	Dr P. Sreerama Kumar	Principal Scientist (Plant Pathology)
20.	Dr Kesavan Subaharan	Principal Scientist (Agricultural Entomology)
21.	Dr G. Sivakumar	Principal Scientist (Microbiology)
22.	Dr Deepa Bhagat	Principal Scientist (Organic Chemistry)
23.	Dr A. Kandan	Principal Scientist (Plant Pathology) (Joined NBAIR on 23.06.2017)
24.	Dr U. Amala	Scientist (Agricultural Entomology)
25.	Dr Richa Varshney	Scientist (Agricultural Entomology)

Division of Genomic Resources		
26.	Dr S.K. Jalali	Principal Scientist (Agricultural Entomology) & Head, Division of Genomic Resources
27.	Dr. M. Nagesh	Principal Scientist (Nematology)
28.	Dr T. Venkatesan	Principal Scientist (Agricultural Entomology)
29.	Dr K. Srinivasa Murthy	Principal Scientist (Agricultural Entomology)
30.	Dr R. Rangeshwaran	Principal Scientist (Microbiology)
31.	Dr M. Pratheepa	Principal Scientist (Computer Applications)
32.	Dr Mahesh Yandigeri	Senior Scientist (Microbiology)
33.	Dr R. Gandhi Gracy	Senior Scientist (Agricultural Entomology)
34.	Dr K. Selvaraj	Scientist (Agricultural Entomology)
35.	Dr R.S. Ramya	Scientist (Agricultural Entomology)
Technical Officers/Assistants		
36.	Ms Shashikala S. Kadam	Chief Technical Officer
37.	Dr Y. Lalitha	Assistant Chief Technical Officer
38.	Dr B.K. Chaubey	Assistant Chief Technical Officer
39.	Mr Satandra Kumar	Assistant Chief Technical Officer
40.	Mr P.K. Sonkusare	Senior Technical Officer (T6)
41.	Ms B.L. Lakshmi	Senior Technical Officer (T6) (Took VRS from NBAIR on 11.07.2017)
42.	Ms L. Lakshmi	Senior Technical Officer (T6)
43.	Mr H. Jayaram	Senior Technical Officer (T6)
44.	Ms S.K. Rajeshwari	Technical Officer (T5)
45.	Mr P. Raveendran	Technical Officer (T5)
46.	Dr A. Raghavendra	Technical Assistant (Laboratory Technician)
47.	Mr Umesh Kumar Sanjeev	Technical Assistant (Laboratory Technician)
48.	Mr M. Chandrappa	Technical Assistant (Driver)
49.	Mr R. Narayanappa	Technical Assistant (Generator operator)
50.	Mr P. Madanathan	Technical Assistant (Driver)
Administrative Staff		
51.	Mr G. Ramesh	Administrative Officer (Left NBAIR on 02.01.2018)
52.	Mr Alok Kumar	Administrative Officer (Joined NBAIR on 03.01.2018)
53.	Mr T.A. Viswanath	Finance & Accounts Officer
54.	Mr K.N. Visveswara	Private Secretary to Director
55.	Mr Ajit Desai	Assistant Administrative Officer
56.	Ms S. Kaveriamma	Personal Assistant
57.	Mr M. Eswar Reddy	Assistant
58.	Ms Dipanwita Deb	Assistant

59.	Ms M.S. Uma	Junior Stenographer
60.	Ms Nazia Anjum	Upper Division Clerk
61.	Ms P. Anitha	Lower Division Clerk
Supporting Staff		
62.	Mr Ramakrishnaiah	Skilled Supporting Staff
63.	Mr V. Anjenappa	Skilled Supporting Staff (Superannuated on 31.12.2017)
64.	Mr P. Nagaiah	Skilled Supporting Staff

Participants of SAARC Regional Consultation on Facilitating the Use of Microbial Pesticides in South Asia, 21–23 August 2017, NBAIR

Inauguration of Silver Jubilee celebrations of NBAIR on 24 January 2018

School children receiving prizes for the Quiz Competition conducted during the inaugural function of Silver Jubilee celebrations on 24 January 2018

1993-2018

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