National Bureau of Agriculturally Important Insect Resources, Bengaluru

QRT Executive Summary of

Performance Review and Recommendations

ICAR constituted the Quinquennial Review of the National Bureau of Agriculturally Important Insect Resources (NBAIR), Bengaluru for the period 2012-2017, by a team of eminent experts with Dr. J. H. Kulkarni as Chairman and Dr. Mohammad Hayat, Dr. V. V. Ramamurthy, Dr. R. S. Gill, Dr. H. B. Singh, Dr. Lalith Achoth as members and Dr. K. Srinivasa Murthy as Member Secretary. The members of the QRT visited and reviewed the work of NBAIR for the period from 2012-2017. Team members evaluated the mandate of the Bureau, performance of assigned research project activities, physical facilities and human resources of the Bureau and financial support. The Bureau output i.e. publications; human resources development- training and other outcomes were also assessed. QRT assessed the impact of the Bureau *vis a vis* its mandate.

This Bureau has a team of 33 scientists, 13 technical, 10 administrative and 2 supporting staff working across the three divisions who worked for five years on various aspects of agriculturally important insect collection, identification, systematic, molecular characterization, mass production and utilization**,** with a plan budget of Rs. 791.84 lakhs and non-plan budget of 4120.90 lakhs, out of which 3289.71 lakhs was spent on salaries; Rs. 1216.20 lakhs on equipment including recurring contingency; Rs. 201.69 lakhs on civil works and 73.55 lakhs on TA.

Highlights of the research achievements of NBAIR during the period in reference are seen in;

- Over one lakh insect specimens and 239 type specimens are housed in the National Repository at NBAIR. 11 open access databases of agricultural insects are hosted on NBAIR web site. 2953 identifications were provided. 1329 insects and their resources were molecularly characterized and DNA available in Genomics Repository.
- Identification services for various insect pests and their resources.
- Maintaining the largest live insect repository in Asia holding 130 live insect cultures year-round which are supplied to farmers, KVKs, research organizations and students.
- Management of sugarcane woolly aphid, *Ceratovacuna lanigera* and rugose spiralling whitefly through conservation biocontrol and classical biological control of Eucalyptus gall wasp *Leptocybe invasa* and papaya mealybug, *Paracoccus marginatus*.
- Development and promotion of Multiple Insecticide Tolerant strain (MITS) and high temperature tolerant strain (HTTS) of *Trichogramma chilonis* and *Chrysoperla carnea* for management of stem borers and sucking pests on various crops.
- Development of Novel Entomopathogenic nematode (EPN) formulation for the biological control of soil borne insect pests
- Development of cost-effective liquid formulation of *Bacillus thuringiensis* for the management of pod borers
- Constant vigil for new invasives and the status and spread of the existing invasive. Mealybug *Exallomochlus hispidus* (Morrison) intercepted at Quarantine station at Bengaluru Airport on *Garcinia mangostana* fruits, thus preventing its spread.

- NBAIR played a great role in successful management of the deadly invasive papaya mealybug. The successful mass production, release and conservation of the parasitoid *Acerophagus papayae,* for suppression of the papaya mealybug resulted in the savings of . more than **1500 crores of rupees**
- Management of *Tuta absoluta*, an invasive leaf miner/fruit borer through nano pheromone technology.
- Identification of invasive Rugose Spiralling Whitefly (RSW) *Aleurodicus rugioperculatus* on coconut palm/other crops and its management through releases of natural enemy *Encarsia guadeloupae* and its conservation.

Other Achievements

Outreach programmes

The bureau has programmes on

- Network project on Biosystematics
- Management of Sucking Pests in Horticultural Crops
- Veterinary entomology, parasitology and documenting the species complexity.
- Tribal sub-plan (for field demonstrations, supply of critical inputs to tribal farmers for pest management)

During the period under report, the bureau had developed 27 technologies, out of which 18 were commercialised and 22 patents have been filed. **The total revenue generated was Rs. 54, 75,000/**

Twenty two Software protocols were developed
Thirty externally funded projects are in operation with a total outlay of 3504.03 lakhs

The institute has the largest live insect repository in Asia with a total of 127 live insects continuously maintained. A total of **1159** shipments of insects & insect resources supplied to different parts of the country

A total 479 research papers were published by the bureau of which 189 were NAAS rated Forty two training programmes were organized by the bureau (for framers, Plant protection officers from State department of Agriculture and Horticulture, KVKs, Private entrepreneurs etc.,)

Award:

The Bureau was awarded the Sardar Patel Outstanding ICAR Institution Award 2015

Success stories:

- Development and promotion of Multiple Insecticide Tolerant strain (MITS) and high temperature tolerant strain (HTTS) of *Trichogramma chilonis*
- Management of sugarcane woolly aphid, *Ceratovacuna lanigera*

- Management of Papaya mealybug *Paracoccus marginatus*
- Management of the new invasive tomato pin borer, *Tuta absoluta*
- Novel Entomopathogenic nematode (EPN) formulation for the biological control of insect pests
- Development of cost effective liquid formulation of *Bacillus thuringiensis*

II. The overall recommendations of the QRT are as follows

a. Research

The major thrust areas has been on collection, documentation, conservation and utilization of insects and insect resources for pest management. The discovery and documentation of the diversity of insect fauna across the geographical regions of the country, with traditional and molecular taxonomic base, generation of DNA barcodes, understanding evolutionary relationship, species diversity, role of native pollinators, their ecology and conservation, nutrient cyclers, insects as food and for waste management, impact of climate change on biodiversity and behavior of insects and nano formulations for pest management are the major activities carried out at the Bureau, encompassing the mandate of the institute and the objectives under the three divisions.

Operative costs

QRT remarked that with the redesigned mandate of the Bureau, the number of staff superannuated in the last five years and no additional posts created during 2012-17, there is an urgent requirement for additional scientific, technical and administrative staff either by creating new positions or by redeployment from other ICAR institutes. An additional manpower of 35 scientists from the present 35, 21 technical staff from the present 15., 17 administrative staff from the present 10., and 6 supporting staff from the present 3, is recommended.

The QRT visited different divisions and laboratories of NBAIR and critically evaluated the existing facilities and lab space available and proposed futuristic requirements of the Bureau.. QRT strongly recommended additional space for HOD's, AICRP Cell, PME and Vigilance Cell which are currently operating from the respective scientist's laboratories. Since NBAIR has been recognised by DST for insect taxonomy training, an additional space for auditorium (for holding symposium, conferences etc) and a lab annexe and accommodation facilities need to be provided in future plan projections.

Specific recommendations:

1. Centre of Excellence for Invasives and Molecular Modelling is to be conceived for NBAIR and necessary provisions to be made in future programmes/ budget.

2. As the Bureau's activities have diversified , there is a constant need to maintain insect resources/cultures in confinement and under control conditions for advanced studies, there is a need to develop state of the art, controlled insect rearing facility at NBAIR.
3. A **specialized curator** for the Insect/ Arthropod National Reference Collection and museum must be appointed to maintain the museum as per International standards.

4. NBAIR should have a **Scanning Electron Microscope (SEM)** to address the futuristic need of arthropod systematics which could be a national facility for ICAR/SAU in the country.

5. A need for a **mobile insect museum** cum **insect collection and preservation laboratory** was strongly felt as a necessity to meet the mandate of the Bureau.

6. **The number of taxonomists may be increased to develop expertise in biosystematics of important insect groups to** build up a virtual repository in terms of barcoded digitised domain for easy access for identification of insects and act as a nodal centre for identification and characterization.

7. Field identification guide for arthropod biodiversity (bioagents, honeybees, pollinators, lac insects, silkworms, veterinary pests) of **economic importance is a must**

8. HRD programmes for capacity building of core group of taxonomists well versed in morphological and molecular taxonomy

9. Establish linkages with National (ZSI, FRI, NPC, conventional universities) and Intrernational (CABI, BNHM, National Museum, Washington DC) to facilitate collections, gain expertise to benefit taxonomists
10. Focus on structural genomics and bioinformatics for selected arthropods, with a networking policy and linkage with centres for biotechnology and bio-informatics. Gut microflora must be explored for their utilization and manipulation for pest management.

11. Biosecurity, threat perception with action-plan for putative accidental introduction of invasives.

12. Focus on *in situ* provision of shelters/refugees, crop habitat diversity for encouraging beneficial organisms and natural enemies.

13. Impact of climate change on arthropod diversity, tritrophic interactions, niche overlaps and migration to be studied in the context of population dynamics of the pest and their natural enemies

14. Research on nano formulations/nano sensors of semiochemicals with greater shelf life must be taken up for the management of key lepidopteran pests across the crops.

15. Field demonstrations and transfer of technology to the farming community must be taken up on regular basis through effective extension linkages with State departments/SAUs/KVKs etc. for effective adaption towards doubling the farm income.

16. Socio economic impact analysis of the technologies must be assessed.

17. The Bureau must be made as a centre for advanced insect studies addressing biosystematics, biotechnology, bioinformatics, physiology and ecology.

18. NBAIR to be linked with other crop based institutes for technical support on new diseases/pests specific to the crop. One entomologist must be linked with other institute

19. A full-fledged recreational facility at main campus/Attur campus may be envisioned for the welfare of the staff.

20. Increased laboratory space is required at ICAR-NBAIR for the future plan period considering the mandate and the research activities carried out. The QRT recommends for lab space totaling to 8187.43 sq.m from the existing 4686.743 sq.m.

    The sanctioned manpower strength is 30 scientists, 17 technical staff, 11 administrative staff and 6 supporting staff. Enhanced manpower strength of 35 scientists, 21 technical staff, 17 administrative staff and 6 supporting staff may be provided. Atleast 50% of the additional manpower of scientists must be entomologists. The position of microbiologist, pathologist and biochemist to be retained for more interdisplinary research.

b. Human Resource Development

The human resource development must be strengthened. Capacity building for scientists should be a continuous process to take stock of the latest developments in the area of research and the technical know-how. International trainings and colloboration with institutes to gain expertise must be ensured.

c. Infrastructure

A Scanning Electron Microscope (SEM) to address the futuristic need of arthropod systematics which could be a national facility for ICAR/SAU in the country must be established at the Bureau.

d. Future thrust areas

In order to accomplish its vision and mission, the NBAIR would focus on the following thrust areas, under the mandate of the bureau.

1. Division of Germplasm Collection and Characterization

- Collection and characterization of agriculturally important insects and other arthropod biodiversity including pests, bioagents, honey bees and other pollinators, lac insects, silkworms, vectors, dung beetles, veterinary pests, etc
- Strengthening traditional taxonomy and documenting biodiversity of insect pests; spiders; pollinators and veterinary pests and their natural enemies and act as nodal agency for characterization.
- Creation of a museum on international standards for repository of genetic resources of agriculturally important insects. Curator to be employed..
- Develop identification tools and databases on insects and insect resources and mapping their biodiversity
- Human Resource Development (HRD) in insect systematics and molecular systematics including standing course on arthropod taxonomy to all the in-service/ freshly recruited entomologists of NARS.
- Outreach programs for biodiversity documentation of different crop-based systems

2. Division of Genomic Resources

- Molecular profiling for characterization of genetic diversity and conservation of morphologically well characterized beneficial insects including insect bioagents, lac insects and associated endosymbionts, honey bees and other pollinators, silkworms, etc. and molecular techniques for rapid quarantine screening for alien invasives.
- Nodal agency for characterization, diversity analysis, DNA barcoding, phylogeny, development of species-specific markers for insects, arthropods and other organisms.
- To develop genomic database and library for insect resources in the country; establish genetic and molecular evolutionary trends in insects, genetic prospecting of insect resources for maintenance, conservation, utilization and improvement, and metagenomic analysis of insect derived resources and development of gene barcodes.
- Gene mining for the identification of genes from microbial agents useful in pest management
- Development of databases, software tools and portals for insect resources; development of web consultancy, blogs and e-network for insects, natural enemies, insect resources and workers
- Identifying the potential of *RNAi* in insect pest management. Identification of suitable target genes involved in various physiological processes(growth, development and survival) and silencing them to usher in a new eco-friendly approach that is safe to non-target organism (*Spodoptera litura*, *Tribolium castaneum*)
- Genome mapping of atleast five insects of national importance (*Helicioverpa*, *Spodoptera.*, *Tribolium.*, ,*Apis cerana* , *Holotrichia* etc. ,). Develop a genome database for insect pests.

3. Division of Germplasm conservation and utilization

- Exploration for specific groups of beneficial insect resources and basic studies to evolve protocols for mass production of beneficial insects, insect pathogens and entomophilic nematodes , their utilization and conservation
- Pollination ecology, crop productivity and biological control under protected cultivation
- Understanding the ecology and dynamics of soil arthropods in food webs and their trophic relations in crop ecosystem
- To conduct in-depth studies on areas related to quarantine and biosafety of invasive pests and have an action plan for mitigating accidental introductions; development of containment facility; strengthening international collaboration and public/private sector partnerships.
- Impact of global warming and climate change on arthropod biodiversity with focus on pollinator diversity, parasitoids, pests, etc. with special emphasis on cyclic analysis, population trends and prediction models in select crop-based systems
- Synthesis and evaluation of pheromones for new and major pests, with special reference to chemical communication and tritophic interactions with partnership from selected crop institutes
- Use of nano-formulations of semiochemicals with increased shelf life and greater efficiency on targeted insect pests should be the addressed.

- Identification of semiochemicals to attract parasitoids and predators. The *in situ* provision of shelters and refuges as alternatives for encouraging these beneficial organisms must be encouraged
- Ecology of spiders and their utilization for pest management must be studied in depth.
- Mapping of biodiversity of microbial biocontrol agents in Sub-Himalayan region, Andaman & Nicobar Islands and Northeastern India.
- Cataloguing, conservation, utilization and metagenomic analysis of biodiversity of agriculturally beneficial nematode fauna.
- Biodiversity of major vectors, *viz.* aphids, whiteflies, thrips, leafhoppers, etc.and the role of endosymbionts

Economic analysis of the project by the QRT

SWOT analysis of NBAIR

a) Strength

Conservation of rich biodiversity of India is of prime importance from the point of intellectual property rights. India is one of the 12 countries accounting for maximum diversity in animal and plant species. . India played a key role in export of natural enemies for the biological control of several crop pests in other countries. At least 27 natural enemies of Indian origin have established in other countries. NBAIR has established well equipped laboratories for molecular identification of insects. The bioinformatics and genomics division has already developed DNA barcodes for more than 289 insect species.

NBAIR has facilities to study the possible effects of global warming and climate change on insects. The strong pool of pathologists have identified virulent strains and also developed efficient formulations of antagonistic fungi, bacteria, virus, entomopathogenic nematodes and nematicidal fungi with long shelf life.
The Bureau has well equipped laboratories and hostel facilities for Human Resource Development and Capacity building activities. The Bureau with its strong network of AICRP centres, located in diverse agro-climatic zones has successfully demonstrated the superiority of Bio-intensive Pest Management practices in several crops.

b) Weaknesses

Identification is a prerequisite for all biological control programmes. The diminishing trend of availability of insect biosystematists for specific groups of insects in India is the greatest weakness. Presently NBAIR is having only thirteen insect taxonomists. There is a need for more taxonomists for specific groups of insects. There is lack of awareness about the long term beneficial effects of use of parasitoids and predators for the suppression of crop pests. The limitations for large scale production, storability and supply has has prevented the widespread adoption of biocontrol.

c) Opportunities

The rich biodiversity in our country gives us ample opportunity to be a potential exporter of natural enemies and to earn valuable foreign exchange. Identification of pesticide and temperature tolerant strains of natural enemies has given an opportunity to use them under stressed ecosystems. Both pesticide and heat tolerant strains of natural enemies can be easily integrated with efficient Bio-intensive pest management strategy. Identification of virulent entomopathogens like *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii* and *Nomuraea rileyi* and virulent strains of entomopathogenic nematode also has given very good opportunity for developing good formulations with long shelf-life, which can enhance the use of these bio-pesticides for the management of crop pests.

Creation of international standard quarantine facility has provided for quarantining, conduct of safety tests and mass multiplication of introduced parasitoids for the management of invasive pests.

The augmentation of the natural enemies helps not only in the conservation and enhancement of the existing biodiversity of natural enemies but also favours organic cultivation without the use of pesticides.

d) Threats

The biggest threat to biological control is from the continued and indiscriminate use of broad spectrum pesticides .The hyperparasitoids in certain seasons nullify the effect of inundative release of natural enemies. Despite availability of mass production techniques for some natural enemies, the private companies are not coming forward in a big way for producing natural enemies. The non-availability of natural enemies at appropriate time is hampering the adoption of biological control on a large scale.

The danger of introduction of alien pests has increased with the opening up of the economy to the world market. The absence of a declared policy in recognizing biological control as a high priority area is a major limitation.

Overall performance rating of NBAIR

The different divisions of the Bureau have conducted excellent research work on agriculturally important insects in the area of insect collection, identification, systematics, insect conservation, pollination ecology, semio chemicals for pest management, molecular characterization of insects and developing DNA barcodes. The Bureau has hosted in its website information on biocontrol agents and agriculturally important insects in the form of fact sheets and also a directory of taxonomists available in India for different groups of insect orders/families. Thirty five databases have been developed by the Bureau during the period under report.

A number of technologies were developed and commercialized by the scientists working at the Bureau. About 27 technologies have been developed, 18 were commercialized and 22 patents have been filed.

22 Software protocols were developed and the number of research papers published were 479

The bureau was awarded with the Sardar Patel Outstanding ICAR Institution Award 2015

The Bureau's performance during period under report is graded "Excellent"

A. INTRODUCTION

The Director General, Indian Council of Agricultural Research (ICAR) constituted the VII Quinquennial Review Team (QRT) with the following experts to review the progress of research and impact and other relevant activities undertaken by the National Bureau of Agriculturally Important Insect Resources (NBAIR), Bengaluru and the AICRP on Biological Control of Insects Pests, during the five year period from 2012-13 to 2017-18 vide **Council's order F. No. CS. 15/3/2017-IA-III dated 11th Janaury 2018**

1. Dr. J. H. Kulkarni — Chairman
   Former Vice Chancellor,
   University of Agricultural Sciences,
   Dharwad - 560006 (Karnataka)

2. Dr. Mohammed Hayat — Member
   Department of Zoology
   Aligarh Muslim University
   Aligarh - 202002 (UP)

3. Dr. R. S. Gill — Member
   Professor & Head (Retd.)
   Department of Entomology
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4. Dr. H. B. Singh — Member
   Benaras Hindu University
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   Varanasi

5. Dr. Lalith Achoth — Member
   Professor & Head
   Department of Diary Economics & Business Management,
   Dairy Sience College, Hebbal
   Bengaluru - 560024

6. Dr. V. V.Ramamurthy — Member
   Ex-Principal Scientist (Entomology)
   IARI, Pusa, New Delhi - 110012

7. Dr. K.Srinivasa Murthy — Member Secretary
   Principal Scientist
   NBAIR, Bengaluru - 560 024.

The terms of Reference, as provided in the ICAR Guidelines for QRT, followed for the review are given in Annexure-I.

The Interface meeting of the QRT with **Dr. A. K. Singh.,** Deputy Director General (Crop Science), ICAR, New Delhi, Dr. Pranjib Kumar Chakrabarty, Assistant Director General (Plant Protection and Biosafety), ICAR, New Delhi along with Dr. Chandish R. Ballal, Director, NBAIR, Bengaluru was held on **3rd February 2018** in the conference hall at NASC complex, Pusa, New Delhi.

The members of QRT visited **NBAIR on 26th February, 2018** and reviewed the research achievements, technologies developed and future research programmes. The QRT also visited different laboratories to get a glimpse of the facilities created, space available for scientists and future needs. The QRT also visited NBAIR research farm, at Attur, Bengaluru and reviewed the progress of work and farm development and the activities carried out.

B. THE PROCESS

The Indian Council of Agricultural Research, New Delhi constituted a five-member Quinquennial Review Team under the chairmanship of Dr. J. H. Kulakarni to review the research work undertaken by National Bureau of Agriculturally Important Insect Resources, AICRP on Biological Control of Insects and Weeds, for the period 2012-2017 in February, 2018.

The first interface meeting of the QRT with **Dr. A. K. Singh,** Deputy Director General (Crop Science), ICAR, New Delhi, Dr. Pranjib Kumar Chakrabarty, Assistant Director General (Plant Protection and Biosafety), ICAR, New Delhi along with Dr. Chandish. R. Ballal, Director, NBAIR, Bengaluru was held on 3rd February 2018 in the conference room at NASC complex, Pusa, New Delhi.

The DDG (CS) suggested the need for review of the Bureau. The QRT was appraised about the terms of reference of the QRT and was provided with the background information of NBAIR. A brief presentation was made by the Director, ICAR-NBAIR on the previous QRT report (2007-12) and the current activities and achievements made. The evaluation proforma for the Bureau and recent ICAR Guidelines for the QRT were discussed.

Tour itinerary of the QRT

Date	**Place**	**Centres reviewed**
3rd February 2018	New Delhi	First meeting of QRT with DDG (CS) and ADG (PP)
26th February 2018	Bengaluru	NBAIR, Bengaluru

The methodology for review allowed for lengthy interactive sessions with the PIs of the different research projects as well as members and other scientists. The PIs of different research projects were requested to present the salient achievements made during the last five years followed by a discussion with all the members on future line of work. The members had opinions about the

methodology followed for different experiments and also critically analyzed the results. Wherever possible, the members had discussion with the Director of the Bureau and sought her opinion.

A proforma was also developed to evaluate the Bureau (Annexure-II)

C. MAIN REPORT

i. Brief History of the Project

Brief History of NBAIR

The **ICAR - National Bureau of Agricultural Insect Resources (NBAIR)**, Hebbal, Bengaluru was established on the premises of the erstwhile **Commonwealth Institute of Biological Control (CIBC)**. It has had a long history of changes in names and objectives to cater effectively to the changing needs of the farming community of our country. The Indian station of the Commonwealth Institute of Biological Control with its headquarters in the United Kingdom was established at Bengaluru in 1957 with the express purpose of promoting and strengthening biological control of agricultural pests including weeds in various parts of the world. Recognising the need for a national programme on biocontrol, the **All India Coordinated Research Project on the Biological Control of Pests and Weeds [AICRP (BC)]** was launched by the ICAR with funds from the Department of Science and Technology, New Delhi in 1977 to cater exclusively to conceive and implement pest management programmes using bioagents (both indigenous and exotic) in the context of Indian Agriculture. Having gained over a decade of experience in the field of biological control, the AICRP (BC) took over the Indian station of CIBC in 1988. The biological control programme from then on was totally national in character. This programme was coordinated by the Project Coordinator stationed at Bengaluru but under the administrative control of the National Centre for Integrated Pest Management (NCIPM), Faridabad for a short while. However, in the VIII five-year plan, the Bengaluru Centre was elevated to the **Project Directorate of Biological Control (PDBC)** with effect from 19th October, 1993. Subsequently in 2009, in the XI plan, the PDBC was upgraded to the **National Bureau of Agriculturally Important Insects (NBAII)** and the mandate was modified. The Bureau does not have any regional centres. The AICRP has 16 centres along with 4 voluntary centres (added during XI plan), all functioning under the Bureau. In the 12th five-year plan, it was rechristened to the present name **(ICAR - National Bureau of Agricultural Insect Resources)** with effect from 24th September, 2014. Indian Council of Agricultural Research, New Delhi adjudged it as the best ICAR INSTITUTE, 1998 (FOR THE PERIOD 1993-98). **The bureau was bestowed with the Sardar Patel Outstanding Institution Award during the year 2015.**

Mandate of the NBAIR

- To act as a nodal agency for collection, characterization, documentation, conservation, exchange, research and utilization of agriculturally important insect resources (including mites, spiders and related arthropods) for sustainable agriculture.
- Capacity building, dissemination of technologies and forging linkages with stake holders.
- On farm validation of biocontrol strategies, forging linkages with commodity-based crop research institutes, AICRP/AINP and capacity building.

Objectives

The specific objectives of the Bureau are addressed under three divisions as given below:

Division of Insect Systematics (Presently, Division of Germplasm Collection and Characterization)

- Augmentation of collection and maintenance of a national repository
- Biosystematic studies on insects, spiders and mites using traditional and molecular approaches and DNA barcoding
- Generation of checklists, catalogues, illustrated field identification guides and digitization of collections, networking of institutions and individuals working on biosystematics and identification services
- Classical biological control, biosecurity, threat perception with action-plan for alien pests

Division of Molecular Entomology (Presently, Division of Genomic Resources)

- Whole genome sequencing of some important insects and entomopathogenic nematodes
- Gene and allele mining for the selection of genes of specific interest and their utilization
- *RNAi* technology for IPM
- Genome sequence repository for useful genes
- Endosymbionts and determination of their functional role
- Use of bioinformatics tools and development of genomic databases

Division of Insect Ecology (Presently, Division of Germplasm Conservation and Utilization)

- Utilization of agriculturally important arthropods for the management of insect pests
- Development of protocols and designs for the establishment of state of art mass production units for beneficial insects
- Introduction of beneficial quarantine and post-release monitoring
- Effect of climate change
- Role of pollinators in crop productivity
- Role of semio-chemicals for insect pest management
- Studies on virus-vector dynamics

iii. Priorities, programmes and research projects (Division wise)

Projects

1. Division of Germplasm Collection and Characterization

- Biodiversity of economically important Indian Microgastrinae (Braconidae) supported by molecular phylogenetic studies (21.09.2010 to 31.03.2016)

- Introduction and studies on natural enemies of some new exotic insect pests and weeds (27.08.2010 to 31.03.2016)

- Genetic diversity, biology and utilization of entomopathogenic nematodes (EPN) against cryptic pests (01.04.2012 to 31.03.2015)

- Biosystematics and Diversity of Entomogeneous Nematodes in India (01.04.2012 to 31.03.2017)

- Biosystematics of Trichogrammatidae (Hymenoptera) (01.04.2013 to 30.09.2017)

- Biodiversity of oophagous parasitoids with special reference to Scelionidae (Hymenoptera) (01.04.2008 to 31.03.2018)

- Taxonomic studies on fruit flies (Diptera: Tephretidae) of India (01.04.2012 to 31.03.2017)
- Taxonomic studies on Pentatomidae (Hemiptera: Pentatomoidea) of India with special reference to Pentatominae (01.04.2012 to 31.03.2020)

- Digitization of type specimens in NBAII reference collection (01.04.2013 to 31.09.2018)

- Biosystematics and Diversity of Agriculturally Important Cerambycidae (01.10.2013 to 31.03.2017)

2. **Division of Genomic Resources**

- Mapping of the *cry* gene diversity in hot and humid regions of India (01.04.2011 to 31.03.2017)

- Role of microbial flora of aphids in insecticide resistance (01.10.2012 to 31.03.2017)

- Development of computational tool for prediction of insecticide resistance gene in agriculturally important insects (01.04.2012 to 31.03.2015)

- Mechanism of insecticide resistance in *Leucinodes orbonalis* and *Leucopholis coneophora* (01.10.2012 to 31.03.2016)

- Culturable and unculturable microflora associated with soil insects and other arthropods (01.04.2013 to 31.03.2017)

- Distribution of abiotic stress tolerant genes / alleles across insect orders (01.04.2014 to 31.03.2017)

- Molecular characterization and DNA barcoding of some agriculturally important insect pests (01.04.2013 to 31.09.2018)

- Molecular characterization and DNA barcodding of agriculturally important parasitoids and predators (01.06.2013 to 31.05.2018)

- Molecular characterization and DNA barcoding of subterranean insect diversity (01.04.2014 to 31.03.2019)
- Taxonomy and diversity of sphecids (01.09.2014 to 31.03.2020)

3. Division of Germplasm Conservation and Utilization

- Formulations of pheromones of important borer and other crop pests and kairomones for natural enemies using nanotechnology (01.04.2008 to 31.03.2014)
- Influence of elevated levels of carbon dioxide on the tritrophic interactions in some crops (01.07.2009 to 31.03.2014)
- Biodiversity of aphids, coccids and their natural enemies (01.04.2009 to 31.03.2017)
- Microflora associated with insecticide resistance in cotton leaf hoppers (*Amrasca biguttula biguttula*) (01.04.2012 to 31.03.2015)
- Insect vector components influencing phytoplasma diseases (01.01.2012 to 31.03.2015)
- Pollinator diversity in different agro climatic regions with special emphasis in Non-*Apis* species (01.04.2012 to 31.03.2017)
- Diversity and predator-prey interactions with reference to predatory anthocorids and mites (24.03.2012 to 31.03.2017)
- Influence of infochemical diversity on the behavioural ecology of some agriculturally important insects (01.04.2013 to 31.03.2017)
- Exploitation of *Beauveria bassiana* for the management of maize stem borer (*Chilo partellus*) and tomato fruit borer (*Helicoverpa armigera*) through endophytic establishment (01.04.2014 to 31.03.2017)
- Studies on Tospovirus-Thrips interactions leading to transmission (01.09.2016 to 31.03.2017)
- Synthesis of Nanomaterials to act as sensor for semiochemicals in pest management (01.07.2013 to 31.07.2017)
- Chemical characterization and ethology of economically important dipteran pests of veterinary and fisheries (09.10.2014 to 09.10.2017)
- Climate change effect on the diversity and bioecology of some important sucking pests (01.04.2014 to 31.03.2019)

- Documenting agriculturally important mites and establishing an authentic collection (01.04.2014 to 31.03.2019)

- Diversity and predator-prey interactions in predatory mirids and geocorids (01.10.2015 to 31.03.2019)

Salient Achievements of NBAIR - Division wise for the period 2012-2017

Division of Genomic Resources

2012-13

- Database on Entomopathogenic nematodes developed (http://www.nbair.res.in/EPN-mp/index.html)
- Molecular characterization of 527 insects and their resources were carried out and NCBI accession numbers were obtained. DNA barcodes for 81 insects were developed.
- A strain of *Trichogramma chilonis* was developed for its tolerance to 5 groups of insecticides and resistance factor ranged from 3.0-156.0 folds after selection for more than 65 generations. Similarly, a strain for tolerance to high temperature $\geq 40^0$C with parasitizing ability of ≥55% compared to 5-15% by laboratory strain under high temperature conditions. Various genes for insecticide tolerance and heat shock protein were amplified in these strains.
- *Pichia anomala* and *Metschnikowia reukaufii* were the endosymbionts identified for sex alteration in *T. chilonis* which increased the % parasitism and the fecundity of *T. chilonis*. Percent parasitism in *Trichogramma* with endosymbionts was in the range of 82-98%, with an overall increase of 38% increase over control. Increase in per cent females was 45.0-80.0. Similarly, fecundity was high (35-54) with 84% increase over control. The sex regulatory endosymbiont, *Wolbachia* was determined in *T. chilonis*, cultured and maintained on insect ovarian (Sf9, Sf21 and Aa23) cell lines. For high temperature, back crosses of *T. chilonis* with their tolerant parents recorded high parasitism of 46.8% with 56.4% female emergence compared to the susceptible population (31.2%). For insecticide tolerance, degree of dominance was worked out and for the endosulfan and spinosad, semi-dominance was observed, while for λ-cyhalothrin and indoxacarb, complete dominance was observed.
- Crude preparations of *vip*3A protein was obtained form 20 *Bacillus thuringiensis* isolates and tested against *Spodoptera litura*. The protein from two of the isolates (EG1 and BtAN4) showed high toxicity with a LC_{50} value of 9.09 and 9.92 µg/ml respectively.
- Liquid formulation of NBAII-EG1 was tested against pigeon pea pod borer (*Helicoverpa armigera*) under field conditions. The results showed the per cent pod damage was 11.20% with 2% spray of NBAII-EG1 and was on par with insecticide spray (11.11% pod damage).
- Process developed: protocol for pilot scale *in vivo* production of EPN - 2 tonnes per production cycle of 30-45 days.
- Products developed: Wettable powder formulations of EPN with shelf life of 10-12 months. WP formulations of EPN reduced incidence of rootgrubs in arecanut of Sulya by 62-78% (to an average of 2-4 grubs/plant), and promoted fresh roots and foliage.
- Performance conditions of 8 isolates of EPN identified based on field trials at six locations. Formulations of *H. indica, H. bacteriophora, S. abbasi* consistently reduced grub populations in 3 locations with 3 soil types.

- EPN technology was licensed to Sri Biotech Research Labs Ltd., Hyd, K. N. Biosciences, Hyd and Multiplex Bio-Tech Pvt. Ltd., Bengaluru, and a revenue of Rs.8 lakhs generated.
- *Pochonia chlamydosporia* and *Paecilomyces lilacinus* were included in package of practices in Dept of Agriculture and SAUs, Gujarat through AICRP trials for control of nematodes in citrus, pomegranate and pigeonpea.
- Organized a brainstorming Session on *"Roadmap for Entomopathogenic Nematode Research & Utilization in IPM"* on April 20, 2012.

2013-14

- Developed E-resource on mass production protocols for agriculturally important insects (http://www.nbair.res.in/IOBC-mp/index.html)
- Developed Arthropod Germplasm Information System (AGIS)
- Molecular characterization of 408 insects and their resources were carried out and NCBI accession numbers were obtained. DNA barcodes for 50 insects were developed.
- Status of insecticide resistance for the fourteen population of *H. armigera* was analysed and the *Bt* cotton population from Amreli registerd the highest resistance to all the tested insecticides.
- The multiple insecticides and high temperature tolerant strain of *T. chilonis* were field evaluated in 10 states at 16 different places covering 524 acres in sugarcane, rice, tomato, brinjal and cabbage. In field trials in Punjab on tomato crop, increase in yield was 8.16 q/acre, and % reduction in insecticide was 25 and the additional revenue per acre was Rs. 13872. In Gujarat, increase in rice yield was 158.83 kg/acre and the additional benefit / acre worked out to Rs. 2300/-. In Arunachal Pradesh, rice crop increase in yield was 772.66 kg/acre and Rs. 10199/- was % benefit/acre. In Assam in rice crop yield increased by 364 kg/acre and the additional revenue was Rs. 4805/acre. In Karnataka, yield increase in rice crop was 933 kg/acre with additional revenue of Rs. 14462/acre. In Uttar Pradesh, increase in yield was 1500 kg/acre with additional revenue of Rs. 9000/acre. In Tamil Nadu, increase in yield was 15-20% with additional revenue of Rs. 20000/acre to tomato and brinjal farmers.
- A PCR based method for detection of viral DNA in nucleopolyhedrovirus of three lepidopterans *Spodoptera litura*, *Amsacta albistriga* and *Helicoverpa armigera* was developed by employing the late expression factor-8 (lef-8) gene of three NPV using specific primers. The amplicons of 689, 699 and 665 bp were amplified, respectively, and the nucleotide sequences were submitted to GenBank and the accession numbers were obtained. The sequences of lef-8 gene of *S. litura* NPV and *H. armigera* NPV matched with those of their respective references in the GenBank database, thereby confirming their identity, however, the sequence of *A. albistriga* NPV was the first sequence submitted to the GenBank database.
- Formulations of an abiotic stress tolerant plant growth promoter *Pseudomonas fluorescens* (PFDWD) was evaluated in saline affected fields of Karnataka, Gujarat and Tamil Nadu. In groundnut seed treatment @ 10g/kg of seed showed 10-15% enhanced yield as compared to untreated control plots. This technology was sold to two companies.
- Seven isolates expressing the coleopteran specific *cry3A* gene were tested against the coleopteran pest *Sitophilus oryzae*, (stored grain pest) along with the international standard strain (4AA1). The isolate *Bt*AN4 was comparable with the standard strain and was the most

toxic among the indigenous isolates tested. *Bt*An4 showed the least LC_{50} value of 89.65µg/ml and the standard strain showed LC_{50} value of 85.26µg/ml.

- Thirty five EPN & bacteria were molecularly identified and DNA Barcodes were developed.
- Genomes and transcriptomes of four Indian strains of bacterial symbionts associated with EPN were accomplished first of their kind; genes and pathways related to their virulence and pathogenesis identified during NABG-NAIP overseas training on genomics and transcriptomics.
- LC and LT values for six EPN worked out against *Lepidiota mansueta*, *Holotrichia serrata*, and *Phyllognathus dionycius* in sugarcane. Worked out LC & LT values for 2-4 instar grubs of *Anomala ruficapilla*, *Holotrichia serrata*, *H. consanguinea*, *Phyllophaga*, *Oxycetonia versicolor*, *Protesia* sp., Coffee berry borer, *Coelosterna scabrator*, *Sthenias grisator*.
- Application of WP formulations of *H. indica*, *S. abbasi* and *S. glaseri* at 2.0 $x10^{13}$ IJs/ha at transplanting reduced incidence of *Myllocerus subfasciatus* grubs in brinjal by 44-68% in field and improved yield by 18-24%. *H. indica* with *M. anisopliae* gave 73% control of *Myllocerus* grubs at 90 and 120 days of eggplant growth.
- Licensed and transferred two technologies on production, down-stream processing and development of WP formulations of EPN and *Pochonia chlamydosporia* to Allwin Industries, Indore and Rs. 3.5 lakhs revenue generated.

2014-15

- Molecular characterization of 371 insects and their resources were carried out and NCBI accession numbers were obtained. DNA barcodes for 40 insects were developed.
- Molecular characterization has been done for nine parasitoids and four predators using cytochrome oxidase 1 (CO1) gene and are deposited in GenBank database.
- Fifty-four insect species belonging to five insect orders, *viz*., Lepidoptera, Coleoptera, Orthoptera, Hemiptera and Diptera were molecularly characterized during the period. In Lepidoptera, insects belonged to 4 families consisting of 9 species and 14 populations for molecular genetic diversity study, in Coleoptera, insects belonged to 6 families consisting of 14 species and 2 populations, in Orthoptera, insect belonged to 2 families consisting of 2 species, in Hemiptera, insects belonged to 7 families consisting of 20 species and in Diptera, 1 family and 3 species. The GenBank accession numbers of all species were obtained.
- Gut microflora of insecticides resistant and susceptible population of *Helicoverpa armigera* were analysed using both culturable and non-culturable methods.
- Molecular characterization of 17 gut bacteria from both insecticide resistant and susceptible population has been done.
- The synthetic pyrethroid, insecticide target site protein, Na channel protein- partial mRNA has been sequenced from resistant and susceptible population of *H. armigera* revealed alternative splicing in the 3' region of the gene. Partial m-RNA of Na-channel protein sequence from *H. armigera* is done for the first time in the world.
- Protocol for the DNA extraction and molecular characterization has been standardized for Sphecidae wasps.
- Scarabaied beetles and termites collected from different geographical locations were characterized based on *COI* gene. Thirty-two scarabaeid beetles and thirty-six termites from various locations were characterized and sequences submitted to Genbank.

- Sixty three samples collected from Assam and Karnataka yielded five *Bt* isolates. All harboured *cry1Ac* gene. Protein bioassay against *Plutella xylostella* showed that all were toxic with LC_{50} of 25µg/ml at 24h. *VIP3A* gene was cloned for preparation of formulation with broad spectrum activity.
- Isolated and identified microflora from aphids belonging to *Aphis gossypii*, *A. craccivora* and *Myzus persicae* using molecular tools. Bioassay for insecticide resistance of aphids was conducted with imidacloprid, acephate and λ-cyhalothrin. Screened associated microflora for insecticide degradation by qualitative assays.
- Two populations of *Ha* NPV whole genome sequencing was done and in virulent population, 42 known and 41 hypothetical genes were identified., besides five genes from virulent populations were sequenced for quick and reliable identification.
- Demonstrated NBAIR technology on EPN for the management of whitegrubs in arecanut at Ninasam, Heggodu, Sagar district, Shimoga, on 10 June 2014, for about 250 arecanut growers of Sagar, in collaboration with Heggodu Gramabhivridhi Sangha. Front-line demonstrations of management of whitegrubs in arecanut using EPN formulations and NBAIR technologies were carried out at four villages in Shimoga and Sringeri, covering about 600 farmers during July - September.

2015-16

- Molecular characterization of 474 insects and their resources were carried out and NCBI accession numbers were obtained. DNA barcodes for 72 insects were developed.
- Deep sequncing of gut microflora of three population of *H. armigera,* two insecticide resistance and one susceptible population was carried out using 16srDNA partial gene V-3 region by NGS-based Illumina sequencing. The Bioprojects were created and Biosample were submitted to NCBI database and accession number obtained.
- Quantitative insecticide degradation by aphid associated microflora was accomplished using HPLC analysis and confirmed the role of associated microflora in insecticide resistance. Studied unculturable microflora associated with aphids through metagenomic approaches.
- *Helicoverpa armigera* nucleopolyhedrovirus (HearNPV) from India, HearNPV-L1, was whole genome sequenced and analyzed, with view to look for genes and/or nucleotide sequences that might be involved in the differences among other HearNPVs sequenced from other countries. The entire nucleotide sequence of the HearNPV-L1 genome was 136740 bp in length having GC content of 39.19 mol% and contained 113 ORFs that could encode polypeptides with more than 50 amino acids, the GenBank accession number provided was KT013224.
- Genome size estimation of *L. orbonalis* was confirmed by both flow cytometry and k-mer analysis and was found to be ~850mbp
- The whole transcriptome was sequenced for both resistant and susceptible strains of *L. orbonalis* and submitted to NCBI-GenBank under SRA accession numbers: SRX2338657 (S), SRX2338658 (R), SRX2338657 (S), SRX2338657 (R). Biochemical analysis of esterases and glutathione esterases showed their upregulation in the resistant strain of *L. orbonalis* (Bhubaneshwar) as compared to susceptible (Bengaluru).
- Molecular characterization and DNA barcoding of 262 agriculturally important insect species and populations were done using *CO1* and *ITS* genes, these insects belonged to seven orders,

viz. Lepidoptera, Coleoptera, Hemiptera, Diptera, Odonata, Hymenoptera and Blattodea. The sequences were submitted to GenBank and Barcodes were generated in BOLD systems.

- Ninety *Bt* isolates were isolated from soil samples collected from Western Ghats were screened for *cry* gene diversity using degenerate primers and it was found that all harbored *cry1* gene. Five isolates harbored *cry2* gene. The coleopteran specific *cry8* gene was amplified in one isolate.

2016-17

- Molecular Database on Indian Insects (MODII) has been developed and it contains several databases like Insect Pest Info, Insect Barcode Information System (IBIn), Insect Whole Genome sequence, Other Genomic Resources of National Bureau of Agricultural Insect Resources (NBAIR), Whole Genome sequencing of Honey bee viruses, Insecticide resistance gene database and Genomic tools.
- Molecular characterization of 484 insects and their resources were carried out and NCBI accession numbers were obtained. DNA barcodes for 74 insects were developed.
- Protocol for DNA extraction of thrips was standardized using single thrips by non-invasive method. Around 13 species of thrips have been DNA barcoded using this method.
- Whole genome sequencing of *Leucinodes orbonalis* was carried out using Illumina and PacBio platforms, the draft genome size through hybrid assembly was 816 MB and NCBI accession no. PQWD00000000 was obtained.
- A field demonstration on WP formulation of Entomopathogenic nematode, *Heterorhabditis indica* was organized by ICAR-NBAIR in collaboration with Department of Agriculture, Govt. of Karnataka at Hosur, Matolli, Ingalagi and Enagi villages of Belgaum district in Karnataka under the MGMG programme.
- Liquid formulation technology of *Bacillus thuringiensis* (NBAII-BTG4) for control of lepidopteran pests was evaluated under large scale in Gujarat, Maharashtra and Karnataka to control *Helicoverpa armigera* and *Maruca testulalis* in pigeon pea. The pest was effectively controlled (avg of 15 quintal/ha yield) and the treatment was on par with chemical insecticide (avg. of 16 quintal/ha). This technology was sold to 4 companies.
- Formulations of an abiotic stress tolerant plant growth promoter *Pseudomonas fluorescens* (PFDWD) was evaluated in farmer's saline affected fields of Karnataka, Gujarat and Tamil Nadu. In groundnut seed treatment @ 10g/kg of seed showed 10-15% enhanced yield as compared to untreated control plots. This technology has been sold to two companies.
- Whiteflies, *Bemisia tabaci* on cotton, brinjal, cluster bean, green gram and tapioca; *Aleurodicus rugioperculatus* on coconut, banana, cashew, mango, guava, Indian Almond and many ornamental plants; *Aleurotrachelus trachoides* in chilli, tomato, tobacco and brinjal. *Trialeurodes ricini* on castor and *Dialeurodes kirkaldyi* on jasmine, were documented.
- Natural parasitism of rugose spiralling whitefly by *Encarsia guadeloupae* was recorded which showed about 40-80% parasitism under filed level.
- Collected whitefly specimens from Karnataka, Rajasthan, Punjab, West Bengal, Kerala, Tamil Nadu an Andhra Pradesh in cotton, brinjal, tomato and many other other host plants.
- Unculturable microflora (metagenomic approaches) of *Aphis gossypii* represented Enterobacteriaceae as 89% of total population and 11% belonged to Comamonadaceae. This revealed that the particular bacteria (*Buchnera aphidicola*) are present in higher number (overpopulated) amongst other microflora of gut.

- MitDNA genomes generated for 3 EPN. Eight isolates ready for DNA short sequencing for multiloci (ITS, CO1, SSU, 16sRNA).
- Biology and lifetables of *H. indica, H bacteriophora* and *S. carpocapsae* were determined in coffee stem borer. Ovicidal activity was recorded with *Heterorhabditis* species.
- Scarabaeid beetles were reared on bajra seedlings. Taxonomic identity of museum specimens of termites and scrabaeied beetles was done through molecular characterization. Barcodes were generated for specimens of these subterranean pests.
- Rearing of black soldier fly in designed structures in containment was devised and standardized rearing method. Analysed the compost of degradation through physico-chemical analysis.
- Larval taxonomy to delineate species to link with adults was done. Scarabaeids were reared on bajra seedlings. Taxonomic identity of museum specimens of termites was done. Barcodes were generated for specimens of these subterranean pests.
- *Cry* gene diversity was studied in three North Eastern states namely Meghalaya, Tripura and Assam and 17 types of cry protein genes were identified. Lepidoptera and Diptera specific genes were abundant.
- Molecular characterization of 22 insect species was carried out. These were Dipteran - *Aedes aegypti*, *Anopheles stephensi* and *Culex quinquefasciatus*; Hemiptera - *Neohallys serricollis*, *Eurydema* sp., *Zicrona carrulea*, *Gynenica alami*, *Meridindia salmana*, *Placosternum dama*, *Caystrus abscurus*, *Aleurodicus rugioperculatus*, Cecidomyiidae sp., *Parthenolecanium corni*, *Tuberaphis xinglongensis*; mite - Areca mite (Attur Farm); Lepidoptera - *Parapoynx crissonalis*, *Epicopistis pleurospila*, *Archips* sp.; Hymenoptera - *Trichogramma pretiosum*; *Tuberaphis xinglongensis, Goniozus nephantidis*.
- Transcriptome sequencing was proceeded with extraction of total RNA from the two different populations isolated using the Qiagen RNeasy mini kit. Raw data obtained through Illimina sequencing submitted as SRA a BioProject ID PRJNA352591 SRA were submitted under accessions SRX2338657, SRX2338658, SRX2338659, SRX2338660.
- Transcriptome analysis of *Plutella xylostella* has been done and a set of 41,205 unigenes with an average transcript length of 1077 bp and N50 value 1596 bp has been generated. A number of transcripts encoding genes such as GABA, nAChRs etc. were amongst those selected for analysis through qRT PCR.
- Analysis of NBAIR-BTAN4 sequence showed that it carried *Cry2Ab*, *Cry1Ac*, *Cry1Ia* and *Cry2Aa*. It also carries 22 other toxin genes including a rare mosquitocidal toxin. *Cry1Ia* is active against coleopteran pests. It was tested against *Holotrichia* sp. and 50% mortality observed in 76h.
- Molecular characterization of sphecid wasps was done for three species *viz., Isorophalum, Bembecinus, and Carinostigmus*.
- Survey was done for the collection of pink bollworm in 3 states *viz*., Gujarat, Andhra Pradesh and Karnataka. 10 districts of Gujarat and 1 district each in Andhra Pradesh and Karnataka were surveyed.
- Pink bollworm damage assessment was done in all the ten districts of Gujarat and one district each in Andhra Pradesh and Karnataka on terms of % locule damage, number of larvae/boll and number of exit holes/boll. The rearing and bioassay procedure for pink bollworm was standardized in the laboratory.

Division of Germplasm Collection and Characterization

2012-13

- Online identification aids for agriculturally important insects hosted on NBAIR's website containing fact sheets for biocontrol agents and crop pests, image galleries, directory of taxonomists offering identification services, DNA barcodes for agriculturally important insects - '*Insect Barcode Informatica* - (IBIn), aphids of Karnataka (URL: www.aphidweb.com), Coccinellidae of the Indian Subcontinent, checklist 15 minor orders of insects of the Indian subcontinent.
- Four new taxa of Tephritidae, four of Platygastridae, one Eucharatidae, one Encyrtidae and two of Trichogrammatoidea were described from India and several species of coccids, aphids and anthocorid predators were recorded new from India.
- International Catalogue published for Microgastrinae (Hymenoptera) of Reunion Island (Indian Ocean) cataloguing 18 new taxa and key to species and describing 10 new species along with 200 macro & micro images.

2013-14

- Described 14 new Indian species of braconids and scelionids described. Developed web portal on "Indian fauna of Pteromalidae", "Chalcidoidea" (38 species fact sheets uploaded in NBAIR website with 126 high resolution images) and Websites on Mymaridae and Diapriidae hosted.
- Website on type specimens in NBAIR prepared with details of entomogenous nematodes were isolated from different agro climatic zones and they were maintained live on wax moth *Galleria mellonella*.
- 32 genera of Platygastroidea recorded for the first time from Odisha.
- Total of 8100 specimens of insects collected and 6950 specimens were identified.
- Processed and prepared 450 slides of various trichogrammatids collected and SEM studies of three species, and identified fifteen genera.

2014-15

- Surveys undertaken in Arunachal Pradesh (Pasighat and surrounding areas), Tamil Nadu (Kodaikanal, Shembaganur), Uttar Pradesh (Aligarh), Assam, Himachal Pradesh (Manali and Shimla), New Delhi, Shevaroy hills (Yercaud), Western Ghats (Valparai, Mudigere, and nearby places) and Karnataka. Reference collections augmented by 8000+ specimens.
- Types in NBAIR collections catalogued and web content on the same created.
- *Kikiki huna*, the smallest known flying insect in the world, collected from Shevaroy hills and added to NBAIR holdings.
- A new genus *Chakra* (Platygastridae) with type species *Chakra sarvatra* described.
- *Ceratovacuna silvestri, Pterochloroides persicae, Coloradoa absinthi, Aphis rumicis, Aphis polygonacea, Sinomegoura citricola, Liosomaphis ornata, Cavariella aegopodii, Mastumuraja rubifiliae, M. capitophoroides, Macrosiphum pachysiphon* (Aphididae), *Chionaspis salicis* (Diaspididae) and *Trionymus bruneiensis, Chorizococcus* sp. (Pseudococcidae) added as new to the existing collection.
- Entomopathogenic nematodes belonging to and *Steinernema* sp. (3) and *Heterorhabditis* sp. (4) were documented.

- Web portal for identification of 'Indian fauna of Pteromalidae' updated with additional 12 species
- Illustrated fact sheets for 76 species of insect pests with 504 images and 28 species of insect bioagents with 152 images prepared and hosted on NBAIR's website. Two mymarid genera, *Schizophragma* and *Kikiki,* were added to the web content hosted on Mymaridae of India.

2015-16

- Fifty seven expeditions and regular light trap collections yielded 1509 insect specimens belonging to different orders. Survey was conducted in Goa (2 places), Karnataka (37 places), Tamil Nadu (11 places), Kerala (4 places), Himachal Pradesh (2 places), Arunachal Pradesh (1 place). Mainly insect species belonged to Braconidae, Ichneumonidae, Pteromalidae, Eulophidae, Platygastridae, Trichogrammatids, Sphecidae, aphids, coccids, ticks, thrips and mites.
- Surveys were carried out in tomato fields in Kolar, Bengaluru and around Ramanagara did not record incidence of *Frankliniella occidentalis*.
- Five type species *viz.*, *Cassidibracon repens* Gupta 2015, *Diolcogaster andamanensis* Gupta & Fernández-Triana 2015, *Diolcogaster duocolor* Gupta & Fernández-Triana 2015, *Diolcogaster longistria* Gupta & Fernández-Triana 2015, *Diolcogaster solitarium* Gupta & Fernández-Triana 2015 were digitized and uploaded online.
- The insects which were added as new to collection were *Aphis solitaria*, *Brachycaudus napelli*, *Greenidea eugeniae*, *Paraputo theaecola*, *Aphis caryopteridis*, *Myzus antirrhinii* and *Macrosiphoniella pseudoartemisae*, two entomopathogenic nematodes belonging to *Steinernema* sp. and *Heterorhabditis* sp. were added as new collection.
- A tick collected on cobra was identified as *Aponnomma laevi*, thrips collected from mango were identified as *Haplothrips tenuipennis* Bagnall and from mulberry as *Scolothrips asura* Ramakrishna and Margabandhu and *Megalurothrips distalis* (Karny). A new species group of *Idris* has been proposed with descriptions of five new species in this species group. The monotypic genera *Pardoteleia* and *Apteroscelio* are recorded for the first time in India and are being studied. Invasive leaf miner on chrysanthemum recorded from Nilgiri hills.

2016-17

- Around 200 specimens were collected across four States of India *viz.,* Karnataka and Tamil Nadu. The collected specimens were processed, mounted and added to the NBAIR collection. The specimens were identified using morphological taxonomy, *Carinostigmus atterimus*, male has been discovered after 100 years.
- Survey was done in Karnataka mainly Bengaluru (in and around areas). Collected ~1000 specimens of Hymenoptera, >100 species during ~30 survey days. Identified more than 30 morphospecies for molecular characterization.
- *Megaprosternum cleonarovorum* Gupta & Azevedo (Bethylidae: Scleroderminae) type digitized.
- Two thrips genera (*Rhamphothrips* Karny and *Plesiothrips* Hood) and four species (*Asprothrips bimaculatus* Michel & Ryckewaert, *Plesiothrips perplexus* (Beach), *Pseudodendrothrips darci* (Girault) and *Rhamphothrips pardus* (Bhatti)) were newly added to the reference collection of ICAR-NBAIR.
- A total of 163 species of coccids were identified. Identification services were provided to 35 institutions and Agricultural Universities. *Eulecanium tiliae*, *Parthenolecanium corni* and

Metaceronema japonica were added as new to existing collection of ICAR-NBAIR. *Tuberaphis xinglongesnis* was recorded for the first time from India feeding on arecanut.

- A new species of Trichogrammatoidea described. Identified 50 specimens of *Trichogramma* on request from NIBSM, Chattisgarh
- Thirty one species of cerambycids are considered as agriculturally important pests, causing significant damages to the crop plants. These species were freshly collected from their natural habitats and descriptively examined about their morphology, host plants and distribution records. The list included 16 species of Lamiinae, 12 species of Cerambycinae, two species of Prioninae and one species of Lepturinae. An illustrated taxonomic key for these genera was prepared for their easy field identification.
- Total 95 specimens of weevils were collected/ received from, Udaipur, Goa, Ludhiana, Dharmapuri, Thiruvananthapuram, Jaunpur (UP), Mathura, Kanakpura and Attur. Prepared checklist for the important genera based on the zoological records and available literatures. Two identification services have provided.
- Five species of trichgrammatids belong to *Trichogramma* and *Trichogrammatoidea* were identified. The genus *Megaphragma* and *Trichogrammatoidea* collected for the first time from Uttarakhand.
- Collected white grub specimens from Ranichauri, Uttarakhand; Belgaum, Dharwad, Karnataka; Tirupati, Andhra Pradesh and Kerala and identified to species level. Taxonomic categorization and characterisation of the species and documentation of distributional records was done.
- *Termatophylum orientale* Poppius is reported for the first time from India. It was collected from *Mangifera indica* (mango), *Carica papaya* (papaya) and *Peltophorum pterocarpum* (Copperpod).
- NBAIR has provided identification services for 6500 insect specimens, thus providing savings of US$ 650,000**.**
- Surveys for fruit flies in Karnataka and Tamil Nadu revealed 36 species in 13 genera. Two new species of *Bactrocera* Macquart, *B*. (*B*.) *furcata* David & Hancock, *B*. (*Sinodacus*) *brevipunctata* David & Hancock were described from India. Four species of *Bactrocera* were recorded for the first time from India namely *B*. (*B*.) *rubigina*, *B*. (*B*.) *aethriobasis*; *B*. (*B*.) *tuberculata*; *B*. (*B*.) *syzygii*. Key to all subgenera of *Bactrocera* in India and all species of subgenus *Bactrocera* were published. Twenty-eight species of Tephritidae were barcoded.
- Approximately 120 specimens (19 species belonging to 14 genera) of Pentatomidae were collected and identified from various regions of Karnataka.
- Described a new terebrantian thrips species, *Bregmatothrips ramani* Rachana & Varatharajan, 2017 from Anadaman Islands of India. The presence of New World thrips genus, *Plesiothrips* from India with a note on *P. perplexus* was reported. Specimens of *Phibalothrips peringueyi* (Faure) and *Frankliniella intonsa* (Trybom) were barcoded.
- At the species level, *Neoscona shillongensis* (Family: Araneidae), *Stegodyphus tibialis* (Family:Eresidae) and *Aelurillus kronestedti* were reported as new distribution record from Karnataka, Kerala and Tamil Nadu respectively.The cribellate spider, *Stegodyphus tibialis* (O. Pickard-Cambridge, 1869) (Family: Eresidae)- female still not described is under description.

Division of Germplasm Conservation and Utilisation

2012-13

- Pollinator exclusion studies in sunflower showed that the pollinators enhance seed set by 3.7% over control. In mango, dipteran (Calliphoridae, Syrphidae, Sarcophagidae, Muscidae) and *Apis florea* are major pollinators.
- More than fifty nano-formulations were synthesized from biocompatible materials, such as chitosan and other substances, which allow slow release of absorbed pheromones or kairomones, thereby extending effectiveness. The biosafety of these nano-particles was also established.
- Insecticides degradation with endosymbionts indicated differential response of five different endosymbionts for their ability to degrade imidacloprid and indoxacarb. The endosymbionts could grow 1.59-3.39 times in presence of insecticides as compared to control. *Wickerhamomyces anomolus*, *Pichia ohmeri* and *Zygosaccharomyces rouxii* were found most efficient.

2013-14

- 109 live insect cultures were maintained. 980 consignments of live insect cultures were supplied to different organizations / farmers / students. Revenue of Rs. 3,26,353 was generated through sale of live insect cultures. Ninety-one batches were trained on biological control and production protocols.
- Two new species of *Orius* (*Orius* sp. nov. and *Orius* sp. nr. *O. pallidicornis*) were collected from *Hibiscus* and *Butea,* respectively. *Orius amnesius* Ghauri collected on rose and *Blaptostethoides pacificus* Herring are first records for India.
- Culturable gut microflora associated with *Amrasca biguttula biguttula, Nilaparvata lugens, Empoasca* spp, *Nephotettix nigropictus, Bothrogonia* spp. of various crops were characterized. The predominant bacterial genera associated with these leafhoppers were *Enterobacter* spp., *Stenotrophomonas maltophilia*, *Bacillus* spp. *Micrococcus* spp., *Lysinibacillus fusiformis*, *Microbacterium*, *Agrococcus* and *Staphylococcus*. *Enterobacter cloacae* and *Bacillus pumilus* showed the tolerance towards Acephate insecticide under various concentrations when they were tested under *in vitro.*
- Survey for invasive insects in South India revealed the occurrence of *P. jackbeardsleyi* in Tamil Nadu, and Karnataka. It was found associated with papaya mealybug or aphids or spiralling white fly on different host plants.
- Anthocorid predators *Buchananiella indica*, *Anthocoris muraleedharani* and *Amphiareus constrictus* were amenable to rearing on alternate laboratory hosts.
- Interaction of indigenous and the introduced parasitoid of eucalyptus gall wasps was studied and it was found that the resource utilization by both the parasitoids were mutually exclusive. *Quadrastichus mendeli* preferred young larvae of *L. invasa* which were within the green galls, whereas the local parasitoid, *Megastigmus viggianii* selected larvae within the older pink and brown galls.
- The effect of temperature on the warehouse pirate bug *Xylocoris flavipes* was studied, constant temperatures of 22 and 27°C were most suitable for rearing this predator.

- Indigenous predatory mites were evaluated in net house studies against thrips infesting chilli and found to be promising.
- Erythrina Gall wasp *Quadrastichus erythrinae* was found to be severe in Mandya and Chamarajnagar districts in beetle wine stake plants *Erythrina indica. Aprostocetus gala* was found to be the major parasitoid of *Q. erythrinae.* It was clearly established that *Aprostocetus gala* is not a gall former in *Erythrina* plants but a very good parasitoid of *Quadrastichus erythrinae.*
- *Chromolaena* weed biocontrol agent, *Cecidochares connexa* was released at different places and established well.
- Evaluation of entomofungal pathogens on *Bemisia tabaci* infestation in tomato (variety, NS501) and capsicum (var. Indria) was carried out in the polyhouses in Bengaluru. *L. lecanii* (Vl-8 isolate) and *B. bassiana* (Bb-9 isolate) showed significantly lower white fly population in tomato Vl-8 treated plants showed significantly higher yield. On capsicum, *L. lecanii* (Vl-8 isolate) and *B. bassiana* (Bb-9 isolate) showed significantly lower white fly population. Bb-5a, Ma-6 and Vl-8 isolates were effective in reducing aphid (*Brevicoryne brassicae*) population on cabbage.
- Higher incidence of *Liriomyza trifolii* was noticed in the chambers with higher CO_2 and temperature compared to ambient conditions.
- A plant-based attractant was developed which was evaluated for the attraction of *Bactrocera dorsalis* in the mango orchards. The new dispensers attracted more fruit flies than the standard check methyl eugenol, especially *B. dorsalis.*
- Two hundred insects were molecularly characterized and barcodes for 50 insects were obtained.
- Isolated and identified microflora from three different aphids species for quantification of their role in various abiotic stress tolerance.
- Determined LC_{50} values for various *Helicoverpa armigera* and NPV populations collected from different crops.
- The anthocorid predator, *Orius laevigatus* and the predatory mite, *Amblyseius swirskii* found to be safe to productive insects and parasitoids.
- Chemicals which influence the behaviour of *Helicoverpa armigera* and *Spodoptera litura* were studied. Some promising chemicals were identified as ovipostional attractants.

2014-15

- Maintained the cultures of *Chrysomya megacephala*, sarcophagids and house flies.
- Forty-eight biocontrol agents supplied, 7 samples analyzed and quality analysis done for 7 samples. Total revenue generated is Rs. 1,98,000/-.
- During the period under report, 130 live insect cultures were maintained, 525 consignments of live insect cultures were supplied to different organizations. Revenue of Rs 2,73,232 was generated through sale of insect cultures and 39 batches were trained on production protocols and biological control.
- Wax moth, *Galleria mellonella* was maintained on artificial diet and 7 species of entomopathogenic nematodes were maintained on *Galleria mellonella*. 150 3rd instar of *Galleria mellonella* were supplied.
- *Gaillardia pulchella* (Asteraceae) was identified as to be an important, drought tolerant plant that flowers round the year and supports a wide range of pollinators.

- New formulations were tested for trapping mango fruit fly and melon fruit fly with good catches.
- A large-scale rearing methodology for *Hishimonus phycitis* optimised to produce and maintain over 2,000 adults at any given time on 200 brinjal plants in the greenhouse.
- Studied metabolic profiling during different growth periods of tomato leaves and stems using GC-MS spectrometry. A total of 47 metabolites (22 in leaves and 25 in stems) were detected. Non-polar metabolites were identified based on molecular weight and m/z fragmentation pattern. Metabolites include organic acids, fatty acids, amino acids, polyol, phytosterols and tocopherol. Some chemicals are absent in healthy plants, whereas present in infested plants.
- Insecticides recommended for soil pests, Imidachloprid (17.8% SL), chlorpyriphos (500 EC) and cypermethrin (20% EC) were screened for toxicity to ten strains of *Heterorhabditis* and seven strains of *Steinernema* in petriplates and in ice-cream cups at recommended doses. All the strains exposed to imidachloprid and cypermethrin for 48 hours were active and infective to wax moth larvae. Direct exposure to chlorpyriphos for 48 hours inactivated the nematodes but on replacement in plain water, the activity and infectivity of nematodes were restored.
- Four applications of *Heterorhabditis bacteriophora* or *S. feltiae* at 21 days interval from 2nd week of May-August to substratum effectively reduced the soil forms of thrips in capsicum, carnation and gerbera in polyhouses. LD and LC values for EPNs against sweet potato weevil grubs worked out.
- Promising isolates of *B. bassiana* (Bb-5a, 7, 14, 19, 23 and 45) were identified against *Chilo partellus* causing 71.1- 97.8% mycosis in laboratory bioassay studies.

2015-16

- The cuticular hydrocarbons in coconut red palm weevil, *Rhynchophorous ferrugineus* were identified as hexacosane, heptacosane, octacosane and nonacosane.
- During the period, 100 live insect cultures were maintained and 620 consignments of live insect cultures were supplied.
- 38 microbial biocontrol agents were supplied to various centers like state biocontrol units, entrepreneurs, KVKs etc.
- Identified over 50 species of pollinators on different host plant species.
- The endophytic *Beauveria bassiana*, Bb-45 isolate showed significantly higher suppressive effect on maize stem borer, *Chilo partellus* as indicated by lesser dead hearts and stem tunnelling compared to untreated control plots.
- The pectinase, an important enzyme involved in insect nutrition was detected from endosymbionts of *Bacillus pumilus*, *Filobasidium floriformie*, *B. licheniformis* and *Staphylococcus aureus*.
- The role of endosymbionts *Bacillus pumilus* and *Enterobacter cloacae* on Acephate degradation was confirmed by growing them in minimal media and LC-MS studies. LCMS analysis indicated the ability of *E. cloacae and B. pumilus* of *A. biguttula biguttula* to degrade Acephate (183.78) into methamidophos (143.04).
- A field demonstration on WP formulation of the entomopathogenic nematode, *Heterorhabditis indica* was organized by ICAR–NBAIR in collaboration with the Department of Agriculture / Horticulture and Gramabhivridhi Sanghas for the management whitegrubs in sugarcane in western Maharashtra (Varanagar and Nagaon), U.P., Hosur, Matolli, Ingalagi

and Enagi villages of Belgaum district in Karnataka and for the management of whitegrubs in arecanut at Ninasam, Heggodu, Sagar, Shimoga and Sringeri.

- About 200-250 acres of arecanut and sugarcane were treated with WP formulations of *H. indica* @ 4-5 kg/acre and 6-8 kg/acre, respectively. Arecanut root grub incidence was consequently reduced by 62-78% and 70-80% in sugarcane and other crops.
- More than 1000 Kg of WP of EPN formulation was distributed to farmers for the management of root grubs in arecanut, coconut, sugarcane, maize, banana, citrus, cabbage, onion etc.
- Through AICRP – BC, in Kerala, the exotic weed insect *Cyrtobagous salviniae* was released against the water fern *Salvinia molesta* which was choking the waterways. The weed insect established and could clear the waterways. The spread and establishment is continuously being monitored.
- In cole lands of Kerala, biocontrol-based IPM, comprising the use of *Trichogramma chilonis* and *T. japonicum* as well as antagonistic organisms (*Pseudomonas fluorescens* and *Trichoderma* spp.), covering 5000 ha effectively controlled rice pests and diseases and enhanced yield.
- For management of fruit flies in Karnataka, fruitfly trap Dorsa-lure has been utilised successfully in an area of 810149.8 ha.
- The introduced parasitoid *Quadrastictus mendeli* with the indigenous *Megstigmus* sp. is playing an important role in the suppression of the eucalyptus gall wasp, providing 66-80% control in the released locations, providing significant savings to paper pulp industry.

2016-17

- Collected, identified and preserved 140 predatory mites, including two undescribed phytoseiids, *Euseius* sp.nr. *bhadrakaliensis* and *Neoseiulus* sp.nr. *reticulatus*, which showed biocontrol potential against *Tetranychus* spp.
- 40 bee specimens belonging to subfamily Halictinae (4 numbers), Nomiinae (27 numbers), family Megachilidae (9 numbers) were collected and added to NBAIR reference collections.
- A total of 200 specimens of spiders belonging to 10 families have been collected from 10 locations.
- About 30 whitefly specimens were collected from Tamil Nadu, Karnataka, Haryana, Rajasthan and Punjab. Most of the whitefly specimens collected was *Bemisia tabaci*. The natural enemies associated with whiteflies were also collected during the survey.
- Bisexual attractant was tested in the field in delta traps with more than 50% females in the trap.
- Molecular characterization of 7 Steinernematids and 2 Heterorhabditids nematodes were carried out and sequences were submitted to GenBank and accession numbers were obtained.
- Black soldier fly associated microflora was isolated. Morphological and biochemical characterization of microflora is in progress.
- Culture of black soldier fly was initiated in pots and drums maintained. Biology of black soldier fly was accomplished.
- Intraguild predation (IGP) study was carried out between *Geocoris ochropterus* and *Blaptostethus pallescens*. *Geocoris ochropterus* was found to be most aggressive predator at different extraguild prey (thrips) density when it had a chance to interact with *Blaptostethus*

pallescens. However, *G. ochropterus* predates more on young nymph of *B. pallescens* nymph compared to adult *B pallescens*.

- Developed an easily synthesizable amphiphilic probe for optical detection as well as quantification of *HaNPV* in various commercial formulations. Low-cost paper strips were also developed for rapid, on-site detection purpose.
- Bioassays for intra and interspecific EPNs such as *Steinernema abbasi, S. feltiae and Heterorhabidtis indica* were tested as a possible biological control agent for engorged female ticks. Infective juveniles of *S. feltiae* and *H. indica* appeared to be the most effective in killing ticks.
- EPN formulations were screened for field efficacy against whitegrubs in turmeric, sugarcane, groundnut under farmer's fields in Karnataka, Maharashtra and Rajasthan.
- Liquid and wettable powder formulations of EPNs nematodes were evaluated against ash weevil on brinjal
- Ecological characterization of *H. pakistanense* was studied and IJs of *H. pakistanense* was able to infect insect host at lower temperatures.
- Conducted method demonstration on use of pheromone to trap coconut rhinoceros beetle and red palm weevil.
- Demonstrated the use of controlled release dispensers for trapping tomato pin worm, *Tuta absoluta*.

Achievements of Mass Production Unit

2012-13

- 113 live insect cultures were maintained. 887 consignments of live insect cultures were supplied to different organizations / farmers / students.

2013-14

- 109 live insect cultures were maintained. 980 consignments of live insect cultures were supplied to different organizations / farmers / students. Revenue of Rs. 3,26,353 was generated through sale of live insect cultures. Ninety-one batches were trained on biological control and production protocols.

2014-15

- 130 live insect cultures were maintained, 525 consignments of live insect cultures were supplied to different organizations. Revenue of Rs 2,73,232 was generated through sale of insect cultures and 39 batches were trained on production protocols and biological control.

2015-16

- During the period, 100 live insect cultures were maintained and 620 consignments of live insect cultures were supplied.
- 38 microbial biocontrol agents were supplied to various centers like state biocontrol units, entrepreneurs, KVKs etc.

2016-17

- 127 live insect cultures were maintained. and 1251 shipments off insects & insect resources supplied to different parts of the country

- Collected, identified and preserved 140 predatory mites, including two undescribed phytoseiids, *Euseius* sp.nr. *bhadrakaliensis* and *Neoseiulus* sp.nr. *reticulatus*, which showed biocontrol potential against *Tetranychus* spp.

Insect identification services

Nearly 3000 specimens of parasitic Hymenoptera (involving ~ 500 identification requests) were identified for many ICAR institutes, SAUs and private organisations: IIHR, UAS (Dharwad and Bangalore), NRC grapes-Pune, GBPUA&T-Uttarakhand, CSR&TI-Berhampore and Pampore, several KVKs, CSTRI-Mysore, CSB-Bangalore, SKAUST-Jammu, IGKVV-Raipur, KAU-Kerala, MPUAT Udaipur etc. Species of pentatomids and thrips were identified for Consultant-Education, Suchindrum and IIHR respectively. For aphids/coccids, a total of 703 identification services were provided to different SAUs, ICAR institutes, NGOs and private organisations, through which 1425 aphids/coccids were identified. Thirty three specimens belong to Cerambycidae were identified for three Institutes. A total of 2000 specimens (34 species) of dipterans were identified for different SAUs and ICAR Institutes. Of these 1928 (22 species) were fruit flies (Tephritidae); 30 were agromyzids (two species, 6 were cecidomyiids (one species), 17 were syrphids (four species), 4 were tachinids (four species) and 15 were drosophilids (single species). Also a mermithid insect parasitic nematode sample was identified for SAU. A total of 6459 specimens were identified during the period.

Success stories

Development and promotion of Multiple Insecticide Tolerant strain (MITS) and high temperature tolerant strain (HTTS) of *Trichogramma chilonis*

NBAIR has successfully developed Multiple Insecticide Tolerant strain (MITS) and high temperature tolerant strain (HTTS) of *Trichogramma chilonis*. Multi-locational field demonstration was done for MITS and HTTS strains of *Trichogramma chilonis* in 10 states at 16 different places covering an area of 524 acre of sugarcane, rice, tomato, brinjal and cabbage. Field trials conducted with HTTS at Tapi (Gujarat) under NAIP, C-4 project, revealed the effectiveness the strain in high temperature affected areas. In released area, an additional paddy grains of 1540/ac was obtained as compared to control. The revenue generated for farmers is Rs. 2800/ac. The results of field trials with MITS (Multiple insecticide tolerant strain) developed at NBAII under NAIP, C-4 project, revealed the usefulness of the strain in insecticide overused areas. In MITS released area, 9866 kg/ac of tomato was obtained where as in unreleased area only 9538 kg/ac of tomato was obtained. The additional revenue generated by farmers is Rs. 5616/ac.

Management of sugarcane woolly aphid, *Ceratovacuna lanigera*

Sugarcane woolly aphid (SWA), *Ceratovacuna lanigera* (Aphididae) has been recently reported in outbreak proportions from western and southern India especially in many parts of Maharashtra and Karnataka. Insecticides failed to check the spread of the pest. It was then that a parasitoid *Encarsia flavoscutellum* (Hymenoptera: Chalcididae) was translocated from Jorhat, Assam by the erstwhile Project Directorate of Biological Control (renamed as ICAR-NBAIR) to Karnataka and multiplied in the field for release across the affected states in the country. Studies revealed the natural occurrence of other predators such as *Dipha aphidivora* (Lepidoptera), *Micromus igorotus* and *M. timidus* (Neuroptera) in sugarcane fields infested by the SWA. Techniques were developed at NBAIR for the production of these natural enemies. A successful strategy involving the withdrawal of chemical pesticides and augmentative releases of the natural enemies was evolved and recommended to the concerned Departments of Agriculture and sugarcane farmers to combat this pest. Release of either 1000 larvae of *Dipha* or 2500 larvae of *Micromus* per hectare as soon as woolly aphids are seen resulted in very good control of the pest in 45-60 days. It was estimated that the successful management of the pest resulted in savings to the Indian exchequer to the tune of Rs.1,500 crore. Periodic surveys have subsequently revealed that the natural enemies continue to keep the SWA in check in the areas of its occurrence and save considerable sums of money that would otherwise have to be spent on measures to manage the pest.

3. Classical biological control of papaya mealybug, *Paracoccus marginatus*

Mealy bugs are major agricultural pests and pose serious problems when they invade new areas of the world without natural enemies. *Paracoccus marginatus* (papaya mealybug) attacks about 86 host plants including papaya, pomegranate, sapota, avocado, mulberry, tapioca, cocoa, cotton, rubber and teak. Crop losses to the tune of 80-100 per cent were observed in case of papaya, mulberry and cassava. Three parasitoids, *Acerophagus papayae*, *Anagyrus loecki* and *Pseudleptomastix mexicana* were procured hrough the collaboration with USDA –APHIS (United States Department of Agriculture –Animal and Plant health inspection Service) the training on mass production of the parasitoids was imparted to more than 250 specialists across India the parasitoids were released in several places

Farmers returned to cultivating their favourite crops like papaya, mulberry, Tapioca, Teak, Cocoa and rubber without fear. NBAIR played a great role in successful management of the deadly invasive papaya mealybug. It is crucial that the released parasitoids as well as naturally occurring predators like *Spalgis* and *Cryptolaemus* are conserved by avoiding the use of chemical pesticides for the effective suppression of the papaya mealybug. The introduction of parasitoids the country has benefitted by more than 1500 crores of rupees in addition avoiding huge amount of pesticide usage which would have polluted our soils, water and environment.

Management of the new invasive tomato pin borer, *Tuta absoluta*

The invasive pest, *Tuta absoluta* was recorded infesting tomato crop in the country. Survey carried out in five states and 15 places recorded up to 52.4% infestation of fruits and stems. Sex pheromone compound 3E, 8Z, 11Z -3, 8, 11 –tetradecatrien -1 -yl acetate was loaded on a

novel nonomatrix developed at NBAIR for delivery. The results of field trial conducted at farmers' field in Hosur (Tamil Nadu) and Kolar (Karnataka) districts revealed that Nanomatrix lure (NML) trapped 20% more moths than a commercial lure available in the country. The advantage of NBAIR nanomatrix lure had a lower load of pheromone, thus is highly cost effective. The technology has been successfully demonstrated in about 80 acres of tomato crop in farmer's field at Hosur and ready for commercialization.

Novel Entomopathogenic nematode (EPN) formulation for the biological control of insect pests

The wettable powder formulation of the EPN, *Heterorhabditis indica* (strain NBAII Hi1) has been developed and found effective for the management of whitegrubs in arecanut, banana, sugarcane, potato and corn. The novel formulation has improved shelf-life wherein at least 90% of the juveniles are viable even after eight to twelve months of storage at a temperature of between 25 and 37°C and exempted from CIB registration.

Field demonstrations of the formulation were carried out in Karnataka, Tamil Nadu, Maharashtra and U.P. Around 250 Ha arecanut and 200 Ha sugarcane fields were applied with WP formulations of *H. indica* @ 4-5 kg/acre, 6-8 kg/acre respectively. The technology could reduce the arecanut root grub incidence by 62-78% and coconut root grub inciden by 70-80%.

NBAIR has distributed, more than 1000 Kg of WP EPN formulation to the farmers for the management of root grubs in different crops.

Development of cost effective liquid formulation of *Bacillus thuringiensis*

Developed a cost effective technology on stable liquid formulation (10% a.i.) of *Bacillus thuringiensis* strain NBAII-BTG4 with one year shelf life. The formulation containing the spores and crystalline inclusions is used as spray (1%) for control of lepidopterous pests like *Plutella xylostella, Helicoverpa armigera, Chilo partellus, Sesamia inferens, Cnaphalocrocis medinalis, Leucinodes orbonalis* and *Amsacta albistriga.*

The effectiveness of the formulation was demonstrated under large scale field trials in Gujarat, Maharashtra and Karnataka to control *Helicoverpa armigera* and *Maruca testulalis* in pigeon pea. The pest was effectively controlled (Pod yield of 15 quintal/ha yield) and was on par with chemical insecticide (16 quintal/ha). This technology was sold to four private companies namely Abdec Biotech Pvt. Ltd. Kerala, Agribiotech, Kerala, Alwyn Industries Pvt. Ltd. and Ponalab Industries Pvt. Ltd. The PCR amplification of *cry* genes from the isolates NBAII-BTAS and NBAII-BTG4 revealed that they harboured diverse *cry* genes like *cry*1Aa, *cry*1Ab, *cry*1Ac, *cry*1E, *cry*1G, *cry*1I, and *cry*2.

Commercialisation of Technologies

- **Technologies developed and commercialized**

Activity	
No. of technologies developed	**27**
No. of technologies commercialized	**18**
List of Technologies Developed ➢ Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis*. ➢ High temperature tolerant strain of egg parasitoid *Trichogramma chilonis*. ➢ Pesticide tolerant strain of aphid lion, *Chrysoperla zastrowi sillemi*, an important predator of sucking pests. ➢ Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests. ➢ Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes. ➢ Liquid formulation of *Bacillus thuringiensis*. ➢ Closed system for mass production of predatory mites. ➢ A dispenser for the alinity tolerant *Trichoderma harzianum* with biocontrol potential. ➢ Bio formulation of carbendazim tolerant *Trichoderma harzianum* with biocontrol potential. ➢ Powder based formulation of *Pseudomonas fluorescens*. ➢ Powder based formulation of *Bacillus megaterium* as growth promoter. ➢ A plant volatile based attractant for enhanced attraction of fruit fly. ➢ Promising plant growth promoting strain of *Bacillus megaterium* for vegetable crops. ➢ Promising antagonist of *Trichoderma harzianum* for management of chilli anthracnose disease. ➢ A simple technique of rearing brinjal shoot and fruit borer, *Lucinodes orbonalis.* ➢ A semi solid formulation of dispenser for trapping mango fruit fly for surveillance. ➢ Protocol for designing lure for impregnating parapheromone 4[4-acetoxy) phenyl-butanone to attract male flies of *Bactrocera* spp attacking cucurbit crops for mass trapping and monitoring its population thereof. ➢ Control release dispensers for semiochemicals.	

➢ EuGalLure- A plant based attractant dispenser for trapping Eucalyptus gall wasp, *Leptocybe invasa*. ➢ Dorsa lure- Plant volatile dispensers for increasing the trap efficiency for mango fruit flies. ➢ Protocol for designing lure for impregnating parapheromone 4[4-acetoxy) phenyl-butanone to attract male flies of *Bactrocera spp*. attacking cucurbit crops for monitoring its population. ➢ Method for Continuous Rearing of An Anthocorid Predator *Blaptostethus Pallescens*	
Total Number of Companies / Firms / licensee for which ICAR-NBAIR commercialized the technologies.	**16**
List of the companies/Firms/Licensee for which ICAR-NBAIR commercialized the technologies: ✓ Allwin Industries, Pithampur, Distt. Dhar (M.P.) ✓ Foundation for Agricultural Resources Management and Environmental Remediation (FARMER), New Delhi ✓ Sri Biotech Research Laboratories India Ltd., Hyderabad ✓ Multiplex Biotech Pvt. Ltd, Bangalore ✓ Sri Venkateshwara Chemicals Pvt. Ltd., Hyderabad ✓ Camson Bio Technologies Limited, Bangalore ✓ Sun Agro biotech Research Centre, Chennai ✓ Excel Crop Care, 184/87, Mumbai ✓ Agro Bio-tech Research Centre Limited, Kottayam, Kerala ✓ M. S. Swaminathan Research Foundation, Chennai ✓ Agri Bio Care, Kottayam, Kerala ✓ Dr. Abdul Rauf Agri-Research Foundation, Sirsi ✓ PonaLab, Rajaji nagar, Bangalore ✓ University of Agriculture and horticultural sciences campus, Shivamogga ✓ M/s. Bio95.com Agrotech Private limited, Bangalore	

Externally Funded Projects

Sl. No.	Name of the project	Period	Name of the PI	Total budget allocated
1	Microbial Control of Insect Pests-II **(AMAAS)**	01.04.2007 to 31.03.2014	Dr. B. Ramanujam	46.38
2	**ICAR-IPR:** Intellectual property management and transfer / commercialization of Agricultural Technology Scheme	06.06.2008 to 31.03.2017	Dr. T. Venkatesan	40.00
3	**NAIP:** Effect of abiotic stresses on the natural enemies of crop pests *Trichogramma Chrysoperla Trichoderma* and *Pseudomonas* and mechanism of tolerance to these stresses	19.07.2008 to 30.06.2014	Dr. S. K. Jalali	412.57
4	Biological Control of Colletotrichum Diseases of Chillies (**ORP on Leaf Spot Diseases**)	23.06.2009 to 31.03.2014	Dr. B. Ramanujam	35.57
5	**DBT:** Development of fungal bionematicides, scale up, post-harvest processing, storage stability, toxicology and field evaluation	24.07.2009 to 01.06.2013	Dr. M. Nagesh	39.37
6	**NAIP:** National Agricultural Bioinformatics Grid for Insect Domain	31.03.2010 to 30.06.2014	Dr. S. K. Jalali	602.96
7	**DBT**: Nanoparticles for enhancing shelf life / storage and field application of semiochemicals	05.07.2010 to 09.07.2015	Dr. Deepa Bhagat	95.00
8	**DBT:** Genetic and functional analysis of novel genes from Photorhabdus luminescens and *Xenorhabdus nematophilus*, symtiotic bacteria associated with entomopathogenic nematodes for insect pest management	12.11.2010 to 30.07.2013	Dr. M. Nagesh	8.42
9	**NASF:** Identification of nucleopolyhedrovirus (NPV) encoded protein and small RNAs and the	01.01.2011 to 31.03.2016	Dr. S. K. Jalali	66.98

	feasibility of their expression in plant to control *Helicoverpa*			
10	**ORP:** ORP on Management of Sucking Pests of Horticultural Crops - Taxonomy of Aphids and Coccids	04.01.2012 to 31.03.2017	Dr. Sunil Joshi	3.00
11	**ICAR Project** - Network project on Insect biosystematics	09.04.2012 to 31.03.2017	Dr. Ankita Gupta	197.00
12	**IISc**: Characterization, functionalisation and assembly of nanosensors and their applications	03.08.2012 to 31.08.2015	Dr. Deepa Bhagat	200.00
13	**DBT:** Studies on extending the shelf life and improving the delivery methods of trichogrammatid egg parasitoids for promoting their commercial mass production in India	01.07.2013 to 31.07.2016	Dr. C. R. Ballal	25.01
14	**AMMAS:** Culturable and unculturable microbial diversity of aphids and their role in insecticide resistance and other fitness attributes	01.04.2014 to 31.03.2017	Dr. Mahesh Yandigeri	36.48
15	**CRP:** Consortium Research Platform (CRP) on Borer in Network Mode	01.04.2014 to 31.03.2017	Dr. N. Bakthavatsalam	170.00
16	**AMAAS:** Development of formulations of *Beauveria bassiana*, *Metarhizium anisopliae* and *Lecanicillium* spp. for management of certain sucking pests in vegetable crops.	01.04.2014 to 31.03.2017	Dr. B. Ramanujam	12.86
17	**DST:** Diversity and distribution entomopathogenic nematodes in coconut and arecanut ecosystems	16.05.2014 to 15.05.2017	Dr. Jagadeesh Patil	24.00
18	**ICAR-CABI**: The study of biological control of invasive plant species & Indian natural enemies	01.07.2014 to 31.07.2016	Dr. C. R. Ballal	8.00
19	**CST:** Studies on pest status and ecofriendly management of thrips (*Pseudodendrothrips mori*) (Thysanoptera: Thripidae) on Mulberry in Tamil Nadu	09.10.2014 to 31.10.2016	Dr. C. R. Ballal	5.94

20	**CRP**: CRP on Nanotechnology project	18.11.2014 to 31.03.2017	Dr. Deepa Bhagat	300.00
21	**DBT**: Controlled release dispensers for delivery of semiochemicals	25.11.2014 to 24.11.2017	Dr. K. Subaharan	27.80
22	**ORP-SP:** ICAR-Outreach Programme on Management of Sucking Pests in Horticultural Crops	02.01.2015 to 31.03.2017	Dr. T. Venkatesan	6.00
23	**CRP on Bioinformatics – ICAR:** Centre for Agricultural Bioinformatics (Network Project on Insect Bioinformatics)	01.01.2015 to 31.03.2017	Dr. T. Venkatesan	190.00
24	**CSRTI**: Investigation on semiochemicals of the silkworm uzifly *Exorista bombycis*	01.01.2015 to 31.12.2016	Dr. N. Bakthavatsalam	720.00
25	**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	24.72
26	**CRP on Genomic – ICAR:** Insect Genomics	01.04.2015 to 31.03.2017	Dr. S. K. Jalali	200.00
27	**Coffee Board:** Ecofriendly management of Coffee stem borer	01.07.2012 to 30.06.2015	Dr. N. Bakthavatsalam	5.97
28	**Natiional Tea Research Foundation** Feasibility of suppression of Tea shot hole borer *Euwallacea fornicates* through its mutulaistic *Fusarium* spp	01.01.2016 to 31.03.2019	Dr G.Sivakumar	29.65
29	**NICRA:** Development of IPM strategies to combat whitefly and other emerging pests	04.08.2016 to 31.03.2019	Dr.Chandish Ballal	40.45
30	**TSP**	2012-2018		**44.50**
	Total (in lakhs)			**3548.03**

Infrastructure and physical facilities developed

The following additional infrastructural developmental works were taken up during the period from 2012-13 to 2016-17

- Pavement of roads at the main building at Hebbal.
- Procured 100 KV generator for the quarantine laboratory.
- Renovation of laboratory for Veterinary pest research
- Procured 100 KV generator for the Attur farm.
- Construction of Museum at Hebbal campus
- Creation of recreation facility.

Equipments purchased

The following equipments costing more than one lakh were added during the XI plan: Leica Microscope, Benchtop laboratory fermentor, Stereozoom microscope, preparatory gel electrophoresis unt, Leica microscope verticabGMBH, Stereozoom microscope with digital, Particle size analyser, Zeta sizer, BOD incubators, Agilent bipolar supply unit, Thermal cycler, Refrigerated microfuge centrifuge, Kaleidoscope BOD incubator, Gel Documentation System, Stereozoom microscope Stemi 305D, Trinocular stereozoom microscope, Waterbath digital PID controller and Trinocular research microscope, insect storing boxes, desktop computers and printers.

Observation and recommendations of the QRT

1. The chairman and members of the QRT visited different divisions and laboratories of NBAIR and critically evaluated the existing facilities and lab space available and proposed futuristic requirements of the Bureau as given in the table. QRT strongly recommended additional space for HOD's, AICRP Cell, PME and Vigilance Cell which are currently operating from the respective scientist's laboratories.

   Since NBAIR has been recognised by DST for insect taxonomy training, an additional space for auditorium (for holding symposium, conferences etc) and a lab annexe and accommodation facilities need to be provided in future plan projections.

Sl. No.	**Division/laboratory/ Unit**	**Existing work space (in sq. meter)**	**Additional work space required (in sq. meter)**
1	**Germplasm Collection and Characterization**		
	a.National Insect Reference Collection	104.16 m^2	
	b. Laboratory space in main campus, Hebbal	304.40 m^2	500 m^2
	c. Laboratory space in Attur campus	47.43 m^2	
	d. Insect Museum	500 m^2	

		(*under construction)	
	Total	**955.99 m^2**	
2	**Genomic Resources**		
	e. HPC facility	93.15 m^2	
	a. Laboratory space in main campus, Hebbal	264.37 m^2	500 m^2
	f.Laboratory space in Attur campus	94.86 m^2	
	Total	**452.38 m^2**	
3	**Germplasm conservation and utilization**		
	g. Mass production laboratory	183.2 m^2	
	h. Growth chambers	58.28 m^2	
	i. Laboratory space in main campus, Hebbal	307.01 m^2	500 m^2
	j. Laboratory space in Attur campus	141.02 m^2	
	Total	**689.51 m^2**	
4	Quarantine building	424.28 m^2	
5	ITMU	67.39 m^2	100 m^2
6	AICRP Cell	-	100 m^2
7	Vigilance Cell	-	100 m^2
8	PME Cell	-	100 m^2
9	Auditorium	-	500 m^2
10	Insect Rearing facility	-	300 m^2
11	Space for HOD's	-	300 m^2
12	Lab Annexe	-	500 m^2
	Total	4687.43 m^2	3500 m^2

2. QRT remarked that with the redesigned mandate of the Bureau, as number of staff members superannuated in the last five years and no additional posts were created during 2012-17, there is an urgent requirement for additional scientific, technical and administrative staff either by creating new positions or by redeployment from other ICAR institutes. Hence, the scientific, technical, administrative and supporting staff as per the details given in the table was recommended.

Discipline		**Sanctioned**	**In-position**	**Proposed**
Scientific				
Entomology	Pr. Scientist Sr. Scientist Scientist	4 5 11	0* 4 18	3* 4 18
Microbiology	Sr. Scientist Scientist	1 1	2 1	2 1
Plant Pathology	Sr. Scientist Scientist	1 2	1 2	1 2
Nematology	Sr. Scientist Scientist	1 2	0 2	0 2

Agricultural Chemistry	Scientist	1	1	1
Flexi Discipline- Computer application	Scientist	1 0	0 1	0 1
Total		**30**	**32**	**35**
Technical	Technical	**17**	**15**	**21**
Administrative	Administrative	**11**	**10**	**17**
Supporting	Supporting	**6**	**3**	**6**

*HOD'S (Three HOD's vacant)

3. Centres of Excellence for invasives and molecular modelling to be conceived for NBAIR and necessary provisions to be made.

4. As the Bureau's activities have expanded, there is a constant neeed to maintain insect resources/cultures in confinement and under control conditions for advanced studies, HRD programmes and extension activities, there is a need to develop state of the art, controlled insect rearing facility in NBAIR.

5. A specialized curator for the Insect/ Arthropod National Reference Collection and musuem must be appointed to maintain the musuem as per International standards.

6. NBAIR should have a Scanning Electron Microscope (SEM) to address the futuristic need of arthropod systematics which could be a national facility for ICAR/SAU in the country.

7. A need for a mobile insect museum cum insect collection and preservation laboratory was strongly felt as a necessity to meet the mandate of the Bureau. So, a provision for a mini van with state-of-the-art facilities needs to be made in the future budget.

8. Augmentation of existing collections and maintenance of a national repository. To build up a virtual repository in terms of barcoded digitised domain for easy access for identification of insects and act as a nodal centre for identification and characterisation. The number of taxonomists may be increased to develop expertise in biosystematics.

9. Field identification guide for arthropod biodiversity (bioagents, honeybees, pollinators, lac insects, silkworms, veterinary pests)

10. HRD programmes for capacity building of core group of taxonomists well versed in morphological and molecular taxonomy.

11. Intensify exploratory surveys in biodiversity hot spot areas, comprehensive collections must include diversity of natural enemies, host-insects, EPN, PPN, veterinary pests, pollinators, entomathogenic fungi and *Bt*.

12. Establish linkages with National (ZSI, FRI, NPC, conventional universities) and Intrernational (CABI, BNHM, National Museum, Washington DC) to facilitate collections, gain expertise to benefit taxonomists

13. Establishment of a credible and affordable identification service for insects and mites of agricultural importance to cater to national and regional needs.

14. Focus on structural genomics and bioinformatics for selected arthropods, with a networking policy and linkage with centres for biotechnology and bio-informatics. Gut microflora must be explored for their utilization and manipulation for pest management. Smart and superior natural enemies must be developed for better pest management.

15. Development of computational tools for prediction of insecticide resistance genes in agriculturally important insects.

16. Biosecurity, threat perception with action-plan for putative accidental introduction of invasives. Monitor and prevention of introdution and spread of invasives in co-ordination with national agencies to support quarantine activities.

17. Focus on *in situ* provision of shelters/refugees, crop habitat diversity for encourgaing beneficial organisms and natural enemies.

18. Impact of climate change on arthropod diversity, tritrophic interactions, niche overlaps and migration to be studied in the context of population dynamics of the pest.

19. Research on nano formulations/nano sensors of semiochemicals with greater shelf life must be taken up for the management of key lepidopteran pests across the crops.

20. Field demonstrations and transfer of technology to the farming community must be taken up on regular basis through effective extension linkages with State departments/SAUs/KVKs etc. for effective adaption towards doubling the farm income.

21. Socio economic impact analysis of the technologies must be assessed.

22. The Bureau must be made as a centre for advanced insect studies addressing biosystematics, biotechnology, bioinformatics, physiology and ecology.
23. A full-fledged recreational facility at main campus/Attur campus may be envisioned for the welfare of the staff.

Human resource development

1. Human resource development efforts for different categories of staff

a) Training programme attended by ICAR-NBAIR staff during 2012-2017:

Sl. No.	**Name & Designation**	**Period**	**Place**	**Training programme**
1	Dr. Deepa Bhagat Principal Scientist	16.04.2012 to 28.04.2012	CeNSE under INUP, IISc., Banglore	Handling the equipments under nanofabrication
2	Dr. M. Nagesh Principal Scientist	08.10.2012 to 19.10.2012	NAARM, Hyderabad	Management development programme in agricultural research (a pre-RMP programme)

3	Mr. J. N. L. Das Administrative Officer	19.11.2012 to 23.11.2012	ISTM, New Delhi	Good Governance
4	Mr. P. K. Sonkusare Technical Officer (T-5)	04.03.2013 to 12.04.2013	IASRI, New Delhi	Database Management System
5	Mr. P. K. Sonkusare Technical Officer (T-5)	18.03.2013 to 22.03.2013	IASRI, New Delhi	Web Development and Hosting
6	Dr. P. Sreerama Kumar Principal Scientist	24.06.2013 to 12.07.2013	Ohio State University, Columbus	Acarology Summer Program
7	Dr. M. Nagesh Principal Scientist	01.09.2013 to 30.11.2013	Washington State University, Pullman, USA	Genomic & Transcriptome Analysis, Protein Docking & Modeling
8	Dr. Mahesh Yandigeri Senior Scientist	18.09.2013 to 16.12.2013	University of California Riverside, USA	Microbial Molecular Taxonomy (NRM)
9	Dr. M. Mohan Principal Scientist	18.09.2013 to 16.12.2013	University of Kentucky, Lexington, USA	Biomolecules (Crop Science)
10	Dr. Deepa Bhagat Principal Scientist	18.06.2013 to 27.06.2013	TNAU, Coimbatore	Nanotechnology and plant disease management
11	Dr. Sreerama Kumar Principal Scientist	26.09.2013	Select Biosciences India Pvt. Ltd., Chandigarh	Introduction to real-time qPCR
12	Dr. M. Pratheepa Principal Scientist	26.08.2013 to 30.08.2013	IASRI, New Delhi	CLC Bio Software
13	Dr. M. Pratheepa Principal Scientist	28.10.2013 to 30.10.2013	NBFGR, Lucknow	HPC administration
14	Mr. P. K. Sonkusare Technical Officer (T-5)	29.10.2013 to 01.11.2013	IASRI, New Delhi	Advance workbench training of CLC-Bio software
15	Dr. Deepa Bhagat Principal Scientist	01.06.2014 to 15.06.2014	Penn State University, USA	Insect Chemical Ecology - 14
16	Dr. M. Pratheepa Principal Scientist	03.06.2014 to 13.06.2014	Thapar University, Patiala	Summer school on "Machine learning algorithms and data analytics"

17	Dr. K. Srinivasa Murthy Principal Scientist	04.08.2014 to 08.08.2014	NAARM, Hyderabad	MDP on Priority setting, Monitoring and Evaluation (PME) of Agricultural Research projects
18	Dr. Deepa Bhagat Principal Scientist	10.11.2014 to 15.11.2014	NAARM, Hyderabad	Analysis of Experimental Data
19	Dr. A. Raghavendra Technical Assistant (T-3)	16.11.2014 to 30.11.2014	NIPHM, Hyderabad	Phytosanitary treatment (MBr & ALP Fumigation)
20	Mrs. L. Lakshmi Senior Technical Officer	15.12.2014 to 20.12.2014	University of Agricultural Sciences, Bengaluru	Taxonomy on Arthropods
21	Dr. Ankita Gupta Scientist	29.12.2014 to 03.01.2015	University of Agricultural Sciences, Bengaluru	Taxonomy of Bees and other Insect Pollinators
22	Dr. Y.Lalitha, Chief Technical officer	24.08.2015 to 28.08.2015	IIPA,NEW DELHI	Training programme on Science & Technology for Rural societies for women scientist & Technologists
23	Dr.M.Mohan Senior Principal Scientist	21.09.2015 to 29.09.2015	MSSRF,Chennai	Agrobiodiversity conservation sustainable livelihoods and need for climate change adaption
24	Dr.A.N.Shylesha, Principal Scientist	26.10.2015 to 02.11.2015	NIPHM,Hyderabad	Training on "Pest Surveillance"
25	Dr.Kesavan Subaharan Principal Scientist	10.11.2015 to 30.11.2015	NCBS, Bengaluru	Arthropod Infochemistry
26	Dr. Y.Lalitha, Assistant Cheif Technical officer	08.02.2016 to 12.02.2016	National Institute of Advanced Studies,IISC, Banglore	Science for progress in India;Innovations in Technologies
27	Dr. B.K.Chaubey Assistant Cheif Technical officer	01.06.2016 to 10.06.2016	NAARM HYDERABAD	Competence enhancement programme on soft skills and personality development for Technical officer of ICAR

28	Mr. P. Raveendran, Technical Officer	02.08.2016 to 11.08.2016	ICAR-NBAIM,KeshMau, Uttar Pradesh	Microbial Culture Handling and Maintenance
29	Dr. B.K.Chaubey Assistant Cheif Technical officer	16.08.2016 to 25.08.2016	CIAE,Bhopal	Selection,Adjustment,operation and Maintenance of Agriculture implementrs for Field and Horticultural Crops
30	Mr. P. Raveendran,Technical Officer	17.08.2016 to 26.08.2016	NAARM HYDERABAD	Competence enhancement programme on Motivation and Positive Thinking
31	Mr.Satendra Kumar,Assistant Cheif Technical officer	24.09.2016 to 06.09.2016	IASRI, New Delhi	Experimental Data Analysis
32	Mr.P.K.Sonkusare,Senior Technical Officer	28.09.2016 to 05.10.2016	ICAR-IASRI, New Delhi	Cyber Security for ICAR-Technical personnel
33	Mr.Satendra Kumar,Assistant Cheif Technical officer	05.11.2016 to 18.11.2016	ICAR-NBAIM,KeshMau, Uttar Pradesh	Techniques in Microbiology
34	Dr. B.K.Chaubey Assistant Cheif Technical officer	01.12.2016 to 14.12.2016	ICAR-IARI New Delhi	Identification of Insect pests/Vectors/their Damaging Symptoms and Management
35	Dr.A.Raghavendra, Senior Technical Assistant	03.12.2016 to 08.12.2016	ICAR-IARI New Delhi	Extraction,Estimation and characterization of Biomolecules from plant samples
36	Dr.A.Raghavendra, Senior Technical Assistant	23.01.2017 to 30.01.2017	ICAR-IARI New Delhi	National Training on Trace Level Analysis of Pesticides,Phytochemical sugars and Organic acid
37	Mr.Jayaram,Senior Technical Officer	27.01.2017 to 27.01.2017	Karnataka Veternary,Animal and Fisheries Science University,Bengaluru	Southern Region training cum Awareness Workshop on J-Gate @CeRA

38	Dr.M.Pratheepa,Senior Principal Scientist	03.03.2017	ICAR-NIANP,Bengaluru	Procurement through Gem portal at NIANP
39	Mrs.S.Rama, Senior Administrative Officer	03.03.2017	ICAR-NIANP,Bengaluru	Procurement through Gem portal at NIANP
40	Mr.T.A.Vishwanath Finance and Accounts	03.03.2017	ICAR-NIANP,Bengaluru	Procurement through Gem portal at NIANP
41	Mrs.Dipanwita Deb,Assistant	03.03.2017	ICAR-NIANP,Bengaluru	Procurement through Gem portal at NIANP
42	Mrs.Thejaswini,Young Professional-2	20.03.2017 to 25.03.2017	ICAR-IASRI, New Delhi	Training Programme on ICAR-ERP for ICAR Technical Personnel
43	Mr.P.K.Sonkusare,Senior Technical Officer	20.03.2017 to 25.03.2017	ICAR-IASRI, New Delhi	Training Programme on ICAR-ERP for ICAR Technical Personnel
44	Dr.A.Raghavendra, Senior Technical Assistant	13.08.2017 to 18.03.2017	Southern Regional Station,ICAR-NDRI,Bengaluru	Technology Management & Business planning for Entrepreneurship Development
45	Dr.Ramya.R.S, Scientist	05.09.2017 to 25.09.2017	ICAR-NBAIR Bengaluru	Winter School Training Programme on "Current techniques and advances in Mass culturing of Microbials for Production of Biopesticide
46	Dr.K.Sreedevi, Senior Scientist	16.09.2017 to 15.12.2017	Zoologisches Forchergsmuseum A.Koenig,Bonn,Germany	The Phylogeny and Biogeography of Indian Sercini Chafers
47	Dr.Kesavan Subaharan Principal Scientist	14.11.2017 to 04.12.2017	Veterinary College,Hebbal,Bengaluru	An update on Vectors and Vector borne Diseases

b) Training programmes conducted at ICAR-NBAIR during 2012-2017

Total training programmens conducted during 2012-17 : 45
Total trainees attended the training programme : 187

Sl. No.	Programme	Duration	No. of Participants	From
2012-13				
1.	Mass production of *Helicoverpa armigera* and *Spodoptera litura*, *Plutella xylostella*	07.05.2012 to 09.05.2012	1 no.	North Maharashtra University, Jalgaun,
2.	Mass production of Bt, *Beauveria*, *Verticillium*, *Metarhizium*, coccinellids, *Paecilomyces lilacinus*, & EPN.	30.07.2012 to 03.08.2012	2 nos.	State Biocontrol Laboratory, Mannuthy, Thrissur, Kerala
3.	Isolation of vegetative insecticidal protein from *Bacillus thuringiensis*	04.06.2012 to 05.08.2012	1 no.	Tamil Nadu Agricultural University, Coimbatore
4.	Entomopathogenic fungi: Isolation of soluble protein extract and their toxic effect on *Spodoptera litura*, Molecular Characterization and Mass Production	04.06.2012 to 05.08.2012	1 no.	Tamil Nadu Agricultural University, Coimbatore
5.	Molecular characterization of microbes associated with Cotton mealybug *Phenacoccus solenopsis*	04.06.2012 to 05.08.2012	1 no.	Tamil Nadu Agricultural University, Coimbatore
6.	Molecular characterization of *Trichoderma*	05.06.2012 to 05.08.2012	1 no.	Tamil Nadu Agricultural University, Coimbatore
7.	Mass production of *Trichoderma* spp., *Pseudomonas fluorescens*, *Paecilomyces lilacinus*	06.08.2012 to 09.08.2012	2 nos.	Genewin Biotech, Hosur, Tamil Nadu
8.	Mass production of *Trichoderma* spp., *Pseudomonas fluorescens*, *Trichogramma chilonis*, *Metarhizum* spp., *Beauveria bassiana*, *Verticillium* spp.	06.08.2012 to 10.08.2012	2 nos.	• Krishi Bhavan, Madakkathara, Thrissur, Kerala • State Bio Control Laboratory, Mannathy, Thirssur, Kerala
9.	Characterization of dipteran toxic *cry* genes	01.01.2013 to 30.06.2013	1 no.	VIT University, Vellore -632 014 Tamil Nadu
10.	Field of Computational Biology as a part of curriculum	03.01.2013 to 31.03.2013	3 nos.	St. Joseph's college Trichirappalli, Tamil Nadu

11	Production quality control and formulation of biocontrol agents and biopesticides	18.02.2013 to 21.02.2013	2 nos.	State Biocontrol Laboratory, Mannuthy, Thrissur, Kerala,
2013-14				
12	Mass production and quality control of *Trichoderma* and *Pseudomonas*	18.06.2013	1 no.	Bapooji Krishi Vigyan Kendra, Idukki, Kerala
13	Mass production of biocontrol agents for the management of insect pests	22.08.2013 to 23.08.2013	29 nos.	Department of Horticulture Govt. of Karnataka Lalbagh, Bengaluru
14	DNA Isolation and PCR Techniques	07.09.2013 to 13.09.2013	1 no.	N.R.C for Orchids, Darjeeling
15	Detection and Measurement of Insecticide Resistance including molecular aspects in Insect pests	02.09.2013 to 11.09.2013	25 nos.	Scientists / Subject Matter specialists / Asst. Proffesors from ICAR/SAUs and KVKs
16	Development of DNA barcode of coconut lacebug *Stephanitis typicus* and *Proutista moesta*	29.03.2013 to 06.04.2013	1 no.	Coconut Research Institute of Sri Lanka
17	DNA Barcoding	21.11.2013 to 23.11.2013	1 no.	NIPHM, Rajendra Nagar, Hyderabad
18	Rearing of biocontrol agents	21.11.2013 to 23.11.2013	1 no.	NIPHM, Rajendra Nagar, Hyderabad
19	Eco-friendly management of white grubs and other soil arthropods using entomopathogenic nematodes	06.12.2013 to 13.12.2013	15 nos.	Agriculture and Horticulture Departments from several states viz., Assam, Meghalaya, Maharashtra, Rajasthan Karnataka, Odisha, Himachal Pradesh and Haryana
20	Mass production of bio-control agents for the management of insect pests	28.01.2014 to 29.01.2014	25 nos.	Department of Horticulture Govt. of Karnataka Lalbagh, Bengaluru
2014-15				
21	Bio-intensive pest and disease management	01.06.2014 to 05.06.2014	7 Nos.	Plant Protetion Directorate/ IPM projects for Plant production and Protection, Iraq
22	Biosystematics of Potato aphids	03.06.2014 to 05.06.2014	9 nos.	International Potato Centre (CIP, Lima, Peru) (Different parts of the country)

2015-16				
23	Biocontrol products	05.03.2015 10.03.2015	1 no.	Future Biotech Vadodara, Gujarat
24	Mass production of biocontrol agents and isolation techniques of microbial cultures	15.04.2015 20.04.2015	2 nos.	NRC on Pomegranate, Solapur
25	Insect rearing and maintenance	25.05.2015 26.05.2015	1 no.	Bioseed Research India – ICRISAT, Hyderabad
26	Entomopathogenic nematodes on mass multiplication	18.06.2015 19.06.2015	1 no.	NARP, ZAHRS, Shimoga
2016-17				
27	Mass production of biocontrol agents and microbials	23.05.2016 28.05.2016	7 nos.	PG students from BCKV, Kalyani
28	Mass Production of Biocontrol Agents	25.05.2016 26.05.2016	1 no.	Technical Officers from NIPHM, Hyderabad
29	Rearing of Pink bollworm and spotted bollworm	25.05.2016	1 no.	Metahelix Pvt. Ltd., Maharashtra
30	Mass Production of bioagents	25.05.2016 26.05.2016	1 no.	NGO, Bengaluru
31	Mass production of biocontrol agents and microbial biopesticides	27.06.2016 28.06.2016	2 nos.	Fruit research station, KVK, Sindhudurg
32	Identification of Mealy bugs	18.07.2016 23.07.2016	1 no.	Department of Entomology, HP Agricultural University
33	Mass culturing Techniques of anthocorid predators	25.07.2016 27.07.2016	1 no.	Department of Entomology, TNAU, Coimbatore
34	Mass production of biocontrol agents and microbial biopesticides	01.08.2016 08.08.2016	2 nos.	Department of Entomology, PAU, Ludhiana
35	Mass production of *Corcyra* and *Trichogramma*	09.08.2016 10.08.2016	1 no.	Cotton Research Station, Nanded
36	Use of Novel insecticidal WP formulations	09.08.2016	3	Mitra Kida, Pune

	of *Hetrorhabditis indica* for the biological control of whitegrubs and other insect pests	10.08.2016	nos.	
37	Mass production of *Trichogramma chilonis* on Eri Silk worm	29.08.2016	1 no.	ANGRAU, Hyderabad
38	Mass production techniques of *Cryptolaemus montrouzieri* and *Paracoccus marginatus*	26.09.2016 27.09.2016	1 no.	S V Agricultural College, ANGRAU, Tirupathi
39	Thrips Taxonomy	19.09.2016 24.09.2016	1 no.	College of Agriculture, Shivamoga
40	Mass production of bioagents	05.10.2016 06.10.2016	1 no.	Deejay Farms, Bengaluru
41	Mass production of bioagents	25.10.2016 26.10.2016	1 no.	College of Agriculture UAS, V. C. Farm, Mandya
42	Mass production of bioagents	28.11.2016 29.11.2016	1 no.	ICAR-Krishi Vigyan Kendra (BSS), Santhanpara, Idukki, Kerala
43	Advances and innovation in promotion and utilisation of microbials for biological control of crop pests	14.12.2016 24.12.2016	14 nos.	ICAR and AICRP Centers
44	Bioassay of pesticides and rearing of host insects	19.12.2016 12.12.2016	1 no.	Govt. College of Pharmacy (RGUHS), Bengaluru
45	Interactive Workshop on Administrative and Finance matters to Administrative and Finance staff of NBAIR	01.01.2017 04.01.2017	9 nos.	ICAR-NBAIR, Bengaluru

c. NBAIR scientists trained abroad

Sl. No.	Name & Designation	Period	Place	Training programme
8	Dr. Mahesh Yandigeri Senior Scientist	18.09.2013 to 16.12.2013	University of California Riverside, USA	Microbial Molecular Taxonomy (NRM)
9	Dr. M. Mohan Principal Scientist	18.09.2013 to 16.12.2013	University of Kentucky, Lexington, USA	Biomolecules (Crop Science)
15	Dr. Deepa Bhagat Principal Scientist	01.06.2014 to 15.06.2014	Penn State University, USA	Insect Chemical Ecology -14

Observations and recommendations of the QRT

1. The efforts made by NBAIR in human resource development are commendable as many young scientists have obtained adequate training in the internationally reputed laboratories. Scientists' participation in international meet especially women scientists is a good sign.
2. The QRT appreciates progress made by NBAIR in conducting training programmes for scientists, students, in-service personnel, entrepreneurs and stakeholders in the last five years.

vi. Publications 2012-2017

Total research papers published = 479 nos. (189 NAAS rated)

2. Production, process, technologies developed by the institute with credited scientists.

Products/process/protocols developed	: 27
Software protocols	: 22
Technology commercialized	: 18
Patents copyright files	: 20

Technical bulletins and documents (Published during 2012-17)

Folders :

1. The South American Tomato Leaf Miner (Tuta absoluta): Monitoring and Management Strategies - 2015
2. Farm Level Production of *Trichogramma chilonis* on Eri silkworm eggs and its utility in Tribal Areas - 2013
3. Biological Control of Grapevine Mealybugs -2013
4. Biological Control of Papaya Mealybug (English & Kannada) - 2012
5. Biological Control of the Sugarcane woolly aphid (English & Kannada) - 2012
6. Insectarium & Insect Photo Gallery -2015

Bulletins

1. Sequence submission made from NBAII under DBT -2013
2. Status, prospects and road map for enhancing the uptake of antagonistic organisms in nematode management in India - 2012
3. Proceedings of Classical Biological Control of Papaya Mealybug - 2012
4. Insect Genetic Resources -2017

News letters

NBAII News letter, Vol IV, No. 1-4, 2012
NBAII News letter, Vol V, No. 1-4, 2013
NBAII News letter, Vol VI, No. 1-4, 2014
NBAIR News letter, Vol VII, No. 1-4, 2015
NBAIR News letter, Vol VIII, No. 1-4, 2016
NBAIR News letter, Vol IX, No. 1-4, 2017

Annual Reports

NBAII Annual Report 2012-13 published in 2013
NBAII Annual Report 2013-14 published in 2014
NBAIR Annual Report 2014-15 published in 2015
NBAIR Annual Report 2015-16 published in 2016
NBAIR Annual Report 2016-17 published in 2017

i. Patents filed

Patent Application number	Title of patent	Date of Filling Status
WIPO 2016/059641 A1 5201/CHE/2014(Indian)	A Pheromone Detector	13/02/2015
372/CHE/2014A(Indian), 41/2015	Nanogels, methods & device thereof in pest management	2014
201641024309	Nanogels, methods & devices thereof, for managing *Holotrichia consanguinea*	15/07/2016
3696/CHE/2015	Optical Nanosensor for early stage detection of *Bactrocera oleainfestation*	18/07/2015
5166/CHE/2014	Surface functionalization for sensing of volatile organic compounds	16/10/2014
201741016464	A Reusable charge transfer based agrogel	2017
201741019790	Method and device for rapid detection of HearNPV	2017
344/CHE/2015	Method for continuous rearing of an anthocorid predator *Blaptostethus pallescens*	23/01/2015
201641002448	Dorsa lure - plant volatile composition to increase the trap efficiency for mango fruit flies	22/01/2016
201641002449	Plant volatile composition for trapping eucalyptus gall wasp, *Leptocybe invasa*	22/01/2016
201641015523	A herbal based repellent for termites on woody trees	05/04/2016
201641006014	Protocol for alcohol free plywood-laced melon fly attractant	22/02/2016
4227/CHE/2012	A process for preparation of biofumigants from leaves of *Lantana camara* against stored grain insect pests	15/10/2012
1310/CHE/2012	Development of novel wettable powder formulation of *Paecilomyces lilacinus* strain Nbaii Plft5 (Pl55) as bionematicide and methods thereof for scale-up production and down-stream processing for commercial use	02/04/2012

Observations and recommendations of the QRT

1. The annual reports, research highlights and newsletters were published on time by the Bureau.
2. The scientists of the Bureau had published reasonably good number of research articles in research journals.
3. The Bureau had provisionally filed 9 patents which are very much appreciated.

4. The Bureau must bring out DVD films on various aspects of mass production of biocontrol agents, biological control of crop pests and classical biological control of crop pests and success stories

viii. Structure and organization

Staff position

Directors

- Dr. Abraham Verghese, M.Sc.(Ag.), Ph.D(Agrl..Entomology), FERS - Director (Superannuated on 31.05.2016)
- Dr. Prashanth Mohanraj, M.Sc.(Ag.), Ph.D(Agrl..Entomology), -Director (Acting) (31.05.2016 to 18.07.2016)
- Dr. Chandish R. Ballal, M.Sc., M. Phil, Ph. D -Director (18.07.2016 to Till Date)

Division of Germplasm Collection and Characterization			
Scientists		Qualification	Designation
1	Dr. Sunil Joshi	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Principal Scientist & Head I/c
2	Dr. K. Veenakumari	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Principal Scientist
3	Dr. M. Mohan	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Principal Scientist
4	Dr. S. Salini,	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Scientist
5	Dr. K. J. David Scientist	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Scientist
6	Dr. G. Mahendiran	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Scientist
7	Dr. Ankita Gupta	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Scientist
8	Dr. Jagadeesh Patil	M.Sc.(Ag.), Ph.D(Nematology)	Scientist
9	Dr. M. Sampath Kumar	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Scientist
10	Ms. R. R. Rachana	M.Sc.,(Agri, Entomology)	Scientist
11	Mr. Navik Omprakash Samodhi	M.Sc.(Ag.Entomology)	Scientist

Division of Genomic Resources			
12	Dr. S. K. Jalali	M.Sc.(Ag.), Ph.D(Zoology)	Principal Scientist & Head
13	Dr. M. Nagesh	M.Sc.(Ag.), Ph.D(Nematology)	Principal Scientist
14	Dr. T. Venkatesan	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Principal Scientist
15	Dr. K. Srinivasa Murthy	M.Sc.(Ag.),Ph.D(Agrl..Entomology)	Principal Scientist
16	Dr. R. Rangeshwaran	M.Sc.(Ag.),Ph.D(Agrl.Microbiology)	Principal Scientist
17	Dr. M. Pratheepa	M.Sc.,Ph.D.(Computer Applications)	Principal Scientist
18	Dr. Mahesh Yandigeri	M.Sc.(Ag.),Ph.D(Agrl.Microbiology)	Senior Scientist
19	Dr. R. Gandhi Gracy	M.Sc.(Ag.), Ph.D(Agrl.Entomology)	Senior Scientist
20	Dr. S. Selvaraj	M.Sc.(Ag.), Ph.D(Agrl.Entomology)	Scientist
21	Dr. R.S. Ramya	M.Sc.(Ag.), Ph.D(Agrl.Entomology)	Scientist
22	Ms. Daliyamol	M.Sc.(Ag.), Ph.D(Plant Pathology)	Scientist Left NBAIR on 15.03.2017

Division of of Germplasm Conservation and Utilization			
23	Dr. N. Bakthavatsalam	M.Sc., Ph.D(Agrl.Entomology)	Principal Scientist & Head I/c
24	Dr. B. Ramanujam	M.Sc., Ph.D.(Pathology)	Principal Scientist
25	Dr. A. N. Shylesha	M.Sc.(Ag.),Ph.D(Agrl.Entomology)	Principal Scientist
26	Dr. T.M Shivalingaswamy	M.Sc.(Ag.),Ph.D(Agrl.Entomology)	Principal Scientist
27	Dr. P. Sreerama Kumar	M.Sc.(Ag.), Ph.D(Plant Pathology)	Principal Scientist
28	Dr. K. Subaharan	M.Sc.(Ag.),Ph.D(Agrl.Entomology)	Principal Scientist
29	Dr. G. Sivakumar	M.Sc.(Ag.),Ph.D(Agrl.Microbiology)	Principal Scientist
30	Dr. Deepa Bhagat	M.Sc., Ph.D.(Organic Chemistry)	Principal Scientist
31	Dr. U. Amala	M.Sc.(Ag.), Ph.D(Agrl.Entomology)	Scientist
32	Dr. Richa Varshney	M.Sc.(Ag.), Ph.D(Agrl.Entomology)	Scientist

Technical Staff			
33	Ms. Shashikala S. Kadam	(B.Sc., M.A.)	Chief Technical Officer
34	Dr. Y. Lalitha	(M.Sc., Ph.D.)	Asst. Chief Technical Officer
35	Dr. Birendra Kumar Chaubey	(M.Sc., PGDPA, Ph.D	Asst. Chief Technical Officer
36	Mr. Satendra Kumar	MSc (Ag)	Asst. Chief Technical Officer
37	Mr. P. K. Sonkusare	M.Sc.	Senior Technical Officer (T6)
38	Ms. B. L. Lakshmi	M.Sc	Senior Technical Officer (T6)
39	Ms. L. Lakshmi	M.Sc.(Ag.)	Senior Technical Officer (T6)
40	Mr. H. Jayaram	M. Li. Sc.	Senior Technical Officer (T6)
41	Ms. S. K. Rajeshwari	B.Sc.	Technical Officer (T5)
42	Mr. P. Raveendran	PUC	Technical Officer (T5)
43	Dr. A. Raghavendra	M.Sc., Ph.D.	Technical Assistant (Laboratory Technician)
44	Mr. Umesh Kumar Sanjeev	M.Sc.	Technical Assistant (Laboratory Technician)
45	Mr. M. Chandrappa	S.S.L.C.	Technical Assistant (Driver)
46	Mr. R. Narayanappa	S.S.L.C	Technical Assistant (General Operator)
47	Mr. P. Madanathan		- Technical Assistant (Driver)
Administrative Staff			
48	Mrs. S. Rama		Senior Administrative Officer (Left NBAIR on 22.03.2017)
49	Mr. T. A. Vishwanath	B.A., LL.B	Finance & Accounts Officer
50	Mr. K. N.Visweswara	B.A., LL.B	Personnel Secretary
51	Mr. Ajit Desai	M.Com	Assistant Administrative Officer
52	Ms. S. Kaveriamma	P.U.C	Personal Assistant
53	Mr. M. Eswar Reddy	B.E.	Assistant
54	Ms. Dipanwita Deb	B.Sc.	Assistant
55	Ms. M. S. Uma	B.Com	Junior Stenographer
56	Mrs Nazia Anjum	B.Sc.	Upper Division Clerk
57	Ms. Anitha, P.	S. S. L. C., DIP-SP	Lower Division Clerk

Supporting Staff			
58	Mr.Ramakrishnaiah		Skilled Supporting Staff
59	Mr.V. Angenappa		Skilled Supporting Staff
60	Mr.Pamulu Nagaiah		Skilled Supporting Staff

Staff cadre strength (2012-2017)

Discipline		**Sanctioned**	**In- position**	**Proposed**
Scientific				
Entomology	Pr. Scientist Sr. Scientist Scientist	4 5 11	0* 4 18	3* 4 18
Microbiology	Sr. Scientist Scientist	1 1	2 1	2 1
Plant Pathology	Sr. Scientist Scientist	1 2	1 2	1 2
Nematology	Sr. Scientist Scientist	1 2	0 2	0 2
Agricultural Chemistry	Scientist	1	1	1
Computer application	Scientist	1 0	0 1	0 1
Total		**30**	**32**	**35**
Technical	Technical	**17**	**15**	**21**
Administrative	Administrative	**11**	**10**	**17**
Supporting	Supporting	**6**	**3**	**6**

*HOD's (Three HOD's vacant)

Observations and recommendations of QRT

1. **The QRT observed that there is no addition of scientific and technical manpower at this Bureau in the X and XI plan period though the Project Coordinator cell was upgraded to PDBC in 1993, PDBC to NBAII in 2009 and subsequently to NBAIR.**

2. **There is an urgent need for additional scientific and technical manpower either by creating new positions or by redeployment from other ICAR Institutes to conduct research activities to meet the changed objectives envisaged in the vision 2050 document. The QRT recommends for the additional scientific and technical manpower as below:**

Sl. No.	**Category**	**Sanctioned**	**Existing**	**Additional**	**Total**
1	**Scientific**	**30+1**	**32*+1**	**5**	**35+1**
2	**Technical**	**17**	**15**	**4**	**21**
3	**Administrative**	**11**	**10**	**6**	**17**
4	**Supporting**	**6**	**3**	**- #**	**6**

*HOD's (Three HOD's vacant)

sanctioned positions to be retained

ix. Management practices

a) Meetings conducted:

Institute Management Committee meetings - 8
Institute Research Council Meetings - 9
Research Advisory Meetings - 5

b) Budget 2012-2017

The major source of funding was from the Indian Council of Agricultural Research under 'Non-plan' and 'Plan' and in addition from lateral sources like Department of Biotechnology, Ministry of Science and Technology, Government of India, National Agricultural Research Project (World Bank), the details of the funds are as follows:

Plan (2012-13 to 2016-17) **(Rupees in lakhs)**

Head	**Years**					**Total**
	2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**	
Establishment	0.00	0.00	0.00	0.00	0.00	0.00
TA	11.99	10.50	11.00	9.77	7.36	50.62
Other charges including equipment	142.23	127.08	138.18	163.55	48.18	619.22
Information Technology	0.00	0.00	0.00	0.00	0.00	0.00
Vehicle	0.00	0.00	0.00	0.00	0.00	0.00
Works	3.00	0.00	0.00	73.69	37.37	114.06
HRD	0.77	2.42	2.34	1.11	1.30	7.94
Total	157.99	140.00	151.52	248.12	94.21	791.84

Non-Plan (2012-13 to 2016-17)

Head	**Years**					**Total**
	2012-13	**2013-14**	**2014-15**	**2015-16**	**2016-17**	
Establishment	525.15	583.08	664.37	690.51	826.60	3289.71
TA	3.58	3.37	5.00	4.98	6.00	22.93
Other charges including equipment	95.82	134.33	140.49	122.45	103.89	596.98
Information technology	2.75	0.00	0.00	0.00	0.00	2.75
Vehicle	0.00	0.00	0.00	0.00	0.00	0.00

Works	14.00	19.90	19.40	15.33	19.00	87.63
OTA	0.00	0.00	0.00	0.00	0.00	0.00
Pension	2.26	56.00	12.83	17.85	25.87	114.81
Loan	1.05	0.99	3.00	0.45	0.60	6.09
Total	644.61	797.67	845.09	851.57	981.96	4120.90

Resource generation (2012-13 to 2016-17)

Year	Target (in Lakhs)	Achievement (in Lakhs)
2012-13	20	8.74
2013-14	8	13.12
2014-15	13.78	26.79
2015-16	14	33.55
2016-17	27	38.76
Total	82.78	120.96

x. Collaboration with other institutes, linkages with clients, end users, etc.

NBAIR has collaboration with the University of Agricultural Sciences, Bengaluru; University of Agricultural Sciences, Dharwad; University of Agricultural Sciences, Raichur, University of Mysore, and Bengaluru University for extending post graduate students' research facilities on various aspects of biological control (fundamental and applied aspects). Besides, active technical collaboration between NBAII and Bio-control Research Laboratory (BCRL), Bengaluru was established for mass production of biopesticides, disease antagnosists, pheromones, neem products and formulation technology.

The Bureau is recognised as a centre for Post graduate research by the University of Agricultural Sciences, Bengaluru, University of Agricultural Sciences, Dharwad, University of Mysore, Mysore, Bengaluru University, Jain University, Bengaluru, Kuvempu University.

a) Collaborations with national institutes, SAUs and others

NBAIR had active collaboration with various SAUs, ICAR research institutes and other stakeholders in specific areas as details below:

Major programme (crops/insect pests)	Area of collaboration	Institute/organisation
Biological Suppression of Crop Pests		
Sugarcane – *tissue borers* Cotton – boll worm complex, sucking pest Rice – tissue borers and leaf roller Maize – stem borer Mustard – aphids Tomato – fruit borer Cabbage – diamondback both Pigeonpea – pod borer Chickpea – pod borer *Papaya*- mealybug *Eucalyptus* – gall wasp	Mass production of quality bioagents/bio-pesticides	PAU, Ludhiana; GAU, Anand; UAS, Dharwad TNAU, Coimbatore MPKV, Pune CSR & TI, Mysore IIHR, Bengaluru
Validation of BIPM_Technology for major pests on cotton, pigeonpea, chickpea, groundnut, cabbage, tomato, apple and mango	Validation and Promotion of BIPM Technology in Selected Crops in Different Agro-ecological Regions	PAU & KVK, Ludhiana; CCSHAU & KVK, Hisar; MAU & KVK, Parbhani; RAU & KVK, Durgapur; KVK, Gulbarga; IAS, Varanasi; KVK, Kota; IIHR, Bengaluru; IIVR, Varanasi; KVK, Ranchi; Dr.YSPUH&F, Solani; CISH, Lucknow
Cotton – development of protocols for mass production of natural enemies	Control of leaf curl viral diseases and development of protocols for mass multiplication of predators, parasitoids and insect pathogens	CICR, Nagpur; CICR (RS), Sirsa; PAU. Ludhiana; RAU, Sirganganagar; CCSHAU, Hisar; NCIPM, New Delhi
Biological suppression of plant parasitic nematodes		
Meloidogyne spp. (vegetables, tobacco, potato)	Identification, testing and evaluation of nemato-phagous fungi and bacteria	CTRI, Rajahmundry; MPKV, Pune ANGRAU, Hyderabad

Biological suppression of plant diseases		
Plant diseases on rice (*Rhizoctonia, Sclerotium*), sunflower (*Rhizoctonia, Verticillium*), tobacco (*Alternaria, Pythium, Phytophthora, Sclerotium*), pulses- chickpea, pigeonpea (*Fusarium, Rhizoctonia*), vegetables - brinjal, tomato, crucifiers (*Pythium, Phytophthora, Macrophomina,Sclerotinia),* fruits- apple, citrus, mango *(Venturia, Botrytis, Rhizopus),* spices- pepper, cardamom *(Phytophthora, Pythium)*	Testing of host specific Pathogens and their field evaluations	GBPUA&T, Pantnagar;

Cyperus rotund **Biological Suppression of Weeds** *us, Mikania micrantha*	Testing of host specific insects and pathogens and their field evaluations	KAU, Thrissur; NRCWS, Jabalpur; IIHR, Bengaluru; NBPGR, New Delhi AAU, Jorhat
Chromolaena odorata	Establishment of the gall fly, *Cecidochares connexa*	KAU, Thrissur, UAS, Bengaluru, AAU, Jorhat, TNAU, Coimbatore

b) Collaborations with international institutes

NBAIR established active collaboration with various international organizations as detailed below for research and training collaborations during the period 2012-13 to 2016-17.

Organization	**Area of collaboration**
Ohio State University, Columbus	Acarology Summer Program
Washington State University, Pullman, USA	Genomic & Transcriptome Analysis, Protein Docking & Modeling
Ohio State University, Columbus	Acarology Summer Program
Washington State University, Pullman, USA	Genomic & Transcriptome Analysis, Protein Docking & Modeling
University of California Riverside, USA	Microbial Molecular Taxonomy (NRM)
University of Kentucky, Lexington, USA	Biomolecules (Crop Science)
Alexander Koenig Museum, Bonn, Germany,	Larval taxonomy -Immature Beetles, Molecular Taxonomy

c) Extension and Development Agencies

NBAIR has linkages and collaboration with extension and development agencies to promote economically viable and effective biocontrol and BIPM strategies developed in the institute. Following are some of the linkage activities with the State Departments and other development agencies:

- Suppression of papaya mealybug in Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala and mass multiplication of natural enemies of papaya mealybug at TNAU, Coimbatore, Tamil Nadu and MPKV, Pune, Maharashtra
- Mass production and supply of *Goniozus nephantidis* for the biological control of coconut black headed caterpillar by State Government of Kerala.
- Biological control of eucalyptus gall wasp with Indian Paper Manufacturers Association.
- Biological suppression of rice pests with Kerala Centre for Pest Management and State Department of Agriculture, Kerala
- Training programmes conducted on mass production of various biocontrol agents to entomologists of KVKs, Plant Protection Specialists and extension field functionaries of State Department of Horticulture and Agriculture of the States of Maharashtra, Andhra Pradesh, Tripura, Kerala and Karnakata, Central Integrated Pest Management Centre of the Directorate of Plant Protection, Quarantine and Storage, NGOs, etc.
- Newsletters and technical bulletins on various aspects were regularly published and circulated to extension agencies of different states for enhancing knowledge and skill on biocontrol.

d) Collaboration with Industry

- Allwin Industries, Pithampur, Dist.Dhar (M.P.) Liquid formulation of *Bacillus thuringiensis*
- M/s Multiplex Biotech Pvt. Ltd., Bengaluru: Licensing of Know-how of *Heterorhabditis indica* Hi1- production, downstream processing and wettable powder formulation.
- M/s Agri Bio-Tech Research Centre, Kerala: Licensing of know-how of liquid formulation of *Bacillus thuringiensis*.
- Camson Bio Technologies Ltd, Bengaluru, Entomopathogenic nematode, Heterorhabditis indica strain NBAIIHi1 - in-vivo production, downstream processing and wettable powder formulation and field use for biological control of white grubs.
- Ponalab, Bengaluru, Liquid formulation of *Bacillus thuringiensis*, Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes
- Om99 Agrotech Private Limited, A Herbal Based Repellant For Termites On Woody Trees – REPTER"
- State Biocontrol Lab, Mannuthy, Thrissur, Kerala. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests.
- Rainbow Agrilife India Pvt Ltd, Kadapa, A.P. A Herbal Based Repellant For Termites On Woody Trees – REPTER
- Mitrakida, Pvt ltd, Pune. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests.
- Godavari Biofertilizer industries, Nashik, Maharastra. Novel insecticidal WP formulations of Heterorhabditis indica for the biological control of white grubs & other soil insect pests.

- Bio95.com Agrotech Pvt. Ltd. Dorsa lure- plant volatile dispensers for increasing the trap efficiency for mango fruit flies
- Bioseed Research India PVT Ltd, Hyderabad. A simple technique of rearing brinjal shoot and fruit borer, *Lucinodes orbonalis.*
- Planttech Solutions, Chikkamagaluru, Karnataka. A Herbal Based Repellant For Termites On Woody Trees – REPTER
- Aspartika Biotech Pvt Ltd, Bengaluru. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests
- Natura Crop Care, Bengaluru. Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests

The collaborative efforts/linkages established with various institutions/organizations both in public and private sectors have been in consonance with Vision-2050 document.

Observations and recommendations of the QRT

1. The QRT observed that NBAIR has adequate collaborations and linkages with SAUs, AICRP centres, AINP centres, private industries and entrepreneurs and stakeholders.

i. Constraints

The QRT has identified the following constraints at NBAIR, hindering the institute in achieving its objectives and implementation of its programme and goals.

1. There is no addition of work space at NBAIR since inception.
2. There is a need for creation of a bigger national insect repository as the present one does not support future collections.

D. OVERALL ASSESSMENT

The various divisions of the Bureau have done very good research work complying with the mandate and objectives thereon. A lot of information pertaining to the area of research has been hosted in the Bureau's website., with quality photographs and explanation, making it a ready rtecknor for researchers/subject matter specialists/plant protection personnel, private enterpreneurs and farmers. Success stories on biological control of Sugarcane woolly aphid, rice pests, eucalyptus gall wasp, entomopathogenic nematodes and mass production technologies for biocontrol agents have been brought out and bulletins on these have been published.

The Bureau has a well-maintained insect repository which needs to be further strenghtened with collections from other organisations/museums. Molecular taxonomy of insect pests, natural enemies and insect resources has been well diocumented with generation of authentic barcodes. The research work on semio chemicals and nano formualtions /sensors for the management of key pests would go a long way as ecofriendly and cost-effective tools in the management of pests with greater economic returns. Research on waste management through insects (detrivores) and insect as food and management of veterinary insect pests is a new venture befitting the mandate.

Several technologies (27) have been developed and commercialised (18). Research publications, Technical bulletins, Newsletters, Annual reports and Extension folders were periodically

published and are noteworthy. Databases and E-Resources for farmers has been hosted on the website providing information on insect pests of crops and their biological control in a lucid manner for effective dissemination and adaption.

The Bureau is recognised as a centre for research by several universities (UAS, Bengaluru, UAS, Dharwad, Bengaluru University, Kuvempu University, University of Mysore, Jain University) and has established good linkages with other research organisations, State departments of Agriculture and Horticulture, KVKs, Private entrepreneurs, NGOs and progressive farmers.

Overall assessment of the Bureau based on the achievements and progress made is commendable.

Notable outputs NBAIR commendable by the QRT include the following:

- Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests
- Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes
- Liquid formulation of *Bacillus thuringiensis*
- Powder based formulation of *Pseudomonas fluroscens,* a DAPG producing abiotic stress tolerant isolate for rainfed and stressed agricultural soil
- Closed system for mass production of predatory mites
- A dispenser for the monitoring of eucalyptus gall wasp
- Bio formulation of salinity tolerant *Trichoderma harzianum* with biocontrol potential
- Bioformulation of carbendazim tolerant *Trichoderma harzianum* with biocontrol potential
- Powder based formulation of *Bacillus megaterium* as growth promoter & management of bacterial wilt disease
- A plant volatile based attractant for enhanced attraction of fruit fly
- A simple technique of rearing brinjal shoot and fruit borer, Lucinodes orbonalis
- Protocol for designing lure for impregnating parapheromone 4[4-acetoxy] phenyl-butanone to attract male flies of *Bactrocera* spp attacking cucurbit crops for mass trapping and monitoring its population thereof
- Control release dispensers for semiochemicals
- Mass production of *Trichogramma chilonis* & *T. embryophagum* using *Eri* silkworm eggs
- A Herbal based Repellant for Termites on woody trees
- Herbal swabber for the management of white stem borer *Xylotrechus quadripes* in Coffee (organic and non-pesticidal). Booster for boosting plant health in coffee (not for certified organic coffee)
- Adsorption and delivery of molecules using Nanoporous materials
- Dorsa-Delta, an efficient trap for mango fruit fly
- A Bisexual attractant for *Bactrocera dorsalis* in delta trap
- A Technique for rearing of Housefly parasitoid *Spalangia*
- A Technique for rearing of Housefly parasitoid *Nasonia vitripennis* (Pteromalidae)
- Waste to wealth: Technology on Black Soldier Fly mediated bioconversion of farm and kitchen wastes
- Insect repellent formulation and methods thereof

- Novel Device for field release of parasitoids
- One day group meeting on the status of invasive tomato leaf miner, Tuta absoluta in India was organized by ICAR-NBAIR in collaboration with DPPQ&S at NBAIR conference hall on 21.02.2015.
- Online identification aids for agriculturally important insects hosted on NBAII's website containing fact sheets for biocontrol agents and crop pests, image galleries, directory of taxonomists offering identification services, DNA barcodes for agriculturally important insects - 'Insect Barcode Informatica - (IBIn), aphids of Karnataka (URL: www.aphidweb.com), Coccinellidae of the Indian Subcontinent, checklist 15 minor orders of insects of the Indian subcontinent.
- International Catalogue published for Microgastrinae (Hymenoptera) of Reunion Island (Indian Ocean) cataloguing 18 new taxa and key to species and describing 10 new species along with 200 macro & micro images.
- Website on type specimens in NBAIR prepared with details entomogenous nematodes were isolated from different agro climatic zones and they were maintained live on wax moth Galleria mellonella.
- A plant-based attractant was developed which was evaluated for the attraction of Bactrocera dorsalis in the mango orchards. The new dispensers attracted more fruit flies than the standard check methyl eugenol, especially B. dorsalis.
- Kikiki, the smallest known flying insect in the world, collected from Shevaroy hills and added to NBAIR holdings.
- The anthocorid predator, Orius laevigatus and the predatory mite, Amblyseius swirskii found to be safe to productive insects and parasitoids.
- Web portal for identification of 'Indian fauna of Pteromalidae' updated with additional 12 species
- Illustrated fact sheets for 76 species of insect pests with 504 images and 28 species of insect bioagents with 152 images prepared and hosted on NBAIR's website.
- A large-scale rearing methodology for Hishimonus phycitis optimised to produce and maintain over 2,000 adults at any given time on 200 brinjal plants in the greenhouse.
- Two populations of Ha NPV whole genome sequencing was done and in virulent population, 42 known and 41 hypothetical genes were identified., besides five genes from a-virulent populations were sequenced for quick and reliable identification.
- Trained 7 Iraqi delegates from 1st to 15th June 2014 on Biological Control and IPM and 5 trainees on Biosystematics of potato aphids (3rd June to 5th June 2014)
- The cuticular hydrocarbons in coconut red palm weevil, Rhynchophorous ferrugineus were identified as hexacosane, heptacosane, octacosane and nonacosane.
- Identified over 50 species of pollinators on different host plant species.
- Molecular characterization and DNA barcoding of 262 agriculturally important insect species and populations were done using CO1 and ITS genes, these insects belonged to seven orders, viz., Lepidoptera, Coleoptera, Hemiptera, Diptera, Odonata, Hymenoptera and Blattodea.
- The pectinase, an important enzyme involved in insect nutrition was detected from endosymbionts of Bacillus pumilus, Filobasidium floriformie, B. licheniformis and Staphylococcus aureus.
- The complete nucleotide sequence of the HANPV_L1 (virulent strain) was determined.

- Liquid formulation technology of *Bacillus thuringiensis* (NBAII-BTG4) for control of lepidopteran pests was evaluated under large scale in Gujarat, Maharashtra and Karnataka against Helicoverpa armigera and Maruca testulalis in pigeon pea
- Formulations of an abiotic stress tolerant plant growth promoter Pseudomonas fluorescens (PFDWD) was evaluated in farmer's saline affected fields of Karnataka, Gujarat and Tamil Nadu
- Arecanut root grub incidence reduced by 62-78% and 70-80% in sugarcane and other crops with the use of WP formulations of *H. indica* @ 4-5 kg/acre and 6-8 kg/acre, respectively.
- For management of fruit flies in Karnataka, fruitfly trap Dorsa-lure has been utilised successfully in an area of 810149.80.ha.
- The introduced parasitoid *Quadrastichus mendeli* with the indigenous *Megstigmus* sp. is playing an important role in the suppression of the eucalyptus gall wasp, providing 66-80% control in the released locations, providing significant savings to paper pulp industry.
- Eleven NBAIR technologies have been commercialised and a revenue of Rs 43.31 lakhs has been generated (2016-17). These technologies are being adopted by commercial units for producing superior strains of bio-pesticides and biocontrol agents which are now available for farmers in different parts of the country.
- NBAIR has provided identification services for 6500 insect specimens, thus providing savings of US$ 650,000.
- The Regional Consultation on 'Facilitating the use of microbial pesticides in South Asia' was organized by SAARC Agriculture Centre (SAC), Bangladesh, ICAR-NBAIR, India and CABI-South Asia at ICAR-National Bureau of Agricultural Insect Resources, Bengaluru from 21 - 23 August, 2017
- TRAINING on "Recent Advances in Insect Bioinformatics and its applications in Pest Management" 15th - 20th February, 2016
- One day workshop on Nanotechnology in Agriculture: A focus on Insects and Insect resources 19th March, 2016.
- A Brainstorming on "Access and Exchange of Insect Germplasm Resources" on 23th July 2016 at NBAIR.
- Capacity Building Program on Advances and innovations in promotion and utilization of microbials for biological control of crop pests December 14-24, 2016.
- Database called the "Arthropod Germplasm Information System" (AGIS) in India developed. (documents the live arthropod resources of agricultural importance being maintained by institutions across the country.
- Veterinary & Fisheries Arthropod Laboratory and ICAR - NAIP Funded Pilot Scale Production of Bio Pesticides Unit set up at ICAR- NBAIR, Attur Campus. The Veterinary & Fisheries Arthropod Laboratory is mandated to collect, characterize and utilize arthropods in animal and fisheries sciences.

Following databases were developed.

- Agriculturally Important Insects
- Aphids of Karnataka
- Featured Insects
- Indian genera of Aphelinidae
- Indian Genera of Chalcididae
- Indian genera of Diapriinae
- Indian Genera of Mymaridae
- Indian Fauna of Pteromalidae
- Introduction of Biocontrol agents in India
- Type Specimens in NBAIR Collections
- Database on Indian Platygastroidea
- Bee Fauna of India
- Common soft scales of India
- Indian Longhorn Beetles
- National Biodiversity Authority (NBA) voucher specimen list
- Database and Documentation of Genetic Resources
- E-resource on mass production protocols for some agriculturally important insects in India
- Database on Entomopathogenic Nematodes
- Database on Host Insects, Parasitoids and Predators maintained at NBAIR
- Entomofungal pathogens maintained at NBAIR
- Antagonistic fungi for plant parasitic nematodes\
- Database on Mite pathogens
- Database on NBAIR Accessions of Bacterial Biocontrol Agents
- Database of microbes associated with insects
- Insect Biodiversity Analysis Portal
- Insect Barcode Information system
- Insect Pest Info Database
- Arthropod Germplasm Information System
- Insecticide resistance gene database
- Whole genome sequence of honey bee viruses
- Whole genome sequence of insects
- Other Genomic Resources
- iGenTools
- Trichoderma culture collection database

E- Learning for farmers:

Following extension folders with quality photographs are made available on the web in languages for easy access by the farmer.

- Potential Indian Anthocorid Predators at the ICAR-NBAIR Live Insect Repository
- Field day on "The effect of Natural enemies on crop pests" held at KVK, Paparapatti,T.N. on 23/02/14
- Biological Control of Pests of Tomato, Brinjal, Cotton, Sugarcane and Rice using Stress Tolerant Natural Enemies
- Biological Control of Pests of Tomato, Brinjal, Cotton, Sugarcane and Rice using Stress Tolerant Natural Enemies (Tamil)
- The South American Tomato Leaf Miner (Tuta absoluta) : Monitoring and Management Strategies (Tamil)
- Farm Level Production of *Trichogramma chilonis* on Eri Silkworm Eggs and its Utility in Tribal Areas
- Biological Control of Grapevine Mealybugs
- Biological Control of Grapevine Mealybugs (Hindi)
- Classical Biological Control of Papaya Mealybug

- Classical Biological Control of Papaya Mealybug (Hindi, Kannada and Odiya)
- Biological Control of the Sugarcane woolly aphid
- Biological Control of the Sugarcane woolly aphid (Kannada)
- Provisional filing of seven patents.

Following Technologies commercialised. The total revenue generated was **Rs. 5,475,000/**

S.No	Name of the Licensee	Name of the ICAR-NBAIR technology commercialized	Cost paid by licensee in (Rs.)	Year
1	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Liquid formulation of *Bacillus thuringiensis*	150,000	06.12.2013
2	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Powder based formulation of *Bacillus megateriumas* growth promoter	75,000	06.12.2013
3	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Bioformulation of carbendazim tolerant *Trichoderma harzianum*with biocontrol potential	150,000	19.07.2013
4	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	High temperature tolerant strain of egg parasitoid *Trichogramma chilonis*	37,500	06.12.2013
5	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis*	112,500	06.12.2013
6	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes	150,000	06.12.2013
7	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Entomopathogenic nematode, *Heterorhabditis indica* strain NBAIIHi1 - *in-vivo* production, downstream processing and wettable powder formulation and field use for biological control of white grubs	150,000	06.12.2013

8	Allwin Industries, Pithampur,Dist.Dhar (M.P.)	Pesticide tolerant strain of aphid lion, *Chrysoperla zastrowisillemi*, an important predator of sucking pests	150,000	06.12.2013

9	Foundation for Agricultural Resources Management and Environmental Remediation (FARMER), New Delhi	Entomopathogenic nematode, *Heterorhabditis indica* strain NBAIIHi1 - *in-vivo* production, downstream processing and wettable powder formulation and field use for biological control of white grubs	150,000	18.03.2013
10	Camson Bio Technologies Ltd, Bengaluru	Entomopathogenic nematode, *Heterorhabditis indica* strain NBAIIHi1 - *in-vivo* production, downstream processing and wettable powder formulation and field use for biological control of white grubs	200,000	04.02.2013
11	Dr.Abdul RaufAgri Research foundation	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	150,000	30.04.2014
12	Agri Bio Care, Kottayam-Kerala	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	150,000	04.04.2014
13	Agri Bio Care, Kottayam-Kerala	Multiple insecticide tolerant strain of egg parasitoid, *Trichogramma chilonis*	112,500	04.04.2014
14	Agri Bio Care, Kottayam-Kerala	Powder based formulation of *Bacillus megaterium* as growth promoter	75,000	04.04.2014

15	Agri Bio Care, Kottayam-Kerala	Liquid formulation of *Bacillus thuringiensis*	150,000	04.04.2014
16	Agri Bio Care, Kottayam-Kerala	Promising plant growth promoting strain of *Bacillus megaterium* for vegetable crops	112,500	04.04.2014
17	Ponalab, Bengaluru	Liquid formulation of *Bacillus thuringiensis*	150,000	17.11.2014
18	Ponalab, Bengaluru	Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes	150,000	17.11.2014
19	Ponalab, Bengaluru	Powder based formulation of *Bacillus megaterium* as growth promoter	75,000	17.11.2014
20	Ponalab, Bengaluru	Bioformulation of salinity tolerant *Trichoderma harzianum* with biocontrol potential	75,000	17.11.2014
21	Ponalab, Bengaluru	Bioformulation of carbendazim tolerant *Trichoderma harzianum*with biocontrol potential	75,000	17.11.2014
22	Ponalab, Bengaluru	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	150,000	17.11.2014
23	UAHS, Shivamogga	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	150,000	10.09.2015
24	Bio95.com Agrotech Pvt. Ltd	Dorsa lure- plant volatile dispensers for increasing the trap efficiency for mango fruit flies	125,000	20.10.2015
25	Dr.Abdul RaufAgri Research foundation	Novel insecticidal WP formulations of *Heterorhabditis indica*	50,000	23.11.2015

		for the biological control of white grubs & other soil insect pests		
26	Bioseed Research India PVT Ltd, Hyderabad	A simple technique of rearing brinjal shoot and fruit borer, Lucinodes orbonalis	50,000	21.03.2016
27	Om99 Agrotech Private Limited, C1-404, White House , 15th cross, 6th Main road, R.T. Nagar, Bengaluru - 560032	A. Herbal swabber for the management of white stem borer *Xylotrechus quadripes* in Coffee (organic and nonpesticidal). B. Booster for boosting plant health in coffee (not for certified organic coffee)	125,000	30.03.2016
28	Om99 Agrotech Private Limited, C1-404, White House , 15th cross, 6th Main road, R.T. Nagar, Bengaluru - 560032	A Herbal Based Repellant For Termites On Woody Trees – REPTER"	100,000	30.03.2016
29	State Biocontrol Lab, Mannuthy, Thrissur, Kerala	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	200,000	11.03.2016
30	State Biocontrol Lab, Mannuthy, Thrissur, Kerala	Novel wettable powder formulation of *Pochonia chlamydosporia* as bionematicide against plant parasitic nematodes	200,000	11.03.2016
31	State Biocontrol Lab, Mannuthy, Thrissur, Kerala	Liquid formulation of *Bacillus thuringiensis*	200,000	11.03.2016
32	Rainbow Agrilife india pvt ltd, Kadapa, A.P	A Herbal Based Repellant For Termites On Woody Trees – REPTER	100,000	16.05.2016

33	Rainbow Agrilife india pvt ltd, Kadapa, A.P	Protocol for designing lure for impregnating parapheromone 4[4-acetoxy) phenyl-butanone to attract male flies of Bactrocera spp attacking cucurbit crops for monitoring its population – (CUELURE)	75,000	16.05.2016
34	Rainbow Agrilife india pvt ltd, Kadapa, A.P	A. Herbal swabber for the management of white stem borer *Xylotrechus quadripes* in Coffee (organic), B. Booster for boosting plant health in coffee (not for certified organic coffee)	125,000	16.05.2016
35	Planttech Solutions, Chikkamagaluru, Karnataka	A. Herbal swabber for the management of white stem borer *Xylotrechus quadripes* in Coffee (organic and nonpesticidal). B. Booster for boosting plant health in coffee (not for certified organic coffee)	125,000	26.08.2016
36	Planttech Solutions, Chikkamagaluru, Karnataka	A Herbal Based Repellant For Termites On Woody Trees – REPTER	100,000	28.11.2016
38	Mitrakida, Pvt ltd, Pune	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	200,000	27.07.2016
39	Aspartika Biotech Pvt Ltd, Bengaluru	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	200,000	07.09.2016

40	Natura Crop Care, Bengaluru	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	200,000	07.11.2017
41	Godavari Biofertilizer industries, Nashik, Maharastra	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	200,000	26.09.2017
42	Khandelwal Biofertilizers private limited, Borgaon – 591216, Karnataka	Novel insecticidal WP formulations of *Heterorhabditis indica* for the biological control of white grubs & other soil insect pests	200,000	12.07.2017
Total revenue generated from 2013-2017			**Rs. 5,475,000/**	

Overall assessment

C. CONSOLIDATED RECOMMENDATIONS

The chairman and members of the QRT visited different divisions and laboratories of NBAIR and critically evaluated the existing facilities and lab space available and proposed futuristic requirements of the Bureau as given in the table. QRT strongly recommended additional space for HOD's, AICRP Cell, PME and Vigilance Cell which are currently operating from the respective scientist's laboratories.

Since NBAIR has been recognised by DST for insect taxonomy training, an additional space for auditorium (for holding symposium, conferences etc) and a lab annexe and accommodation facilities need to be provided in future plan projections.

Sl. No.	Division/laboratory/ Unit	Existing work space (in sq. meter)	Additional work space required (in sq. meter)
1	**Germplasm Collection and Characterization**		
	a. National Insect Reference Collection	104.16 m^2	
	b. Laboratory space in main campus, Hebbal	304.40 m^2	500 m^2
	c. Laboratory space in Attur campus	47.43 m^2	
	d. Insect Museum	500 m^2 (*under construction)	
	Total	955.99 m^2	
2	**Genomic Resources**		
	b. HPC facility	93.15 m^2	
	c. Laboratory space in main campus, Hebbal	264.37 m^2	500 m^2
	c. Laboratory space in Attur campus	94.86 m^2	
	Total	452.38 m^2	
3	**Germplasm conservation and utilization**		
	a. Mass production laboratory	183.2 m^2	
	b. Growth chambers	58.28 m^2	
	d. Laboratory space in main campus, Hebbal	307.01 m^2	500 m^2
	d. Laboratory space in Attur campus	141.02 m^2	
	Total	689.51 m^2	
4	Quarantine building	424.28 m^2	
5	ITMU	67.39 m^2	100 m^2
6	AICRP Cell	-	100 m^2
7	Vigilance Cell	-	100 m^2
8	PME Cell	-	100 m^2
9	Auditorium	-	500 m^2
10	Insect Rearing facility	-	300 m^2
11	Space for HOD's	-	300 m^2
12	Lab Annexe	-	500 m^2
	Total	4687.43 m^2	3500 m^2

QRT remarked that with the redesigned mandate of the Bureau, the number of staff superannuated in the last five years and no additional posts created during 2012-17, there is an urgent requirement for additional scientific, technical and administrative staff either by creating new positions or by redeployment from other ICAR institutes. Hence, the scientific, technical, administrative ad supportive staff as per the details given in the table was recommended.

Discipline		Sanctioned	In- position	Proposed
Scientific				
Entomology	Pr. Scientist Sr. Scientist Scientist	4 5 11	0* 4 18	3* 4 18
Microbiology	Sr. Scientist Scientist	1 1	2 1	2 1
Plant Pathology	Sr. Scientist Scientist	1 2	1 2	1 2
Nematology	Sr. Scientist Scientist	1 2	0 2	0 2
Agricultural Chemistry	Scientist	1	1	1
Computer application	Scientist	1 0	0 1	0 1
Total		**30**	**32**	**35**
Technical	Technical	**17**	**15**	**21**
Administrative	Administrative	**11**	**10**	**17**
Supporting	Supporting	**6**	**3**	**6**

*HOD'S(Three HOD's Vacant)

- Centres of Excellence for invasives and molecular modelling of to be conceived for NBAIR and necessary provisions to be made.

- As the Bureau's activities have expanded, there is a constant neeed to maintain insect resources/cultures in confinement and under control conditions for advanced studies, HRD programmes and extension activities, there is a need to develop state of the art, controlled insect rearing facility in NBAIR.

- A specialized curator for the Insect/ Arthropod National Reference Collection and musuem must be appointed to maintain the musuem as per International standards.

- NBAIR should have a Scanning Electron Microscope (SEM) to address the futuristic need of arthropod systematics which could be a national facility for ICAR/SAU in the country.

- A need for a mobile insect museum cum insect collection and preservation laboratory was strongly felt as a necessity to meet the mandate of the Bureau. So, a provision for a mini van with state-of-the-art facilities needs to be made in the future budget.

- Augmentation of existing collections and maintenance of a national repository. To build up a virtual repository in terms of barcoded digitised domain for easy access for identification of insects and act as a nodal centre for identification and characterisation. The number of taxonomists may be increased to develop expertise in biosystematics.

- Field identification guide for arthropod biodiversity (bioagents, honeybees, pollinators, lac insects, silkworms, veterinary pests)

- HRD programmes for capacity building of core group of taxonomists well versed in morphological and molecular taxonomy
- Intensify exploratory surveys in biodiversity hot spot areas, comprehensive collections must include diversity of natural enemies, host-insects, EPN, PPN, veterinary pests, pollinators, entomathogenic fungi and *Bt*.
- Establish linkages with National (ZSI, FRI, NPC, conventional universities) and Intrernational (CABI, BNHM, National Museum, Washington DC) to facilitate collections, gain expertise to benefit taxonomists
- Establishment of a credible and affordable identification service for insects and mites of agricultural importance to cater to national and regional needs.

- Focus on structural genomics and bioinformatics for selected arthropods, with a networking policy and linkage with centres for biotechnology and bio-informatics. Gut microflora must be explored for their utilization and manipulation for pest management. Smart and superior natural enemies must be developed for better pest management.

- Development of computational tools for prediction of insecticide resistance genes in agriculturally important insects.

- Biosecurity, threat perception with action-plan for putative accidental introduction of invasives. Monitor and prevention of introdution and spread of invasives in co-ordination with national agencies to support quarantine activities

- Focus on *in situ* provision of shelters/refugees, crop habitat diversity for encourgaing beneficial organisms and natural enemies.

- Impact of climate change on arthropod diversity, tritrophic interactions, niche overlaps and migration to be studied in the context of population dynamics of the pest.

- Research on nano formulations/nano sensors of semiochemicals with greater shelf life must be taken up for the management of key lepidopteran pests across the crops.

- Field demonstrations and transfer of technology to the farming community must be taken up on regular basis through effective extension linkages with State departments/SAUs/KVKs etc. for effective adaption towards doubling the farm income.

- Socio economic impact analysis of the technologies must be assessed.

- The Bureau must be made as a centre for advanced insect studies addressing biosystematics, biotechnology, bioinformatics, physiology and ecology.

- The bureau must be recognisaed as a centre for Post doctoral research on Biological control

- A full-fledged recreational facility at main campus/Attur campus may be envisioned for thewelfare of the staff.

LIST OF ANNEXURES

Annexure I – Terms of reference for QRT

Annexure II – Evaluation proforma for the Bureau

Annexure III – Overall performance of the institute.

Annexure I

Terms of Reference to Quinquennial Review Team

Basically, the idea is to examine whether the research and development programmes are in conformity with the priorities of the ICAR and the nation.

A. Institute/Unit

(i) Research achievements and impact

- To critically examine and identify research achievements of the Institutes, Projects/KVKs, and their Regional Stations and Sub-Stations, AICRPs operated by them vis-a-vis sectoral programmes since the previous QR and critically evaluate them. Commensurate with the objectives, mandates and resources of the organization, the socio-economic impact of research on farmers/beneficiaries, and transferability of results to farmers through extension should be critically reviewed.
- The research and its impact should be brought out in quantifiable benchmarks wherever possible.
- To know the value for money, QRT should assess and bring out the physical outputs and outcomes vis-a-vis the budget spent during the period under report. If the likely outcomes are going to take considerable time, the projected outcomes should be indicated.
- The socio-economic impact of research on farmers/beneficiaries and transferability of results to farmers being an important aspect of research outcome the transferability should be mandatory for major research projects.

(ii) Research relevance and budget allocation

To examine objectives, scope and relevance of the research programmes and budget of the institute for the next 5 years in relation to overall state/regional/national plans, policies and long-and short-term priorities and also the Perspective Plan and Vision 2020 documents.

(iii) Relationship/collaboration with SAUs and other stakeholders

To pinpoint whether the research programmes of the past and proposal for future are in harmony with the Vision of the ICAR (Hq) and the programme of the related centres of research and agricultural universities state government, private sector and IARCs.

(iv) Linkages with clients/end-users

To examine the kind of linkages established with the clients and end users of the research results, i.e. farmers/fishermen and the extent of interest displayed in conducting "on-farm research". On farmers' fields and in organizing demonstrations/training courses for the transfer of technology to extension agencies and KVKs of the ICAR.

(v) Proposed changes in organization, programme and budget

To examine whether any changes in the organizational set-up are called for manpower and funds allocation. The decentralization in day-to-day working and the transparency should be highlighted. Further, the Committee may also examine the resource generation efforts and implementation of Project-based Budgeting.

(vi) Constraints

To examine constraints hindering the institute in achieving its objectives and implementation of its programme and goals, and to recommend ways and means of minimizing or eliminating them.

(vii) Looking forward

To look into any other point considered relevant by the Committee or referred to it by the ICAR, the Institute Director or the Management Committee, in respect of future programme development, research prioritization and management changes.

ANNEXURE – II

EVALUATION PROFORMA FOR THE BUREAU-ICAR-NBAIR

Sl. No.	Evaluation parameter	Remarks	Total marks	Marks assigned
1	Staff position and vacancy	Good (To be strenghtened)	10	7
2	Research achievements in terms of technical programme	Excellent	10	9
3	Quality of work output	Excellent	10	9
4	Quantity of work in relation to staff in position	Excellent	10	9
5	Technologies developed	Excellent	10	9
6	Technologies adapted	Very good	10	8
7	Infrastructure and facilities developed	Excellent	10	9
8	HRD	Excellent	10	9
9	Extension activities	Very good	10	8
10	Publications	Excellent	10	9
11	Utilization of budget	Very good	10	8
		Total	**110**	**94**

Any other general remarks, comments, suggestions for the improvement/strengthening the centre:

Overall assessment and remarks :

The bureau has done exemplary work and is graded A+ (Excellent)

Date: 31.12.2018

Signature of the QRT Chairman
(J.H.Kulkarni)

Annexure – III

OVERALL PERFORMANCE OF THE BUREAU :

ICAR-National Bureau of Agriculturally Important Insect Resources
Bengaluru - Excellent

Date: 31.12.2018

Signature of the QRT Chairman
(J.H.Kulkarni)