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ICAR-National Bureau of Agricultural Insect Resources

Value-added products from insects

Around 1 million insect species are estimated to be in existence in this world, and among them, only around 5,000 species are considered pests, though a majority of them are phytophagous. Fortunately, several species of insects are natural enemies of the pests, quietly managing the pests naturally; scavengers, recycling the waste; or play an important role in the food web.

Value-added products from insects are well known. In India, more than 1,20,000 metric tonnes of honey is produced with an estimated 57,537 metric tonnes being exported. Apart from traditional honey, stingless bee honey is being produced in several parts of India since they have very high medicinal value and economic returns. The other products such as lac and cochineal dyes are well known.

Insects as food and feed are known from time immemorial and species of crickets, black soldier fly, termites, beetles, heteropteran bugs, etc. have been used for this purpose often. The recent focus is on the production of insects for human food due to lesser water requirements and reduced emissions of greenhouse gases.

Insects are a valuable source of nutraceuticals. Rumpold and Schluter (2013) mentioned that many edible insects provide satisfactorily with energy and protein, meet amino acid requirements for humans, are high in mono-unsaturated fatty acids (MUFA) and/or polyunsaturated fatty acids (PUFA), and rich in several micronutrients such as copper, iron, magnesium, manganese, phosphorous, selenium, and zinc as well as riboflavin, pantothenic acid, biotin, and in some cases folic acid. Cricket's flour has twice the amount of protein compared to beef and spinach. Besides, the protein they provide, 25g/day of roasted cricket powder for 14 days increases probiotic bacteria and decreases plasma tumor necrosis factor. Larval probiotics from dry mealworm (*Tenebrio molitor*) and super mealworm (*Zophobas morio*) help in the reduction of infection by *Escherichia coli* and *Salmonella* in chicken. Glycominoglycan, a polysaccharide from crickets has anti-inflammatory effect on arthritis by inhibiting C- reactive protein and rheumatoid factor which reduces blood glucose and increases antioxidant enzymes such as catalase, supreroxide etc. Vitamin B12 from cricket was found to prevent anemia, bone fractures with decreased cognition in elderly people.

Chitosan, a biological material that was traditionally derived from shrimps and lobsters as a filler in tablets to improve the way certain drugs dissolve and to mask bitter tastes has been recently obtained from black soldier fly (BSF), *Hermetia illucens.*

Insect venoms, particularly bee venoms such as melittin and tertiapin are known to have an analgesic effect while alpha-helical peptides from solitary wasps are known to have antimicrobial and antiparasitic effects.

ICAR-NBAIR apart from its expertise in biological control and biopesticide development, has started diversifying on the value addition of insects such as food and feed. The technology on production of black soldier fly has been licensed to several entrepreneurs. The studies on the use of black soldier fly pupae as a supplement to fish and animal feed have given encouraging results and are likely to be commercialised.

Rearing methodologies for the mealworm and super worms are being standardised for their use in animal and fish feed. The hygienic production system for these insects is necessary to produce the insects for the nutraceutical value to higher animals and humans. Technologies for the production of chitin and chitosan from BSF also will be a challenge in the future. With the increasing demand, the sustained scientific efforts and with the renewed interest of entrepreneurs for the insect-related technologies, we may anticipate soon an "*Entomophagy Revolution*".

N. Bakthavatsalam
Director (Acting)

Research Highlights

Investigation on the erroneous published reports of an invasive bug species, *Halyomorpha halys* from India

Various queries regarding the false reports on the occurrence of *Halyomorpha halys,* a species native to East Asia which is also an alien invasive pest of several economically important crops in India were addressed. Original specimens studied by the earlier workers (Nikkam & More, 2016) were re-examined and compared with the original types deposited at the Swedish Museum of Natural History (SMNH) (Fig.1a–f). The specimens studied were confirmed as *H. picus*, the native Indian species and thus the ambiguity regarding the presence of *H. halys* in India was resolved. Examination of images in the report regarding the incidence of a fungus of medicinal importance, *Ophiocordyceps nutans* on *H. halys* in the Western Ghats, India (Karun & Sridhar, 2013) revealed that the bug imaged was not a species of *Halyomorpha*, but a species of *Tipulparra*. Illustration in another erroneous report of *H. halys* (Gupta & Pathania, 2017) was that of a species of *Cahara*. Besides, the distribution map for *H. picus* was also prepared.

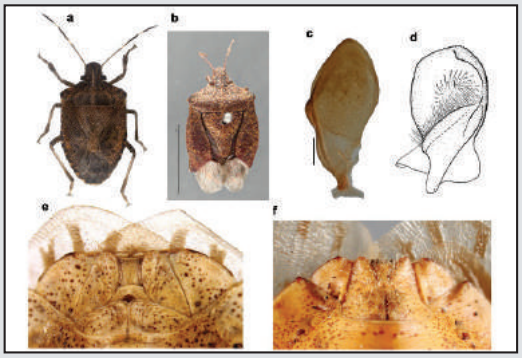

Fig.1:a–f: *Halyomorpha* spp: a, *H. picus*; b, *H. halys* (NHRS-GULI 000067489) (© Gunvi Lindberg, SMNH); c, paramere of *H. picus*; d, paramere of *H. halys* (© Magnolia press); e, terminalia of *H. picus*; f, terminalia of *H. halys* (© Gunvi Lindberg, SMNH)

A new thrips species

A new terebrantian thrips species, *Neohydatothrips biconcavus* (Fig. 2), was described from specimens collected in the flowers of *Jasminum sambac* at Jorhat, Assam.

Fig. 2 : *Neohydatothrips biconcavus*

New distribution record of invasive Neotropical coconut whitefly, *Aleurotrachelus atratus*

Invasive Neotropical palm infesting whitefly, *Aleurotrachelus atratus* was recorded for the first time in Dharmapuri and Krishnagiri districts of Tamil Nadu on coconut (Fig. 3). It is an oligophagous pest, which prefers to feed on palms and is mostly distributed in tropical and subtropical regions. Low (less than 10 live colonies or adults/leaflet) to moderate (11–20 live colonies or adults/leaflet) levels of infestation were observed during the surveys. It is assumed that the pest might have spread to Tamil Nadu from the adjoining districts *viz.* Mandya and Ramanagara of Karnataka through transportation of infested seedlings. It was found to be co-existing with other invasive whiteflies, like *Aleurodicus rugioperculatus*, *Paraleyrodes minei* and *P. bondari*. A generalist predator, *Pseudomallada astur* was recorded during the surveys. Stringent domestic quarantine mechanisms, as well as sensitisation of farmers and other stakeholders, need to be advocated to avoid its further spread to other palm-growing areas of India.

Fig. 3: *Aleurotrachelus atratus* on coconut

Typhlodromus (*Anthoseius*) *transvaalensis*, a useful generalist predator

The phytoseiid *Typhlodromus* (*Anthoseius*) *transvaalensis* was recorded for the first time in India. The species was redescribed based on morphometric measurements of the specimens collected on an unidentified plant in Ramanagara district of Karnataka. This Type III generalist predator showed significant potential as a biocontrol agent for economically important phytophagous mites. In mulberry, it reduced populations of the broad mite, *Polyphagotarsonemus latus*, by 86–94% in two field trials conducted from September 2020 to January 2021 in Ramanagara district. Its efficacy was comparable to that of a mycelial–conidial formulation of the acaropathogenic fungus, *Hirsutella thompsonii* [isolate ICAR–NBAIR–MF(Ag)66].

Trichoderma asperellum strain NBAIR-TATP to manage the mulberry root rot

Mulberry root rot caused by *Rhizoctonia bataticola* (=*Macrophomina phaseolina*) is a disease causing major economic loss to the mulberry farmers in Karnataka. Drenching with 2% of *Trichoderma asperellum* strain NBAIR-TATP @ 50 ml per plant effectively suppressed the disease and controlled its further spread in the mulberry ecosystem. It was observed that the plant growth was boosted and healthy leaves were developed post the application in field conditions at Magadi Taluk, Ramanagara District, Karnataka. The study was carried out under the supervision of the Deputy Director of Sericulture, Magadi seed area during August 2020–January 2021.

Emerging lepidopteran pests of mango

In recent surveys, severe infestations of four occasional lepidopteran pest species, viz. *Chlumetia transversa*, *Citripestis eutraphera*, *Dudua aprobola* and *Penicillaria jocosatrix* were noticed in Pochampalli Taluk, Krishnagiri District, Tamil Nadu during the fruiting season (Figs 4–10). Larvae were found to feed extensively on developing fruits. Per cent infestation level for each species was quantified (Table 1) at Nagarasampatti, N. Thattakal, Nagojanahalli, and Veppalampatti villages of Krishnagiri District. The indiscriminate use of synthetic pyrethroids and Paclobutrazol, a plant growth regulator might have caused the sudden flare-up of these occasional pests. The pest identities were confirmed morphologically and then molecularly characterised using mitochondrial cytochrome c oxidase (*COI*) gene.

Table 1: Pest species and damage status

Pest species	GenBank Accession No.	Damage level
Mango fruit borer, *Citripestis eutraphera* (Lepidoptera: Pyralidae)	MZ165364	Severe (~33% fruit damage)
Mango shoot borer, *Penicillaria jocosatrix* (Lepidoptera: Noctuidae)	MZ165363	Severe (~43% shoot damage and ~26% fruit damage)
Mango shoot borer, *Chlumetia transversa* (Lepidoptera: Noctuidae)	-	Severe (~43% shoot damage and ~26% fruit damage)
Mango flower webworm, *Dudua aprobola* (Lepidoptera: Tortricidae)	MZ165365	Severe (on ~10% of the fruits and shoots)

Fig. 4: Larvae of *Chlumetia transversa*

Fig. 5: Larva of *Citripestis eutraphera*

Fig. 6: Damage caused by *C. eutraphera*

Fig. 7: Damage caused by *Penicillaria jocosatrix* larvae

Fig. 8: Larvae of *Dudua aprobola*

Fig. 9: Fruit damage by multiple pest species

Fig. 10: Scientists' interaction with farmers

Harnessing the potential of semiochemicals for pest management at ICAR-NBAIR

Insects rely on semiochemicals to locate their mates, food and oviposition sites. Among the behaviour modifying chemicals, the pheromone released are species-specific. Though pheromones have been isolated and characterised for an array of insects, only a few have been exploited for commercial purposes for monitoring, mass trapping and mating disruption. Among the various types of pheromones existing in the insect world, the sex pheromone and aggregation pheromones are widely used in pest management. The commercial pheromone market is projected to grow 15% per year from 2019 to 2025 and North America dominates the commercial pheromone market. As the clean and green technologies in crop protection are receiving greater attention in India, there is huge potential for the use of pheromone as a tool that is compatible with bio-intensive pest management methods. ICAR-NBAIR has facilities and expertise to identify and characterise the volatile organic compounds that are involved in trophic interaction and exploit them for pest management. In case of pheromones, the commercial lure is sold as rubber and silicone septa. These lures have a very short field life and they work with a higher load of chemistry that lead to an increase in cost. ICAR-NBAIR has developed platforms to aid in the slow/ controlled release of pheromones that have longer field efficacy and work with a lower load of pheromone. This technology makes pheromone lures to be cost-effective with enhanced efficacy over a spatiotemporal scale. The technology so developed is licensed to commercial firms to scale up the production. ICAR-NBAIR has also developed sensors that aid in the early detection of pests to time the pest management strategies to scale down the damage caused. Sensors have also been developed to identify the quality of biopesticides. The research and development on semiochemicals have gaps, which if addressed would bring in strategies that could be harmoniously blended with eco-friendly pest management measures. The regional variation in insect pests may have a shift in the composition of pheromone which they release and this dynamic nature demands revisiting the isolation, characterisation and blending of pheromones to suit a population of locality. Equipping ICAR-NBAIR with equipments having better sensitivity to decipher the chemo ecological response and synthesising those compounds that cause physiological and behavioural response will be of immense use in developing eco-friendly pest management methods (Fig 11 & 12).

Fig 11: Trap catch of *Tuta absoluta*

Fig. 12: A) Trap placed in field; B)Trap catch of *Holotrichia consanguinea*; C) Slow release pheromone formulations

An attractant for uzifly, a pest of silkworm, developed under collaboration with the Central Sericultural Research and Training Institute, Mysuru

Uzifly, *Exorista bombycis* is a serious pest in sericulture sector, causing serious yield losses to silkworm cocoon production. Due to the possible side effect to the silkworm, there are no insecticides to manage this pest.

Pheromones, the female produced chemicals which attract the males of *E. bombycis* were identified under a ICAR-NBAIR and Central Sericultural Research and Training Institute (CSRTI) collaborative project during 2017-19. The chemicals were evaluated under a Transfer of Technology project (ToT) funded by CSRTI in more than 1000 sericulture farmers' field in the states of Karnataka, Tamil Nadu, Andhra Pradesh and Maharashtra. Five traps on the windows and entry points were installed along with vials impregnated with pheromone compounds in each rearing house when the worms are in second instar stage.

The studies indicated greater trapping of the males along with the reduction in silkworm damage and increase in cocoon yield (Figs 13–15). In areas where no control measures were undertaken earlier the yield increase was over 12%. Farmers just by spending Rs. 500-600 can expect increase in income by Rs. 6,000 per crop. Adoption in village level for successive 3–4 years will drastically reduce infestation. The technology has been commercialised to firms.

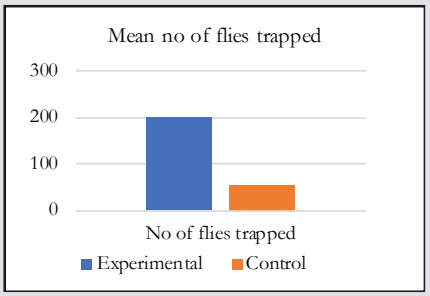

Fig. 13: Trap catch of uzi flies

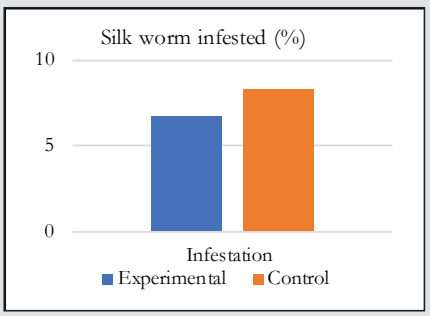

Fig. 14: Per cent infestation of silkworm by uzi fly

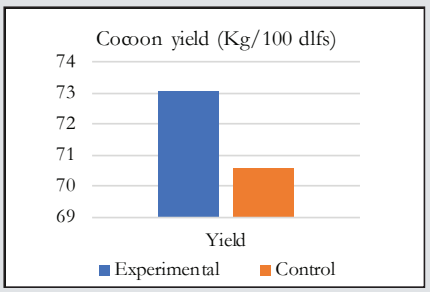

Fig. 15: Mean cocoon yield (Kg/100 dfls)

Republic Day celebrations at ICAR-NBAIR

NBAIR celebrated the 72nd "Republic Day" on 26 January 2021. Dr N. Bakthavatsalam, Director hoisted the national flag at ICAR-NBAIR, Hebbal campus and delivered the republic day message. As a part of celebrations, a badminton tournament (men/women doubles) was organised and the winners were felicitated. Dr. T.M. Shivalingaswamy, the farm-in-charge, unfurled the national tricolor flag at Yelahanka campus of NBAIR.

NBAIR organised an International webinar on "Insect systematics: importance, challenges, and way forward"

An International webinar on "Insect systematics: importance, challenges, and way forward" was organised by NBAIR on 29 January 2021. Dr T.R. Sharma, Deputy Director General (Crop Sciences), ICAR in his chief guest's address highlighted the importance and status of insect systematics at national and global level. He urged the scientists to integrate morphological and molecular taxonomy. Dr Dirk Ahrens, Head, Department of Arthropoda, Alexander Koenig Museum, Bonn, Germany delivered a talk on 'Integrative Taxonomy - an outlook for the future of taxonomy'. In his talk he stressed upon the importance of DNA barcoding in species recognition and delineation and biogeographical analyses. Dr Petr Sipek, Assistant Professor, Faculty of Science, Charles University, Prague, Czech Republic in his address on 'Taxonomy of immature insects – scope and challenges' emphasized the importance of immature taxonomy. Dr R. Swaminathan, Emeritus Professor, MPUAT, Udaipur, Rajasthan, India delivered a talk on 'Orthoptera diversity in the Indian subcontinent: their pestiferous status. Amongst the participants were former Directors of ICAR-NBAIR, distinguished entomologists like Dr T.M. Manjunath, Dr V.V. Belavadi and Dr S. Ramani, researchers from NARS and other experts. Dr Kolla Sreedevi, Principal Scientist (Entomology), NBAIR organised the webinar.

Demonstration on biological control of rugose spiralling whitefly using *Isaria fumosorosea*

ICAR-NBAIR conducted an awareness-cum-demonstration on biological control of invasive rugose spiralling whitefly in the coconut gardens of Ramanagara District, Karnataka on 30 January 2021. Mr R. Shanker, Honourable Minister of Horticulture and Sericulture, Government of Karnataka reviewed the status of whitefly infestation in coconut gardens in the district and interacted with farmers and stakeholders. He showed keen interest on the initiatives taken jointly by Department of Horticulture and ICAR-NBAIR to contain the pest. The importance of augmentation and conservation of the parasitoid, *Encarsia guadeloupae* and foliar application of entomopathogenic fungus, *Isaria fumosorosea* for the management of rugose spiralling whitefly was demonstrated to farmers. The programme was jointly organised by Dr K. Selvaraj, Scientist (Entomology), NBAIR and Department of Horticulture, Government of Karnataka.

Igniting young minds

Around 13 students from Ohana School, Kengeri, Bengaluru visited the Insectarium at Hebbal campus of ICAR-NBAIR on 5 February 2021. Insect diversity and the amazing facts of insects were explained. Live and preserved specimens of both crop pests and beneficial insects were shown to students to arouse their interest.

The children also visited the insect photo gallery to get an insight into the variety of insects. The curiosity in students to learn about the insects was reflected in their active interaction.

Participation of ICAR -NBAIR in exhibition

ICAR-NBAIR participated in the **'National Horticulture Fair 2021'** held at ICAR-Indian Institute of Horticultural Research, Bengaluru, during 8–12 February 2021. The technologies commercialised by the institute were exhibited to public.

NBAIR organises biocontrol training programme for North-Eastern Hilly Region (NEH)

NBAIR in collaboration with Central Agricultural University (CAU), Imphal organised a workshop on 'Biocontrol of invasive crop pests and utilisation of insects as food and feed' at College of Agricultural Engineering & Post Harvest Technology, Ranipool, Sikkim during 11–12 February 2021. Dr N. Bakthavatsalam, Director, NBAIR explained the role of pheromones in insect pest management. The mobile app 'Shatpada-BPM-2' on fall armyworm management was released for the benefit of farmers in the NEH region. The biocontrol agents, microbial formulations, and pheromone lures developed by the Bureau were exhibited. Participants from various parts of northeastern states participated in the programme. Dr M. Nagesh, Principal Scientist & HOD, Division of Genomic Resources, NBAIR, and Dr Shravan M. Haldhar, Associate Professor, CAU, Imphal organised the training programme.

NBAIR promotes biological control among the tribal farmers in Yelagiri hills, Tamil Nadu

NBAIR in association with KVK, Vellore organised a farmers' awareness programme on biological control-cum-distribution of inputs/kits under tribal sub-plan on 15 February 2021 at Yelagiri, Thirupathur District, Tamil Nadu. Dr N. Bakthavatsalam, Director along with three scientists of the Bureau attended the programme and emphasised the importance of biological control and use of macrobials and microbials for insect pest management without using harmful insecticides to preserve the fragile hill ecosystem. A total of 50 farm families from the tribal settlements from villages, Yelagiri and Mangalam benefitted from this programme. The bioagents, viz. *Trichoderma*, *Pseudomonas*, *Bacillus* spp., *Pochonia chlamydosporia*, *Metarhizium anisopliae*, *Beauveria bassiana*, EPN, predators and parasitoids and kits comprising of traps with insect lures, battery-operated sprayers, solar insect light traps with single stand and adjustable stand, mega solar insect light traps and electrical insect light traps were distributed to the farmers.

NBAIR organises a workshop in Pasighat, Arunachal Pradesh

NBAIR organised two days' workshop on 'Biocontrol of invasive crop pests and utilisation of insects as food in North-East region of India' during 8–9 February 2021 at College of Horticulture & Forestry (COHF), Pasighat, Arunachal Pradesh. The workshop aimed at addressing the recently introduced invasive insects in the country, promotion of biological control, and utilisation of insect-derived resources as food and feed in North-Eastern India. NBAIR scientists, Drs K. Subaharan, G. Sivakumar, Ankita Gupta, M. Sampath Kumar and Richa Varshney as experts delivered lectures on invasive insects and the utilisation of macrobials and microbials for insect pest management. A total of 40 officials under the category, agricultural officers and KVK subject matter specialists from Arunachal Pradesh and Assam attended the workshop and benefitted. The officials from COHF, Pasighat and CAU, Imphal coordinated the programme.

International Women's Day at ICAR-NBAIR

NBAIR celebrated "International Women's Day" on 8 March 2021 with the theme 'Women Leadership in Agriculture: Entrepreneurship, Equity, and Empowerment (3 E's)". Dr Chandish R. Ballal, Former Director, NBAIR was the chief guest and Dr D.M. Mamatha, Registrar, Sri Padmavathi Mahila Viswavidyalaya, Tirupati, Andhra Pradesh was the Guest of Honour. Dr N. Bakthavatsalam, Director, NBAIR presided over the function. The chief guest addressed the gathering on women empowerment and rights. She highlighted the contribution of women in different fields and most importantly in agriculture. The challenges faced by women in personal and professional fields were also discussed. Successful women farmers involved in sericulture and millets cultivation were felicitated.

Conferences organised by NBAIR

Sixth National Conference on Biological Control

Society for Biocontrol Advancement, NBAIR organised Sixth National Conference on Biological Control under the theme 'Innovative approaches for Green India' during 3–5 March 2021. Dr T.R. Sharma, Deputy Director General, ICAR stressed upon the identification of potential local isolates and utilization of the isolates in biocontrol in the inaugural session. He also emphasised generating DNA fingerprinting data for indigenous strains of biocontrol agents to facilitate their registration as biopesticides. Dr S.C. Dubey, Assistant Director General (Plant Protection & Biosafety), ICAR stressed the need for exploitation of native strains of biocontrol agents for the management of pests and diseases of crop plants. Eminent entomologists like Dr B. Vasantharaj David and Dr T.M. Manjunath gave their valid remarks on biological control. Seven technical sessions were conducted and around 150 participants from various SAUs and ICAR institutes participated and presented their papers in the conference. Drs G. Sivakumar, T. Venkatesan, A. Kandan, R. Gandhi Gracy, Ankita Gupta, G. Mahendiran, M. Sampath Kumar and U. Amala organised the conference.

National Conference on Priorities in Crop Protection for Sustainable Agriculture

NBAIR and Central Agricultural University (CAU), Imphal jointly organised the 'National Conference on Priorities in Crop Protection for Sustainable Agriculture' at College of Agriculture, Iriosemba, Imphal during 16–18 March 2021. Prof. M. Premjit Singh, Former Vice-Chancellor, CAU, Imphal was the chief guest for the conference. Special addresses were made by Dr S.N. Puri, Former Vice-Chancellor, CAU, Imphal; Dr H.C. Sharma, Former Vice-Chancellor, YSPUHF, Solan; and Prof. M. Premjit Singh.

Dr. S.N. Puri pointed out the scope of utilising transgenic approaches to improve the efficiency of biopesticides and natural enemies so that the change in climatic conditions can be better adapted. Dr H.C. Sharma stressed the need to generate genetic linkage maps to identify regions of chromosomes responsible for imparting resistance against insect pests. Prof. M. Premjit Singh pointed out how climate change might influence insect biology and migration and suggested strategies to cope with these effects. Around 125 participants from various SAUs and ICAR institutes participated in the conference. 25 lead talks, 43 oral presentations, and 51 poster presentations were made in 4 themes. Dr M. Nagesh was the convenor of the conference and Dr A.N. Shylesha and Dr Sunil Joshi acted as co-organising secretaries.

Awards and Recognitions

Awards from Society for Biocontrol Advancement, NBAIR

Dr K. Subaharan: *Dr M. Swamiappan Award* for outstanding contribution in Biointensive IPM.

Dr K. Srinivasamurthy: *Dr S. Sithanantham Award* for outstanding impact of biological control research and development.

Dr M. Mohan: *Dr T.M. Manjunath Award* for outstanding contribution to biological control research.

Dr K. Sreedevi: *Dr H. Nagaraja Memorial Award* for outstanding contributions to Insect Systematics.

Dr K. Selvaraj: *Dr B.S. Bhumannavar Team Research Award* for the Best Innovative Biocontrol Research.

Dr Richa Varshney: *Dr B.S. Bhumannavar Team Research Award* for the Best Innovative Biocontrol Research for the year 2017-18.

Awards bagged by NBAIR scientists at Sixth National Conference on Biological Control, Bengaluru (3–5 March 2021)

Best oral presentations

Dr R. Gandhi Gracy
Dr Ankita Gupta
Dr S. Salini
Dr K.J. David
Dr M. Sampathkumar
Dr Navik Omprakash Samodhi
Dr Y. Lalitha

Best poster presentations

Dr M. Sampathkumar
Dr Rachana R.R.

Awards bagged by NBAIR scientists at National Conference on Priorities in Crop Protection for Sustainable Agriculture, Imphal (16–18 March 2021)

Best oral presentations

Dr Ankita Gupta
Dr R.S. Ramya

Externally funded projects

Dr K. Selvaraj

Coconut Development Board, Kochi funded a project entitled "Development and validation of bio-intensive integrated pest management strategies for coconut invasive whiteflies in Karnataka" under Technology Mission on Coconut.

Welcome!

Dr C. Manjunatha, Scientist (Plant Pathology), joined NBAIR on 22 January 2021 on transfer from ICAR–Indian Agricultural Research Institute, Regional Station, Wellington.

Obituary

Dr Veereshkumar, Scientist (Entomology) passed away due to illness on 1 March 2021. He served ICAR for five years. May his soul rest in peace!

Transfer of Technologies

"Potential entomopathogenic fungus, *Isaria fumosorosea* (strain ICAR-NBAIR– Pfu-5) for management of rugose spiralling whitefly, *Aleurodicus rugioperculatus* in coconut and oil palm" to Department of Horticulture, Government of Karnataka & M/s Godrej Agrovet Limited, Mumbai.

"Mass multiplication of *Encarsia guadeloupae* for the management of rugose spiralling whitefly in oil palm gardens" to M/s Godrej Agrovet Limited, Mumbai.

"A technique for rearing of parasitoid, *Nesolynx thymus* (Girault) and their use in housefly, *Musca domestica* management" to M/s SRK Seri Bio Control Unit.

"Metarhizium anisopliae ICAR-NBAIR Ma4 for management of white grubs in sugarcane" to M/s Multiplex Biotech Pvt Ltd. Bengaluru.

"Wettable powder based formulation of *Bacillus megaterium* NBAII 63 for the growth promoting ability in brinjal and tomato" to M/s Siddaganga Oil and Bio Industries, Tumkur, Karnataka.

"Liquid formulation of indigenous *Bacillus thuringiensis kurstaki* (Btk) isolates against lepidopteran pests" to M/s Siddaganga Oil and Bio Industries, Tumkur, Karnataka.

"Powder based formulation of *Pseudomonas fluorescens* (NBAIR-PFDWD),anantimicrobial2,4-diacetylphloroglucinol (DAPG) producing biotic and abiotic stress tolerant strain for diseases and thrips management" to M/s Siddaganga Oil and Bio Industries, Tumkur, Karnataka.

Selected Publications

David, K.J., Hancock, D.L., Sachin, K. & Sankararaman, H. 2020. A new species of *Hemilea* Loew and two new records of Trypetini (Diptera: Tephritidae: Trypetinae) from India. *Zootaxa*, 4896(4): 571–576.

David, K.J., Hancock, D.L., Salini, S., Gracy, R.G. & Sachin, K. 2020. Taxonomic notes on the genus *Campiglossa* Rondani (Diptera: Tephritidae: Tephritinae: Tephritini) in India with description of three new species. *ZooKeys*, 977: 75–100.

David, K.J., Hancock, D.L., Sankararaman, H., Sachin, K. & Singh, S. 2020. A new species of *Euphranta* Loew (Diptera: Tephritidae: Trypetinae: Adramini) from India. *Zootaxa*, 4868(4): 584–590.

Rachana, R.R. 2021. A new species of *Neohydatothrips* (Thysanoptera: Thripidae) from India. *Zootaxa*, 4920(2): 297–300.

Ranjith, M., Ramya, R.S., Boopathi, T., Kumar, P., Prabhakaran, N., Raja, M. & Bajya, D.R. 2021. First report of the fungus *Actinomucor elegans* Benjamin & Hesseltine belonging to *Odontotermes obesus* (Rambur) (Isoptera: Termitidae) in India. *Crop Protection*, 145: 105622.

Salini, S., David, K.J. & Pratheepa, M. 2021. Does India have the invasive brown marmorated stink bug, *Halyomorpha halys* (Stål). *Current Science*, 120(2): 268–269.

Sundararaj, R., Selvaraj, K. & Sumalatha, B.V. 2021. Invasion and expansion of exotic whiteflies (Hemiptera: Aleyrodidae) in India and their economic importance. *Phytoparasitica*, https://doi.org/10.1007/s12600-021-00919-7.

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