ICAR-NBAIR Newsletter

June 2022

Volume 14
Issue 2

ICAR-National Bureau of Agricultural Insect Resources

Existence of life is the most unique feature of Earth, and the most extraordinary feature of life is its diversity with an estimated 10 million types of life forms (Cardinale et al., 2012). There has been intensive cataloguing of biodiversity in terrestrial and aquatic ecosystems, while interests in subterranean and soil biodiversity have been nascent. Soil is one of the fundamental components for supporting life on Earth. Soil biodiversity is the total community from genes to species that exist in a given natural soil, and it varies tremendously depending on the environment and ecological situations. The astounding diversity in soil allows for a great variety of functional relationships among the diverse groups of life that benefit the species that inhabit it, the species (including us) that use it, and its surrounding environment. Biologically the soil functions include - primary productivity, carbon and nutrient cycling, erosion control, the maintenance of a stable soil structure, and helping to mitigate climate change. Soil biodiversity ensures a healthy soil system and is directly proportional with the soil health that is necessary for the sustainable functioning of any natural ecological niche. At the 1st Global Earth Summit, the nations declared that anthropogenic activities were destructing the Earth›s ecosystems, eliminating genes, species and biological traits at an alarming rate.

Soil biodiversity and their biota are in peril due to the global change factors, including nitrogen deposition, land use change, climate change and other anthropogenic disturbances, overall altering the function and critical services the soil provides for human well-being. Earth is experiencing a substantial loss of biodiversity at the global scale, while both species gains and losses are occurring at local and regional scales. However, the losses and gains in species can be estimated unless a clear database with time scale is available for each region.

Last 2 decades witnessed immense research interest in soils as reservoirs of biodiversity encompassing a wide range of functional attributes in addition to biodiversity of species in subterranean ecosystems thus contributing to the concepts on biodiversity, ecological health of the soil. The USDA-Natural Resources Conservation Service defined soil health as the "continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans". A boundless diversity of organisms dwell healthy soils in natural and well-managed agricultural soil ecosystems, where they support ecosystem multi-functionality, making soil biodiversity a key factor in regulating the functioning of ecosystems.

The two desirable functions of healthy soil from agriculture point of view are nutrient cycling and pest suppression. The contributions of soil microarthropods to soil health through their intersecting roles in decomposition and nutrient cycling and direct and indirect suppression of plant pests.

Our knowledge on species richness, status of endangered species, functional roles, impact of anthropogenic and climate change factors on soil microbiota etc., in different soil ecosystems viz., natural forest, savannah, agricultural, sodic, alkaline etc., situations are very limited. Twelve percent of birds and nearly 20% of mammals are considered threatened with extinction, and that from 5 to 10% of fish and plants are similarly threatened (Chapin et al., 2000). With many of the soil invertebrates yet undescribed, it cannot be arrived at a numerical value to losses of soil invertebrates and microarthropods.

The biotic functions belowground include the following: degradation of organic matter, cycling of nutrients, sequestration of carbon, production and consumption of trace gases, and degradation of water, air, and soil pollutants (Groffman and Bohlen, 1999).

The two most abundant groups of soil microarthropods are the collembolans (Animalia; Arthropoda, Insecta) and mites (Animalia, Chelicerata: Arachnida), and are found near the surface of the soil and in plant litter. Populations range between 10^3 m^{-2} in agricultural soils and 10^6 m^{-2} in forest soils.

Collembolans, also known as springtails, are wingless insects a few millimeters in length and 0.2–2 mm in width. Collembolans are omnivorous, feeding on bacteria, fungi, nematodes, algae, other collembolans, and decaying plant material. Ecological function of springtails that consume plant detritus include shredding the litter and increase the susceptibility and surface area of the litter to microbial colonization.

Mites are the other important group of known microarthropods in the soil. Functionally, Oribatid mites, the most abundant soil mites, feed on fungi and decomposing plant detritus. The mesostigmatid mites are primarily predators of small arthropods and nematodes. Prostigmatid mites include some fungal feeders, but most species are predators of small arthropods and nematodes.

Further, biological control of pests by natural enemies is a key ecosystem service in both unmanaged and managed systems. Even though natural control of pest organisms is a critical and well-studied ecosystem service in agroecosystems, very little is documented on the extent of the contribution of soil microarthropods in regulating pest populations excepting the entomopathogenic nematodes. Numerous soil microarthropods function primarily as predators. For example, several mite taxa within the orders Prostigmata and Mesostigmata are voracious and agile predators with a broad feeding range on many different organisms, including collembolans, other soil mites, nematodes, leaf-miners, thrips, small flies, enchytraeids, and insect larvae and eggs.

Key development in biodiversity identification and cataloguing of complex of populations is the application of molecular tools. The use of signature DNA sequences resulted in accuracy, speed and increased numbers of identified taxa, with hundreds of novel DNA sequences being added annually. DNA metabarcoding has the potential to greatly advance understanding of soil biodiversity. DNA metabarcoding of bulk soil enables rapid, large-scale assessments of soil arthropod and invertebrate diversity.

Accurate predictions of impact of climate change on soil and its biodiversity require a better understanding of the complex interactions of environmental factors on soil faunal community dynamics. Rising temperatures moisture regimes, plant cover/ organic litter, are expected to impact below-ground ecosystems and alter relationships among plants, soil microorganisms, and fauna. Information on indicator microarthropods, invertebrates and microorganisms to stress factors becomes essential for evolving successful prediction models and strategies to mitigate loss of soil health.

ICAR ideally has developed a chain of research labs, scientific expertise, infrastructure etc., including crop-based and region-specific institutions, soils and Bureaus for soils, insects and microbes that can ideally network for developing soil biodiversity maps, crop and region-specific databases, prediction models for better soil health and productivity. ICAR-NBAIR can play a pivotal role in cataloguing the soil microarthropods across the agro-climatic situations.

Selected references

Anderson JM. 1975. The enigma of soil animal species diversity. In: Vaněk J, editor. *Progress in soil zoology.* Dordrecht: Springer Netherlands; 1975. pp. 51–58.

Coleman, D. 2004. *Fundamentals of Soil Ecology. Soil Biodiversity and Linkages to Soil Processes. 247–270.* doi:10.1016/B978-012179726-3/50008-3.

Dr M. Nagesh
Director (Acting)

Research Highlights

A new parasitoid wasp species

Globally, the fourth species of the genus *Doddifoenus* (Pteromalidae: Leptofoeninae), was described and illustrated from India. *Doddifoenus burksi* (Fig. 1) is the first species of the genus reported from India and also the first species of the genus with biological information - Cerambycidae (Coleoptera) as the host record. The species shared the morphological adaptations seen in hymenopteran parasitoids of endoxylous hosts. The new species was compared with all the other existing species and an updated key to the world species was also provided.

Fig. 1: *Doddifoenus burksi* female

Two new species of fruit flies

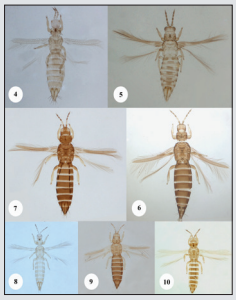
Two new species of fruit flies, *Platensina flavistigma* (Fig. 2) and *Platensina rabbani* (Fig. 3) were described from India. Flies were found associated with weeds.

Fig. 2: *Platensina flavistigma*

Fig. 3: *Platensina rabbani*

Diversity of thrips species on cotton

Exploratory surveys were conducted to study the diversity of thrips species on cotton in Coimbatore, Tamil Nadu. Taxonomic studies revealed the presence of three species, viz. *Scirtothrips dorsalis*, *Thrips palmi* and *Thrips tabaci* on leaves and four species, viz. *Thrips florum*, *Thrips hawaiiensis*, *Frankliniella schultzei* and *Thrips parvispinus* on flowers (Figs 4–10).*Thrips parvispinus* is one of the notorious pest species of South East Asia and also a serious pest of quarantine importance. The invasion and infestation of *T. parvispinus* on cotton was reported for the first time in India. *Frankliniella schultzei*, *S. dorsalis*, *T. palmi* and *T. tabaci* are notorious pests as well as vectors of plant viruses. Since these species may attain major pest status, regular monitoring is needed in cotton ecosystem.



Figs 4–10: Thrips species: 4, *Frankliniella schultzei*; 5, *Scirtothrips dorsalis*; 6, *Thrips hawaiiensis*; 7, *Thrips florum*; 8, *Thrips palmi*; 9, *Thrips parvispinus*; 10, *Thrips tabaci*.

Small RNA sequencing and novel miRNAs from fall armyworm, *Spodoptera frugiperda*

Small RNAs are involved in the regulation, protection and also in other physiological functions in insects. They can be mostly endogenous (siRNA, miRNA and piRNA) or otherwise external factors also can cause induction of these small RNAs in insects especially double strand RNAs (virus or artificial dsRNA). At ICAR-NBAIR, small RNAs from *Spodoptera frugiperda* adult males and females (Fig. 11) were sequenced. The small RNA sequencing was carried out using 1*75bp chemistry on Illumina NextSeq500 platform (Fig. 12). The raw sequences were trimmed for adaptor, filtered and >35bp sequences were removed. The raw sequencing data was submitted to the NCBI Sequenced Read Archive (Bio project number: PRJNA778342). Annotation of the trimmed data was carried out with the "small RNA analysis" tool in CLC Genomics Workbench by comparing with all the available insect miRNA precursors in the miRBase-R 22.1. miRDeep 2 (v 0.1.3) software was used to predict novel miRNAs. In this study, a total number of 223 known and 32 novel miRNAs were identified and a differential expression study was also performed using *S. frugiperda* male and female small RNA sequencing data.

Fig. 11: *Spodoptera frugiperda* (Left– male; Right– female)

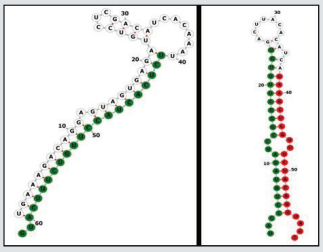


Fig. 12: Predicted structure of miRNA by RNA hybrid software (green and red colours represent 5p (mature 5p) and 3p (mature 3p, star) miRNAs, respectively)

Research Advisory Committee Meeting

The "XXV Research Advisory Committee Meeting" was held in the conference hall of Dr S.P. Singh Lab Research Complex at ICAR–NBAIR on 19 April 2022. The committee consisting of Drs H.C. Sharma, Former Vice-Chancellor, Dr Y.S. Parmar University of Horticulture & Forestry, Solan; S.C. Dubey, Assistant Director General (Plant Protection & Bio-safety), S. Mohankumar, Director, Centre for Plant Molecular Biology and Biotechnology, Tamil Nadu Agricultural University, Coimbatore; A.R. Prasad, Retired Chief Scientist & Head, Centre for Semiochemicals, Indian Institute of Chemical Technology, Hyderabad; Sudhir Singh, Retired Scientist-G & Head, Division of Forest Protection, Forest Research Institute, Dehradun; Pradyumn Kumar, Emeritus Scientist, ICAR–Indian Agricultural Research Institute & Ex-Director, ICAR–Indian Institute of Maize Research, Ludhiana and two progressive farmers, Mrs N. Nanjundappa and Shivakumar, reviewed the research achievements and progress of the Bureau. The need to develop strong network for exchange and sharing of digitised collections with various institutions and museums across the country was discussed. The committee emphasised upon the improvement and modernisation of the insect rearing facilities in the Bureau. The necessity of utilising integrated taxonomic approach for pest diagnostics, identification of immature taxa and invasive pests was also discussed.

The committee advised the Bureau to develop formulations and toxicological data for potential microbial strains in collaboration with other Institutes, and in a public private partnership mode. The importance of integrated taxonomic approach for pest diagnostics and linking molecular markers with specific traits was discussed. The committee emphasised on the biological control of insect pests in orchard and plantation crops, and crops under protected cultivation.

ICAR–NBAIR organised 'Plant Protection Scientists' Meeting'

An interactive meeting of the plant protection scientists of the ICAR institutes located in Bengaluru with Dr S.C. Dubey, Assistant Director General (Plant Protection & Biosafety) was organised on 20 April 2022 at ICAR–NBAIR, Bengaluru. Sixteen plant protection scientists deputed from ICAR-Indian Institute of Horticultural Research (IIHR), one scientist from Regional Station of ICAR-Indian Institute of Seed Science (IISS) and all the scientists of ICAR–NBAIR attended the meeting. Former Directors of the Bureau, Dr Abraham Verghese, Dr Prashanth Mohanraj, Dr Chandish R. Ballal and Dr N. Bakthavatsalam participated in the meeting and emphasised the importance of strengthening the National Insect Museum at ICAR–NBAIR. Dr Dubey stressed on the importance of generating data on phytotoxicity, drift, and dosage of pesticides. The need for standardising method and dosage of pesticide application using drones was emphasised. The revised guidelines so as to facilitate ease of registration of bio-pesticides were also discussed. The need for establishing a "Plant Protection Network" so as to bring better visibility of plant protection scientists in the national and international level was emphasised. The possibility of generating toxicological data for the bio-control agents in public-private partnership or in collaboration with private companies was also discussed. Two eminent plant protection scientists, Dr M. Krishna Reddy, Principal Scientist & Head of Division, Division of Crop Protection, ICAR–IIHR, Bengaluru and Dr P.D. Kamala Jayanthi, Principal Scientist, ICAR–IIHR, Bengaluru were felicitated during the meeting.

ICAR–NBAIR organised Campaign on 'Promotion of Organic/Natural farming'

ICAR–NBAIR organised a campaign on 'Annadata Devo Bhava' under 'Azadi Ka Amrit Mahotsav' at Thowdanahalli village, Chikkaballapura district, Karnataka on 24 April 2022. Dr A.N. Shylesha, Principal Scientist & Head of Division, Division of Germplasm Conservation and Utilisation explained the importance of organic and natural farming. He further emphasized on the different plant protection inputs, viz. pheromone traps, sticky traps, macrobials like parasitoids and predators to tackle insect pest damage in different crops. The farmers were also sensitized about the importance of conservation of macrobials. Farmers shared their problems and also experiences in managing different insect pests. Later, inputs like different traps, trichocards, chrysopids and *Blaptostethus pallescens* were distributed to the farmers. Dr Richa Varshney, Scientist (Entomology) and Mr. P. Raveendran, Technical Officer demonstrated the method of release of the predators and parasitoids to the participants. Dr Deepa Bhagat, Principal Scientist (Organic chemistry) demonstrated the method of placement of pheromone traps for the trapping of adult moths of fall armyworm infesting maize. Around 30 farmers growing different crops like brinjal, cabbage, grapes, maize, pomegranate and tomato attended the programme.

ICAR–NBAIR organised 'Kisan Bhagidari Prathmikta Hamari' program

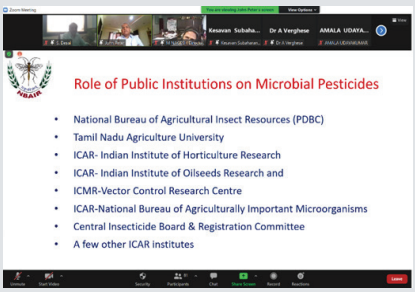
ICAR–NBAIR in collaboration with Department of Sericulture, Karnataka organised 'Kisan Bhagidari Prathmikta Hamari' program as a part of 'Azadi Ka Amrit Mahotsav' at Devahanahalli, Karnataka on 26 April 2022. Dr A. Kandan, Principal Scientist (Plant Pathology) delivered a talk on 'Use of microbials like Shatpada All-Rounder and Shatpada Master Blaster for the management of mites and thrips infesting mulberry'. He explained the efficacy of NBAIR-TATP strain *Trichoderma asperellum* for the management of root rot of mulberry. The root-zone application of NBAIR-TATP strain *T. asperellum* enriched with farm yard manure for the control of root rot was demonstrated. After the programme, microbial formulations were distributed to the participants. Around 50 mulberry growers participated in the programme. Dr C. Manjunatha, Scientist (Plant Pathology) clarified the queries raised by the farmers related to insect pest and disease management in mulberry.

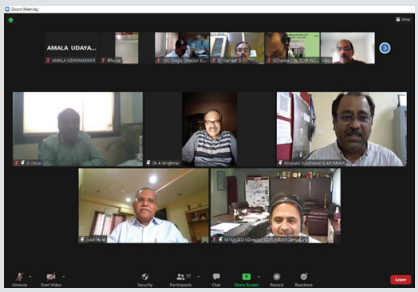
ICAR–NBAIR organised 'Awareness Programme on Protection of Plant Varieties and Farmers' Rights Act'

ICAR–NBAIR organised 'Awareness programme on Protection of Plant Varieties and Farmers' Rights Act (PPV&FR Act)' for the conservation of varieties among the farmers in Devanahalli, Karnataka on 26 April 2022. Dr A. Kandan, Principal Scientist & ITMU in-charge elaborated about the PPV&FR Act to the farmers and addressed the queries raised by the farmers. The guidelines of National Biodiversity Act for the protection of environment and conservation of plant varieties was also explained to farmers and Krishi Vigyan Kendra (KVK) personnels. Around 50 people which include farmers and KVK personnels participated in the programme.

ICAR–NBAIR organised webinar on 'The progress and future of green pesticides in India'

ICAR-NBAIR organised an online webinar series 0011 on 'The progress and future of green pesticides in India' as a part of 'Azadi Ka Amrit Mahotsav' on 29 April 2022. Dr M. Nagesh, Director (Acting) in his introductory remarks briefed on the importance of green pesticides and urged upon the need for regulatory framework for their use in agriculture. The speaker Dr A. John Peter, Chairman, Varsha Bioscience and Technology Pvt. Ltd, Hyderabad, delivered a talk on 'The progress and future of green pesticides in India'. In his talk, he explained about the importance of development of industry-institute co-operation and multi-functional formulations with efficient delivery systems. The need for use of combination bio-pesticides and their efficacy and safety concerns were discussed. The scope for broadening the label claim of green pesticides was deliberated. Development of regulatory framework to have a check on the use of spurious pesticides was discussed. The quality control and extended shelf life of green pesticides without loss in their efficacy against target pests was also addressed. Dr M. Nagesh in his concluding remarks explained about the need to integrate green pesticides in the IPM of emerging insect pests for their effective management. The program was organised and co-ordinated by Drs Kesavan Subaharan, Amala Udayakumar and M. Pratheepa.





ICAR-NBAIR organised 'Training Programme on Mite Taxonomy, including Collection, Mounting, Identification and Preservation'

Two Ph.D. research scholars and an M.Sc. (Ag.) student from Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, attended an in-house training programme on 'Mite taxonomy, including collection, mounting, identification and preservation' during 2–7 May 2022 at NBAIR. The course covered, among others, theoretical and practical aspects of traditional and molecular taxonomy of mites; mass production protocols for predatory mites and acaropathogenic fungi; stereozoom microscopy; phase contrast and differential interference contrast microscopy; and use of the Foldscope. The schedule included a field trip and a special virtual lecture by Dr S.K. Gupta, a distinguished acarologist. Dr Prakya Sreerama Kumar, Principal Scientist, customised and coordinated this programme.

Director General, ICAR visits ICAR–NBAIR

Dr Trilochan Mohapatra, Secretary (DARE) & Director General, ICAR visited ICAR–NBAIR on 16 May 2022 to inaugurate the laboratory research complexes Dr S.P. Singh Research Lab Complex and Dr R.J. Rabindra Research Lab Complex in dedication to the service rendered by the former Directors, Late Dr S.P. Singh and Dr R.J. Rabindra. The programme started with the welcome remarks by Dr M. Nagesh, Director (Acting). Dr T. Mohapatra in his address urged the Bureau to publish success stories on invasive insect pest management. Former Directors, Dr Abraham Verghese, Dr N.K. Krishna Kumar and Dr Chandish R. Ballal; Dr. Sudha Mysore, CEO, Agrinnovate; Dr V. Venkatasubramanian, Director ICAR–Agricultural Technology Application Research Institute, Bengaluru; Dr B.N. Srinivasa Murthy, Director, ICAR–Indian Institute of Horticultural Research; Dr Raghavendra Bhatta, Director, ICAR–National Institute of Animal Nutrition and Physiology and Dr K.P. Ramesha, Principal Scientist & Station In-Charge, ICAR–National Dairy Research Institute Regional Station, Bengaluru attended the event.

ICAR–NBAIR organised 'Farmers' Demonstration Meeting on Insect Pest and Disease Management in Mulberry'

ICAR–NBAIR in collaboration with Department of Sericulture, Karnataka organised a training programme for village farmer producers organisations for mass production of various microbial bio-agents and microbial production units in Pavagada, Tumkur district, Karnataka on 24 May 2022. More than 25 sericulture farmers participated in the programme. The meeting was organised to create awareness to manage the economically important mulberry root rot and wilt disease caused by fungus complex like *Rhizoctonia bataticola* (=*Macrophomina phaseolina*), *Fusarium solani*, *F. oxysporum* and *Botryodiplodia theobromae* using NBAIR-TATP strain *Trichoderma asperellum*. Scientists from the Bureau demonstrated the enrichment of farm yard manure with *T. asperellum* and root zone application for the control of root rot and wilt in mulberry.

ICAR–NBAIR organised fifth batch of 'Trainer's Training on Mass Production and Release Techniques of *Anagyrus lopezi* for the Classical Biological Control of Cassava Mealybug in India"

ICAR–NBAIR organised the fifth 'Trainer's training on mass production and release techniques of *Anagyrus lopezi* for the classical biological control of cassava mealybug in India' on 31 May 2022. A total of 15 trainees from three organisations of Kerala, viz. ICAR–Central Tuber Crops Research Institute, Kerala Agricultural University and Department of Agriculture Development and Farmers' Welfare attended the training programme. The trainees were trained on the identification of different species of mealybug infesting cassava and identification of the cassava mealybug parasitoid, *A. lopezi*. The method of mass production and release of *A. lopezi* and protray method of cassava mealybug multiplication were explained to the participants. Trainees were also given insight about *in situ* production of the parasitoid in farmers' field. The participants expressed their confidence in rearing the parasitoid after attending the training programme. Based on the four trainings organised by the Bureau during November–December 2022, mass production units for rearing of *A. lopezi* were established in different districts of Tamil Nadu for the management of cassava mealybug. Drs. M. Sampath Kumar, M. Mohan and Ankita Gupta coordinated the programme.

Fifth Batch: Trainer's training on Mass Production and Release Techniques of *Anagyrus lopezi* for the Classical biological Control of CassavaMealybug in India on 31.05.2022

Awards and Recognitions

Dr K.J. David, Senior Scientist (Entomology) received T.N. Ananthakrishnan Award under Senior Scientist category for the biennium 2020–21.

ICAR–NBAIR facilitated the participation of tribal centres in 'International Agriculture and Horti Expo, New Delhi'

ICAR–NBAIR facilitated the participation of its funded Tribal-Sub Plan centres, viz. Araku Valley and Krishi Vigyan Kendra, Idukki at International Agriculture and Horti Expo, New Delhi during 17–19 June 2022. Organic millet products, coffee, honey, jackfruit powder and spices like black pepper, cardamom, clove and turmeric were displayed by Lambasingi Tribal Products, Lambasingi, Visakhapatnam, Andhra Pradesh; Susag Millets Producer Company Ltd., Anakapalle, Visakhapatnam, Andhra Pradesh; Sarada Valley Development Samithi, Araku, Visakhapatnam, Andhra Pradesh and Chinnakanal Tribal Society, Idukki, Kerala. The stall bagged the first prize for best display in the Expo.

Transfer of Technology

"A volatile attractant for trapping uzi fly, *Exorista bombycis*, parasitiod on mulberry silkworm, *Bombyx mori* based on pheromonal compounds" to M/s. Sri Jenu Associates, Tiptur, Karnataka.

Selected Publications

Aditi, A., Gracy, R.G., Jyoti, P., Nishtha, N., Mohan, M., Pratheepa, M., Rai, A & Venkatesan, T. 2022. Deciphering the molecular mechanisms of insecticide resistance from the transcriptome data of field evolved spinosad resistant and susceptible populations of *Plutella xylostella* (Lepidoptera: Plutellidae). *Journal of Economic Entomology*, 115(4): 1268–1278.

Amutha, M. & Rachana, R.R. 2022. Species diversity of thrips on cotton. *Indian Journal of Entomology*, https://doi.org/10.55446/IJE. 2022. 522.

Gupta, A., Kumar, H.H.M. & Sankararaman, H. 2022. First report of the genus with first host record and description of an enchanting new species of *Doddifoenus* Bouček (Hymenoptera: Pteromalidae: Leptofoeninae) from India. *Biologia*, https://doi.org/10.1007/s11756-022-01133-4.

Gupta, A., Zeya, S.B., Corin, F.P., Joshi, S. & Ballal, C.R. 2022. First description of the male of *Anagyrus almoriensis* Shafee, Alam & Agarwal (Hymenoptera: Encyrtidae) with details of new host *Pseudococcus calceolariae* (Maskell) (Hemiptera: Pseudococcidae) on *Rubus ellipticus* (Rosaceae) from Himalayas. *Zootaxa*, 5159(4): 593–600.

Kumara, G.T., Omprakash, N., Venkatesan, T., Arunkumar, H., Jagadeesh, P., Mohan, M. & Jalali, S.K. 2021. Performance and field efficacy of indigenous egg parasitoid *Trichogrammatoidea bactrae* (Hymenoptera: Trichogrammatidae) against the cotton pink bollworm *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) in transgenic Bt cotton. *Biological Control*, 70: 104902.

Pal, S., Natarajan, P. & Gupta, A. 2022. New Record of *Tetrastichus epilachnae* (Giard) (Hymenoptera: Eulophidae) parasitizing *Anisolemnia dilatata* (Fab.) (Coccinellidae: Coleoptera) in West Bengal (India). *National Academy Science Letters*, 45: 349–351.

Sandeep, A., Selvaraj, K., Kalleshwaraswamy, C.M., Hanumanthaswamy, B.C. & Mallikarjuna, H.B. 2022. Field efficacy of *Isaria fumosorosea* alone and in combination with insecticides against *Aleurodicus rugioperculatus* on coconut. *Egyptian Journal of Biological Pest Control*, 32: 106.

Selvaraj, K., Sumalatha, B.V., Gundappa, B. & Pratheepa, M. 2022. Maximum entropy modeling based prediction on potential distribution of invasive rugose spiraling whitefly, *Aleurodicus rugioperculatus* in India. *Journal of Agrometeorology*, 24(3): 269– 275.

Shivakumara, K.T., Keerthi, M.C., Polaiah, A.C., Gupta, A. & Joshi, S. 2022. Incidence of invasive mealybugs, *Phenacoccus solenopsis* Tinsley and *Paracoccus marginatus* Williams & Granara de Willink (Hemiptera: Pseudococcidae) on *Gymnema sylvestre* (R. Br) and its natural enemies in the semi-arid region of India. *International Journal of Pest Management*, https://doi.org/10.1080/09670874.2022.2088880.

Compiled and edited by: **Kesavan Subaharan, U. Amala, R.S. Ramya, R.R. Rachana & M. Nagesh**
Published by: Director, ICAR–National Bureau of Agricultural Insect Resources, Hebbal, Bengaluru 560 024, India
Phone: +91 80 2341 4220 ✦ Fax: +91 80 2341 1961 ✦ Website: www.nbair.res.in