MEETING REPORT

Understanding tephritid fruit flies in toto for today and tomorrow*

Tephritids are major insect pests of horticulture crops across the globe with high genetic diversity, taxonomic complexity, ethology, pest management and quarantine issues. There are nearly 5000 species described under 500 genera of Tephritidae with re-categorization occurring constantly with deeper taxonomic investigations. The increasing transnational exchanges of horticultural produce need new standards of measures and control. Tremendous information available each year with new technological innovations in management practices needs to be shared and deployed across various sectors of research, extension and policy-making. In this direction, a one-day meeting was held, a first among the series on tephritids, organized in horticultural systems for bringing research and technological advances to a single platform.

The meeting began with introductory remarks on tephritid status in India by A. K. Chakravarthy (Indian Institute of Horticultural Research (IIHR), Bengaluru). The keynote address by N. K. Krishna Kumar (Indian Council of Agricultural Research (ICAR), New Delhi) emphasized the need for strict quarantine protocols with respect to tephritids to bring down their future invasive possibilities with detailed specimen vouchers and digitization. He expressed concern about lack of potential natural enemies for fruit flies. The diverse nature of tephritids was put on display with taxonomic support by K. J. David (National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru). Till date, India hosts 279 species of fruit flies classified into 80 genera. New subfamilies were included in Tephritidae, such as Tachniscinae, Blepharoneurinae, Phytalmiinae, Dacinae, Trypetinae and Tephritinae, based on advancement in taxonomic keys. Few fruit-fly species such as *Bactrocera latifrons* (Hendel) do not respond to any of the lure and few species are univoltine. The genetic variability in fruit-fly populations can be determined using segments of mitochondrial cytochrome oxidase I and the Z-linked triose phosphate isomerase genes.

A survey conducted in North East India by Sreedevi Kolla (Indian Agricultural Research Institute (IARI), New Delhi) revealed *Bactocera minax* (Enderlein) (Chinese fruit fly) incidence on oranges; sterile insect technique has been extensively used in China to eradicate this fly. The phenotypic plasticity in adult *Bactrocera dorsalis* (Hendel) populations reasoning the temperature-dependent trident pattern variation in thorax was discussed by Arthikirubha (IIHR). She highlighted the temperature-dependent DNA methylation as the possible mechanism of pigment variation in these flies. Studies on the endosymbiont associations of melon fruit fly, *Bactrocera cucurbitae* (Coquillett) have been carried out by V. S. Jilu (IARI). She was of the opinion that these bacterial isolates could be utilized for trapping female flies.

P. D. Kamala Jayanthi (IIHR) opined that tephritid fruit flies (Figure 1) are ideal experimental objects to understand insect behaviour as they have fairly long life cycle with distinct physiological needs, and their foraging habits for food, mates and oviposition sites are amenable for experimentation. Fruit-fly food foraging habit is being exploited widely as BAT (bait annihilation technique), a successful component in current management practices. This apart, fruit flies exhibit more complex mating behaviour through formation of 'leks' (aggregation), where males compete for females for successful courtship. Kamala Jayanthi *et al.*[1,2] have explored the semiochemical basis of oviposition by females to isolate and identify potent cues that help females choose suitable oviposition sites. Female receptivity plays a major role in the establishment of colonies in polyandrous insects like the fruit-fly. Full ejaculate is the mechanism observed in *Anastrepha ludens* (Loew) and *Anastrepha fraterculus* (Wiedemann) to inhibit female remating. Abraham *et al.*[3] explored the possibilities of male accessory gland products in *Anastrepha* species with respect to oviposition, host location and foraging behaviours. They also explored the role of protein supplements in increasing the male mating performance in *Bactrocera tryoni* (Froggatt). Infochemicals in economical damaging groups of tephritids such as *Anastrepha*, *Bactrocera*, *Ceratitis* and *Rhagoletis* were mined from the Pherobase website. The presentation of T. Raghava (IIHR) revealed that pheromones and attractants are the major infochemicals found in these tephritids and exploited in a major way for management in cultivated ecosystems.

Methyl eugenol traps laid in field for males often capture females during peak mango season. The presence of host fruit volatiles on bodies of male flies that have visited the host-habitat would have attracted conspecific females, and this needs more probing into the identification of responsible volatile cues for such behaviour. The spatial and temporal distributions of fruit flies (*B. dorsalis*) are influenced by abiotic factors. A two-year study by Gundappa (Central Institute for Subtropical Horticulture (CISH), Lucknow) showed the positive correlation of fruit-fly catches with temperature, relative humidity and rainfall. Lures that are attractive to both sexes and more than one species are required for establishing effective trapping networks.

Figure 1. Economically important female tephritid fruit flies in India. ***a***, Oriental fruit fly, *Bactrocera dorsalis*; ***b***, Melon fly, *B. cucurbitae*; ***c***, Peach fruit fly, *B. zonata*; ***d***, Guava fruit fly *B. correcta*.

*A report on the one-day meeting on 'Understanding Tephritids in Toto: Taxonomy, Ecology, Quarantine and Management' held at the Indian Institute of Horticultural Research, Bengaluru on 27 May 2016.

M. Shravan Haldar (Central Institute for Arid Horticulture (CIAH), Bikaner) pointed out biochemical and physical factors of fruit as novel antibiosis and antixenotic characters of snap melon against melon fly. He was of the opinion that alkaloids, phenolics, ovary length and rind hardness of melon are desirable characters for resistance breeding programmes. Host plant can recognize the initial stage of herbivory and launch defence strategies to curb future loss. The study presented by Vivek Kempraj (IIHR) hypothesized the concept of egg fertilization of melon fly that initiates primary defence response in *Scehium edule*[4]. His pilot experiment could identify the release of H_2O_2 and nitric oxide in the host, which are deleterious for egg development.

Host range and their preferences in fruit fly *Bactrocera caryeae* (Kapoor) were reconfirmed in the humid tropical region. The studies carried out by Jayanthi Mala *et al.* (Central Horticultural Experiment Station (CHES), Kodagu) revealed that *B. caryeae* preferred mango the least. Another interesting finding of fruit fly was uncovered in the Andaman and Nicobar Islands by H. R. Ranganath (IIHR). *Bactrocera albistrigata* (Meijere) was misidentified as *Bactrocera frauenfieldi* (Schiner) that colonized the South and Little Andamans. This fruit-fly species is known to exploit hosts of *B. carambolae* in Nicobar Islands.

The oriental, peach and ber fruit flies (*B. dorsalis*, *Bactrocera zonata* (Saunders), *Carpomya vesuvinana* Costa, respectively) are the major damaging pests in horticultural ecosystems in Punjab. An integrated pest management with use of PAU fruit fly trap (@ 16 traps per acre) achieved best control across a wide range of crops. Sandeep Singh (Punjab Agricultural University (PAU), Ludhiana) recorded *Biosteres longicaudatus* Ashmead as egg and pupal parasitoid of fruit flies. *Anastrepha* species were managed effectively by a combination of bioinsecticide (abamectin) and attract-and-kill bait stations[5]. The Sterile Insect Technique (SIT) is an advanced methodology of fruit-fly management, claimed as the best for Indian scenario in future. P. V. Rami Reddy (IIHR) presented two critical factors, viz. standardization of radiation quantity and mass rearing that are necessary for establishment of SIT. A live fruit-fly trap was developed using sensor-based tools. Carolin Rathina Kumari (IIHR) used image-based sensor that detects the movements of flies with changes in pixels captured and analysed by MOTION, Arduino software.

In the recent past, with increased fruit imports/exports, the risk of invasive pests spreading to newer areas has also increased. The Bengaluru-based regional station of Directorate of Plant Protection, Quarantine and Storage (DPPQS) has invested considerable time in bringing down the interception number from 108 (in 2012) to 2 (in 2016) during the four-year period. D. K. Nagaraju (DPPQS) mentioned that stringent measures were formulated to reduce interception frequencies. V. S. Sridhar *et al.* (IIHR), using the CLIMEX modelling predicted the possibilities of invasiveness of alien fruit flies with changing climate scenario. Distribution maps with possible spread across the Indian subcontinent were generated in these studies, which call for stringent quarantine measures. To establish the movement of fruit flies from infested areas, to pest-free areas, MaxEnt and CLIMEX models can be used so that fruits infested with these flies can be prohibited to enter pest-free areas.

The meeting was unwrapped with a special lecture 'Discovering the fruit fly' by Abraham Verghese (NBAIR) on understanding the preferences of male and female fruit flies with respect to age, host and semiochemicals. He was of the opinion that fruit flies follow the rule of 'breed first and feast later', where the young (<10 days) preferred to mate with the females and the aged ones preferred to forage for food. With fundamental understanding of flies' behaviour[6], the nature of pest management needs to be redesigned based on 'catch them young' strategies. Deepa Bhagat and her group (NBAIR) developed a nanosensor for *Bactrocera oleae* (Rossi) that could be useful in quarantine regulations through early pest detection. A stable nanogel prepared from methyl eugenol using a low-molecular mass gelator that reduces the frequency of pheromone recharging in the orchards is also in offing[7].

Today, fruit-fly management in India is considered on an orchard or farm basis. Clean cultivation (sanitation), timely harvest, and use of parapheromone traps are current popular methods among the farming community and seldom these are integrated. Under changing scenarios of climate and extensive monocropping in horticultural systems, fruit-fly management needs to be relooked with new initiatives like area-wide management with community participation, SIT, nano formulations for enhanced lure release, trapping females in addition to males using female attractants and strict quarantine measures. Hopefully, this will be the agenda for the next fruit-fly meet to be held at Punjab Agricultural University, Ludhiana in 2018.

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