Pest Management in Horticultural Ecosystems
Vol. 25, No.1 pp 116-118 (2019)

RESEARCH NOTE

Unnoticed sojourners at retail fruit outlets - Away from orchards, stray female mango fruit flies, *Bactrocera dorsalis* leisurely search for egg laying sites

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ABSTRACT: Tephritid fruit flies' induced damage in several commercial fruits is quite noticeable and usually inflicted at the orchard prior to harvest. The present study highlights the egg laying behaviour of these frugivorous tephritid flies in urban environment. Surveillance at retail outlets *viz.*, super markets, road side fruit vending push carts as well as fruit shops revealed the presence of actively foraging stray female fruit flies, *Bactrocera dorsalis* (Hendel) hovering on ripe mango fruits to offload their eggs, thereby attending to the unattended job. Unaware of this 'fruit fly inflicted damage at retail outlet', consumers often pick the fruits loaded with the fruit fly eggs or early stage maggots. These flies display an opportunistic behaviour in salvaging the fragmented resources in an urban setup. Their ability to survive in the highly modified niches of an urban environment is quite amazing and worth exploring.

Keywords: Oriental fruit flies, urban environment, egg laying behaviour, supply-chain, fruit fly damage

Come summer, colourful, juicy delicious mangoes flock the markets across India luring people of all age groups. Mango, *Mangifera indica* often fondly called as 'king of fruits' is native to Indo-Burmian region and widely grown across the tropical and sub-tropical regions (Sagar *et al.,* 2007). Despite the huge production, Indian mango exports are meagre mainly due to the quarantine issues like incidence of insect pests' *viz.,* tephritid fruit flies, stone weevils etc (Verghese and Kamala Jayanthi, 2001). Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae) is the most notorious of these insect pests, causing huge economic losses to mango growers and a major hurdle for both domestic as well as export markets (Verghese and Kamala Jayanthi, 2001).

Usually fruit flies damage the physiologically mature green mangoes on the tree prior to harvest. The gravid females pierce the fruit rind with their sharp ovipositors and insert whitish boat shaped eggs beneath. These oviposition punctures appear like pinpricks on the exterior fruit surface and turn dark later. Such fruit fly damage to fruits may go unnoticed during the initial stages (1-3 days), but becomes conspicuous as the days pass. The eggs hatch within 2-3 days and the newly emerged maggots start feeding on the pulp making the fruit rot. The damaged fruits are soft with loosened pockets of rotting pulp around the oviposition sites. Such rotting fruits are quite easily identifiable and culled during the routine supply chain grading/ sorting operations. After a series of such discards, it is assumed that usually uninfested, ripe mangoes only reach the retail outlets. Thus, in all probability the fruits at retail outlets are free of 'fruit fly inflicted damage at orchard' due to the continuous culling process at different levels.

Roving surveys were carried out during the year 2018-2019 at different retail outlets (N = 52) across the southern part of India between March to May. The displayed fruits were carefully inspected for the presence of tephritid fruit flies and their foraging behaviour in these highly fragmented niches was observed continuously for 10-30 min. The fruits from such outlets were collected randomly and dissected later to ascertain fruit fly infestation.

The surveillance data revealed the presence of the gravid female *B. dorsalis* flies in various fruit vending outlets. These stray female flies were found to be actively hovering on displayed fruits in urban spaces. At a given time, the mean foraging females noticed were 1.35$\pm$0.18/ per outlet (Minimum: 0.00, Maximum: 5.00, kurtosis: 1.18). Considering the reported fecundity of female fly at 1200 eggs in its life time (~3 months) (Butani, 1979), the observed stray flies have a potential egg load anywhere between 1200-6000 for ready insertion in to the fruits on multiple occasions (13.33 to 66.67 eggs per day; considering equi-distribution across the temporal scale). This clearly establishes that these stray females are potent fruit infesters at retail outlets.

Fig.1. Female *B. dorsalis* (inset); Gravid *B.dorsalis* females foraging for egg laying sites (green circle, a,b,c,d,e,f,g,h,j) and adult solitary tephritid endoparasitoid, *D. longicaudata* (yellow circle, h,i)

Observations on the behaviour of these stray female flies in urban environment revealed that they are active foragers on the fully ripe, displayed mango fruits of different varieties. Moving on the fruit surface, they were seem to be in search of suitable egg laying sites and at times caught in the act of egg laying. Majority of the flies were found to insert the eggs at stalk end (76.37%), though eggs were also inserted on other portions of the fruit like shoulders and beak. Preference for bruised, cut fruit surfaces was also noticed (Fig. 1).

During the last phase of marketing, the fruits which arrived otherwise healthy from orchard, were being damaged by fruit flies in retail out lets i.e., 'fruit fly inflicted damage at retail outlet'. This nature of damage by Oriental fruit fly, *B. dorsalis* in urban spaces as observed by the author is the first of its kinds ,has never been reported before, and different from the conventional 'fruit fly damage usually inflicted at orchard'. In spite of intensive anthropogenic alterations disturbing their oviposition substrates (=fruits), these stray female fruit flies were quite successful in finding their egg laying niches away from their native habitats. In the present study, the highly fragmented urban niches (= retail fruit outlets) are becoming survival patches for *B. dorsalis.* Considering the fact that urbanization leads to habitat fragmentation with altered biotic and abiotic ecosystem properties (Corcos *et al.,* 2019), these fruit flies seem to be an opportunistic species taking the advantage of available fragmented resources. The impact of urbanization on arthropods at multiple spatial scales revealed that the herbivore density in urban spaces depends on the availability of resources as some species can exploit the available resources efficiently in urban areas and are capaable of surviving in highly disturbed habitats (McFrederick and Lebuhn, 2006; Heneberg *et al.,* 2016,2017; Corcos *et al.,* 2019).

Random inspection of fruits through destructive sampling revealed 0.00 to 80.00 per cent fruit fly damage with active maggots (I, II instars) in the pulp. This clearly establishes that the fruit flies can forage away from orchards in search of potent oviposition substrates and can inflict damage to otherwise healthy fruits. These stray female flies would have emerged from nearby discarded fruits or dumping places where the rotten fruits were thrown. Interestingly, the male flies were absent in these outlets emphasizing the females are out on their journey in search of egg laying sites. Some progressive retailers were found installing male lure, methyl eugenol (ME) traps in their shops to attract/kill fruit flies. Considering the fact that male fruit flies are not visiting the stalls, erecting ME traps to attract/kill females may not help to curtail their eleventh hour oviposition attempt. Thus, erecting female attractant traps may serve the purpose.

Considering the bionomics and life-cycle studies of *B. dorsalis*, the developmental duration of the egg and maggot stages range between 1.5-3.0 days, ~ 6 days during summer (Butani, 1979). Thus, in all probability, the fruits from retail outlet to consumer plate may take between zero to seven days. The fruits that were oviposited initially may show partial rotting at consumers' home, and may be discarded giving the maggots an opportunity to pupate and eclose into adults. However, eggs that were laid at later stages may not hatch due to shorter incubation periods or may hatch to reach the early maggot stages and escape the consumer's attention. Thus, one of the major challenges to understand is the mother insect instinct to lay eggs in such oviposition substrates in spite of the uncertainty of progeny survival. Thus, the female fruit flies once again prove that 'insects certainly cannot think but they can surely react to the stimuli' (Kamala Jayanthi *et al.,* 2015).

Interestingly, *Diachasmimorpha longicaudata* (Ashmead), a solitaory larval endoparasitoid of tephritids was also seen hovering on fruits along with female flies in search of their prey (Fig.1). These trophic interactions happening away from the traditional orchard ecosystems often go unnoticed in urban environment, where producer-primary/secondary consumers are seen interacting in a makeshift ecosystem. Earlier studies indicated that in an urban environment a particular herbivore density depends on the availability of resources and similarly the presence of natural enemies in such areas often indicates the availability of greater resources for their survival (Corcos *et al.,* 2019). In the present context, the simultaneous foraging of *D. longicaudata* along with the female fruit flies highlights the ample presence of the hosts to fruit flies as well as parasitoids. In spite of intensive anthropogenic alterations involved, the observed trophic interactions away from their native habitat are worth studying. Along with fruit flies, other dipterans [*Musca domestica* L., *Chrysomya megacephala* (Fab.)] and hymenopterans (*Apis dorsata* Fab., *Apis florea* Fab.) were found foraging for fruit nectar. Earlier studies stated that urbanization does influence the trophic interactions favouring generalists that are able to exploit multiple resources (Buczkowski and Richmond, 2012; Geslin *et al.,* 2013; Corcos *et al.,* 2019). In the present context both *B. dorsalis* and its parasitoid, *D. longicaudata* being generalists, may survive successfully due to continuous resource availability.

Exploring the meta-population dynamics of *B. dorsalis* in human dominated landscapes and knowing their pattern of occurrence/survival rate/ reproductive success in these heterogenous/variable niches gives us an interesting opportunity to understand their urban behaviour.

ACKNOWLEDGEMENTS

Author thanks the Director, ICAR-Indian Institute of Horticultural Research, Bangalore for providing research facilities and the retail outlet vendors for their forbearance and support during the surveys. I acknowledge Dr Meenal Vyas support for editing final draft.

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MS Received 30 May 2019
MS Accepted 25 June 2019