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MIGRATORY BEHAVIOUR OF MANGO HOPPERS, *IDIOSCOPUS* SPP. IN RELATION TO HOST PLANT FLOWERING PHENOLOGY: A SYNCHRONOUS SHIFT

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ABSTRACT

A study was conducted to understand the seasonal migratory behaviour of mango hoppers, *Idioscopus* spp. from main tree trunk to flowering panicles in relation to host plant flowering phenology. A significant positive correlation (r = 0.65) between the hoppers present on the flower panicle with the availability of inflorescence on the tree and a significant negative correlation (r = -0.24) with the hoppers present on the main tree trunk strongly associates the flowering phenomenon as a major factor triggering the niche shift in *Idioscopus* spp. The local migration of hoppers with the changing host plant phenology was explained by linear ($y = 0.078x - 0.066$; $R^2 = 0.48$) and exponential ($y = 0.0387^{e0.0033x}$; $R^2 = 0.62$) models. As hoppers is the major hindrance during flowering season, this study helps in developing accurate models for seasonal hopper dispersal to enable precise forecasting of pest pressure on mango inflorescence and also for off-season management to reduce crop loss.

INTRODUCTION

Insect migration is the seasonal movement of insects particularly evident in species of butterflies, moths, locusts, dragonflies and beetles. A popular example of insect migration is that of the monarch butterfly (= milk weed butterfly), *Danaus plexippus* which migrates from southern Canada to wintering sites in central Mexico where they spend the winter. The *migratory locust (Locusta migratoria)* is the earliest reference to migration that goes back to biblical times, takes wind assisted flights covering 5-130 km or more per day. However, the distance can vary with species and in most cases these movements involve local shifting of large numbers of individuals. Broadly speaking, insect migration is of three types- some insects emigrate on one-way journeys to breed; others migrate from a breeding area to a feeding area; still others migrate from breeding areas to hibernation sites (Williams, 1957). In the second type of migration-migration in the strict sense-insects do migrate with in an area where they congregated during off-season to an area where intensive feeding and active breeding takes place. Such shifting of niches is all the more important in case of herbivorous insects that can cause economic damage to crops. Nevertheless, such sectional migrations are often omitted as a component of IPM (Integrated Pest Management) programs at the local level, mainly because too little is known about the factors that influence migration and dispersal by a particular insect pest (http://ipmworld.umn.edu., 2013). Generating such information on the local migration/ shifting of insect pest is essential to develop accurate models of insect dispersal to enable realistic forecasting of pest pressure on crops and also for off-season management particularly in case of monophagous pests like mango leaf hoppers that can cause enormous crop loss.

Leaf hoppers are most serious and widespread monophagous pests on mango, *Mangifera indica* L. throughout India. The hopper species viz., *Amritodus atkinsoni* (Lethierry), *Idioscopus nitidulus* (Walker), *I. nagpurensis, I. clypealis* (Lethierry) (Homopetera: Cicadellidae) are prevalent in different mango growing belts viz., Karnataka, Andhra Pradesh, Tamil Nadu, Maharashtra, Uttar Pradesh etc (Joshi and Sanjay Kumar, 2012). These hoppers cause heavy damage to mango crop during flowering season resulting in 25-60% yield loss (Patil *et al.,* 1988).

Usually these hoppers found colonized during both vegetative (on newly emerging leaves) and reproductive (on inflorescence) phases of the mango (*Mangifera indica* L.) crop. New leaves in mango arise in terminal growth flushes that occur several *times* a year and only mature terminal branches bear pyramidal *flower* panicles that *have* several hundred white flowers that are about a 1/4 inch wide when open. Usually, the flowering in mango occurs during cooler months of the year viz., December to March, as a *period* of cold stress is needed before flowering. The leaf hoppers are the major problem during flowering causing huge losses. Enormous numbers of nymphs and adult hoppers are found clustering on the inflorescence, sucking the sap during spring. The infested flowers shrivel, turn brown and ultimately fall off. The hoppers excrete honeydew that covers the inflorescence, leaves and fruits encouraging black sooty mold, *Meliola mangiferae* (Earle) which affects photosynthetic activity of leaves and market quality of fruits (Verghese and Kamala Jayanthi, 2001).

After the flowering season, the hoppers leave the blossoms and move on to the new leaves and main trunk. However, the hoppers peak activity was confined to flowering season (Patil *et al*., 1988). During flowering season, swarms of adults are commonly seen hovering in mango groves, sitting on all plant parts. Though the peak activity of mango hoppers confined to mango flowering season, hoppers remain in cracks and crevices of mango trunk throughout the year and start infesting the emerging young shoots/ inflorescence in the last week of the December (Babu *et al.*, 2002) Very little work on movement of mango hoppers from trunk to insert new shoots/ inflorescence has been reported so far. Therefore, it is important to investigate the pattern of population shift in mango hoppers from main trunk where they confine during off season to new shoots/inflorescence during peak infestation periods in relation to phenological development of host plant.

MATERIALS AND METHODS

The study was conducted in the mango orchards of Indian Institute of Horticultural Research (IIHR), Bangalore (12°58' N; 77°35' E) during 2012-13. Periodical surveys were conducted in mango orchards at fixed intervals during October - March to record observations on the number of hoppers present on main trunk, new shoots and flower panicles of the mango tree. For each survey, 20 trees were selected randomly and three sweeps were done on the tree trunk with polythene cover (45 cm length x 30.5 cm breadth) to collect the surviving hopper population on trunk. After collection the polythene covers were tied with rubber bands to prevent the escape of hoppers and brought to the laboratory. Similarly, each of 10 shoots /flower panicles were tapped in to the polythene covers (45 cm length x 30.5 cm breadth) that were draped over the respective shoots and flower panicles to collect the hopper population present on the shoot/inflorescence. After collection of the hoppers the polythene covers were tied with rubber bands to prevent the escape of hoppers and brought to the laboratory. The numbers of hoppers present in each polythene cover were counted separately and sorted according to the species viz., *A. atkinsoni, I. nitidulus* and *I. nagpurensis.* Visual scoring of each mango tree phenology was carried out on whole tree basis during surveys, mainly for emergence of new leaves and inflorescence on 0-100 scale, where 0 = no new leaves emergence/no flower panicle development; 100 = complete emergence and development of pink new leaves/ flower panicles all over the tree. The data were subjected for the correlation and regression analysis using the SPSS statistical package (SPSS ver. 16.0).

RESULTS AND DISCUSSION

The correlation between the hopper population levels with host plant phenology is presented in the Table 1. The hoppers present on the flower panicle were positively correlated with the availability of inflorescence (r = 0.65) on the tree, but negatively correlated with the hoppers present on the trunk (r = -0.24). Nevertheless, hoppers present on the trunk were significantly negatively correlated with the availability of inflorescence (r= -0.23). The negative correlation between the mango hoppers present on the flower panicle and hoppers present on main trunk clearly reveals that as the flowering takes place in mango, the hibernating hoppers shift from the trunk to inflorescence. Further, a significant positive correlation was also observed between the plant phenological events viz., the emergence of flower panicles and new flush of leaves (Table 1). This further supports the hoppers colonization on

Table 1: Correlation between the mango hoppers and host plant phenology

Hoppers on flower panicle	Hoppers on trunk	Inflorescence availability (%)	New leaves availability (%)
Hoppers on flower pancile	-		
Hoppers on trunk	-0.24*	-	
Inflorescence availability (%)	0.65**	-0.23*	-
New leaves availability (%)	-0.14	-0.03	0.22* -

Table 2: Relationship between the mango hoppers and host plant phenological variables

Parameters	Regression model	R^2
a) Hoppers on flower panicle vs.		
Hoppers on main trunk	$y = -0.14x + 1.44$	0.06
Inflorescence availability	$y = 0.078x -0.066$	0.48
Availability of new leaves	$y = -0.535x + 14.81$	0.02
Hoppers on main trunk and inflorescence availability	$y = -0.16x^2-0.07x+0.36$	0.43
Hoppers on main trunk and availability of new leaves	$y = -0.42x^2-0.04x+3.36$	0.08
Availability of inflorescence and new leaves	$y = -0.08x^2+0.08x+0.91$	0.50
Hoppers on trunk, availability of inflorescence and new leaves	$y= -0.15x^3+0.08x^2-0.08x+1.14$	0.51
b) Hoppers on main trunk vs.		
Inflorescence availability	$y = -3.61x + 36.26$	0.05
Availability of new leaves	$y = -0.19x + 13.76$	-
Hoppers on panicle and availability of inflorescence	$y = -0.09x^2+0.09x+1.58$	0.07
Availability of inflorescence and new leaves	$y = -0.02x^2+0.003x+1.54$	0.05
Hoppers on panicle & availability of new leaves	$y = -0.15x^2+0.01x+1.58$	0.06
Hoppers on panicle, availability of inflorescence and new leaves	$y= -0.10x^3+0.01x^2-0.004x+1.63$	0.26

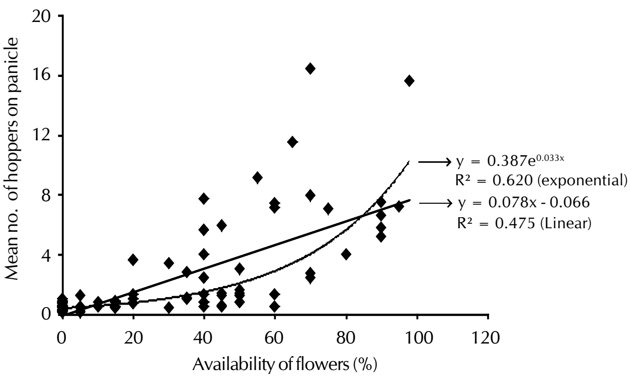

Figure 1: Scatter plot showing the relationship between mango hoppers present on the panicle and inflorescence availability

the tree as usually mango hoppers actively breeds on new leaves as well as inflorescence.

The step-wise regression analysis carried out with hoppers present on flower panicle as dependent variable along with availability of inflorescence as independent variable alone explained 47.5% ($F = 64.35$; $p < 0.01$; Fig.1) of variability in the hopper population levels on the panicle through linear model ($y = 0.078x - 0.066$, $R^2 = 0.48$). However, availability of inflorescence alone could explain the variability in the hopper population present on the panicles to the tune of 62% through exponential model ($y = 0.387e^{0.033x}$). Whereas the availability of inflorescence along with the hoppers present on trunk could explain only 43.1% ($F = 32.97$; $p < 0.01$) of hopper population variability on the flower panicles. However both inflorescence availability (%) and new flush of leaves (%) together explained 50.4% ($F = 44.25$; $p < 0.01$) of variability in the hopper population that was present on flower panicles. Further inclusion of variable viz., hoppers present on the trunk to the above equation could improve the R^2 marginally to 51.10% ($F = 30.06$; $p < 0.01$). The independent variables *viz*., hoppers present on the main trunk and availability of new leaves independently could not explain the variability in the hopper population levels on flower panicles beyond 6% (Table 2).

When hoppers present on the trunk was taken as the dependent factor, and regressed against independent variables viz., hoppers present on flower panicle, availability of inflorescence and new leaves together could explain only 26.20% ($F = 2.11$; $p < 0.1$) of variability in the hopper population present on main trunk. Independently all these variables viz., hoppers on flower panicles, availability of inflorescence and new leaves could not explain the variability in the hopper population present on main trunk beyond 7% (Table 2).

The hoppers are the serious monophagous pests of mango causing heavy damage of inflorescences, flowers, young fruits and young tender foliage. The present findings are in agreement with earlier studies (Venkatesan, 1990; Talpur *et al*., 2002; Talpur and Khuro, 2003) that reported the phenological relationship in mango between *Idioscopus* spp and occurrence of inflorescence as well as fruits. They reported significant positive correlation between hopper population and inflorescence. Viraktamath et al. (1996) reported that *I. nitidulus* breeds during January on inflorescence which is also the reason for the abundance hoppers on inflorescence. This clearly indicates that appearance of new leaves and inflorescence on the mango tree is the critical event for the migration of hoppers. Among the availability of inflorescence and new leaves, the former is the most important phenomenon that directs the shifting of hoppers from main trunk to flower panicles. This migration of hoppers intern may be influenced by the specific volatiles emitting from inflorescence. Such pronounced local movement of mango hoppers from main trunk to inflorescence indicates the need for management of residual population on main trunk during off-season to bring down the hopper infestation in main cropping period.

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