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Orientation Behaviour of Legume Pod Borer, *Maruca vitrata* Fabricius (Lepidoptera: Crambidae) on Different Pulses

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ABSTRACT

Background: The legume pod borer, *Maruca vitrata*, is recognized as serious insect pest on grain legumes and cause significant yield loss. Much research work has been carried out on management of *M. vitrata* with synthetic pesticides and biocides, there is paucity of knowledge on alternative non chemical methods to overcome this menace. Chemical signals from reproductive structures of host plants act as a key for lepidopteran phytophagous insects.

Methods: Effects of volatiles from flowers and pods of different pulses such as pigeonpea, greengram, blackgram, cowpea and lablab on orientation pattern of *M. vitrata* larvae and adult moths and attractance behaviour of male moths to their females were investigated under laboratory conditions by using multi arm olfactometer and wide spaced basins.

Result: One day old female moths showed significantly maximum orientation towards flowers of pigeonpea (42.7%) while elder age groups had the orientation ranging from 0.0 to 34.0 per cent on blackgram flowers and control (without host) respectively. The order of host preference of *M. vitrata* larvae observed as cowpea (32.2%) >lablab (32.0%) >pigeonpea (18.8%) >greengram (9.0%) >blackgram (4.8%) >unsettled (3.0%). These results clearly showed the maximum preference of lablab by *M. vitrata* than other pulses tested. In an another experiment, one, two and three day old male moths had maximum orientation towards two day old females (31.3 to 40.0%) and this indicated more amount of sex pheromone emitted by female moths on two days after their emergence.

Key words: Attraction, Cowpea, Lablab, Legume pod borer, *Maruca vitrata,* Pigeonpea.

INTRODUCTION

Pulses are important source of protein and contributes major share to total food production in India. The legume pod borer, *Maruca vitrata* Fabricius, is recognized as serious insect pest on majority of grain legumes (Shanower *et al.,* 1999) cause tremendous yield loss across the country. Larvae mainly hide inside webbings made out of flowers and pods of legumes and voraciously feed by remain inside (Zadda Kavitha and Vijayaraghavan, 2023). Its concealed nature feeding by webbing flowers and pods make it harder for natural enemies (Singh and Singh, 2021) to access feeding sites and more difficult to manage with insecticides (Sambathkumar *et al.,* 2015). In these circumstances, farmers use array of synthetic pesticides to overcome its menace and this pose an adverse effect to environment and human beings throughout India. Nevertheless, these give only limited success and failed to reach satisfactory level of reduction in larval population (Yule and Srinivasan, 2013). Even though much research work has been carried out on management of *M. vitrata*, there is paucity of knowledge on alternative non chemical methods to overcome this menace. Presently much emphasis is being given to utilization of non-chemical, eco-friendly and sustainable pest management measures.

Generally, odors that are emitted by host plants can attract many herbivorous insects and foraging parasitoids (Wäckers, 2005). Normally, host plants release odours specifically attract herbivore insects whereas, the same plants under herbivore damage produce herbivore-induced plant volatiles (HIPVs) that attract many natural enemies (Aartsma *et al.,* 2017). According to Wang *et al* (2011), the mixture of odour from legume flowers play significant role in identification and differentiating the ideal host plants by *M. vitrata*. Hence, strong knowledge on influence of host plant volatiles on behaviour of this pest will be an ideal alternate to manage this pest. So far, only little attention has been paid to study the effect of plant volatiles on *M. vitrata* in locating suitable host for feeding and oviposition. Hence, the present study is focused to understand the orientation preference of larvae and adult moths of *M. vitrata* to different pulses and sexual attractance of their adult moths.

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MATERIALS AND METHODS

Preliminary studies on interaction of *M. vitrata* with its host plants

Mass culturing

Larvae of *Maruca* collected from different pulses such as pigeonpea, greengram, blackgram, cowpea and lablab raised in crop fields of Tamil Nadu Agricultural University (TNAU), Coimbatore and mass cultured at Department of Agricultural Entomology, TNAU, Coimbatore, Tamil Nadu during 2012-13. They were inoculated separately on plastic basin (30 cm dia. and 10 cm height) contain a dry filter paper along with fresh flowers and pods of their corresponding hosts as food source. Periodically, fresh flowers and pods were replaced with respect to host from which larvae were collected. Healthy pupae were retained in plastic buckets (22.5 cm dia. and 25 cm height) for adult emergence. In each bucket, ten pairs of healthy and active male and female adult moths were released along with bunch of fresh flowers and pods of corresponding hosts for egg laying with a piece of absorbent cotton swabbed with diluted honey (10%) and drop of vitamin E solution in small sterile glass vials to facilitate healthy mating and oviposition. The mouth of the plastic bucket was fastened with black coloured sterile muslin cloth. This also acted as oviposition substrate and black color helped to identify the eggs. At every time, fresh eggs were stored in separate plastic basins (30 cm dia. and 10 cm height) according to host. The whole mass culturing was done in a culture room with a temperature of 27.9±2.2°C and relative humidity (RH) of 76.6±9.1 per cent.

Kairomonal studies with respect to females of *M. vitrata*

Invitro studies were carried out to find out the influence of host plant volatiles on attraction of *Maruca* females. Totally, ten grams of flowers of pigeonpea, greengram, blackgram, cowpea and lablab were taken in separate glass bottles (20.0 cm height and 6.0 cm dia.) and was firmly closed with a lid comprised of an inlet and outlet glass tubes. The inlet of each bottle (with host) was connected to an aquarium pump (220-240 volt AC) and the outlet end was individually connected to the individual arm of a six arm olfactometer (Plate 1) in that one arm was maintained as control without any host. The air current was passed from aquarium pump at the rate of 4 lit/ min in to olfactometer. After five minutes of saturation of different host odour in the olfactometer, ten numbers of one day old virgin female moths were released from mass cultured population in the olfactometer through a central hole which also served as odour exit hole. Observation was made on number of female moths settled on each arm at 10, 20 and 30 MAR (Minutes After Release) for their host preference. This experiment was replicated thrice. Similarly, other two experiments were conducted with two and three day old female moths of *M. vitrata* following the same methodology. Since, moths of *M. vitrata* are nocturnal, this experiment was conduted between 18:00 to 23:00 hrs. The data on number of female moths settled on each arm was recorded and per cent moth orientation was also calculated.

Effect of kairomonal odour on larvae of *M. vitrata*

In order to find out the host odour perception by *M. vitrata* larvae, an experiment was conducted in Completely Randomized Design using flowers of pigeonpea, blackgram, greengram, cowpea and lablab. Twenty grams of flowers of each pulse host arranged in circular fashion at the periphery of plastic basin (30 cm dia. and 10 cm height) with a filter paper at the base. Twenty five numbers of fourth instar *Maruca* larvae were released in the centre of the basin (Plate 2). This experiment was replicated five times. Observations were made on number of larvae settled on each host at 24 Hours After Release (HAR). The per cent orientation towards each host was computed and statistically analysed. In order to study the perception of larvae from wider distance another study was carried out with bigger container made out of thermacol pith (120 ×

Plate 1: Experiment setup to study the kairomonal response of *M. vitrata* females to different pulses.

Plate 2: Experiment setup for kairomonal response of *M. vitrata* larvae to different pulses using Plastic Basin.

Plate 3: Experiment setup for kairomonal response of *M. vitrata* larvae to different pulses using Bigger container.

120 x 30 cm) (Plate 3) and same methodology was followed as described above. Since, *Maruca* larvae are hidden feeder and active throughout the day, this study was conducted during day time.

Response of different age groups of males of *M. vitrata* to females

Studies were carried out to find out the response to different age groups of *M. vitrata* males to different age groups of females between 18:00 to 23:00 hrs. Virgin females of one, two, three and four days old moths were individually confined in separate glass bottles (20.0 cm height and 6.0 cm dia.) and firmly closed with a glass lid comprised of a inlet and outlet glass tubes. One end of glass tube was connected to an aquarium pump (220-240 volt AC) and another end was connected to the individual arms of a six arm olfactometer (Plate 4). Two opposite arms were kept as control. This setup was maintained with three replications. Air flow was made in olfactometer at the rate of 4 lit/min through the bottles containing females of different age groups. After five minutes of saturation of odours from different age groups of females in to the olfactometer, ten numbers of one day old, virgin male moths were released in to the olfactometer through a central hole. Observation was taken on number of male moths settled on each arm at 10, 20 and 30 MAR for their host preference. This experiment replicated thrice. Similarly, other two experiments were conducted with two and three day old male moths following the same methodology. The data on number of female moths settled on each arm was recorded as per cent moth oriented.

Statistical analyses

The data obtained between 1.0 to 100.0 per cent, arcsine transformation was used and for zero values, X + 0.5 was added to all values and analysed. Paired 't' test (Gomez and Gomez (1984) was adopted to find out the significant difference of larval orientation in both plastic and larger

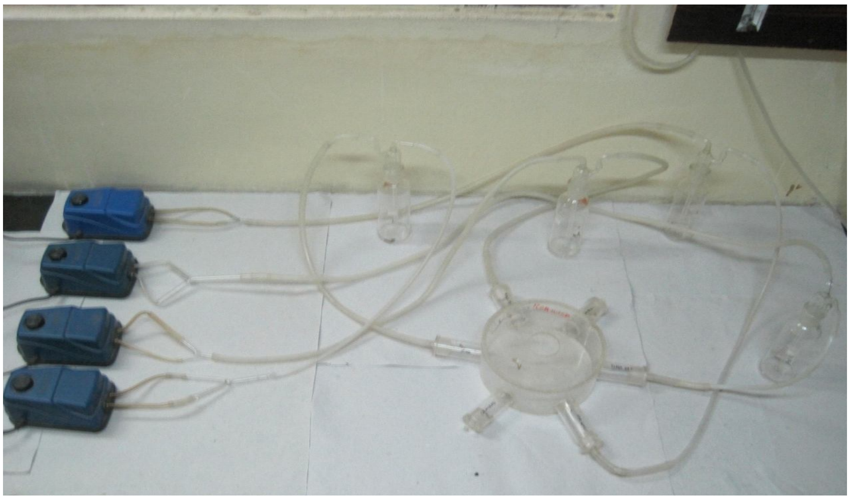


Plate 4: Experiment setup for the orientation behaviour of different age groups of *M. vitrata* males to calling behaviour of females.

container with respect to different hosts studied. Analysis of variance was done and means were separated by Tukey's HSD (Tukeys, 1953) at 5 per cent significance level. Statistical analysis was conducted using SPSS 16.0 version. The critical 'p' value of 0.05 was set and analyzed for each test.

RESULTS AND DISCUSSION

Kairomonal studies with reference to *M. vitrata* female moths

The experimental results showed a significant variation on orientation behaviour of *Maruca* female moths towards flowers of different pulses (Table 1). At 10 MAR (Minutes After Release), the maximum orientation of one day old females recorded in lablab (44.0%). Pigeonpea and cowpea stand next to lablab with the per cent orientation of 20.0 and 18.0 respectively when compared to 4.0 per cent towards control arm. At 20 MAR, the highest orientation (44.0%) recorded towards flowers of lablab and found to be significant to other hosts. On 30 MAR, also same trend was recorded and the orientation level ranged from 2.0 to 40.0 per cent on blackgram and lablab respectively. On 10 MAR, the response of two day old *Maruca* females was more (28.0 %) towards pigeonpea and control arm (without host) followed by 18.0, 16.0 and 10.0 per cent on lablab, cowpea and greengram respectively. In 20 and 30 MAR also, the maximum orientation of female moths recorded towards control arm (26.0%) followed by pigeonpea (24.0%) and greengram (22.0%). There was no female orientation recorded from 10 to 30 MAR on blackgram (Table 1). At 10 MAR, the highest orientation of three day old *Maruca* females recorded towards control arm (34.0%). Lablab and pigeonpea recorded orientation of 24.0 and 22.0 per cent and stand next to control arm (Table 1). On blackgram flowers containing arm, there was no orientation of *Maruca* females observed during the entire observation period.

Among the response showed by different age groups of female moths to flowers of pulses, the significant orientation was recorded only in one day old females. The mean data showed that maximum female moth orientation was towards flowers of lablab (42.7%) followed by 21.3 per cent on flowers of pigeonpea and cowpea as compared to 4.0 per cent in control (without any hosts) (Fig 1). Whereas, the maximum orientation of two (26.7%) and three day old females (34.0 %) was found towards control followed by 25.3 and 22.0 per cent respectively on pigeonpea for same the age groups. It clearly showed that the one day old females are having strong orientation towards its preferable host than other elder age groups. This kind of behaviour might be useful to find its suitable pair for subsequent mating and oviposition for further progeny development. The above phenomenon was in conformation with the laboratory studies by Sambathkumar (2023) who recorded maximum fecundity on lablab followed by pigeonpea when compared to other pulse hosts. Generally, volatile chemical compounds of host plant parts are mainly influence on identification of ideal site for oviposition and development. Bo Feng *et al.* (2017) recorded β-caryophyllene as strong oviposition attractant

Table 1: Orientation behaviour of different age groups of *M. vitrata* females to pulses.

Host	Female moth orientation* (%)								
	One day old			Two days old			Three days old		
	10 MAR	20 MAR	30 MAR	10 MAR	20 MAR	30 MAR	10 MAR	20 MAR	30 MAR
Pigeonpea	20.0[b]	20.0[bc]	24.0[ab]	28.0[a]	24.0[a]	24.0[a]	22.0[abc]	22.0[abc]	22.0[abc]
	(26.6)	(26.6)	(29.3)	(31.9)	(29.3)	(29.3)	(28.0)	(28.0)	(28.0)
Greengram	12.0[bc]	8.0[bc]	8.0[bc]	10.0[ab]	22.0[a]	22.0[a]	10.0[b]	10.0[b]	10.0[b]
	(20.3)	(16.4)	(16.4)	(18.4)	(28.0)	(28.0)	(18.4)	(18.4)	(18.4)
Blackgram	2.0[c]	2.0[c]	2.0[c]	0.0[b]	0.0[b]	0.0[b]	0.0[c]	0.0[c]	0.0[c]
	(8.1)	(8.1)	(2.6)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)
Cowpea	18.0[bc]	22.0[b]	24.0[ab]	16.0[ab]	12.0[ab]	12.0[ab]	10.0[b]	10.0[b]	10.0[b]
	(25.1)	(28.0)	(29.3)	(23.6)	(20.3)	(20.3)	(18.4)	(18).4)	(18.4)
Lablab	44.0[a]	44.0[a]	40.0[a]	18.0[ab]	16.0[ab]	16.0[ab]	24.0[ab]	24.0[ab]	24.0[ab]
	(41.6)	(41.6)	(39.2)	(25.1)	(23.6)	(23.6)	(29.3)	(29.3)	(29.3)
Control	4.0[bc]	4.0[bc]	4.0[bc]	28.0[a]	26.0[a]	26.0[a]	34.0[a]	34.0[a]	34.0[a]
	(11.5)	(11.5)	(11.5)	(31.9)	(30.7)	(30.7)	(35.7)	(35.7)	(35.7)
SEd	8.2462	9.3808	9.7639	8.3267	9.2376	9.2376	10.2632	10.2632	10.2632
CD (P=0.05)	17.2013	19.5681	20.3671	17.1530	19.0295	19.0295	21.1422	21.1422	21.1422

MAR- Minutes after release.

*Mean of five replications and 10 female moths per replication.

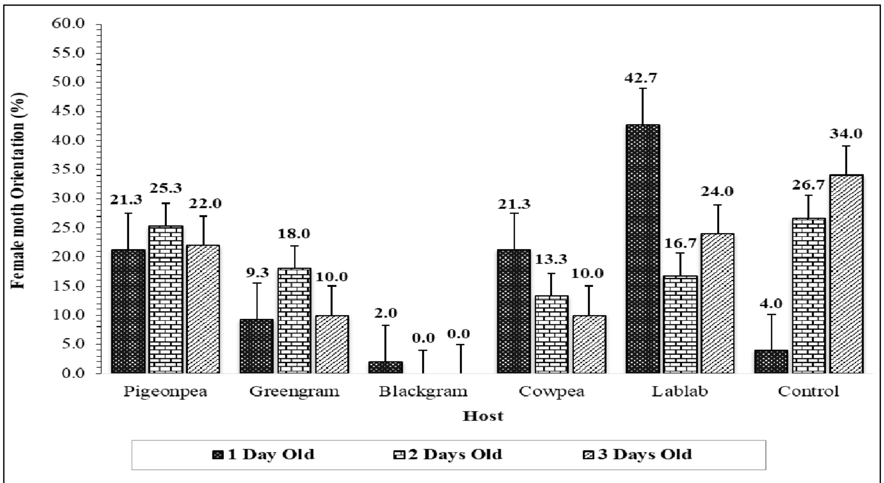
*Figures in the parentheses are arcsine transformed valuesIn a column mean(s) followed by a common letter are not significantly different at 5 % level in LSD.

to *M. vitrata* in cowpea. Apart from locating preferable hosts by female moths, host plant volatiles also have tremendous influence on various sexual responses and courtship behaviour of many phtophagous insects.

Effect of kairomonal odour on larvae of *M. vitrata*

Based on the settling behaviour of *Maruca* larvae on different pulses using plastic basin (30 cm dia. and 10 cm height), it was clear that the most preferred hosts were cowpea and lablab which attracted about 32.4 and 30.4 per cent of the larvae followed by pigeonpea (23.6%) and they were statistically on par with each other. Greengram (6.8%) and blackgram (3.6%) had minimum orientation and about 2.8 per cent of larvae did not show preference for any hosts (Table 2). The experiment conducted with bigger container revealed a significant attraction in lablab (33.6%) and cowpea (32.0%) than other hosts. Pigeonpea (14.0%), greengram (11.2%) and blackgram (6.0%) were preferred less by the larvae.

During many instances, the plants that are under biotic stress, release many Volatile Organic Compounds (VOC) and this cause remarkable response in host insects which are receiving these chemicals (Adhab, 2021). Hence, by knowing the insect pest attracting specific plant volatiles, it can be recommended the planting of non-crop hosts that could yield considerable amount of the same volatile and thereby the main crop get protected. The current study showed that the maximum orientation of *M. vitrata* larvae was towards flowers of cowpea and lablab followed by pigeonpea than blackgram and greengram (Table 2). Similar kind of studies on *M. vitrata* has not done earlier. Maximum larval orientation towards lablab followed by pigeonpea is in agreement with reports of Sambathkumar *et al.,* (2017) in terms of desirable nutritional indices values



Observations of each age are cumulative mean of 10, 20 and 30 minutes after release of female moths on hosts Each observation comprise of five replications and 10 female moths tested per replication Standard error calculated @ *P* value = 0.05.

Fig 1: Orientation of different age groups of *M. vitrata* females towards pulses.

Table 2: Orientation of *M. vitrata* larva to different pulses.

Host	Plastic basin		Bigger container		't' value
	Larvae settled after 24 hours* (%)	Mean±SD	Larvae settled after 24 hours* (%)	Mean±SD	
Pigeonpea	23.6a (29.1)	5.9±2.2	14.0b (22.0)	3.5±1.0	-2.6759*
Greengram	6.8b (15.1)	1.7±1.06	11.2b (19.6)	2.8±0.63	-2.9055*
Blackgram	3.6b (10.9)	0.9±0.88	6.0c (14.2)	1.5±1.35	-0.0467NS
Cowpea	32.4a (34.7)	8.1±2.23	32.0a (34.4)	8.0±1.94	0.1196NS
Lablab	30.4a (33.5)	7.6±1.84	33.6a (35.4)	8.4±2.27	-0.6827NS
Unsettled	2.8b (9.6)	0.7±0.82	3.2c (10.3)	0.8±0.79	-0.5571NS
SEd	2.8925	-	2.5456	-	-
CD (P=0.05)	5.7991	-	5.1436	-	-

*Mean of five replications and 25 larvae per replication.

*Figures in the parentheses are arcsine transformed values.

In a column mean(s) followed by a common letter are not significantly different at 5 % in LSD 't' table value @ 9, 0.05= 2.262.

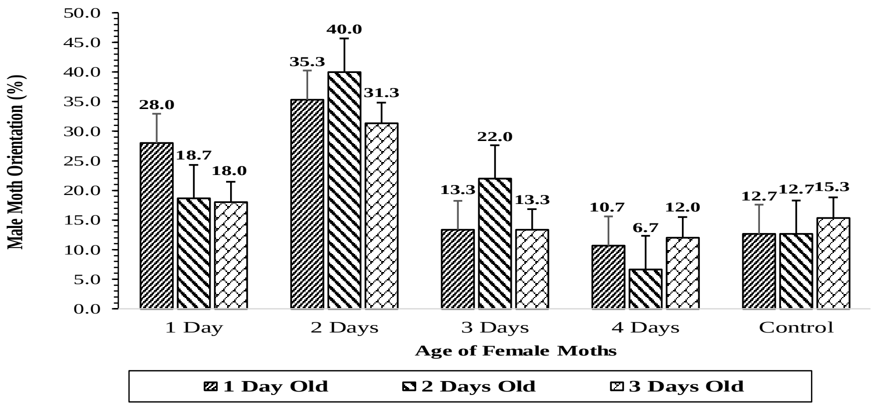
on growth and development and to support for maximum generation production of *M. vitrata.* Results on paired't' test of the present study revealed that the significant difference only existing in orientation behaviour of larvae towards greengram and pigeonpea. The reason for this significant difference on two hosts might be due to unavailability of enough space for the larvae to locate its highly preferred host (with mixture of odour) in plastic basin. However, in the bigger container, chance for mixing host odour is very less and hence, larvae could able to orient towards its most preferable host.

In the present study, less orientation of *M. vitrata* larvae and adults recorded towards blackgram and greengram. Even though these two hosts are seem to be the best choice for the establishment of *M. vitrata*, the poor larval preference might be due to availability these two hosts in the pool of other pulses. Therefore, the VOCs from highly preferred host plants and the combination of odour from all host plants play a crucial role in larval preference of *M. vitrata* for feeding when many legume hosts are available. In case of phytophagous lepidoperans, selection of suitable host plant for its larval feeding is bestowed with the choice of mother moths (Singer, 1984) and the emerged larvae have ability to discriminate hosts based on quality and emanating volatiles from the host plant. Further based on visual and a wide array of semiochemical cues from host plants further, suitability will be decided by olfactory, gustatory and tactile cues (Harris *et al.,* 1999). Likewise, larvae would search thoroughly and settle on suitable food among complex matrix of food source.

Response of different age groups of males of *M. vitrata* to female moths

The results on response of one day old male moths of *M. vitrata* to different age groups of females showed that, at 10 MAR, the orientation of male moths was maximum (34.0%) towards two days old females followed by 28.0 per cent towards one day old females when compared to 4.0 per cent towards four day old females. At 20 MAR, there was no significant variation in orientation of *Maruca* males towards different age group of females and it ranged from 10.0 to 36.0 per cent on two and three day old females respectively. Same trend was registered at 30 MAR (Table 3). The response of two day old male moths of *M. vitrata* showed significant variation with respect to its orientation towards females. At 10 MAR, maximum orientation was observed towards two day old females (40.0%) followed by one (24.0 %) and three day old females (16.0%). On control arm (without host), 16.0 per cent of males were settled. At 20 and 30 MAR, more number of male moths was oriented towards females of two day old (40.0%) and during the both times of observation, the least orientation (8.0%) of male moths recorded towards four day old female moths of *M. vitrata*. The response of three day old male moths was almost similar from 10 to 30 MAR (Table 3). On 10 MAR, the per cent orientation ranged from 10.0 to 34.0 towards control arm and two day old females respectively. At 20 and 30 MAR also, the orientation was more towards two day old females followed by 18.0 per cent towards both one day old females and control arm (without host).

A pheromone is a substance secreted externally by an organism causing a specific reaction in a receiving organism of the same species led to interaction between organisms (Nordlund, 1981). In recent past, there has been more use of pheromone mediated monitoring of insect pest population. Mean orientation response of different age groups of male moths towards females showed that maximum orientation of one day old males (35.3 %) towards two day old female moths followed by 28.0 and 13.0 per cent orientation towards one and three days old females respectively. Similarly, highest mean orientation response of two (40.0%) and three (31.3%) day old males also recorded towards two day old females (Fig 2). The present result might be due to the influence of releasing sex



Observations of each age are cumulative mean of 10, 20 and 30 minutes after release of female moths on hosts Each observation comprise of five replications and 10 female moths tested per replication Standard error calculated @ *P* value = 0.05.

Fig 2: Response of different age groups *M. vitrata* male moths to females.

pheromones in two day old females to attract more number of male moths through series of differential electrophysiological stimulatory response in antenna of males. Age of insects is very important factor that significantly affect their mating success, mate preference and fitness outcome (Lai *et al.* 2020). As the age of female moth increases there could be reduction in the rate and titre of sex pheromone release. The present results clearly revealed that the maximum male moth orientation is towards 2 days old female moths which coincided with more release of pheromone. Whereas on older (3 and 4 days age) female moths, the lesser male moth attraction has showed the decreased rate of pheromone emission. Similarly the male moths up to 2 days old attracted more towards young female moths (up to 2 days aged). This indicated that the maximum orientation between younger male and female moths and this response could be gradually reduced with increase in the age of both sexes. Earlier reports also indicating that, the mating delay between unsuitable pairs reduce the reproductive output of both sexes but female moths were more negatively affected than male moths (Xia-Lin Zheng *et al.,* 2020). Hence, the present study suggest that the ideal mating attempts can be done up to two days old male and female moths during pheromone related experiments.

The current findings are in conformity to the findings of Downham (2003), who extracted maximum amount of attracting pheromones from two day old female moths of *M. vitrata*. In contrast, the chance of pheromone release is very less in one day old female would cause less attraction. Similar kind of phenomena was observed in *Spodoptera litura* Fabricius and *H. armigera* (Hong-Lei-Wang *et al.,* 2005). Results of present study may be further extrapolated with respect to frequency of adult moth mating rhythms. Since, *M. vitrata* female moths of two days after emergence (DAE) released maximum amount of pheromones, the peak mating frequency might be expected during this time. This is closely in line with earlier findings on occurrence of highest mating frequency of *Mauca* adults on 3 DAE (Lu Peng-Fei, 2007). Many earlier EAG studies are also confirming these findings. Based on the present findings, it can be further studied the maximum attraction of different age groups of male moths of *M. vitrata* to its females in order to find the ideal time and age for female moths to extract its natural attractants including the sex pheromones.

This phenomena also useful in designing specific kairomones based management techniques for *M. vitrata* in future. Further studies are required to correctly identify chemistry of olfactory stimuli that are influencing the orientation behaviour of both larvae and adult moths in different hosts tested. If highly attractive chemical cues identified, this may be produced in large scale and utilized as alternate pest management tool for monitoring, mass trapping and mating disruption of *Maruca* populations. Additionally, by applying these kairomones on non-host plants in nearby fields, both larvae and adult moths of *M. vitrata* made to attract for feeding and oviposition, respectively on these plants to achieve incomplete growth

Table 3: Response of different age groups of male moths of *M. vitrata* to calling behaviour of females.

Age of female moths (days)	Male moth orientation* (%)								
	One day old			Two days old			Three days old		
	10 MAR	20 MAR	30 MAR	10 MAR	20 MAR	30 MAR	10 MAR	20 MAR	30 MAR
1	28.0^{ab} (31.9)	28.0^{a} (31.9)	28.0^{a} (31.9)	24.0^{ab} (29.(3)	16.0^{b} (23.6)	16.0^{b} (23.6)	18.0^{a} (25.1)	18.0^{a} (25.1)	18.0^{a} (25.1)
2	34.0^{a} (35.7)	36.0^{a} (36.9)	36.0^{a} (36.9)	40.0^{a} (39.2)	40.0^{a} (39.2)	40.0^{a} (39.2)	34.0^{a} (35.7)	30.0^{a} (33.2)	30.0^{a} (33.2)
3	20.0^{abc} (26.6)	10.0^{a} (18.4)	10.0^{a} (18.4)	16.0^{bc} (23.6)	24.0^{ab} (29.3)	26.0^{ab} (30.7)	16.0^{a} (23.6)	12.0^{a} (20.3)	12.0^{a} (20.3)
4	8.0^{c} (16.4)	12.0^{a} (20.3)	12.0^{a} (20.3)	4.0^{c} (11.5)	8.0^{b} (16.4)	8.0^{b} (16.4	12.0^{a} (20.3)	12.0^{a} (20.3)	12.0^{a} (20.3)
Control	10.0^{bc} (18.4)	14.0^{a} (22.0)	14.0^{a} (22.0)	16.0^{bc} (23.6)	12.0^{b} (20.3)	10.0^{b} (18.4)	10.0^{a} (18.4)	18.0^{a} (25.1)	18.0^{a} (25.1)
SEd	9.4657	11.6619	11.6619	8.5790	9.7980	9.7160	11.3137	1.9331	1.9331
CD (P = 0.05)	19.7452	24.3264	24.3264	17.8956	20.4382	20.2672	23.6001	24.8922	24.8922

MAR- Minutes after release.

*Mean of five replications and 10 male moths per replication.

*Figures in the parentheses are arcsine transformed values.

In a column mean(s) followed by a common letter are not significantly different at 5 % in LSD.

and development of insects. Simultaneously, application of pesticides could be concentrated only on these non-host plants to reduce this globally distributed insect threat.

CONCLUSION

The present study clearly revealed that among different age groups of female moths of *M. vitrata*, one day old moths had maximum orientation towards flowers of pigeonpea (42.7 %) followed by 21.3 per cent towards lablab and cowpea. Similarly, the highest larval orientation was recorded towards flowers of cowpea and lablab. With respect to orientation behaviour of adult moths, one, two and three day old male moths had maximum orientation towards two day old females (31.3 to 40.0 %). However, further studies are required on identification of attractive chemical cues for both larvae and adult moths, blending of most attractive host plant volatiles with pheromone chemicals along with standardization of optimum blend ratio in order to increase the efficiency of trap catches under field conditions.

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Conflict of Interest

All authors declare that they have no conflicts of interest.

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