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Feeding potential of zigzag beetle on sucking insect pests of brinjal

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Abstract
Study was carried out on Feeding potential of Zigzag beetle on sucking insect pests of brinjal. Observations on the fecundity, fertility, adult emergence, longevity and mortality were recorded. The results indicated that average pre-copulation, copulation and post-copulation periods were higher on aphid compared to whiteflies and thrips, whereas on thrips were most least. Oviposition & post-oviposition periods showed quite similar pattern i.e. higher on aphids and most least on thrips. The mean fecundity/female was extended on aphids compared to whiteflies and thrips while, maximum incubation period showed the same pattern. The results further revealed that the percent male emergence of Zigzag beetle was most least (36%) on thrips and highest on aphids (50%) and female emergence was highest (70 %) on aphids and most least (40%) on thrips. The average life span and feeding potential of male and female on aphids was highest on aphids compared to whiteflies and thrips which showed that aphids were most preferred food and thrips was least preferred prey for male adults of *M. sexmaculatus.* All larval instars showed similar pattern whereas, 3rd and 4th instars were found more voracious than other instars. Overall data shows that female adults lived longer and consumed more sucking pests of brinjal than male adults of *M. sexmaculatus*. Whereas, The average feeding potential of female was more compared to male adults.

Keywords: Feeding potential, life cycle of zigzag beetle, sucking pests of brinjal

1. Introduction
Insect pests have always been a threat to agricultural productivity, resulting crop less productivity per unit area in Pakistan compared to developed countries of the world. The major pests of eggplant, cotton and okra includefruit and shoot borer, leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer, blister beetle, red spider mite, etc. To control such insects pests, different chemicals (pesticides) are being applied all over the world [1]. Biological control is the use of an organism to reduce the population density of another organism and thus includes the control of pests, weeds and diseases. Firstly, in nature, most organisms are consumed by predators, which in many cases leads to drastic reductions in the population of the prey species; in biological control, man exploits this 'natural control' to suppress the numbers of pest species. Secondly, biological control reduces rather than eradicates pests, in order to sustain an agro-ecosystem by presence of predator and prey at low densities [2]. The Coccinellid beetles are widely distributed throughout the world and they are found on a wide variety of trees, shrubs, weeds, grasses and cultivated crops. Coccinellid beetles represent one of the most beneficial and recognized groups of insects. For most species, both adults and larvae are voracious predators of a wide range of prey, such as aphids, thrips, jassids, scale insects, whiteflies, mites and eggs of moths [3]. The coccinellids are predators of a variety of pest *viz*., aphids, whiteflies, thrips leaf-hoppers, scale insects, mealy bugs, mites and other soft bodied insects [4]. In this view, Zigzag beetle has an improtance as a biological control agent against aphid, whiteflies, thrips. In our study, preference by Zigzag beetles for three different sucking insect pests of brinjal as a diet is examined in laboratory conditions.

2. Material and Methods
2.1 Culture Development
Adult beetles of coccinellid predator, *Menochilus sexmaculatus* and host aphids, whiteflies and thrips were collected from brinjal, berseem and other crops.

The adult beetles were brought to laboratory and confined in cubicular plastic cage (25″×10″×15″). The side of cages were secured by wire gauze and front of each cage had an operator/observer hole guarded by muslin cloth sleeve to provide food for predators. The fresh young leaves of respective hosts containing the aphids, whiteflies and thrips (prey) were provided daily to the adult beetles.

2.2 Life cycle

2.2.1 Eggs

The eggs deposited mainly on host plant leaves were removed daily with the help of camel hair brush and kept in paired Petri dishes (9 cm. dia.) having a filter paper spread over bottom. The number of eggs laid per female in each Petri dish was counted under binocular microscope. This procedure was repeated till the death of the Ovipositing females. Each experiment was replicated ten times. The laboratory temperature of 25±2 ^{0}C and at 60 to 70% R.H was made.

2.2.2 Larval instars

After hatching of eggs, the duration of larval stages were determined by placing each larva in Petri dish provided with aphids, whiteflies and thrips and replicated 10 times. The observations were recorded daily up to last larval instars.

2.2.3 Pupal and adult stages

The pupal stages were observed by placing 4th instars larva in Petri dishes (9.0×1.5 cm). The duration of pupation was observed two times daily, until the pupae were Ecdyced and the adults emerged. The newly emerged adults were sexed and replaced in Petri dishes by placing a male and female pair in each Petri dish and replicated 10 times. Adults were provided with counted aphids, whiteflies and thrips on fresh leaves of brinjal .The percent emergence of male and female adults, their longevity and sex ratio were determined. The pupal and adult mortality was recorded daily by counting the dead pupae and adults.

2.3 Mating behaviour of adult coccinellid beetle

Newly emerged adults (male and female) were released in glass bowls (7 cm ×2.5 cm) in pairs to record the mating behavior, duration of mating, pre-oviposition, oviposition and post oviposition periods. The number of eggs (fecundity) lay by each female during her life time, incubation period of eggs, hatching percentage of eggs and mortality were recorded.

2.4 Feeding preference of *M. sexmaculatus* in laboratory Larval (grub) instars

After hatching from eggs, the first instar larvae of *M. sexmaculatus* were transferred into petri dishes (9 cm. dia.) by camel hair brush. For recording feeding preference of 1st, 2nd, 3rd and 4th instar grub providing 30, 60, 90 and 150, aphids, whiteflies and thrips along with the leaves of brinjal crop and replicated five times. The aphids, whiteflies and thrips consumption of each instar was observed after 24 hrs daily until the grub entered into next development stage. The experiment was continued till pupation of predator.

2.4.1 Adults

Newly emerged adults of *M. sexmaculatus* were collected from the laboratory culture at random. Male and female adults were kept in separate Petri dishes providing 250 aphids, whiteflies and thrips to each adult beetle. The consumption of aphids, whiteflies and thrips were recorded after 24 hours daily. The experiment was repeated five times.

3. Results

The results (Table-1) indicated that pre- copulation (latent) period of male *M. sexmaculatus* was 5.23±0.62 days on aphids followed by 4.11±0.76 days on whiteflies and 2.11±0.15 days on thrips, copulation period was an average of (49.69±5.26 minutes) on aphids followed by (37.36±3.91 minutes) on whiteflies and (33.87±3.85 minutes) on thrips, and post-copulation period was (3.81±0.25 days) on aphids followed by (3.41±0.75 days) on whiteflies and (2.36±0.12 days) on thrips.

Similarly, mean oviposition period of *M. sexmaculatus* found (43.60±4.14 days) on aphids followed by (34.15±3.78 days) on whiteflies and (29.10±3.65 days) on thrips whereas, mean post-oviposition period was 5.05±0.71 days on aphids followed by 4.24±0.45 days on whiteflies and 3.16±0.16 days on thrips (Table-1).

The data (Table-2) shows that total number of eggs laid by females of *M. sexmaculatus* (fecundity) during her life time was maximum mean number of 388.26±11.35 eggs when reared on aphids followed by 239.89±10.25 eggs on whiteflies and 212.61±9.92 eggs on thrips. The results thus indicated that the maximum fecundity was recorded in the females reared on aphids. However, lowest fecundity was on thrips. Our result showed that the incubation period of eggs was significantly higher (3.74±0.08 days) on aphids followed by (3.36±0.14days) on whiteflies and (3.21±0.22 days) on thrips. Furthermore, mean hatching percent of eggs was higher (64%) on aphids followed by (50%) on whiteflies *and* (44%) on thrips recorded in laboratory conditions**.**

The results (Table -3) showed that the larval and pupal duration of *M. sexmaculatus* at 25±2 ^{0}C temperature and 55±5% R.H in laboratory conditions. The data indicated that larvae passed through four instars on all prey hosts. The maximum mean duration of life of first, second, third and fourth instar larvae on aphids were 3.60±0.35, 4.11±0.15, 4.69±0.37 and 5.36±0.87 days respectively followed by whiteflies 3.10±0.13, 3.98±0.82, 4.12±0.93, 4.46±0.98 and thrips 2.30±0.40, 2.36±0.27, 2.87±0.42 and 3.66±1.15 days respectively. In addition, pupal duration of *M. sexmaculatus* (Table 3) was maximum on aphids (4.37±0.49 days), followed by whiteflies (4.00±0.33 days) and thrips (3.12±0.28 days).

The results (Table- 3) indicated that the total immature (Larval + Pupal) stages duration of *M. sexmaculatus* higher on aphids (22.13±2.23days) as compare to whiteflies (19.66±3.19days) and thrips (14.31±2.52days.

Results (Table-4) showed that the highest pupation percentage of *M. sexmaculatus* was observed reared on aphids (80.0%) followed by whiteflies (66.0%) and thrips (52%). The data further indicated that cannibalism was normal among the larvae of *M. sexmaculatus* reared on different host pests. The highest percent of cannibalism was observed on aphids (20%) followed by whiteflies (34%) and thrips (48%). Cannibalism is a wide spread phenomenon, found in many arthropods. It is generally considered that this behavior showed by coccinellids during the shortage of natural prey. During present study it was observed that in fourth instar larvae of *M. sexmaculatus* cannibalism percentage was low as compare to others**.**

The results (Table-5) indicated that the emergence percent of male and female adults M. sexmaculatus was 36% and 58% on aphids, 30% and 50% on whiteflies and 24%, 40% on thrips respectively. Similarly, the result thus indicated that emergence of female adults was higher than male adults.

However there was no significant difference in the emergence of both sexes (P>0.05).

The data (Table-6) indicates the longevity of male and female adults of *M. sexmaculatus* reared on different sucking insect pests of brinjal. The longevity of females was higher as compared to males on three different hosts. The mated male adults survived for 46.12±3.12 days on aphids, 32.25±2.79 days on whiteflies and 28.69±2.59 days on thrips. Similarly the female adult longevity was 48.41±4.15days on aphids, 38.56±3.63 days on whiteflies and 33.78±3.87 days on thrips. The result thus suggested that maximum longevity in both male and female adults was higher when reared on aphids followed by whiteflies and thrips.

The data (Table-7) shows the feeding potential of larval instars of *M. sexmaculatus* during (24 hours) on different sucking insect pests of brinjal. The results indicated that the first instar larvae of *M. sexmaculatus* were consumed 9.28±1.47aphids/day. Similarly on whiteflies the feeding rate was 7.56±1.05, and on thrips 5.28±0.98 .The mean highest consumption of 1st instar was recorded on aphids, and lowest on. Similarly in the second instar larva the mean highest consumption rate during 24 hours was recorded on aphids. (19.21±1.97 / day) followed by whiteflies *(*13.39±2.82/day) and thrips (10.36±1.89/day). In case of third instar larvae the maximum feeding rate was recorded on aphids (35.26±2.06/day) followed by whiteflies. (23.15±2.45/day) and thrips *(*16.36±3.82/day). The fourth instar larvae of *M. sexmaculatus* was consumed *(*52.69±3.89aphids/day) followed by whiteflies (39.64±3.02/day) and thrips *(*26.85±5.56/day). The results indicated that fourth instar larvae of *M. sexmaculatus* was more voracious feeder of different sucking insect pests of brinjal as compare to 1st, 2nd and 3rd instar larvae.

The data mentioned in table-8 reveals that the mean feeding rate of male adults of *M. sexmaculatus* on different host species varied with the age of male adults. The results show that male life span on aphids was 36 days and it devoured mean 61.17±4.67aphids per day. On whiteflies the longevity of male adult was 30 days and whiteflies consumption per day was 42.89±4.12. Similarly on thrips the life span of male adult was 28 days and it devoured 32.56±6.26 thrips/ day. The data reveals that aphids was most preferred food and thrips was least preferred prey for male adults of *M. sexmaculatus.*

The results in table-8 indicated that female adults lived longer on aphids (39 days) followed by whiteflies (36 days) and thrips (34 days). The mean aphid consumption by female adults was more on aphids (72.34±5.33 / day) followed by whiteflies (47.23±4.93/day) and thrips (37.89±7.19/day). The overall data shows that female adults lived longer and consumed more sucking pests of brinjal than male adults of *M. sexmaculatus*. However, there is no significant difference between both sexes.

4. Discussion

The present experiment was conducted to study the" Lifecycle of Zigzag beetle on sucking insect pests aphids, whiteflies and thrips in Tando Jam, Pakistan" under laboratory conditions during the year 2012. Aphid, whitefly and thrip are the sucking pests which damage the plants by sucking the saps. For the management of these pests biological control is the best way, so the biology of Zigzag beetles was necessary to know the breeding information of predators on studied sucking pests. It was observed from the results of the present studies that pre-copulation, copulation duration, post copulation days, oviposition days as well as post oviposition days varied to a considerable extent within the replications/pairs of ladybird beetles. Similarly, fecundity, fertility, and within zigzag beetle pairs deviation situation was considerable. The incubation period, 1st, 2nd, 3rd and 4th instars durations were relatively similar, while duration was greater for the pupal stage. Adult emergence was greater in female Zigzag beetles as compared to male and thus the sex ratio was higher in females as compared to males. The present study agrees with those (Rajesh Soni Deol *et.al*. 2004) studied biological of *Menochilus sexmaculatus* on the five aphid species, *Lipaphis erysimi* (Kalt.). *Aphis craccivora* (Koch.). *Hyadaphis coriandri* (DAS), *Aphis nerii* (BLF) and *Uroleucon compositae* (Theobald). *U. compositae* hindered the larval development of the predator and adults transformed from the larvae fed on *U. compositae* failed to lay nymphs. *A. nerri* was the most suitable host. The fecundity was higher when fed on adults than nymphs. The consumption of nymphs on *H. coriandri* was maximum during larval development and lowest of *U. compositae*. The present study also partially agrees with (Solangi, B.K. 2004) evaluated the predatory potential of *Coccinella undecimpunctata* on cotton aphid (*Aphis gossypii*) under laboratory conditions. Larvae of the 1st, 2nd, 3rd and 4th instars, and adults were provided with aphids on cotton leaves. Predatory potential and aphid mortality due to injury by larvae significantly varied among the larval instars except the 2nd and 3rd instars, for which both parameters did not significantly vary. The number of aphids consumed per larva increased with the larval age, and the 4th-insar larvae recorded the greatest predatory potential (21.28 aphids per grub). Aphid mortality due to injury caused by larvae, which decreased with the increased in larval age, was highest for 1st-instar larvae (15.87%). The present study also in agreement with those [5] studied the biology of 11-spotted beetle *Coccinella undecimpunctata* L. on mustard aphid during the year 2006. The oviposition, fecundity, adult emergence, fertility percentage, sex ratio, longevity and mortality were studied in the laboratory on 10 separately reared pairs of beetles. The results indicated that average pre-copulation period was 4.1±1.28 days post copulation period 3.6±1.26 days, oviposition period, 37.7±6.88 days and post oviposition period 4.0±1.63 days. The mean fecundity was 593.4±86.5 eggs, fertile eggs were 531.80±76.16 with the fertility percentage of 89.63±3.44. The incubation was 3.1±1.19 and 3.1±0.94 days while 1st and 2ndinstar larva period was 3.1±1.19 and 3.1±0.87 days and for 3rd and 4th instar larvae averaged 3.5±1.26 and 3.3±0.94 days, respectively whereas the total larval period was 12.9±1.28 days and pupal period 5.6±0.96 days. The average number of pupae observed was 19.9±6.69, while the male emergence was 7.4±2.63 (38.50±13.12%) and the female emergence was 8.9±3.66 (43.48±8.24%). The sex ratio (male: female) averaged 1:1.25±1: 0.45. Thus the total male + female emergence was 81.99±13.37 per beetle pair. The mortality recorded was 3.7±3.43 beetles showing an averaged mortality of 17.57±14.51%. Adult emergence was greater in females of 11-spotted beetles as compared to males and thus the sex ratio was higher in females as compared to males.

Table 1: Copulation period of *M. sexmaculatus F.* reared on different sucking insect pests of brinjal in laboratory condition.

Hosts	Pre-oviposition period			Oviposition Period	
	Pre-copulation (days)	Copulation (minutes)	Post- copulation (days)	Oviposition (days)	Post-oviposition (days)
Aphids	5.23±0.62	49.69±5.26	3.81±0.25	43.60±4.14	5.05±0.71
Whiteflies	4.11±0.76	37.36±3.91	3.41±0.75	34.15±3.78	4.24±0.45
Thrips	2.11±0.15	33.87±3.85	2.36±0.12	29.10±3.65	3.16±0.16

Table 2: Effect of hosts on the fecundity and eggs hatch percentage of *M. sexmaculatus F.* in laboratory conditions.

Hosts	Fecundity per female	No. of eggs kept for hatching	Incubation period (days)	No. of eggs hatch	Hatching (%)
Aphids	388.26±11.35	50	3.74±0.08	32.11±0.73	64
Whiteflies	239.89±10.25	50	3.36±0.14	25.07±0.56	50
Thrips	212.61±9.92	50	3.21±0.22	22.02±0.43	44

Table 3: Larval and pupal duration of life (Days) of *M. sexmaculatus F.* reared on different sucking insect pests of brinjal in laboratory conditions.

Host	Duration of larval instars (days) (X ± S.E)				Total larval period (days) (X ± S.E)	Total Pupal period (X ± S.E)	Total Immature stages (larval and Pupal)
	1st Instar	2nd instar	3rd instar	4th instar			
Aphids	3.60±0.35	4.11±0.15	4.69±0.37	5.36±0.87	17.76±1.74	4.37±0.49	22.13±2.23
Whiteflies	3.10±0.13	3.98±0.82	4.12±0.93	4.46±0.98	15.66±2.86	4.00±0.33	19.66±3.19
Thrips	2.30±0.40	2.36±0.27	2.87±0.42	3.66±1.15	11.19±2.24	3.12±0.28	14.31±2.52

Table 4: Cannibalism percent of *M. sexmaculatus F.* grubs and pupal emergence reared on different sucking insect pests of brinjal in laboratory conditions

Host	No. Larvae observed	No. of Pupae (emerged)	Pupation rate (%)	% Level cannibalism
Aphids	50	40	80	20
Whiteflies	50	33	66	34
Thrips	50	26	52	48

Table 5: Emergence rate of adult males and females of *M. sexmaculatus* F. reared on different sucking insect pests of brinjal in laboratory conditions.

Hosts	No. of pupae observed	Adult emergence			
		Males		Females	
		Emerged	%age	Emerged	%age
Aphids	50	18	36	29	58
Whiteflies	50	15	30	25	50
Thrips	50	12	24	20	40

Table 6: Adult males and females longevity of *M. sexmaculatus* F. reared on different sucking insect pests of brinjal in laboratory.

Host	Male	Female
Aphids	46.12±3.12 days	48.41±4.15 days
Whiteflies	32.25±2.79 days	38.56±3.63 days
Thrips	28.69±2.59 days	33.78±3.87 days

Table 7: Mean host consumption of 1st, 2nd, 3rd, & 4th instars grub of *M. sexmaculatus* F. on different sucking insect pests of brinjal in laboratory.

Hosts	Host consumption per (24 hours) (Mean ± S.E)			
	1st instar	2nd instar	3rd instar	4th instar
Aphids	9.28±1.47	19.21±1.97	35.26±2.06	52.69±3.89
Whiteflies	7.56±1.05	13.39±2.82	23.15±2.45	39.64±3.02
Thrips	5.28±0.98	10.36±1.89	16.36±3.82	26.85±5.56

Table 8: Mean host consumption of adult males and females of *M. sexmaculatus* F. on different sucking insect pests of brinjal in laboratory.

Hosts	Host consumption per (24 hours) (Mean ± S.E)	
	Male	Female
Aphids	61.17±4.67	72.34±5.33
Whiteflies	42.89±4.12	47.23±4.93
Thrips	32.56±6.26	37.89±7.19

5. Conclusion

Zigzag beetle performed well to control aphid as our result shown in respect of all parameters. Furthermore, this beetle can be a better option to control whitefly as well but showed poor performance against thrips. Therefore, our study suggests that Zigzag beetle could be more beneficial as a biological control agent against aphid and white fly and can play a vital role in the brinjal cultivating fields.

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