ISSN 1023-1072

Pak. J. Agri., Agril. Engg., Vet. Sci., 2012, 28 (2): 150-159

BIOLOGY AND FEEDING POTENTIAL OF PREDATOR, *HIPPODAMIA CONVERGENS* GUIR, (COLEOPTERA: COCCINELLIDAE) ON MUSTARD APHID, *LIPAPHIS ERYSIMI* (KALT.) IN LABORATORY

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ABSTRACT

A laboratory experiment was conducted to study the biology and feeding preference of *Hippodamia convergence* on mustard aphid, *Lipaphis erysimi* from January to March, 2006. The results indicated that average pre-copulation and post copulation periods were (2.6 ±0.30 hrs) and (2.3±0.3 minutes) mean ± S.E, respectively and copulation period was (62.0 ± 2.65 minutes). Oviposition and post oviposition periods were (32.0±1.45 and 2.9±0.27 days), respectively. The mean fecundity/female was (312.3±9.51 eggs), hatching (79.0±1.91%) and mortality (21.0 ± 1.91 %) were also recorded, whereas the incubation period 3.6 ± 0.30 days and larval duration of 1st, 2nd 3rd and 4th instars were recorded as 1.8 ± 0.24; 2.4 ± 0.22; 2.6 ± 0.26 and 2.1 ± 0.43 days, respectively. The results further revealed that the percent male and female emergence of *H. convergence* was 29.5 ± 4.24 % and 36.0 ± 4.26 %, respectively. The percent adult emergence was greater in females of *H. convergence* as compared to males. The average consumption rate day^{-1} of female and male predators was 91.90 ± 0.23 and 78.85 ± 0.84 aphids. Whereas, 4th and 3rd instars consumed 70.04 ± 1.31 and 52.65 ± 1.14 aphids day^{-1} and 2nd and 1st instars consumed 30.67 ± 3.12 and 18.81 ± 2.23 aphids day^{-1}, respectively. The 4th and 3rd instars are voracious feeders as compared to 2nd and 1st instars. The analysis of variance showed that the duration of different life stage and duration between larval instars were significant different (P<0.001). Also, the adult age of male and female beetle were significantly different (P<0.001).

Keywords: Biology, feeding potential, *Hippodamia convergens*, *Lipaphis erysimi,* laboratory studies, temperature.

INTRODUCTION

The ladybird beetles (Coleoptera: Coccinellidae) occur world wide and about 4000 species of these insects are recorded in different parts of world. Most of them are predators which feed on many different kinds of soft-bodied insects (e.g. aphids and scales) (Rizvi *et al*, 1994). There are many species of lady bird beetles in the natural agro ecosystem of Sindh. Among these, the Convergent beetle, *H. convergens;* 7-spotted beetle, *C. septempunctata* (Lenous); Transverse beetle, *C. transversalis;* (Fabricious) 11-spotted beetle, *C. undecimpunctata* (Lenous); striped beetle, *B. sutuaralis* (Fabricious); Zigzag beetle, *M. sexmaculatus* (Fabricious); and *Stethorus punctum; Scymnus* sp. were reared on *L. erysimi* (Lohar and Khuhro, 2007).

The adult convergent beetle, *Hippodamia convergens* is an important predator of many aphid species. Its adult is domed shaped, oval convex and shiny with short legs and antennae. Wing covers are dark, redish orange to pale yellow, with or without black spots or irregular marks. Some are solid black with a red spot. The head is concealed from above and they have three distinct tarsi. Larvae are elongate somewhat flattened and covered with minute tubercles or spines. Most larvae have large, sickle-shaped mandibles. They are six legged blue-black in colour with orange spots. The eggs are tiny yellow, laid

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upright in clusters of 10 to 50 on underside of leaves or at the corners of cages (Lyon, 1998). The beetle has a huge appetite and reproductive capacity that often allows it to rapidly clean out its prey (Evans and Bellamy, 1996). These predatory beetles contribute to the regulation of populations of their prey, and in some situations contribute a high level of their regulation (Lyon, 2001). The successful natural enemies are those which have high reproduction rate, good searching ability for its host, adaptability in different environmental conditions and synchronized with its host (Buchanan, 1996). There is a great importance of biological control in Integrated Pest Management strategy. Keeping in view the importance of this predator, present studies were planned to determine the "Biology and feeding potential of predator, *Hippodamia convergens* Guir. (Coleoptera; Coccinellidae) on *Lipaphis erysimi* (Kalt). Hopefully, this research work will be helpful to progressive farmers and extension workers for the biological control of aphids to enhance the Integrated Pest Management (IPM) strategies in Sindh, Pakistan.

MATERIALS AND METHODS

Biology

Biology of *H. convergens* was studied during January- March-2006 in the laboratory, Department of Entomology, Sindh Agriculture University, Tandojam.

Culture development

Adult beetles *H. convergens* were collected from the crops, i.e, mustard, maize, cotton, brinjal, okra, nerium and sunflower etc. The adults were brought to laboratory and confined in cubicular wooden cage (25″×10″×15″cm). The fresh young leaves of mustard containing the aphids (prey) were provided daily to the adults for feeding.

Life cycle studies

Eggs

Ten pairs were released in Petri dishes for oviposition. The eggs deposited were 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.

Larval instars

After hatching of eggs, the duration of larval stages were determined by placing each larva in Petri dish provided with aphids and total 10 larvae were kept in Petri dishes and replicated 10 times. The observations pertaining to obvious morphological changes and moulting were recorded daily up to last larval instar.

Pupal and adult stages

The pupal stages were observed by placing 4^{th} 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 placed one pair in Petri dishes and replicated 10 times. Adults were provided with 150-250 fresh aphids, 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.

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 behaviour, 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 also recorded.

Feeding preference of *H. convergens* in laboratory

Larval (grub) instars

After hatching from eggs, the first instar larvae of *H. convergens* were transferred into Petri dishes (9 cm. dia.) by camel hair brush. For feeding potential of 1^{st}, 2^{nd}, 3^{rd}, and 4^{th} instar larvae, 30, 80, 130 and 250, aphids were provided to one larva and replicated five times. The aphid consumption of each larval instar of each predator was observed after 24 hrs daily till the larvae entered into next development stage. The experiment was continued until pupation.

Adults

Newly emerged adults were collected from pupal culture at random. Ten pairs of each male and female adult were kept separately in Petri dishes and same experiment was repeated 10 times by providing counted number of aphids to each adult beetle. The consumption of aphids was recorded after 24 hrs daily by counting the number of live aphids. The experiment was repeated five times.

RESULTS AND DISCUSSION

Biology of *Hippodamia convergens*

Precopulation (Latent period)

In this study (Table 1) it was observed that the pre- copulation (latent) period (duration of males standstill between genital contact and first bout of body shaking) in male *H. convergens* was 2.6 ± 0.30 hrs reared on *L. erysimi*.

Copulation period

Table, 1 indicate that the direct visually observed duration of copulation in adult male and female *H. convergens* was 62.0 ± 2.65 minutes when reared on *L. erysimi.*

Post copulation period

The post copulation behaviour (Table, 1) was observed and recorded in the male *H. convergens*. In this act, after separation of the genital connection, the male remained for approximately 2.3 ± 0.3 minutes on the female back in *L.erysimi* fed adults. The male then licks the females elytra and pronotum while circling on the females dorsal surface. This may be assumed that during post copulation period male *H. convergens* after licking and chasing female makes sure that the female is unattractive to other males, thus ensuring probability that the copulated male's sperms fertilized her eggs.

Oviposition and post oviposition period

Oviposition

As indicated in Table 1 the mean oviposition period in the female *H. convergens* lasted for 32.0 ± 1.45 days when reared on *L. erysimi*.

Post oviposition period

Similarly the post ovipositon period (Table 1) in *L. erysimi* fed female was 2.9 ± 0.27 days.

Table 1. Biological parameters (mean ± S.E.) of *Hippodamia convergens* reared on *L. erysimi* in laboratory in January-March-2006. (Mean temp: 26 ± 2 ^{o}C, R.H. 65 ± 5%).

Parameters	Developmental Stages
Pre-copulation (latent) period (Hours)	2.6 ± 0.30
Copulation period (minutes)	62.0 ± 2.65
Post-copulation period (minutes)	2.3 ± 0.3
Oviposition period (days)	32.0 ± 1.45
Post-oviposition period (days)	2.9 ± 0.27
Fecundity	312.3 ± 9.51
Egg Incubation period (days)	3.6 ± 0.30
Hatching % (n=50)	79.0 ± 1.91
Mortality % (n=50)	21.0±1.91
Larval period	
1st instar (days)	1.8 ± 0.24
2nd instar (days)	2.4 ± 0.22
3rd instar (days)	2.6 ± 0.26
4th instar (days)	2.1 ± 0.43
Total larval duration (days)	8.9 ± 0.64
Pupation & Larval mortality %	
Pupation %(n=60)	53.83 ± 2.99
Larval mortality %(n=60)	46.16 ± 2.99
Adult emergence %	
Male %	29.5 ±4.24
Female %	36.0 ± 4.26

Fecundity, incubation period, egg hatching rate and egg mortality.

Fecundity

Number of eggs (fecundity), incubation period of female *H. convergens* is shown in (Table 1). The mean number of eggs laid by individual females of *H. convergens* was 312.3 ± 9.51.

Incubation period

The mean incubation period (Table 1) for the eggs of *H. convergens* was 3.6 ± 0.30 days.

Egg hatching rate

Table 1 further shows the hatching rate of eggs in *H. convergens.* The mean percent egg hatching was 79.0 ± 1.91.

Egg mortality

Table 1 also shows the mortality in eggs of *H. convergens* under laboratory conditions. The mean percent mortality in eggs of females reared on *L. erysimi* was 10.5 ± 0.95. The mortality % was 21.0±1.91.

Larval period

Table 1 depicts that the larval period (days) for first, to fourth instars of *H. convergens* recorded were first instar (1.8 ± 0.24), second instar (2.4 ± 0.22), third instar (2.6 ± 0.26) and fourth instars (2.1 ± 0.43) with total larval duration of (8.9 ± 0.64) days reared on *L. erysimi* at 26 ± 2 ˚C under laboratory conditions.

Pupal period

Table, 1 further indicates that the pupal period of *H. convergens* reared on *L.erysimi* was 3.5 ± 0.34 days and the total period of immature stages (larvae+pupae) was 12.5±0.54 days.

Pupation rate and larval mortality

The data given in Table 1 show that in 4th instar larvae of *H. convergens* mean pupation rate % was 53.83 ± 2.99 when reared on *L. erysimi* and replicated to ten times . The larval mortality due to cannibalism was also observed in larvae of *H. convergens.* The Table 1 shows that in larvae reared on *L. erysimi* the cannibalism rate was 46.16 ± 2.99 %.

Adult emergence rate and sex ratio

The results in the Table 1 reveal the adult emergence of *H. convergens* when reared on *L. erysimi*. The mean male adult emergence rate was 29.5 ±4.24% and the mean female emergence rate was 36.0±4.26 %.

Feeding potential of larval instars and adults of *H. convergens*
Larval instars

The results given in Table 2 indicate the comparative feeding potential and development period (days) of different larval instars and adults of *H. convergens* fed on mustard aphid, *L. erysimi* during December-05 to March-06 in laboratory at (Mean temp. 26 ± 2 ºC; R.H. 65.5 ± 5%). The data reveal that the feeding behaviour of larval instars was significantly different from each other. Highest number of aphids was consumed by fourth instar larva per day (70.04 ± 1.31) followed by third instar (52.65 ± 1.14), second instar (30.67 ± 3.12) and first instar (18.18 ± 2.23). The third and fourth instar larvae were voracious feeders and they devoured significantly more number of aphids/day/larva. Table 2 further indicates that the duration (days) of first instar was 1.0 days, second instar 2.0 day, third instar 2.0 days and fourth instar 3.0 days. The data also showed that the fourth instar larva of *H. convergens* consumed 84.05 % aphids/day/larva. It was followed by third instar (81.0 %), second instar (76.67 %) and first instar (62.7 %). Analysis of data indicated that there was significant ($P<0.01$) feeding rate of larval instars.

Table 2. Feeding rate (Mean ± S.E) during larval instars and adults of *H. convergens* reared on *L. erysimi* in laboratory (Mean temp: 26 ± 2 ˚C, R.H. 65 ±

Predator development stage	Feeding period (days)	Host density in each replication	Aphid consumption	Aphid consumption/ day	Consumption rate (%)
First instar	1	30	18.81 ± 2.23	18.81 ± 2.23	62.7
Second instar	2	80	61.34 ± 6.24	30.67 ± 3.12	76.67
Third instar	2	130	105.31 ± 3.12	52.65 ± 1.14	81.0
Fourth instar	3	250	210.13 ± 4.21	70.04 ± 1.31	84.05
Adult male	30	2840	2365.50± 25.2	78.85 ± 0.84	83.29

Adult female	30	3170	2757.00 ± 6.9	91.90 ± 0.23	86.31

ANALYSIS

A. Larva						
SOURCE	DF	SS	MS	F-ratio	P	Significant levels
Life stage (Instars)	3	2113.24	1056.62	13.43	0.0001	**
Duration	3	39731.8	13243.9	168.36	0.0001	**
Replications	4	151.725	37.9313	0.48	0.7486	NS
Residuals	30	2359.92	78.6639			
Total	39	44356.7		Total	39	44356.7
B. Adult (Male)						
Age	29	26598.0	917.174	Age	29	26598.0
Replications	4	876.267	219.067	Replications	4	876.267
Residuals	116	12950.5	111.643	Residuals	116	12950.5
Total	149	40424.8		Total	149	40424.8
C. Adult (Female)						
Age						
Replications	Replications	Replications	Replications	Replications	Replications	Replications
Residuals	Residuals	Residuals	Residuals	Residuals	Residuals	Residuals
Total	Total	Total	Total	Total	Total	Total

Adults

The data in Table 2 also indicate that the longevity of male and female adults was (30 and 30) respectively on *L. erysimi* but their aphid consumption was higher as compared to other aphids. The data further revealed that the male adults consumed 78.85 ± 0.84 apdids/day/beetle (83.29 %) as compared to female adults 91.90 ± 0.23 aphid/day/beetle. The female feeding percent was (86.31 %). The results indicate that female adults devoured more number ($P<0.01$) of aphids than males.

The present experiment was conducted to study the biology and feeding potential of predator *H. convergens* reared on *L. erysimi* under laboratory conditions during the year 2006. Our results agreed with Obata, (1987) and Kaufmann, (1996) who reported that the precopulation period in *H. convergens* is much less than the precopulation (latent) period of 35 minutes in *H. axyridis*. In the latter species the male commenced body shaking only when sufficient material (for spermatophore formation) had been transferred from the males accessory glands to the bursacopulatrix of the female. In contrast since body shaking in *H. convergens* also served as copulatory courtship so its latent period is different from that of *H. axyridis*. During copulation, the male produce a spermatophore followed by sperm transfer. The post copulation behaviour in male insects was a strategy to ensure that the sperm would successfully fertilize the female eggs. Many factors influence the ovipositon, fecundity and longevity of females (Wigglesworth, 1965; Alcock and Gwynne, 1991; Agarwala and Bardhanroy,1997. The results of the study are partially supported by those of Rodriguez-Saona and Miller (1995). After selection, survivorship from 1st-instar larvae to adult emergence at 18, 22, and 26 °C was improved by 9.4, 8.5, and 22.2%, respectively, in the intensely selected line. Selection of individuals for fast development did not affect adult weight (19.6 mg), fecundity (344 eggs), longevity (53 days), or 3rd- to 4th-instar larval consumption of aphids (106 mg of *Acyrthosiphon pisum*). There are reports where biological parameters of *H. convergens* varied due to feeding on different hosts. Kato *et al.* (1999) studied the biology of *H. convergens* on three diets and found that larval and adult period varied due to feeding on different diets. Similarly, Figueira *et al.,* (2003) found the developmental period shorter and weight greater on aphid than *B. tabaci* eggs and nymphs.

CONCLUSION

The results of the biology and feeding preference of *Hippodamia convergence* on mustard aphid, *Lipaphis erysimi* indicated that average pre-copulation and post copulation periods were (2.6 ±0.30 hrs) and (2.3±0.3 minutes) mean ± S.E, respectively and copulation period was (62.0 ± 2.65 minutes). Oviposition and post oviposition periods were (32.0±1.45 and 2.9±0.27 days), respectively. The mean fecundity/female was (312.3±9.51 eggs), hatching (79.0±1.91%) and mortality (21.0 ± 1.91 %) were also recorded, whereas the incubation period 3.6 ± 0.30 days and larval duration of 1^{st}, 2^{nd} 3^{rd} and 4^{th} instars were recorded as 1.8 ± 0.24; 2.4 ± 0.22; 2.6 ± 0.26 and 2.1 ± 0.43 days, respectively. The results also

revealed that the percent male and female emergence was 29.5 ± 4.24 % and 36.0 ± 4.26 %, respectively. The percent adult emergence was greater in females. The average consumption rate/day of female and male predators was 91.90 ± 0.23 and 78.85 ± 0.84 aphids. Whereas 4th and 3rd instars consumed 70.04 ± 1.31 and 52.65 ± 1.14 aphids per day and 2nd and 1st instars consumed 30.67 ± 3.12 and 18.81 ± 2.23 aphids/day, respectively. The 4th and 3rd instars are voracious feeders as compared to 2nd and 1st instars.

ACKNOWLEDGEMENTS

The reported data are a part of research work carried out under HEC sponsored project “Mass Rearing of Coccinellid Predators on Different Insect Pests”. The authors are thankful to HEC Islamabad and authorities of Sindh Agriculture University, Tandojam, Pakistan for providing funds and other necessary facilities.

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(Received 27 March, 2012; Revised 04-12-2012)