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Biology of 11-Spotted Beetle *Coccinella undicimpunctata* L. (Coccinellidae: Coleoptera) on Mustard Aphid *Lipaphis erysimi* Kalt.

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Abstract: A laboratory experiment was conducted to study 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 2nd instar 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 were 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%. Longevity of the male was 36.5±4.17 days and the female longevity of 46.0±9.14 days. It was recorded that longevity period was significantly greater in case of female ladybird beetles as compared to their males. 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. The longevity was comparably higher in case of females than in male beetles.

Key words: Biology, beetle, *Coccinella undecimpunctata*, predators, mustard, *Lipaphis erysimi*

INTRODUCTION

Pakistan has basically an agricultural based economy and agriculture and insect pests have always parallel position. Insect pests have always been a threat to agricultural productivity in Pakistan, Thus for controlling these harmful insects, different chemicals (pesticides) are applied against different insect pests. The farmers spray toxic chemicals (pesticides) on cotton, vegetables, oilseeds and fruit crops in order to avoid the pest infestation. Due to the intensive and indiscriminate use of many pesticides' poison, people suffer from many diseases and some of these are chronic for human beings (Solangi, 2004).

Biological control is a component of an integrated pest management strategy. It is defined as the reduction of pest population by natural enemies. Virtually, all insect populations are affected to greater or lesser extent by natural enemies. Natural enemies means 'balance of nature' and natural regulation. Natural enemies are the primary regulating force in the dynamics of their populations. Thus, It is very important to know what natural enemies are affecting an insect pest population and to obtain an estimate of their impact. Such information may be the basis for explaining pest population density and predicting outbreaks (Shepard, 1999).

The development of the predator population depends on availability of the prey. A number of beneficial insects are found in fields, where there food habits are different. A high reproductive rate is important so that populations of the natural enemy can rapidly increase when hosts are available (Pearson, 2004). The lady beetles,* often called lady bugs or lady bird beetles, live in a variety of habitats. The adults are minute to medium-size beetles, from 0.8 to 10 mm, or 1/32 to 3/8 inch, long. The typical body shape is oval with the dorsal surface convex and the ventral portion almost completely flat.

Both the adult beetle and larvae feed upon aphid, scale insects and mealybugs that are serious pests of fruit trees, vegetables and flowers. Several species of lady beetles are collected and sold to growers for control of insect pests (Nielsen, 1997).

Beetles belong to different orders and species; but in the Coccinella (Coleoptera: Coccinellidae), commonly five

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lady bird beetles are found such as; nine spotted lady beetle, *Coccinella novemnotata* Herbst., eleven spotted lady beetle, *Coccinella undecimpunctata* L., transverse lady beetle, *Coccinella transversoguttata* richardsoni Brown., three banded lady beetle *Coccinella trifasciata* perplexa Mulsant and Coccinella hieroglyphica kirbyi Crotch (Nielsen, 1997; Marshall, 2005).

Since, aphids are serious pests of a number of crop plants and their control through natural enemies has effectively been experienced by known predators including 11-spotted beetle, *Coccinella undecimpunctata* and the adults and larvae of the two-spotted ladybird *Adalia bipunctata* (L.) and the eleven-spotted ladybird *Coccinella undecimpunctata* L. (Zondag, 2001). The present research work was carried to study the biology of 11-spotted beetle *Coccinella undecimpunctata* L. on mustard aphid under laboratory conditions at Tandojam.

MATERIALS AND METHODS

The present experiment was conducted to study the biology of 11-spotted beetle *Coccinella undecimpunctata* L. on mustard aphid under laboratory conditions at the Department of Entomology, Sindh Agriculture University, Tandojam during the 2006. The following aspects related to biology of the predator following procedure was adopted. To obtain eggs, the beetle's collected from mustard fields were confined in cubicular wooden cages (25×10×15 cm^3) in the laboratory. The top and other sides were secured by wire gauze, the front had an operator/observe hole guarded by muslin cloth sleeve to provide food and collection of eggs aphid infested leaves were kept in cage to serve as food for the predator. The fresh young leaves mustard were provided daily as oviposition substrate. The eggs deposited by the females were removed and kept in the paired petridishes (15 cm dia) having a circular paper spread over the bottom for studying incubation period. Observations on hatching of eggs were recorded twice daily. The larvae obtained were used to determine larval stage.

The rearing of larvae was carried out individually on mustard aphids in petridishes. The observations pertaining to obvious morphological changes and moulting were recorded. The pupal periods were determined following the techniques used to determine incubation period of eggs. Newly emerged adults were released in petridishes in pairs to record the observation on behaviour, duration of pre-copulation, copulation, pre-ovipsition, oviposition and post-oviposition periods. Fecundity, fertility, the longevity of male and female adults and sex ratio and percent emergence were also recorded.

RESULTS

Pre-and post oviposition period: The oviposition process of 11-spotted beetle started when the insects initiated mating practice and the copulation time is the duration of a single mating practice. Post copulation duration is a period lagging between one mating to next. The oviposition period is the total laying days of the beetle and post oviposition is the period when beetle becomes infertile and duration from infertile state to death is considered as post oviposition days.

The results indicated that pre-copulation period was 4.1±1.28 days on average in the range of 2-6 days for 10 beetle pairs. The copulation period recorded on 10 beetle pairs was 41.5±10.95 min, in the minimum to maximum range of 27-65 min, while the post copulation period recorded in the present study on 10 beetle pairs was 3.6±1.26 days within the range of 2-6 days (Table 1).

While studying the oviposition days, it was observed that the 11-spotted ladybird beetles (10 pairs) had average oviposition period of 37.7±6.88 days ranging from 28 to 50 days, while the post oviposition period of the beetles on average was 4.0±1.63 days with minimum and maximum limits of 2 and 6 days, respectively (Table 1).

Fecundity and fertility: Fecundity is the total number of eggs laid by a 11-spotted ladybird beetle female during its

Table 1: Oviposition and post oviposition period of 11-spotted beetle *Coccinella undicimpunctata* L. (Coccinellidae:Coleoptera) on mustard aphid *Lipaphis erysimi* kalt

Replication No	Pre-copulation (days)	Copulation (min)	Postcopulation (days)	Ovipsoition (days)	Postoviposition (days)
1	5	43	4	45	4
2	6	40	3	40	2
3	3	27	2	50	5
4	4	35	5	31	3
5	5	45	2	40	2
6	2	30	4	30	5
7	3	65	3	38	6
8	5	50	6	28	2
9	3	35	4	40	6
10	5	45	3	35	5
X±SD	4.1±1.28	41.5±10.95	3.6±1.26	37.7±6.88	4.0±1.63

whole life span, while the fertility is based on the number of hatchable eggs emerge into larval stage. The results indicated that the average fecundity was 593.4±86.5 eggs. The highest fecundity (740 eggs) was recorded by beetle pair No. 2, while beetles in pair Nos. 9, 3 and 8 had fecundity of 700, 630 and 620 eggs, respectively. The fecundity of 10 beetle pairs was in the range of 480 to 740 eggs (Table 2).

The results further showed that mean number of fertile eggs of 10 11-spotted beetle pairs was 531.80±76.16 with the fertility percentage of 89.63±3.44%. The number of fertile eggs was in the minimum and maximum range of 402 and 660 eggs, while fertility was in the range of 83.75 to 96.29% (Table 2).

Development period: The observation on the development period of 11-spotted beetle was recorded from the egg incubation upto adult stage, i.e. period of egg incubation, first instar larvae, 2nd instar larvae, third instar larvae and 4th instar larvae were recorded. The pupal period was calculated when the insects passed larval stages and from start of pupal period upto the start of adult stage, the in-between period was considered as the pupal period. The results indicated that the mean incubation period of the ten 11-spotted ladybird beetles in the laboratory was 3.7±0.94 days within the range of 2-5 days, while 1st and 2nd instar larvae period was 3.1±1.19 and 3.1±0.87 days within the range of 2-5 and 2-4 days, respectively.

The development period for 3rd instar larvae and 4th instar larvae was averagely 3.5±1.26 and 3.3±0.94 days within the range of 2-6 and 2-5 days, respectively. Thus, the total larval period was 12.9±1.28 days within the range of 1-14 days. The pupal period recorded in this study was averaged 5.6±0.96 days within the range of 4 to 6 days (Table 3).

Adult emergence, sex ratio mortality: Out of total pupae observed, number of adults emerged were counted and percentage was worked out, while the sex ratio was obtained by counting the total number of adults emerged from pupae and male and female beetles were separated and ratio of male over female was worked out. Whereas, the mortality was recorded from the total number of pupae managed for adult emergence, the adults emerged were recorded and remaining were considered dead and on that basis mortality percentage was observed. The results (Table 4) indicated that out of 10 ladybird beetle pairs, the average pupae observed were 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 results further indicated that the sex ratio (male: female) was averaged 1: 1.25±1: 0.45. Thus the total male+female emergence was 81.99±13.37 per beetle pair. The mortality recorded 3.7±3.43 beetles for each pair showing an average mortality of 17.57±14.51% (Table 4).

Longevity: The longevity indicated the total life span of an insect. The life span both of the male and female 11-spotted ladybird beetles was recorded separately and average longevity was worked out. The mean longevity of the male ladybird beetles was 36.5±4.47 days against the female longevity of 46.0±9.14 days. It was recorded that longevity period was significantly greater in case of female ladybird beetles as compared to male beetles (Table 5).

Table 2: Fecundity and fertility of eggs of 11-spotted beetle *Coccinella undicimpunctata* L. reared on mustard aphid *Lipaphis erysimi* kalt under laboratory

Replication No.	Fecundity/ female (eggs)	Fertility	Fertility (%)
1	610	530	86.88
2	740	660	89.19
3	630	570	90.48
4	520	480	92.31
5	610	540	88.52
6	512	460	89.44
7	480	402	83.75
8	620	571	92.10
9	700	612	87.43
10	512	493	96.29
X±SD	593.4±86.5	531.80±76.16	89.63±3.44

Table 3: Development period of various larval instars of 11-spotted beetle *Coccinella undicimpunctata* L. reared on mustard aphid *Lipaphis erysimi* kalt under laboratory

Replication No	Egg incubation period (day)	1st instar (days)	2nd instar (days)	3rd instar (days)	4th instar (days)	Total larval period	Pupal period
1	3	4	3	3	4	14	5
2	5	5	4	2	3	14	4
3	4	3	4	5	2	13	6
4	4	2	3	3	4	12	5
5	3	2	4	3	5	14	6
6	4	5	2	4	3	14	6
7	5	2	3	2	3	10	5
8	3	3	2	6	2	13	5
9	2	3	4	3	3	13	7
10	4	2	2	4	4	12	7
X±S.D	3.7±0.94	3.1±1.19	3.1±0.87	3.5±1.26	3.3±0.94	12.9±1.28	5.6±0.96

Table 4: Adult emergence and sex ratio of male and female of 11 spotted beetle *Coccinella undicimpunctata* L. (coccinellidae coleopleria) mustard aphid *Lipahis erysimi* kalt

		Male		Female					
Rep No.	No of. pupa observed	Emerged	%	Emerged	%	Sex ratio male and female	Total male and female emerged (%)	Mortality male + female	Mortality (%)
1	30	9	30.0	11	36.66	1:1.2	66.66	10	33.33
2	18	11	61.11	07	38.88	1:0.6	100.00	0	0.00
3	14	08	57.14	04	28.57	1:0.5	85.71	02	14.28
4	22	08	36.36	11	50.00	1:1.3	86.36	03	13.31
5	31	09	29.03	16	51.61	1:1.7	80.64	06	19.35
6	15	05	33.33	08	53.33	1:1.6	86.66	02	13.33
7	20	07	35.00	09	45.00	1:1.2	80.00	05	25.00
8	10	04	40.00	05	50.00	1:1.2	90.00	01	10.00
9	17	03	17.64	06	35.29	1:2.0	52.93	08	47.05
10	22	10	45.45	12	45.54	1:1.2	90.99	0	0.00
X±SD	19.9±6.69	7.4±2.63	38.50±13.12	8.9±3.66	43.48±8.24	1:1.25±1:0.45	81.99±13.37	3.7±3.43	17.57±14.51

Table 5: Longevity (day's) in male and female of 11 spotted beetle *Coccinella undicimpunctata* L. (*Coccinellidae coleopleria*) mustard aphid *Lipaphis erysimi* kalt. Under laboratory condition

	Longevity (days)	
Replication No.	Male	Female
1	38	48
2	40	60
3	36	38
4	31	58
5	39	50
6	40	45
7	41	45
8	30	32
9	30	35
10	40	49
X±SD	36.5±4.47	46.0±9.14

DISCUSSION

The present experiment was conducted to study the biology of 11-spotted beetle *Coccinella undecimpunctata* L. on mustard aphid under laboratory conditions during the year 2005.

It was observed from the results 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. Similar was the situation for fecundity and fertility and within ladybird beetle pairs deviation was considerable. The incubation period, 1st, 2nd, 3rd and 4th instar durations were relatively similar, while duration was greater for the pupal stage. Adult emergence was greater in female 11-spotted ladybird beetles as compared to male beetles and thus the sex ratio was higher in females as compared to males. The longevity was comparably higher in case of female ladybird beetles than male beetles.

Eraky and Nasser (1995) reported egg production per female averaged 142.33, incubation period of eggs lasted 2-9 days, 4 larval instars and the larval stage was completed in 7, 7.5, 12, 16 and 23 days, pupal development period averaged 2.5 days, at 30°C and 7.5 days at 14°C and the complete life cycle from egg to adult averaged 12, 14, 21, 27.5 and 38.5 days at 30, 26, 22, 18 and 14°C, respectively. Agarwala and Dixon (1996) concluded that both egg and larval cannibalism was inversely related to the abundance of aphid and eggs were a better food, in terms of larval growth and survival, than aphid. Jackson *et al.* (1997) found that percentage of hatch and time to 50% hatch were optimized with 1-day-old eggs incubated at 15°C for 3 weeks.

The results of the study are partially supported by those of Agarwala *et al.* (2003), who discussed oviposition responses of *Coccinella undecimpunctata* L. females were exposed to larvae or adults of *Scymnus pyrocheilus* and reported that ratio of eggs laid to numbers of aphids consumed by *Coccinella undecimpunctata* L females was also affected by the presence of conspecific or *C. transversalis* larvae and fecundity of this predator may be affected by both conspecific and heterospecific competitors in a patchy resource. In another study, Omkar and Srivastava (2003) studied the reproduction of *Coccinella undecimpunctata* L. and observed that pre-adult development was shortest (13.93±0.12 days) when fed on *L. erysimi* and longest (22.85±0.10 days) on *A. nerii* and adult emergence, growth index, relative growth rate, development rate, male and female longevity, oviposition period, fecundity and hatching percent were maximal, i.e., 73.47±0.89%, 90.07±1.43%, 8.62±0.23, 1.52±0.02, 0.07, 81.10±1.26 days, 85.70±1.45 days, 69.80±1.32 days, 1764.10±8.46 and 87.88±1.05, respectively when *C. septempunctata* were fed on *L. erysimi*. Moreover, Ozder and Saglam (2003) determined the developmental time and mortality rate of *Coccinella undecimpunctata* L. and reported that the development time (±SE) varied from 16.7±0.76 to 20.7±1.03 days and the mortality (50%) was highest on *H. pruni* and it was more active and effective in feeding on aphids than other predators. In another relevant study, Xia *et al.* (2003) examined the larval and adult stages of *Coccinella undecimpunctata* L.s and reported that the biology of the predator changed with increase of decrease in the

temperature. Marshall (2005) mentioned that its abundance is largely determined by climate and weather: it prefers warm, moist places; populations decline seriously after hard winters.

CONCLUSIONS

- 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.
- Similar was the situation for fecundity and fertility and within ladybird beetle pairs deviation was considerable.
- The incubation period, 1st, 2nd, 3rd and 4th instar durations were relatively similar, while duration was greater for the pupal stage.
- Adult emergence was greater in female 11-spotted ladybird beetles as compared to male beetles and thus the sex ratio was higher in females as compared to males.
- The longevity was comparably higher in case of female ladybird beetles than male beetles.

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