

NUMERICAL RESPONSE OF *LIPOLEXIS OREGMAE* (HYMENOPTERA : APHIDIINAE) AGAINST *APHIS CRACCIVORA* (HEMIPTERA : APHIDIDAE)

Nishat Parween
Md. Eqbal Ahmad

Aphid Systematics and Bio-control Laboratory,
University Department of Zoology
T.M. Bhagalpur University, Bhagalpur, Bihar (INDIA)

Abstract

The performance of the parasitoids is usually evaluated by studying its life-table which involves the statistics of birth and death rate illustrating the condition of the biological community. The study of numerical response provides the data for the calculating the number of parasitoid needed to regulate the pest population. Thus, parasitoid density also influences the life-table statistics of the parasitoids especially net fecundity, total fecundity, progeny sex ratio etc. *Lipolexis oregmae* is very common parasitoid and found abundantly in several districts of Bihar (India). Few aspects of biological and ecological studies were made by few workers. We need more information about it especially in a relation to the future production. *Aphis craccivora* (cowpea aphids) is a sporadic pest in Bihar and abundantly found in all localities. This aphid has an extensive host range, hence the performance of the parasitoids at different density on three host plants *Lablab purpureus* (= *Dolichos lablab*), *Phaseolus sinensis* and *Vicia faba* on *A. craccivora* was investigated. At six parasitoid, the maximum fecundity of *L. oregmae* was recorded on *V. faba* (64.20 ± 6.85) and minimum on *P. sinensis* (53.20 ± 4.65).

Keywords : Numerical response, *Lipolexis oregmae* , *Aphis craccivora* and life - table statistics

Introduction

Aphids are an important group of plant insect pests. They have a high biological potential with some of aphids species (Aphididae) having more than ten generations in one year. Because of their direct sucking and due to

infestation of almost all parts of plant surfaces, they are of great agricultural significance and now a day aphids are considered as serious pest of agriculture and horticulture plants. There are several abiotic as well as biotic factors that have been observed which limits pest population in nature. Natural enemies are among them. A parasitoid is an organism that spends a significant portion of its life attached to or within a single host organism which it ultimately kills (and often consumes) in the process. Thus, they are similar to typical parasites except in the certain fate of the host. In a typical parasitic relationship, the parasite and host live side by side without lethal damage to the host. Typically, the parasite takes enough nutrients to thrive without preventing the host from reproducing. In a parasitoid relationship, the host is killed, normally before it can produce offspring. Parasitoids are often closely coevolved with their hosts.

Chemical stimuli are the most important elements on the process of locating the host, which involve finding its habitat, recognizing and attacking the host. Aphids respond to volatile compounds, produced by the plants from which they get food (Powell & Zhi- Li, 1983). That may be the most common means of locating aphids through their parasitoids (Bundenberg, 1990). There is evidence that natural enemies may keep aphid populations at low levels, preventing economical damages on cereal cultures (Giller et al., 1995). The microhymenopteran parasitoids play an important role in this process.

Lipolexis oregmae Gahan is very common parasitoid, it was abundantly found in the target area (Ahmad & Parween, 2009). Different aspects of biology and ecological studies were made by several workers in India and abroad. Biology, seasonal history, diapause, emergence, effect of food plants (Shuja-Uddin 1977; Rao et al.1969; Parween & Ahmad, 2015). Rate of development, longevity of adults, food of adults, reproductive capacity, host instar preference, laboratory host range, distribution in habitats, abundance, hyperparasitoids (Dharmadhikari & Ramaseshiah 1970). Pandey & Singh (2005) studied the reproductive behaviour and sex ratio on *Aphis gossypii* Glover. It parasitised 9 species of aphid species in India viz., *Aphis citricola*, *Aphis craccivora*, *Aphis fabae*, *Aphis gossypii*, *Aphis nerii*, *Aphis ruborum longisetosus*, *Aphis solanella*, *Toxoptera aurantii*, *Toxoptera odinae* (Stary & Ghosh 1983, Ahmad & Singh 1996).

In a population, the number of host parasitized per unit time depends upon the number of parasitoids present and parasitized at variable number of hosts. Thus in any target area, ratio of parasitoid to host greatly affect parasitoid population dynamics (Hassell & Waage, 1984) particularly when the hosts are patchily distributed like aphids (Tripathi & Singh, 1991). It is one of the two essential ingredients in modeling an host-parasitoid

interaction. This response is usually of more interest than functional response (Singh, 1994) because it is more often responsible for the suppressing the population (Hassell, 1978). Thus, the study of numerical response provides the data for calculating the number of parasitoids needed to regulate the pest population. The parasitoids density also influences the life table statistics of the parasitoids especially net fecundity, total fecundity, progeny sex ratio etc. Hence, in the present study, the numerical response of *L. oregmae* against *A. craccivora* on different host plants was investigated for possible use in the biological control.

Materials & Methods

a. Rearing of the aphids

The aphid hosts for the parasitoid *L. oregmae* were cultured in the laboratory. For this the host aphids (*Aphis craccivora* Koch) were reared in the fields as well as in the laboratory on the seedlings of different food plants, viz., *Lablab purpureus*, *Phaseolus sinensis*, *Vicia faba*. Each food plant was covered with 80 cm tall, rectangular iron-frame cages fitted with fine mesh nylon netting around it while in the laboratory they were reared in large insectaries. Alate forms of the aphids collected from the fields were placed on the seedlings of the food plants, with at least 4-6 leaves.

b. Rearing of the parasitoids

The culture of *L. oregmae* was established on the aphid on different food plants viz. *L. purpureus*, *P. sinensis*, *V. faba* inside the laboratory. To maintain the culture of the parasitoid, the host aphids were reared on respective food plants grown in clay/plastic pots. When the aphid population had risen to a high level, field collected female parasitoids after feeding with honey and honeydew mixture were kept with field collected male parasitoids for copulation. Thereafter, they were introduced into the above mentioned cages. The parasitoid-host ratio was kept about 1 : 100. Several drops of the mixture of honey, honeydew and water (30 : 30 : 40) were put on the nylon mesh of the cages which serve as food for the females. The cages were sprayed with water from an atomizer at least once a day to maintain proper humidity. The females were removed from the cages after 24 hours to avoid superparasitism. The parasitised aphids mummified after a week, thereafter, they were collected selectively. After eclosion, the parasitoids were transferred into other vials. The culture was maintained at room temperature ranging from 20-25 °C with 60-80% relative humidity.

C. Calculation of life- table statistics

The age-specific survival and net fecundity rates is called as “intrinsic rate of increase (r_0)”. The calculation of growth rate under natural condition

is known as “intrinsic rate of natural increase (r_m)”. The values of r_m under optimum conditions indicates the maximum biological potential of the population and growth in that situation. Age-specific survival rate, l_x (l_x = proportion of surviving females of the cohort) and net fecundity rate, m_x (m_x = number of female progeny per female of age X) were calculated for the adult female parasitoids using data obtained from the experiments. The survival of the female and the daily production of female progeny observed during each day were recorded. The probability of surviving from birth to age X (l_x) and the mean number of female progeny produced were calculated. A close approximation of the intrinsic rate of natural increase (r_m) was made following Andrewartha and Birch (1954) using trial and error substitute of r_m in the Lotka- Euler equation:

$$\sum l_x m_x \exp(-r_m X) = 1$$

Where X is the pivotal age, l_x is age-specific survival rate, m_x is net fecundity rate. The net productivity rate (R_0) was calculated by the equation: $R_0 = \sum l_x m_x$. The number of eclosed adults was considered as an index of total fecundity of *L. oregrmae*. The total fecundity (R_t) was calculated as: $R_t = \sum l_x t_x$. The generation time (GT) which is equivalent to the mean period of elapsing between the birth of the parents and the birth of the offspring $GT = \ln R_0 / r_m$ and doubling time ($DT = \ln 2 / r_m$), defined as the time required to double the population size, and the finite rate of natural increase (λ_m) were calculated by the formulae: $\lambda_m = \exp(r_m)$.

Results & Discussion

a. Total fecundity

Total fecundity of a parasitoid was observed maximum (47.20 ± 6.97) and lowest (25.20 ± 3.84). Similar result was also observed at varying parasitoid density (Table -1). At six parasitoids, the maximum fecundity was recorded on *V. faba* (64.20 ± 6.85) and lowest on *P. sinensis* (53.20 ± 4.65). The analysis of variance test (ANOVA) of data reveals that there is significant difference between host plants ($F = 8.139$, $P < 0.05$) and varying parasitoid density ($F = 11.922$, $P < 0.05$). The relation between fecundity and parasitoid density was observed linear on each host plants (Fig – 1)

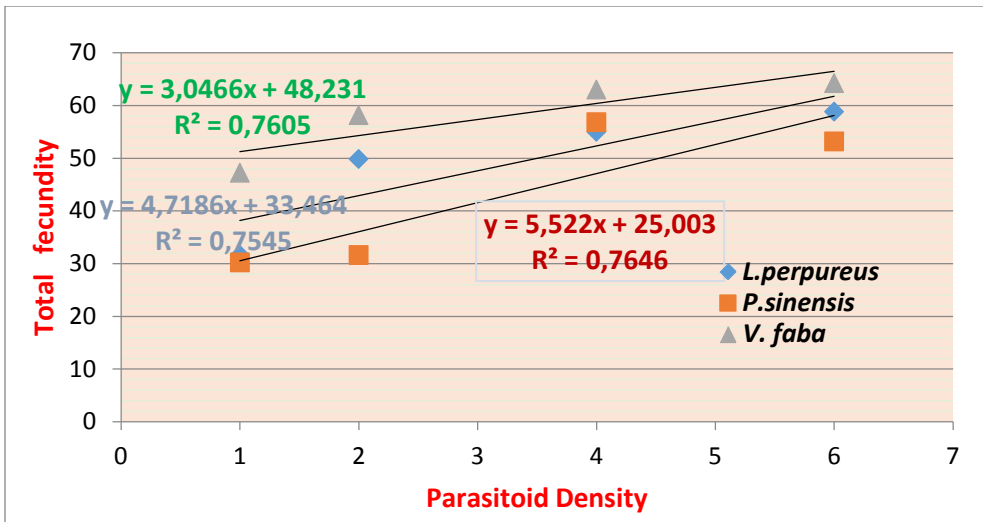


Fig -1: Relationship between parasitoid density and the total fecundity of *L. oregmae* against *A. craccivora* at different host plants

b. Net fecundity

The net fecundity was recorded maximum (32.00 ± 5.07) on *V. faba* and lowest on *P. sinensis* (21.40 ± 3.44) using one parasitoid (Table-1. Similarly at six parasitoids, the maximum fecundity was recorded (43.20 ± 6.85) on *V. faba* lowest on *P. sinensis* (36.20 ± 5.76). The analysis of variance test revealed that there was a significant variation between host plants ($F = 5.1925, P < 0.05$) and parasitoid density ($F = 6.8918, P < 0.05$). The relation between fecundity and parasitoid density was observed linear (Fig – 2).

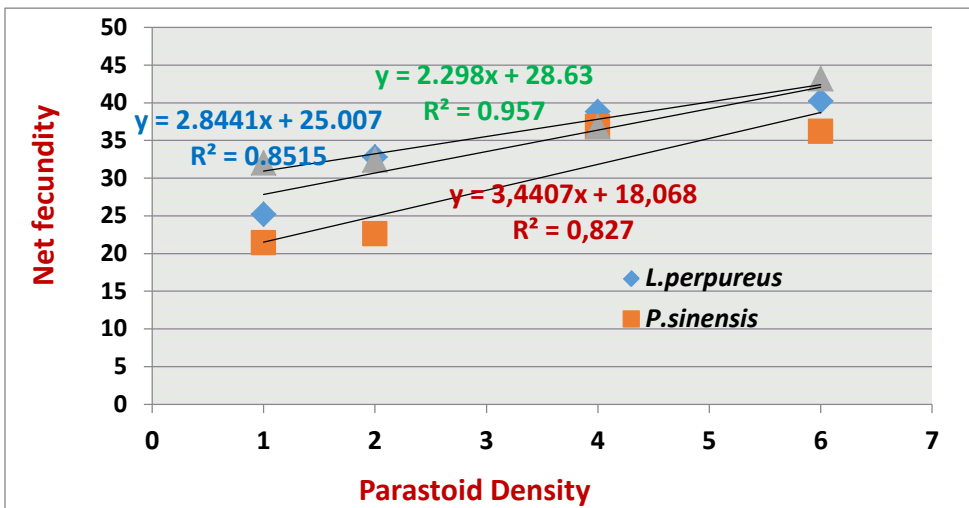


Fig – 2: Relationship between parasitoid density and net fecundity of *L. oregmae* against *A. craccivora* at different host plants

c. Progeny sex ratio

In the present study, the effect of parasitoid density was also observed on three host plants. The progeny sex ratio of *L. oregmae* was also observed to be parasitoid density dependent. The maximum value of progeny sex ratio was recorded at four parasitoids (0.3820 ± 0.1295). The analysis of variance test indicated that there was no significant variation between food plants and between parasitoid density in relation to progeny sex ratio (Fig-3).

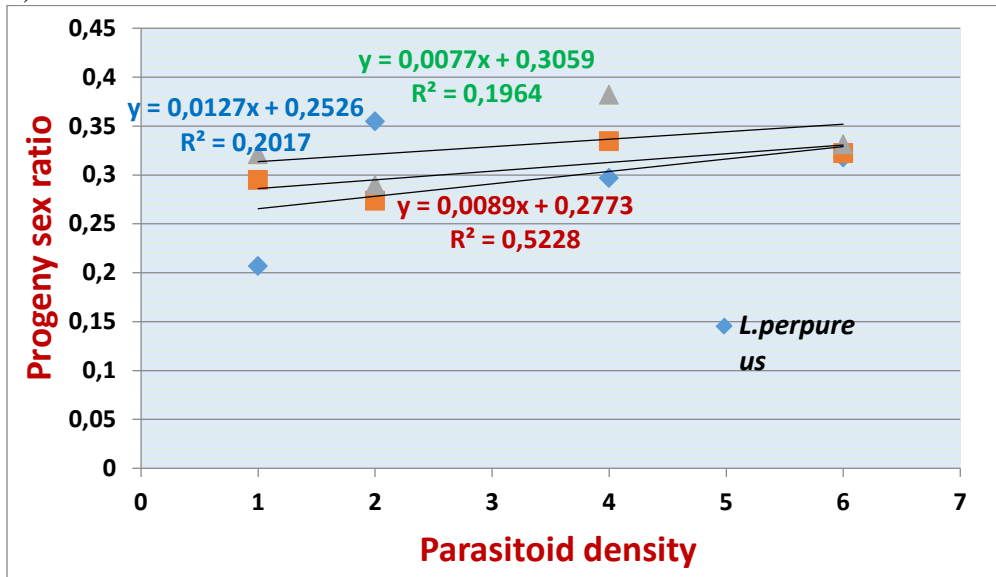


Fig-3 : Relationship between parasitoid density and progeny sex ratio of *L. oregmae* against *A. craccivora* at different host plants

In the field, higher population densities of more than one female per host patch was seldom observed, employing thereby that the females have tendency to disperse to minimize the probability of encounter with each other. (Sinha & Singh, 1979; Campos & Gonzalez, 1991). Therefore, in *L. oregmae* the higher offspring sex ratio in response to more parental females appears to be a result of maternal manipulation of offspring sex ratio as observed for other parasitoids (King & Skinner, 1991; Singh & Srivastava, 1993). The production of high proportion of sons with increasing the population of ovipositing females is generally explained by Hamiltonian local mate competition theory (Hamilton, 1967, 1979). Reinert & King (1971), Orzack & Parker (1986), Legner & Warkentin (1988) observed less effect of the higher female parasitoid density on the offspring sex ratio. The result discussed so far revealed that the presence of more females during oviposition inhibited the fertilization of eggs in *L. oregmae*, but how it is operated is not known. Following are some explanation : (i) presence of more females increases the rate of superparasitism. Females deposit more

haploid eggs in parasitised host (Holmes, 1972; Wylie, 1973) or an unsuitable hosts (Wylie, 1966, 1973; Legner, 1967; Sinha & Singh, 1979; Bhatt & Singh, 1991). However, the female aphidiids have host discrimination capacity, that is, they recognize parasitised host among healthy ones and are always reluctant to oviposit in parasitised hosts (Singh & Sinha, 1981, 1982; Mackauer, 1990) (ii) ovipositing females respond to the presence of other females changing their sequence of sex allocation (Waage, 1986). The results presented herein strengthen the theory of local mate competition in concept but deviate in numerical values. It also shows that for maximising female progeny in the population for mass culture, individual mated females should be released in the closed environment.

Table-1 : Different parameters of Life-table statistics of *L. oregonae* on different host plants and parasitoid

One parasitoid			
Host plants	<i>Lablab purpureus</i>	<i>Vicia faba</i>	<i>Phaseolus sinensis</i>
<i>r_m</i>	0.2147	0.2231	0.2036
<i>R₀</i>	32.00	32.00	21.40
<i>R_t</i>	25.20	47.20	30.20
<i>DT</i>	3.23	3.11	3.41
<i>GT</i>	15.03	15.53	15.05
<i>PSR</i>	0.2068±0.058	0.321±0.0394	0.2948±0.0286
Two parasitoids			
<i>r_m</i>	0.2070	0.2258	0.2111
<i>R₀</i>	32.80	41.40	22.60
<i>R_t</i>	49.80	58.13	31.60
<i>DT</i>	3.35	3.07	3.28
<i>GT</i>	16.86	16.49	14.77
<i>PSR</i>	0.3546±0.0178	0.2894±0.0373	0.2736±0.0348
Four parasitoids			
<i>r_m</i>	0.2219	0.2170	0.2338
<i>R₀</i>	38.80	36.80	36.80
<i>R_t</i>	55.00	63.00	56.80
<i>DT</i>	3.12	3.19	2.97
<i>GT</i>	16.49	16.62	15.42
<i>PSR</i>	0.2968±0.0457	0.3820±0.1295	0.3344±0.0143
Six parasitoids			
<i>r_m</i>	0.2252	0.2264	0.2364
<i>R₀</i>	40.20	43.20	36.20
<i>R_t</i>	58.80	64.20	53.20
<i>DT</i>	3.08	3.06	2.93
<i>GT</i>	16.40	16.63	15.18
<i>PSR</i>	0.3177±0.0210	0.3312±0.0433	0.3222±0.0571

Abbreviation

r_m - Intrinsic rate of natural increase
R₀ - Total fecundity
GT- Generation time

R₀ - Net reproductive rate
DT- Doubling time
PSR- Progeny Sex ratio

Acknowledgement

The authors are grateful to the Head, P. G. Dept. of Zoology, T. M. Bhagalpur University, Bhagalpur for providing facilities. We are also thankful to Department of Science and Technology (DST) New Delhi for providing financial assistance.

References:

- Ahmad, M. E. & Singh, R. (1996). Records of aphids, parasitoids from the north Bihar and associations with their hosts and food plants. *J. Adv. Zool.*, **17** : 26 - 33.
- Ahmad, M.E. and Parween, N. (2009) New records of aphids and their parasitoids and hyperparasitoids from from northeast Bihar. *Journal of Adv. Zool.* 30(1): 7-9.
- Andrewartha, H.G. & Birch, L.C. (1954). The Distribution and Abundance of Animals. Univ. Chicago Press, pp. 782, Chicago and London.
- Bhatt, N. & Singh, R. (1991). Bionomics of an aphidiid parasitoid *Trioxys indicus* Subba Rao and Sharma 33. Impact of food plants on the behaviour and sex allocation by the female parasitoid at her varying densities. *Biol. Agric. & Hort.* **7**: 247-259.
- Budenberg, W.J. (1990). Honeydew as a contact kairomone for aphid parasitoids. *Ent. Exp. Appl.* **55**: 139-149.
- Campos, M. & Gonzalez, R. (1991). Effect of parent density on fecundity of the parasitoids (Hymenoptera : Pteromalidae) of the olive beetle *Phloeotribus scarabaeoides* (Col. : Scolytidae). *Entomophaga*, **36** : 473-480.
- Dharamadhikari, P.R. & Ramaseshiah, G. (1970) : Recent records of Aphidiids. (Hym.: Aphidiidae) in India. *Tech. Bull. Commow. Inst. Biol. Control* **13** : 83-89.
- Giller, P.S., Ryan, B., Kennedy, T. & Connery, J. (1995) : Aphid-parasitoid interactions in a winter cereal crop; field trials involving insecticides application. *J. Applied Entomology*, **119**: 233-239.
- Hamilton, W. D. (1967). Extra-ordinary sex ratios. *Science* **156**: 477-488.
- Hamilton, W. D. (1979). Wingless and fighting males in fig wasps and other insects, In : *Reproductive competition and sexual selection in Insect* (eds. M. S. Blum and N. A. Blum), Academic Press, New York, U.S.A. pp. 167-220.
- Hassell, M. P. (1978). *The Dynamics of Arthropod Predator-Prey Systems*. Princeton University Press, Princeton.
- Hassell, M. P. & Waage, J. K. (1984). Host parasitoid population interactions. *Ann. Rev. Entomol.*, **29** : 89 - 114.

- Holmes, H.B.(1972). Genitic evidence for fewer progeny and a higher percent males when *Nasonia vilripennis* oviposits in previously parasitized host. *Entomophaga* **17**, 79-88.
- King, B.H. & Skinner, S.W. (1991). Sex ratio in a new species of *Nasonia* with fully winged males. *Evolution*, **45** : 225-228.\
- Legner, E. F. (1967). Behaviour changes the reproduction of *Spalangia cameroni*, *Spalangia endius*, *Muscidifurax raptor* and *Nasonia vitripennis* (Hymenoptera : Pteromalidae) at increasing fly host densities. *Ann. Ent. Soc. Amer.*, **60** : 819 – 824.
- Legner, E. F. & Warkentin, R.W.(1988). Parasitisation of *Goniozs legneri* (Hymenoptera : Bethylidae) at increasing parasite and host, *Amyelois transitella* (Lepidoptera : Phycitidae) densities. *Ann.Ent. Soc.Amer.*, **60** : 819-824.
- Mackauer, M. (1990). Host discrimination and larval competition in Solitary endoparasitoids, **In** : *Critical Issues in Biological Control* (eds. Mackauer, M., Ehler, L. E. and Roland, J.) Intercept, Andover, Hants. PP. 41-62.
- Orzack, S. H. & Parker, E.D. Jr. (1986). Sex ratio control in a parasitic wasp *Nosonia vitripennis*. I. Genetic variation in a facultative sex ratio adjustment. *Evolution*, **40** : 331-340.
- Pandey, S. & Singh, R. (2005). The reproductive behaviour of *Lipolexis scutellaris* Mack. (Hym : Braconidae). a parasitoid *Aphis gossypii* Glover (Hem : Aphididae) : adjustment of sex ratio in response to host size. *J. Adv. Zool.*, **26** (1) : 7 - 19 .
- Parween, N. & Ahmad, M.E. (2015). Effect of food plants on the life table statistics of *Lipolexis oregmae* (Hymenoptera: Aphidiidae) against *Aphis craccivora* (Hemiptera: Aphididae). *J. of Advanced Zoology* **Accepted**
- Powell, W. & Zhi-li, Z. (1983). The reactions of two cereal aphid parasitoids, *Aphidius uzbekistanicus* and *A. ervi* to host aphids and their food- plants. *Physiol. Ent.*, **8** : 439- 443.
- Rao, V. P., Dharamadhikari, P. R., Ramaseshiah, G., Phalak, V. R. & Sethumadhavan, T. V. (1969). Study of natural enemies of aphids (for the U.S.A.). *Report Commonw. Inst. Biol. Control for 1968*, 45-47.
- Reinert, J.A. & King, E.W.(1971). Action of *Bracon hebetor* Say as a parasite of *Plodia interpunctella* at controlled densities. *Ann. Ent. Soc. Amer.*, **64** : 1335-1340.
- Shuja-Uddin (1977). Field observations on *Aphidius uzbekistanicus* Luzheteki (Hymenoptera : Aphidiidae) infesting *Triticum aestivum* L. *Indian J. Ent.*, **37** : 191 - 193.

- Singh, R. (1994). Demography of the aphid parasitoid *Trioxys indicus* (Hymenoptera: Aphidiidae) on different host patches. In: *Environment and Applied Biology* (eds. V.P. Agarwal, S.A.H. Abidi, R.K. Sharma & M.D. Zingde), Society of Biosciences, Muzaffarnagar, India, pp. 121-138.
- Sinha, T. B. & Singh, R. (1979). Studies on the bionomics of *Trioxys (Binodoxys) indicus* (Hym. : Aphidiidae) : Effect of population densities on sex ratio *Entomophaga*, **24** : 289-294.
- Singh, R. & Sinha, T. B. (1981). Bionomics of *Trioxys (Binodoxys) indicus*, an aphidiid parasitoid of *Aphis craccivora*. 9. Factors responsible for superparasitism. *Ind. J. Parasitol.*, **5** : 9-15.
- Singh, R. & Sinha, T. B. (1982). Factors responsible for the superparasitic ability of the parasitoid wasp *Trioxys indicus* (Hymenoptera: Aphidiidae). *Ent. Gen.* **7**: 295-300.
- Singh, R. & Srivastava, M. (1993). Factors affecting offspring sex ratio in the Aphidiidae (Hymenoptera), a review. *J. Aphidol.*, **6**.
- Sary, P. & Ghosh, A. K. (1983). Aphis parasitoids of India and Adjacent Countries (Hymenoptera : Aphidiidae.) Tech. Monograph, 7. *Zoological survey of India*, Calcutta, PP. 96 .
- Tripathi, R. N. & Singh, R. (1991). Aspects of life-table studies and functional response of an aphidiid parasitoid *Lysiphlebia mirzai*. *Ent. Exp. Appl.* **59**: 279-287.
- Waage, J. K. (1986). Family planning in parasitoids: Adaptive patterns of progeny and sex allocation, **In** : *Insect parasitoids* (eds. J. K. Waage and D. J. Greathead), Academic Press, London. pp. 63-95.
- Wylie, H. G. (1966). Some effects of female parasite size on reproduction of *Nasonia vitripennis* (Wald.) (Hymenoptera: Pteromalidae). *Can. Ent.* **98**: 196-198.
- Wylie, H. G. (1973). Control of egg fertilization by *Nasonia vitripennis* (Hymenoptera : Pteromalidae) when laying on parasitised house fly pupae. *Can. Ent.*, **105** : 709- 718.