J. Biol. Control, 23(2): 115-120, 2009

Biometrics and reproductive behaviour of *Meteorus spilosomae* Narendran and Rema, an important parasitoid of *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae), a pest of mulberry

B. MARIMADAIAH and M. GEETHA BAI
Karnataka State Sericulture Research and Development Institute, Thalaghattapura 560062, Karnataka, India.
E-mail: insects_geetha@yahoo.co.in

ABSTRACT: The biology and morphometrics of *Meteorus spilosomae* Narendran and Rema (Hymenoptera: Braconidae), a solitary larval endoparasitoid of Bihar hairy caterpillar, *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae) were studied under laboratory conditions. The life cycle comprised of egg, three larval instars, pupa and an adult stage. The average duration of the life cycle was 33.73 days at 19 ± 1°C, 70-75% RH; 23.73 days at 24 ± 1°C, 75-90% RH and 20.21 days at 29 ± 1°C, 70-85% RH. Males are polygamous and females are monandrous. *M. spilosomae* is an arrhenotokous species. The total number of eggs laid ranged from 153 to 270, with an average of 213 ± 53.42. Sex ratio is female-biased, and male to female sex ratio was 1: 1.22 at 19 ± 1°C, 1: 1.24 at 24 ± 1°C and 1: 1.38 at 29 ± 1°C. The average number of female progeny was higher than males from the 1st to 7th day at 29 ± 1°C. On the 8th day, only female progeny emerged. Among the various food evaluated, the average longevity of mated males and females was highest when fed on 50% sucrose (19.6 and 29.7 days, respectively), while with no food the longevity was 1.8 and 2.2 days, respectively.

KEY WORDS: Bihar hairy caterpillar, *Meteorus spilosomae*, mulberry, parasitoid, *Spilosoma obliqua.*

INTRODUCTION

Meteorus spilosomae Narendran and Rema (Hymenoptera: Braconidae) is a parasitoid of *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae) (Narendran and Rema, 1996). Kumar and Yadav (1987) recorded *Meteorus* nr. *arctiicida* Viereck on *S. obliqua* from Bihar. *M. dichomeridis* has been recorded from *S. obliqua* infesting mulberry (Katiyar *et al.,* 1999). *Meteorus* sp. was recorded from *S. obliqua* affecting sunflower crop in Punjab (Singh and Singh, 1995) and on cultivated *Vigna mungo* and wild *Xanthium strumarium* in Jammu and Kashmir (Gupta and Narendran, 2007). *M. spilosomae* causes heavy mortality of *S. obliqua* caterpillars. Average mortality of *S. obliqua* due to *M. spilosomae* ranged from 3.7% to 33.5%. Parasitization of *S. obliqua* by *M. spilosomae* commenced during May-June, after the onset of southwest monsoon. Maximum parasitization occurred during November and minimum during June-July.

During the present investigations, studies on development, mating behaviour, oviposition, sex ratio and longevity were carried out and the results are presented here.

MATERIALS AND METHODS

Laboratory culture of *M. spilosomae*

Colonies of young caterpillars of *S. obliqua* collected from the field were released on potted mulberry plants in the laboratory and were reared up to third instar, till the end of gregarious phase. Later, the caterpillars in each colony were held in polythene bags (25 × 37cm) and fed on mulberry leaves daily. Cocoons formed by parasitoid larvae from infested *S. obliqua* caterpillars were collected and isolated in glass vials (1.5 × 15cm). Adult parasitoids emerged from these cocoons were fed on 50% honey solution and allowed to mate. Mated females were provided with 1 to 2 days old, laboratory reared colony of uninfested *S. obliqua* caterpillars for 24 hours. These parasitised *S. obliqua* caterpillars were reared in the laboratory. Parasitoid larvae emerged from these host caterpillars, spun cocoons and pupated inside them. Wasps emerging from these cocoons were fed on 50% honey solution. Thus, a parasitoid culture was maintained in the laboratory.

Biology of *M. spilosomae*

Studies on the development of *M. spilosomae* were conducted at 19 ± 1°C, 70-75% RH; 24 ±1°C, 75-90% RH and 29 ±1°C, 70-85% RH. The temperature was maintained in the laboratory using an environment test chamber. Mated gravid parasitoids were allowed to oviposit on 1 to 2 days old *S. obliqua* caterpillars for two hours. The parasitised caterpillars were dissected at periodic intervals and were observed. *M. spilosomae* larvae were cleared in Sinton's fluid (Chloral hydrate, 2 parts; phenol, 1 part and lactic acid, 1 part), washed in water, mounted on cavity glass slides and observed under a compound microscope (Geetha Bai, 1980). The egg, larval and pupal duration and adult emergence were noted.

Freshly emerged adults in different ratios, *viz*., 1: 1, 10: 1 and 1: 10 (female: male) were released separately in glass conical flasks and their mating behaviour was observed and recorded. Mated, gravid female parasitoids were provided with 1 to 2 days old *S. obliqua* caterpillars and their oviposition behaviour was studied. Each mated, gravid female parasitoid was provided with 100 host caterpillars daily, from the day of emergence till death and the sex of the emerging parasitoids was noted.

To record parthenogenesis, unmated female *M. spilosomae* were provided with 1 to 2 days old *S. obliqua* caterpillars daily, from the day of emergence till death. The sex of the emerging progeny was recorded. Longevity of ten mated male and female *M. spilosomae* for each food source was studied by providing 50% honey, sucrose, glucose, jaggery solutions, mucilage from hibiscus flowers or water. Another set of ten parasitoids was not provided with any type of food. Their mortality was recorded daily. This study was carried out at 25°C and 70 ± 5% RH.

The experiments to study development, oviposition, sex ratio and parthenogenesis were replicated five times and statistical analysis was carried out using analysis of variance and standard deviation.

RESULTS AND DISCUSSION

The life cycle comprises egg, three larval instars, pre-pupal, pupal and adult stages. The duration of immature stages is furnished in Table 1. The eggs were sausage shaped, caudate and translucent (Fig. 1a) and measured 0.26 to 0.69mm long and 0.08 to 0.40mm broad in the widest region. As development of the embryo proceeded, the eggs became oval in shape. The mean duration of egg stage was 6.02 days at 19 ± 1°C, 4.40 days at 24 ± 1°C and 3.09 days at 29 ± 1°C. The mean duration of egg stage varied significantly with temperature (Table 1). Katiyar *et al.* (1999) have reported the duration of egg stage of *M. dichomeridis* to be 3.37 ± 0.33 days at 24 ± 1°C, 70-75% RH. Gupta and Narendran (2007) reported the duration of egg stage of *Meteorus* sp. to be 4-5 days.

The first instar larvae were translucent, elongate, caudate and slightly curved (Fig. 1b). The body is demarcated into head, thorax with three distinct segments and abdomen with twelve segments and the last abdominal segment is drawn into a tail. The head capsule on the dorsal surface was brown, with a pair of sclerotised and sickle shaped mandibles. First instar larvae measured 1.51 to 5.45mm long and 0.17 to 0.49mm broad in the widest region. The mean duration of first instar larvae was 12.00 days at 19 ± 1°C, 7.79 days at 24 ± 1°C and 7.03 days at 29 ± 1°C. The mean duration of first instar larva varied significantly with temperature. The second instar larvae were elongate, caudate, partially translucent, stout and curved (Fig. 1c). The three segments in the thoracic region and twelve segments in the abdominal region and the last segment in the abdomen drawn into a tail were clearly seen. A pair of sclerotised and triangular mandibles was observed. The second instar larvae measured 4.62 to 6.05mm long and 0.54 to 1.62mm broad in the widest region. The mean duration of second instar larva was 3.48 days at 19 ± 1°C, 2.47 days at 24 ± 1°C and 2.25 days at 29 ± 1°C. The third instar larvae were elongate, caudate, creamish white and curved (Fig. 1d). There were three segments in the thoracic region and twelve segments in the abdominal region and the last segment in the abdomen was drawn into a tail. The third instar larvae measured 7.00 to 8.77mm long and 1.23 to 2.00mm broad in the widest region. Fully grown larva, after shedding its tail, pierces through the host caterpillar and emerges. The larva turns light brown after emergence, secretes a brown filament, and spins a cocoon and pupates inside. The mean duration of the third instar larvae was 2.43 days at 19 ± 1°C, 2.09 days at 24 ± 1°C and 1.54 days at 29 ± 1°C.

The cocoon was elongate and dark brown (Fig. 1e) with both the ends slightly pointed. The cocoon was found attached to the mulberry plant through a thread. Adult parasitoids emerged after cutting a circular lid at one end of the cocoon. The cocoons measured 4.77 to 5.42mm long and 1.85 to 2.15 mm broad in the widest region. Pre-pupae adhered closely to the cocoons and were light brown. Pupae also closely adhered to the cocoons and were yellowish brown. The mean duration of pupal stage was 9.80 days at 19 ± 1°C, 6.98 days at 24 ± 1°C and 6.30 days at 29 ± 1°C. The duration of pupal stage varied significantly with difference in temperature (Table 1). Pupal duration of *M. dichomeridis* was reported to be 6.20 ± 0.40 days at 25 ± 1°C, 70 ± 5% RH (Katiyar *et al.,* 1999). In case of *Meteorus* sp., pupal duration was 6 - 9 days (Gupta and Narendran, 2007). The average duration of life cycle was 33.73 days at 19 ± 1ºC, 23.73 days at 24 ± 1ºC and 20.21 days at 29 ± 1ºC at RH of 70 to 75%, 75 to 90% and 70 to 85%, respectively. The adult parasitoids were yellowish brown. Females (Fig. 1e) had a prominent ovipositor and were slightly larger than the males. Males measured 4.08 to 4.54mm long and 1.00 to

Table 1. Duration of immature stages of *Meteorus spilosomae*

Stage of Development	19 ± 1°C 70 - 75% RH		24 ± 1°C 75-90% RH		29 ± 1°C 70-85%RH		F test for Mean	CD	
	Duration (days)		Duration (days)		Duration (days)				
	Range	Mean	Range	Mean	Range	Mean		5%	1%
Egg	5.98 - 6.06	6.02 ± 0.03	4.04 - 4.75	4.40 ± 0.32	2.85 - 3.17	3.09 ± 0.13	HS	0.092	0.139
Larvae									
I Instar	10 – 13	12.00 ± 1.28	6.89 - 8.25	7.79 ± 0.42	6 – 8	7.03 ± 0.86	HS	0.081	0.123
II Instar	3 – 4	3.48 ± 0.53	2.06 - 2.89	2.47 ± 0.41	1 – 3	2.25 ± 0.57	HS	0.052	0.078
III Instar	2 - 3	2.43 ± 0.40	1.79 - 2.29	2.09 ± 0.18	1 - 3	1.54 ± 0.88	HS	0.019	0.028
Pupa	9 – 11	9.80 ± 0.79	6.50 - 7.25	6.98 ± 0.25	5 - 7	6.30 ± 0.67	HS	0.103	0.155
Total duration		33.73		23.73		20.21			

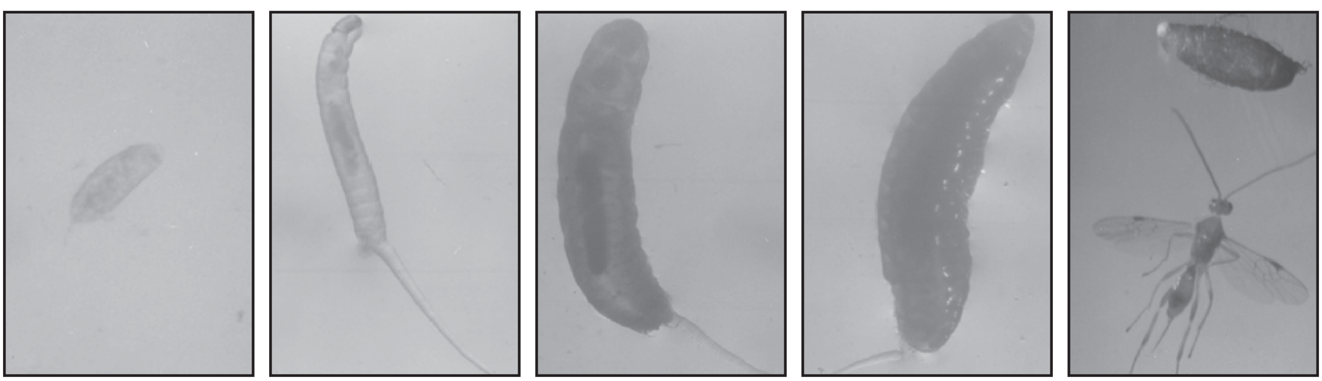

Fig. 1a. Egg   Fig. 1b. 1st instar larva   Fig. 1c. 2nd instar larva   Fig. 1d. 3rd instar larva   Fig. 1e, Female with cocoon

Fig. 1. Development stages of *Meteorus spilosomae*

1.15mm broad, whereas females measured 4.08 to 5.00mm long and 1.05 to 1.31mm broad. The ovipositor measured 1.38 to 1.54mm long with an average of 1.49 ± 0.06mm.

M. spilosomae adults do not mate soon after emergence. The pre-mating period ranged from 3 to 4h with an average of 3.72 ± 0.54h. Katiyar *et al.* (1999) have reported the pre-mating period to be 3.09 ± 0.32h in case of *M. dichomeridis*, a parasitoid of *S. obliqua*. When a male *M. spilosomae* becomes excited, it approaches a female, raises its wings and vibrates and taps the female with its antennae repeatedly and chases the female. If the female is found receptive, it stops moving away, and raises its abdomen and her antennae become erect. Subsequently, the male mounts the female from behind, bends its abdomen below that of female and engages in copulation. At the end of mating, the copulating pairs move in opposite directions still in copula for a few seconds, until separation. Mating lasts for 45 to 60 seconds (mean 53.8 sec). Mating period in case of *M. dichomeridis* was reported to be up to one minute (Katiyar *et al.,* 1999). In case of *T. howardii,* a parasitoid of uzi fly, mating duration has been reported to be 40-50 seconds (Ramkishore *et al*., 1993). The male mates with many virgin females, suggesting it is polygamous. Similar observations were reported in case of *T. howardii* (Ramkishore *et al*., 1993). Virgin female of *M. spilosomae* mated only once, suggesting monandry. Monandry has been reported *Dirhinus pachycerus (=himalayanus)* Masi (Geetha Bai,1990) and *Pachycrepoideus veerannai* Narendran and Anil (Veeranna and Jyothi, 1994). Courtship behavior in insects generally involves a series of actions by the male to which the female may respond with a sequence of actions, which suppress the escape and aggressive reactions and stimulate receptiveness (Atkins, 1980).

The average number of females male mates on the first day was 0.8 and gradually increased to 1.2 on 2nd day and reached the maximum number on 3rd day with an average of

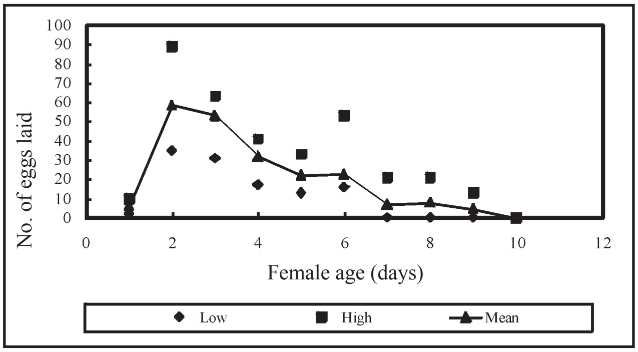

Fig. 2. Oviposition pattern in *M. spilosomae*

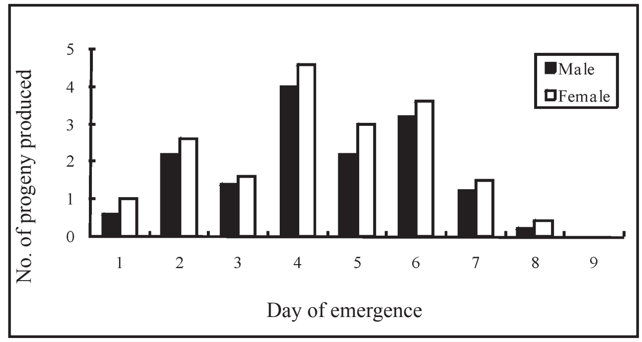

Fig. 3a. Sex-ratio in *M. spilosomae* at 19 ± 1°C

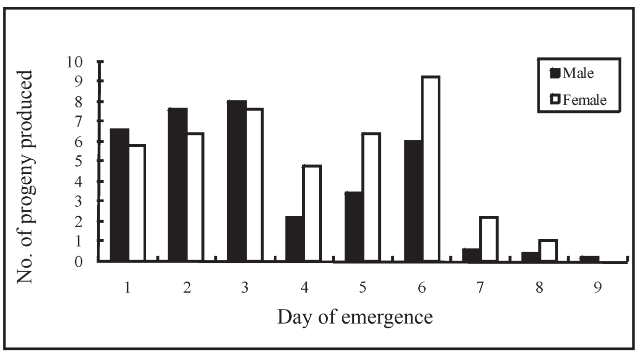

Fig. 3b. Sex ratio in *M. spilosomae* at 24 ± 1°C

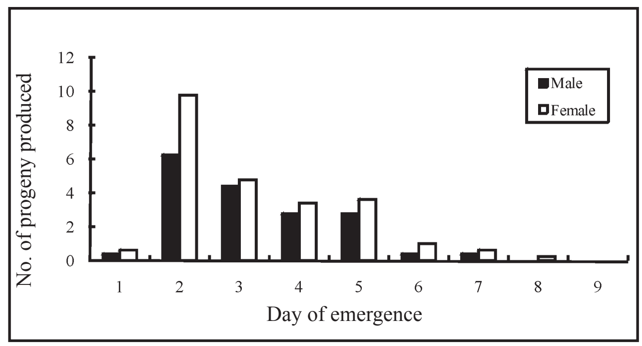

Fig. 3c. Sex ratio in *M. spilosomae* at 29 ± 1°C

1.8. Subsequently, from the 4th day onwards, frequency of mating decreased gradually until death on the 9th day. The total number of females mated by a male ranged from 3 to 9 with an average of 7.2. Male *M. spilosomae* inseminated all the females it mates with. Only those females which mated and were inseminated produced both male and female progeny. The average number of male progeny produced on the first day was 6.6 and reached the peak to 16.20 on the second day, declined to 8.00 on the 3rd day and further declined to 5.00 on the 4th day and 1.8 on the 5th day. The total average number of males emerged were 37.60. Unmated females produced only male progeny. Arrhenotokous reproduction has been reported in *Meteorus* sp., a parasitoid of *S. obliqua* (Pal *et al*., 1999).

Pre-oviposition period in *M. spilosomae* ranged from 0.79 to 1.08 days with an average of 0.91 days and the oviposition period ranged from 1 to 9 days. Katiyar *et al.* (1999) have reported the pre-oviposition and oviposition period in case of *M. dichomeridis* to be 1.24 ± 0.42 and 20 ± 2.09 days, respectively. Gravid *M. spilosomae* accepted first and second instar *S. obliqua* caterpillars for parasitisation. She examines *S. obliqua* caterpillars with her antennae. If the caterpillar was acceptable, it pierced the host caterpillar with its ovipositor on the dorsal or dorso-lateral side and laid an egg inside the caterpillar. It does not oviposit on the head region. The time taken for one oviposition is one to two seconds. Gravid females oviposit at a stretch for 3.5 to 6 minutes (mean = 4.3 ± 0.92 minutes). Ovipositing females resume oviposition after 1 to 2 h of rest. Normally only one egg is laid in each *S. obliqua* caterpillar. However, when host caterpillars were in short supply, up to 15 eggs were laid in each host. After egg hatching only one parasitoid larva survived and completed its development. The remaining parasitoid larvae were eliminated. Similar observations were reported in case of *Phanerotoma hendecasisella* (Peter and David, 1992).

The average number of eggs laid on the first day of oviposition was 6.2 and it reached its peak on the 2nd day (58.2) (Fig. 2). Subsequently, the number of eggs laid gradually decreased as the age of the adult advanced. It was 52.8 on 3rd day, 31.6 on 4th day, 22.0 on 5th day, 22.4 on the 6th day and finally ceased on 7 to 9 days. The total number of eggs laid ranged from 153 to 270, with an average of 213.0 ± 53.42. Katiyar *et al.* (1999) have reported that each female *M. dichomeridis* laid 236 ± 12 eggs with maximum number of eggs laid between 1 and 5th day.

The sex ratio of *M. spilosomae* progeny was found to be female-biased at all the three temperatures tested. At 19 ± 1°C, 65 - 80% RH, female progeny were predominant from the first day of oviposition till death on 8th day. The male to female sex ratio was 1: 1.22 (Fig 3a). Male progeny were predominant from first to 3rd day and female progeny were predominant from 4th day to 8th day at 24 ± 1°C, 70-

Table 2. Longevity of adult *M. spilosomae*

Type of Food provided	Mated Male (days)		Mated female (days)	
	Range	Mean ± SD	Range	Mean ± SD
Sucrose 50%	1 - 41	19.6 ± 13.58	10 - 55	29.7 ± 15.87
Glucose 50%	5 - 32	14.8 ± 8.39	5 - 32	19.2 ± 11.82
Honey 50%	4 - 31	12.5 ± 9.53	4 - 65	26.6 ± 16.56
Jaggery 50%	3 - 8	4.5 ± 1.52	4 - 8	6.3 ± 1.25
Mucilage (Hibiscus flower)	2 - 5	3.5 ± 0.97	2 - 7	4.2 ± 2.25
Water	1 - 5	2.9 ± 1.52	2 - 5	3.2 ± 0.92
No food (Control)	1 - 3	1.8 ± 0.79	1 - 4	2.2 ± 1.03
F Test		HS		HS
CD (P = 0.05)		0.463		1.169
CD (P = 0.01)		0.608		1.530

85% RH. On the 9th day only male progeny emerged. The male to female sex-ratio was 1: 1.24 (Fig 3b). The average number of female progeny was higher compared to males from the 1st to 7th day at 29 ± 1°C, 65 - 85% RH. On the 8th day, only female progeny emerged. The male to female sex ratio was 1: 1.38 (Fig. 3c). Female–biased sex ratio has been reported in case of other hymenopteran parasitoids of *S. obliqua*. Sex ratio of *M. dichomeridis* at 25°C was 1: 1.92 (Male: Female) (Katiyar *et al.,* 1999). Pal *et al.* (1999) have reported the sex ratio of *Meteorus* sp. to be 1: 1.50 (Male: Female).

Food provided to the parasitoids played an important role in enhancing their longevity and fecundity. In nature, insect parasitoids generally feed on dew, nectar or mucilaginous secretions of plants. The average longevity of mated males fed on 50% sucrose, glucose, honey or jaggery solutions, mucilage from hibiscus flowers, water or provided with no food was 19.6, 14.8, 12.5, 4.5, 3.5, 2.9 or 1.8, respectively, whereas the average longevity of mated females was 29.7, 19.2, 26.6 or 6.3, 4.2, 3.2 or 2.2 (Table 2). *M. spilosomae* males fed on sucrose lived for the longest duration followed by glucose, honey or jaggery. Those given mucilage from hibiscus flowers, water or no food lived for shorter duration. *M. spilosomae* females fed on sucrose lived for the longest duration followed by honey, glucose or jaggery. Those given mucilage from hibiscus flowers, water or no food lived for shorter duration. Female lived longer than males. The mean longevity of *M. spilosomae* varied significanatly with different foods.

Several workers have tested honey, sucrose, glucose and water as food on other hymenopteran parasitoids. Katiyar *et al*. (1999) have reported that honey fed *M. dichomeridis* lived longer than those fed on water or no food. *Trichopria khandalus* (Sharma) (Hymenoptera: Diapriidae) lived longer when fed on aqueous solutions of honey or glucose than those provided no food (Prasuna *et al*., 1993). Longevity of non-ovipositing *M. spilosomae* females fed on 50% honey solution was higher (mean = 26.6 days) than ovipositing females (mean = 6.8 days) at 24 ± 1ºC. Prasuna *et al*. (1993) have reported similar observations in *T. khandalus*. Ovipositing 50% honey fed female *M. spilosomae* lived for 6 to 9 days (mean = 6.8 days) at 24 ± 1ºC (Marimadaiah, 2002), while at high temperature (29 ± 1ºC), the longevity was reduced to 4 - 8 days (mean = 6.2 days) (Marimadiah, 2002). Similar observations were reported by Prasuna *et al.* (1993) in *T. khandalus*.

ACKNOWLEDGEMENTS

The authors are grateful to Director and Divisional Chief, KSSRDI, for the facilities, Dr. Venkataramu for the statistical analysis and the supporting staff of Entomology Unit for technical assistance.

REFERENCES

Atkins, M. D. 1980. *Introduction to insect behaviour.* Macmillan Publishing Co., New York. 237pp.

Geetha Bai, M. 1980. *Studies on some natural enemies of housefly and certain other Muscoid flies*. Ph.D. thesis, University of Mysore, Mysore.

Geetha Bai, M. 1990. Host parasite relationship of *Dirhinus pachycerus* Masi (Hymenoptera: Chalcididae), with particular reference to its housefly control potential, pp. 11-27 In: Rutz, D. A. and Patterson, R. S. (Eds.). *Biocontrol of arthropods affecting livestock and poultry,* Westview Press, Boulder.

Gupta, R. K. and Narendran, T. C. 2007. Field parasitism and biological characteristics of potent larval endoparasitoids of *Spilosoma obliqua* Walker in Jammu and Kashmir, India. *Journal of Biological Control*, **21**: 43-52.

Katiyar, R. L., Manjunath, D. and Datta, R. K. 1999. Biology and behaviour of *Meteorus dichomeridis* (Wilkinson) (Hymenoptera: Braconidae), a larval endoparasitoid of Bihar hairy caterpillar, *Spilosoma obliqua* (Walker). In: Govindan, R., Chinnaswamy, K. P., Krishnamurthy, N. K. and Reddy, D. N. R. (Eds.). *Silkworm management in Tropics, Proceedings of National Seminar on Tropical Sericulture*. University of Agriculture Sciences, Bangalore, India.

Kumar, N. and Yadav, R. P. 1987. A new record of parasitism of *Meteorus* nr. *arctiicida* Viereck (Hymenoptera: Braconidae) on *Spilosoma* (=*Diacrisia*) *obliqua* Walker. *Current Science*, **56**: 1122-1123.

Marimadaiah, B. 2002. Studies on some natural enemies of *Spilosoma obliqua* Walker (Lepidoptera: Arctiidae) and certain other important lepidopteran pests infesting mulberry. Ph. D. thesis, Bangalore University, Bangalore, 208p.

Narendran, T. C. and Rema, C. G. 1996. Three species of Braconidae (Hymenoptera) from India. *Journal of Ecobiology*, **8**: 135-142.

Pal, B. C., Ahamad, M., Haque, M. A. and Qudus, A. 1999. Biology and parasitism of *Meteorus* sp. in *Spilarctia obliqua*. *Indian Journal of Entomology*, **61**: 469-470.

Peter, C. and David, B. V. 1992. Biology of *Phanerotoma hendecasisella* (Hymenoptera: Braconidae), a parasitoid of *Diaphania indica* (Lepidoptera: Pyralidae). *Entomophaga*, **37**: 3-9.

Prasuna, A. L., Jyothi, K. N. and Jamil, K. 1993. Biology and biocontrol potential of *Trichopria khandalus* (Hymenoptera: Diapriidae), pp.161-166. In: ChannaBasavanna, G. P., Veeranna, G. and Dandin, S. B. (Eds.). *Recent Advances in Uzi fly Research*. *Proceedings of National Seminar on Uzi fly and its control*. Bangalore, India.

Ramkishor, Kumar, P. and Manjunatha, D. 1993. Biology of *Tetrastichus howardii*, a parasitoid of Uzi fly, *Exorista sorbillans,* pp.127-133. In: ChannaBasavanna, G. P., Veeranna, G. and Dandin, S. B. (Eds.). *Recent Advances in Uzi fly Research*. *Proceedings of National Seminar on Uzi fly and its Control*. Bangalore, India.

Singh, I. and Singh, G. 1995. New record of *Meteorus* sp. from the larvae of *Spilosoma obliqua* Walker. *Journal of Insect Science*, **8**: 209.

Veeranna, G. and Jyothi, H. K. 1994. Life-table studies on *Pachycrepoideus veerannai* Narendran and Anil, (Hymenoptera: Pteromalidae), a parasitoid of *Exorista sorbillans* Wied. (Diptera: Tachinidae) *Entomon*, **19**: 1-5.

(Received: 12.09.08; Revised: 14.10.08; Accepted: 12.03.09)