BIOLOGY AND HOST ACCEPTANCE OF *MICROPLITIS MANILAE* (HYMENOPTERA:BRACONIDAE) RAISED ON FALL ARMYWORM LARVAE *SPODOPTERA FRUGIPERDA* (LEPIDOPTERA: NOCTUIDAE)

ROHAN H. S. RAJAPAKSE, AND TOM R. ASHLEY
Insect Attractants, Behavior, and Basic Biology Research Laboratory,
Agricultural Research Service, U. S. Department of Agriculture,
Gainesville, FL 32604
AND
VAN H. WADDILL
Tropical Research and Education Center,
Institute of Food and Agricultural Sciences, University of Florida,
18905 S. W. 280th Street, Homestead, FL 33031

ABSTRACT

Studies were carried out on host age preference, developmental period and longevity of *Microplitis manilae* (Ashmead) a larval parasitoid of *Spodoptera* species imported from Thailand. Experiments conducted with 4 larval age groups (1, 24-48 h; 2, 49-72 h; 3, 73-96 h; 4, 97-130 h) of the fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), revealed that age groups 1 and 2 were most suitable for the development of the endoparasitoid *Microplitis manilae*. The highest parasitization rates and the highest proportion of female parasitoids were from larvae in the 2nd age group. The developmental period of *M. manilae* ranged between 13-18 days for temperatures between 23-27°C, 50-70% RH and 14:10 LD photoperiod. Highest parasitization was observed for *M. manilae* when 2 females were exposed to 20 hosts for 30 min at 26±1°C. Adult longevity of males and females was approximately 6 days at 26±1°C. This biological information will be used for rearing this parasitoid for additional laboratory studies or in the event *M. manilae* is considered for inundative or inoculative releases.

RESUMEN

Se hicieron ensayos sobre la preferencia de la edad del hospedero, prioridad del desarrollo, y la longevidad de *Microplitis manilae* (Ashmead), un parasitoide larval de especies de *Spodoptera* importadas de Tailandia. Experimentos conducidos con 4 grupos larvales de distintas edades (1, 24-48 hrs.; 2, 49-72 hrs.; 3, 73-96 hrs.; 4, 97-130 hrs.) del cogollero *Spodoptera frugiperda* (J. E. Smith), revelaron que los grupos de edades 1 y 2 fueron los más adecuados para el desarrollo del endoparásito *Microplitis manilae*. El grado de parasitismo y la proporción más alta de hembras parasitoides fue de larvas del segundo grupo de edad. El período de desarrollo de *M. manilae* varió entre 13-18 días a las temperaturas entre 23-27°C, 50-70% HR, y al fotoperíodo de 14:10 luz-obscuridad. El mayor parasitismo por *M. manilae* fue observado cuando 2 hembras fueron expuestas a 20 hospederos por 30 min. a 26+1°C. La longevidad de los machos y hembras adultos fue aproximadamente de 6 días a 26+1°C. Esta información biológica será usada para hacer ensayos adicionales en el laboratorio, o en la eventualidad que *M. manilae* sea considerada para liberaciones inundativas o inoculativas.

The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), is a major pest of corn and Bermudagrass in the southeastern United States (Luginbill 1928) and may extend its range as far north as the Canadian border during the summer and fall months (Snow and Copeland 1969). However, since this pest has no mechanism for diapause or

overwintering its populations are restricted to portions of south Florida and Texas during the winter months (Luginbill 1928). Average estimates of annual crop losses caused by the FAW exceed $300 million (Mitchell 1979). Therefore, reducing the density of overwintering FAW populations may result in a significant decrease in the amount of damage done by this pest.

Microplitis manilae (Ashmead) is a parasitoid of *Spodoptera* spp. in Thailand from where it was imported into the U. S. Even though the FAW does not occur in Thailand *M. manilae* develops successfully in larvae of the FAW under laboratory conditions (Shepard, personal comm.). The biologies and distributions of some members of this genus are known (Hafez 1951, Putter and Thewke 1970). Lewis (1970) describes the life history of *M. croceipes* (Cresson) for *Heliothis* spp. and reports that the parasitoid prefers 1st and 2nd instars as hosts. No research data could be found that document the life cycle and host age acceptance of *M. manilae* developing within FAW larvae nor has this parasitoid been reported as a natural enemy of FAW anywhere within its range (Ashley 1979).

The objectives of our research are to gain relevant information about the biology and host age acceptance of *M. manilae* when reared on FAW larvae. This information may prove useful in mass production of this parasitoid for inoculative or perhaps inundative releases should *M. manilae* eventually demonstrate the potential of becoming a significant mortality agent of FAW populations.

Materials and Methods

Female parasitoids were 24 h old and had been exposed to males since female eclosion. Each replicate consisted of exposing FAW larvae (number varied according to experiment) to 6 female parasitoids in a plastic container (7 x 10 cm diam) with 2 screened vents (1.5 x 3.0 cm) and having honey streaked on the underside of the lid. During host exposure FAW larvae fed on cubes (3 cm^3) of pinto bean diet (Leppla et al. 1979) after which the larvae were transferred individually to 30-ml plastic cups that contained pinto bean diet where they remained until their fate was determined. FAW larvae were kept at 23±2°C, 70±2% RH and under a 14:10 LD photoperiod. These larvae were divided into 4 groups depending on their age: 1, 24-48 h; 2, 49-72 h; 3, 73-96 h; and 4, 97-130 h). Hosts older than 130 h were excluded because *M. manilae* females would not accept them as hosts. The laboratory rearing method for *M. manilae* consisted of exposing parasitoids to ca. 50 FAW larvae which were 48-72 h old for 3-5 h.

Age group acceptance

Depending on host availability 4-6 replicates of 3-4 FAW larvae of the same age group were presented to 2 female *M. manilae* for 30 min on the same day. Data from 4 consecutive days comprised a single test and tests were replicated 4 different times.

Developmental rates

Microplitis manilae were exposed for 24 h to hosts in the 4 age groups. Parasitoid developmental times were determined from oviposition to pupation and from pupation to adult emergence. Progeny sex ratios were recorded for each age group.

Adult longevity

Freshly eclosed parasitoids were exposed to hosts under continuous light at 26±1°C and longevity was recorded for 2 groups: (1) the females (n = 41) and males (n = 57) were separated into different cages and (2) both sexes were kept together and allowed to mate for 2 h and then to oviposit for 24 h inside a plastic container with 20 FAW

larvae. After the host exposure period larvae were removed and adult parasitoids were retained in the plastic containers.

Time of Host Exposure

In order to determine optimal host exposure time, 2 female *M. manilae* were exposed to 20 hosts from the 2nd age group for 15, 30, 45 and 60 min and then removed. Four replicates were run.

Results and Discussion

Parasitoids displayed the highest host acceptance for 1st and 2nd age group larvae and a lesser acceptance for 3rd age group larvae (Table 1). Highest parasitization rates occurred most frequently in 2nd age group larvae. Significantly fewer 4th age group larvae were parasitized compared to larvae of other groups, and there were several occurrences of significant differences in host acceptance between 2nd and 3rd age group larvae. Similar results have been reported for other members of this genus (Hafez 1951, Lewis 1970). Putter and Thewke (1969) showed that *M. feltiae* preferred 1st to 3rd instar larvae (1st to 3rd age groups) of its host *Agrotis ipsilon* (Hufnagel) and Harcourt (1960) demonstrated a similar instar preference for *M. plutellae* Muesebeck and its host the diamond back moth *Plutella maculipennis* (Curtis). In contrast, Shepard et al. (1983) reported that *M. demolitor* (Wilkinson) preferrd 3rd or 4th instar larvae of *Heliothis* spp. However, larvae of this size displayed a vigorous defense response and often damaged or destroyed the parasitoid. We observed also that when *M. manilae* females attempted to oviposit in 4th age group larvae that these larvae aggressively attempted to thwart the ovipositional attempt by swinging their heads and thoraxes from side to side in an attempt to bite the parasitoid.

The larval and pupal developmental times for *M. manilae* were similar for age groups 1-3 (Table 2). Egg to pupa and pupa to adult developmental times for *M. manilae* parasitizing 4th age group hosts increased by ca. 2 days. Significantly more male progeny were produced from the 1st age group in contrast to the 2nd group from which more female progeny emerged. No significant differences were presernt in the sex ratios of progeny from 3rd or 4th age group larvae. The highest and lowest proportions of female progeny were observed for age groups 2 and 4, respectively. Bryan et al. (1969) showed that the sex ratio of emerging progeny of *M. croceipes* was ca. 1:1 when reared at 25°C. Only a single *M. manilae* emerged per host larvae irrespective of the age group parasitized. Bryan et al. (1969) reported an occasional emergence of 2 *M. croceipes* adults from a single *Heliothis* spp. larva. Emerging *M. manilae* larvae appeared to prefer a dry surface on which to pupate and would frequently form cocoons on the underside of the lid rather than on the moist diet surface.

Male and female longevity was about 6-7 days. Mating increased female longevity to ca. 10 days. An increase of ca. 10% in parasitization was observed when the host exposure period for *M. manilae* females was increased from 15 to 30 min (Table 3). Host exposure periods longer than 30 min did not increase significantly the parasitization rate.

Biological knowledge about this parasitoid is necessary in any attempt to establish *M. manilae* as an additional mortality agent in the overwintering range of FAW. Ashley et al. (1982) showed that the native parasites destroyed ca. 63% of each of the 1st 4 instars and parasitization rates followed closely the increase or decrease in FAW larval populations. Parasitization rates of 3.5-30.1% by *M. manilae* in FAW larvae were observed in the laboratory. The results of our research will be used to rear *M. manilae* and to support efforts to establish this parasitoid in the overwintering range of FAW.

TABLE 1. PERCENT PARASITIZATION BY *M. manilae* OF FALL ARMYWORM

Age group (h)	Test numbers[1]			
	1	2	3	4
1 (24-48)	24.5 a	26.7 a	26.7 a	13.2 a
2 (49-72)	28.3 a	30.1 a	27.8 a	11.4 a
3 (73-96)	22.5 a	20.7 b	19.5 b	12.3 a
4 (97-130)	6.9 b	5.2 c	6.8 c	3.5 b
Total	369	481	521	279

[1]Percentages followed by the same letter in the same column are not significantly different by Duncan's multiple range test (P = 0.05).

TABLE 2. DEVELOPMENTL PERIODS ($\bar{X}$ ± S.E.) AND PROGENY SEX RATIOS FOR *M. manilae* IN FALL ARMYWORM LARVAE.

Age group (h)	Hosts exposed	Developmental period (days)			Sex ratio (%)[1]	
		Egg-pupa	Pupa-adult	Total	Males	Females
1 (24-48)	106	10 ± 2.3	4 ± 0.7	14 ± 3.0	62.5	37.5
2 (49-72)	127	10 ± 2.9	3 ± 0.9	13 ± 3.8	42.9	57.1
3 (73-96)	93	10 ± 2.1	4 ± 1.1	15 ± 3.2	46.8	53.2
4 (97-130)	43	12 ± 1.9	6 ± 1.7	18 ± 3.6	46.7	55.3

[1]Asterisk indicates significance at the 5% level by Student's *t*-test.

TABLE 3. PERCENT PARASITIZATION OF SECOND AGE GROUP FALL ARMYWORM LARVAE EXPOSED TO *M. manilae* FOR VARIOUS AMOUNTS OF TIME.

Host exposure (min)	No. containers[1]	% Parasitization ($\bar{X}$ ± S.E.)[2]
15	8	13.0 ± 3.7 a
30	11	22.0 ± 3.1 b
45	13	26.0 ± 1.7 b
60	9	24.5 ± 1.6 b

[1]Two female parasitoids and 20 larvae/container.
[2]Means followed by the same letter are not significantly different (P <0.05) by Duncan's multiple range test.

ENDNOTE

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References Cited

ASHLEY, T. R. 1979. Classification and distribution of fall armyworm parasites. Florida Ent. 62: 114-123.

ASHLEY, T. R., V. H. WADDILL, E. R. MITCHELL, AND J. RYE. 1982. Impact of native parasites on the fall armyworm, *Spodoptera frugiperda*, (Lepidoptera: Noctuidae) in South Florida and release of exotic parasite *Eiphosoma vitticole* (Hymenoptera: Ichuemonidae). Environ. Ent. 11: 833-837.

BRYAN, D. E., C. G. JAKSON, AND R. PATANA. 1969. Laboratory studies on *Microplitis croceipes* a braconid parasite of *Heliothis* spp. J. Econ. Ent. 62: 1141-1144.

HARCOURT, D. G. 1960. Biology of the diamond-back moth *Plutella maculipennis* (Curtis) (Lepidoptera: Plutellidae) in eastern Ontario. III. Natural enemies. Canadian Ent. 92: 420-421.

HAFEZ, M. 1951. Notes on the introduction and biology of *Microplitis demoliter* (Hymenoptera: Braconidae). Bull. Soc. Ent. Egypte 35: 107-121.

LEPPLA, N. C., P. C. VAIL, AND J. R. RYE. 1979. Mass rearing and handling techniques for the cabbage looper, Proc. Radioisotopes and Radiation in Entomology, Training course, FAO/IAEA, pages 19-75.

LEWIS, W. J. 1970. Life history and anatomy of *Microplitis croceipes* (Hymenoptera: Braconidae) a parasite of *Heliothis* spp. (Lepidoptera: Noctuidae). Ann. Ent. Soc. America 63: 67-71.

LUGINBILL, P. 1928. The fall armyworm. USDA Tech. Bull. 34, 92 pp.

MITCHELL, E. R. 1979. Fall armyworm symposium: preface. Florida Ent. 62: 81.

PUTTER, B. AND S. E. THEWKE. 1970. Biology of *Microplitis feltiore* (Hymenoptera: Braconidae) a parasite of black cutworms *Agrotis ipsilon*. Ann. Ent. Soc. America 63; 645-648.

SHEPARD, M., J. E. POWELL, AND W. A. JONES. 1983. Biology of *Microplitis demolitor* (Hymenoptera: Braconidae) an imported parasitoid of *Heliothis* (Lepidoptera: Noctuidae) spp. and the soybean looper *Pseudoplusia includens* (Lepidoptera: Noctuidae). Environ. Ent. 12: 641-645.

SNOW, J. W. AND W. W. COPELAND. 1969. Fall armyworm: use of virgin female traps to detect males and to determine seasonal distribution. USDA Prod. Res. Report No. 110, 9 pp.