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Weight Differences of Male and Female Pupae of Gypsy Moth (*Lymantria dispar*) and Host-Sex Preference by Two Parasitoid Species *Lymantrichneumon disparis* and *Exorista larvarum*

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Abstract: Weight differences of male and female pupae of gypsy moth [*Lymantria dispar* L. (Lepidoptera: Lymantriidae)] and its two parasitoids *Lymantrichneumon disparis* (Poda) (Hymenoptera: Ichneumonidae) and *Exorista larvarum* (L.) (Diptera: Tachinidae) host preference were examined in this study. *Lymantria dispar* pupae were collected from trunks and branches of 20 Ironwood trees (*Parotia persica*) in two sampling dates, 10 July 2005 and 24 July 2005. The pest pupae were weighted and then saved at room temperature until adults of gypsy moth or its parasitoids emerged. The most *L. dispar* pupae collected in the first sampling were male whereas those in the second one were female and both male and female pupae in the second sampling were smaller than those in first sampling. The majority of male pupae (98.29%) were less than 0.6 g and most of female pupae (79.39%) were more than 0.6 g in weight. The most of *L. disparis* emerged from male pupae of *L. dispar*, whereas the majority of *E. larvarum* emerged from female pupae. Implications of the results for biological control strategy of gypsy moth are discussed.

Key words: Biocontrol, host size, ichneumonidae, ironwood, sex selection, Tachinidae

INTRODUCTION

Gypsy moth, *L. dispar* (Lepidoptera: Lymantriidae), is one of the most important pests of forest trees in Iran and occasionally causes outbreaks in the Northern forests of Mazandaran and Guilan Provinces. The larvae feed on the leaves of different plant species especially Oak, *Quercus castaneifolia* (DC.) C. A. Mey and Ironwood, *Parotia persica* (DC.) C. A. Mey and cause severe damage. This pest has one generation per year and hibernates as eggs on the trunks of its host plants. At the beginning of spring, the overwintered eggs hatch and the larvae feed on the leaves of the host plants and pupate on the trunks. In the middle of July, adult moths emerge from pupae and mating, females lay their eggs on the trunks and branches of the host trees (Behdad, 2002).

Lymantria dispar larvae and pupae are attacked by several parasitoids such as *Lymantrichneumon disparis* (Poda) (Hymenoptera: Ichneumonidae) a solitarious endoparasitoid of pupa (Maier, 1995) and *Exorista larvarum* (L.) (Diptera: Tachinidae) a gregarious endoparasitoid of larva (Simões *et al*., 2004).

Host size may affect sizes and sex ratios of parasitoids (Fidgen *et al*., 2000). Urano and Hijii (1995) reported that size of parasitoid was positively correlated with host size. In many cases, the sex ratio of parasitoids, emerging from small hosts is strongly male-biased and from large hosts is female-biased (Ueno, 1998; Bertschy *et al*., 2000).

In this study (1) weight differences in male and female pupae of gypsy moth, (2) the host-sex preference of the parasitoids, *E. larvarum* and *L. disparis*, (3) the parasitism rate of male and female gypsy moth by two parasitoids and (4) the sex ratio of gypsy moth were studied.

MATERIALS AND METHODS

This study was carried out at the outbreak time of *L. dispar* in the North of Iran in 2005. *Lymantria dispar* pupae were collected from trunks and branches of 20 Ironwood trees on two sampling dates (hence after SPD) in Lemrask forest area of Behshahr, Mazandaran, Iran. The first SPD was on 10 July (one week after observing the first pupa) and the second SPD was on 24 July (one week before the end of pupation stage).

In the first and second SPD 400 and 250 pupae were collected from 20 trees, respectively. The pupae were collected from each direction of trees at 0 to 2 m height. Each pupa was sexed and then weighted with a digital

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balance in the scale of 0/00 g [the weight of adults and pupae were accepted as indices of their sizes (Teder and Tammaru, 2005)]. Individually *L. dispar* pupa was saved in the cylindrical plastic plate (5×10 cm) at room temperature until adult pest or parasitoids emerged.

On emergence time, the numbers of male and female moth were counted and the emerged hymenopterous and dipterous parasitoids were identified by George Melika from Hungary and Kenan Kara from Turkey, respectively and counted. The weight range of male and female pupa and those of gypsy moth pupa from which dipterous or hymenopterous parasitoids had emerged, were determined [Larval or pupal parasitism exert no influence on pupal weight of host moth (Milward de Azevedo *et al*., 1991)]. The data were analyzed using student t-test.

RESULTS AND DISCUSSION

Results showed that gypsy moth sex ratio (male/female) was different in the first and second SPD. Sex ratios in the first SPD and second SPD were 2.34 and 0.59, respectively. In both SPD, the weight average of female pupae was greater than those of male (Table 1). Comparison of male and female pupal weight in the first and second SPD showed that there were significant differences between them ($p<0.01$) (Table 2). It appeared that male pupa of *L. dispar* was significantly smaller than female pupa. Interestingly, the weights of male and female pupae collected on the first SPD were statistically different from those collected on the second SPD. The weight range of male and female pupa varied in both SPDs (Fig. 1, 2). While the most male pupal weight (98.29%, n = 264) were less than 0.6 g (Fig. 1), the female pupal weight (79.39%, n = 188) were more than 0.6 g (Fig. 2).

Two parasitoid species, *Lymantrichneumon disparis* and *Exorista larvarum*, emerged from *L. dispar* pupae, which were previously reported from Iran by Herard *et al.* (1979) and Sâmet *et al.* (1977), respectively. *Lymantrichneumon disparis* parasitized 17.07% female and 82.93% male pupae in the first SPD and 22.58% female and 77.42% male pupae in the second SPD (Table 3). Whereas 66.04% of *E. larvarum* emerged from female pupae and 33.96% from male pupae on the first SPD, 85% from female and 15% from male pupae on second SPD (Table 3).

This study reported the effective occurrence of two important parasitoid species (*E. larvarum* and *L. disparis*) of gypsy moth and also provided new information about the status of gypsy moth and its parasitoids in Iran. The results suggest that *E. larvarum* and *L. disparis* are two key parasitoids of gypsy moth in Iran. The former is a dipterous larval endoparasitoid (Simões *et al*., 2004) and the latter is a hymenopterous pupal endoparasitoid (Maier, 1995).

This study indicated that the population density of male gypsy moth in the first SPD was greater than those

Table 1: Gypsy moth pupae collected during two sampling dates

	No. of pupae				Mean weight of pupae (g)	
SPD	Total	Unparasitized	Parasitized	Died	Male	Female
First	400 (269♂+131♀)	285 (202♂+83♀)	94 (52♂+42♀)	21 (15♂+6♀)	0.42±0.01	0.98±0.03
Second	250 (96♂+154♀)	167 (62♂+105♀)	71 (30♂+41♀)	12 (7♂+5♀)	0.33±0.01	0.73±0.02

First SPD: 10 July 2005; Second SPD: 24 July 2005

Table 2: Comparison of the weight of male and female gypsy moth pupae in two sampling dates

Compared groups	df	t	E
Male (SPD1)-Female(SD1)	283	-29.05**	1.944 E-02
Male (SPD2)-Female(SD2)	165	-17.15**	2.377 E-02
Male (SPD1)-Male(SD2)	262	7.04**	1.184 E-02
Female (SPD1)-Female(SD1)	186	8.08**	2.687 E-02

SPD1: 10 July 2005; SPD2: 24 July 2005. **$p<0.01$

Table 3: Percentage of parasitism of male and female gypsy moth pupae by dipterous parasitoid (*E. larvarum*) and hymenopterous parasitoid (*L. disparis*) in two sampling dates

				Parasitized pupae (%)		
Parasitoid	SPD	No. of parasitized pupae	Mean weight of parasitized pupae (g)	Male	Female	χ^2-value
E. larvarum	SPD1	53	0.73±0.05	33.96	66.04	5.45*
	SPD2	40	0.81±0.06	15.00	85.00	19.60**
	SPD1+SD2	93	-	25.81	74.19	-
L. disparis	SPD1	41	0.43±0.02	82.93	17.07	17.78**
	SPD2	31	0.33±0.07	77.42	22.58	9.32**
	SPD1+SPD2	72	-	80.56	19.44	-

SPD1: 10 July 2005; SPD2: 24 July 2005. *$p<0.02$, **$p<0.01$

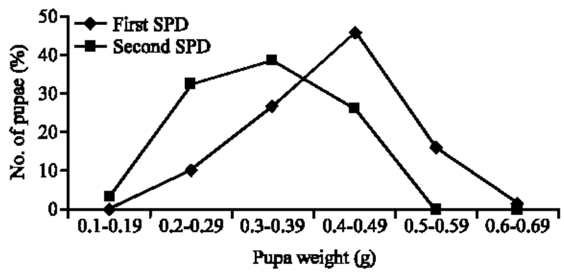

Fig. 1: The weight of male gypsy moth pupae in two sampling dates (SPD): first SPD = 10 July 2005; second SPD = 24 July 2005. n = 264

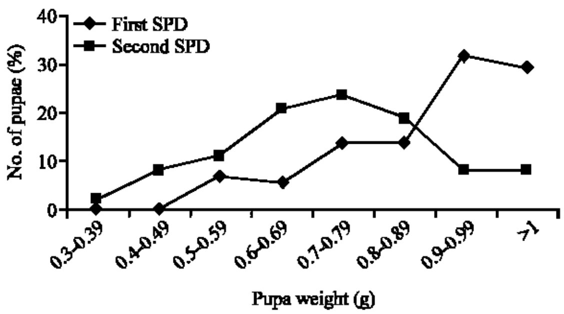

Fig. 2: The weight of female gypsy moth pupae in two sampling dates (SPD): first SPD = 10 July 2005; second SPD = 24 July 2005. n = 188

of female, while in the second SPD the female had higher density. This result agrees to some of earlier studies on this pest. Madrid and Stewart (1981) showed that sex ratio of gypsy moth varied among collecting sites and different collecting times. The numbers of male pupae increased with increasing of larval density at the beginning of outbreak season (first SPD), while at the end of season this trend inversed and consequently, the number of female pupae increased (second SPD). Therefore, changes in male and female density or sex ratio can be an important indicator in the population dynamics of *L. dispar* (Mauffette and Jobin, 1985).

In this study, the pupal weight of both male and female moths decreased in the second SPD compared with the first SPD. This reduction in pupal weight may result of the high density of the pest larvae at outbreak situation and food limitation at the end of the season. In this case more food resources are available for the first emerged pest larvae than for those emerged later in the season. Therefore, size and weight of gypsy moth larva, pupa and adult vary during an outbreak season, possibly that, severely defoliation of host trees at late outbreak season reduce the available food for larvae and consequently reduce the pupal weight of gypsy moth (Miller *et al*., 1991; Tuncer and Erzen, 1995).

The majority of *E. larvarum* emerged from female pupae of *L. dispar* on both SPDs. This indicates that *E. larvarum* significantly prefers female host larvae (larger larvae) for oviposition. Similar host preferences were reported for other dipterous parasitoids (tachinid flies) (Herbert and Cloutier, 1990; Bourchier, 1991). *Winthemia fumiferana* Tothill (Diptera: Tachinidae), the parasitoid of *Choristoneura fumiferana* (Clemens) (Lepidoptera: Tortricidae), preferred larger host larvae (the 6th to 5th instar) for oviposition and the host sex also affected the successful larval development and the pupal weight of this tachinid (Herbert and Cloutier, 1990). Bourchier (1991) reported that when *Compsilura concinnata* (Meigen) (Diptera: Tachinidae) parasitized 5th instar larvae of gypsy moth there were more successful parasitism than those attacked 3rd instar larvae.

Lymantrichneumon disparis parasitized more male pupae than females in the both SPDs. Even with decreasing male pupal density in the second SPD (Table 1). *Lymantrichneumon disparis* parasitized more male pupae (77.42%) than female pupae (22.58%) (Table 3). This suggests that *L. disparis* prefers to parasitize male pupae (smaller pupae) of gypsy moth. This is in agreement with some other studies on hymenopterous parasitoids. Kean and Barlow (2000) showed that the proportion of males in parasitized weevil, *Sitona discoideus* Gyllenhal (Coleoptera: Curculionidae), by *Microctonus aethiopoides* Loan (Hymenoptera: Braconidae) was twice than those of females, whereas weevil sex ratio was female-biased. Weseloh *et al.* (1983) suggested that there were strong correlations between percentage of parasitism and the size of gypsy moth larva; the greatest abundance of *Apanteles melanoscelus* (Ratz.) (Hymenoptera: Braconidae) occurred in the plots with the smallest caterpillars.

The rate of female host-parasitism is an integral part of a successful biological control strategy. In our study, *E. larvarum*, parasitized more female larvae than male larvae compared with the hymenopterous parasitoid, *L. disparis*, which parasitized more male pupae than female pupae. Therefore, *E. larvarum* could have a potential to act as an effective biocontrol agent of gypsy moth. This parasitoid has been used to release and control of *L. dispar* in northern united states for many years (Simões *et al*., 2004). However, further studies are required especially effects of environmental factors (e.g., temperature, day light, interactions between host and parasitoids and also competition between parasitoid species) to address conclusively the effectiveness of these biological control agents.

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