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Phoresy by an Egg Parasitoid, *Protelenomus* sp. (Hymenoptera: Scelionidae), on the Coreid Bug *Anoplocnemis phasiana* (Heteroptera: Coreidae)

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Abstract. Phoretic association between the egg parasitoid *Protelenomus* sp. and the coreid bug *Anoplocnemis phasiana* was studied on Ishigaki-jima Island, Japan. The egg parasitoids were associated only with adult bugs. The parasitoids were found on 28.7% of female bugs and on 20.0% of male bugs, and there was no significant difference in the frequency between female and male bugs. The mean and maximum numbers of parasitoids on a bug were 1.2 and 24 for female bugs, and 0.6 and 14 for male bugs, respectively. The number of parasitoids attached to a bug sometimes exceeded the number of eggs in a batch of host bugs. The parasitoids exhibited clumped distribution among the bugs. Most parasitoids were found on the hind femora in male bugs, while about half of parasitoids were attached to the antennae in female bugs. The transfer of parasitoids from a male bug to a female bug was observed to occur while the bugs were copulating. Therefore, phoresy on male bugs is not always disadvantageous for the egg parasitoid. Since the bugs change their host plant seasonally, phoresy on male bugs can be advantageous if the bugs are used as vehicles for transportation to distant places according to the host plant changes of the host bugs.

Key words: Ishigaki-jima Island, host plant, *Eupatorium luchuense* var. *kiirunense, Cajanus cajan, Indigofera kotoensis* var. *liukiuensis*

Introduction

The term phoresy designates the transportation of certain insects on the bodies of other insects for purposes other than direct parasitization (Clausen, 1976). In scelionid egg parasitoids, the transport of female adults on the bodies of host adults is common (Clausen, 1976). Most phoretic scelionids utilize the eggs of Orthoptera as their host (Clausen, 1976), and only three species are known to utilize the eggs of Heteroptera: *Microphanurus sulmo* Nixon on the pentatomid *Cantheconidea gaugeri* Schneider in Sumatra (Schneider, 1940), *Epinomus anoplocnemidis* Ghesquiere on the coreid *Anoplocnemis curvipes* (Fabricius) in Senegal (Clausen, 1976) and *Telenomus calvus* Johnson on the pentatomid *Podisus maculiventris* (Say) in parts of the USA (Orr *et al.*, 1986).

Among Japanese phoretic insects, *Telenomus euproctidis* Wilcox, an egg parasitoid on lymantriid moths (*Euproctis taiwana* (Shiraki) and *E. pseudoconspersa* (Strand)), is well studied (Arakaki, 1990; Arakaki *et al.*, 1995). Also, two egg parasitoids, *Telenomus dendrolimsi* (Matsumura) (Scelionidae) and *Trichogramma dendrolimi* Matsumura (Trichogrammatidae), are reported to be phoretic on the Siberian silkworm moth, *Dendrolimus sibiricus albolinealus* Matsumura (Clausen, 1976). Phoresy on heteropterous insects by egg parasitoids has not been reported in Japan.

On July 1, 1998, I found a small wasp on the body of the female coreid bug *Anoplocnemis phasiana* (Fabricius). This species has erroneously been treated as *A. castanea* (Dallas) (Miyamoto *et al.*, 1999). This bug was captured with an insect net while it was flying. The bug and the wasp were reared together in a plastic container. Several weeks later, wasps emerged from the bug eggs, and the wasp proved to be an egg parasitoid of the bug. This parasitoid was identified as *Protelenomus* sp. (Hymenoptera: Scelionidae) by H. Honda.

This paper describes the phoretic association between the egg parasitoid *Protelenomus* sp. and the coreid bug *A. phasiana.*

Table 1. Seasonal changes of the host plants of the coreid bug *A. phasiana* on Ishigaki-jima Island.

Host plants	April	May	June	July	August	September	October
Eupatorium luchuense var. *kiirunense*	+	+	+	+			
Cajanus cajan				+	+		
Indigofera kotoensis var. *liukiuensis*				+	+	+	+
Indigofera suffruticosa				+			
Uraria crinita						+	

Materials and Methods

Field observation was conducted on Ishigaki-jima Island from August 1999 to October 2001. The sex and the stadium of the host bugs associated with the parasitoids, the number of parasitoids, and the position at which they were attached on the bugs were recorded. The behavior of the parasitoids on the host bugs was observed. The host plants of the bugs and the conditions of the host plants were recorded in different seasons.

The egg batch size of the coreid bug was examined both in the field and in the laboratory. In the laboratory, the egg batch size was examined by rearing female bugs collected in the field. These females were confined individually or with a male in a plastic container with newly sprouted shoots of the host plant as food.

Results

Seasonal host plant changes in the coreid bug

Anoplocnemis phasiana bugs were found on five different plant species (Table 1). Most of the bugs were observed on the first three plant species listed in Table 1. They were sucking exclusively from newly sprouted shoots of the host plants, but not from reproductive organs such as flowers or pods. Both adults and nymphs were observed on each host plant in each month. Copulation was observed from July to September.

From April to July, many individuals were observed on *Eupatorium luchuense* var. *kiirunense*, which is a perennial herb that flowers from December to the following February. Newly sprouted shoots are most abundant from April to June, and these shoots grow continuously until flowering. The bug density on *E. luchuense* var. *kiirunense* peaked in June, and no bugs were found from August to following March.

From July to October, many individuals were observed on *Indigofera kotoensis* var. *liukiuensis*. Although the flowers and pods were observed in this period, most bugs sucked from the newly sprouted stem.

Table 2. Frequency of phoresy by the egg parasitoid *Protelenomus* sp. on adults and nymphs of the coreid bug *A. phasiana*.

Stages of the host bug	No. of bugs examined	No. of bugs carrying wasps
Adult		
Female	101	29
Male	125	25
Nymph		
5th stadium	77	0
4th stadium	41	0
3rd stadium	40	0
2nd stadium	37	0
1st stadium	11	0

Frequency of the phoresy

The frequency of the phoretic association between the coreid bug and the egg parasitoid was compared between the sexes and nymphal stadia of the bugs (Table 2). Parasitoids were found on adult bugs but not on nymphs. The proportion of bugs associated with the parasitoid was not significantly different between female and male bugs (χ^2-test; $\chi^2=2.32$, $P>0.1$).

Seasonal changes in the frequency of phoresy

Seasonal changes in the proportion of bugs associated with the egg parasitoid are shown in Table 3. A few bugs were found in April and May, when no parasitoid was found on the bugs. The number of host bugs increased gradually from June to August. During this season, the ratio of bugs associated with the parasitoid also increased, with the peak in September, but decreased soon thereafter in October. Female and male bugs showed similar trends in the frequency of phoresy.

Number of parasitoids on the bugs

The numbers of parasitoids on female and male bugs are shown in Fig. 1. The parasitoids exhibited clumped distribution ($s^2/\bar{x}=8.20>1$). The mean

Table 3. Seasonal changes in the frequency of phoresy by *Protelenomus* sp. on adult *A. phasiana*.

Date of observation	Female bugs		Male bugs	
	No. examined	with parasitoids	No. examined	with parasitoids
April	2	0 (0%)	4	0 (0%)
May	6	0 (0%)	7	0 (0%)
June	9	2 (22.2%)	10	2 (20.0%)
July	28	9 (32.1%)	38	7 (18.4%)
August	31	11 (35.5%)	37	8 (21.6%)
September	15	7 (46.7%)	17	7 (41.2%)
October	10	0 (0%)	12	1 (8.3%)
Total	101	29 (28.7%)	125	25 (20.0%)

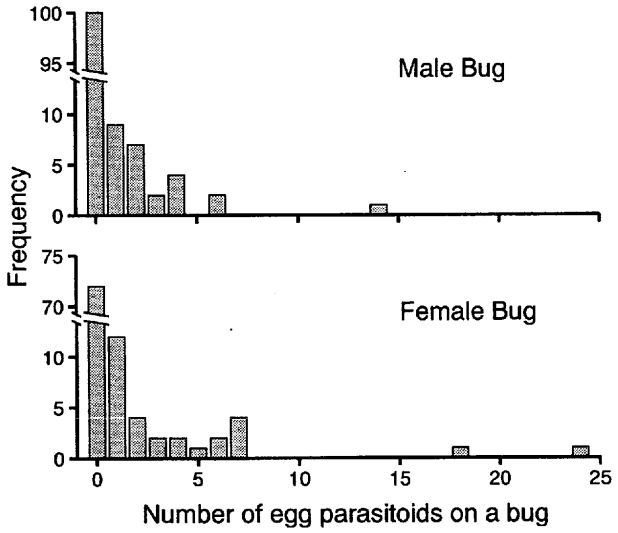

Fig. 1. Number of *Protelenomus* sp. egg parasitoids on adult *A. phasiana* bugs of each sex in the field on Ishigaki-jima Island.

number of parasitoids per female and male bug was 1.2 and 0.6, respectively, with no significant difference between the host sexes (t-test after $\sqrt{0.5+x}$ transformation; $P>0.05$). Maximum numbers of 24 and 14 parasitoids were found on female and male bugs, respectively.

Position of phoretic attachment

The positions of the parasitoids' attachment differed between male and female hosts (Table 4). On male hosts, most parasitoids attached on the hind femur (88.7%) (Fig. 2A). In contrast, on female hosts, about half (44.7%) of the parasitoids were found on the antenna (Fig. 2B).

Host egg batch size

The egg batch size of the bugs in the field was 11 (based on only one observation on the stem of *E. luchuense* var. *kiirunense*) and the number (mean±SD) of egg batches obtained by rearing in the laboratory was 9.0±1.8 (range 7–12, N=6).

Table 4. Position of phoretic attachment of *Protelenomus* sp. on adult *A. phasiana*.

Position of attachment	Total number of parasitoids	Ratio
Male bug		
pronotum	7	(9.9%)
mid tibia	1	(1.4%)
hind femur	63	(88.7%)
(male total)	71	(100.0%)
Female bug		
antenna	57	(47.1%)
pronotum	12	(9.9%)
pleuron or sternum of thorax	11	(9.1%)
mid tibia	2	(1.7%)
hind femur	10	(8.2%)
hind tibia	9	(7.4%)
tergum of abdomen	4	(3.3%)
sternum of abdomen	7	(5.8%)
unknown and others	9	(7.4%)
(female total)	121	(100.0%)

Other remarks

Field observation showed that one *Protelenomus* sp. individual transferred from the hind femur of a male host bug to the antenna of a female bug by walking while the bugs were copulating on a leaf of *Cajanus cajan* in the late afternoon on August 30, 1999.

Discussion

Generally, phoretic egg parasitoids obtain reproductive opportunities when they attach to female adult hosts. Previous studies showed that the phoretic egg

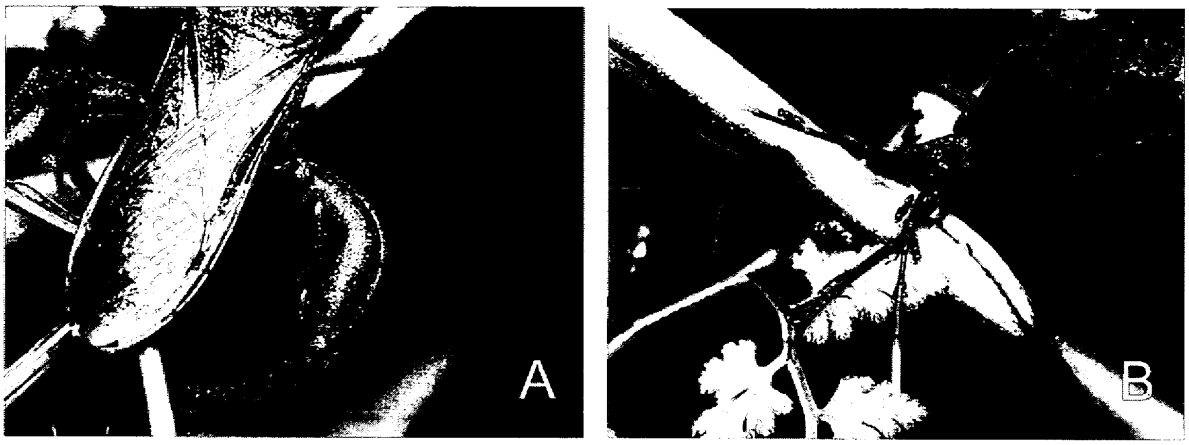

Fig. 2. Egg parasitoids *Protelenomus* sp. on the hind femora of a male (A) and on the antennae and pronotum of female *A. phasiana* (B). Both bugs were discovered on *Eupatorium luchuense* var. *kiirunense* on Ishigaki-jima Island in July, 2001.

parasitoids of pentatomid bugs were found only on female host bugs (Schneider, 1940; Orr *et al.*, 1986). In the other phoretic parasitoid species, a similar tendency has been reported (e.g. Arakaki, 1990; Arakaki *et al.*, 1995). However, the egg parasitoid *Protelenomus* sp. was found on both female and male host bugs (Table 2).

A phoretic egg parasitoid tends to be attracted to a male host or to an aggregation pheromone produced by male hosts, although phoresy by the parasitoid is found only on female bugs (Aldrich *et al.*, 1984). Aldrich *et al.* (1984) supposed that the phoretic egg parasitoid *Telenomus* sp. is oriented first to the male aggregation pheromone, and then searches for females in the vicinity of the male. Although the aggregation pheromone of *A. phasiana* has not yet been studied, the present study suggests that both sexes of *A. phasiana* attract the phoretic egg parasitoids in the field.

Protelenomus sp. exhibited clumped distribution on *A. phasiana* adults (Fig. 1); i.e. some bugs harbored many egg parasitoids. This finding suggests that the attractiveness of each host bug to the egg parasitoid may differ within the same population. The number of egg parasitoids on a bug sometimes exceeded the egg batch size of the bug. Such cases may be due to overcrowding, and in such situations a competition for reproductive resources among egg parasitoids must occur. The reason that the egg parasitoid exhibited clumped distribution remains obscure; however, some variations in the characteristics such as age and size of the bugs may affect the attractiveness of the host bugs to the egg parasitoid.

The egg parasitoid *Protelenomus* sp. was found on male bugs as well as on female bugs (Table 2). However, the position of the egg parasitoid on a bug was different according to the sex of the bug (Table 4). This may indicate that the egg parasitoid has the ability to discriminate the sex of the host. The egg parasitoid on male bugs concentrated on the hind femora, which are well developed in male bugs and are used as weapons for fighting with other males (Miyatake, personal communication; Kohno, unpublished). In female bugs, in contrast, most of the egg parasitoids concentrated on the antennae, a behavior that is similar to that of *Microphanurus sulmo* on *Cantheconidea gauglei* (Schneider, 1940). Since the transfer of the egg parasitoids from male to female bugs was observed in the field, the mating behavior of the bugs might have an influence on the difference in the attachment position of the parasitoid based on the sex of the bug. To elucidate this, however, more precise observation of the mating behavior of the bugs is necessary.

Phoresy by *Protelenomus* sp. on male bugs is not always disadvantageous because it provides the opportunity to transfer from male to female bugs. Besides, if the bugs are used as vehicles for transportation to distant places, phoresy on male bugs can be advantageous. The concept may apply in the system of *A. phasiana* and *Protelenomus* sp., since *A. phasiana* changes its host plant seasonally (Table 1). The egg parasitoids can transfer to distant places more easily by attaching to bugs than by flying themselves. For this reason, it is reasonable that the egg parasitoid is found only on adult bugs.

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