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Host preference: parasitism, emergence and development of *Trissolcus semistriatus* (Hym., Scelonidae) in various host eggs

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Abstract: *Trissolcus semistriatus* is an important egg parasitoid of the sunn bug, *Eurygaster integriceps*. Conservation and the supportive augmentation of populations of egg parasitoids appears to offer high potential for the biological control of sunn bug in an integrated pest management system. The present study was conducted to determine the host preference of *T. semistriatus* on various heteropteran host eggs. When each host species was examined separately, the eggs of *E. integriceps*, *Dolycoris baccarum*, *Graphosoma lineatum*, *Carpocoris pudicus* and *Holcostethus vernalis*, were parasitized at high levels, namely 88.0, 83.6, 94.8, 87.3 and 80.8%, respectively, whereas a smaller portion of *Eurydema ornatum* eggs were parasitized (24.0%). There was no parasitism in *Nezara viridula* eggs by *T. semistriatus*. Similar high rates were recorded for the percentage of adult emergence in each host species, with the exception of *E. ornatum*. The average development time was shorter for males than for females. The average development period for both male and female was significantly longer in eggs of *E. ornatum* than in those of the other host species. These results and observations recorded during the experiments showed that *G. lineatum* and *D. baccarum* were available, cheap hosts and it was demonstrated that these hosts could be used for the mass production of egg parasitoids.

1 Introduction

The sunn bug, *Eurygaster integriceps* Put., is among the most important pests of wheat causing severe losses in Turkey. An integrated pest management (IPM) system is currently being developed for *Eurygaster* species, based on the utilization of a complex of scelionid egg parasitoids. One of the dominant species of scelionid egg parasitoids in the Thrace region is *Trissolcus semistriatus* (Nees). However, *T. semistriatus* and other scelionid species, have failed to provide adequate control of sunn bugs in Turkey. At present, conventional chemical insecticides are the most widely used means of control of sunn bugs. An IPM system which includes natural and supportive augmentation of egg parasitoids appears to offer great potential for biological control (Waage, 1998).

Some important studies have been carried out to obtain a better understanding of some factors which influence the mass production and release of scelionid parasitoids and the evaluation of their efficacy (e.g. Safavi, 1968; Lazarov et al., 1969; Kartavtsev et al., 1974, 1977; Suntsova and Shirinyan, 1974; Orr et al., 1985; Popov et al., 1987; Braman and Yeargan, 1989; Correa-Ferreira and Zamataro, 1989; Öncüer and Kivan, 1995; Correa-Ferreira and Moscardi, 1994; Awadalla, 1996). In order to obtain a greater understanding of the host–parasitoid relationships and improve the utilization of *Trissolcus* spp. in IPM of the sunn bug, more investigations into the egg parasitoids, alternative pentatomid hosts and inter-relationships of *E. integriceps* were needed. The present study was conducted to determine the host preference in terms of parasitism, emergence and development of *T. semistriatus* on various heteropteran host eggs. The aim was to select suitable hosts of the egg parasitoids in order to achieve the most economical mass production for the development of a biological control system for the sunn bug.

2 Materials and methods

To evaluate host acceptance and preference, the method used the percentage of parasitized eggs and parasitoids developing in parasitized eggs after a set time period as criteria (Castaneda-Samayoa, 1994).

2.1 Parasitoid cultures

The *T. semistriatus* used in all the experiments were laboratory-reared progeny of field-collected insects. Adults were maintained in glass tubes supplied daily with sugar solution (30%) absorbed in filter paper (1 cm × 5 cm) for food (Kivan, 1998). *Eurygaster integriceps* eggs were used as hosts. The culture was kept at 26 ± 0.5°C, 60 ± 10% relative humidity with an 18 h light : 6 h dark photoperiod.

2.2 Host insects

Table 1 lists the host insects used for host-choice experiments and the plants from which they were collected in Tekirdag, Turkey during April and May 2000. *Eurygaster integriceps* adults were maintained on potted wheat plants covered with cages (20 cm × 27 cm) (Kivan, 1998). The pentatomids collected were reared on the relevant plants or seedlings according to their known host species. The method developed by Jones (1985) were adapted to the present study. As the insects used in the experiment are polyphagous, a lot of different seedlings were given together as food to them. In addition to this, a separate water source was supplied because the seedlings given were dried.

Dolycoris baccarum was reared on sunflower (*Helianthus annuus* L), sesame (*Sessamum* sp.), tobacco (*Nicotiana tabacum* L), false safflower (*Carthamus tinctorius* L), soybean (*Glycine max* (L.)) and peanut (*Arachis hypogea* L) seedlings. *Graphosoma lineatum* was placed on dried umbelliferous seedlings from carrot (*Daucus sativus* Hayek), anise (*Pimpinella anisum* L) and fennel (*Foeniculum vulgare* (Mid.)). Radish (*Raphanus sativus* L), garden cress (*Lepidium sativum* L), oilseed rape (*Brassica napus* L), cabbage (*Brassica oleracea* L) and cauliflower (*Brassica oleracea* var. *botrytis* L) seedlings were used as food for *Eurydema ornatum* (Kivan and Kilic, 2000). *Carpocoris pudicus* and *Holcostethus vernalis* were also provided with a supply of dried sunflower, false safflower, oilseed rape and peanut seedlings. *Nezara viridula* was reared on soybean, tomato (*Solanum lycopersicum* L), Jimson weed (*Datura stromonium* L) and peanut seedlings.

Batches of seeds were glued onto index cards (5 cm × 10 cm) 1 day before use. The cards were removed once a week and water was added every day. A strip of paper (2 cm × 20 cm) was placed on the top part and sides of each cage for egg deposition. These rearing cages were cleaned and the paper oviposition strips were changed once a week. Egg masses were cut out from oviposition strips or from any other surfaces on which they were deposited and then placed in Petri dishes using forceps. The deposited eggs were collected daily as described above and used in all experiments. All host insect cultures were maintained in a environmentally controlled room at a temperature of 26 ± 1°C with an 18 h light : 6 h dark photoperiod.

2.3 Host-preference trials

Parasitoid females, 1–2 days old, that were previously mated and fed on water and sugar solution, were used for the host-preference trials. Fifty eggs of each host species were put separately put in glass tubes and five female parasitoids were released into each tube. A female parasitoid was used only once. The host eggs were exposed to the parasitoid for 24 h and then removed and placed in another tube for incubation. After the emergence of adult parasitoids, they were counted and sexed. The remaining eggs were dissected and eggs in which perceptibly mature or immature forms of the parasitoid were identified, were considered to be parasitized. The percentage of egg parasitism and adult emergence, sex ratio and development time were calculated.

2.4 Data analysis

A one-way analysis of variance (anova) was carried out and means compared by the Duncan's multiple range test (level of significance 95%). The data that were calculated as a percentage were subjected to angle transformation before the statistical analysis.

3 Results

The data gathered from the host-preference experiments with *T. semistriatus* are summarized in table 2. The experiments showed that *T. semistriatus* did not successfully parasitize *N. viridula* eggs. The experiment was repeated several times to verify this behaviour. Nymphs of *N. viridula* emerged from a large portion of eggs supplied to the parasitoid. When some of the eggs became darker and appeared to be parasitized they were dissected but no evidence of parasitoid stages was found. Thus it was clear that the eggs of *N. viridula* were not parasitized by and not a host to *T. semistriatus* and so no further tests on *N. viridula* were carried out.

Table 1. *Host insects used for host-choice tests with* Trissolcus semistriatus

Species	Family	Collection on plants
Eurygaster integriceps Put.	Scutelleridae	Wheat
Dolycoris baccarum (L)	Pentatomidae	Wheat, common vetch, wild crucifer, composite
Graphosoma lineatum L.	Pentatomidae	Carrot, fennel, wild umbellifer
Eurydema ornatum (L)	Pentatomidae	Oilseed rape, common vetch, turnip weed, wild mustard, wild crucifer
Carpocoris pudicus (Pd.)	Pentatomidae	False safflower, common vetch, wild composite, crucifer
Holcostethus vernalis (W)	Pentatomidae	Common vetch, wild composite and crucifer
Nezara viridula (L)	Pentatomidae	Jimson weed, black nightshade, soybean, bean

Table 2. *Percentage of egg parasitism, adult emergence and sex ratio of* Trissolcus semistriatus *in different host eggs*

Host species	Egg parasitism (%)	Adult emerged (%)	Sex ratio (F/F + M)
Eurygaster integriceps	88.0[1] ab	98.6[1] a	0.6[1] ab
Dolycoris baccarum	83.6 ab	97.6 a	0.6 ab
Graphosoma lineatum	94.8 a	100.0 a	0.4 bc
Eurydema ornatum	24.0 c	45.8 b	0.2 c
Carpocoris pudicus	87.3 ab	95.9 a	0.7 a
Holcostethus vernalis	80.8 b	98.6 a	0.3 bc

[1] Means followed by the same letter, in the column, do not differ according to Duncan's multiple range test (P = 0.05).

The highest level of parasitism, included in table 2, was obtained for *G. lineatum* with 94.8% and *E. integriceps*, *C. pudicus* and *D. baccarum* also yielded high parasitism rates of 88.0, 87.3 and 83.6%, respectively. In addition, parasitism of *H. vernalis* eggs was also high (80.8%) and only the parasitism rate of *E. ornatum* eggs (24.0%) was significantly lower than the other species.

Table 2 shows that high emergence ratios (from 100.0 to 95.9%) occurred for all the host species tested except *E. ornatum*, which had an emergence ratio (45.8%) that was significantly lower.

The average sex ratio was the same for *E. integriceps* and *D. baccarum*, with a value of 0.6, and it was similar for *G. lineatum* and *H. vernalis* with 0.4 and 0.3, respectively (table 2). The highest sex ratio was found in *C. pudicus* (0.7) and the lowest in *E. ornatum* (0.2).

The development times, from egg to adult, for males and females are shown in fig. 1. The average development period for both male and female was longest in *E. ornatum*. However, there was no difference between the development times of males developed in the other host eggs. Males completely developed within 9.4 to 9.7 days in all the investigated species. The development time of *G. lineatum* females was longer at 12.1 days, whereas in the other host species the females developed within 11.0 to 11.1 days. The average time of development was shorter for males than for females and male emergence began 1 to 3 days earlier than female emergence for all host species, as shown in fig. 2.

4 Discussion

These experiments showed that the preference of *T. semistriatus* greatly varied between the seven species tested. The eggs of *E. integriceps*, *D. baccarum*, *G. lineatum*, *C. pudicus* and *H. vernalis* were successfully parasitized. There were no parasitism of *N. viridula* eggs by *T. semistriatus*, indicating that the stink bug is not a preferred host species for *T. semistriatus*. We could find no literature other than the report by Lodos (1961), showing that *N. viridula* is a host of *T. semistriatus*.

The results for development time and emergence ratio of egg parasitoids obtained in the present study for the five host species used, other than *E. ornatum*, agree with the literature on *Trissolcus basalis* (Wollaston) Correa-Ferreira and Moscardi, 1994), *Trissolcus euschisti* (Ashmead) (Yeargan, 1983), *Trissolcus oenone* Dodd (James and Warren, 1991), *T. basalis* and *Telenomus chloropus* (Thomson) (Orr et al., 1985), although both the egg parasitoids and hosts used in the present study were different from these reports. Development times for *T. basalis* of 10.8 days for males and 12.1 days for females at 26°C were recorded by Correa-Ferreira and Moscardi (1994). The development time was 13.7 days in *T. chloropus* and 10.5 days in *T. basalis* at 27°C (Orr et al., 1985) and 11.2 days at 27.5°C and 12.1 days at 25.0°C in *T. oenone* (James and Warren, 1991) for both sexes. In contrast to *T. semistriatus* and *T. euschisti* in which males develop faster than females, there was no sex difference in developmental rates in *T. oenone*.

Parasitism trials indicate that the egg parasitoids exposed to eggs of *E. ornatum* have the lowest range of parasitism, adult emergence and a longer developmental time than in other species of heteropteran host. Dissection of the eggs showed that adult parasitoids did not emerge completely and died during emergence from *E. ornatum* eggs, although part or all of the heads of adults emerged by breaking the chorion. We did not carry out any morphologic and anatomic investigations on eggs of these heteropteran species. Nevertheless, according to our observations during dissection, the parasitoid females had difficulty in parasitizing the *E. ornatum* eggs. It was also difficult for the adult parasitoids to emerge from *E. ornatum* eggs, depending on the hardness and thickness of the chorion, and this also made dissection more difficult compared with the other species. Some previous work has been carried out by rearing egg parasitoids on *Eurydema* and *Graphosoma* spp. (Suntsova and Shirinyan, 1974; Laraichi, 1979) and for this reason this species was specifically chosen for the experiment, but earlier research (Kivan, 1998) and the present results have shown that *E. ornatum* is not suitable for mass production of *T. semistriatus*. Nevertheless *E. ornatum* is an important species for egg parasitoids.

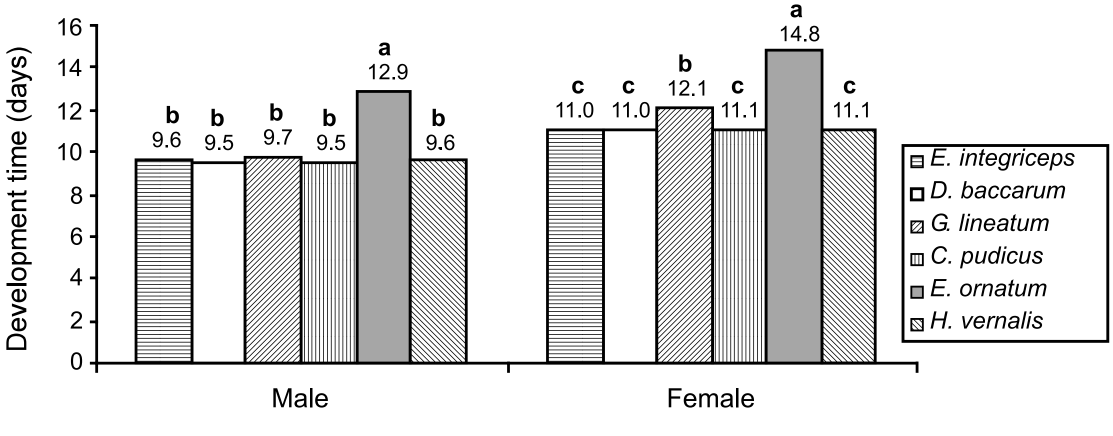

Fig. 1. *Developmental period of* Trissolcus semistriatus *males and females from egg to adult in different host eggs*

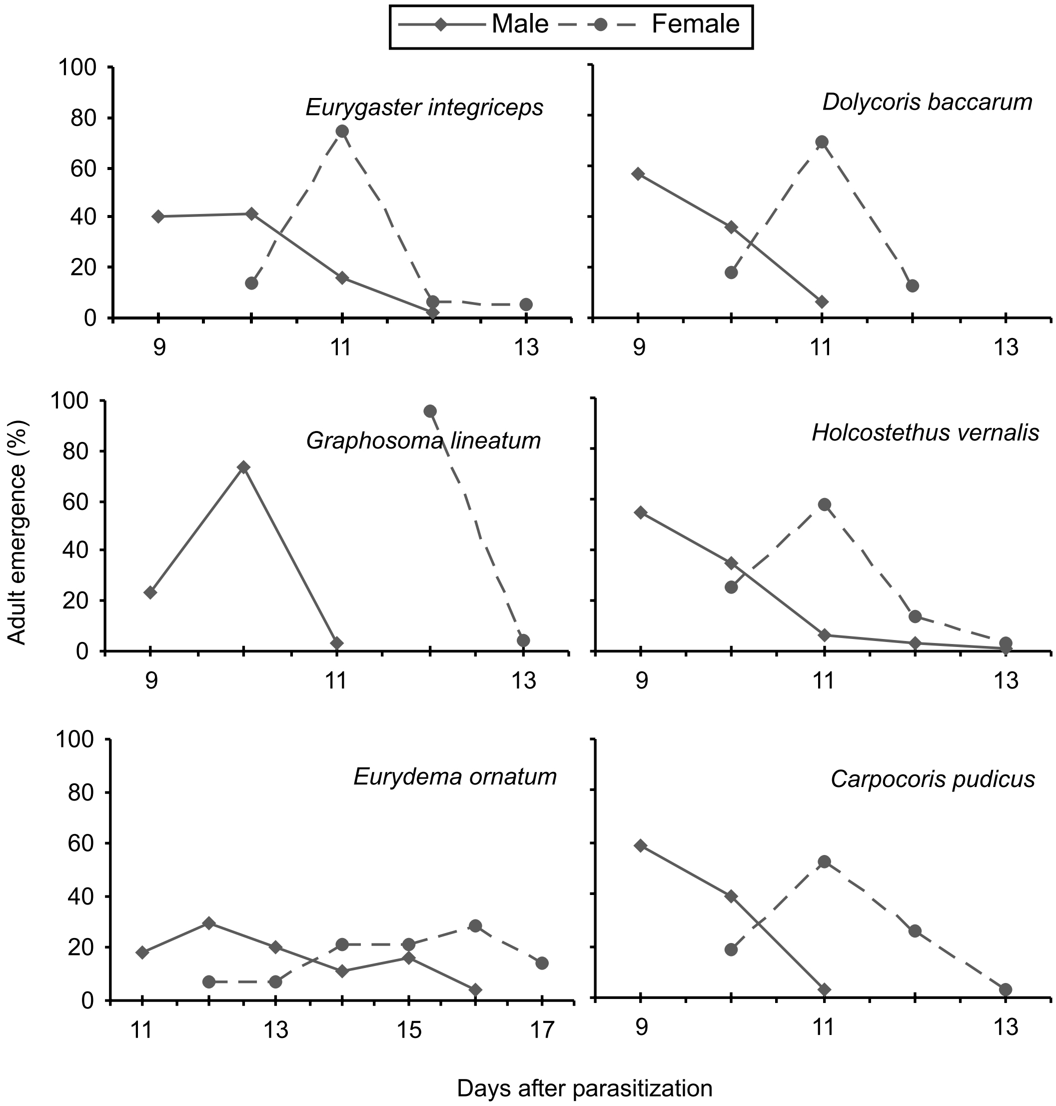

Fig. 2. *Percentage of emergence of* Trissolcus semistriatus *adults from eggs of different heteropteran species*

Parasitoids move from cereals to other plants on which pentatomid species exist as alternative hosts because the sunn bugs begin to migrate to their overwintering places during the ripening stage of the cereal and harvest. Thus, other pentatomids, some of which were included in this study, as secondary hosts have great importance in the life cycle of egg parasitoids.

When the heteropteran hosts used in this study were evaluated as candidates for mass production of egg parasitoids, it was suggested that *G. lineatum* was the most suitable host and *D. baccarum* the second. Although *C. pudicus* and *H. vernalis* were also suitable hosts, mass production of these species were more difficult than the others. They were very sensitive and showed a low rate of survival and fecundity during culture in laboratory according to our observations. If the problems concerning the mass production of these two species are solved, they can be used in the production of egg parasitoids, because their egg parasitoids developed and emerged at similar high rates to those of *D. baccarum*.

Although the sunn bug is not suitable for use in mass production of egg parasitoids because it is a univoltine species, it could be used as a host during the sunn pest season to cure parasitoid production. Of course, to produce a healthy colony of hosts, field-collected adults should be introduced and used for recolonization in order to ensure the continuous maintenance of a vigorous colony (Jones, 1985). At present, the additional use of sunn bugs seems to be an efficient way. Finally and essentially, the egg parasitoid will be used against *E. integriceps*.

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