

THE ALTERNATIVE HOSTS OF *TRISSOLCUS* SPECIES, EGG PARASITOIDS OF SUNN PEST AND HOST-PARASITOID INTERACTIONS IN SOUTH EASTERN ANATOLIA REGION, TURKEY

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Abstract

Trissolcus species (Hymenoptera, Scelionidae) are important egg parasitoids of Sunn pest, *Eurygaster integriceps* Put. (Heteroptera, Scutelleridae). They need alternative host eggs to survive in the nature, at the end of the wheat growing season. This study was carried out to determine the alternative hosts of *Trissolcus* species and host-parasitoid interactions in laboratory and different ecosystems in Adıyaman, Diyarbakır and Şanlıurfa provinces during 2007-2009. The parasitoid adults were reared from Scutelleridae and Pentatomidae (Heteroptera) eggs, collected from wild plants and kept in tubes in the laboratory at 25±1°C and 65±5% r.h. In this study, it was determined that 23 species belonging to Pentatomidae and Scutelleridae are alternative egg-hosts of *Trissolcus* spp. 13 species of which have been identified as the first time for alternative hosts of *Trissolcus* species.

Key words: *Trissolcus* species, alternative hosts, Southeastern Anatolia Region, Turkey.

Introduction

One of the factors limiting the wheat production which is an essential source for human nutrition is phytophagous insects. Among these insects Sunn pest, *Eurygaster* spp. (Heteroptera: Scutelleridae) is the most injurious crop pest in Turkey. Considerable yield losses occur every year in case of this pest is not controlled. Egg parasitoids from Scelionidae (Hymenoptera), adult and nymph parasitoids belonging to Tachinidae (Diptera), and numerous polyphagous predators are reported within the natural enemy complex of Sunn pest (Waage, 1998). The egg parasitoids, *Trissolcus* species, are the most effective ones among the natural enemies of the pest (Brown, 1962; Safavi, 1968; Yüksel, 1968; Barbulescu, 1971; Popov and Paulian, 1971; Semyanov et al., 1981; Lodos, 1982; Novozhilov and Dzyuba, 1983). *T. anitus*, *T. basalis*, *T. choaspes*, *T. culturatus*, *T. festiva*, *T. grandis*, *T. histani*, *T. rufiventris*, *T. pseudoturesis*, *T. rungsi*, *T. reticulatus*, *T. scutellaris*, *T. semistriatus*, *T. simoni*, and *T. vassilievi* are identified as egg parasitoids of the pest in Turkey (Brown, 1962; Yüksel, 1968; Kılıç et al., 1980; Dikyar, 1981; Şimşek & Sezer, 1985; Akıncı and Soysal, 1992; Melan, 1994; Memişoğlu & Özer, 1994; Şimşek et al., 1994;

Öncüer & Kivan, 1995; Koçak and Kılınçer 2002). Common and dominant ones of these species are *T. semistriatus*, *T. grandis* and *T. vassilievi* (Yüksel, 1968; Kivan, 1992; Şimşek et al., 1994; Melan, 1994; Memişoğlu et al., 1994; Tarla, 1997; Doğanlar, 1999; Koçak and Kılınçer 2001; Kodan, 2007; Gözüaçık and Yiğit, 2011). It has been reported that *T. semistriatus* reproduces approximately 3 times during oviposition of Sunn pest in wheat fields (Lodos, 1961). In Thrace Region, the parasitoid coming from winter quarters to wheat fields reproduces 9 times during the oviposition period of Sunn pest in the field conditions and laboratory (Kivan, 1998). Lazarov et al., (1969) stated that the parasitoid reproduced 7 times in nature and 8 times in laboratory during summer season. Alternative hosts of *Trissolcus* have a quite significant place in maintaining their life-span in nature during the period when eggs of Sunn pest do not exist in nature. Numerous Scutelleridae and Pentatomidae (Hemiptera) species of are known to be alternative hosts for *T. semistriatus* (Kılıç et al., 1980; Kivan 1998; Tarla & Doğanlar 1999; Kodan et al., 2007; Çetin et al., 2009; Gözüaçık & Yiğit, 2011). This study was conducted at different ecosystems and laboratories in order to

determine Pentatomidae and Scutelleridae (Heteroptera) species, which are the alternative hosts of *Trissolcus*, in terms of contributing the egg parasitoids of Sunn pest, *T. semistriatus*, *T. grandis* and *T. vassilievi* to maintain their existence in nature during the seasons after wheat harvesting in Adıyaman, Diyarbakır, and Şanlıurfa provinces of Southeastern Anatolia Region during the years of 2007-2009.

Material and methods

Field studies

Adult individuals, nymphs, and eggs of Scutelleridae and Pentatomidae species were collected from weed/wild plants, trees, and cultivated plants present in lands neighboring to wheat fields in the provinces of Adıyaman, Diyarbakır, and Şanlıurfa intervals of 4-7 days during May-November in 2007-2009. The eggs were cultured in the glass tubes (2x10cm) reserved with cotton and labeled, in

the incubator adjusted to 25±1°C and %65±5 RH. Emerged adult parasitoids were kept in absolute alcohol (96%) for identification. *Trissolcus* species were identified according to Doğanlar (2001) and Koak & Kılıner (2003).

Scutelleridae and Pentatomidae adults, collected from field and/or reared from nymphs were killed with ethyl acetate for identification. The samples were identified by Assoc. Prof. Dr. Meral Fent (Trakya University, Faculty of Science, Department of Biology, Edirne, Turkey).

Laboratory studies

In order to determine the alternative hosts of *Trissolcus* species, Scutelleridae and Pentatomidae adults collected from different ecosystems were cultured with their native host plants in plastic culture containers (23x23x30 cm) in the laboratory (Table1). Foods in plates were changed daily.

Table1. Some Pentatomidae and Scutelleridae species to be alternative hosts for *Trissolcus* and their host plants in laboratory

Pentatomidae and Scutelleridae species	Host Plants
<i>Carpocoris pudicus</i>	<i>Centaurea solstitialis</i> L.
<i>Anchyrosoma leucogrammes</i>	<i>Daucus carota</i> L.
<i>Eurydema ornate</i>	<i>Sinapis arvensis</i> L.+ <i>Brassica oleracea</i> L.
<i>Dolycoris baccarum</i>	<i>S. arvensis</i> + <i>B. oleracea</i>
<i>Piezodorus lituratus</i>	<i>Lens culinaris</i> M.+ <i>Trifolium</i> spp.
<i>Holcostethus vernalis</i>	<i>Helianthus annuus</i> + <i>Trifolium</i> spp.
<i>Codophila varia</i>	<i>Centaurea calcitrapa</i> L.+ <i>Carduus pycnocephalus</i> L.
<i>Graphosoma semipunctatum</i>	<i>D. carota</i> + <i>Conium maculatum</i> L.
<i>Acrosternum breviceps</i>	<i>Capparis</i> spp.
<i>Bagrada abeillei</i>	<i>S. arvensis</i> + <i>Symbrium</i> sp.
<i>Odontotarsus obseletus</i>	<i>C. calcitrapa</i> + <i>C. pycnocephalus</i>
<i>Pasias martini</i>	<i>Morus</i> spp.
<i>Staria lunata</i>	<i>C. pycnocephalus</i>

Egg packs obtained daily from cultures were attached to cardboards (1x5 cm) and put in test glass tubes (2x10 cm). Females of *T. semistriatus*, *T. grandis*, and *T. vassilievi* were confined with Sunn pest egg packs within the tubes separately for parasitization. They also are provided as food with honey droplets on a small strip of wax paper. Studies were conducted as two repeats in an incubator adjusted to 25±1°C and %65±5 R.H.

Results and discussion

Twenty three species belonging to Pentatomidae and Scutelleridae (Heteroptera) were identified as alternative hosts of

Trissolcus semistriatus Nees, *T. vassilievi* Mayr and *T. grandis* Thomson (Hymenoptera: Scelionidae), the egg parasitoids of Sunn pest, *Eurygaster integriceps* Put. (Hemiptera: Scutelleridae) in laboratory and in non-agricultural lands of Adıyaman, Diyarbakır and Şanlıurfa during the years of 2007-2009 (Table 2 and 3).

In order to determine the alternative hosts of *Trissolcus semistriatus*, *T. grandis* and *T. vassilievi*, a total of 1019 eggs belonging to *C. pudicus* (n=48), *A. leucogrammes* (n=60), *E. ornata* (n=232), *D. baccarum* (n=97), *P. lituratus* (n=60), *H. vernalis* (n=60), *C. varia* (n=100), *G. semipunctatum* (n=107), *A.*

breviceps (n=120), *B. abeillei* (n=24), *O. obseletus* (n=42), *P. martini* (n=57), and *S. lunata* (n=12) from Pentatomidae and Scutelleridae were used in the laboratory. As a result of experiments, *T. semistriatus* and *T. grandis* females parasitized the eggs belonging to 12 species, and *T. vassilievi* parasitized the eggs belonging to 11 species from Pentatomidae and Scutelleridae (Table 2). *T. semistriatus* parasitized the eggs of all the species except for *C. iranus*, *A. lunata* and *R. nebulosa*; *T. grandis* parasitized the eggs of all the species except for *C. pudicus*, *C. iranus*, *E. ornata*, *D. flavoguttata*, *A. lunata*, *H. vernalis*, *A. heegeri*, *B. amoenula*, *R. nebulosa*, *O. plicatulus*, *O. robustus*, *S. lunata* and *V. horvathi*; and *T. vassilievi* parasitized the eggs of all the species except for *C. fuscispinus*, *E. ornata*, *D. flavoguttata*, *A. lunata*, *H. vernalis*, *G. semipunctatum*, *B. abeillei*, *B. amoenula*, *R. nebulosa*, *O. obseletus*, *O. plicatulus*, *O. robustus*, *S. lunata*, and *V. horvathi* (Table 3). The reason behind why *Trissolcus* species did not parasitize some Pentatomidae and Scutelleridae eggs were thought to be the eggs was not suitable for development of parasitoid and the number of eggs collected failed to satisfy. In related studies conducted in different countries, *Troilus luridus* (Fabricius), *A. acuminata* (Linnaeus), *A. cognata* Fieber, *A. furcula* Fieber, *A. germari* Küster, *A. rostrata* Boheman, *A. virgata* (Herrich-Schäffer), *Carpocoris pudicus* (Poda), *Dolycoris baccarum* (Linnaeus), *Holcostethus strictus vernalis* (Wolff), *Palomena prasina* (Linnaeus), *Eurydema ornata* (Linnaeus), *E. ventralis* Kolenati, *Graphosoma lineatum* (Linnaeus), *Ventocoris fischeri* (Herrich-Schäffer) and *Odontotarsus impictus* Jakovlev were reported as hosts of *T. semistriatus* *Aelia cognata* Fieber, *A. germari*, *C. pudicus*, *D. baccarum*, *D. indicus* Stål, *Chlorochroa pinicola* (Mulsant and Rey), *Palomena prasina* (Linnaeus), *A. acuminata*, *E. ornata*, *E. ventralis*, *G. lineatum* as hosts of *T. grandis*; and *A. acuminata*, *A. furcula*, *A. rostrata*, *C. pudicus* and *D. baccarum* as hosts of *T. vassilievi* (NDSU, 2015). Furthermore, *A. acuminata*, *C. fuscispinus*, *C. mediterraneus*,

C. purpureipennis, *C. pudicus*, *Aelia rostrata*, *Eurydema ornata*, *E. blandum*, *E. festivum*, *E. oleracearum*, *E. ventrale*, *D. baccarum*, *N. viridula*, *R. nebulosa*, *P. lituratus*, *N. viridula*, *Codophila pusia*, *Graphosoma lineatum*, *G. stali*, *G. semipunctatum* and *H. vernalis* were reported as alternative host of egg parasitoids of Sunn pest in Turkey (Memişoğlu and Melan 1998; Tarla and Doğanlar 1999; Kıvanç and Kılıç 2002, 2003; Kodan, 2007; Çetin et al., 2014).

In the studies conducted in nature, totally 20838 eggs from *C. pudicus* (n=28), *C. fuscispinus* (n=14), *C. iranus* (n=14), *A. leucogrammes* (n=7680), *E. ornata* (n=2112), *Derula flavoguttata* (n=12), *D. baccarum* (n=2200), *P. lituratus* (n=66), *A. lunata* (n=96), *H. vernalis* (n=60), *C. varia* (n=240), *G. semipunctatum* (n=588), *A. breviceps* (n=5796), *A. heegeri* (n=240), *B. abeillei* (n=1056), *B. amoenula* (n=60), *R. nebulosa* (n=14), *O. obseletus* (n=224), *O. plicatulus* (n=56), *O. robustus* (n=42), *P. martini* (n=168), *S. lunata* (n=12), and *V. horvathi* (n=60) were found on host plants belonging to Poaceae, Asteraceae, Brassicaceae, Scrophulariaceae, Apiaceae, Caryophyllaceae, Ranunculaceae, Verbenaceae, Lamiaceae, Euphorbiaceae, and Boraginaceae (Table 4). *T. semistriatus*, *T. grandis* and *T. vassilievi* were reared from eggs of 20, 11 and 9 Pentatomidae and Scutelleridae species, respectively.

Regarding the combined results of field and laboratory *A. breviceps*, *A. heegeri*, *A. millerei*, *A. lunulata*, *A. leucogrammes*, *B. abeillei*, *B. amoenula*, *C. varia*, *C. pudicus*, *C. fuscispinus*, *C. iranus*, *D. baccarum*, *E. ornata*, *H. strictus vernalis*, *S. lunata*, *P. martini*, *P. lituratus*, *R. nebulosa*, *D. flavoguttata*, and *V. horvathi* from Pentatomidae and *O. plicatulus*, *O. robustus*, and *O. obseletus* from Scutelleridae were found to be as alternative hosts of *T. semistriatus*, *T. grandis* and *T. vassilievi*. Among these species *A. breviceps*, *A. heegeri*, *A. lunulata*, *B. abeillei*, *C. varia*, *S. lunata*, *P. martini*, *A. leucogrammes*, *D. flavoguttata*, *V. horvathi*, *O. plicatulus*, *O. robustus* and *O. obseletus* were determined as new alternative hosts for *Trissolcus* species.

Table 2. Parasitization status of *Trissolcus semistriatus*, *T. grandis* and *T. Vassilievi* on eggs of some Scutelleridae and Pentatomidae species under laboratory conditions

Family	Species	<i>T. semistriatus</i>	<i>T. grandis</i>	<i>T. vassilievi</i>
Pentatomidae	<i>Acrosternumbreviceps</i>	+	+	+
	<i>Anchyrosoma leucogrammes</i>	+	+	+
	<i>Bagrada abeillei</i>	-	+	Ω
	<i>Carpocoris pudicus</i>	+	+	+
	<i>Codophila varia</i>	+	+	+
	<i>Dolycoris baccarum</i>	+	+	+
	<i>Eurydema ornata</i>	+	+	+
	<i>Graphosoma semipunctatum</i>	+	+	+
	<i>Holcostethus strictus vernalis</i>	+	+	+
	<i>Pausias martini</i>	+	+	+
	<i>Piezedorus lituratus</i>	+	+	+
	<i>Staria lunata</i>	+	Ω	Ω
Scutelleridae	<i>Odontotarsusobseletus</i>	+	+	+

+: Parasitizing, -: Not parasitizing, Ω: No given eggs

Table 3. Parasitizing status of *Trissolcus semistriatus*, *T. grandis* and *T. vassilievi* species on eggs of some Scutelleridae and Pentatomidae species in non-agricultural lands of Adıyaman, Diyarbakır and Şanlıurfa during the years of 2007-2009

Family	Species	<i>T. semistriatus</i>	<i>T. grandis</i>	<i>T. vassilievi</i>
Pentatomidae	<i>Acrosternumbreviceps</i>	+	+	+
	<i>A.heegeri</i>	+	-	+
	<i>Anchyrosoma leucogrammes</i>	+	+	+
	<i>Anthemina lunulata</i>	-	-	-
	<i>Bagrada abeillei</i>	+	+	-
	<i>B. amoenula</i>	+	-	-
	<i>Carpocoris pudicus</i>	+	-	+
	<i>C. fuscispinus</i>	+	+	-
	<i>C. iranus</i>	-	-	+
	<i>Codophila varia</i>	+	+	+
	<i>Derula flavoguttata</i>	+	-	-
	<i>Dolycoris baccarum</i>	+	+	+
	<i>Eurydema ornata</i>	+	-	-
	<i>Graphosoma semipunctatum</i>	+	+	-
	<i>Holcostethus strictus vernalis</i>	+	-	-
	<i>Pausias martini</i>	+	+	+
	<i>Piezedorus lituratus</i>	+	+	+
	<i>Raphigaster nebulosa</i>	-	+	-
	<i>Staria lunata</i>	+	-	-
<i>Venthocoris horvathi</i>	+	-	-	
Scutelleridae	<i>Odontotarsusobseletus</i>	+	+	-
	<i>O. plicatulus</i>	+	-	-
	<i>O. robustus</i>	+	-	-

+: Parasitizing, -: Not parasitizing

Table 4. Pentatomidae and Scutelleridae species, alternative hosts of *Trissolcus* spp. and their host plants found in Adiyaman, Diyarbakır, and Şanlıurfa

Pentatomidae and Scutelleridae species	Host plants
<i>Acrosternum breviceps</i>	<i>Punica granatum</i> L., <i>Rosa canina</i> L., <i>Lycoperscium esculentum</i> L., <i>Morus</i> sp., <i>Phaseolus vulgaris</i> L., <i>Capparis spinosa</i> L., <i>Medicago</i> sp.
<i>Acrosternum heegeri</i>	<i>P. granatum</i> , <i>R. canina</i> , <i>Lycoperscium esculentum</i> L., <i>Morus</i> sp., <i>P. vulgaris</i> , <i>C. spinosa</i> , <i>Medicago</i> sp.
<i>Acrosternum milleri</i>	<i>P. granatum</i> , <i>R. canina</i> , <i>L. esculentum</i> , <i>Morus</i> sp., <i>P. vulgaris</i> , <i>C. spinosa</i>
<i>Bagrada abeillei</i>	<i>Brassica napus</i> var. <i>Oleifera</i> D.C., <i>Symbrium officinale</i> L. <i>C. Spinosa</i> , <i>Eryngium campestre</i> L., <i>Sinapis arvensis</i> L.
<i>Bagrada amoenula</i>	<i>B. napus.</i> , <i>S. officinale</i> , <i>C. spinosa</i> , <i>E. campestre</i> , <i>S. arvensis</i>
<i>Carpocoris pudicus</i>	<i>Helianthus annuus</i> L., <i>E. creticum</i> , <i>E. campestre</i> , <i>Centaurea calcitrapa</i> L., <i>Echinops microcephalus</i> Sibth and Sm., <i>Centaurea iberica</i> Trever ex Sprengel, <i>C. solstitialis</i> L., <i>Carduus pycnocephalus</i> L., <i>Trifolium</i> spp.
<i>Carpocoris fuscipinus</i>	<i>H. annuus</i> , <i>E. creticum</i> , <i>E. campestre</i> , <i>C. calcitrapa</i> , <i>E. microcephalus</i> , <i>C. iberica</i> , <i>C. solstitialis</i> , <i>C. pycnocephalus</i> , <i>Trifolium</i> spp.
<i>Codophila varia</i>	<i>Helianthus annuus</i> L., <i>Sesamum indicum</i> L., <i>E. creticum</i> , <i>E. campestre</i> , <i>Echinops ritro</i> L., <i>Scolymus</i> sp. <i>C. iberica</i> , <i>C. solstitialis</i> , <i>C. pycnocephalus</i>
<i>Anthemina lunulata</i>	<i>Euphorbia helioscopia</i> L.
<i>Dolycoris baccarum</i>	<i>Lens culinaris</i> Medik., <i>B. napus</i> , <i>S. indicum</i> , <i>Ervum ervilia</i> L., <i>Silene colorata</i> Poir., <i>Onopordum acanthium</i> L., <i>Onopordum carduchorum</i> , <i>Verbascum thapsus</i> L., <i>S. arvensis</i> , <i>S. officinale</i> , <i>Gundelia</i> sp.
<i>Piezodorus lituratus</i>	<i>L. culinaris</i> , <i>M. sativa</i> , <i>E. ervilia</i> , <i>Trifolium</i> spp.
<i>Eurydema ornate</i>	<i>B. napus</i> , <i>S. arvensis</i> , <i>Lepidum sativum</i> L., <i>Cardaria draba</i> (L.) Desv., <i>Crambe orientalis</i> L., <i>S. officinale</i>
<i>Holcostethus vernalis</i>	<i>Morus</i> sp., <i>M. sativa</i> , <i>Trifolium</i> sp.
<i>Anchyrosoma leucogrammes</i>	<i>Daucus carota</i> L., <i>E. creticum</i> , <i>E. campestre</i>
<i>Derula flavoguttata</i>	<i>Verbena officinalis</i> L.
<i>Graphosoma semipunctatum</i>	<i>E. creticum</i> , <i>E. campestre</i> , <i>D. carota</i> , <i>Conium maculatum</i> L.
<i>Staria lunata</i>	<i>C. pycnocephalus</i>
<i>Pausias martini</i>	<i>Morus</i> spp.
<i>Ventocoris horvathi</i>	<i>Chondrilla</i> sp.
<i>Odontotarsus plicatulus</i>	<i>C. calcitrapa</i> , <i>C. iberica</i> , <i>C. pycnocephalus</i> , <i>E. creticum</i> , <i>E. campestre</i>
<i>Odontotarsus robustus</i>	<i>C. calcitrapa</i> , <i>C. iberica</i> , <i>C. pycnocephalus</i> , <i>E. creticum</i> , <i>E. campestre</i>
<i>Odontotarsus obsoletus</i>	<i>S. indicum</i> , <i>C. calcitrapa</i> , <i>C. iberica</i> , <i>C. pycnocephalus</i> , <i>E. creticum</i> , <i>E. campestre</i>

Conclusions

As a result of three-year studies, 23 species belong to Pentatomidae and Scutelleridae were found in Adiyaman, Diyarbakır, and Şanlıurfa as alternative hosts for *T. semistriatus*, *T. grandis*, and *T. vassilievi*, egg parasitoids of Sunn pest. Thirteen of these species were determined as newhosts of *Trissolcus* spp.

As a result of the prohibition of aerial pesticide applications for Sunn pest control in recent years in Turkey, biological control approach is emphasized for control of the pest. In order to increase the efficiency of egg parasitoids in nature bio-diversity attempts came into prominence to support the surviving and increasing the efficacy of the egg parasitoids, *Trissolcus* spp. throughout the year under field conditions. Due to these reasons it has become gradually more important to determine the

alternative host species for *Trissolcus* spp. belong to Pentatomidae and Scutelleridae and their host plants which they feed from and shelter on.

It is considered that taking precautions regarding to form a green zone is necessary by composed of the host plants above determined species, afforest and protect the wild plants around the wheat fields for the mentioned parasitoid species to over winter, shelter, feed, and find their alternative hosts to realize the natural biological control of Sunn pest throughout the year.

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