

Full Length Research Paper

# Determination of heteroptera species on canola plants in Hatay province of Turkey

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Canola (*Brassica napus* L.) is an important oil crop grown for animal feed, oil and biodiesel. Aim of this research was to determine Heteroptera species on canola in Hatay province of Turkey. Twenty-one (21) species belonging to Miridae, Pentatomidae, Lygaeidae, Rhopalidae and Scutelleridae families were identified. Distribution of a total of 1431 adults according to the families and species was as follow: Miridae (1010), *Exolygus gemallatus* (472), *E. rugulipennis* (254), *Adelphocoris lineolatus* (246), *E. pratensis* (36), *Acetropis carinata* (1) and *Calocoris nemoralis* (1); Pentatomidae (235), *Eurydema ventrale* (140), *Holcostethus vernalis* (33), *E. ornatum* (26), *Dolycoris baccarum* (16), *Carpocoris pudicus* (10), *C. purpureipennis* (5), *C. fuscispinus* (2), *Eysarcoris inconspicuus* (1), *E. fabricii* (1) and *Nezara viridula* (1); Rhopalidae (114) *Liorhyssus hyalinus* (101), *Rhopalus subrufus* (11) and *Corizus hyosciami* (2); Lygaeidae (71) and *Nysius cymoides* (71); Scutelleridae (1) and *Odontotarsus robustus* (1). Adults of species belonging to Miridae (70.5%), Pentatomidae (16.4%), Rhopalidae (7.96%), Lygaeidae (4.96%) and Scutelleridae (0.069%) were determined in whole sampling sites and all of the canola varieties. Additionally, nymphs belonging to Miridae (79.7%), Pentatomidae (19.4%) and Lygaeidae (0.8%) families were identified. Miridae was the highest followed by Pentatomidae, Rhopalidae and Lygaeidae; Scutelleridae was the lowest in the whole sampled areas and all canola varieties. *Exolygus gemallatus* (472), *E. rugulipennis* (254) and *A. lineolatus* (246) belonging to Miridae had the highest population densities, especially increasing after the flower stage of canola and reaching the maximum levels at the pod stage.

**Key Words:** Canola (*Brassica napus* L.), Heteroptera, Hatay.

## INTRODUCTION

Canola (*Brassica napus* L.) is an important oil crop grown for animal feed, oil and biodiesel (Scarbrick and Daniels, 1986; Shahidi, 1990; Raymer, 2002; Karaosmanoğlu, 2004). Miridae species, commonly known as plant bugs or *Capsids*, includes important pests of cultivated plants (Kelton, 1975; Schuh and Slater, 1995; Pedigo, 1999; Nordlund, 2000; Wheeler, 2001; Jay et al., 2004; Önder et al., 2006). It is suggested that there are approximately 10,000 Miridae species (Wheeler, 2000) and 559 of them were described in Turkey (Önder et al., 2006). The species of *Lygus lineolaris* (Palisot de Beauvois), *Lygus hesperus* Knight, *Lygus elisus* Van Duzee and *Lygus desertinus* Knight are well-known species in North America (Kelton, 1975; Schuh and Slater, 1995; Wheeler, 2000). The species of *Lygus rugulipennis* (Poppius, 1911), *Lygus pratensis* (L.), *Lygus gemellatus* (Herrich-Schäffer) and *Adelphocoris lineolatus* (Goeze, 1778) are

widely distributed on a large diversity of host plants in Europe (Holopainen and Varis, 1991; Jay et al., 2004; Önder et al., 2006).

*Lygus* are also important pests of oilseed brassicas (Schwartz and Footitt, 1992a; Schuh and Slater, 1995) feeding primarily on buds, flowers, pods and seeds (Lamb, 1989). Visible injuries to *Brassica napus* L. (canola, rape) and *Brassica campestris* L. (oilseed mustard) appear as surface lesions and can cause buds and flowers to abscise and seeds to collapse (Lamb, 1989; Butts and Lamb, 1990). *Lygus* damage to buds and flowers usually results in an apparent reduction in the yield of canola seed, although the plants compensate to some extent by replacing lost buds and flowers (Butts and Lamb, 1990). In a survey of commercial fields in Alberta, *Lygus* bugs destroyed an average of 6% of the canola seed in some regions with some fields sustaining

seed losses of > 20% (Butts and Lamb, 1991). In Turkey, there was only one previous study in Adana to determine pest species on canola (rape) plants (Atakan et al., 2005). They found the species of *Exolygus gamellatus* H.S., and *Creontiades pallidus* Ramb from family of Miridae.

Pentatomidae are well-known groups and easily recognized by their round or ovoid shape and five segmented antennae (Borror et al., 1989). Stink bugs are largely plant feeders, sucking sap from leaves, stems and reproductive parts (Pedigo, 1999). Önder et al. (2006) reported that 188 Pentatomidae species found on various plants in Turkey but they did not report which of them found on canola plants in Turkey. Atakan et al. (2005) in Adana (Turkey) reported the species of *Eurydema ornatum* L., *Dolycoris baccarum* L., *Carpocoris pudicus* Poda, *Holcostethus vernalis* Wolff and *Nezara viridula* L. from family of Pentatomidae.

Some of the Lygaeidae species, especially the false chinch bug, *Nysius raphanus* Howard (1872), is important pest on canola (Miles and McDonald, 1999; Sweet, 2000; Capinera, 2002). Some of the Lygaeidae species, especially the false chinch bug, *Nysius raphanus* Howard (1872), is important pest on canola (Miles and McDonald, 1999; Sweet, 2000; Capinera, 2002). The false chinch bug is a general feeder with preference for plants in the family Brassicaceae (Sweet, 2000; Capinera, 2002). Injury is caused by removal of sap sucked from plants while feeding. Önder et al. (2006) mentioned 227 Lygaeidae species are known in Turkey where they did not mention which species feed on canola.

The purpose of this study was to determinate Heteroptera species on canola plants for developing integrated pest management of economical pest species in Hatay region of Turkey.

## Materials and Methods

Samples were collected from four (4) canola varieties at eleven canola fields in Hatay region of Turkey (Table 1). Samplings were done by using a 45-cm diameter sweep-net, taking 25 (back-forth) sweep samples per site, on 28 February, 13 March, 27 March, 10 April, 24 April, 7 May and 14 May in 2008. Sampling took place between 10 AM to 4 PM to allow warming so that insects may move onto the surface of plants. All samples were done by the same person, usually a straight line transect across the sample site. Samples were immediately placed into (0.5 L) plastic cups containing 96% ethyl alcohol and returned to the lab for evaluation. Adults and nymphs of Heteroptera species were sorted out from plants materials. They were counted and recorded for each of the sampling locality and canola variety. Adults of Heteroptera were identified by using the key of Stichel (1956–1962) Hemipter-Heteroptera Europae Cilt II, III and IV. In addition, nymphs of Miridae were identified by using the key of Schwartz and Foottit (1992b).

## RESULTS

Twenty-one (21) species belonging to Miridae, Pentatomidae, Lygaeidae, Rhopalidae and Scutelleridae families

**Table 1.** Sampling of Heteroptera species on four canola varieties at eleven localities in Hatay in 2008.

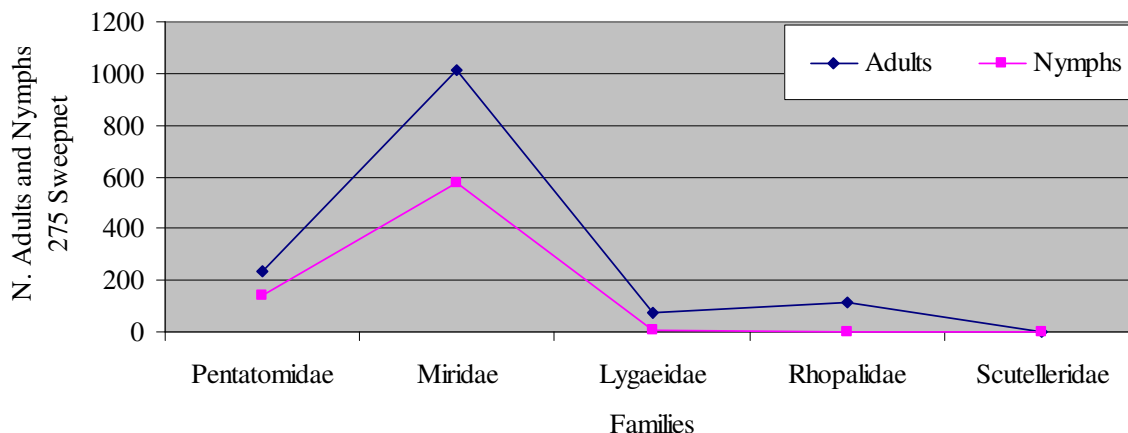
Localities	Varieties	Planted area (da)
Atcana I	Elvis	40
Atcana II	Elvis	30
Atcana III	Elvis	30
Demirköprü I	Sarı	9
Demirköprü I	Hunter	9
Demirköprü II	Sarı	15
Demirköprü II	Lycosmos	16
Demirköprü II	Hunter	8
Demirköprü III	Sarı	45
Demirköprü III	Hunter	5
Demirköprü IV	Sarı	40

were identified on four canola varieties at eleven localities in Hatay region of Turkey. During the sampling period, a total of 1431 adults were recovered on four canola varieties and at whole localities. Adults of species belonging to Miridae (70.5%), Pentatomidae (16.4%), Rhopalidae (7.96%), Lygaeidae (4.96%) and Scutelleridae (0.069%) families were determined in whole sampling sites and all of the canola varieties (Figure 1).

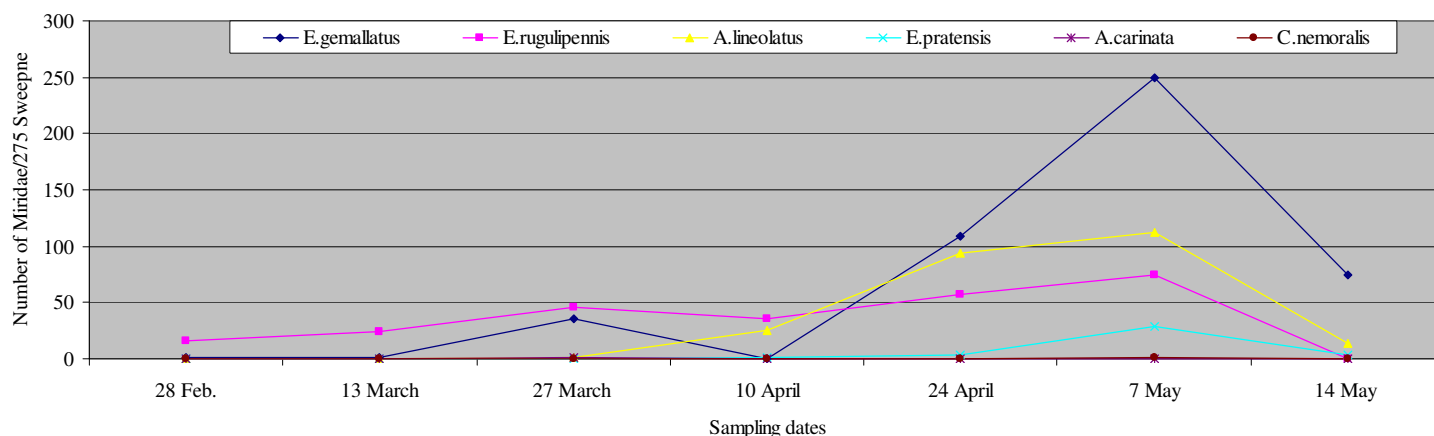
Additionally, during the sampling period a total of 720 nymphs were sampled on four canola varieties and at whole localities. Nymphs belonging to Miridae (79.7%), Pentatomidae (19.4%) and Lygaeidae (0.8%) families were obtained. A total of 574 nymphs, *A. lineolatus* (18) and *Exolygus spp.* (556) from Miridae, 140 nymphs, *Carpocoris spp.* (6), *D. baccarum* (57), *E. ornatum* (60) and *N. viridula* (17) from Pentatomidae and 6 nymphs from Lygaeidae were recovered during the sampling periods.

A total of 1010 adults belonging to the Miridae, *Exolygus (Lygus) gemellatus* (472), *E. rugulipennis* (254), *Adelphocoris lineolatus* (246), *E. pratensis* (36), *Acetropis carinata* (1) and *Calocoris nemoralis* (1) were sampled on four canola varieties at eleven localities in Hatay (Figure 2). The species of *E. gemellatus* was the most abundant at all of the localities and the canola varieties. The species of *E. rugulipennis*, *A. lineolatus*, *E. pratensis*, *A. carinata* and *C. nemoralis* followed.

Population densities of *E. gemellatus* gradually increased from 10 April to 24 April and peaked on 7 May. Population densities of *A. lineolatus* and *E. pratensis* increased from 27 March to 24 April and peaked on 7 May. Although *E. rugulipennis* were recovered throughout the sampling period (28 February to 14 May), its population density was not significantly changed. The species of *Acetropis carinata* and *Calocoris nemoralis* were the least abundant species on canola plants. Moreover, the population densities of all Miridae species increased significantly from the flower stages (10 April) to pod stages (7 May) and peaked during the pod stages of canola plants.



**Figure 1.** Population densities of adults and nymphs of five families on four canola varieties at eleven different localities in Hatay in 2008.



**Figure 2.** Population densities of adult pest species of Miridae on four canola varieties at eleven different localities in Hatay in 2008.

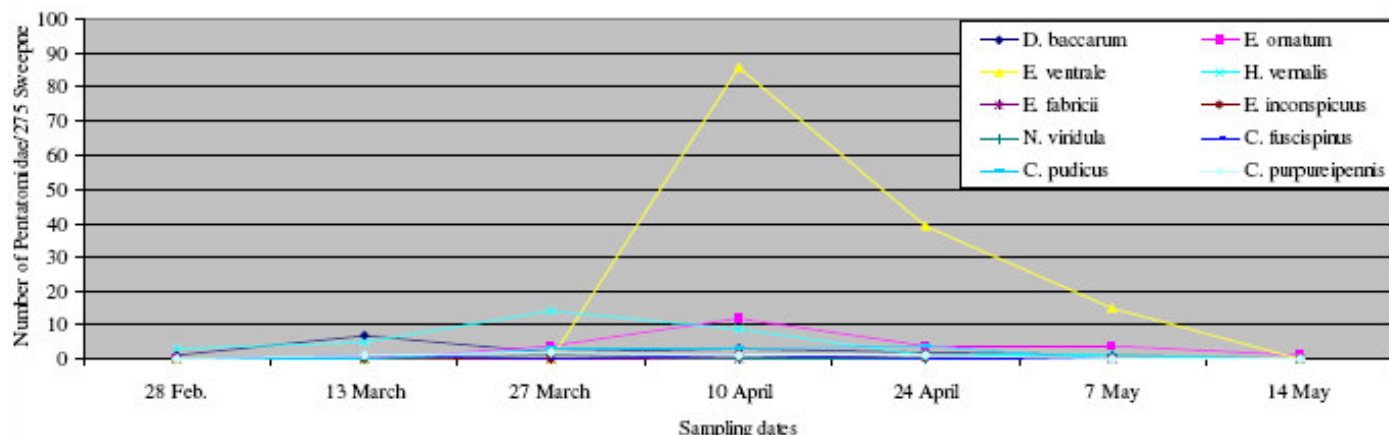
A total of 235 adults of Pentatomidae species, *Eurydema ventrale* Kolenati, 1846 (140), *Holcostethus vernalis* (Wolff, 1804) (33), *E. ornatum* (Linnaeus, 1758) (26), *D. baccarum* (Linnaeus, 1758) (16), *Carpocoris pudicus* (Poda, 1761) (10), *C. purpureipennis* (De Geer, 1773) (5), *C. fuscispinus* (Boheman, 1849) (2), *Eysarcoris inconspicuus* (Herrich-Schäffer, 1844) (1), *E. fabricii* Kirkaldy, 1904 (1) and *N. viridula* (Linnaeus, 1758) (1) were sampled on four canola varieties at eleven localities during the sampling period (Figure 3).

Population densities of *E. ventrale* and *E. ornatum* gradually increased starting in late March and peaked in the middle of April. The population densities of *D. baccarum* and *H. vernalis* peaked in the middle and late of March. *Carpocoris* spp. was found from the beginning of the sampling and population densities peaked in March and April. Overall population densities of Pentatomidae decreased during the flower and pod stages of canola. A total of 114 adults of Rhopalidae species, *Liorhyssus*

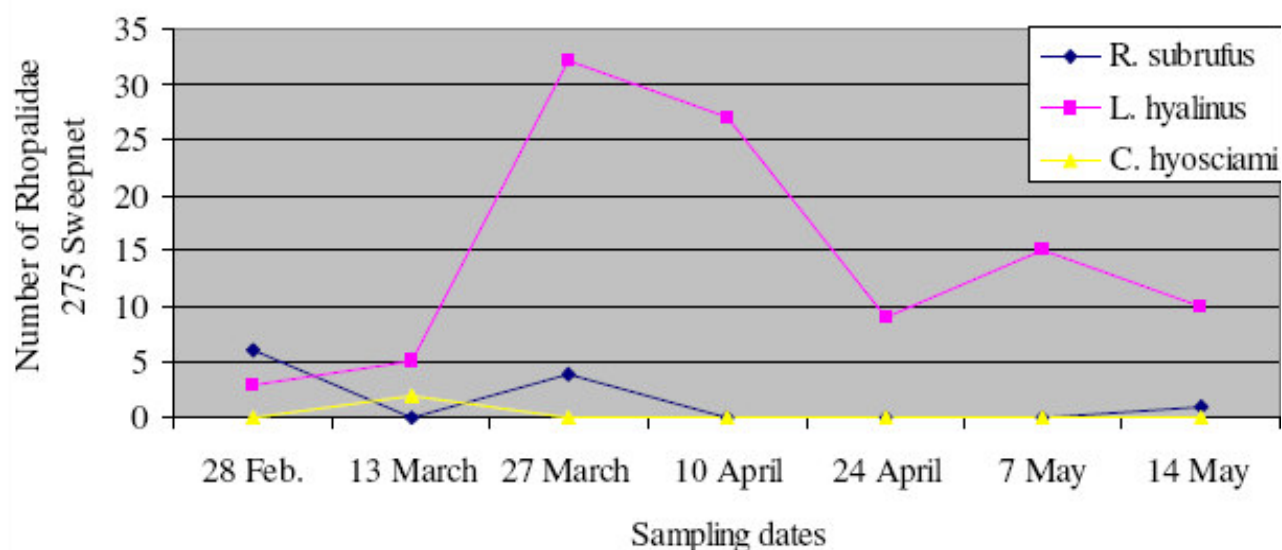
*hyalinus* (101), *Rhopalus subrufus* (11) and *Corizus hyosciami* (2) were sampled on four canola varieties at eleven localities during the sampling period (Figure 4). *Liorhyssus hyalinus* was the most abundant species during the sampling period. This species were obtained during the whole sampling period and its population level peaked in late March and decreased gradually after March. The species of *R. subrufus* were also observed during whole sampling period and yet their population decreased during the flower and pod stages of canola.

Adults of *Nysius cymoides* (Spinola, 1837) (71) (Lygaeidae) and *Odontotarsus robustus* Jakovlev, 1883 (1) (Scutelleridae) were recovered on four canola varieties at all of the localities during the sampling period. The species of the *N. cymoides* were observed during whole sampling period and their population peaked in the middle of May (Figure 5).

Population densities of adults and nymphs varied during the sampling period. Adult pest species were observed



**Figure 3.** Population densities of adult pest species of Pentatomidae on four canola varieties at eleven different localities in Hatay in 2008.



**Figure 4.** Population densities of adult pest species of Rhopalidae on four canola varieties at eleven different localities in Hatay in 2008.

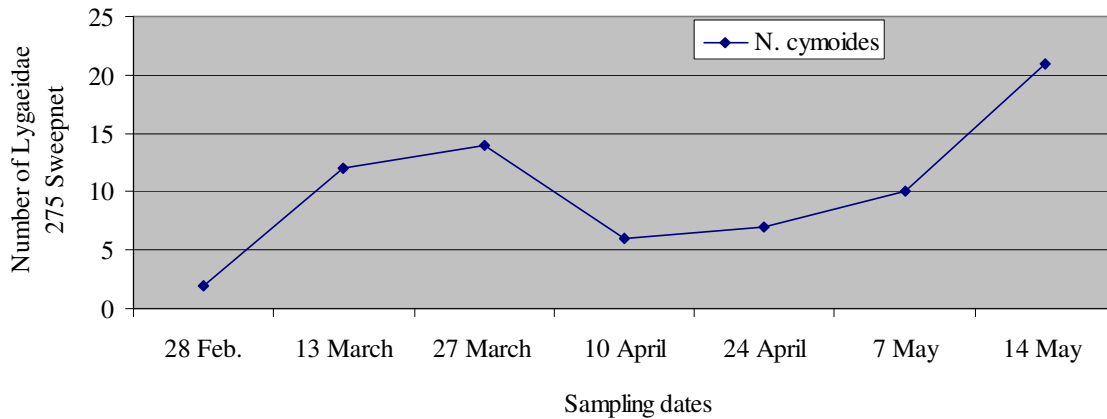
during the sampling period and also their populations were the highest in late April and in the beginning of May (Figure 6). However, population densities of the nymphs were gradually increased and peaked in late April.

Population densities of adults varied on each canola variety during the sampling period. The variety of Elvis (Atçana III) had the highest population density of adult pests on 24 April, 7 and 14 May (Figure 7). It was followed by the varieties of Elvis (Atçana II and I) and Lycosmos (Demirköprü II). Lower population densities of adult pests were observed on varieties of Sarı and Hunter (Demirköprü III). Population densities of the nymphs were varied on each of the canola variety (Figure 8). The variety of Hunter (Demirköprü II) had the highest population densities of the nymphs on 24 April and the variety of Elvis (Atçana III, II) followed it at the same date and on

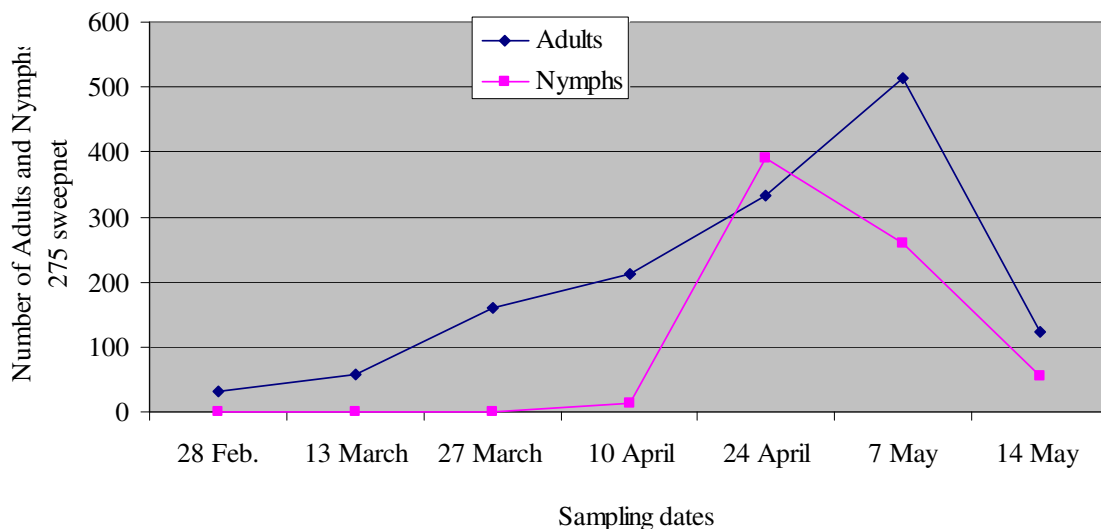
7 May.

## DISCUSSION

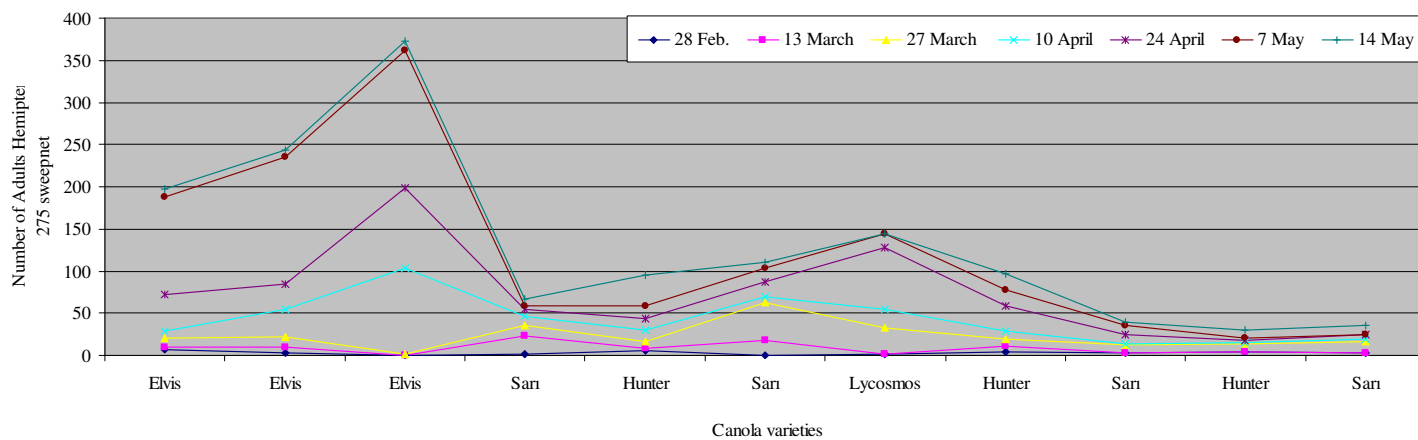
Several previous studies indicated that some of *Lygus* species are significant pests and cause economic losses on canola plants (Lamb, 1989; Brown et al., 1999; Gu et al., 2007). In a study, conducted by Önder et al. (2006) it is reported that the species of *A. lineolatus*, *E. pratensis*, *E. rugulipennis* and *C. nemoralis* found on various plants but not on canola plants in Hatay region of Turkey. In surveys of *Lygus* associated with oilseed brassicas, Leferink (1991) reported that *L. lineolaris* made up the highest population density with 82.9 % and 55.2 % in two years of Alberta, Canada. *L. borealis* and *L. desertinus* comprised the great



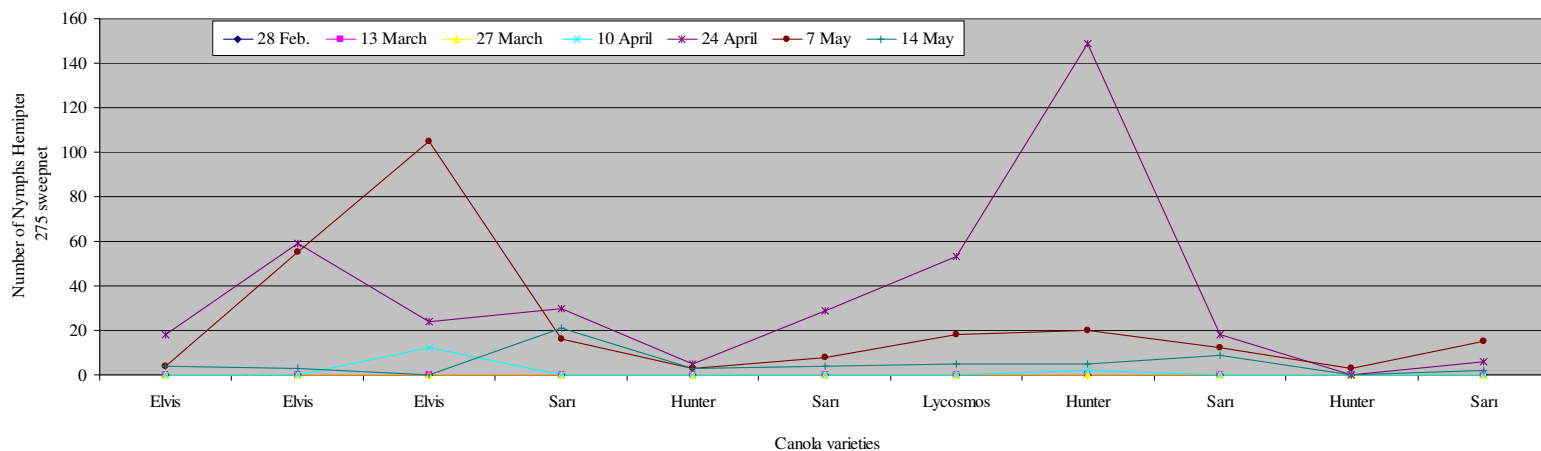
**Figure 5.** Population densities of adult pest species of Lygaeidae on four canola varieties at eleven different localities in Hatay in 2008.



**Figure 6.** Population densities of adults and nymphs on four canola varieties at eleven different localities in Hatay in 2008.



**Figure 7.** Population densities of adult pest species on whole canola varieties at eleven different localities in Hatay in 2008.



**Figure 8.** Population densities of nymph pest species on whole canola varieties at eleven different localities in Hatay in 2008.

majority of the remaining species. Butts and Lamb (1991) found *L. elisus* the most abundant *Lygus* species in oilseed rape during four years of sampling in Alberta. In some contrast, Leferink and Gerber (1997) found *L. lineolaris* to be the dominant species in all seeding in southern Manitoba, making up 55.2 % of pooled adult samples. *Lygus elisus* was second in abundance (37.1 %) and *L. borealis* was the least abundant (7.7 %).

Population densities of *Lygus* varied between plant growth stages in oilseed brassica crops (Timlick et al., 1993; Gerber and Wise, 1995; Leferink and Gerber, 1997; Wise and Lamb, 1998a, b). Population densities of Miridae species are significantly higher during early flower and pod stages of canola (Leferink, 1991; Timlick et al., 1993; Leferink and Gerber, 1997; Wise and Lamb, 1998a, b; Demirel et al., 2005; Cranshaw and Demirel, 2006; Demirel and Cranshaw, 2006; Demirel and Cranshaw, 2007). The results of the current studies were also supported by previous studies. Leferink (1991), sampling *L. lineolaris*, *L. borealis* and *L. desertinus* in canola, first observed adult *Lygus* at the beginning of flowering stages. Population density peaked during pod stages of canola. Timlick et al. (1993) reported that adults of both *L. lineolaris* and *L. elisus* reached a peak during the flowering of the host (growth stages 4.1-4.4), declined, and then peaked again in the pod stages (growth stages 5.3-5.4). Wise and Lamb (1998a) also reported that the highest plant bug densities occurred as pods developed, at growth stages 5.1 or later in the untreated check plots of each test. In Manitoba, canola is usually colonized by the second generation of *L. lineolaris* that is produced during the season and completes one generation on the crop (Gerber and Wise, 1995). Second-generation nymphs first appear at the flowering stages of the canola crop and adult *Lygus* populations reached the highest level during early pod stages (Leferink and Gerber, 1997).

Previous studies showed that there are significant pests causing significant injuries on canola plants (Lamb, 1989;

Brown et al., 1999; Gu et al., 2007). In a study, conducted by Önder et al. (2006) it is reported that the species of *A. lineolatus*, *E. pratensis*, *E. rugulipennis* and plants in Hatay region of Turkey. There was only one study conducted by Atakan et al. (2005) regarding to the canola pests in Turkey and they reported that there were 19 pest species belonging to nine different families in Adana, among which the species of *Exolygus gamellatus* H.S. and *Creontiades pallidus* Ramb. were from family of Miridae. The current study indicated that the species of *E. gemallatus*, *E. rugulipennis*, *A. lineolatus*, *E. pratensis*, *A. carinata* and *Calocoris nemoralis* of Miridae on canola plants in Hatay.

Önder et al. (2006) also reported that there are 188 Pentatomidae species in Turkey. Lodos et al. (1998) and Önder et al. (2006) reported the presence of the species of *C. purpureipennis*, *C. fuscispinus*, *C. pudicus*, *D. baccarum*, *E. ornatum*, *H. vernalis*, *E. inconspicuus* and *N. viridula* on various plants in Hatay but not canola plants. However, Atakan et al. (2005) reported the species of *E. ornatum* L., *D. baccarum* L., *C. pudicus* Poda, *H. vernalis* Wolff and *N. viridula* L. on rape (canola). With the current study the species of *E. ventrale*, *H. vernalis*, *D. baccarum*, *E. ornatum*, *C. pudicus*, *C. purpureipennis*, *C. fuscispinus*, *E. inconspicuus*, *E. fabricii* and *N. viridula* were sampled on canola plants in Hatay region of Turkey. In addition, the species of *E. ventrale* and *E. fabricii* was reported the first time in Hatay region. It can be suggested that the population levels of Pentatomidae species were too low to cause significant injuries on canola plants.

Some of the Lygaeidae species such as the false chinch bug, *Nysius raphanus* Howard (1872) and *N. vinitor* (Bergröth) are important pests on canola (Miles and McDonald, 1999; Sweet, 2000; Capinera, 2002; Demirel and Cranshaw, 2005; Demirel and Cranshaw, 2006 a,b,c,d; Demirel and Cranshaw, 2007; Gu et al., 2007). Previous study by Önder et al. (2006) reported 227

Lygaeidae species on various plants in Turkey. Lodos et al. (1999) and Önder et al. (2006) indicated that these species presented on various plants in Hatay, but not on canola plants. In the current study, *N. cymoides* was the only observed Lygaeidae species on canola plants, and its population density gradually increased and peaked during the harvest time.

Rhopalidae species of *L. hyalinus*, *R. subrufus* and *C. hyosciami* were found throughout the sampling period. Previous study conducted by Önder et al. (2006) reported that the species of *L. hyalinus* and *C. hyosciami* found commonly in Turkey. However, they did not report the species of *R. subrufus* in the Mediterranean region of the Turkey. Önder et al. (2006) reported this species on various plants but not on canola. With the current study the species of *O. robustus* (Scutelleridae) were found on canola plants in Hatay. Previous studies were conducted by Lodos et al. (1998) and Önder et al. (2006) reported this species on various plants but not on canola in Hatay. In conclusion, twenty-one species belonging to Miridae, Pentatomidae, Lygaeidae, Rhopalidae and Scutelleridae families were identified in 2008. Adult Heteroptera species of *E. gemallatus*, *E. rugulipennis*, *A. lineolatus*, *E. pratensis*, *A. carinata* and *C. nemoralis* (Miridae), *E. ventrale*, *H. vernalis*, *E. ornatum*, *D. baccarum*, *C. pudicus*, *C. purpureipennis*, *C. fuscispinus*, *E. inconspicuus*, *E. fabricii* and *N. viridula* (Pentatomidae), *L. hyalinus*, *R. subrufus* and *C. hyosciami* (Rhopalidae), *N. cymoides* (Lygaeidae), *O. robustus* (Scutelleridae) were sampled on four canola varieties at eleven localities during the sampling periods.

Population density of Miridae was the highest following by Pentatomidae, Rhopalidae, Lygaeidae and Scutelleridae at whole localities and on all four canola varieties. The species of *E. gemallatus*, *E. rugulipennis* and *A. lineolatus* (Miridae) had the highest population densities, especially increasing after the flower stage of canola and reaching the maximum levels at the pod stage.

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## REFERENCES

- Atakan E, Akdağcık Z, Ölçülü M (2005). Harmful and beneficial insect fauna and natural parasitization of some pest species in rape in Adana province. Çukurova Üniversitesi Ziraat Fakültesi Dergisi 20: 89–96.
- Borror DJ, Triplehorn CA, Johnson NF (1989). An Introduction to the Study of Insects, 6th Edition. New York, Saunders College Publishing 875p.
- Brown J, McCaffrey JP, Harmon BL, Davis JB, Brown AP, Erickson DA (1999). Effect of late season insect infestation on yield, yield components and oil quality of *Brassica napus*, *Brassica rapa*, *Brassica juncea*, and *Sinapis alba* in the Pacific Northwest region of the United States. J. Agric. Sci. 132: 281–288.
- Butts RA, Lamb RJ (1990). Injury to oilseed rape caused by mirid bugs (*Lygus*) (Heteroptera: Miridae) and its effect on seed production. Ann. Appl. Biol. 117: 253–266.
- Butts RA, Lamb RJ (1991). Seasonal abundance of three *Lygus* species (Heteroptera: Miridae) in oilseed rape and alfalfa in Alberta. J. Econ. Entomol. 84: 450–456.
- Capinera JL (2002). Handbook of Vegetable Pests. Academic Press. San Diego, San Francisco, New York, Boston, London, Sydney, Tokyo 729p.
- Cranshaw W, Demirel N (2006). Early Season Sampling of Three Pests of Oilseed Brassicas (False Chinch Bug, Phyllotreta Flea Beetles, Lygus Bugs) on Cultivated and Non-Cultivated Crops. Colo. Agric. Expt. Stn. Bull. TB06–02. 18p.
- Demirel N, Cranshaw W, Norton A (2005). Survey of *Lygus* spp. and an associated parasitoid, *Leiophron uniformis* (Gahan), in Colorado. Southwestern Entomol. 30: 9–15.
- Demirel N, Cranshaw W (2005). Evaluation of spring Canolas and Mustards of varying Age for relative Preference by False chinch Bugs, *Nysius raphanus* (Howard). Pakistan. J. Biol. Sci. 8: 665–668.
- Demirel N, Cranshaw W (2006a). Plant Yield Response to Artificial Infestation of the False Chinch Bug, *Nysius raphanus*, Confined on Spring Canola. Phytoparasitica 34: 477–485.
- Demirel N, Cranshaw W (2006b). Surveys of False Chinch Bug (FCB), *Nysius raphanus* (Howard) (Hemiptera. Lygaeidae) and their movement on cultivated crops and non-cultivated habitats throughout growing season in Colorado. J. Entomol. 3: 149–155.
- Demirel N, Cranshaw W (2006c). Permethrin treatment of pollination bags as a protecting from False Chinch Bug, *Nysius raphanus* (Howard) (Hemiptera. Lygaeidae), injury to canola in Colorado. Crop Protection 25: 1062–1064.
- Demirel N, Cranshaw W (2006d). Relative Attraction of Color Traps and Plant Extracts to the False Chinch Bug *Nysius raphanus* and Its Parasitoid, *Phasia occidentis*, on Brassica Crops in Colorado. Phytoparasitica 34:197–203.
- Demirel N, Cranshaw W (2006). Surveys of *Lygus* spp. and their movement on cultivated crops and non-cultivated habitats throughout growing season in Colorado. Pakistan. J. Biol. Sci. 9: 197–200.
- Demirel N, Cranshaw W (2007). Evaluation of Plant Yield Responses to Artificial Infestations of *Lygus elisus* (Van Duzee) and *Nysius raphanus* (Howard) on Spring Canola. J. Entomol. 4: 225–230.
- Gerber GH, Wise IL (1995). Seasonal occurrence and number of generations of *Lygus lineolaris* and *Lygus borealis* (Heteroptera: Miridae) in southern Manitoba. Can. Entomol. 127: 543–559.
- Gu H, Fitt GP, Baker GH (2007). Invertebrate pests of canola and their management in Australia. A review. Austr. J. Entomol. 46: 231–243.
- Holopainen JK, Varis AL (1991). Host plants of the European tarnished plant bug *Lygus rugulipennis* Poppius (Het., Miridae). J. Appl. Entomol. 111: 484–498.
- Jay CN, Cross JV, Burgess C (2004). The relationship between populations of European tarnished plant bug (*Lygus rugulipennis*) and crop losses due to fruit malformation in everbearer strawberries. Crop Prot. 23: 825–834.
- Karaoşmanoğlu F (2004). Biyodizel-Biyomotorin-Biodiesel. <http://www.biyomotorin-biodiesel.com/biodiesel.html>.
- Kelton LA (1975). The *Lygus* bugs (Genus *Lygus* Hahn) of North America (Heteroptera. Miridae). Mem. Entomol. Soc. Can. 95:1–101.
- Lamb RJ (1989). Entomology of oilseed brassica crops. Ann. Rev. Entomol. 34: 211–229.
- Leferink JM (1991). The biology of *Lygus* spp. (Heteroptera. Miridae) on oilseed rape in Manitoba. M.S. Thesis. University of Manitoba. pp.78.
- Leferink JM, Gerber GH (1997). Development of adult and nymphal populations of *Lygus lineolaris* (Palisot de Beauvois), *Lygus elisus* Van Duzee, and *Lygus borealis* (Kelton) (Heteroptera. Miridae) in relation to seeding date and stage of plant development on canola (Brassicaceae) in Southern Manitoba. Can. Entomol. 129: 777–787.
- Lodos N, Önder F, Pehlivan E, Atalay R, Erkin E, Karsavuran Y,



- Tezcan S, Aksoy S (1998). Faunistic studies on Pentatomoidea (Plataspidae, Acanthosomatidae, Cydnidae, Scutelleridae, Pentatomidae) of western black sea, central anatolia and mediterranean regions of Turkey. Ege Üniversitesi Basımevi. Bornova-İzmir 75p.
- Lodos N, Önder F, Pehlivan E, Atalay R, Erkin E, Karsavuran Y, Tezcan S, Aksoy S (1999). Faunistic studies on Lygaeidae (Heteroptera) of Western Black Sea, Central Anatolia and Mediterranean Regions of Turkey. E.Ü.Basımevi. Bornova, İzmir 58p.
- Miles M, McDonald G (1999). Insect pests of canola. In. Canola in Australia- the First Thirty Years (eds P.A., Salisbury, T.D., Potter, G. McDonald and A.G.Green). The canola association of Australia Inc, Young, New South Wales, Australia pp. 53–58.
- Nordlund DA (2000). The *Lygus* problem. Southwestern Entomologist. Suppl. No. 23. pp. 1–5.
- Önder F, Karsavuran Y, Tezcan S, Fent M (2006). Türkiye Heteroptera Insecta Kataloğu. Meta Basım Matbaacılık Hizmetleri. Bornova-İZMİR. 164p.
- Pedigo LP (1999). Entomology and Pest Management. Third Edition. Prentice Hall, New Jersey. 691p.
- Raymer PL (2002). Canola. an emerging oilseed crop. In. Trends in New Crops and New Uses (eds J. Janick and A. Whipkey), ASHA Press, Alexandria, USA. pp. 122–126.
- Scarisbrick DH, Daniels RW (1986). Oilseed Rape. Collins Professional and Technical Books. London 309p.
- Schuh RT, Slater JA (1995). True Bugs of the World (Hemiptera: Heteroptera). Classification and Natural History. Comstock Pub. Associates. Ithaca, NY. 336p.
- Shahidi F (1990). Canola and Rapeseed. Production, Chemistry, Nutrition and Processing Technology. Department of Biochemistry. Memorial University of Newfoundland. Van Nostrand Reinhold. New York 355p.
- Stichel W (1956 –1958). Illustrierte Bestimmungstabellen der Wanzen II Europa (Hemiptera-Heteroptera Europae) 2: 170–907.
- Stichel W (1958 –1960). Illustrierte Bestimmungstabellen der Wanzen II Europa (Hemiptera-Heteroptera Europae) 3: 1-428.
- Stichel W (1957–1962). Illustrierte Bestimmungstabellen der Wanzen II Europa (Hemiptera-Heteroptera Europae) 4: 1–830.
- Schwartz MD, Footitt RG (1992a). *Lygus* species on oilseed rape, mustard, and weeds. A survey across the prairie provinces of Canada. Can. Entomol. 124: 151- 158.
- Schwartz MD, Footitt RG (1992b). *Lygus* bugs on the prairies biology, systematics and distribution. Agriculture Canada, Research Branch. Tech. Bull.4 E: 44p.
- Sweet MH (2000). Seed and Chinch Bugs (Lygaeoidea). pp. 143–264. In. C.W. Schaefer, and A. R. Panizzi (eds). Heteroptera of Economic Importance. CRC Press, Boca Raton, London, New York, Washington, D.C. 828p.
- Timlick BH, Turnock WJ, Wise I (1993). Distributions and abundance of *Lygus* spp. (Heteroptera. Miridae) on alfalfa and canola in Manitoba. Can. Entomol. 125: 1033–1041.
- Wheeler AG Jr (2000). Plant Bugs (Miridae) as Plant Pests. Pp. 37–83. In. C.W. Schaefer, and A. R. Panizzi (eds). Heteroptera of Economic Importance. CRC Press, Boca Raton, London, New York, Washington, D.C. 828p.
- Wheeler AG Jr. (2001). Biology of the Plant Bugs (Hemiptera. Miridae). Pests, Predators, Opportunists. Comstock Publishing Associates. Cornell University Press. Ithaca and London 507p.
- Wise IL, Lamb RJ (1998a). Economic threshold for plant bugs, *Lygus* spp. (Heteroptera. Miridae), in canola. Can. Entomol. 130: 825–836.
- Wise IL, Lamb RJ (1998b). Sampling plant bugs, *Lygus* spp. (Heteroptera. Miridae), in canola to make control decisions. Can. Entomol. 130: 837–851.