Entomological Research

Entomological Research **50** (2020) 601–608

RESEARCH PAPER

Determination of some biological parameters of *Capsodes infuscatus* Brulle on summer asphodel (*Asphodelus aestivus* Brot.) in pastures of Canakkale Province

Ali ÖZPINAR[1], Efecan YAZMIŞ[1], Baboo ALI[2] and Ali Kürşat ŞAHIN[1]

[1] Faculty of Agriculture, Department of Plant Protection, Canakkale Onsekiz Mart University, Terzioglu Campus, Canakkale 17100, Turkey
[2] Faculty of Agriculture, Department of Field Crops, Canakkale Onsekiz Mart University, Terzioglu Campus, Canakkale 17100, Turkey

Correspondence
Baboo Ali, Canakkale Onsekiz Mart University, Faculty of Agriculture, Department of Field Crops – 17100, Turkey.
Email: babooali@comu.edu.tr

Received 11 May 2020;
accepted 24 September 2020.

doi: 10.1111/1748-5967.12485

Abstract

This study has been carried out in the years of 2016–2017 to determine biological parameters of *Capsodes infuscatus* Brulle (Hemiptera: Miridae) on asphodel (*Asphodelus aestivus* Broth.) in the pastures of Canakkale, Turkey. In order to determine the population fluctuation of *C. infuscatus*, counting was done twice in a week on leaves, stems and flowers of plants in two different locations in the pasture. It was determined that the *C. infuscatus* aestivates in dried asphodel stalks as eggs. The first nymphal stages can be seen at the end of February, while adult population ends at the end of May. It was observed that both the nymphal and adult stages of *C. infuscatus* were feeding together on *A. aestivus* from March to May. In 2016, an average of 7.86%, 57.26%, 8.72% and 34.12% *C. infuscatus* individuals were recorded on plant, leaves, stems and flowers, respectively. In 2017, an average of 22.08%, 67.5%, 15.0% and 17.56% *C. infuscatus* individuals were recorded on plant, leaves, stems and flowers, respectively. The mortality rates of *C. infuscatus* nymphal stages were 94.76% in grazing area and 95.77% in non-grazing area. We concluded that *C. infuscatus* has potential for the biological control of *A. aestivus*.

Key words: *Asphodelus aestivus*, *Capsodes infuscatus*, Pastures, Population fluctuation, Rangeland biocontrol

Introduction

Pastures are generally stony, arid or humid areas, which are used for animal grazing. Pastures consist of 25% of the land masses in the world that, provide 16% of the world's food production (Ojima *et al*. 1993). Turkey is in the 46th place in the world with 14.6 million ha pasture area (Work Group for Meadow and pasture plants n.d.). In our country, pastures have lost 70% of their area because of agricultural land development and urbanization. Excessive and untimely grazing are also important factors that cause hay yield loss in pastures. Related to these, weeds are not consumed by the grazing animals, resulting in invasion of the pasture in time and causing losses in fodder yield and biodiversity (Alatürk *et al*. 2018).

Asphodel (*Asphodelus* spp.) is specialized to the Mediterranean climate and it is an invasive species in pastures of Turkey (Davis 1984; Onder & Karsavuran 1986; Ozturk & Pirdal 1986; Uygun *et al*. 1994). A total of 14 different asphodel species were identified in pastures in different regions (Tuzlacı 1988). Birincioğlu *et al*. (Birincioglu *et al*. 2005) reported that the most common species *Asphodelus aestivus* (Asparagales: Asphodelaceae) is present in 10–50% of pastures. Thus, it is imperative to control asphodel population for pasture improvement studies. *Capsodes infuscatus* Brulle (Hemiptera: Miridae) is one of the herbivorous insects that can only feed on asphodel plants. This insect has been identified in South Russia, Iran, Caucasus and Turkmenistan, in addition to Mediterranean countries (Ayal & Izhaki 1993; Carvalho 1959; Stichel 1962; Wagner 1974).

In Turkey, this insect pest has been recorded in Gaziantep, Hatay, Adana, İzmir, Manisa, Balıkesir, Bursa, Canakkale

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

and Edirne Provinces (Hoberlandt 1955; Lodos *et al.* 1978; Onder 1972; Uygun *et al.* 1994). By studying the biology of *C. infuscatus* on *Asphodelus microcarpus*, different researchers have reported that the *C. infuscatus* feed on asphodel species as its host plant in the pastures of İzmir Province (Eltez 1995; Onder 1972; Onder & Karsavuran 1986).

During this research work, the presence, population fluctuation and certain biological parameters of *C. infuscatus* on asphodel (*A. aestivus*) in pastures of Canakkale Province were studied.

Materials and Methods

The main materials of this study consisted of the individuals from different biological stages of *C. infuscatus* that have been taken from pastures of Canakkale Province. A total of 20 asphodel plants were controlled in five different locations in Ayvacık, Ezine, Bayramic, Biga and Central Districts between February and May after each of 10–15-days interval aimed to determine the presence and distribution of *C. infuscatus* in Canakkale pastures, as shown in Figure 1. Pastures in Gerlengec Village of Biga District, which has the highest asphodel plant density, were selected as the location to study some biological parameters of *C. infuscatus*.

Properties of the research site

The research site is located in an area reaching out to the Marmara Sea at 26 m elevation and 20 km to Biga District situated on the Canakkale–Bursa main road with the coordinates of 40° 16′58.68“ N; 27° 26’23.37” E (Fig.1). The research site is situated in a transition zone between Mediterranean and Black Sea climates, where the total annual precipitation is recorded as 650–850 mm. Mostly, the rainfall (85%) occurs in winter and spring in these regions. Precipitation ratio is higher and more stable as compared to the other districts of Canakkale Province. The lowest temperatures have been recorded in January (3.7°C) and February (7.9°C). Summer months are found to be arid and the highest temperature reaches to 27°C in the month of August in this region (Climate Station Data from Canakkale Agriculture and Forestry Provincial Directorate 2017).

Population development of nymphal and adult stages of *Capsodes infuscatus*

Adult and immature stages of *C. infuscatus* have been sampled twice in a week periodically, between January and May of 2016 and 2017, on asphodel plants naturally found in the pastures of Gerlengec village, which is open for grazing animals. Samplings have been done from 20 randomly selected plants at two different places in the pasture



Figure 1 Gerlengec village (Biga District) pasture and its location.

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

on a total of 40 asphodel plants. Distribution of *C. infuscatus* individuals on different plant parts were determined by counting the leaves, stem and flowers of plants. We continued taking samples until the cessation of the adult emergence of *C. infuscatus*. We also counted the immature stages of *C. infuscatus* following the same method as for the adults (except on roots) in the controlled pasture, where animal grazing has been prohibited in 2017. Natural mortalities were calculated by using life tables according to procedure established by Morris (Morris 1963; Morris & Miller 1954), while parameters regarding the life tables were established as per Harcourt (Harcourt 1969).x:, sampled age group; lx:, total number of age groups in the x column; dx:, total number of dead individuals from the age groups in the x column; 100 qx:, mortality for the individuals in the x column

The number of individuals in each age group was calculated from values of peak points of individuals, because of the intermingling pre-adult age groups of *C. infuscatus* (Cheng & LeRoux 1965).

lx; Egg = Egg+ $N_1 + N_2 + N_3 + N_4 + N_5 + A$
lx; Nymph 1 = $N_1 + N_2 + N_3 + N_4 + N_5 + A$
lx; Nymph 2 = $N_2 + N_3 + N_4 + N_5 + A$
lx; Nymph 3 = $N_3 + N_4 + N_5 + A$
lx; Nymph 4 = $N_4 + N_5 + A$
lx; Nymph 5 = $N_5 + A$
lx; Adult = E

Results and Discussion

Presence and distribution of *Capsodes infuscatus*

Presence of *C. infuscatus* on the invasive weed asphodel (*Asphodelus aestivus*) was determined on all sampling areas in Canakkale Province at differing rates. The presence of *C. infuscatus* was recorded at 48% of the samplings from pastures of Biga District. This was followed by pastures in Ayvacık (38%), Ezine (17%), Bayramiç (16%) and Canakkale center (13%). Sarac and Kiyak (Saraç & Kıyak 2001) reported that the presence of *C. infuscatus* in Bozcaada (Tenedos), in addition to 38 species from nine families of Hemiptera order. The presence of *C. infuscatus* in the pastures along the coastal region from Edirne to Sanliurfa was also documented previously by Hoberlandt (Hoberlandt 1955) and Onder and Karsavuran (Onder & Karsavuran 1986).

Biological parameters of *Capsodes infuscatus*

Stems were cut at 10 cm lengths to locate eggs of *C. infuscatus*, and a high variation in the distribution of the number of eggs was recorded on 63% of the samples. There was no nymph emergence from the eggs in the stems collected on November 04, 2016 and December 27, 2016 in the climate chamber. The rate of deformation in the eggs was noted in between 24% and 36%, depending on sampling dates. The highest number of deformed eggs was observed from the initial samplings and the number of deformed eggs decreased at the later samplings (13%). Different rates of nymph emergence were recorded on the following dates and the emergence continued throughout May, as shown in Figure 2. There wasn't any nymphal emergence from the eggs in asphodel stems collected until the end of December. Nymphal emergence from the stems collected in the later dates continued parallel to the ones in natural conditions. This result has been evaluated as a failure on the part of the conditions of the climate chamber, to end the egg diapause. Eltez (Eltez 1995) reported that the egg diapause is not compulsory in the egg stages of *C. infuscatus* and nymphal emergence is possible under suitable climatic conditions, but some eggs do not hatch even under suitable conditions. Onder and Karsavuran (Onder & Karsavuran 1986) stated that the nymphal emergence starts at the beginning of December, while Eltez (Eltez 1995) reported that the emergence starts in the second week of December. But, Onder (Onder 1972) reported that the emergence of nymph in the same region starts at the end of February. According to these studies, the dates of nymphal emergence vary even in the same region and according to Eltez (Eltez 1995) the rate of nymphal emergence increases with the early rainfall in autumn and it may bring the dates of emergence earlier. Our observation on the emergence of nymphs after the beginning of February in Ayvacık district which possesses Aegean climatic conditions, supports this situation. It has also been evaluated that a lack of determining the first emergence period of the nymphal stages, which was caused by the nymphs' inability to move after emergence and moving toward the new plants for a while.

Furthermore, the hatching of eggs can take up to 9–10 months, as the eggs laid in the stem during May, start hatching in February in the pastures in Gerlengec village, reflecting the egg diapause. Similar findings on egg diapause were reported by Onder (Onder 1972) in the İzmir province.

Population development of nymphal and adult stages of *Capsodes infuscatus*

In the pastures of Gerlengec village, first nymphal emergence of *C. infuscatus* was recorded at the beginning of March and the population density consisted of different nymphal stages throughout March in the case of the studies in 2016. We observed a population mix of adult and different nymphal stages at the beginning of April. The number of adult individuals was 4.47% of the population (April 06, 2016) that reached to 92.36% a week later (April 13, 2016). By April 20 of 2016, the population density of *C. infuscatus* consisted

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

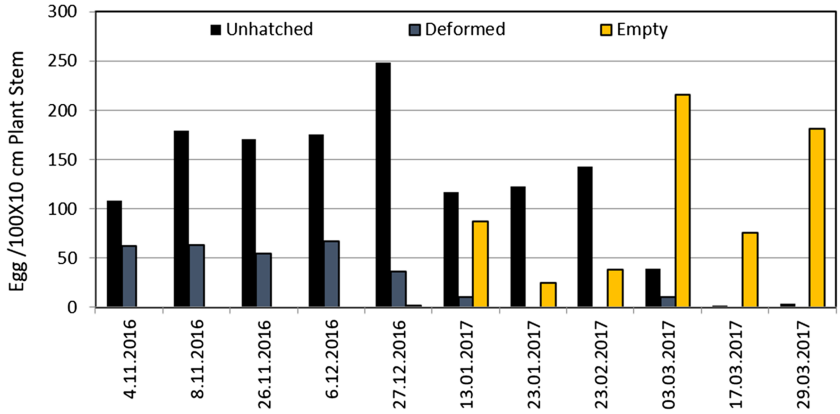

Figure 2 General properties of *Capsodes infuscatus* eggs in asphodel stems collected and cultured on different dates.

entirely of adult stage. The period of highest adult density was parallel to the flowering period of asphodel and egg laying spots were visible on flower stalks. These stalks started to dry when flowers turned to form seed and adult flight ended on May 19 of 2016 (Fig. 3). The mean number of *C. infuscatus* adult individuals per plant was recorded as 7.86% during the sampling period, and 57.26% of the population was observed on leaves, 8.72% on stems and 34.12% on flowers.

The population was made entirely from adults in the first week of May and adult flight ended on 26 May. In this period, 24.21% of the population was found on leaves, 45.23% on stems and 30.53% on flowers. Similarly, Ayal and Izhaki (Ayal & Izhaki 1993) and Samocha and Sternberg (Samocha & Sternberg 2010) found that the adult individuals of *C. infuscatus* were denser on flowers of *A. aestivus* in their studies.

On the other hand, the mean number of individuals of *C. infuscatus* per plant has been recorded as 22.08%; a ratio of 67.5% on leaves, 15% on stems and 17.56% on flowers during the sampling period in our study.

When nymph and adult emergence of both years were compared, it has been observed that the emergence of nymphal stages of *C. infuscatus* started a week earlier and adult flight ended a week later in 2016 as compared to the studies of 2017. With the increase of flowering rate resulting from the drought of 2016, the number of *C. infuscatus* individuals on flowers has also increased and the number of individuals on flower were found to be higher than 2017 (Fig. 4). Such situation shows that the biology of *C. infuscatus* is highly consistent with the physiology of *A. aestivus*. Ayal (Ayal 1994) reported that the insects feed on leaves but move to flowers with the development of plant stems. According to Sawidis (Sawidis 2012), nectar in the flowers of *A. aestivus* is attractive to *C. infuscatus* and encourages reproduction by feeding. On the other hand, nymphs forming 77.42% of the population and concentrating on leaves shows the importance of nymphs for the suppression of the plant. Reduction of development and desiccation of leaves were observed because of the necrotic lesions resulting from nymphal feeding. Ayal and Izhaki (Ayal & Izhaki 1993) also reported the negative

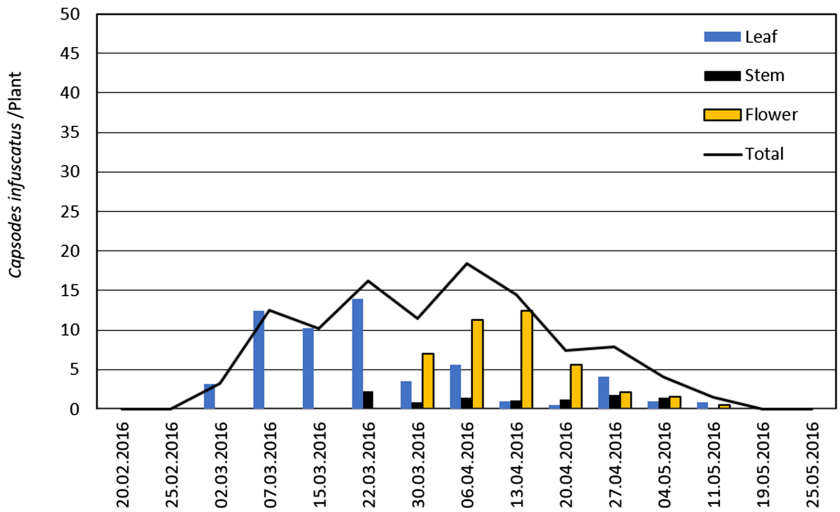

Figure 3 Population density and distribution of *Capsodes infuscatus* on different parts of *Asphodelus aestivus* in 2016.

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

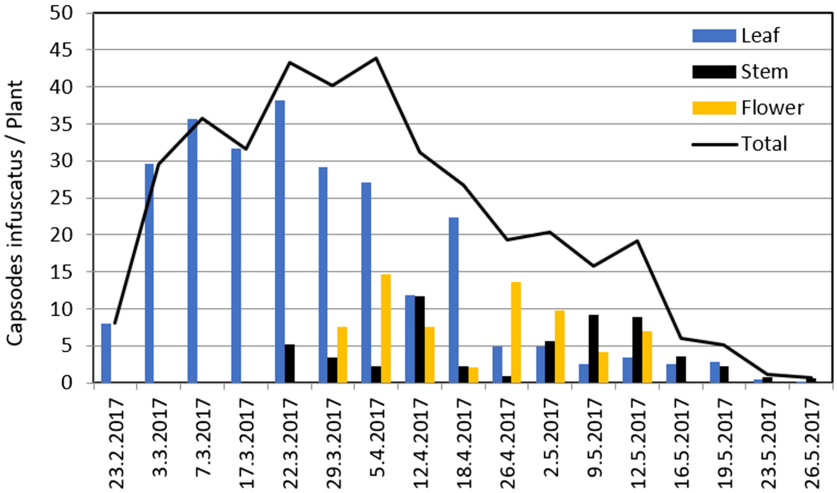

Figure 4 Population density and distribution of *Capsodes infuscatus* on different parts of *Asphodelus aestivus* in 2017.

effect of nymphal feeding on the development of stems and flowers of *A. aestivus*, with atrophy in the plant with high population density.

The effect of the relation between climatic conditions and plant development has been observed on the nymph emergence period and the termination of the adult population. Ayal and Izhaki (Ayal & Izhaki 1993) determined that the first nymph individuals of *C. infuscatus* were observed in the beginning of March and they have been attracted to fresh leaves of summer asphodel. Moreover, Onder and Karsavuran (Onder & Karsavuran 1986) reported that the feeding behavior of the first nymphal instars of *C. infuscatus* on the fresh leaves of *A. aestivus*. Another observation was the fact that the plants only develop generative organs with drought, can actually continue vegetative development with enough rainfall.

Comparison of the population development of *Capsodes infuscatus* between the non-grazing and grazing pastures

The number of individuals from grazing pasture (388.40) has been observed to be higher than that of the non-grazing pasture (280.51) throughout the sampling period (23.02.2017–26.05.2017). In the non-grazing pasture, 57.78% of the *C. infuscatus* individuals were found on leaves, 17.42% on stems and 24.79% on flowers of *A. aestivus*. In the case of the grazing pasture, the ratio was recorded as 67.5% on leaves, 15% on stems and 17.56% on flowers of the summer asphodel. Individuals of *C. infuscatus* have mostly been concentrated on leaves in the grazing pasture, while they were higher in number on stems and flowers in case of non-grazing pasture. In other words, nymphs were higher in number in March in the grazing pasture and adults were more concentrated in May in the non-grazing pasture (Fig. 5).

In May, 24.21% of the adult individuals have been recorded on leaves, 45.23% on stems and 30.53% on flowers in the grazing pasture, but this ratio has been observed as 26.53% on leaves, 41.11% on stems and 32.24% on flowers in the non-grazing pasture. In mid-April, when nymph density was high, 80.40% of the population was found on leaves, 8.58% on stems and 11.01% on flowers in case of grazing pasture, while this ratio reached 75.29% on leaves, 7.23% on stems and 17.46% on flowers in the non-grazing pasture. Insect population has been observed to be higher on flowers in non-grazing pasture with the passage of time. Izhaki *et al.* (Izhaki *et al.* 1996) mentioned the importance of the *C. infuscatus* feeding on the flowers for the suppression of the plant on the long run by weakening the sexual development of the plant.

Natural mortalities of *C. infuscatus* in grazing as well as in non-grazing pastures were compared in life tables (Table 1). In the case of the non-grazing pasture, 5.62% of the insect population reached the adult stage with a mortality of 94.76%, while the adult percentage was 4.2% and the mortality rate has been noted as 95.77% in grazing pasture. Mortality in egg stage has been recorded as 66% in non-grazing pasture with 56% of mortality rate in grazing pasture. In both pastures, natural mortality rate in the egg stage has been found to be high and this situation is thought to be related to the negative effects of abiotic factors by causing deformities because of the lengthy duration of the egg stage of *C. infuscatus*, as well as the possibility of the parasitoid species from hymenopteran order from the insect samples collected from the plant stems. In addition, an herbivorous species, *Agapanthia asphodeli,* was found during sampling (a total of 54 individuals) on the plants that is thought to have an adverse effect on nymphal emergence from the eggs of *C. infuscatus*. Because of this, more detailed studies to determine other herbivorous species on asphodel is needed. It is important to collect further information about this subject for the success of biological control.

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

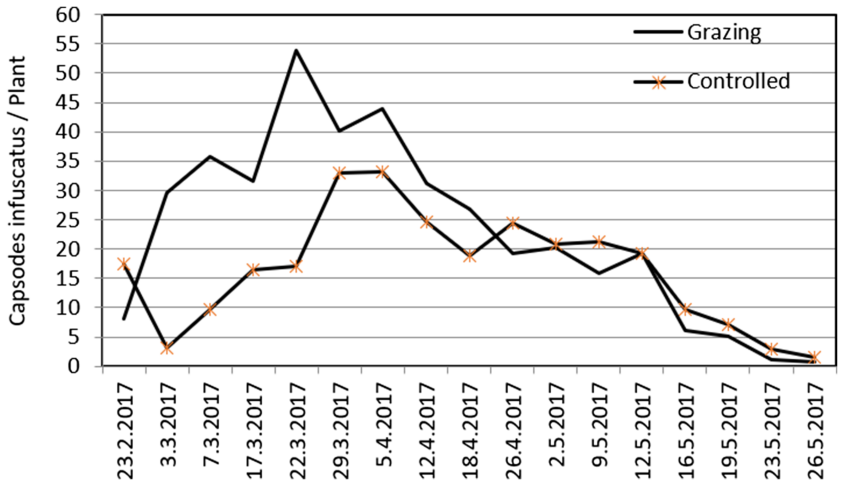

Figure 5 Population development of *Capsodes infuscatus* on *Asphodelus aestivus* in two different pastures.

Table 1 Mortality comparison of immature age groups of *Capsodes infuscatus* in grazing and non-grazing pastures with life tables

Age groups	Non-grazing pasture			Grazing pasture		
	lx	dx	100 qx	lx	dx	100 qx
Egg	402.13	265.00	0.66	480.04	265.00	0.56
1st nymph	137.13	17.50	0.13	215.04	29.55	0.14
2nd nymph	119.63	16.50	0.14	185.49	35.73	0.20
3rd nymph	103.13	32.93	0.32	149.76	31.63	0.22
4th nymph	70.20	24.65	0.35	118.13	53.90	0.46
5th nymph	45.55	24.40	0.54	64.23	43.93	0.68
Adult	21.15	0.00	0.00	20.30	0.00	0.00

x, sampled age group; 1x, total number of age groups in the x column; dx, total number of dead individuals from the age groups in the x column; 100 qx, mortality for the individuals in the x column.

In the early nymphal stages, mortality rate has been found similar in both pastures, while it was higher in grazing pasture in the 4th and 5th nymphal stages. This result was evaluated as a result of the effect of decreasing humidity on the plants and *C. infuscatus* individuals, which was caused by the increase in grazing activities in April. This hypothesis is confirmed by the shorter period of adult presence on flowers in the grazing pasture than that of the non-grazing pasture.

Even though the mean number of individuals in the non-grazing pasture (16.50) was lower than that of the grazing pasture (22.08), the number of adult individuals in the non-grazing pasture was found to be higher as compared to the grazing pasture. Non-grazing pasture was found to be a more stable environment for the continuation of the population.

Consequently, the population of the nymphal and adult stages of *C. infuscatus* was mostly concentrated on flowers in 2016 and on leaves in 2017. This finding is associated with the early generative development of the plants caused by an arid April in 2016. Population density of *C. infuscatus* was three to four times higher in 2017 than that of 2016 before the flowering period of *A. aestivus* plants.

In the pasture of Gerlengec village, 1st and 2nd nymphal stages of *C. infuscatus* were observed at the end of February in 2017, while 3rd nymphal stages have been found on 7March, 4th nymphal stage on 22 March and 5th nymphal stage on 12 April. Adults were first observed on the 18 April, and nymph and adult density have reached maximum level at the end of April. In natural conditions, nymphal stages of *C. infuscatus* have continued for a period of 50–60 days and adult stages for 25–30 days. First egg laying was observed on 2 May and continued until 26 May. According to Eltez (Eltez 1995), there was a 14-day period between the first appearances of adults until a complete population of the adult individuals with adult flight ending on 30 May. It has been determined that *C. infuscatus* completes one generation per year under natural conditions, its biology is in harmony with asphodel and the egg stage continues for 9–10 months, mostly in desiccated stems, and nymphal emergence generally starts after the end of February. Population density of *C. infuscatus*

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

has reached its peak point at the end of May and at the beginning of April. The quantitative increase on the flowers after mid-April is associated with the egg laying behavior of female adult individuals.

The feeding damage caused by *C. infuscatus* nymph as well as the adult individuals on the leaves, stems and flowers of summer asphodel, and the harmony between the phenology of the plant and the biological stages of the insect indicates the importance of *C. infuscatus* for the biological control of *A. aestivus* in pastures.

Conclusions

Based on the results of the study, we can say that the presence of *C. infuscatus* on the invasive weed asphodel (*Asphodelus aestivus*) was determined on all sampling areas in Canakkale Province at differing rates. In this study, we determined the hatching period of *C. infuscatus* as 9–10 months in nature and first nymphs emerge in March, with the population consisting of completely adults from April. We also observed that *C. infuscatus* feeds on different parts of the plants and this kind of choice of feeding areas seems to be related to the phenological development of the plant and climate. These results indicate that feeding damage from *C. infuscatus* on flowers seems to have an important effect on the reproduction of asphodel. Results of this study can be used as a basis to develop biological control programs against the invasive plant *A. aestivus* in meadows.

References

Alatürk F, Gökkuş A, Ali B *et al*. (2018) The effects of different herbicides and their application seasons on controlling of *Asphodelus aestivus*. *New Knowledge Journal of Science* **7**: 105–111.

Ayal Y (1994) Time-lags in insect response to plant productivity: significance for plant insect interactions in deserts. *Ecological Entomology* **19**: 207–214.

Ayal Y, Izhaki I (1993) The effect of the Mirid Bug *Capsodes infuscatus* on Fruit Production of the Geophyte *Asphodelus ramosus* in a Desert Habitat. *Oecologia* **93**: 518–523.

Birincioglu SS, Çalış I, Avcı H *et al*. (2005) Pathological and Phytochemical Investigation of Neuronal Lipofuscinosis Caused by *Asphodelus aestivus* in sheep: I. Pathological Findings. *Turkish Journal of Veterinary and Animal Sciences* **29**: 1351–1356.

Carvalho JCM (1959) Catalogue of the Miridae of the World. Part IV. Subfamily Mirinae. *Arquivos do Museu Nacional* **48**: 1–384.

Cheng HH, LeRoux EJ (1965) Preliminary life tables and notes on mortality factors of the birch leaf miner, *Fenusa pusilla* (Lepeletier) (Hymenoptera: Tenthredinidae), on blue birch, *Betula caerulea grandis* Blanchard, in Quebec. *Annal. Soc. Entomol. du Quebec* **11**: 81–104.

Climate Station Data from Canakkale Agriculture and Forestry Provincial Directorate 2017.

Davis, PH (1984) Flora of Turkey and the East Aegean Islands. *Flora of Turkey* (Vol. **8**, pp. 632). Edinburg, Scotland: Edinburg University Press. https://www.pandora.com.tr/kitap/flora-of-turkey-and-the-east-aegean-islands-v-8/428754

Eltez, S. Researches on morphology, biology and damage types of *Capsodes infuscatus* (Brul.) (Heteroptera: Miridae) living on asphodel (*Asphodelus microcarpus* Viv.) in İzmir Province. Doctorate Thesis, E.Ü. Fen Bilimleri Enst., Turkey, 1995.

Harcourt DC (1969) The development and use of life tables in the study of natural insect populations. *Annual Review of Entomology* **14**: 175–196.

Hoberlandt L (1955) Results of the Zoological Scientific Expedition of the National Museum in Prague to Turkey. 18. Hemiptera IV. Terrestrial Hemiptera-Heteroptera of Turkey. *Acta Entomologica Musei Nationalis Pragae* **3**: 1–264.

Izhaki I, Maestro N, Meir D *et al*. (1996) Impact of the mirid bug *Capsodes infuscatus* (Hemiptera: Miridae) on fruit production of the geophyte *Asphodelus aestivus*: the effect of plant density. *Florida Entomologist* **79**: 510–520.

Lodos N, Önder F, Pehlivan E, Atalay R (1978) Ege ve Marmara Bölgesinin Zararlı Böcek Faunasının Tespiti Üzerinde Çalışmalar; Zir. Müc.Zir. Lar. Gn. Md. Yay. İzmir, Turkey, 301 p.

Morris RF (1963) The dynamics of epidemic spruce budworm populations. *Memoirs of the Entomological Society of Canada* **31**: 180–189.

Morris RF, Miller CA (1954) The development of life tables for the spruce budworm. *Canadian Journal of Zoology* **32**: 283–301.

Ojima DS, Dirks BOM, Glenn EP *et al*. (1993) Assessment of C budget for grasslands and drylands of the world. *Water, Air, and Soil Pollution* **70**: 95–109.

Onder F (1972) Researches on identification, hosts, distribution and short biologies of plant pest Mirinae (Miridae: Hemiptera) species in İzmir Province. *Ege Üniversitesi Ziraat Fakültesi Dergisi* **9**: 221–224.

Önder F, Karsavuran Y (1986) Observations on effectiveness of Capsodes infuscatus (Brul.) (Heteroptera: Miridae) as a biological control agent of asphodel (*Asphodelus microcarpus* Viv.). Türkiye 1st BBiological Control Congress, Feb. 12–14, 1986.

Ozturk M, Pirdal M (1986) Studies on the germination of Asphodelus aestivus Brot. *Biotronics*, **15**: 55–60.

Samocha Y, Sternberg M (2010) Herbivory by Sucking Mirid Bugs can Reduce Nectar Production in *Asphodelus aestivus* Brot. *Arthropod-Plant Interactions* **4**: 153–158.

Saraç Ö, Kıyak S (2001) A study on the Heteroptera Fauna of Bozcaada (Canakkale Province). *Turkish Journal of Zoology* **25**: 313–322.

Sawidis T (2012) The Secretory Glands of Asphodelus aestivus Flower, Botany, Dr. John Mworia (Ed), ISBN: 978-953-51-0355-4, InTech. Available from: http://www.intechopen.com/

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd

books/botany/the-secretory-glands-of-asphodelus-aestivus-flower

Stichel W (1962) Illustrierte Bestimmungstabellen der Wanzen, II. Europa (Hemiptera Heteroptera Europae). 5 vol., Berlin Hermsdorf (Martin–Lutherstrasse 39), 1955–1962, Bulletin de la Société entomologique de France, **67**(7–8): 192–194.

Tuzlacı E (1988) Distribution of Asphodeline (Liliaceae) axons in Turkey. *Doğa. Türk. Bot. Derg.* **12**: 71–84.

Uygun N, Koç NK, Uygur N, Karaca I, Uygur S, Küskek M (1994) Weeds and their natural enemies in pasture areas in the South-east Mediterranean Region. Türkiye 3rd Biological Control Congress, Jan. 25–28 1994, İzmir, Turkey, 321–330.

Wagner E (1974) Die Miridae Hahn,1831, des Mittelmeerraumes und der Makaronesischen Inseln (Hemiptera). Teil 2. *Entomologische Abhandlungen Museum für Tierkunde* **39**: 1–421.

Work Group for Meadow and pasture plants n.d. Available online: https://www.tarim.gov.tr/TAGEM/Belgeler/Sunular/%C3%87MYB_Birg%C3%BClG%C3%BCner.PDF (accessed on 05.09.2019).

© 2020 The Entomological Society of Korea and John Wiley & Sons Australia, Ltd