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Density of *Centaurea solstitialis* L. and Its Natural Enemies *Ceratapion* spp. in Southern Turkey

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Abstract: *Centaurea solstitialis* L., yellow star thistle, is an annual weed that belongs to the family Asteraceae. In Turkey, this weed can be found in pasture areas, along roadsides, in cultivated areas and in field margins. Yellow star thistle is native to Mediterranean and western Asian countries. Alternative management strategies to chemical control have been and still are being studied; for example, management strategies to control this weed in the USA concentrate on the biological control approach. In addition, chemical control methods in pasture areas are banned in Turkey, which led us to carry out this field study. The average percentage cover of yellow star thistle on the selected study sites at an altitude of 0-1623 m in southern Turkey was 22.56%. Three fungi and 15 arthropod species were found on yellow star thistle during the survey and rearing study. These were *Helminthosporium* sp., *Alternaria* sp., *Puccinia* sp., *Bangasternus orientalis, Ceratapion basicorne, Ceratapion* sp., *Phytoecia humeralis, Eustenopus villosus, Haplothrips reuteri, Lixus cardui, Strophosoma melanorammum, Uroleucon jacea, Diplapion detritum, Larinus curtus, Larinus grisescens, Lixus scolopax, Urophora* sp. and *Aceria solstitialis*. Among these species, *Ceratapion* spp. had the highest infestation rate (18.4%), and 1-6 larvae per attacked plant. An important observation made with regard to *Ceratapion* spp. was that they do not feed on yellow star thistle seeds, but their larvae mine the root crown of plants that have reached the rosette stage.

Key Words: Biological control, weed, *Centaurea solstitialis*, *Ceratapion* spp.

Centaurea solstitialis L.'in ve Doğal Düşmanı Ceratapion'un Türkiye'nin Güneyindeki Yayılışı

Özet: Sarı Peygamber Çiçeği, *Centaurea solstitialis* L., Asteraceae familyasından tek yıllık bir yabancı ottur. Ülkemizde çayır-mera alanları, tarla ve yol kenarları ile bazı kültür alanlarında bulunmaktadır. Yabancı otun anavatanı Akdeniz ve Asya ülkeleridir. Yabancı otun mücadelesi için kimyasal ve alternatif mücadele yöntemleri araştırılmakta olup, araştırmalar özellikle ABD'de biyolojik mücadele üzerine yoğunlaşmıştır. Ülkemizde de çayır-mera alanlarında kimyasal bir yabancı ot mücadelesi mümkün olmadığından biyolojik mücadeleye yönelik olarak bu çalışma planlanmıştır. Türkiye'nin güney kısmında, 0-1623 m. yüksekliğindeki alanlarda bu yabancı otun kapladığı alan ortalama % 22,56 bulunmuştur. Sarı Peygamber Çiçeği üzerinde üç fungus türü ve 15 artropod türü saptanmıştır. Bunlar; *Helminthosporium* sp., *Alternaria* sp., *Puccinia* sp., *Bangasternus orientalis*, *Ceratapion* basicorne, *Ceratapion* sp., *Phytoecia humeralis, Eustenopus villosus, Haplothrips reuteri, Lixus cardui, Strophosoma melanorammum, Uroleucon jacea, Diplapion detritum, Larinus curtus, Larinus grisescens, Lixus scolopax, Urophora* sp. ve *Aceria solstitialis*'dir. Bunlardan en fazla bulaşıklık oranına % 18,39 ile *Ceratapion* türleri sahip olup bir bitki 1 ila 6 arasında larva içermektedir. Bu böceğin bir önemi de yabancı otun tohumları ile değil henüz rozet döneminde iken larvaların kök boğazında beslenmesinden kaynaklanmaktadır.

Anahtar Sözcükler: Biyolojik mücadele, yabancı ot, *Centaurea solstitialis*, *Ceratapion* spp.

Introduction

Centaurea solstitialis (yellow star thistle) is an annual weed species and belongs to the family Asteraceae and tribe Carduinae. There are 3 subspecies of this weed in Turkey (Davis, 1975). It is native to Eurasia and occurs throughout the Mediterranean Basin. This species has been recorded as a weed in pastures, rangelands, and some croplands in the eastern Mediterranean region of Turkey and in central Anatolia (Kurçman, 1991; Uygun et al., 1996; Uygur, 1997). It reduces the productivity of pastures because sheep, goats and cattle avoid the spiny flower heads. It is a successful competitor and can also

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dominate the native plant community and reduce biodiversity. The weed is toxic to horses, causing brain lesions that eventually kill the animal (Cordy, 1978), and a high population stand can become a fire hazard along roadsides and irrigation canals.

Yellow star thistle is known as a summer weed in southern Turkey. The plants germinate in spring, grow during the summer and become mature at the end of summer. Flowering time is between June and August, as reported by Davis (1975).

This species is also an invasive alien weed in the USA, where it replaces native vegetation in pastures and rangelands in California and western United States (Duncan, 2001). Biological, chemical or integrated management strategies have been researched and applied, mainly in the United States, against yellow star thistle (Balciunas and Villegas, 1999; DiTomaso et al., 1999). Introduced biocontrol insects in the United States were all capitula feeders. Capitulum-infesting insects have been investigated on yellow star thistle in different countries over the past 30 years.

Recently, special attention has been paid to *Ceratapion* species, because they attack the seedlings and rosettes of yellow star thistle. Species of this genus, that have therefore been considered important potential biological control agents, were identified in Greece and Italy (Clement et al., 1989). However, little is known about the population density of yellow star thistle and its natural enemy complex, in particular *Ceratapion* spp., in Turkey.

The objectives of this study were to measure density of the yellow star thistle population, as well as to develop a list of insect and fungal natural enemies occurring on yellow star thistle in Turkey. In addition, we investigated the occurrence of potential biological control agents, and the importance of root-borer weevils, *Ceratapion* spp., and the plant's ecological needs such as habitat, soil type and altitudes in southern Turkey.

Materials and Methods

Field surveys were carried out in central and southern Anatolia between May and August in 1999 and 2000. Starting from Adana, we drove in selected directions, and stopped every 25 km if *C. solstitialis* occurred in the site. Each site was visited once.

In total, 22 sites were surveyed in 1999, and 19 sites in 2000 (Figure 1). During these surveys, the areas surrounding Adana, Mersin, Niğde, Konya, Nevşehir, Kayseri, Karaman, Isparta, Burdur and Antalya provinces were investigated. Surveys were performed during May-August, when *C. solstitialis* was in the rosette or flowering stage.

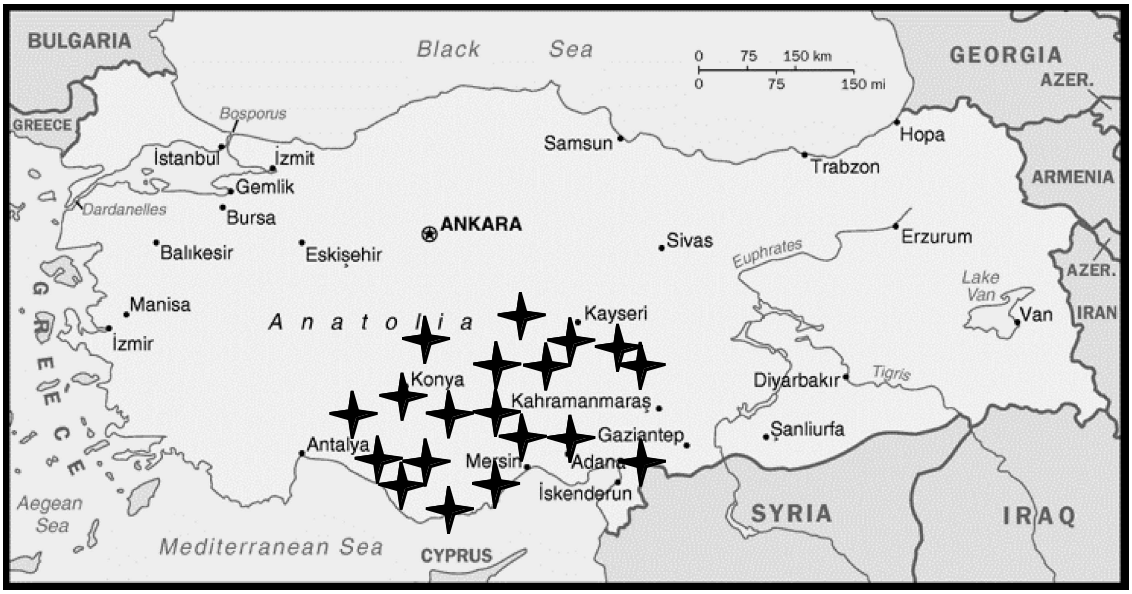

Figure 1. Surveyed areas in Turkey (1999-2000).

At each survey point (25 m^2 area), the population of yellow star thistle was recorded as percentage cover. Certain numbers (minimum 2, maximum 20 plants) of yellow star thistle (depending on the weed population) were examined for arthropods (especially *Ceratapion* spp.) and pathogens visually and by dissecting the plants. In addition, date, geographical coordinates, soil type (classified as loam, silt, clay, sandy, stony, peat, sandy-stony, clay-stony, stony-silt or silt-stony), habitat (classified as field, roadside, field margin, forest, aquatic, coastal area or other), plant stage, altitude, infestion rate of *Ceratapion* spp. and other natural enemies were recorded. Percentage infestion rate was that of all *C. solstitialis* plants that were infested. All data were recorded on the survey data sheet.

When disease symptoms were found on *Centaurea* plants, specimens were taken to the laboratory. Fungi were isolated from differently sized and colored lesions. They were maintained on potato dextrose agar and identified by specialists.

During the surveys, arthropod species were collected from the inside or the outside of the weed were pinned or stored in ethanol, and were sent to specialists for identification.

Flower heads of *C. solstitialis* were collected from 3 different ecological habitats to determine attack by insects. Matured capitula collected from 10 randomly selected plants at 3 sites (August 2, 1999 in Çatalan/Adana and July 27, 1999 in Çamardı/Niğde and Göreme/Kayseri) were counted to determine numbers of capitula and were then transferred to paper bags and overwintered in the laboratory. In February 2000, the bags were opened. Adult insects reared from the heads were recorded and pinned to be identified by a specialist. Larvae of a species in the stem of *C. solstitialis* were seen later and reared for adult emergence in laboratory conditions.

Results

The percentage cover of yellow star thistle at the infested sites surveyed was on average 22.6% (range 3 to 60%). Yellow star thistle was primarily found on field margins and roadsides (Figure 2).

The soil types were different at the survey points (Figure 3). These were sandy-stony, clay-stony, stony, silt-stony, clay and sandy.

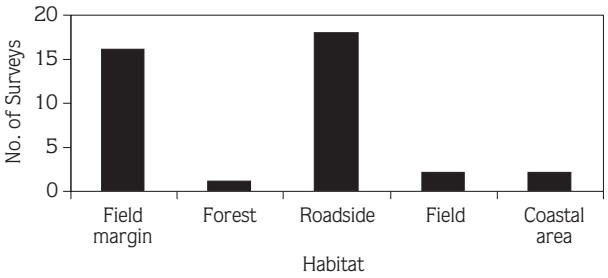

Figure 2. Habitats of surveyed area.

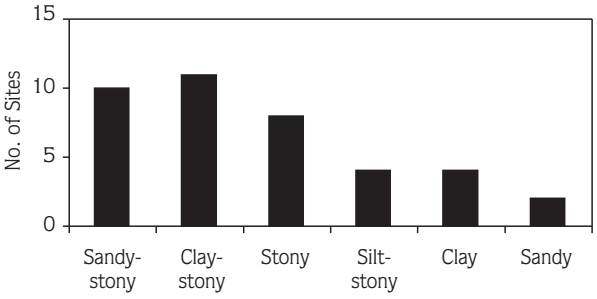

Figure 3. Soil types of surveyed areas.

Altitudes of the survey points varied between 0 and 1623 m. Most areas were in the 1000-1500 m range (Figure 4).

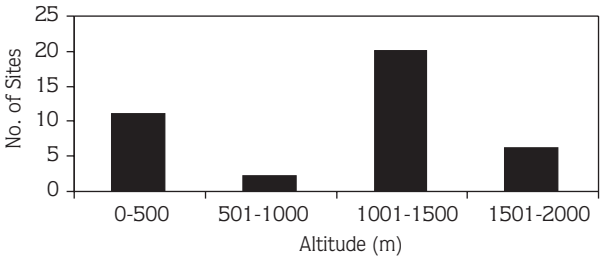

Figure 4. Altitudes of surveyed areas.

Three fungi species and 11 arthropod species were identifed on the leaves, stems, flower heads and in the root crown of yellow star thistle (Table 1). *Ceratapion* species were identified as *Ceratapion basicorne* (Illiger) and *Ceratapion* sp. These adults were collected directly in the field from inside the root crown of *C. solstitialis*.

An additional 3 species were recorded belonging to the family Curculionidae: *Diplapion detritum*, *Larinus curtus* and *Larinus grisescens* were reared from the flower head of yellow star thistle under laboratory conditions. *Lixus scolopax* was also reared from the stem of the weed.

Table 1. Natural enemies of *Centaurea solstitialis* L. in southern Turkey .

Natural Enemies	Plant Part Attacked	Infestation Rate (%)
Helminthosporium sp.	Leaves	6.43
Alternaria sp.	Leaves	2.06
Puccinia sp.	Leaves	2.75
Bangasternus orientalis (Coleoptera: Curculionidae)	Leaves and flower head	3.21
Ceratapion basicorne *Ceratapion* sp. (Coleoptera: Curculionidae)	Root crown, flower	18.39
Phytoecia humeralis (Coleoptera: Cerambycidae)	Stem	7.35
Aceria solstitialis (Acarina: Eriophyidae)	Leaves	2.29
Eustenopus villosus (Coleoptera: Curculionidae)	Flower head	1.37
Haplothrips reuteri (Thysanoptera: Thripidae)	Flower head	1.60
Lixus cardui (Coleoptera: Curculionidae)	Stem	0.22
Strophosoma melanorammum (Coleoptera: Curculionidae)	Flower head	0.22
Uroleucon jacea (Hemiptera: Aphididae)	Leaves	5.97
Urophora sp. (Diptera: Tephritidae)	Flower head	0.45
Lixus scolopax (Coleoptera: Curculionidae)	Stem	Reared
Diplapion detritum (Coleoptera: Curculionidae)	Flower head	Reared
Larinus curtus (Coleoptera: Curculionidae)	Flower head	Reared
Larinus grisescens (Coleoptera: Curculionidae)	Flower head	Reared

The larval stage of *Ceratapion* spp. was found between May and July (above 1000 m). The larvae feed on the root crown of yellow star thistle. In the rearing study, adults emerged in June. Each infested plant contained between 1 and 6 larvae in its root (Figure 5). In total, 80 out of 435 yellow star thistle were infested by *Ceratapion* spp. (18.4% infestation rate). In *Ceratapion* the areas infested weree nearly 60%, 80 out of 135 plants. The infestation rate of other natural enemies is shown in Table 1.

When we looked at the ecological parameters of the surveyed areas and the occurrence of *Ceratapion* spp., the

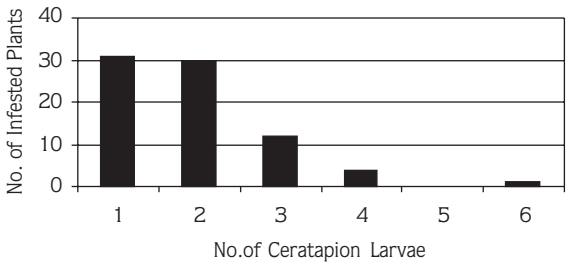

Figure 5. Number of *Ceratapion* sp. larvae in the root crown of *Centaurea solstitialis* L.

highest percentage was found in field margins. It was observed that 37.50% of field margins surveyed were infested with *Ceratapion* species, although in forest and coastal areas there were not *Ceratapion* species recorded (Table 2).

Among the soil types studied, sandy-stony soil was the most suited to *Ceratapion* spp. (50.00%). Stony soil was the second choice for the insect (Table 3). In terms of altitude, the frequency of *Ceratapion* species was between 18.18 and 50.00%, and altitudes greater than 500 m seem desirable for the insect (Table 4).

Discussion

Biological control is the most preferable method for managing weeds because it is cheaper and safer in the

Table 2. Relationship between habitat and occurrence of *Ceratapion* spp.

Habitats	No. of Surveyed Areas	No. of *Ceratapion* spp. infested areas	Frequency (%) of *Ceratapion* spp.
Field margins	16	6	37.50
Forest	1	0	0.00
Roadside	19	7	36.84
Field	3	1	33.33
Coastal area	2	0	0.00
Total	41	14	35.00

Table 3. Relationship between soil types and occurrence of *Ceratapion* spp.

Soil Types	No. of Surveyed Areas	No. of *Ceratapion* spp. infested areas	Frequency (%) of *Ceratapion* spp.
Sandy-stony	10	5	50.00
Clay-stony	12	3	25.00
Stony	8	3	37.50
Silt-stony	4	1	25.00
Clay	4	1	25.00
Sandy	3	1	33.33
Total	41	14	35.00

Table 4. Relationship Between Altitudes and Occurance of *Ceratapion* spp.

Altitude (m)	No. of Surveyed Areas	No. of *Ceratapion* spp. infested areas	Frequency (%) of *Ceratapion* spp.
0-500	11	2	18.18
501-1000	3	1	33.33
1001-1500	21	8	38.09
1501-2000	6	3	50.00
Total	41	14	35.00

long term. Other control strategies can be expensive and logistically difficult.

The first step in biological control studies is to learn more about the target weed population, its ecological parameters and natural enemies. The results of this study indicated that yellow star thistle is a common weed species in the southern parts of Turkey and its coverage reaches 60% in some locations.

Rust fungi, *Puccinia jacea* var. *solstitialis* in central Anatolia, *Puccinia centaurea* in the eastern Mediterranean region and *Puccinia calcitrapae* in Erzurum have been previously found in Turkey (Erciş, 1989; Uygun et al., 1996; Demirci et al., 1997). Although no pathogens have yet been released for the control of yellow star thistle, a number of species have been evaluated, including *Fusarium oxysporum* f. sp. *carthami, Verticillium dahliae, Phytophthora* spp., *Botrytis cinerea, Sclerotinia sclerotiorum, Sclerotinia minor, Ascochyta* n. sp., *Colletotrichum gloeosporioides*, and *Puccinia jaceae*. Some of these pathogens have been found to be promisiny (DiTomaso, 2003).

However, there are no records concerning *Helminthosporium* sp. and *Alternaria* sp. These pathogens may be of interest for a mycoherbicidal approach to control yellow star thistle in future studies.

Control of the weed with insect agents can be achieved by species boring into the roots, shoots and stems, defoliators, seed predators, or by species extracting plant fluids. All these effects can reduce the competitive ability of the plant relative to the surrounding vegetation (DiTomaso, 2003). Insect species that have been released in California against yellow star thistle are a seed-head fly (*Urophora sirunaseva*), a seed-head weevil (*Bangasternus orientalis*), a peacock fly (*Chaetorellia australis*), a false peacock fly (*Chaetorellia succinea*), a hairy weevil (*Eustenopus villosus*) and a flower weevil (*Larinus curtus*). However, only 4 of these are widely established; *C. succinea, B. orientalis, E. villosus* and *L. curtus*. The latter 3 species were found in this study in southern Turkey. Additional biological control agents have been reported by Sforza and Cristofaro (2002), who found *C. basicorne*, *Tingis grisea, Larinus filiformis, Aceria* sp. and *Psylliodes* sp. on yellow star thistle in eastern and central Anatolia.

From the *Ceratapion* species, root-boring weevils attack the seedlings and rosettes of yellow star thistle. They were also the most important agents in terms of infestion rate; their infestation rate is 18.39% for all locations. This rate was 59.25% in attacked locations in the areas studied. These results show how important and promising this insect is. Frequency (%) of *Ceratapion* species under different ecological parameters was highest in field margins, sandy-stony soil types and at altitudes greater than 1500 m. This indicated that this insect could be useful in the future, especially for pasture areas, if further studies prove promising. *Ceratapion basicorne, C. orientale* (Gerstaecker), *C. scalptum* and *Diplapion detritum* (Mulsant & Rey) have been reared from yellow star thistle in central Turkey (Rosenthal et al., 1994), but all of these were rare on yellow star thistle, except for *C. basicorne*. The second most important agent was *Phytoecia humeralis*,with an infestation rate of 7.4%. Another promising agent may be *Aceria solstitialis* found during this survey, because Eriophyid mites are host specific and have been repeatedly used for biological control of weeds. Other natural enemies may also be of interest, but further studies are needed to assess this.

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