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Investigation of Symptoms and Hosts of Semi Parasite Plant Species in East Mediterranean and Central Anatolia Region of Turkey

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ABSTRACT

This study was carried out to determine the symptoms and hosts of the semi parasitic plant species causing problems on the forest and fruit trees in the East Mediterranean (Kahramanmaras) and Central Anatolia region (Nigde) in 2012-2016. When these semi parasitic plants appear on the plants, they can cause swelling at the germinated sites of branches of their host and resulting backward tissue drying. It has also been observed to cause the host to die completely in some host such as almonds and apricot. The study was conducted in Nigde, through the Mistletoe survey performed on some fruit and park trees and the results indicated that a subspecies of semi parasitic. *Viscum album* naming *Viscum album ssp. album* was living on these trees. The whitethorn, wild pear, Ankara pear, almond, Braeburn apple, plum, apricot, sour cherry, locust, Canada poplar and willow were found to be the host for *Viscum album* ssp. *album.* Other mistletoe species; *Viscum album* ssp. *abietis* was seen on Taurus fir and Taurus cedar while *Viscum album* subsp. *austriacum* on *Pinus nigra* subsp. *pallasiana.*

In Kahramanmaras, Dwarf mistletoe *(Arceuthobium oxycedri)* was seen on Small fruited pine (*Juniperus oxycedrus* subsp. *oxycedrus*), Crimean juniper (*Juniperus excelsa* Bieb.) and Syrian juniper (*Juniperus drupacea* Labill.); Yellow mistletoe (*Loranthus europaeus*) was seen on Turkey oak (*Quercus cerris*) and Aleppo oak (*Quercus infectoria*); White mistletoe (*Viscum album* subsp. *abietis)* on Taurus fir (*Abies cilicia* subsp. *cilicica)* and Taurus cedar (*Cedrus libani*); Pine mistletoe (*V. album* subsp. *austriacum*) was seen on Pinus nigra (*Pinus nigra* subsp. *pallasiana*). On the other hand, *Viscum album* ssp. *a lbum* was not found on any host in Kahramanmaras.

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Türkiye'nin Doğu Akdeniz ve İç Anadolu Bölgeler'inde Görülen Yarı Parazit Bitki Türlerin Konakları ve Simptomlarının Araştırılması

ÖZET

Bu çalışma 2012-2016 yıllarında Niğde ve Kahramanmaraş illerinde meyve ve orman ağaçlarında sorun olan yarı parazit bitki türlerinin, konukçuları ve simptomlarını belirlemek için yapılmıştır. Bu yarı parazit bitkiler konukçuların dallarında çimlendiği yerde şişkinliklere neden olduğu gibi sürgün uçlarından geriye doğru kurumalara da neden olmaktadır. Ayrıca kayısı ve badem gibi bazı konukçularda ağaçların tamamen kurumasına neden olduğu gözlenmiştir. Niğde ilinde; meyve ve park ağacı türlerinde yapılan ökseotu sürveyi neticesinde bu ağaçlarda yarı parazit yaşayan *Viscum album* türüne ait alt türün *Viscum album* ssp. *album* olduğu belirlenmiştir. Alıç, ahlat, Ankara armudu, badem, elma, erik, kayısı, vişne, akasya, kanada kavağı ve söğüt ağaçlarında *Viscum album* ssp. *album*'a rastlanmıştır. Diğer ökse otu türleri, *Viscum album* ssp. *abietis* Toros göknarı ve Toros sedirinde, *Viscum album* subsp. *austriacum* ise karaçamda görülmüştür.

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AnahtarKelimeler
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AraştırmaMakalesi

Kahramanmaraş ilinde; Ardıç ökseotu (*Arceuthobium oxycedri);* küçük kozalaklı katran ardıç (*Juniperus oxycedrus* subsp. *oxycedrus)*, boylu ardıç (*Juniperus excelsa)* ve andızda (*Juniperus drupacea),* meşe ökseotu (*Loranthus europaeus)* saçlı meşe (*Quercus cerris)* ve mazı meşesinde (*Q. infectoria),* Göknar ökseotu (*Viscum album* subsp. *abietis*) Toros göknarı (*Abies cilicica* subsp. *cilicica)* ve Toros sedirinde (*Cedrus libani*) ayrıca çam ökseotu (*V. album* subsp. *austriacum*) kara çamda (*Pinus nigra* subsp. *pallasiana*) görülmüş diğer yandan Kahramanmaraş'ta *Viscum album* ssp. *album'* a hiç bir konukçuda rastlanmamıştır.

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INTRODUCTION

Conifer trees and fruit production are among the important agro-forestry activities in Turkey. Many external factors and pests affect yield and quality of the timber production, and parasitic and semi-parasitic plants are the foremost pests among them. Miller (1982) showed that the term mistletoe was first applied to the European mistletoe (*Viscum album*). Viscum species include three subspecies belonging to the species of *Viscum album* in Turkey. These subspecies are *Viscum album* ssp. *album, Viscum album* ssp. *abietis* and *Viscum album* ssp. *austriacum*. Ball (1993) showed that three widely distributed subspecies of *V. album* that differ in host specificity have been recognised in Europe: *V. album* subsp. *album* on dicotyledonous trees, *V. album* subsp. *abietis* on *Abies* spp. and *V. album* subsp. *austriacum* on *Pinus* spp. and rarely *Larix* spp.

Mistletoe species can perform photosynthesis because of having chlorophyll. However they do not possess a root system like the other plants. Haustorium of mistletoe penetrates to xylem of host to take minerals and water. Mistletoe species have flowers and seedsand the external surfaces of the seeds are sticky, so they can easily stick on tree branches and can germinate on hosts (Hawksworth and Scharpf, 1986; Hawskworth and Wiens, 1996). Loranthusis a genus of parasitic plants that grow on the branches of woody trees. Modern systematists consider it as a monotypic genus with the only species *Loranthus europaeus* Jacq. the summer mistletoe or European yellow mistletoe. According to Hegi (1981) *Loranthus europaeus* Jacq. exists on oaks, mostly on downy oak (*Quercus pubescens* Willd.), Turkey oak (*Quercus cerris* L.), pedunculate oak (*Quercus robur* L.) and sessile oak (*Quercus petraea* (Matt.) Liebl.). *Arceuthobium oxycedri* was reported in Balkan states of Slovenia, Croatia, Bosnia Herzegovina, Yugoslavia and Pakistan on *Juniperus communis, J. drupacea* and *J. oxycedrus* (Bondev and Lybenova, 1984; Khaldi et al., 2000; Sarangzai et al., 2010). Species of the genera Psittacanthus, Phoradendron, and Arceuthobium have the greatest economic and ecological impacts in the Western United States and in Mexico (Geils et al., 2002a-2002b). Viscum species spread in many regions of Europe, North Africa, Austria, Asia, China, Western Europe, southern England, Scandinavia, the Balkans, Russia, Japan and Nigeria (Frohne and Pfander, 1984; Kirkup et al., 2000; Ciesla et al., 2004). The study in Kahramanmaras showed that the ratio of existence of *A. oxycedri* on the host were determined as high dense 16.99 number/host for *J. oxycedrus* subsp.*oxycedrus,* 15.33 for *J. excelsa* and 14.38 for *J. drupacea.* Also *L. europaeus* was found dense 3.32 on *Q. cerris* and 2.74 on *Q. infectoria.* Another semi-parasite plant, *V. album* subsp. *abietis* was determined as dense 9.92 on *A. cilicica* subsp*. cilicica,* while it was mid dense 0.44 on *C. libani.* Besdies, *V. album* subsp. *austriacum* was found as high dense 14.53 number/host on *P. nigra* subsp. *pallasiana* (Üstüner, 2016).

To our knowledge, so far, there was no any studies related symptoms of semi parasitic plants conducted in Kahramanmaras and Nigde.

MATERIALS and METHODS

Materials

The material of this research is mistletoe species, fruit and forest trees. Surveys were conducted in East Mediterranean (Kahramanmaras province) and Central Anatolia region (Nigde province) in 2012-2016.

Methods

Mistletoe branches were counted to using field glass for tall trees. Special coverage was calculated via formula proposed by Odum (1971), where SC= Total % coverage of each species/measuring the count of each species found (1)

Infection severity of the semi parasites was calculated with formula proposed by Üstüner et al. (2015) with the following equations;

Infection severity (%) = (a*Co) + (b*Dried Branches Rate) + (c*T.A) + (d*S.R.) (2)

where Co= Coverage, a=1. Coefficient value, D.B.R.= Dried branches rate, b=2. Coefficient value, TA=Tree age. c= 3. Coefficient value, Swelling rate= S.R. d= 4. Coefficient value.

The presentation of infection severity scales were given in Table 1.

Table 1. Scale of infection severity of mistletoe species on hosts

Scale value	Infection rate	Scale of infection
1	0-10	Less severe
2	10-40	Moderate to severe
3	40-70	Severe
4	70-100	Very severe

RESULTS

Symptoms and hosts of *Viscum*, *Arceuthobium* and *Loranthus* species were investigated in East Mediterranean (Kahramanmaras province) and Central Anatolia region (Nigde province).

V. album ssp. album in shrub shape and 19-28 cm tall, the leaves are dark green, opposite pairs, strap-shaped, entire, leathery textured, 3-5cm long and 1-1.5 cm broad, fruits are round and white colour (Figure1). The stems length are13-38 cm with dichotomous branches.

Based onthe survey in Nigde, *V. album* ssp. *album* was seen on the fruit trees including almond (*Amygdalus* spp.), Ankara pear (*Pyrus communis* L.), Apricot (*Prunus armenica* L.), Braeburn apple (*Malus domestica* cv *Braeburn*), Plum (*Prunus* spp.), Sour cherry (*Prunus cerasus* L.), Whitethorn (*Crataegus monogyna* Jacq) and Wild pear (*Pyrus elaeagnifoila* Pallas),while also it was seen on the park trees; Locust (*Robinia* spp.), Canada poplar (*Populus canadensis* Michx) and Willow (*Salix* spp.). Whereas, *V. album* ssp. *album* was not seen on any host in Kahramanmaras.

The infection rates by *V. album* ssp. *album* was high on Almond (*Amygdalus* spp.) 50.5%, Apricot (*Prunus armenica* L.) 36.90%, Pear (*Pyrus communis* L.) 29.66% and were low on plum (*Prunus* spp.) 3.60% and on apple (*Malus domestica* cv *Braeburn*) 3.20%. After germinating and penetrating its hostourium to host xylems, mistletoe results sweelling in the germination site. As result of this infection, almond and apricot shoot tips died, and after 3 to 4 years some trees were completely dead (Figure 2). But smilar symptoms were not seen on locust (*Robinia* spp.), Canada poplar (*P. canadensis* Michx) and willow (*Salix* spp.).

V. album ssp. *abietis* similar to *V. album* ssp. *album* but there were some diffreneces like leaves size 2x0.8 cm and stem length 9-30 cm (Figure 3). Also the leaves were yellowish-green and fruit eliptic.

The infection severity of *V. album* subsp. *abietis* on *A. cilicica* subsp. *cilicica* was determined as moderate to severe with the ratio of 15.80%, while it was less severe on *Cedrus libani* with the ratio of 4.80% in Nigde. Simultaneously, the infection severity on *A. cilicica* subsp. *cilicica* was moderate to severe with the ratio of 10.73%, and was less severe on *C. libani* with the ratio of 3.40% in Kahramanmaras. Two symptom case of *V. album* subsp. *abietis* infections were observed. One of which was at needle leafed. *A. cilicica* subsp. *cilicica* where shoot tips were dried (Figure 4), while the other case was on *C. libani* where no dryness were occured. However, the swelling at branches of both mistlete hosts were observed during the infection (Figure 5, 6 and 7).

Figure 1. White fruit of *V. album* ssp. *album* (Üstüner et al., 2015) and seed germination (Heide-Jørgensen, 2015)

Figure 2. *V. album* ssp. *album* caused to swelling at the germination site on the branches of the pear (left) and to dry and die back of the shoot tips of apricot (right) (Üstüner at al., 2015).

Figure 3. White fruits of *V. album* subsp. *abietis* and dichotomous branching (Üstüner at al., 2015)

Figure 4. Symptoms of *V. album* subsp. *abietis* on pine needles of *A. cilicica* subsp. *cilicica*

Figure 5. *V. album* subsp. *abietis* dried shoot tips of *A. cilicica* subsp. *cilicica*

Figure 6. *V. album* subsp. *abietis* germination sites on *C. libani* branch.

Figure7. *V. album* subsp. *abietis* is causing clogging of xylem, resulting swelling left, drying and dying back of the shoot tips of pine needles (Üstüner at al., 2015).

V. album ssp. *austriacum* is similar to *V. album* ssp. *album* and *V. album* ssp. *abietis* but there are some diffreneces like leave size 2.80x0.70 cm and stem length 15-28 cm (Figure 8). Also the leaves are slightly yellowish-green. The ratio of infection severity of *V. album* subsp. *austriacum* was 10.24% on *P. nigra* subsp. *pallasiana* in Nigde and was 16.23% in Kahramanmaras. The symptoms of *V. album* subsp. *austriacum* resulted swelling at the germination site at branches, and needle leaf driyness. Pine trees infected by mistletoe have a tendency to live longer.

Figure 8. *V. album* subsp. *austriacum*cause swelling on the branche.

Shoots of Dwarf mistletoes (*A. oxycedri*) are mostly 5-10 cm tall, deep green and verticillate branching. The mature fruit is elips and 3.0x1.5-2.0 mm in size. *A. oxycedri* was not seen in Nigde. While in Kahramanmaras the infection severity of *A. oxycedri* was determined as moderate to severe with a ratio of 10.82% for *J. oxycedrus* subsp. *oxycedrus,* as less severe with that ratio of 8.57% for *J. excelsa* and as 7.78% for *J. drupacea*. Symptoms followed at first on needle leaf then on shoot tips causing them to dry on the hosts (Figure 9 and 10), and causing shoots completely to dry at the end.

Figure 9. *A. oxycedri* on *J.oxycedrus* subsp. *oxycedrus*.

Figure 10. *A. oxycedri* on *J. excelsa* and *J. drupacea*

L. europaeus possess a similar branching pattern to the evergreen mistletoe *Viscum album*, but it is deciduous, yellow-berried mistletoe with dull brown twigs. *L. europaeus* was not seen in Nigde, but it was seen on two host in Kahramanmaras. Infection severity of *L. europaeus* was less severe and was 8.69%, 7.97% for *Q. cerris* and *Q. infectoria,* respectively. Symptoms occurred resulting shoot tips and leaves of hosts to dry. In addition, *L. europaeus* caused swelling in the branches (Figure 11) resulting Oak shoots to dry completely (Figure 12).

Figure 11. *Loranthus europaeus* caused swelling on branches.

Figure 12. *L. europaeus* dried shoot tips of *Quercus cerris* and *Q. infectoria.*

V. album ssp. *album* was observed on 11 hosts in Center of Nigde, 10 hosts in Bor, 9 hosts in Ulukısla, 7 hosts in Altunhisar and 5 hosts in Ciftlik district and none in Camardı. *V. album* subsp. *abietis* and *V. album* subsp. *austriacum* were seen on 2 hosts in Center Nigde, Ulukısla and Camardı, 1 host in Bor district of Nigde. *V. album* subsp. *abietis* was seen on 1 host in Center, Afsin and Ekinozü, 2 in Andırın and Göksunnone in Caglayancerit, Elbistan, Nurhak, Pazarcık and Türkoglu. *V. album* subsp. *austriacum* was seen on 1 host in Center, Afsin, Andırın, Caglayancerit, Göksun, Pazarcık, Türkoglu and Ekinozü while it was not seen in Elbistan and Nurhak district of Kahramanmaras. *A. oxycedri* was not seen on hosts in Nigde, while it was seen on 3 hosts in Center, Afsin, Andırın, Caglayancerit, Ekinozü, Elbistan, Göksun, Nurhak; yet, it was not seen in Pazarcık and Türkoglu district of Kahramanmaras. *L. europaeus* was not found in Nigde but it was foundon 2 hosts in Afsin, Andırın, Caglayancerit, Ekinozü, Elbistan, Göksun and Nurhak.

DISCUSSION

Infection severity of mistletoe species were determined according to hosts in Nigde and Kahramanmaras. *V. album* subsp. *album* was found in different rate (3.2-50.50%) on host of Nigde but it was not seen in Kahramanmaras. *V. album* subsp. *abietis* was detected different rate (3.40-15.80%) on hosts; *V. album* subsp. *austriacum* was detected at different rate (10.24-16.23%) on hosts. *A. oxycedri* was not seen in Nigde. The ratio of infection severity of *A. oxycedri* on the host were determined between 7.78-0.82% in Kahramanmaras. *L. europaeus* was not seen in Nigde but infection severity of *L. europaeus* was found less severe between 7.97-8.69% on hosts of Kahramanmaras.

The rate of infection by *V. album* ssp. *album* was high on Almond 48.54%, Apricot 34.98% and on Pear 28.64%. The ratio of infection severity of *V. album* subsp. *abietis* was moderate to severe with the ratio of 2.40-9.73% on hosts. Similarly, *V. album* subsp. *austriacum* was found moderate to severe with a ratio of 15.25% on *P. nigra* subsp. *pallasiana.* Another semi parasite plant, the ratio of infection severity of *A. oxycedri* on the host were detected moderate to severe with a ratio of 7.78-10.82% for related hosts. Also infection severity of *L. europaeus* was found less severe as 7.97-8.69% on hosts (Üstüner et al., 2015; Üstüner 2016). *A. oxycedri* is widespread in Turkey, *A. oxycedri* was usually found on *J. oxycedri* and *J. drupacea* trees in Turkey (Miller, 1982; Hawksworth and Wiens, 1996).

Arceuthobium species were detectedat various rates of 10-20% on *Juniperus* species (Lazarev and Grigorov, 1980), 3-32% on pinus (Hawksworth and Johnson, 1989),42% on Douglas-fir (Bolsinger, 1978) and 57% on conifer (Marsden et al., 1991). *V. album* ssp. *austriacum* has killed 15-20% of *Pinus sylvestris* branches (Dobberting and Rigling, 2006). The infection severity of mistletoe was 14% in Spain (Oliva and Colinas, 2007), 30% in Croatia (Idžojtić et al., 2008) and 22% in Romania (Barbu, 2009). *V. album* ssp. *abietis* infected Silver fir at a 20-40% rate (Barbu, 2012). The infection rate of *V. album* ssp. *album* on oak was 12.9% (Matula et al., 2015). Infection severity of Mistletoe species may varies according to different host, density, region, ecology and growing conditions. The results of previous studies were partially similar with these results.

After mistletoe germination hostourium penetrated to host xylems, the sweelling was formed at germination site. Mistletoe infections lower the vigor of the host, induce premature mortality, reduce the quality and quantity of wood produced. Heavily infected trees die following a few years (Bhattacharyya and Uniyal, 1982; Hawksworth, 1983). Most infected trees with *A. oxycedri* can survive for several decades; generally the smaller trees decline and die more quickly than the larger ones. The first symptom of dwarf mistletoe infection is a slight swelling of the bark at the infection site (Hawksworth and Geils, 1990; Hawksworth and Wiens, 1996; Koski et al., 2013). *L. europaeus* has a similar branching pattern to the evergreen mistletoe *Viscum album* L., infected trees with *L. europaeus* may be reduced in vigor, stunted, or even killed. On some host species large swelling occure at the infected branches where the mistletoe penetration taken place (Perry et al., 2006; Zebec and Idsotij, 2006).

Different symptoms and hosts range of mistletoe species were determined in Nigde and Kahramanmaras. Similar results reported by Miller (1982), Hawksworth and Wiens (1996), Üstüner et al. (2015) and Üstüner (2016) in Turkey. Simultaneously Hawksworth and Johnson (1989), Dobberting and Rigling (2006), Oliva and Colinas (2007), Idžojtić et al. (2008) and Barbu (2012), Matula et al. (2015) reported partially similar results with the current study in the world.

CONCLUSION

Infection severity of mistletoe species may be differ according to hosts, density, region and ecosystem in Nigde and Kahramanmaras.

Mistletoe species caused swelling at the germinated site in the branches of the host and caused the shoot tips of host to dry. *V. album* subsp. *abietis* caused *A. cilicica* subsp. *cilicica* needles leaves to dry first, then the shoot and finaly kill the host completely. Pine trees infected by *Viscum* can live longer but apricots and almonds could not. Swellings on the branches and shoot tips of *Q. cerris* and *Q. infectoria* were killed by *L. europaeus*.

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