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Full Length Research Paper

Hosts and distribution of yellow mistletoe (*Loranthus europaeus* Jacq. (Loranthaceae)) on Northern Strandjas Oak Forests-Turkey

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Yellow mistletoe (*Loranthus europaeus* Jacq. (Loranthaceae)) host selection and distribution were assessed on Northern Strandjas oak forests to document yellow mistletoe presence on different oak species and investigate the effect of host species and stand characteristics on the yellow mistletoe infection. 2.3% of trees were infected with yellow mistletoe for all species considered. Infection rate was greatest in Sessile oak (*Quercus petraea* (Fagaceae)) and no infection was detected in Turkey oak (*Quercus cerris* (Fagaceae)). Oak species, size class, canopy closure, parent material, aspect and elevation were important parameters and significantly affected yellow mistletoe infection in the study area.

Key words: Oak decline, mistletoe infection, *Quercus*, tree and stand characteristics, Thrace.

INTRODUCTION

Oak forests have the second largest area after pine forests and their distribution area consists 22.4% of total forest cover in Turkey. Similarly, oaks wide spread on Northern Thrace and the area of pure oak forests is 23042 ha in a total of 75750 ha forest area. In addition, oak distributes on 41154 ha mixing with beach. Oak declines have also been observed in Turkey, as well as in the world. The main consensus on possible reason of oak decline is the complexity of several biotic and abiotic factors.

Mistletoes are one of the biotic factors which have significant importance on oak decline. Mistletoes are hemiparasitic flowering plants which produce their own photosynthetic products, but they provide water and mineral nutrients from their host plants (Calder and Bernhardt, 1983). The genus *Loranthus* Jacq.(Loranthaceae) has about 600 species (Krüssman, 1977), and approximately 500 species distributed in tropical region (Hegi, 1981). In Turkey, six taxa have been determined: *Viscum album* L., *V. album* subsp. *austriacum* (Wiesb.) Vollmann, *V. album* subsp. *abietis*

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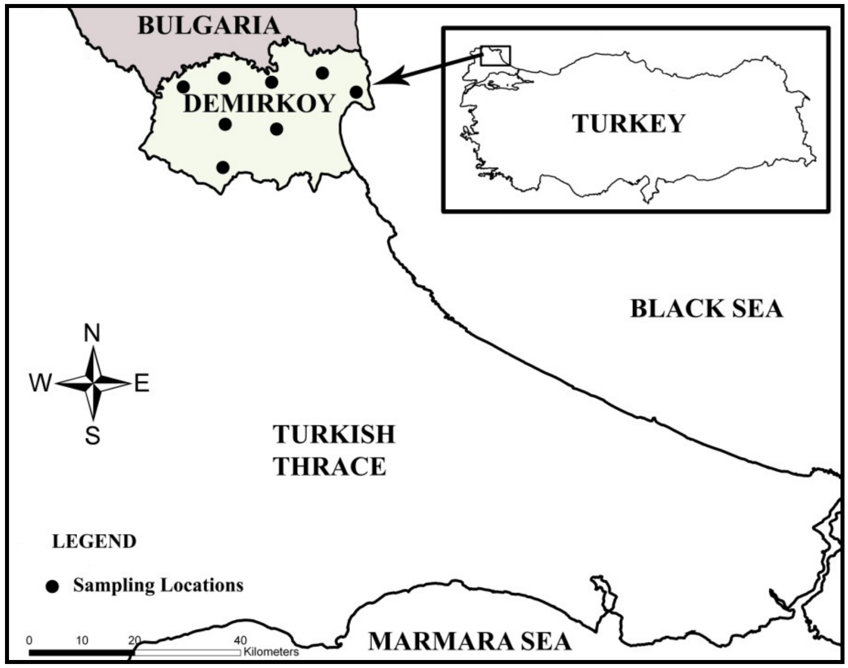

Figure 1. Geographical distribution of sample plots on Northern Strandjas Oak Forest.

(Wiesb.) Abromeit, *V. album* subsp. *album*, *Loranthus europaeus* Jacq. and *Arceuthobium oxycedri* (DC.) Bieb. (Dutkuner, 1999). *L. europaeus* is similar to *V. album*, but the main differences are that *L. europaeus* is summer-green and that the flowers and berries are located in stipitate inflorescences (Kuijit, 1969; Calder, 1983). Yellow mistletoe is the only European species of that genus and is a specialized species occurring only on certain hosts. *L. europaeus* appears on oaks, mostly on downy oak (*Quercu pubescens* Willd.), Turkey oak (*Quercu cerris* L.), pedunculate oak (*Quercu robur* L.) and sessile oak (*Quercu petraea* (Matt.) Liebl.) (Hegi, 1981).

Birds are the main vectors of yellow mistletoe. Most important birds for yellow mistletoe dispersal are the Mistle thrush (*Turdus viscivorus* L.) and Eurasian jay (*Garrulus glandarius* L.) (Cramp and Perrins, 1994). The presence of mistletoes is also regulated by a range of abiotic factors (Norton and Reid, 1997) such as soil, relief, aspect, etc. Mistletoe presence can be influenced by the distribution of suitable host species (Norton and Reid, 1997), habitat fragmentation (Lavorel et al., 1999), herbivory (Reid and Yan, 2000) and topographical features such as elevation, steepness of slope and aspect (Hawksworth, 1968; Merrill et al., 1987; Aukema, 2004).

This study investigates yellow mistletoe presence on oak forests in Northern Strandjas-Turkey. Specifically, the study objectives were to: determine yellow mistletoe presence on different oak species and investigate the effect of host species and stand characteristics on the yellow mistletoe infection.

MATERIALS AND METHODS

Study site

The study was carried out on conversion of coppice oak ecosystems in Northern Strandjas (Demirköy and İğneada region) (NW Turkey, 41º 50′ N, 27º 46′ E) during the 2008 and 2009 summers. In this region, the most dominant *Quercus* species are (*Q. petraea* (Matt.) Lieb. subsp. *iberica* (Steven ex Bieb.) Krassilin), *Quercus frainetto* Ten. and *Q. cerris* L. var. *cerris*). According to the Thornthwaite (1948) climate system, this region has a humid and mesothermal sea climate with minumum temperature of the coldest month is -14°C, and a maximum of 38°C at the hottest. Mean annual rainfall varies from 550 to 1500 mm. Growing season length is about 8 months, from April through November (Kantarci, 1979). Soils are formed primarily from granites, moderately deep and well-drained (Makineci, 1993).

Plot selection

To investigate mistletoe presence on different oak species, a total of 192 sample plots were selected to represent study area (2 parent materials × 3 size classes × 4 canopy closure × 8 locations)(Figure 1). Each sample plot was 0.04 ha in area (20 × 20 m) and all trees were assessed in the sample plot that allowed us to determine the composition of oak species as well as the presence of mistletoe. In order to investigate the relationship between landscape features and yellow mistletoe presence, certain landscape features were recorded for each of the 192 sample plots to determine yellow mistletoe occurrence on different oak species. Landscape features determined were oak species, size classes, canopy closure, parent material, aspect, and elevation. Size classes factor include three

Table 1. Interactions among host tree characteristics and landscape features on mistletoe infection.

Source	Mistletoe infection		
	df	Chi-square	P
Oak species	2	45.919	0.000*
Size classes	2	126.047	0.000*
Canopy closure	3	33.565	0.000*
Parent materials	1	118.482	0.000*
Aspect	1	74.149	0.000*
Elevation	2	87.603	0.000*
Oak species*Size classes	4	1.631	0.202ns
Oak species*Canopy closure	6	0.920	0.821ns
Oak species*Parent materials	2	0.132	0.716ns
Oak species*Aspect	2	5.231	0.073ns
Oak species*Elevation	4	0.271	0.873ns
Size classes*Canopy closure	6	0.307	0.959ns
Size classes*Parent materials	2	30.299	0.000*
Size classes*Aspect	2	5.702	0.058ns
Size classes*Elevation	4	3.866	0.145ns
Canopy closure*Parent materials	3	11.982	0.007*
Canopy closure*Aspect	3	19.010	0.004*
Canopy closure*Elevation	6	9.698	0.138ns
Parent materials*Aspect	1	18.741	0.000*
Parent materials*Elevation	2	2.855	0.240ns
Aspect*Elevation	2	56.615	0.000*

* significant effect (P<0.05), ns non significant effect. Data were analyzed using Chi-square tests.

groups: a (diameter at breast height (DBH) between 0 and 8 cm), b (DBH between 9 to 20 cm) and c (DBH between 21 to 36 cm). Canopy closure was grouped in four groups: 0 (canopy cover less than 10%), 1 (10 to 40% canopy cover), 2 (40 to 70% canopy cover) and 3 (70 to 100% canopy cover). The elevation factor was classified into three categories (0 to 250 m, 250 to 500 m, 500-(+) m above sea level) and the aspect factor was classified into two groups: sunny which included “SE, S, SW, W” and shady which included “NW, N, NE, E” directions. Parent materials of the study area are mainly formed by granite (granitoids and metagranitoids) and schist (kalkschist and shelf).

Data analyses

A chi-square test was used to investigate whether there is dependency between the two parameters on yellow mistletoe infection.

RESULTS

Yellow mistletoe presence on different oak species

A total of 5016 individual oak trees in a total of 192 sample plots, representing 3 different species, were assessed for yellow mistletoe presence across the study area. Oak forests in study area were composed of 59.7% Sessile oak (*Q. petraea*), 26.1% Hungarian oak (*Q. frainetto*) and 14.2% Turkey oak (*Q. cerris*). 2.3% of trees (116 trees) were infected with yellow mistletoe for all species considered. The proportion of trees infected with *L. europaeus* was significantly different among oak species (χ^2 = 45.919, d.f. = 2, P < 0.000) (Table 1). Among the three oak species represented in our study area, the infection rate was greatest for Sessile oak (3.5%) followed by Hungarian oaks (0.9%) and no infection was detected in Turkey oak (Figure 2).

Tree characteristics-yellow mistletoe presence

Size classes and canopy closure are two factors related oak trees characteristics that have been reviewed and play a significant role at yellow mistletoe infection (χ^2 = 126.047, d.f. = 2, P = 0.000; χ^2 = 33.565, d.f. = 3, P = 0.000 respectively) (Table 1). From these 116 infected trees, a similar number of large (c) (58%) and medium large (b) (42%) trees was infected, but no infection was detected on juvenile (a) trees (Figure 3). Yellow mistletoe infection is also influenced by the canopy closure; 79% of

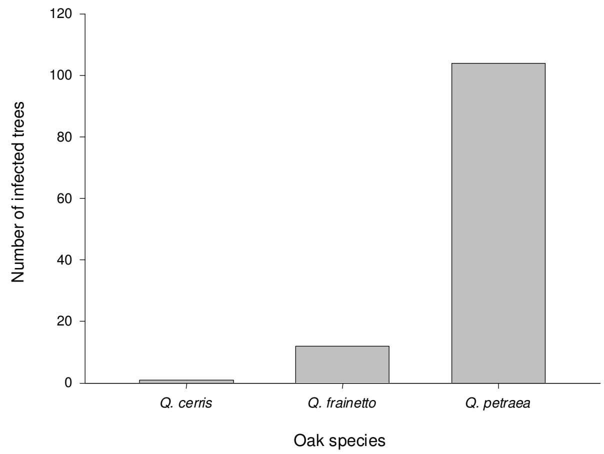

Figure 2. Distribution of mistletoes among oak species.

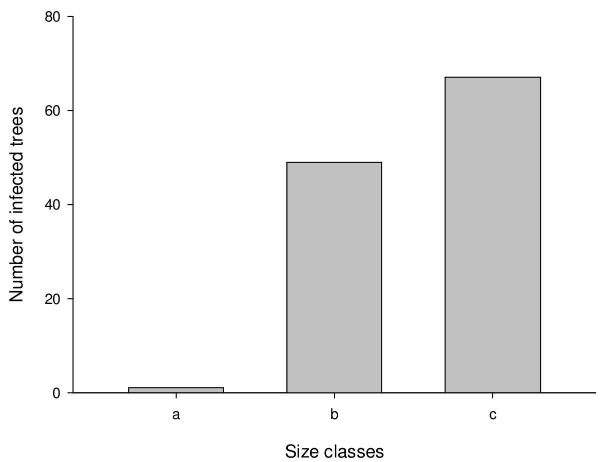

Figure 3. Distribution of mistletoes according to oak size classes. a: 0 to 8 cm; b: 9 to 20 cm; c: 21 to 36 cm diameter.

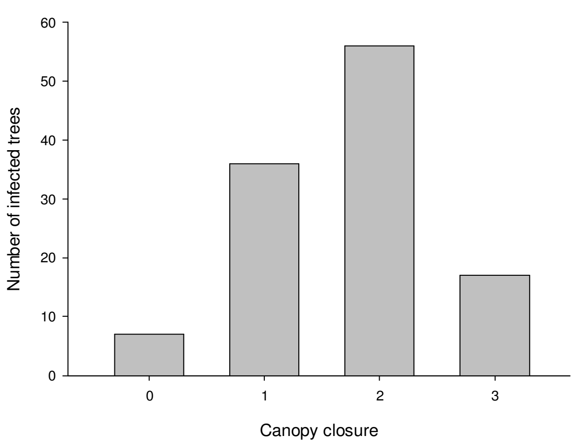

Figure 4. Distribution of mistletoes in different canopy closures. 0: canopy cover less than 10%; 1: 10 to 40% canopy cover; 2: 40 to 70% canopy cover; 3: 70 to 100% canopy cover.

infected trees are located in medium crown closure stands (1 and 2 canopy closure) while this rate is smaller at open (0) and dense (3) stands (Figure 4).

Landscape features-yellow mistletoe presence

Parent material, aspect and elevation are physical factors associated with the suitability of host trees that affects mistletoe infection (χ^2 = 118.482, d.f. = 1, P = 0.000; χ^2 = 74.149, d.f. = 1, P = 0.000; χ^2 = 87.603, d.f. = 2, P = 0.000 respectively) (Table 1). Majority of yellow mistletoe infection was assessed on soils derived from granite parent material (79%, Figure 5), and on sunny aspects (72%, Figure 6). The highest mistletoe infection was observed between 250 and 500 m elevations (91%). Only two infected trees (1.7%) were founded over 500 m (Figure 7).

DISCUSSION

Mistletoes are considered as forest tree pathogens by impairing host growth and vigor, reducing wood quality and quantity. Infected trees are often predisposed to other pathogen attacks or killed directly by mistletoes (Hawksworth, 1980). Some oak decline symptoms have also been recorded in Turkey (Balci, 2003; Kantarci et al., 2005; Yurdabak, 2006). However, the results of the present study demonstrate that yellow mistletoe does not represent a great economical problem in Northern Strandjas (2.3% infection rate) unlike *V. album* L. subsp. *austriacum*, which is a considerable parasite of Anatolian black pine (*Pinus nigra* Arn. subsp. *pallasiana*) (Kanat et al., 2010).

Turkey oak was cited as yellow mistletoe host plant by several studies (Dutkuner, 1999; Zebec and Idzojtic, 2006). The host with largest mistletoe infection was the sessile oak (104 infected trees) followed by the Hungarian oak (12 infected trees) but contrary to these results, no infection was detected in Turkey oak in our study area. Failure of the establishment of mistletoes may be due to penetration of the bark by the germinant. As mistletoe seeds must strongly adhere to the bark to allow the germinant to penetrate the bark, small differences in physical or chemical properties of the bark obviously can make a large difference in establishment (Glatzel and Geils, 2009). Hariri et al. (1992) studied the resistance of three species of oak (*Q. robur*, *Quercus rubra*, and *Q. petraea*) to *V. album* L. and described that four variables were shown to have high discriminant values: thickness of the cortex, density of polyphenol-containing cells, thickness of the first layers of fibers, and thickness of collenchyma. For an oak biomass research conducted in our study area, many Sessile oak, Hungarian oak and Turkey oak trees have been cut. We observed that the Turkey oak bark thickness was higher

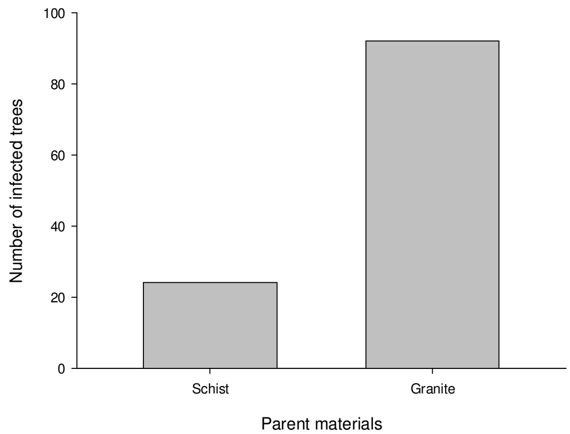

Figure 5. Distribution of mistletoes in different parent materials.

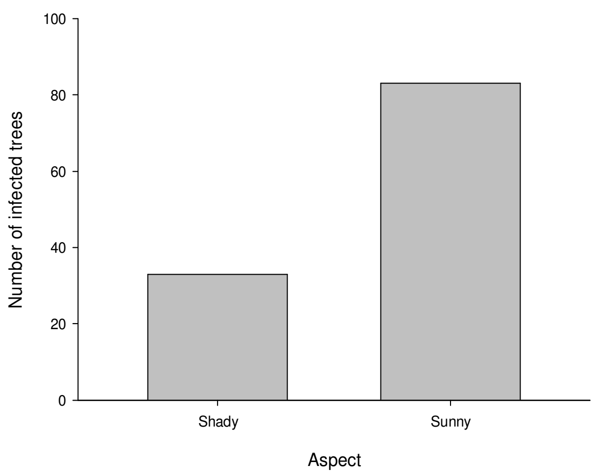

Figure 6. Distribution of mistletoes according to landscape aspect. Shady: NW, N, NE, E; Sunny: SE, S, SW, W.

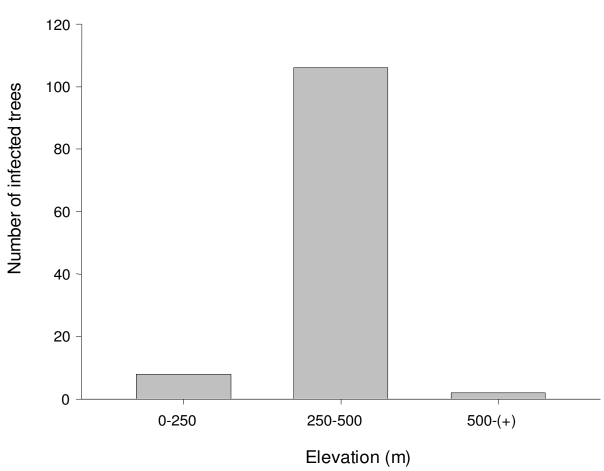

Figure 7. Distribution of mistletoes according to elevation.

than the others and Turkey oak secretes a brown liquid just after the cut that is absent in others. These may explain absence of mistletoe infection in Turkey oak in our study area.

Host compatibility and habitat quality are considered as important regulators of mistletoe abundance and distribution (Norton and Reid, 1997). On the other hand, birds are shown as the main factors of yellow mistletoe dispersal. Cramp and Perrins, (1994) indicated that most important birds for yellow mistletoe dispersal are the Mistle Thrush (*Turdus viscivorus* L.) and Eurasian jay (*Garrulus glandarius* L.). In accordance with this, these birds were observed in research area. Tree characteristics (oak species, size class, canopy closure) and stand characteristics (parent material, aspect, elevation) were important parameters assessed that affect yellow mistletoe infection in our study. Mayer (1982) reported that better host condition reduces mistletoe performance for yellow mistletoe on *Quercus* L. According to his study, the host tree grows well and can even shade out the mistletoe in favorable moisture and nutrient environment but on droughty and infertile sites the oaks grows more slowly with the increasing mistletoe abundance. In our study area, majority of yellow mistletoe infection was assessed on soils derived from granite parent material known as low water and nutrient capacity and our data support Mayer's hypothesis.

On the other hand, Lopez de Buen et al. (2002) founded that the high amount of light and canopy opening could be explaining factors on the increment of *Psittacanthus schiedeanus* (Loranthaceae) infection. We also observed a similar infection rate increase on sunny aspects and on opening canopy closures.

Statistically significant interactions emerged from the study are size classes*parent materials, canopy closure*parent materials, canopy closure*aspect, parent materials*aspect and aspect*elevation. This demonstrated that parent material has the most interaction influence with others factors.

Our data demonstrated elevation as a limiting parameter of yellow mistletoe infection. Zebec and Idzojtic (2006) reported a negative correlation between the elevation and yellow mistletoe infection on the sessile oak. It is obvious that high elevations have more moisture environment increasing *Quercus* tree growth. As mentioned in Mayer (1982), for hemiparasitic *L. europaeus* on *Quercus*, better host condition reduces mistletoe performance. In a favorable moisture and nutrient environment, the host tree grows well and can even shade out the mistletoe; but on droughty, infertile sites the oaks grows more slowly, the mistletoe increases, and eventually severe disease impacts develop (Glatzel and Geils, (2009).

The primary dispersers of yellow mistletoe in Northern Strandjas are the Mistle Thrush (*T. viscivorus* L.) and Eurasian jay (*G. glandarius* L.). These birds are observed in the study area but additional work should be conducted to better understand the population level as well as dispersal movements and behavior of these birds.

In conclusion, the present study has highlighted the host preference and important factors affecting mistletoe infection on conversion of coppice oak ecosystems in Northern Strandjas. The infestation is influenced by crown closure, fertility of site (habitat quality), oak species, tree size class and elevation.

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