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Orthotomicus tridentatus Eggers: distribution and biology in cedar forests of Turkey

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Abstract: *Orthotomicus tridentatus* Eggers, 1921 (Col.: Curculionidae, Scolytinae) is the most important forest pest of cedar stands in Turkey. Yet, very little is known about its distribution and biology. Therefore, the distribution and biological characteristics of *O. tridentatus* were studied in the Taurus Mountains in southern Turkey between 2006 and 2008. It was determined to be a species common to all cedar forests. The length of adults was between 2.5 and 3.9 mm and the main galleries were "S" shaped. *O. tridentatus* was determined to be a monophagus species for *Cedrus libani* A. Rich. and as endemic to Turkey. It was observed that the species had 2 generations per year. The first mating season occurred at the end of April and the second during the second half of August. It hibernates as a young adult.

Key words: *Orthotomicus tridentatus*, morphology, biology, trap trees, cedar, Turkey

Orthotomicus tridentatus Eggers: Türkiye sedir ormanlarında yayılışı ve biyolojisi

Özet: *Orthotomicus tridentatus* Eggers, 1921 (Col.: Curculionidae, Scolytinae) Türkiye sedir alanlarında zarara neden olan en önemli orman zararlısıdır. Bununla birlikte böceğin yayılışı ve biyolojisi çok az bilinmektedir. Bu nedenle *O. tridentatus*'un yayılışı ve biyolojisinin belirlenmesi amacıyla 2006-2008 yıllarında Türkiye'nin güneyinde Toros dağlarında çalışılmıştır. Zararlının sedir ormanlarında yaygın olarak bulunduğu görülmüştür. Erginlerin uzunluğu 2.5-3.9 mm arasında olup ana yolları "S" şeklindedir. *O. tridentatus Cedrus libani* A. Rich.'nin monofag bir zararlısı ve aynı zamanda Türkiye için endemik olduğu belirlenen türün yılda iki generasyon verdiği gözlenmiştir. Böceğin ilk uçma dönemi nisan ayının sonuna, ikinci uçma döneminin ise ağustos ayının ikinci yarısına rastladığı ve kışı genç ergin olarak geçirdiği tespit edilmiştir.

Anahtar sözcükler: *Orthotomicus tridentatus*, morfoloji, biyoloji, tuzak ağaçları, sedir, Türkiye

Introduction

The natural distribution area of the Taurus cedar (*Cedrus libani* A. Rich.) is the Taurus Mountains in Turkey. Cedar forests in Turkey cover approximately 420,000 ha and a quarter of this area is comprised of pure stands (Boydak and Çalıkoğlu, 2008). In recent years, *Orthotomicus tridentatus* Eggers (Col.: Curculionidae) has caused significant damage to the cedar forests in the Taurus Mountains, mainly in Antalya, Isparta, Konya, Kahramanmaraş, and Mersin

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provinces. During outbreaks this beetle is capable of killing relatively vigorous trees (Aytar et al., 2008). The number of trees that die due to damage caused by *O. tridentatus* has increased significantly in recent years. This increase is seen especially in damaged forests in which windstorms and snowy conditions result in broken and downfallen trees. Additionally, outbreaks were observed in stands with low-quality growth during drought seasons. Inadequate silvicultural techniques augment the impact of *O. tridentatus*. Between 1994 and 2007 in Mersin Province 15,806 wilted cedar trees were cut in a 7714-ha area due to *O. tridentatus* damage. Furthermore, 9900 trees in a 2405-ha area were cut in cedar forests in the western Mediterranean region between 2000 and 2007. In addition, *Phloesinus acatayi* Schedl. and *Carphoborus henscheli* Reitter were also determined to be bark beetles of considerable significance to cedars, but the damage they caused was not considered economically important (Sarıkaya, 2008).

O. tridentatus is a species endemic to Turkey and was first identified by Schedl (1961). This beetle is often confused with *Orthotomicus erosus* Woll. because of their morphological similarities. *O. tridentatus* has been considered as *O. erosus* or *O. erosus* var. *tridentatus* (Ekici, 1971; Postner, 1974; Tosun, 1975; Özkazanç et al., 1985; Selmi, 1998; Usta and Keskin, 1994). *O. tridentatus* was referred to as a different species by Can (1964), Graf (2003), Pfeffer (1995), and Aytar et al. (2008), who confirmed to Schedl (1961). *O. tridentatus* was reported as a monophagus species on *C. libani* (Can, 1964; Aytar et al., 2008, Sarıkaya, 2008).

The objective of the present study was to improve our knowledge of the morphology, seasonal history, and distribution of *O. tridentatus* in Turkish cedar forests.

Materials and methods

This study was carried out in cedar forests between 2006 and 2008. Surveys to determine the existence of the pest were conducted throughout the Mediterranean region. Trees which were weakened by needle, shot, and bud pests, such as *Acleris undulana* (Wlsghm.) and *Dichelia cedricola* (Diakonoff) (Lep.: Tortricidae), or by drought were used to determine the distribution of *O. tridentatus*. Identification studies were conducted on bark beetle specimens taken from trap trees. The area for detailed study observations was selected in the cedar forests of Bucak-Karlık (37°20′N, 30°39′E) (Table 1). In recent years, large quantities of wilting cases have been observed in the cedar forests of Bucak-Karlık due to *O. tridentatus* damage; therefore, this site was selected for the current study. The area with the greatest damage (a size of 10 ha) was used to locate trap trees. Trap trees were located at 20 points within this study area. In the selection of these points, similarity of the degree of canopy closure was the main consideration. Each trap tree spot consisted of 12-16 trees, and fresh cut stems 15-22 cm in diameter and 100-120 cm long.

Trap trees were checked weekly and galleries were examined for entrance holes and wood particles made by the beetle. The length of the main and larval galleries, and number of eggs were recorded. Adult beetles were collected and placed in small plastic boxes. Sections of bark 35 × 25 cm with beetle galleries were removed carefully, placed in sealed pouches, and examined in the laboratory to determinate the biological stages in field conditions.

Table 1. Observations on the biology of *Orthotomicus tridentatus* in trap trees (at Bucak-Karlık).

Date	Biological Observations
04.08.2006	Preparation of trap trees
15.08.2006	Adults entered the trap trees for the first time
21.08.2006	Females laid eggs, singly in niches
04.09.2006	Adults, eggs, and young larvae (young larvae were up to 1-2 mm)
11.09.2006	Adults and larvae (main galleries were 3.5-15 mm)
18.09.2006	Larvae and pupae
25.09.2006	Larvae and pupae (larval galleries were 24-46 mm long)
02.10.2006	Pupae and young adults
09.10.2006	Young adults
10.04.2007	Renewal of trap trees
21.04.2007	Adults entered the trap trees for the first time
04.05.2007	Adults and eggs
20.05.2007	Adults, eggs, and young larvae
07.06.2007	Adults and larvae (larval galleries were length 7-10 mm long)
17.07.2007	Larvae and pupae
24.07.2007	Larvae, pupae, and young adults
31.07.2007	Larvae, pupae, and young adults
07.08.2007	Adults

Results

Distribution area of *Orthotomicus tridentatus*

O. tridentatus was associated with only the Taurus cedar, *Cedrus libani*. Damage caused by the beetle was observed in the regions of Adana-Feke, Antalya (Gazipaşa, Elmalı, Kaş, Demre, Finike, Akseki, Manavgat, and İbradı), Burdur (Bucak), Isparta (Sütçüler and Şarkîkaraağaç), Denizli (Tavas, Acıpayam), Mersin (Anamur, Bozyazı, Gülnar, Mut, and Tarsus), Kahramanmaraş (Andırın), Muğla (Fethiye), and Karaman (Ermenek) (Figure 1). The bark beetle was found at altitudes ranging from 1300 to 1785 m. (Table 2). It is clearly seen that the distribution of this pest corresponded closely to that of its host, *C. libani*.

Morphology

O. tridentatus adults were between 2.5 and 3.9 mm long, and were dark brown with a blackish brown pronotum. The second tooth placed in elytral declivity of the wind cover was combined with the wider third tooth in the form of a dovetail. The fourth tooth was apart from these 2 teeth and it had a sharp edge. Eggs were pearly white. Larvae were white, c-shaped, legless grubs with an amber-colored head capsule. The pupae were white and mummy-like, and had some adult features, including wings that folded behind the abdomen.

O. tridentatus differs from *O. erosus* by a sharp angle between the second and third teeth placed elytral declivity of the wind cover and by a slight difference in the pattern of its antennal club.

Biology

The results of the present study indicate that *O. tridentatus* has 2 generations per year. The first mating season occurs at the end of April and the second mating season occurs during second half of August in the cedar forests of the Mediterranean Region (Tables 1 and 2, and Figure 3).

Observations of the biology of *O. tridentatus* from trap trees in the Karlık research area are given in Table 1. Biological findings on *O. tridentatus* reported in studies conducted in the Mediterranean Region are given in Table 2. Data regarding the biology of beetles collected from different places, and observations obtained over a 2-year period from the same forests were compared and no significant differences were observed in the biological stages.

Dense resin outflows were observed in the entry holes, which were caused by the insects' damage to the tree trunks. Females construct several types of galleries within the inner bark and outer sapwood (Figure 2c-f). The galleries were generally two- or three-branched. Galleries either lie in the same

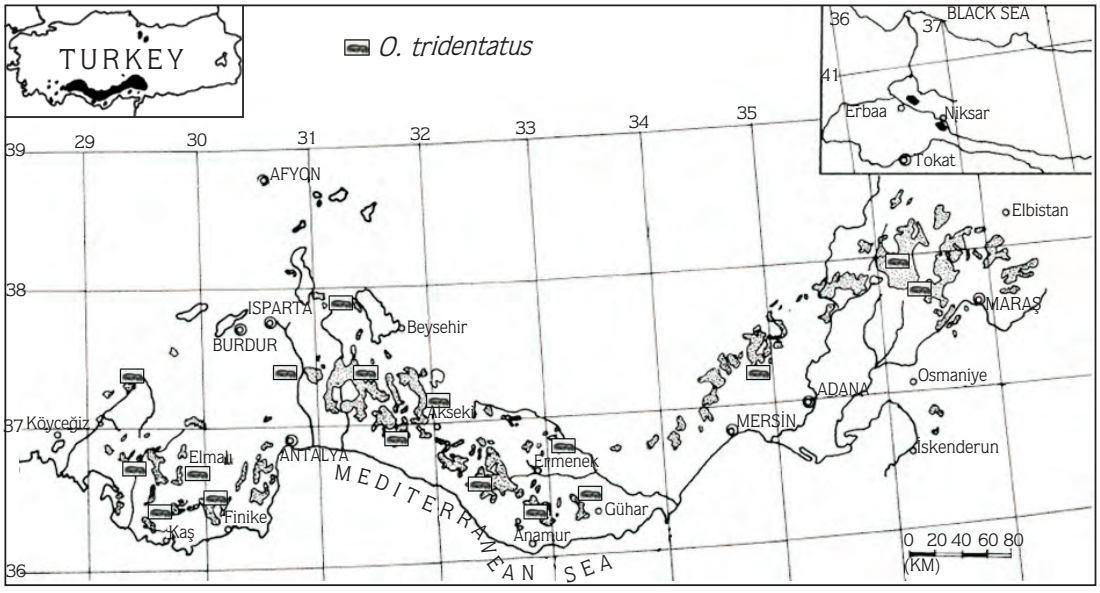


Figure 1. Distribution of *Cedrus libani* forests in Turkey and *Orthotomicus tridentatus* observation sites.

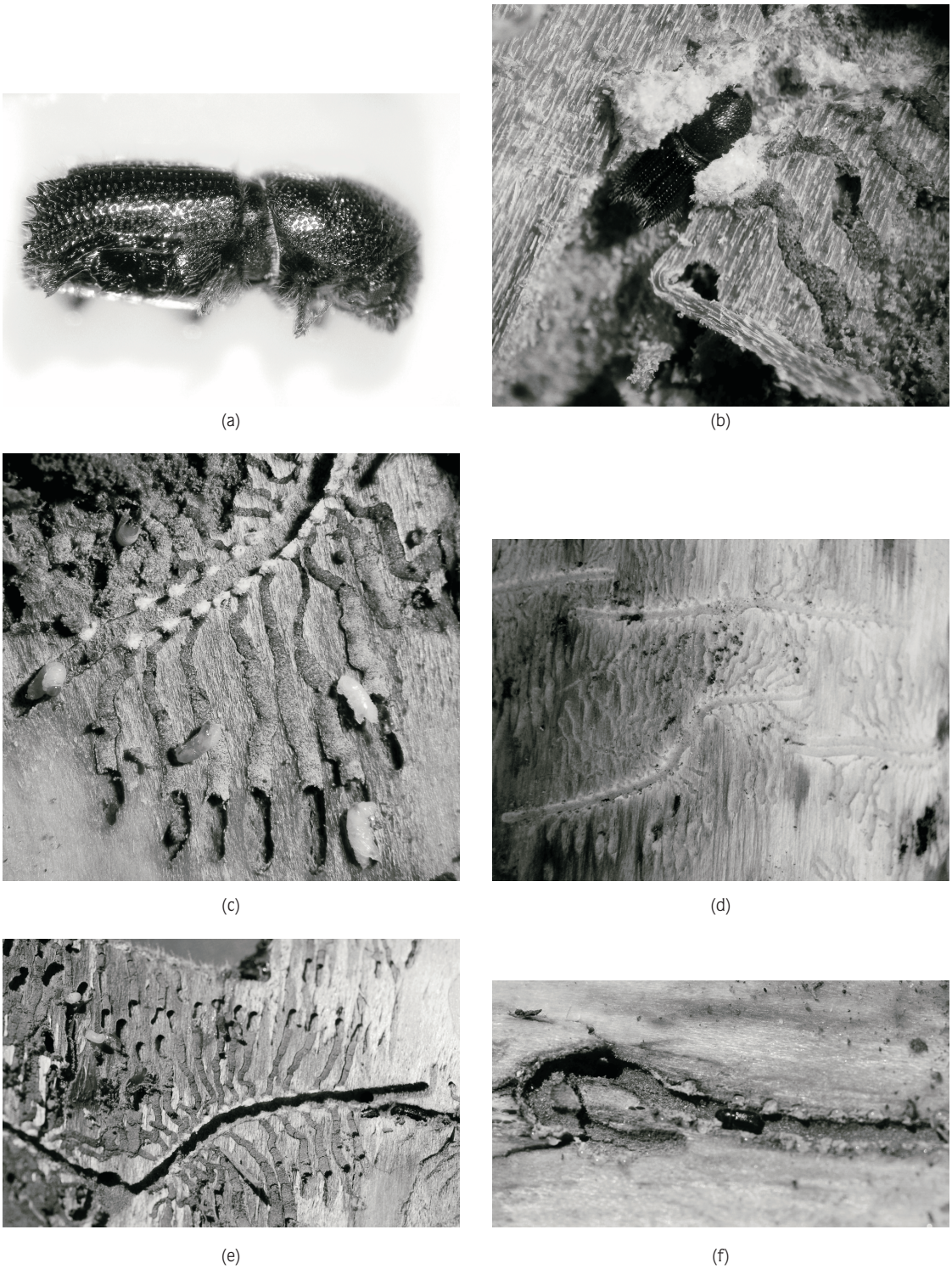
Table 2. Biological observations on *Orthotomicus tridentatus* in the Mediterranean Region.

Date	Location	Altitude (m)	Biological Stage	Observations
21.08.2006	Bucak-Karlık	1330	Adults	Dense resin outflows were observed in the entry holes located in the joints of trunks and side branches of the trees.
29.03.2007	Bucak-Karlık	1330	Overwintering young adults	Single branched vertical galleries were observed in the trunks of the trees.
19.04.2007	Akseki-İbradı Genboz	1300	Adults and eggs	Many adults were seen under the bark of old and drying cedar trees. The adults were observed opening S-shaped and double-branched galleries, and ovulating on the sides of the galleries.
12.05.2007	Elmalı-Çığlıkara	1785	Adults and young larvae	Many wood particles were observed surrounding the entry holes of the insects. Adults were observed heading perpendicular to the tree's fibers. Young larvae were detected in the larval galleries, which were perpendicular to the galleries.
23.05.2007	Bucak-Karlık	1330	Adults, eggs, and young larva	Larvae were observed hatching from eggs.
24.05.2008	Finike-Üçkuzluk	1420	Adults and eggs	Adults were detected opening double-branched galleries 5-9 cm long.
18.06.2008	Anamur-Abanoz	1480	Adults, eggs, and larva	Many eggs and larvae were observed in the trap trees.
25.06.2008	Bozdağ	1550	Adults and larvae	Mature larvae were observed in cedar trees in the study area.

direction or lie in different directions, forming an "S" shape. The galleries are either the two-branched type in which the branches lie horizontally or the three-branched type in which 1 branch lies down and the remaining 2 lie upwards, vertically. Main gallery length varies between 3.5 and 15.0 cm (mean: 7.0 cm), and larval gallery length, which lies perpendicular to the galleries, varies between 24 and 46 mm. Females lay eggs singly in niches cut into both sides of the egg gallery. Likewise, the number of eggs contained in each gallery varies between 22 and 48 (mean: 38). The beetle larvae develop in the bark and cambium layers. Pupation can occur in a cell at the end of larval galleries.

O. tridentatus adults were observed entering the trap tree that was exposed on 4 August 2006 in the Karlık study area and on 15 August 2006 for the first time; larvae were observed hatching on 4 September 2006. Pupation was observed on 18 September 2006 and finally become adults on 2 October 2006. *O. tridentatus* overwinters as young adults in the sapwood of the tree trunk. After overwintering, *O. tridentatus* adults were observed colonizing the trap trees exposed on 21 April 2007 for the first time. Larval hatching was recorded (for the first time) on 20 May 2007 and pupation was observed on 17 July 2007. *O. tridentatus* callow adults were first observed in the trap trees on 24 July 2007.

During our surveys we observed that *O. tridentatus* was apparently capable of attacking trees exposed to biotic and abiotic stress, such as damage due to the cedar needle moth (*A. undulana*) and the cedar shoot moth (*D. cedricola*), as well as drought, poor site conditions, and related factors.



(a) (b)

(c) (d)

(e) (f)

Figure 2. a) Adult *Orthotomicus tridentatus*. b) An adult in an egg gallery.
c) Larvae and pupae. d) S-shaped galleries in sapwood.
e) Adult and larval galleries in the bark. f) Oviposition and eggs.

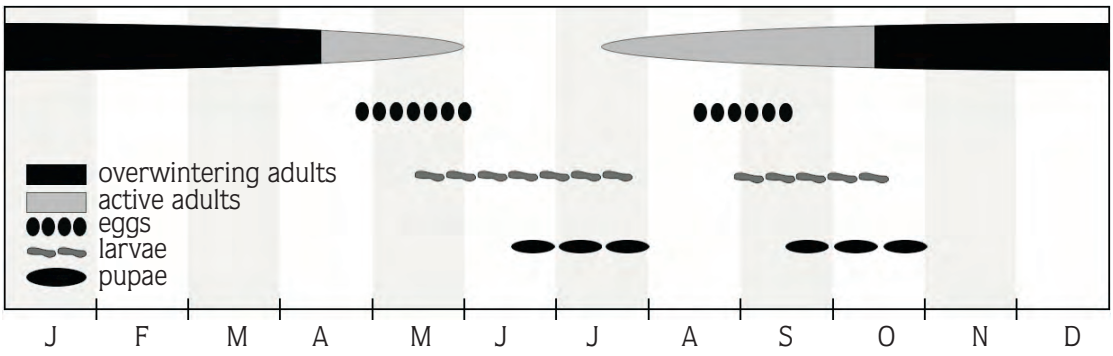


Figure 3. Biology of *Orthotomicus tridentatus* in cedar forests of Turkey.

Discussion

O. tridentatus has been incorrectly identified as *O. erosus* because of their morphological similarities. *O. tridentatus* was first recorded in Turkey by Schedl (1961), who found the insect in cedar trees in Cevizli, Manavgat, and Feke. *O. tridentatus* has been observed in the Mediterranean Region and only in cedar woods. *O. erosus* was not observed in the present study. This result further supports the notion that *O. erosus* does not develop on cedar trees (Can, 1964; Aytar et al., 2008). Aytar et al. (2008) reported that *O. tridentatus* occurs only in Turkey in cedar forests of the Taurus Mountains, and that it's reported occurrence on *Pinus brutia* in Turkey or on *P. nigra* in Austria, as suggested by Pfeffer (1995), is probably related to misidentification. Similarly, Ekici (1971) erroneously gave morphological details of *O. tridentatus* as *O. erosus* in cedar forests of Antalya.

We observed that *O. tridentatus* had 2 generations per year. The first mating season occurs at the end of April and the second mating season occurs during the second half of August. Our findings on the biology of the insect also show similarities to reports by Can (1964), Ekici (1971), and Aytar et al. (2008). In addition, the results of the present study and biological observations on *O. erosus* by Tosun (1975) in the cedar forests of Antalya-Elmalı are very similar. *O. tridentatus* was determined to be the only aggressive bark beetle on cedars during our field studies. It is suggested that necessary preventive measures should be taken to control the harmful effects of *O. tridentatus*, the main cause of cedar tree death in cedar forests.

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