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Original article (Orijinal araştırma)

Contributions to the knowledge of Turkish saproxylic beetle fauna of Anatolian sweetgum forests[1]

Anadolu sığla ormanlarının Türkiye saproksilik böcek faunasına katkıları

İsmet HARMAN[2*] **Mustafa AVCI[3]**

Abstract

The aim of this study was to determine the saproxylic beetle species (Coleoptera) present in Anatolian sweetgum, *Liquidambar orientalis* Miller (Saxifragales: Altingiaceae) forests, to reveal the contribution of this endemic tree species to insect biodiversity. Beetles were sampled in two areas in Muğla province of Türkiye, where *L. orientalis* is the most widely distributed tree species. Five old trees (diameter at breast height 36.0-51.9 cm) were selected in each area and two trap types were used on each tree. Traps were set on March 13, 2021, and checked once a month for six months. At the end of the study, 1,302 individuals belonging to 108 species from 33 families were obtained. Fifteen beetle species were new records for the fauna of Türkiye. The families with most individuals were Curculionidae (555), Anobiidae (325) and Tenebrionidae (104). Families with the highest number of represented species were Anobiidae (15), Elateridae (13), Curculionidae (8) and Tenebrionidae (8). According to the IUCN Mediterranean Red List, *Ectamenogonus montandoni* (Buysson, 1889) (Coleoptera: Elateridae) is classified as endangered (EN) and *Propomacrus bimucronatus* (Pallas, 1781) (Coleoptera: Euchiridae) as vulnerable (VU).

Keywords: Coleoptera, dead wood, hollow trees, *Liquidambar orientalis*, saproxylic beetle

Öz

Bu çalışmada, Anadolu sığla ağacı, *Liquidambar orientalis* Miller (Saxifragales: Altingiaceae) ormanlarındaki saproksilik böcek türlerinin (Coleoptera) belirlenmesi ve endemik olan bu ağaç türünün böcek biyolojik çeşitliliğine katkısının ortaya konulması amaçlanmıştır. Çalışma, *L. orientalis* türünün en geniş yayılış yaptığı Türkiye'de Muğla iline bağlı iki örnek alanda gerçekleştirilmiştir. Böcekleri örneklemek amacıyla, her iki alanda beşer adet yaşlı (göğüs yüksekliği çapı 36.0-51.9 cm) ağaç seçilmiş ve her ağaçta iki tuzak tipi kullanılmıştır. Tuzaklar 13 Mart 2021 tarihinde kurulmuş ve altı ay boyunca ayda bir kere kontrol edilmiştir. Çalışmanın sonunda 33 familyadan 108 türe ait 1302 adet birey elde edilmiştir. 15 böcek türünün Türkiye faunası için yeni kayıt olduğu belirlenmiştir. Curculionidae (555), Anobiidae (325) ve Tenebrionidae (104) en yaygın bulunan familyalardır. Tür sayısı en yüksek familyalar ise Anobiidae (15), Elateridae (13), Curculionidae (8) ve Tenebrionidae (8)'dir. IUCN'in Akdeniz kırmızı listesine göre *Ectamenogonus montandoni* (Buysson, 1889) (Coleoptera: Elateridae) tehdide açık (EN) ve *Propomacrus bimucronatus* (Pallas, 1781) (Coleoptera: Euchiridae)'un duyarlı (VU) sınıfında yer aldığı belirlenmiştir.

Anahtar sözcükler: Coleoptera, ölü odun, kovuklu ağaçlar, *Liquidambar orientalis*, saproksilik böcek

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[2] Karadeniz Technical University, Faculty of Forestry, Department of Forest Engineering, 61080, Trabzon, Türkiye
[3] Applied Sciences University of Isparta, Faculty of Forestry, Department of Forest Engineering, 32260, Isparta, Türkiye
* Corresponding author (Sorumlu yazar) e-mail: ismetharman@ktu.edu.tr
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Introduction

The presence of dead standing trees or wood helps to increase forest productivity by providing moisture, nutrients, organic matter and regeneration areas, and biodiversity by providing habitat and nutrition for many species (Kirby et al., 1998; Nilsson et al., 2001; Aakala et al., 2008; Thorn et al., 2020), reducing soil erosion and minimizing the negative impacts of climate change by sequestering carbon (Krankina & Harmon, 1995; Chambers et al., 2000; WWF, 2004). Many species depend on the micro-habitats formed by dead trees for their basic needs such as feeding, hiding, sheltering and nesting (Kaila et al., 1997; WWF, 2004). Species of saproxylic insects inhabiting these habitats are amongst the most important groups of endangered invertebrates associated with old and dead trees in Europe (McLean & Speight, 1993; Sama et al., 2011). Many species are also included in the European Red List (Nieto & Alexander, 2010; Avgın et al., 2014).

Saproxylic insects contribute directly or indirectly to important ecosystem services associated with wood fragmentation and decomposition (Stokland, 2012; Ramírez-Hernández et al., 2019), nutrient cycling (Samuelsson et al., 1994; Sverdrup-Thygeson & Ims, 2002), forest pest management and pollination (Ulyshen, 2016; Micó, 2018). These insects bring their associated predators and fungi to the areas where they occur (Hammond et al., 2001; Vanderwel et al., 2006; Dennis et al., 2018), thus indirectly accelerating wood degradation (Müller et al., 2002; Dennis et al., 2018). The IUCN European Red List gives an assessment of 693 species of saproxylic beetles. Overall, 17.9% and 21.7% of species are considered threatened in Europe and in the EU, respectively (Cálix et al., 2018). Sixty-one species of the 320 saproxylic beetles evaluated are threatened in the Mediterranean region, 29 species are near threatened and 131 species are data deficient (Garcia et al., 2018).

The genus *Liquidambar*, in the Altingiaceae, has four species globally (Ickert-Bond et al., 2005). *Liquidambar orientalis* Miller (Saxifragales: Altingiaceae), Anatolian sweetgum tree is a relict and endemic species from the third (Tertiary) period dating back to approx. 65 million years ago (Yıldırım Şenyer, 2014). In Türkiye, it is distributed in Denizli (Günlük Brook, Gerenis Brook, Gölcük village), Antalya (Aksu Valley) and Isparta (Sütçüler), and is common in Muğla (Marmaris, Fethiye, Köyceğiz and Ula) (Efe, 1987, 2008; Velioğlu et al., 2008; Göçmen, 2010; Ürker & Yalçın, 2011; Teker, 2013). Since *L. orientalis* is an endemic species with a narrow distribution, it is of great importance in terms of protecting biodiversity and ensuring the continuity of the forest ecosystem. The forest area of *L. orientalis,* one of the two species producing sweetgum oil in the world (Öztürk, 2008), has decreased from approximately 7000 hectares in 1947 to 900 hectares today (Huş, 1949; Topçuoğlu, 1968; Özmen, 2011). *Liquidambar orientalis* was considered to be in the category "Species under High Threat in the Medium-Term Future in Nature" in the list prepared according to the IUCN Threat Categories in 2000, and in 2001, it was recognized by EUFORGEN as a species that should be protected throughout Europe and included in the 'Valuable Leaves' status. In 2018, it was upgraded from 'vulnerable-sensitive (VU-Vulnerable)' to 'threatened (EN-Endangered)' status in the IUCN Red List, which classifies the threat status of species on a global scale (Ekim et al., 2000; Alan & Kaya, 2003; Kavak & Wilson, 2018).

Studies on *L. orientalis* are a required part of the necessary measures for the conservation and continuity of this species to future generations. As an important part of this process, Coleoptera saproxylic insect species in *L. orientalis* forests in Muğla province were determined and the contribution of this endemic tree species to insect biodiversity revealed.

Materials and Methods

Study area

The study was conducted in Muğla province in southwestern Türkiye, where *Liquidambar orientalis* has a wide distribution. Two sample areas [Köyceğiz/Kavakarası (36°53'59.00"N, 28°42'42.00"E), Fethiye/ Küçük Kargı Nature Park (36°43'1.00"N, 29°1'17.00"E)] include dense stands of old, hollow, cavity trees and were

found by utilizing the management plans of Muğla Regional Directorate of Forestry (Figure 1). The study areas are at 0 to 15 meters altitude. *Liquidambar orientalis* is the dominant trees species in the study areas and their surroundings. *Smilax excelsa* L. (Liliales: Smilacaceae), *Hedera helix* L. (Apiales**:** Araliaceae), *Vitex agnus-castus* L. (Lamiales: Lamiaceae), *Pinus brutia* Ten. (Pinales: Pinaceae), *Quercus ilex* L. (Fagales: Fagaceae), *Ruscus aculeatus* L. var. *angustifolius* Boiss (Asparagales: Ruscaceae) and *Nerium oleander* L. (Gentianales: Apocynaceae) are also present in the same forests (Akbaş, 2012; Anonymous, 2021).

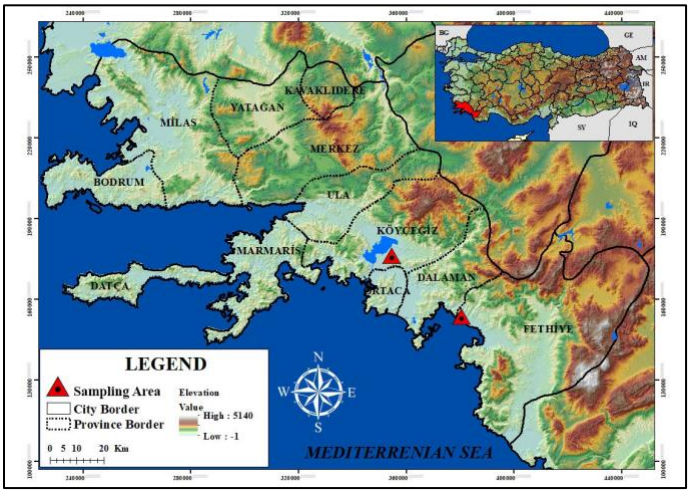

Figure 1. The location of study area.

Selection of trees and sampling of beetles

In the study areas, five old, hollow, cavity trees were located, and pitfall and window traps (Jansson & Lundberg, 2000; Ranius & Jansson, 2002; Milberg et al., 2014) were set in each of them (Figure 2). The traps were set at the beginning of the vegetation period, on 13/03/2021 and were checked once a month for six months (April-September).

Figure 2. Window and pitfall traps used to collect saproxylic beetles in the study (a, b).

Date, location, trap type and trap number were recorded during the sampling times. In Küçük Kargı Nature Park, beetles were obtained by using the light trap (Stork et al., 2016) on 22/07/2021. Ultraviolet and white light were used together in the trap (García-López et al., 2011). In addition, during the field studies, the hollows, parts and other cavities of the fallen, leaning, and old trees in the field were examined and beetles collected manually with an insect aspirator (Neumann et al., 2013). Beetles were brought to the laboratory and placed in plastic tubes filled with 70% alcohol. The tubes were labelled by recording the sampling area, date of collection, coordinates, trap type and number. Familial distinction was made with the help of experts and using identification keys. Photographs of the prepared insect specimens were taken with LEICA Z16 APO.

The species obtained in the study were classified according to the IUCN Europa and Mediterranean Red List (Cálix et al., 2018; Garcia et al., 2018), and saproxylic beetles classified into trophic categories according to their location in the tree and their feeding patterns (Carpaneto et al., 2015; Ulyshen, 2018) (Table 1).

Table 1. Trophic category of saproxylic insects (Carpaneto et al., 2015)

CO	Commensal of SX/XY or of other saproxylic insects
MB	Mycetophagous on carpophora of large fungi (mostly Polyporales) growing on veteran trees or on old stumps
MM	Myrmecophilous or melittophagous inside hollow trees or stumps hosting colonies of ants or of other social Hymenoptera
MY	Mycophagous (developing on ifae of saproxylic fungi or on micromycetes, yeasts and Myxomiceta)
NI	Commensal in bird or small mammal nests, feeding on parts of dead animals including other insects inside hollow trees or other cavities in dead wood
PR	Predator (as larvae or imagoes) of SX/XY or of other saproxylic insects
SF	Feeding on fermented sap and exudates (usually including a mixture of bacteria and yeasts) produced by trees attacked by XY, fungi or wounded by external physical agents
SP	Saprophytophagous on rotting vegetal matter associated with dead wood and wood debris
SX	Saproxylophagous in dead wood during the whole process of its decomposition, including the wood mould inside hollow trees
UN	Trophic category unknown
XY	Xylophagous (fresh wood or bark but also developing on healthy trees)

Results and Discussion

During sampling, 108 species and 1 302 individuals belonging to 33 families of Coleoptera were obtained (Table 2). Fifteen species were new records for Türkiye (Figure 3). Publications, especially Avgın et al. (2014); Koçak (2014); Löbl & Smetana (2006, 2007, 2008, 2010, 2011, 2013); Löbl & Löbl (2015, 2016, 2017); Gülperçin & Tezcan (2016); Tezcan (2020) and Alonso-Zarazaga et al. (2017) were utilized to determine whether the species had been recorded previously in Türkiye. The *Dorcatoma* sp. was determined to be a new species to science and identification studies continue. The newly recorded species of saproxylic beetle fauna for Türkiye were from 11 families; the Curculionidae (Scolytinae) and Eucnemidae (Macraulacinae and Melasinae) had three species each and the Scraptiidae (Anaspidinae and Scraptinae), with two species, were particularly notable.

Table 2. Species and individual numbers by family (*New records for Türkiye)

Family / Species Name	Number of Individuals	Presence Rate (%)	IUCN Category Europa (Mediterranean)	Trophic Category
ADERIDAE				
Aderus populneus (Creutzer in Panzer, 1796)	1	0.08		SX
Gompelia ruficollis (Rossi, 1794)	5	0.38		
ANOBIIDAE				
Anobiinae				
Anobium punctatum (De Geer, 1774)	132	10.14		XY
Dorcatoma farbiaki Zahradník, 1998	8	0.61		MB
Dorcatoma sp.	18	1.38		MB
Falsogastrallus unistriatus (Zoufal, 1897)	15	1.15		XY
Lasioderma sp.	20	1.54		
Mesocoelopus niger (P. W. J. Muller, 1821)	28	2.15		XY
Metholcus phoenicis (Fairmaire, 1859)	27	2.07		XY
Oligomerus ptilinoides Wollaston, 1854	4	0.31		XY
Ptilinus pectinicornis (L., 1758)	1	0.08		XY
Stagetus elongatus (Mulsant & Rey, 1861)	27	2.07		SX
Xyletinus sp.	1	0.08		XY

Table 2. Continued

Family / Species Name	Number of Individuals	Presence Rate (%)	IUCN Category Europa (Mediterranean)	Trophic Category
Ptininae				
Dignomus frivaldszkyi (Reitter, 1884)	1	0.08		
**Dignomus urbanus* Borowski, 1999	40	3.07		
Ptinus (*Bruchiptinus*) sp.1	2	0.15		
Ptinus (*Bruchoptinus*) sp.2	1	0.08		
ANTHRIBIDAE				
Anthribinae				
Noxius curtirostris (Mulsant & Rey, 1861)	8	0.61		XY (SX, MY)
BOSTRICHIDAE				
Bostrichinae				
Scobicia chevrieri (Villa & Villa, 1835)	3	0.23	LC	XY
CERAMBYCIDAE				
Cerambycinae				
Axinopalpis gracilis (Krynicki, 1832)	1	0.08	LC	XY
Gracilia minuta (Fabricius, 1781)	1	0.08	LC	XY
Stromatium unicolor (Olivier, 1795)	1	0.08	LC	XY
Lamiinae				
Anaesthetis testacea (Fabricius, 1781)	1	0.08		XY
Niphona picticornis Mulsant, 1839	1	0.08		XY
Prioninae				
Aegosoma scabricorne (Scopoli, 1763)	2	0.15	LC	XY
Rhaesus serricollis (Motschulsky, 1838)	16	1.23	NT	
CIIDAE				
**Cis tomentosus* Mellié, 1849	4	0.31		MB
Cis villosulus (Marsham, 1802)	1	0.08		
CLERIDAE				
Clerinae				
Clerus mutillarius Fabricius, 1775	8	0.61		PR
Tillinae				
Denops albofasciatus (Charpentier, 1825)	1	0.08		PR
COLYDIDAE				
Colydiinae				
**Colydium filiforme* Fabricius, 1792	1	0.08		
Synchita mediolanensis Villa & Villa, 1833	3	0.23		
CORYLOPHIDAE				
Corylophinae				
Arthrolips sp.	1	0.08		MY
CURCULIONIDAE				
Cossoninae				
Melicius cylindrus (Boheman, 1838)	6	0.46		SX
Stenoscelis (*Stenoscelis*) *submuricata* (Schoenherr, 1832)	33	2.53		SX
Scolytinae				
**Ambrosiodmus rubricollis* (Eichhoff, 1875)	2	0.15		MY
Hypothenemus eruditus (Westwood, 1834)	5	0.38		
Kissophagus vicinius (Comolli, 1837)	3	0.23		
**Scolytus orientalis* Eggers, 1910	1	0.08		
Xyleborinus saxesenii (Ratzeburg, 1837)	492	37.79		MY
**Xylosandrus crassiusculus* (Motschulsky, 1866)	13	1.00		MY

Table 2. Continued

Family / Species Name	Number of Individuals	Presence Rate (%)	IUCN Category Europa (Mediterranean)	Trophic Category
DASYTIDAE				
Dasytinae				
Dasytes (*Dasytes*) *tardus* Schaufuss, 1872	8	0.61		
Rhadalinae				
Aplocnemus (*Aplocnemus*) *rufipes* Miller, 1862	2	0.15		PR
DERMESTIDAE				
Megatominae				
Anthrenus (*Florilinus*) *verbasci* (L., 1767)	7	0.54		
Thorictus grandicollis grandicollis Germar, 1842	1	0.08		
Trogoderma glabrum (Herbst, 1783)	3	0.23		
ELATERIDAE				
Agrypninae				
Adelocera pygmaea (Baudi, 1871)	2	0.15	EN	
Lacon punctatus (Herbst, 1779)	2	0.15	LC	PR
Dendrometrinae				
Elathous emrei Platia et al., 2011	1	0.08		
Elathous rufobasalis Wurst, 1994	6	0.46		
**Hypnoidus riparius* (Fabricius, 1792)	2	0.15		
Elaterinae				
Ampedus cinnabarinus Eschscholtz, 1829	1	0.08	LC	PR
Agriotes acuminatus (Stephens, 1830)	1	0.08		
Agriotes brevis Candèze, 1863	16	1.23		
Agriotes paludum Kiesenwetter, 1859	1	0.08		
Agriotes sputator (L., 1758)	13	1.00		
Ectamenogonus montandoni (Buysson, 1889)	1	0.08	NT (EN)	PR
Haterumelater fulvago (Marseul, 1868)	28	2.15		
Pittonotus theseus (Germar, 1817)	26	2.00		
ENDOMYCIDAE				
Anamorphinae				
Symbiotes gibberosus (Lucas, 1846)	3	0.23		MB
EUCHIRIDAE				
Euchirinae				
Propomacrus bimucronatus (Pallas, 1781)	5	0.38	NT (VU)	
EUCNEMIDAE				
Macraulacinae				
**Dromaeolus simplicifrons* Otto, 2016	2	0.15		
Melasinae				
**Brevisegmentus miyatakei* (Hisamatsu, 1955)	3	0.23		
**Melasis balwanti* Fleutiaux, 1934	2	0.15		
HISTERIDAE				
Dendrophilinae				
Cyclobacanius soliman (Marseul, 1862)	1	0.08		PR
Histerinae				
Platysoma (*Platysoma*) *compressum* (Herbst, 1783)	3	0.23		PR
Tribalinae				
Epierus comptus Erichson, 1834	2	0.15		PR
Tribalus anatolicus Olexa, 1980	1	0.08		
Pseudepierus italicus (Paykull, 1811)	1	0.08		PR

Table 2. Continued

Family / Species Name	Number of Individuals	Presence Rate (%)	IUCN Category Europa (Mediterranean)	Trophic Category
LANGURIIDAE				
Cryptophilinae				
**Cryptophilus integer* (Heer, 1841)	2	0.15		
LATRIDIIDAE				
Corticariinae				
Corticaria sp.	1	0.08		MY
Melanophthalma (*Melanophthalma*) *distinguenda* (Comolli, 1837)	4	0.31		MY
Latridiinae				
Enicmus rugosus (Herbst, 1793)	1	0.08		MY
Latridius minutus (L., 1767)	5	0.38		MY
LUCANIDAE				
Lucaninae				
Dorcus parallelipipedus (L., 1785)	12	0.92	LC	SX
MALACHIIDAE				
Malachiinae				
Troglops sp.	2	0.15		
MONOTOMIDAE				
Monotoma sp.	1	0.08		MY
MORDELLIDAE				
Mordellinae				
Mordellistena sp.1	5	0.38		SX
Mordellistena sp.2	2	0.15		SX
Tomoxia bucephala (Costa, 1854)	1	0.08		SX
MYCETOPHAGIDAE				
Mycetophaginae				
Mycetophagus decempunctatus Fabricius, 1801	1	0.08	LC	MY
NITIDULIDAE				
Nitidulinae				
Amphotis orientalis Reiche, 1861	3	0.23		MM
Omosita discoidea (Fabricius, 1775)	5	0.38		
OEDEMERIDAE				
Oedemerinae				
Oedemera (*Oncomera*) *flavicans* (Fairmaire, 1860)	9	0.69		SX
PHALACRIDAE				
Phalacrinae				
Stilbus sp.	1	0.08		
PYROCHROIDAE				
Hemidendroides ledereri (Ferrari, 1869)	3	0.23		
SCIRTIDAE				
Prionocyphon ornatus Abeille de Perrin, 1881	8	0.61		
SCRAPTIIDAE				
Anaspidinae				
Anaspis (*Anaspis*) *lurida* Stephens, 1832	12	0.92		SX
Anaspis (*Anaspis*) *thoracica* (L., 1758)	2	0.15		
**Anaspis* (*Silaria*) *varians* Mulsant, 1856	6	0.46		
Scraptiinae				
**Scraptia ferruginea* Kiesenwetter, 1861	1	0.08		

Table 2. Continued

Family / Species Name	Number of Individuals	Presence Rate (%)	IUCN Category Europa (Mediterranean)	Trophic Category
SPHINDIDAE				
Sphindinae				
Aspidiphorus orbiculatus (Gyllenhal, 1808)	4	0.31		MY
**Sphindus dubius* (Gyllenhal, 1808)	3	0.23		MY
STAPHYLINIDAE				
Pselaphinae				
Batrisodes sp.	1	0.08		
Staphylininae				
Hesperus auricomus Schillhammer et al., 2007	3	0.23		
Quedius (*Raphirus*) sp.1	1	0.08		
Quedius (*Raphirus*) sp.2	3	0.23		
Tachyporinae				
Tachinus laticollis Gravenhorst, 1802	6	0.46		
Tachyporus hypnorum (Fabricius, 1775)	3	0.23		
Tachyporus nitidulus (Fabricius, 1781)	1	0.08		
Xantholininae				
Xantholinus sp.	3	0.23		
TENEBRIONIDAE				
Alleculinae				
Allecula estriata Seidlitz, 1896	24	1.84		
Mycetochara quadrimaculata (Latreille, 1804)	59	4.53	NT	SX
Prionychus ater (Fabricius, 1775)	10	0.77	LC	SX
Diaperinae				
Diaperis boleti (L., 1758)	2	0.15	LC	MB
Tenebrioninae				
Bolitophagus reticulatus (L., 1767)	2	0.15		MB
Nalassus plebejus (Küster, 1850)	2	0.15		SX
**Uloma ferruginea* (Piller & Mitterpacher, 1784)	5	0.38		
TOTAL	1302	100		

Dignomus urbanus Borowski, 1999 (Coleoptera: Anobiidae) was first identified in Saudi Arabia and described in 1999 (Löbl & Smetana, 2007). With this study, Türkiye became the second known country of distribution of this species, particularly notable because a high number of individuals (40 individuals) were found among the new records.

Cis tomentosus Mellie, 1848 (Coleoptera: Ciidae) is distributed in Europe, Asia, and North Africa (Jelínek, 2008; Amini et al., 2020). It appears to be associated with fungi in the genus *Trichaptum* and reports from *Alnus* sp. (Betulaceae) and *Fagus* sp. (Fagaceae) are available (Amini et al., 2020). *Colydium filiforme* Fabricius, 1792 (Coleoptera: Colydidae) is distributed in Europe and Asia (Węgrzynowicz, 1999; Otero & Ghahari, 2020). No data on host records were found.

Three species of the subfamily Scolytinae are new records for the fauna of Türkiye. Among these species, *Ambrosiodmus rubricollis* (Eichhoff, 1875) is commonly found in the Far East and is endemic to Asia, although it also occurs in Australia (Wood & Bright, 1992), North America (Bright, 1968) and Europe (Italy and Slovenia) (Faccoli et al., 2009; Gomez et al., 2018). It has a wide host range and is mostly found on broad-leaved trees and shrubs (Faccoli et al., 2009; EPPO, 2023). It has been detected on *Liquidambar styraciflua* L. (Saxifragales: Altingiaceae) in the state of Florida in the United States of America (You et al., 2015). *Scolytus orientalis* Eggers, 1910 has been reported from Russia, Bulgaria, Ukraine, Iran, and Turkmenistan (Petrov, 2021; Alonso-Zarazaga et al., 2017). It was detected on *Ulmus glabra* Huds., *U. laevis* Pall., *U. pumila* L. (Rosales: Ulmaceae) and *Zelkova carpinifolia* (Pall.) (Rosales: Ulmaceae) in

European Russia (Petrov, 2021). *Xylosandrus crassiusculus* (Motschulsky, 1866) has been recorded in Europe, Africa, Asia, and America (Atkinson et al., 2011; Gomez et al., 2018; Alonso-Zarazaga et al., 2017). This species, which is polyphagous, including coniferous and broadleaf species, was also found in *L. styraciflua* in Florida (Schedl, 1963; Wood, 1982; Pennacchio et al., 2003; Atkinson et al., 2011).

Some of the species newly recorded in Türkiye were previously detected mostly in Europe. *Hypnoidus riparius* (Fabricius, 1792) (Coleoptera: Elateridae) has been recorded in Europe and Asia (Löbl & Smetana, 2007) and is reported to be rarely seen in agricultural areas (EPPO, 2023). *Cryptophilus integer* (Heer, 1841) (Coleoptera: Languriidae) has been detected in Europe, Asia, Africa and South America (Ljubarsky, 1995; Ljubarsky, 1997; Ottó, 2004). *Anaspis* (*Silaria*) *varians* Mulsant, 1856 of the Scraptiidae family has been found in many countries in Europe and in Cyprus and Syria in Asia, while *Scraptia ferruginea* Kiesenwetter, 1861 was previously reported in Slovakia, Slovenia and Switzerland in Europe (Löbl & Smetana, 2008). *Sphindus dubius* (Gyllenhal, 1808), of the Sphindidae, has been reported from many countries in Europe, Algeria and the Canary Islands in North Africa (Löbl & Smetana, 2007). The species *Uloma ferruginea* (Piller & Mitterpacher, 1784) (Coleoptera: Tenebrionidae) has been detected in Europe; it was found in Albania, Bosnia and Herzegovina, Croatia, and Romania (de Jong et al., 2014).

Three species from the family Eucnemidae identified in the study are also among the species new for the fauna of Türkiye. These species have been reported to spread from Laos, Thailand, Japan, and India in the Eastern Palearctic Region. It was stated that these species [*Dromaeolus simplicifrons* Otto, 2016, *Brevisegmentus miyatakei* (Hisamatsu, 1955) and *Melasis balwanti* Fleutiaux, 1934 (Coleoptera: Eucnemidae)] are rare species. *Brevisegmentus miyatakei* occurs on broad-leaved trees and *M. balwanti* on *Gynocardia odorata* R. Br. (Malpighiales: Achariaceae) (Otto, 2016).

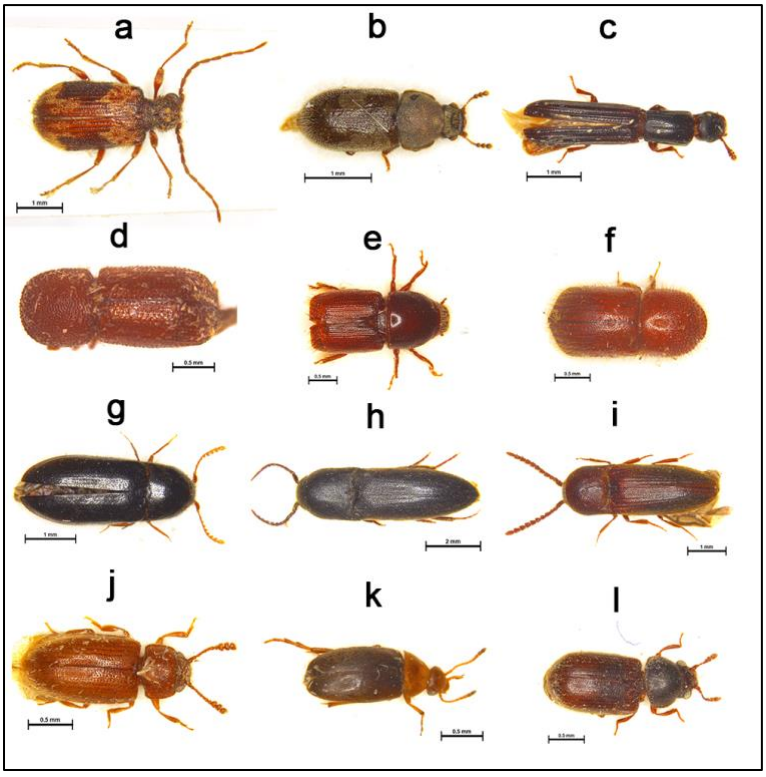

Figure 3. Examples of species of saproxylic beetle new to the fauna of Türkiye: a) *Dignomus urbanus*, b) *Cis tomentosus*, c) *Colydium filiforme*, d) *Ambrosiodmus rubricollis*, e) *Scolytus orientalis*, f) *Xylosandrus crassiusculus*, g) *Hypnoidus riparius*, h) *Dromaeolus simplicifrons*, i) *Brevisegmentus miyatakei*, j) *Cryptophilus integer*, k) *Anaspis* (*Silaria*) *varians*, l) *Sphindus dubius*.

Based on analysis of the numbers of species by family, Anobiidae was most abundant with 15 species, with Elateridae (13 species), Curculionidae and Staphylinidae (8 species each) second and equal third in abundance (Figure 4). The Curculionidae family included 555 individuals, the Anobiidae 325 individuals and the Tenebrionidae 104 individuals, the first three places most abundant in terms of individuals (Figure 5).

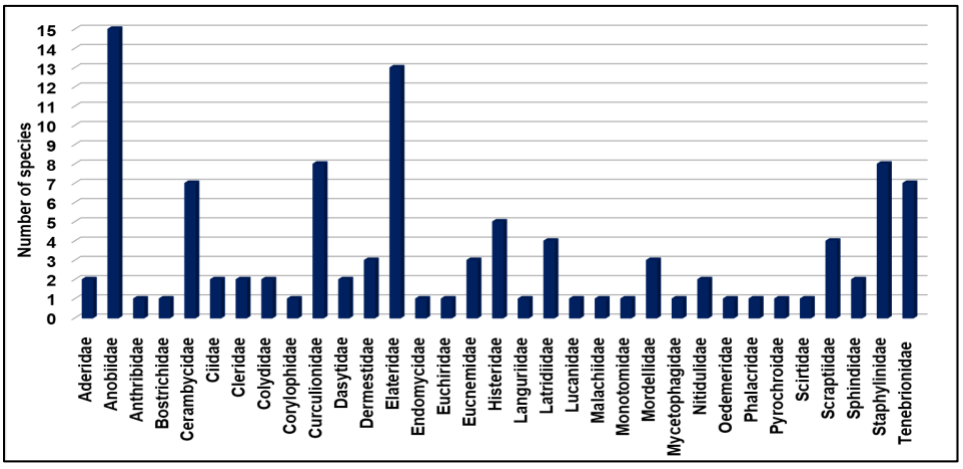

Figure 4. The number of saproxylic beetle species per family caught in studies of *Liquidambar orientalis* in Türkiye.

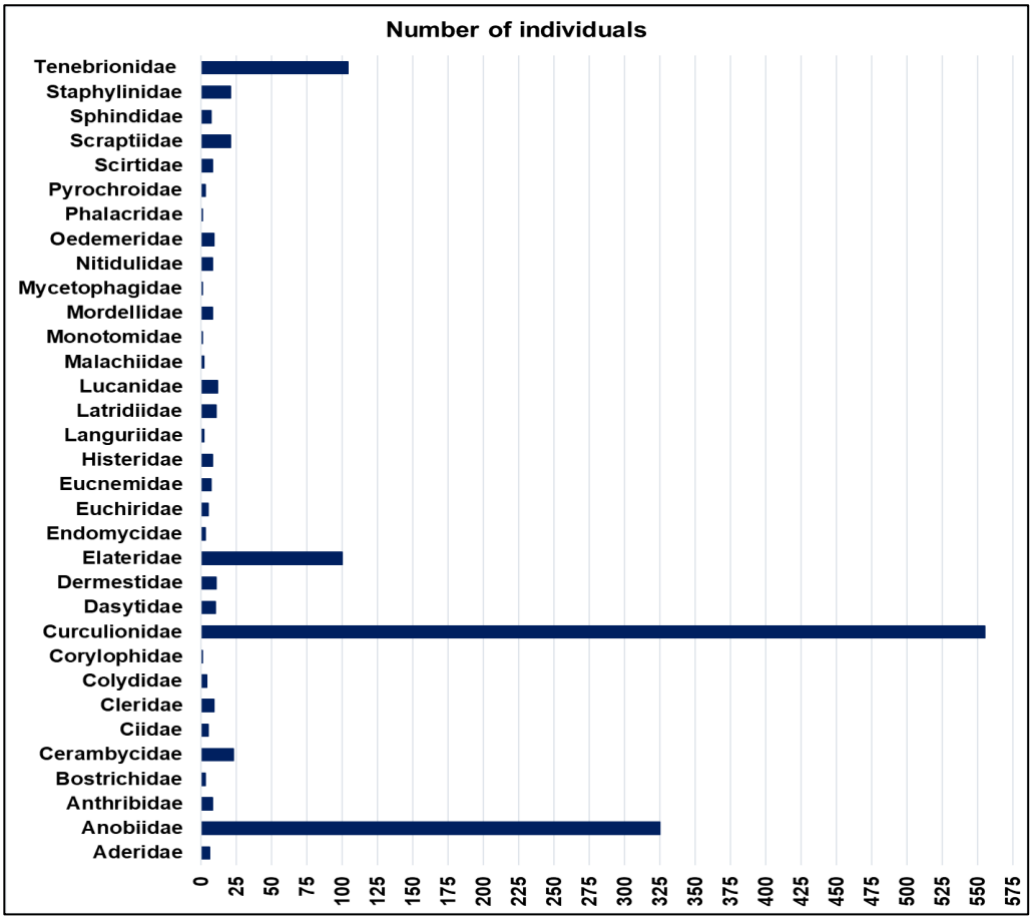

Figure 5. The number of individuals per family of saproxylic beetle caught in studies of *Liquidambar orientalis* in Türkiye.

Although the number of species in the family Buprestidae was high in saproxylic beetle studies conducted on different tree species (oak, cedar-oak, beech) in different areas (Adana-Kozan, Mersin-Gülnar, Kahramanmaraş-Andırın) in Türkiye (Gürkan, 2011; Laz, 2015; Varlı et al., 2021; Göktepe, 2022), no species in this family were detected in our study. These differences may be due to regional differences or the tree species examined (Muñoz-López et al., 2016). However, other studies and the families with high number of species in this study and other studies are similar (Gürkan, 2011; Atay et al., 2012; Laz, 2015; Varlı et al., 2021; Göktepe, 2022).

Examining numbers of species according to trap types, 1219 individuals of 97 species were obtained from window traps and 38 individuals of 19 species from pitfall traps. Of these species, 15 were found in both trap types. Four species [*Ptinus* (*Bruchoptinus*) sp.2 (Coleoptera: Anobiidae), *Stromatium unicolor* (Olivier, 1795) (Coleoptera: Cerambycidae), *Lacon punctatus* (Herbst, 1779) (Coleoptera: Elateridae) and *Tribalus anatolicus* Olexa, 1980 (Coleoptera: Histeridae)] were caught only in pitfall traps. Eighty two of 97 species were found only in window traps. Seven species [*Ptinus* (*Bruchiptinus*) sp.1 (Coleoptera: Anobiidae), *S. orientalis*, *Ectamenogonus montandoni* (Buysson, 1889) (Coleoptera: Elateridae), *Epierus comptus* Erichson, 1834 (Coleoptera: Histeridae), *Pseudepierus italicus* (Paykull, 1811) (Coleoptera: Histeridae), *Stilbus* sp. (Coleoptera: Phalacridae), *Diaperis boleti* (L., 1758) (Coleoptera: Tenebrionidae)] were collected only by light trap and hand; these species were not detected in window or pitfall traps. In places where pitfall traps were set, disturbance problems such as filling of the traps with soil and removal of the traps were encountered. The fact that some larger animal species also use the hollow trees where pitfall traps were located and that the cavities are secluded and sheltered are thought to explain the low number of individuals recovered, compared to window traps. In addition, the larger surface area of the window traps may also affect the results (Peuhu et al., 2019). In studies where these types of traps were used, it was reported that the number of species caught was lower in pitfall traps (Ranius & Jansson, 2002; Milberg et al., 2014; Peuhu et al., 2019).

A comparison of insect numbers caught in the different sampling areas showed that 72 species and 765 individuals were caught in Köyceğiz, with 71 species and 492 individuals caught in Fethiye. Although it was expected that the number of species and individuals would be higher in Fethiye due to its protected status, more individual insects were obtained in Köyceğiz. A possible reason for this effect is that the insect population is negatively affected by human tourism activities in the protected area. Since sweetgum oil is produced by peeling and wounding the bark of the trees in the area in Köyceğiz, the trees are weakened. For this reason, more individuals of Scolytinae (Curculionidae) were obtained, which includes secondary pest species.

In Fethiye, 23 saproxylic beetles belonging to 10 species of Cerambycidae [*Rhaesus serricollis* (Motschulsky, 1838), 8 individuals] and Elateridae (*Elathous rufobasalis* Wurst, 1994, 5 individuals) families were caught with light traps. In addition, 20 individuals of 7 species in Fethiye and 2 individuals of 2 species in Köyceğiz were found in fallen trees by hand collection. *Dorcus parallelipipedus* (L., 1785) (Coleoptera: Lucanidae) in the Lucanidae family was the most common species with 9 individuals.

In the study, *X. saxesenii* from the subfamily Scolytinae was the most common species found, with 492 individuals, representing approximately 38% of the total number of individuals. Of the individuals obtained from this species, 445 were from Köyceğiz and 47 from Fethiye. This situation is also possibly related to the production of sweetgum oil by peeling and injuring the bark of trees in the area in Köyceğiz. In several studies on bark and ambrosia beetle species conducted in Türkiye (Sarıkaya, 2013a, b; Sarıkaya & Sayın, 2016, Sarıkaya, 2019), *X. saxesenii* has been the most common species found. One of these studies was conducted on *L. orientalis* (Sarıkaya, 2013b). In a study conducted in the USA on *L. styraciflua*, a high number (566 individuals) of *X. saxesenii* was also detected (Ulyshen & Hanula, 2009).

Sixteen species found in this study are included in the Red List of the IUCN Europaea (Carpaneto et al., 2015). *Adelocera pygmaea* (Baudi, 1871) (Elateridae) is considered endangered (EN). *Ectamenogonus*

montandoni, *R. serricollis*, *Mycetochara quadrimaculata* (Latreille, 1804) (Coleoptera: Tenebrionidae) and *Propomacrus bimucronatus* (Pallas, 1781) (Coleoptera: Euchiridae) are classified as near threatened (NT). Of these species, 11 are classified as low risk (LC). According to IUCN Mediterranean Red List, *E. montandoni* and *P. bimucronatus* are endangered (EN) and vulnerable (VU), respectively. *Ectamenogonus montandoni* (Jansson & Coskun, 2008; Avcı et al., 2010; Atay et al., 2012) and *P. bimucronatus* (Önuçar & Ulu, 1986; Tezcan & Pehlivan, 2001; Jansson & Coskun, 2008; Göktepe, 2022) were also detected in some saproxylic beetle studies conducted in Türkiye.

The trophic category classification for 57 of the 108 species identified in the study was determined. While some species of Cerambycidae (XY: Xylophagous), Histeridae (PR: Predator), Latridiidae (MY: Mycophagous) were in one category, certain species from, for example, the Curculionidae (MY, SX: Saproxylophagous), Anobiidae (MB: Mycetophagous, SX, XY), Tenebrionidae (MB, SX) are in two or more categories. When examined at the taxon level, 15 species were classified as XY, 13 species as SX, 12 species as MY, 10 species as PR, 6 species as MB and 1 species as MM (Myrmecophilous or melittophagous). *Xyleborinus saxesenii*, with the highest number of individuals found in the study, is in the MY category. *Ectamenogonus montandoni* is also in the PR trophic category, which is categorized as endangered (EN) in the IUCN Mediterranean Red List (Carpaneto et al., 2015).

Conclusion

Understanding biodiversity has a crucial role in the conservation and management of forest areas with a sustainability approach. In particular, creatures living naturally in micro-habitats, such as tree hollows, are indicators of sustainable forest management. When the results of the study and the related literature were examined, the importance of *L. orientalis* forests to biodiversity in Türkiye and even globally becomes clear. Only 15 of the 108 insect species obtained in this study are new to the fauna of Türkiye. There is no doubt that this number will increase with further studies. The protection of this tree species, the distribution area of which is decreasing in Türkiye, will ensure the protection of the biodiversity it contains. However, tourism activities, sweetgum oil production activities, illegal cutting and clearing activities in some areas pose a risk to the future of the species. The main purpose of overall management in sweetgum oil production areas should be the protection of these trees rather than oil production. In these areas, the sustainability of the forest can be ensured by leaving old trees in the field. Moreover, oil production can be continued in these areas. In addition, the presence of old trees is very important for protecting biodiversity and ensuring the continuity of the ecosystem. In this way, it will be possible to transfer this tree species and the biodiversity it supports to future generations.

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