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Researches on determination of saproxylic beetles (Coleoptera) on old hollow broad-leaved tree species in Cataldag (Balıkesir-Bursa) in Western Türkiye

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Abstract

With this study, Cataldag province extending at the provincial borders of Balıkesir and Bursa, the field studies were performed at 11 different study areas per three weeks using pitfall traps and window traps with old and hollow seven different original forest tree species (*Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petrea*e, *Q. cerris*, *Q. cerris x Q. infectoria*) in between April and November months during 2014-2015. At the result of the study, 112 saproxylic beetles species belonging to 83 genus of 25 families were identified. *Anobium hederae* Ihssen, *Gastrallus corsicus* Schilsky, *Hemicoelus canaliculatus* (Thomson), *Cryptophagus pubescens* Sturm, *Symbiotes gibberosus* (Lucas), *Triplax russica* (Linnaeus), *T. scutellaris* Charpentier, *Hylis cariniceps* (Reitter), *Isorhipis marmottani* (Bonvouloir), *Phloiotrya tenuis* (Hampe), *Litargus balteatus* (LeConte), *Sacodes flavicollis* (Kiesenwetter), *Tetratoma desmarestii* Latreille and *Synchita undata* Guérin-Méneville are the new records for Turkish beetles fauna. 89 saproxylic beetles of 22 families are recorded for Balıkesir and Bursa provinces for the first time. 35 species in red list prepared for endangered saproxylic beetle species in Europe and Mediterrenean basin were determined. *Podeonius acuticornis* endangered (EN), *Cardiophorus gramineus*, *Megapenthes lugens*, *Mycetochara quadrimaculata* near threatened (NT), *Ischnodes sanguinicollis* and *Lucanus ibericus* vulnerable (VU) categories are included. 88 saproxylic beetle species were determined in Susurluk and the most species were collected from *P. orientalis* (32 species), nonetheless 56 saproxylic beetle species were determined in Mustafakemalpaşa and the most species were collected from *Q. cerris* (20 species). Saproxylic beetle species were collected with 82 % window trap and 25 % pitfall trap.

Key words: Coleoptera, saproxylic, red list, Cataldag, Türkiye.

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Çataldağ (Balıkesir-Bursa) bölgesindeki yaşlı çökük geniş yapraklı ağaç türlerinde bulunan saproksilik böcek türlerinin (Coleoptera) belirlenmesi üzerine araştırmalar

Özet

Bu çalışma kapsamında 2014-2015 Nisan-Kasım ayları arasında Çataldağ'ın (Susurluk-Mustafakemalpaşa) 11 farklı çalışma sahasında, üçer haftalık periyotlarla, yaşlı ve çökük yedi farklı geniş yapraklı asli orman ağacı türü (*Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petrea*e, *Q. cerris*, *Q. cerris x Q. infectoria*) ile pencere ve çukur tuzak yöntemi kullanarak gerçekleştirilen arazi çalışmaları sonucunda 25 familyaya bağlı 83 cinse ait toplam 112 saproksilik kınkanatlı tür belirlenmiştir. Saproksilik kınkanatlı türlerden *Anobium hederae* Ihssen, *Gastrallus corsicus* Schilsky, *Hemicoelus canaliculatus* (Thomson) (Anobiidae), *Cryptophagus pubescens* Sturm (Cryptophagidae), *Symbiotes gibberosus* (Lucas) (Endomychidae), *Triplax russica* (Linnaeus), *T. scutellaris* Charpentier (Erotylidae), *Hylis cariniceps* (Reitter), *Isorhipis marmottani* (Bonvouloir) (Eucnemidae), *Phloiotrya tenuis* (Hampe) (Melandryidae), *Litargus balteatus* (LeConte) (Mycetophagidae), *Sacodes flavicollis* (Kiesenwetter)

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(Scirtidae), *Tetratoma desmarestii* Latreille (Tetratomidae) ve *Synchita undata* Guérin-Méneville (Zopheridae) türleri Türkiye kınkanatlı faunası için yeni kayıt niteliğindedir. Bu türler dışında bu çalışma ile 22 familyaya bağlı 89 saproksilik kınkanatlı türün Balıkesir ve Bursa illerinde ilk kez bulunduğu ortaya konmuştur. Avrupa ve Akdeniz havzası'nda tehdit altında bulunan saproksilik kınkanatlı türler için hazırlanan Kırmızı Listelerde bulunan 35 tür belirlenmiştir. Bu türlerden Avrupa Kırmızı Listesinde bulunan *Podeonius acuticornis* tehlikede (EN), *Cardiophorus gramineus, Megapenthes lugens*, *Mycetochara quadrimaculata* tehdite yakın (NT), *Ischnodes sanguinicollis* ve *Lucanus ibericus* duyarlı (VU) kategorilerinde yer almaktadır. Susurluk'ta 88 saproksilik kınkanatlı tür belirlenmiş ve en fazla tür *P. orientalis* (32 tür)'den Mustafakemalpaşa'da ise 56 tür belirlenmiş ve en fazla tür *Q. cerris* (20 tür)'ten toplanmıştır. Yakalanan saproksilik kınkanatlı türlerin % 82'si pencere tuzak ile % 25'i ise çukur tuzakla toplanmıştır.

Anahtar kelimeler: Coleoptera, saproksilik, kırmızı liste, Çataldağ, Türkiye.

1. Introduction

Turkey has the richest biodiversity in Europe and the Middle East and ranks ninth in terms of biodiversity on the European continent. With more than 1,000,000 known species worldwide, insects constitute more than 50% of global biodiversity, more than one third (1/3) of which belongs to the Coleoptera taxa with over 200 families and around 400,000 species. While there are more than 11900 species of Coleoptera in Turkiye, there are more than 33800 insect species in total [1].

Saproxylic species are organisms that live on dead or dying wood or in dead trees, or depend on wood-related fungi or other saproxylic organisms during certain periods of their life. Saproxylic organisms represent the core of forest biodiversity. Saproxylic invertebrates are one of the threatened animal groups that are intensively studied especially in the forests of Europe and more recently in the Mediterranean basin. Among saproxylic invertebrates, insects have a very high importance in terms of forest biodiversity. Playing a key role in forest ecosystem dynamics, Saproxylic insects have a vital ecological role for the sustainability of the food chain within natural ecosystems, decay processes of wood and decomposition of dead wood with fungi, and is important for revealing the relationships and interactions between organisms living in forest ecosystems through the perspectives of many different disciplines [2].

Saproxylic insect species and other saproxylic species are among the most threatened groups of organisms. Like all living species, saproxylic species are affected by the adverse conditions caused by loss of forests. Despite the increase in the number of forestlands, the habitats of these species are getting smaller. One of the most important reasons for this is economic uses, which have led to large rate reductions in the number of large diameter dead wood and large mature trees in forestlands [3,4,5]. Impairment of remaining forests and deforestation are among the primary threats to global biodiversity. Unlike many other groups of organisms, saproxylic organisms are more sensitive to the loss of forests. Half of the Earth's original forest cover has rapidly disappeared over the last few decades. Agricultural developments, large-scale cuttings and industrial factors are the main causes of this loss [6].

Saproxylic insects has different relationships with coniferous and broad-leaved primary tree species in forests that serve as their main habitats. Dahlberg and Stokland (2004) analyzed 1257 saproxylic insect species in Northern Europe to find that 329 species (26%) were associated with a single tree species [7]. In the same study, where the trees were grouped as coniferous (23%) and broad-leaved (52%), it was found that at least 75% of the species had a preference for only one of these tree groups, while 11% had a preference for both tree groups. It was further found that 75-90% of the saproxylic insects in Northern Europe tended for trees of two different classes as coniferous and broad-leaved trees. A similar trend was detected in studies conducted in China, suggesting that this is most likely a global trend [8].

According to the results of this and other similar studies, saproxylic insects prefer broad-leaved tree species more than other species. In recent centuries, various factors such as the human impact on old, dead or decayed wood resources, modern forestry practices in forestlands in much of Europe and the Mediterranean basin have led to a decrease in the nutrients (wood) used by these creatures for feeding, reproduction and other purposes and impairment of the natural outlook of forestlands. It is necessary to define the vital relationship between dead wood and saproxylic insects in order to ensure the protection and sustainability of forest biodiversity [2].

2. Materials and methods

2.1. Study area

Cataldag is a mountain in the South Marmara Region, located in the northeast of Balıkesir province, between 39º45′-39º58′ north latitudes and 28º11′-28º32′ east longitudes, hosting the provincial borders of the Balıkesir and Bursa (Figure 1). For this reason, some part of the mountain is located within the borders of Balıkesir and the other part is located within the borders of Bursa. Since Cataldag is an east-west facing mountain, there are clear differences between its northern and southern slopes in terms of floristic composition and climate. One of the most important indicators of this difference is that moisture-loving floristic elements such as *Abies bornmulleriana* (Uludag fir) and *Fagus orientalis* (eastern beech) form groups on the northern slope, which stands out as a quite interesting property for a region in the Mediterranean climate zone.

Therefore, it is possible to see the floristic elements of the Black Sea Region on the northern slopes of Cataldag and floristic elements of the Mediterranean Region on the southern slopes owing to the effect of the exposure and geographical location of the slope. This difference between the two slopes of the mountain has led to both floristic richness and faunistic diversity. 45% of the floristic elements of Cataldag are species that are specific to the Black Sea phyto-geography region. Mediterranean climate elements have a share around 25%. In addition, floristic elements with unknown rigin have a share around 30% in the region [9].

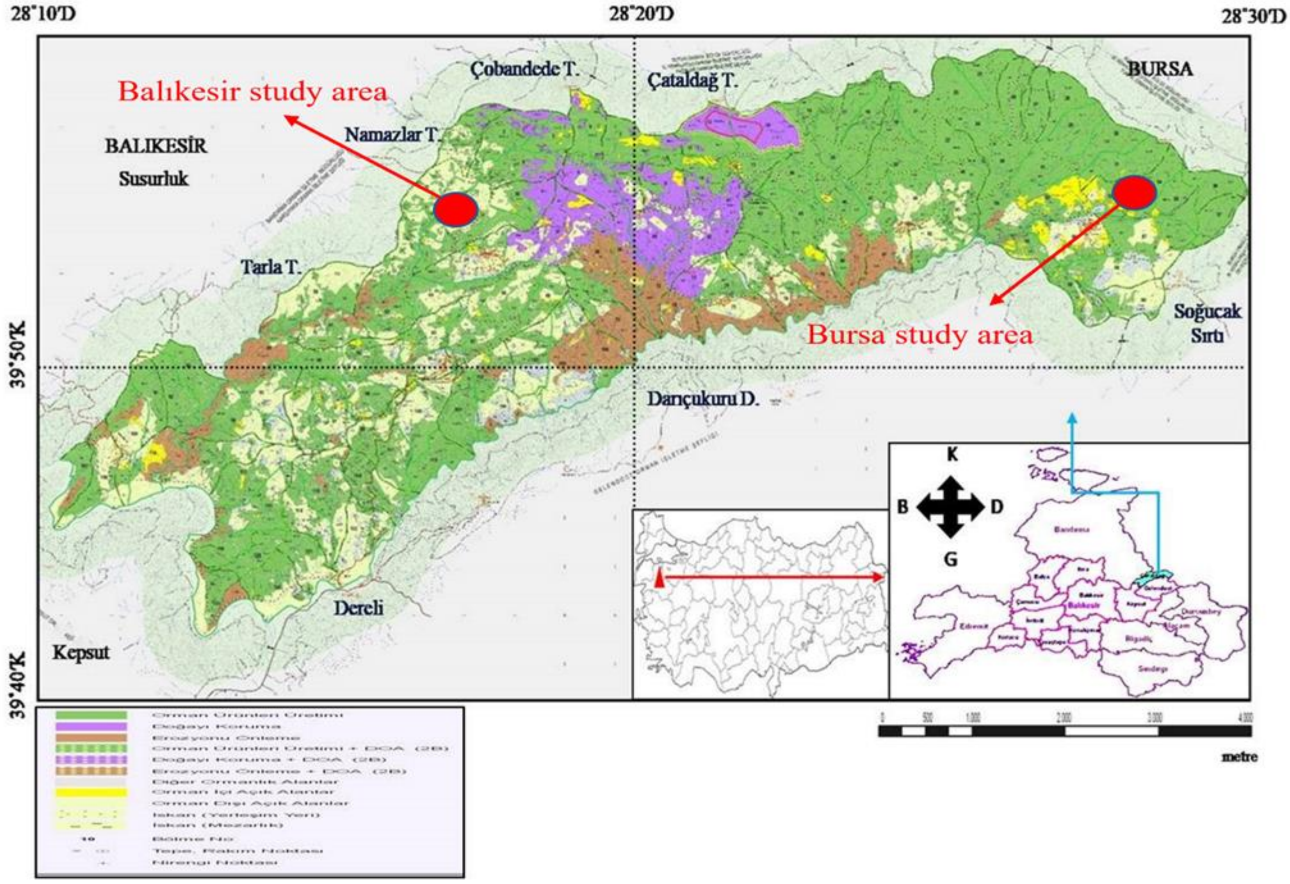

Figure 1. View of the study area (Cataldag, Balıkesir, Bursa)

2.2. Study materials

The main material of the study consisted of seven primary broad-leaved trees from *Quercus*, *Fagus*, *Alnus*, *Carpinus* and *Platanus* species (*Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petreae*, *Q. cerris*, *Q. cerris* x *Q. infectoria*) representing the northern and western slopes of Cataldag (Susurluk and Mustafakemalpasa), in line with the forestry maps of Balikesir Regional Directorate of Forestry and the views of Forest Management Directorates of Balikesir and Bursa (Susurluk and Mustafa Kemalpasa-Pasalar) as well as Coleoptera taxa insects collected at three-week intervals with 54 trap trees in 11 different sampling areas using window (WT) and pitfall traps (PT), from April to November between 2014-2015 (Table 1, Table 2).

Field surveys were made to the sampling areas to select trap trees from old, decayed or decaying broad-leaved tree species. The habitats of saproxylic insect species are more related to tree structure than to forest associations. The degree of decay of the trees selected for the study, distribution of dead wood on the tree and position of the tree on the ground are significant in terms of the efficiency of the study. Selection of sampling areas were also influenced by Cataldag's being a west-east facing mountain, which leads to meteorological differences between the northern and southern slopes of the mountain caused by the difference in exposure of the slopes; distribution of different tree species at different elevations; and the altitude factor.

Table 1. Cataldag (Balıkesir-Susurluk) study area locality information

No	Coordinates	Altitude (m)	Tree species	Method
1.	39°56´777"N /28°12'388''E	46	*P. orientalis*	WT-PT
2.	39°56´771"N /28°12'385''E	50	*P. orientalis*	WT-PT
3.	39°56´783"N /28°12'397''E	58	*P. orientalis*	WT-PT
4.	39°56´786"N /28°12'399''E	58	*P. orientalis*	WT-PT
5.	39°57´010"N /28°12'963''E	84	*P. orientalis*	WT-PT
6.	39°57´008"N /28°12'963''E	97	*P.orientalis*	WT-PT
7.	39°57´000"N 28°12'954''E	114	*P. orientalis*	WT-PT
8.	39°57´002"N /28°12'947''E	99	*P. orientalis*	WT-PT
9.	39°56´307"N /28°14'708''E	262	*C. betulus*	WT-PT
10.	39°56´317"N /28°14'689''E	264	*C. betulus*	WT-PT
11.	39°56´312"N /28°14'676''E	262	*A. glutinosa*	WT-PT
12.	39°56´315"N /28°14'659''E	271	*C. betulus*	WT-PT
13.	39°56´312"N /28°14'653''E	299	*C. betulus*	WT-PT
14.	39°56´311"N /28°14'653''E	299	*F. orientalis*	WT-PT
15.	39°52´844"N /28°16'571''E	483	*A. glutinosa*	WT-PT
16.	39°52´833"N /28°16'582''E	497	*A. glutinosa*	WT-PT
17.	39°52´843"N /28°16'593''E	490	*A. glutinosa*	WT-PT
18.	39°52´017"N /28°16'726''E	563	*C. betulus*	WT-PT
19.	39°52´020"N /28°16'718''E	570	*A. glutinosa*	WT-PT
20.	39°52´005"N /28°17'114''E	601	*Q. petreae*	WT-PT
21.	39°52´007"N /28°17'097''E	601	*Q. petreae*	WT-PT
22.	39°52´010"N /28°17'094''E	617	*Q. petreae*	WT-PT
23.	39°52´991"N /28°17'114''E	613	*Q. petreae*	WT-PT
24.	39°52´013"N /28°17'112''E	617	*Q. petreae*	WT-PT
25.	39°51´784"N /28°17'607''E	688	*F. orientalis*	WT-PT
26.	39°51´793"N /28°17'598''E	688	*F. orientalis*	WT-PT
27.	39°51´793"N /28°17'592''E	671	*F. orientalis*	WT-PT
28.	39°51´785"N /28°17'598''E	669	*F. orientalis*	WT-PT
29.	39°51´796"N /28°17'559''E	664	*F. orientalis*	WT-PT

Table 2. Cataldag (Bursa-Mustafakemalpasa) study area locality information

No	Coordinates	Altitude (m)	Tree species	Trap methods
1.	39°55'307''N 28°20'168''E	655	*Q. cerris*	WT-PT
2.	39°55'279''N 28°20'156''E	666	*Q. cerris*	WT-PT
3.	39°55'277''N 28°20'144''E	659	*Q. petreae*	WT-PT
4.	39°55'280''N 28°20'131''E	651	*Q. cerris x Q. infectoria*	WT-PT
5.	39°55'293''N 28°20'137''E	644	*Q. cerris*	PT
6.	39°55'287''N 28°20'108''E	643	*Q. cerris*	WT-PT
7.	39°55'289''N 28°20'119''E	653	*Q. cerris*	PT
8.	39°55'289''N 28°20'104''E	660	*Q. cerris*	PT
9.	39°55'164''N 28°20'302''E	639	*F. orientalis*	WT-PT
10.	39°55'163''N 28°20'308''E	662	*F. orientalis*	WT-PT
11.	39°55'171''N 28°20'312''E	646	*F. orientalis*	WT-PT
12.	39°55'172''N 28°20'335''E	637	*F. orientalis*	WT-PT
13.	39°55'181''N 28°20'321''E	640	*F. orientalis*	PT
14.	39°55'172''N 28°20'333''E	602	*F. orientalis*	WT-PT
15.	39°55'181''N 28°20'651''E	455	*A. glutinosa*	WT-PT
16.	39°55'191''N 28°21'666''E	452	*A. glutinosa*	WT-PT
17.	39°55'202''N 28°21'686''E	455	*C. betulus*	WT-PT
18.	39°55'266''N 28°21'740''E	451	*A. glutinosa*	WT-PT
19.	39°55'669''N 28°22'452''E	287	*C. betulus*	PT
20.	39°55'662''N 28°22'429''E	280	*A. glutinosa*	WT-PT
21.	39°55'675''N 28°22'433''E	283	*C. betulus*	WT-PT
22.	39°55'736''N 28°22'901''E	180	*C. betulus*	WT-PT
23.	39°55'848''N 28°22'889''E	227	*C. betulus*	WT-PT
24.	39°55'875''N 28°22'980''E	205	*P. orientalis*	WT-PT
25.	39°55'810''N 28°23'097''E	230	*P. orientalis*	WT-PT

2.2. Sampling methods

Two different trap types, window and pitfall traps, were preferred in this study for the collection of saproxylic beetles. These two traps were used in the previously identified study fields, with one window and one pitfall trap in each tree. However, due to land conditions, forest structure and the large distance between the cavity entry and the tree soil, this target could not be achieved in some cases. Therefore, window and pitfall traps had to be set on two different trees in some parts of our study fields. Window and pitfall traps were used on 29 trees in Susurluk region of Cataldag, while window and pitfall traps were used on 20 trees and only pitfall traps were used on 5 trees in Mustafakemalpasa region. Consequently, considering the land conditions, tree structure and distribution of tree species in the study fields, the random parceling method was selected for each study field to perform sampling at three-week intervals from April to November between 2014-2015, with one window and one pitfall trap on each of the 5 trees, featuring a distance of at least 50-60 meters between each trap (except for single trap types).

2.2.1. Window trap

Window traps are one of the most effective methods used in the assessment of forest biodiversity. Besides, window traps are much more selective than other trap types (food traps and colored traps) [10]. Window traps are used to catch active species that can move on and around the tree trunk rather than wingless species. Different types of window traps have been used in many studies to compare their success in trapping saproxylic insect species [11,12,13].

In this study, window trap was preferred, which was placed near the tree trunk depending on the position of the cavity. Window traps were placed in different ways on the selected sample trees depending on the sample tree structure, degree of decay, condition of the cavity and the presence of fungi. Considering these parameters, window traps were placed near the trunk where tree cavities were present (< 1 m), at a 1.5 to 5-meter height from the ground according to the position of the trunk cavity on the tree depending on the degree of decay. The window trap was designed with a 30 x 60 cm bidirectional fiber glass transparent sheet, a 20 x 20 cm rectangular plastic funnel connected to the bottom of the sheet with a metal cable, and a 250 ml plastic bottle with a tip in a diameter of 3 cm, placed in the narrow tip of the funnel and connected with thin wires (Figure 2).

Figure 2. Window trap

2.2.1. Pitfall trap

Pitfall traps are the most effective trapping method used in combination with window traps to catch saproxylic insects (Figure 3). Although pitfall trapping is the simplest and cheapest method for capturing arthropods that move nocturnally on the forest floor, it is inadequate for trapping flying insects or insects that are stationary or move little on the ground. The use of special trapping types in special forestlands is very important for the results to be obtained. For this purpose, they are used in combination with window traps to catch the species living in the debris at the base of the tree, species living at the base of the cavity or the predators feeding on the species living inside the cavity [14].

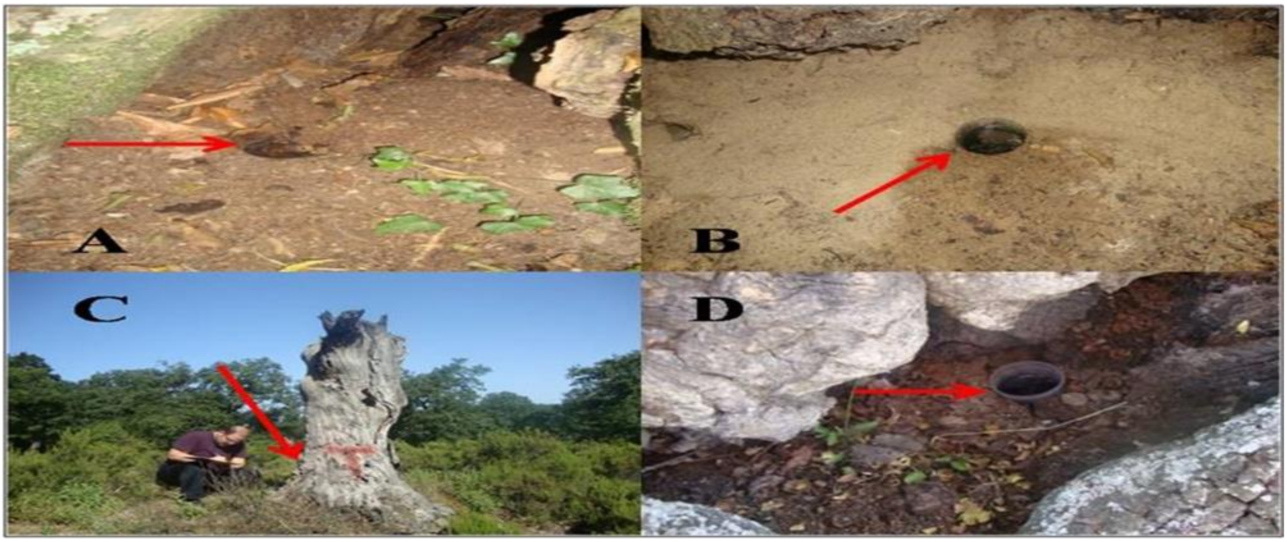

Figure 3. Pitfall trap **A)** Pitfall trap in the hollow on the ground **B)** Moist tree soil and pitfall trap in the hollow **C)** Pitfall trap in dead standing tree **D)** Pitfall trap in the hollow on the trunk.

2.3. Laboratory studies and diagnostics

2.3.1 Seperation of the samples and preparation for diagnostics

Samples were collected from the land and brought to the laboratory in labeled containers for purification from trap liquid with water using 0.1 mm wire strainers. Samples were separated on a 30 x 60 cm rectangular tray placed on a table under Soif Optical 5100L cold light source with LED light, 107 mm desktop latch magnifier with LED light and amplified light sources. Petri dishes, forceps of different thicknesses, 70 % alcohol, 15 and 50 ml falcons and 2 ml eppendorf tubes were used to separate the samples. The samples purified from the trap liquids were subjected to phenological separation according to their families and species. For identification, samples from certain families were preserved in boxes with cardboard lids while samples from some other families were preserved in 15 and 50 ml centrifuge tubes with twist caps and 2 ml eppendorf tubes (depending on their size) in 70% ethyl alcohol in accordance with preparation and labeling procedures, considering their characteristic features. In April and September every year, phenological separation and identification of the samples were carried out at Balikesir University, Faculty of Arts and Sciences, Department of Biology, Zoology Laboratory under the guidance of Nicklas Jansson and by the specialists in Linköping University in Sweden.

2.3.2 Diagnostics of the samples

In order to define the tree species from which the identified saproxylic insect species were collected, leaf and fruit samples were taken from the trap trees, which were then turned into herbarium material with standard techniques for identification of the tree species by Assistant Professor, Suleyman Sonmez. Identification of saproxylic beetles was carried out by; Dr Nicklas Jansson, Dr Jens Esser, Dr Giuseppe Platia, Dr Manfred Niehuis, Assoc. Dr Bekir Keskin, Prof. Dr Dr Serdar Tezcan, Assoc. Dr Nilay Gülpercin, Dr Jyrki Muona, Dr Denis Keith, Dr Roland Gerstemeier, Dr Colin Hawes, Dr Max Barclay, Dr Jiri Hava, Dr Tomas Lackner, Dr Thomas Barnouin and Prof. Dr Sinan Anlas. The identified samples are stored in the Zoology Museum of Balıkesir University, Faculty of Arts and Sciences, Department of Biology.

3. Results

As a result of the identification of the samples collected from 7 different broad-leaved tree species *(Alnus glutinosa*, *Carpinus betulus*, *Platanus orientalis*, *Fagus orientalis*, *Quercus petreae*, *Q. cerris*, Q. *cerris x Q. infectoria*) from 11 different study fields on Cataldag (Balikesir-Susurluk and Bursa-Kemalpasa) between 2014-2015 April-November, a total of 112 saproxylic beetles were identified in 83 species belonging to 25 families of the Coleoptera taxa (Table 3). 35 of the saproxylic beetles identified belong to the insect species included in the European and Mediterranean red list [15,16,17] (Table 4).

Table 3. Distribution of the identified saproxylic beetles according to the study areas

Families	**Saproxylic beetles**	**Balıkesir**	**Bursa**	**Tree species**
Aderidae	*Aderus populneus*		x	*Q. cerris*
Anobiidae	*Anobium hederae*	x		*C. betulus*
	Falsogastrallus unistriatus	x		*F. orientalis*
	Gastrallus corsicus	x		*P. orientalis*
	Gastrallus laevigatus	x		*Q. petreae*
	Hemicoelus rufipennis	x	x	*C. betulus A. glutinosa F. orientalis*
	Hemicoelus canaliculatus	x	x	*C. betulus A. glutinosa F. orientalis Q. petreae*
	Hemicoleus fulvicornis	x	x	*C. betulus*
	Hemicoelus costatus	x		*F. orientalis*
	Oligomerus retowskii	x	x	*P. orientalis C. betulus F. orientalis Q. petreae Q. cerris A. glutinosa*
	Priobium carpini	x		*C. betulus A. glutinosa Q. petreae*
	Stagetus franzi	x	x	*C. betulus F. orientalis Q. petreae Q. cerris x infectoria A. glutinosa Q. cerris*
	Stagetus byrrhoides	x		*Q. petreae*
	Xestobium rufovillosum	x		*C. betulus*
	Xestobium plumbeum	x	x	*P. orientalis F. orientalis A. glutinosa*
Anobiidae	*Mesothes ferrugineus*	x	x	*Q. petreae Q. cerris*
	Ptilinus pectinicornis		x	*A. glutinosa C. betulus*
	Ptinus schlerethi	x		*Q. petreae*
	Metholcus phoenicis	x		*P. orientalis*
Bothrideridae	*Oxylaemus cylindricus*	x		*Q. petreae*
Biphyllidae	*Biphyllus lunatus*		x	*C. betulus*
Buprestidae	*Agrilus hastulifer*	x		*Q. petreae*
	Agrilus graminis	x		*F. orientalis*
	Agrilus laticornis	x		*Q. petreae*
	Agrilus relegatus alexeevi	x	x	*Q. petreae Q. cerris*
	Dicerca berolinensis	x		*A. glutinosa*
Cerambycidae	*Aegesoma scabricorne*	x		*P. orientalis*
	Prionus coriarius		x	*Q. cerris*
	Leiopus femoratus	x		*Q. petreae*
	Tetrops praeustus	x		*P. orientalis*
	Alosterna tabacicolor		x	*P. orientalis*
	Rutpela maculata		x	*A. glutinosa*
	Nathrius brevipennis	x		*P. orientalis*
	Xylotrechus arvicola	x		*C. betulus*
Cetoniidae	*Cetonia aurata*	x	x	*Q. petreae Q. cerris C. betulus*
	Protaetia cuprea	x		*P. orientalis*
	Valgus hemipterus	x	x	*P. orientalis Q. cerris*
Cleridae	*Clerus mutillaroides*	x		*P. orientalis*
Cryptophagidae	*Atomaria nigrirostris*	x		*P. orientalis*
	Cryptophagus dentatus	x	x	*P. orientalis Q. petreae*
	Cryptophagus denticulatus	x		*P. orientalis C. betulus*
	Cryptophagus reflexus	x	x	*C. betulus Q. petreae P. orientalis A. glutinosa Q. cerris*

Table 3. Continued

	Cryptophagus pallidus	x	x	*C. betulus Q. petreae F. orientalis A. glutinosa Q. Cerris*
	Cryptophagus punctipennis	x	x	*C. betulus P. orientalis*
	Cryptophagus micaceus	x	x	*F. orientalis Q. petreae*
	Cryptophagus cylindrellus	x		*C. betulus*
	Cryptophagus pubescens	x		*F. orientalis*
Dermestidae	*Attagenus schaefferi*	x		*Q. petreae*
	Dermestes erichsoni	x	x	*C. betulus Q. petreae P. orientalis Q. cerris*
	Trinodes hirtus	x		*A. glutinosa*
Elateridae	*Cardiophorus gramineus*	x		*C. betulus P. orientalis*
	Cardiophorus parvulus	x		*P. orientalis*
	Cardiophorus anticus	x		*C. betulus P. orientalis*
	Cardiophorus miniaticollis		x	*C. betulus*
	Ampedus pomorum	x		*P. orientalis*
	Athous fragariae	x		*C. betulus Q. petreae*
	Hypoganus inunctus	x		*A. glutinosa*
	Ischnodes sanguinicollis	x	x	*P. orientalis Q. cerris x Q. infectoria*
	Megapenthes lugens		x	*Q. petreae*
	Melanotus villosus	x	x	*F. orientalis C. betulus*
	Melanotus crassicollis		x	*C. betulus A. glutinosa*
	Melanotus fusciceps	x		*F. orientalis*
	Peripontius omissus	x	x	*C. betulus P. orientalis*
	Podeonius acuticornis		x	*Q. cerris*
	Prosternon tessellatum	x		*Q. petreae*
	Reitterelater dubius		x	*C. betulus*
Endomychidae	*Symbiotes gibberosus*		x	*F. orientalis*
Erotylidae	*Triplax russica*		x	*Q. cerris*
	Triplax scutellaris		x	*Q. cerris*
Eucnemidae **Eucnemidae**	*Melasis buprestoides*	x	x	*C. betulus F. orientalis*
	Hylis cariniceps		x	*C. betulus*
	Isoriphis marmottani	x	x	*C. betulus F. orientalis Q. petreae*
Histeridae	*Plegaderus caesus*	x		*F. orientalis A. glutinosa*
	Dendrophilus punctatus	x	x	*A. glutinosa Q. cerris*
	Carcinops pumilio	x	x	*P. orientalis Q. cerris*
	Margarinotus merdarius		x	*Q. petreae*
	Gnathoncus communis	x		*P. orientalis*
	Pseudepierus italicus	x		*A. glutinosa*
Latridiidae	*Latridius minutus*	x		*P. orientalis*
Lucanidae	*Lucanus ibericus*	x		*C. betulus F. orientalis P. orientalis*
	Dorcus parallelipipedus	x	x	*C. betulus F. orientalis A. glutinosa*
	Platycerus caraboides		x	*Q. cerris*
Melandryidae	*Abdera bifasciata*	x		*Q. petreae*
	Abdera quadrifasciata	x		*Q. petreae*
	Phloiotrya tenuis	x		*Q. petreae*
Mycetophagidae	*Litargus balteatus*	x		*P. orientalis*
	Litargus connexus	x		*P. orientalis*
	Mycetophagus quadripustulatus	x		*F. orientalis*
	Mycetophagus quadriguttatus	x		*F. orientalis*

Table 3. Continued

	Mycetophagus piceus	x		*F. orientalis*
Scirtidae	*Prionocyphon ornatus*	x	x	*Q. petreae*
	Sacodes flavicollis		x	*Q. cerris x Q. infectoria*
Silvanidae	*Ahasverus advena*	x		*P. orientalis*
Staphylinidae	*Lordithon exoletus*	x	x	*Q. cerris Q. petreae Q. cerris x Q. infectoria*
	Lordithon trinotatus	x	x	*F. orientalis Q. petreae Q. cerris x Q. infectoria*
	Hypnogyra angularis	x	x	*F. orientalis*
	Zeteotomus brevicornis	x	x	*A. glutinosa*
Tenebrionidae	*Mycetochara quadrimaculata*		x	*Q. petreae*
	Mycetochara maura		x	*Q. petreae*
	Mycetochara kazdagiica	x		*F. orientalis*
	Diaperis boleti		x	*A. glutinosa*
	Neomida haemorrhoidalis		x	*A. glutinosa*
	Palorus depressus	x		*C. betulus*
	Alphitobius diaperinus	x		*P. orientalis*
	Probaticus obesus	x	x	*P. orientalis Q. petreae Q. cerris*
	Pseudoprobaticus granipennis		x	*F. orientalis*
	Uloma cypraea	x	x	*P. orientalis Q. cerris*
Tetratomidae	*Tetratoma desmarestii*	x		*Q. petreae*
Zopheridae	*Colobicus hirtus*	x		*A. glutinosa*
	Synchita undata		x	*A. glutinosa*
	Nosodomodes diabolicus	x		*F. orientalis Q. petreae*
	Pycnomerus sulcicollis	x	x	*A. glutinosa C. betulus*

Table 4. European and Mediterranean red list distribution of the identified saproxylic beetles

Families	Saproxylic beetles	Mediterranean red list category	European red list category
Cerambycidae	*Aegosoma scabricorne*	NE	LC
	Prionus coriarius	NE	LC
	Alosterna tabacicolor		LC
	Rutpela maculata		LC
	Nathrius brevipennis	NE	DD
	Xylotrechus arvicola	NE	LC
Cetoniidae	*Valgus hemipterus*	NE	LC
Elateridae	*Cardiophorus gramineus*	NE	NT
	Cardiophorus anticus	LC	
	Ampedus pomorum	NE	LC
Elateridae	*Hypoganus inunctus*		LC
	Ischnodes sanguinicollis	NE	VU
	Megapenthes lugens	NE	NT
	Melanatus villosus	NE	LC
	Podeonius acuticornis	NE	EN
	Reitterelater dubius		DD
Erotylidae	*Triplax russica*	NE	LC
	Triplax scutellaris		LC
Eucnemidae	*Hylis cariniceps*	NE	LC
	Isoriphis marmottani	NE	LC
	Melasis buprestoides	NE	LC
Lucanidae	*Lucanus ibericus*		VU

Table 5. Continued

	Dorcus parallelipipedus	NE	LC
	Platycerus caraboides	NE	LC
Mycetophagidae	*Litargus connexus*	NE	LC
	Mycetophagus quadriguttatus		LC
	Mycetophagus piceus		LC
Tenebrionidae	*Mycetochara quadrimaculata*		NT
	Mycetochara maura		LC
	Diaperis boleti		LC
	Neomida haemorrhoidalis		LC
Zopheridae	*Colobicus hirtus*	NE	
	Synchita undata	LC	
	Nosodomodes diabolicus	LC	
	Pycnomerus sulcicollis	NE	

4. Conclusions and discussion

Among the saproxylic beetles species, 14 species from 10 families, *Anobium hederae*, *Gastrallus corsicus* and *H. canaliculatus* from Anobiidae, *C. pubescens* from Cryptophagidae, *S. gibberosus* from Endomychidae, *T. russica* and *T. scutellaris* from Erotylidae, *H. cariniceps* and *I. marmottani* from Eucnemidae, *P. tenuis* from Melandryidae, *L. balteatus* from Mycetophagidae, *S. flavicollis* from Scirtidae, *T. desmarestii* from Tetratomidae and *S. undata* from Zopheridae are indeed new records for the Coleoptera species in the fauna of Türkiye.

Nieto and Alexander (2010), Cálix et al. (2018) and García et al. (2018) conducted detailed studies for saproxylic beetles in both Europe and the Mediterranean basin under the coordination of IUCN [15,16,17]. Although species with insufficient ecology or distribution data were included in the lists in the end of these studies, they could not be assessed in the red list categories. 112 saproxylic beetles identified in this study were assessed based on these lists, which revealed that a total of 35 species were included in the studies conducted for saproxylic beetles in Europe and the Mediterranean basin. The highest number of red list species belongs to the Elateridae (9 species). This is followed by Cerambycidae (6 species), Tenebrionidae (4 species) and Zopheridae (4 species) families.

Considering the distribution of the red list saproxylic beetles identified on tree species from two study fields, a total of 20 saproxylic beetles included in the European and Mediterranean red lists were identified for Susurluk study field; namely two species of *Quercus petreae (I. marmottani*, *N. diabolicus*), six species of *F. orientalis (I. marmottani*, *M. villosus*, *L. ibericus*, *M. quadriguttatus*, *M. piceus*, *N. diabolicus*), seven species of *C. betulus (X. arvicola*, *C. gramineus*, *C. anticus*, *I. marmottani*, *M. buprestoides*, *L. ibericus*, *P. sulcicollis*), four species of *A. glutinosa (H. inunctus*, *D. parallelipipedus*, *C. hirtus*, *P. sulcicollis*), and nine species of *P. orientalis (A. scabricorne*, *N. brevipennis*, *V. hemipterus*, *C. gramineus*, C. *anticus*, *A. pomorum*, *I. sanguinicollis*, *L. ibericus*, *L. connexus*). Among the tree species studied, *P. orientalis* had the highest number of red list species caught, followed by *C. betulus*, *F. orientalis*, *A. glutinosa* and *Q. petreae,* subsequently. Within this distribution, they were caught from different tree species including *I. marmottani Q. petreae*, *F. orientalis* and *C. betulus*, *L. ibericus F. orientalis*, *C. betulus* and *P. orientalis*, *N. diabolicus Q. petreae* and *F. orientalis*, *P. sulcicollis C. betulus* and *A. glutinosa*, *C. gramineus C. betulus* and *P. orientalis*, *C. anticus C. betulus* and *P. orientalis*. A total of 22 saproxylic beetles included in the European and Mediterranean red lists were identified for Mustafakemalpasa study field; namely six species from *Q. cerris (P. coriarius*, *V. hemipterus*, *P. acuticornis*, *T. russica*, *T. scutellaris*, *P. caraboides*), one species from *Q. cerris x Q. infectoria (I. sanguinicollis*), three species from *Q. petreae (M. lugens*, *M. quadrimaculata*, *M. maura*), three species from *F. orientalis* (*I. marmottani*, *M. buprestoides*, *D. parallelipipedus)*, six species from *C. betulus* (*M. villosus*, *R. dubius, H. cariniceps*, *I. marmottani*, *D. parallelipipedus*, *P. sulcicollis*), four species from *A. glutinosa* (*R. maculata, D. boleti*, *N. haemorrhoidalis*, *S. undata*), and one species from, *P. orientalis* (*A. tabacicolor*).

As a result of the study, six species were identified with defined threat categories in the European red list. Of these species, *C. gramineus* and *M. lugens* are categorized as near threatened (NT), *I. sanguinicollis* is categorized as vulnerable (VU) and *P. acuticornis* is categorized as endangared (EN) under Elateriadae; *L. ibericus* is categorized as vulnerable (VU) under Lucanidae and *M. quadrimaculata* is categorized as near threatened (NT) under Tenebrionidae. *M. lugens* was caught from *C. gramineus*, *P. orientalis* and *C. betulus*; *I. sanguinicollis* was caught from *Q. petreae*; *P. acuticornis* was caught from *P. orientalis* and *Q. cerris x Q. infectoria*, *L. ibericus* was caught from *Q. cerris*; *M. quadrimaculata* was caught from *P. orientalis, C. betulus* , *F. orientalis* and *Q. petreae*. These species caught from different threat categories were identified from tree species of different diameters at different altitudes. Oak species *(Q. cerris*, *Q. petreae* and *Q. cerris* x *Q. infectoria*), eastern sycamore *(P. orientalis*), hornbeam *(C. betulus*) and eastern beech *(F. orientalis*) were found to be the tree species where saproxylic beetles (6 species) with threat categories in the red lists were caught. Tree species on which the species assessed for the red list (among the 35 species) were caught the most are as follows, subsequently: *C. betulus* (11 species), *P. orientalis* (10 species), *A. glutinosa* (8 species), *F. orientalis* (8 species), *Q. cerris* (5 species), *Q. petreae* (5 species) and *Q. cerris* x *Q. infectoria* (1 species).

In this study, 82% of the saproxylic beetles were collected with window traps (92 species) and 25% (28 species) with pitfall traps. In the assessment of each study field; 88 saproxylic beetles were identified from Susurluk study field. This corresponds to 79% of all saproxylic beetles. Of the 88 saproxylic beetles, 83% (73 species) were collected with window traps and 24% (21 species) with pitfall traps. *A. diaperinus*, *C. denticulatus*, *C. reflexus*, C. *micaceus*, *D. erichsoni* and *D. parallelipipedus* species were caught with both pitfall and window traps in Susurluk study field. 56 saproxylic beetles were identified in Mustafakemalpasa study field. This corresponds to 79% of all saproxylic beetles. Of the 56 saproxylic beetles, 79% (44 species) were collected with window traps and 27% (15 species) with pitfall traps. Although there are differences between the study fields in terms of the number of species, there are similarities in terms of trapping methods. The species caught in each study field had similar rates regarding sampling with window and pitfall trap methods. Again, the window and pitfall trap capture rates of 112 saproxylic beetles caught during the study are similar to the rates found in each study field. In this study, 32 saproxylic beetles were identified in both Susurluk and Mustafakemalpasa study fields. The distribution of the 88 species caught in Susurluk study field according to tree species was as follows; *P. orientalis* with 36% (32 species), *Q. petreae* (30 species) with 36%, *F. orientalis* (22 species) with 25%, *C. betulus* (21 species) with 24% and *A. glutinosa* (15 species) with 17%. The distribution of the 56 species caught in the Mustafakemalpasa study field according to tree species was as follows; *Q. cerris* (20 species) with 35%, *C. betulus* (19 species) with 34%, *F. orientalis* (11 species) with 35%, *A. glutinosa* (10 species) with 18%, *Q. petreae* (8 species) with 14%, *Q. cerris x Q. infectoria* (5 species) with 10%, and *P. orientalis* (2 species) with 4%.

In the light of all study results, oak species *(Q. petreae*, *Q. cerris* and *Q. cerris* x *Q. infectoria*) seem to be very rich in saproxylic beetles. The data obtained in the study further reveal that, oak species also host more species in terms of red list species than other tree species. Oak *(Quercus* spp.) trees have a long life span and their decay process continues for many years. During this process and over the years, the structures on the tree that serve as micro-habitats for saproxylic insect species are extremely important for saproxylic insect diversity [18]. Oak trees have an important place considering the number of saproxylic beetles identified in both study fields. Türkiye has a very important area in terms of oak forests and oak species. *Quercus* are represented by 18 natural species in Türkiye [19]. Oak forests are being destroyed in the region as a result of human impact and social pressure, and habitat loss is likely to occur for species that depend on oak trees. In order to protect these regions and ensure sustainable species diversity, it is necessary to protect oak forests and prevent habitat loss due to old tree cutting and clearing, which will take place as a result of energy, grazing and forestry practices.

While decaying happens very fast in other broad-leaved tree species, oak trees have a short-term supporting effect on the habitats of saproxylic beetles. A significant number of saproxylic beetles were caught from broad-leaved tree species such as hornbeam *(C. betulus*), alder *(A. glutinosa*), beech *(F. orientalis*) and sycamore *(P. orientalis*). In addition, the fact that these tree species also contain red list saproxylic beetles reveals the importance of these tree species in forest ecosystems alongside oak species.

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