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## Epiphytic Bryophyte Flora of *Liquidambar orientalis* Forests

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### Abstract

*Liquidambar orientalis* forests which are very important for Turkey and the world continue to exist in its unique habitat. In the present study, epiphytic bryophyte flora of *L. orientalis*, naturally spreads in Turkey, was investigated between the years of 2016-2019. A total of 27 localities were visited and 433 envelope plant samples were taken. As a result of identifications, in total 49 bryophytes (48 moss, 1 liverwort) were determined. These taxa were taken from the base, trunk and branches of the trees and presented as a table format. And also, *Orthotrichum philibertii* and *Zygodon catarinoides* has been given as the second distributional locality for Turkey. We believe that this study will contribute to the bryophyte flora of Turkey and the preservation of *Liquidambar orientalis* forests.

**Keywords:** Bryophyte flora of Turkey, Riparian Forests, Sweetgum, *Zygodon catarinoides*, Epiphytic.

## *Liquidambar orientalis* Ormanlarının Epifitik Briyofit Florası

### Öz

Türkiye ve dünya için çok önemli olan *Liquidambar orientalis* ormanları, kendine özgü yaşam alanlarında varlıklarını sürdürmektedir. Bu çalışmada, Türkiye’de doğal olarak yayılan *L. orientalis*’in epifitik briyofit florası 2016-2019 yılları arasında araştırılmıştır. Toplam 27 lokalite ziyaret edilmiş ve 433 zarf bitki örneği alınmıştır. Teşhislerin sonucunda, toplamda 49 karayosunu (48 yapraklı karayosunu, 1 ciğerotu) kaydedilmiştir. Bu taksonlar ağaçların taban, gövde ve yan dallarından alınmış olup, tablo formatında sunulmuştur. Ayrıca, *Orthotrichum philibertii* ve *Zygodon catarinoides* Türkiye’den ikinci kayıt olarak tespit edilmiştir. Çalışmanın Türkiye karayosunları florasına ve *Liquidambar orientalis* ormanlarının korunmasına katkı sağlayacağı kanısındayız.

**Anahtar kelimeler:** Türkiye Karayosunları Florası, Kıyı Ormanları, Sığla, *Zygodon catarinoides*, Epifitik

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## 1. Introduction

In recent years, the concept of biodiversity has not only been limited to the scientific environment, but has become an important part of our lives. Plants are an important part of biodiversity. Today, there are more than 391.000 plant species in the world (Kew Gardens, 2016). Epiphytic bryophytes constitute a part of this diversity. Rainforests are the most diverse regions of this group of plants that use almost any substrate from deserts to tundras and especially choose moist and shady places. For example, only about 800 epiphytic taxa have been identified from the Amazon basin (Oliveira and Steege, 2013). There can be up to 67 epiphytic bryophytes in a single tree (Gradstein et al., 1990).

26% of Turkey's territory is covered by forests. 90% of these areas are old-growth forests. These areas home to 560 tree taxa in total, is extremely important to the preservation of biodiversity (Türkiye Orman Varlığı Kitabı, 2015). One of the most important of these taxa is undoubtedly *Liquidambar orientalis* which is a relict and narrowly distributed species.

Epiphytes are organisms that use a plant as a substrate and survive without nutrients and water from its host (Barkman, 1958). These develop on the trunk and branches of the tree. The variety and density of epiphytic bryophytes are under the influence of the tree's chemistry and environmental factors (Barkman 1958; Vanderpoorten et al., 2004). Especially the trunk and branches of old sweetgum trees provide an environment where epiphyte bryophytes can survive.

In recent years, studies on epiphytic bryophytes in the world have been increasing. (Cornelissen and Steege, 1989; Montfoort and Ek, 1989; Burgaz et al., 1994; Lara and Mazimpaka, 1998; Moe and Botnen, 2000, Draper et al., 2003, 2005, 2006; González-Mancebo et al, 2003, 2004; Garcia et al., 2005; Leon-Vargas et al.,

2006; Pereira Alvarenga and Porto, 2007; Mazimpaka et al., 2009; Medina et al., 2010; Sim-Sim, 2011; Odor, 2013; Oliveira and Steege, 2013; Campos and Steege, 2015). There are some studies on the subject in Turkey (Ezer et al., 2009, 2010, 2017, 2019; Ezer and Kara, 2013; Alataş and Batan 2015, Kırmacı and Agcagil, 2018; Alataş et al., 2018, 2019a, b).

The present study was aimed to investigate the diversity of epiphytic bryophytes living on *Liquidambar orientalis* (sweetgum, amber tree) trees.

## 2. Material and Method

The specimens were collected from the parts of trunks of *L. orientalis* during field studies. The collected bryophyte specimens were stored in prepared envelopes. The heights, sampled tree parts (B: base, T: trunk and Br: branch) were noted on these envelopes with collector number (UUR: Uğur Çatak). The samples brought to the laboratory were dried by opening the envelopes under shade conditions. Locality information (GPS, ecology, etc.) was also noted and taxa and their repetitions on the trees were recorded. Here, the height of the base of the tree up to 20 cm has been accepted and above 20 cm has been evaluated as the trunk part. Samples that were re-wetted for diagnosis were examined under the microscope after performing the necessary dissection procedures under the stereo microscope and the naming procedure was carried out using the relevant flora books and revision studies. The names of taxa were checked according to the checklist prepared by Ros et al. (2013). The Orthotrichaceae family was arranged (Lara et al., 2016). And also the validity of all taxa was checked from the Tropicos database. Diagnosed samples were stored in Aydın Adnan Menderes University herbarium (AYDN).

### 2.1. Study Area

It has unique floristic habitats and is spread only in South West Anatolia and Rhodes Island in the world (Kurt and Ketenöglü, 2008).



**Figure 1.** *Liquidambar orientalis*' s distribution area in Turkey (Google earth, 01.03.2020)

Sweetgum forests in Turkey's southwestern province show the following distribution: Antalya, Aydın, Burdur, Denizli, Isparta and Muğla. The localities visited in these provinces are listed below.

**2.1.1. Localities:**

1. Antalya, Serik, Gebiz, Pınargözü, Pınargözü Stream, Köprülü Canyon, confluence region of Gebe Stream and Sinni Stream N 37° 16' 32" E 030° 59' 47,9" 498 m. 10.09.2016. UUR1-15
2. Muğla, Milas, Selimiye, Kandak Village N 37° 26' 16,1" E 027° 39' 58,3" 8 m. 28.09.2016. UUR16-75
3. Muğla, Ula, Gökova, Gökçe, Ferek River N 37° 00' 65,0" E 0,28° 22' 01,6" 10 m. 28.09.2016. UUR76-124
4. Muğla, Ula, Kızılyaka N 37° 00' 16,2" E 028° 27' 97,0" 21 m. 28.09.2016. UUR125-147
5. Muğla, Köyceğiz, Döğüşbelen N 36° 59' 43,7" E 028° 38' 24,9" 21 m. 28.09.2016. UUR148-154
6. Muğla, Köyceğiz, Toparlar N 36° 59' 49,0" E 028° 38' 81,1" 13 m. 29.09.2016. UUR 155-164
7. Muğla, Köyceğiz Center, Köyceğiz Lakeside, Hamitköy, Kulak Hacılar State Forest and Gülpınar State Forest N 36° 57' 90,3" E 028° 40' 62,0" 11 m. 29.09.2016. UUR 165-172
8. Muğla, Köyceğiz, Yangı and Zeytinalan N 36° 55' 97,2" E 028° 43' 95,1" 8 m. 29.09. 2016. UUR 173-229
9. Muğla, Ortaca, Okçular-Sarısu Kavakarası N 36° 50' 27,5" E 028° 40' 14,7" 9 m. 29.09.2016. UUR 230-246
10. Denizli, Acıpayam, Gölcük Series, Alcı Region, Akdere N 37° 11' 33" E 29° 14' 30" 803 m. 05.11.2017. UUR 247-281
11. Muğla, Köyceğiz, Ağla, Kargıcak N 36° 59' 30" E 28° 42' 17" 82 m. 06.11.2017. UUR 282-285
12. Muğla, Köyceğiz, Yuvarlakçay Series N 36° 55' 30" E 28° 49' 40" 162 m. 06.11.2017. UUR 286-292
13. Muğla, Dalaman Center, Forest Management N 36° 47' 42" E 28° 49' 49,3" 14 m. 06.11.2017. UUR 293-298
14. Muğla, Dalaman, Tersakan N 36° 45' 74" E 28° 52' 46" 208 m. 06.11.2017. UUR 299-307
15. Muğla, Dalaman, Şerefler, Karaağaç N 36° 48' 31" E 28° 53' 24" 38 m. 06.11.2017. UUR 308-313
16. Muğla, Dalaman, Elcik N 36° 52' 39" E 28° 57' 34" 233 m. 06.11.2017. UUR 314-320
17. Muğla, Marmaris – Datça road N 36° 50' 56" E 28° 12' 28" 112 m. 22.12.2018. UUR 321-335
18. Muğla, Marmaris – Adaköy road N 36° 49' 56" E 28° 18' 58" 49 m. 22.12.2018. UUR 336-340
19. Muğla, Marmaris – Adaköy N 36° 52' 35" E 28° 34' 07" 110 m. 22.12.2018. UUR 341-353
20. Muğla, Marmaris National Park N 36° 52' 07" E 28° 30' 43" 60 m. 22.12.2018. UUR 354-384
21. Muğla, Marmaris Meriç- Beldi wastewater treatment facility, İsmail river N 36° 51' 24" E 28° 17' 42" 45 m. 29.12.2018. UUR 385-394

22. Muğla, Marmaris İçmeler N 36° 49' 54" E 28° 19' 00" 20 m. 29.12.2018. UUR 395-402
23. Burdur, Kargı village, Sweetgum Forest Nature Conservation Park N 37° 21' 42" E 30° 50' 01" 260 m. 15.06.2019. UUR 402-410
24. Burdur, Melli region, Sarıçay N 37° 20' 42,69" E 30° 48' 10,46" 200 m. 15.06.2019. UUR 411-416
25. Burdur, Melli region N 37° 20' 39" E 30° 47' 59" 225 m. 15.06.2019. UUR 417-421
26. Isparta, Sütçüler, Çandır N 37° 26' 59" E 30° 54' 12" 290 m. 16.06.2019. UUR 422-429
27. Aydın, Umurlu N 37° 52' 21" E 27° 56' 15" 130 m. 18.06.2019. UUR 430-433
28. Aydın, Çine, Çine Dam reserv area N 37° 29' 22" E 28° 08' 47" 180 m. 18.05.1999

### 3. Results and Discussion

During the present study, 7 field studies were carried out and a total of 27 different localities were visited. Finally, 433 packages of bryophyte samples were taken from the base, trunk, and branches of trees. After identification studies, 49

bryophyte taxa were determined belonging to, 13 families and 31 genus. Among these, only one taxa of liverworts were found, no taxa were identified belonging to hornworts. The richest families were listed as Orthotrichaceae, Pottiaceae and Brachythecae respectively. In two previous studies carried out in *Liquidambar orientalis* forests, *O. sprucei* was firstly recorded on the sweetgum trees in Çine Valley/Aydın from Turkey (Erdağ and Kürschner, 2000). This area is sunken under Çine dam reservoir and there are no sweetgum trees around. Also, *Lejeunea cavifolia* (Ehrh.) Lindb. recorded in a phytosociological study recorded by Kürschner et al.. Although these taxa could not be collected during the present study, we added them to the list with the collector's name (Kürschner et al.1998; Erdağ, 2000) because of recorded from sweetgum forests.

The floristic list was given in Table 1 (B: base, T: trunk, Br: branch), locality (Loc: locality), and collection numbers of the trees (UUR: Uğur Çatak collection numbers).

**Table 1.** Floristic list

Taxon	Loc.	B	T	Br	UUR
<i>Frullania dilatata</i> (L.) Dumort.	2, 3, 4, 6, 8, 10, 12, 15, 16, 17, 19, 20, 21, 24, 25, 26		X		149
<i>Lejeunea cavifolia</i> (Ehrh.) Lindb.			X		Kürschner et al., 1998
<i>Grimmia lisae</i> De Not.	3, 5	X	X		92
<i>G. pulvinata</i> (Hedw.) Sm.	2, 10, 19, 20, 21, 22	X	X		247
<i>Fissidens arnoldii</i> R. Ruthe	8, 20	X	X		377
<i>F. taxifolius</i> Hedw.	20, 21		X		393
<i>Bartramia aprica</i> Müll. Hal.	3		X		88
<i>Dialytrichia mucronata</i> (Brid.) Broth.	2, 10, 16, 17, 23, 24, 25, 26	X	X		403
<i>Nogopterium gracile</i> (Hedw.) Crosby & W.R. Buck.	2, 3, 8, 20, 26		X		427
<i>Syntrichia laevipila</i> Brid.	2, 8, 9, 10, 14		X		230
<i>S. montana</i> Nees.	10, 17		X		325
<i>S. princeps</i> (De Not.) Mitt.	4, 27		X		141
<i>S. virescens</i> (De Not.) Ochyra.	1, 4, 9, 27		X		430
<i>Tortella humilis</i> (Hedw.) Jenn.	17		X		322
<i>T. tortuosa</i> (Hedw.) Limpr.	3, 8, 10, 19, 20, 21, 24, 25, 26		X	X	90
<i>Tortula inermis</i> (Brid.) Mont.	9		X		243
<i>T. schimperi</i> M.J. Cano, O. Werner & J. Guerra.	14		X		300
<i>Bryum sp.</i> Hedw.	2, 7, 8, 10, 12, 13, 22		X		351
<i>Rosulabryum capillare</i> (Hedw.) J. R. Spence.	3, 18		X		336
<i>Cryphaea heteromalla</i> (Hedw.) D. Mohr	26		X		423

<i>Lewinskya affinis</i> (Schrad ex. Brid.) F. Lara, Garilleti & Goffinet.	1, 22, 25		X	X	6
<i>L. rupestris</i> (Schleich ex. Schwägr.) F. Lara, Garilleti & Goffinet.	1, 17		X		5
<i>L. speciosa</i> (Nees) F. Lara, Garilleti & Goffinet.	1, 2, 27		X	X	15
<i>L. striata</i> (Hedw.) F. Lara, Garilleti & Goffinet	1, 23, 24, 25, 26		X		405
<i>Orthotrichum anomalum</i> Hedw.	9, 10, 12, 27		X		281
<i>O. diaphanum</i> Brid.	9, 11, 13, 17, 19, 20, 22		X	X	359
<i>O. pallens</i> Bruch ex Brid.	17		X		331
<i>O. patens</i> Bruch ex Brid.	4, 18		X		141
<i>O. philibertii</i> Venturi.	18		X		339
<i>O. pulchellum</i> Brunt.	5, 6, 7, 8, 9, 10		X		150
<i>O. pumilum</i> Sw. ex anon.	9, 22		X		402
<i>O. scanicum</i> Grönvall.	12, 19		X	X	292
<i>O. stellatum</i> Brid.	17, 20, 22		X		329
<i>O. sprucei</i> Mont.	28	X	X		Erdağ, 2000
<i>O. tenellum</i> Bruch ex Brid.	17, 18, 20, 23		X		328
<i>O. vittii</i> Lara, Garilleti & Mazimpaka.	9, 13, 17, 20		X	X	357
<i>Pulviger a lyellii</i> (Hook. & Taylor) Plásek, Sawicki & Ochyra.	10, 23		X		255
<i>Ulota crispa</i> (Hedw.) Brid.	15		X		312
<i>Zygodon catarinói</i> C. Garcia, F. Lara, Sérgio & Sim-Sim.	19, 20, 21, 22		X		361
<i>Z. rupestris</i> Schimp. ex Lorentz.	1, 2, 5, 8, 9, 10, 12, 19, 20, 21, 22, 23, 24, 25, 26		X	X	370
<i>Habrodon perpusillus</i> (De Not.) Lindb.	10, 19, 20	X	X		380
<i>Brachytheciastrum velutinum</i> (Hedw.) Ignatov & Huttunen.	8, 10	X	X		218
<i>Homalothecium sericeum</i> (Hedw.) Schimp.	1, 2, 4, 8, 10, 14, 16, 17, 19, 20, 22		X		269
<i>Rhynchostegiella litorea</i> (De Not.) Limpr.	8	X	X		203
<i>Scleropodium cespitans</i> (Wilson ex Müll.Hal.) L.F. Koch.	3, 8, 15, 17		X		309
<i>Scorpiurium circinatum</i> (Bruch) M. Fleisch.& Loeske.	2, 17, 18		X		338
<i>S. sendtneri</i> (Schimp.) M. Fleisch.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 26, 27	X	X	X	407
<i>Leucodon sciuroides</i> (Hedw.) Schwägr.	1, 2, 3, 4, 7, 8, 10, 11, 12, 15, 17, 19, 20, 21, 22, 23, 24, 25, 26, 27		X	X	426
<i>Hypnum cupressiforme</i> Hedw.	2, 3, 4, 5, 6, 7, 8, 9, 14, 17, 19, 20, 21, 23, 24, 25, 26	X	X	X	67
<i>H. cupressiforme</i> var. <i>resupinatum</i> (Taylor) Schimp.	8, 9, 26		X		208
<i>Leptodon smithii</i> (Hedw.) F. Weber & D. Mohr.	2, 17, 21, 25		X		389

Sweetgum trees maintain their existence especially in habitats where streams and high ground water. Causing the debris residues brought up by rising waters especially in spring, to accumulate at the bottom parts. This accumulation has created a suitable living environment for bryophytes. Taxa determined from the base of the trees; *Grimmia lisae*, *G. pulvinata*, *Fissidens arnoldii*, *Dialytrichia mucronata*, *Tortella inclinata* (R. Hedw.) Limpr., *Fontinalis antipyretica* Hedw., *Habrodon perpusillus*, *Brachytheciastrum velutinum*, *Rhynchostegiella litorea* (De Not.) Limpr., *R. tenella*, *Scorpiurium sendtneri*, *Hypnum cupressiforme*. Among them, *Fontinalis antipyretica*, *Tortella inclinata* and *Rhynchostegiella tenella* are not known as epiphytic. They probably had the chance to live because of the soil accumulated at the base of the trees. For this reason, these taxa are not listed.

Orthotrichaceae is the richest bryophyte family in Turkey and represented with 50 taxa (Erdağ and Kürschner, 2017; Kırmacı and Agcagil, 2018). Among these records, *O. philibertii* was recently recorded from Dilek Peninsula and Büyük Menderes Delta National Park (Aydın) (Kırmacı and Agcagil, 2016), and was given as the second distribution locality in our study. Another interesting record of the genus *Orthotrichum* is *O. stellatum*. This taxon was firstly reported from Trabzon / Turkey by Lara et al. in 2010. And secondly was collected from Samanlı mountains (Sakarya, Kocaeli, Yalova, Bursa) by Gözcü et al. in 2019. And in our study is given as the third record from Turkey. There is a long distance between the three localities, suggesting that this taxon may be in different parts of Anatolia. *O. scanicum* which is on the many European country red list was recorded from two different localities in study area (Hodgetts, 2015). It has been found on different parts of Turkey (Erdağ and Kürschner, 2017; Gözcü et al., 2019). *Zygodon catarinoides*, which is in the family of Orthotrichaceae, was recorded for the first time from the sweetgum forests in Turkey (Vigalando et al., 2012). In the present study, it was found in 4 different localities around Marmaris where the first record was made. This shows that the taxon has a wide spread in the narrow region.

Taxa determined from our research area are quite high compared to some recent studies on epiphytic bryophytes (Alataş et al., 2016, 2018, 2019a, b; Ezer et al., 2009). Among the main reasons for this is the high humidity in which is the main requirement of the bryophytes in the

sweetgum forests. Another factor in terms of epiphytic bryophytes is that tree bark is in a way that enables the bryophytes to hold. Because the bryophytes can not hold on the smooth tree bark. Indeed, no bryophytes were seen on young tree trunks with a smooth bark surface in this study. *Scorpiurio sendtneri-Zygodontetum vulgaris* Walther 1975, *Leptodonto smithii-Leucodontetum sciuroidis* Privitera & Puglisi 1997 and *Scorpiurio sendtneri-Zygodontetum vulgaris cinclidotesum mucronati* Kürschner 1998 are the most common epiphytic association.

*Liquidambar orientalis* forests have an important position both with their distinctive habitat, contribution to human life for a considerable long time and living in limited areas during the evolutionary process. Habitat of this plant is protected with several protection statuses.

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