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Research article/Araştırma makalesi

The bryophytes in the protected *Quercus coccifera* macchia in East Mediterranean Region of Turkey: their life-form, habitat and substratum relations

Atabay DÜZENLİ [1], Recep KARA [*2], Tülay EZER [2], Necattin TÜRKMEN [1]

[1] Çukurova University, Faculty of Science and Arts, Department of Biology, 01330 Adana, Turkey.
[2] Niğde University, Faculty of Science and Arts, Department of Biology, 51100, Niğde, Turkey.

Abstract

In the study, the bryophytes flora in the *Quercus coccifera* macchia protected for approximately 40 years in east Mediterranean part of Turkey was studied. During the floristic surveys, 9 species of 8 families belonging to Hepaticopsida and 47 taxa of 10 families belonging to Bryopsida in total 56 taxa was recorded. Eight different life-form types and nine different microhabitats belonging to these taxa were determined. Additionally the states leaning on the comparisons of the field observations and climatologic conditions of the bryophytes in the study area was determined according to microhabitat differentiations, life-form types, moisture desires, and substrata characteristics.

Key words: Bryophytes, Life-form, Macchia, Microhabitat, Substratum

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Türkiye'nin Doğu Akdeniz Bölgesindeki Korunmuş *Quercus coccifera* Makiliğinin Biryofitleri: Hayat Formları, Habitatları, Substratları arasındaki ilişkiler

Özet

Bu çalışmada, Türkiye'nin Doğu Akdeniz bölgesinde yaklaşık 40 yıldır korunan *Quercus coccifera* makisi içerisindeki biryofit florası çalışıldı. Araştırma boyunca Bryophyta bölümünün Hepaticae sınıfından 8 familyaya ait 9 takson ve Bryopsida sınıfından 10 familyaya ait 47 takson olmak üzere toplam 56 takson kaydedilmiştir. Bu taksonlar ait 9 farklı mikrohabitat ve 8 çeşit hayat formu tanımlandı. Ayrıca çalışma alanında kıyaslamalı iklimsel ve floristik gözlemlere dayanarak mikrohabitat ayrımları, hayat formu, nem istekleri ve substrat özelliklerine göre biryofitlerin maki içerindeki durumları tespit edildi.

Anahtar kelimeler: Biryofitler, Hayat formu, Maki, Mikrohabitat, Substrat

1. Introduction

A melting pot of geological activity, climatic evolution and human civilizations the Mediterranean Basin is a hot spot of plant biodiversity (Thompson, 2005). The Anatolian peninsula is a major centre of diversity and endemism in the eastern Mediterranean concerns the mountains and coast of southern Turkey.

Quercus coccifera L. is undoubtedly one of the most important scrub species in the Mediterranean Basin, which covers more than ~2 million hectares. It grows under typical Mediterranean climates, with a considerable summer drought period and on a great variety of soil types, either on acidic or basic parent materials (Canellas and San Miguel, 2000; Işık and Gemici, 1994).

Macchia–the description of the stress-tolerant, late-succession, high-diversity, scrub typical of the Mediterranean climate. *Quercus coccifera* L. is main a canopy forming species and evergreen sclerophylls (literally hard-or tough-leaved) in macchia (Lo Gullo and Salleo, 1988).

[*] *Corresponding author* / Haberleşmeden sorumlu yazar: Tel.: +90 (388) 2254034; Fax.: +90 (388) 2250180; E-mail: recepkara77@gmail.com
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Variation in habitats, disturbance regime, plant growth form and mainly the evolutionary history of plants are the main causes for the phenologic heterogeneity that can be observed in the vegetation of the east Mediterranean basin (Ne'eman and Goubitz, 2000).

Development and composition of bryophyte layer in forests strongly depend upon the vascular vegetation above it (Steel et al., 2004; Smith, 2006).

Differences in microclimatic condition were the most important factors influencing bryophyte taxa occurence. Bryophytes are known to survive in small microclimatic niches, even when the regional climate has changed enough to alter the surrounding vascular plant community (Smith, 2006).

Bryophyte life-form is defined as recurring arrangements of the photosynthetic tissues that minimize evaporative water loss and maximize primary production (Bates, 1998). Magdefrau has distinguished morphological, these are morphological form annual, cushion, short turf, dendroid, fan, mat, pendant, tail and weft-typical for Bryophytes (Mágdefrau, 1982). Frey and Kürschner (1991) added the category "solitary plants" which is typical for arid habitats. Generally life-form is a stable characteristic for mosses and liverworts. However, many species show plasticity of life-form according to environmental conditions (During, 1979; Bates, 1998; Ezer et al., 2010).

At present, 3 species belong to Anthocerotopsida, 169 species belong to Hepaticopsida and 721 species belong to Bryopsida are known from Turkey for world bryophyte literature (Kürschner and Erdağ, 2005; Özenoğlu Kiremit and Keçeli, 2009). There are many floristic studies concerning these taxa but only a few concerning their life-forms (Kürschner et al., 1998; Kürschner, 1999, 2004). Except Hebrard's papers (Herbrard, 1976, 1977, 1980, 1981) studies on macchia bryophytes, are very limited.

The natural vegetation of the study area has been under protection since 1970. This reserve is known to contain rare species of vascular flora (Türkmen and Düzenli, 2005) but no bryophyte survey has been performed at this location and in the Turkish macchia vegetation. The aim of the present study is determine the bryophyte flora and species' life-form, habitat and substrata types in *Quercus coccifera* L. macchia in Turkey.

2. Materials and methods

The study area is located on hillside near the city of Adana (37°21´N, 35°10´E), neighboring Seyhan Dam Lake, 35-170 m above sea level and 70 km from the Mediterranean Sea (Figure 1).

Generally, the soils of the study area are slightly basic and formed of very calcareous and soft clay materials originating from the Pliocene and of conglomerates, which formed the old alluvial terraces in the Pleistocene. The soil, mainly of limestone, is characterized by low concentration of nutrients (Özbek et al., 1974).

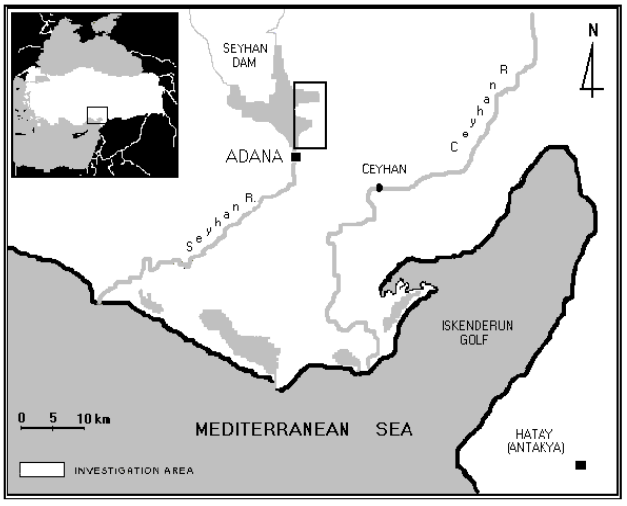

Figure 1. Topographic map of study area

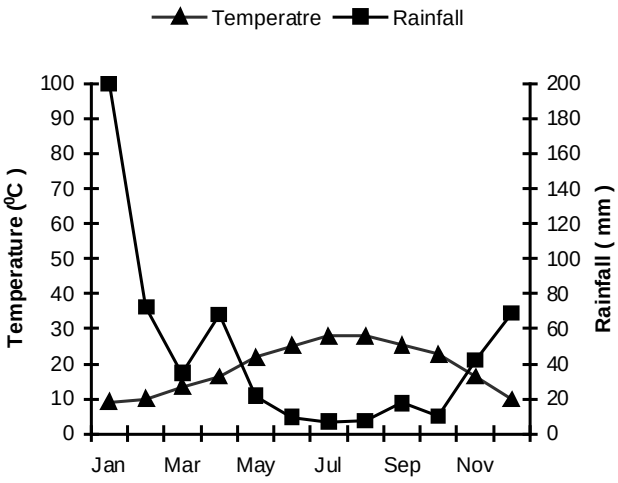

Figure 2. Climatic diagram of the study area

The Mediterranean climate in the study area is characterized by long summer droughts and mild and rainy winters. The mean annual precipitation is about 559.2 mm. The mean annual temperature is 18.8°C. Mean monthly temperatures range from 3,38°C in January to 11,1°C in August. According to the average climatic data for 4 years (2001-2004) obtained from the Meteorological Station of Cukurova University in study area (Vantage Pro Plus-integral meteorology system), suitable rainy period for bryophytes is from October to May (Figure 2).

The natural vegetation of the study area is a typical Mediterranean macchia community mainly composed of *Quercus coccifera*, *Calycotome villosa* (Poiret) Link, *Pistacia terebinthus* L. subsp. *palaestina* (Boiss.) Engl., *Erica manipuliflora* Salisb., *Rhamnus oleoides* L. subsp. *graecus* (Boiss. & Reut) Holmboe., *Phillyrea latifolia* L., *Pinus brutia* Ten., *Olea europaea* L., *Paliurus spina-christi* Mill., *Daphne sericea* Vahl., *Cistus creticus* L., *Smilax aspera* L.,

Myrtus communis L., *Fontenasia phillıraeoides* Labill., *Jasminum fruticans* L., *Styrax officinalis* L. and *Clematis vitalba* L. Small *Pinus brutia* community that is primer vegetation in the area was occurred as a result of protection. There are hydrophilic species as *Rubus sanctus* Schreb., *Salix alba* L., *Arundo donax* L., *Platanus orientalis* L. and *Phragmites australis* (Cav.) Trin. ex Steud. in the wet places of north slopes. The macchia covers of about 126 689 ha in Adana province (Tükel and Hatipoğlu, 1990) but most of it is disturbed by human for various reasons and purposes.

The materials of this investigation were comprised bryophyte specimens gathered in the study area. Herbarium specimens are stored at ADA (Herbarium of the Cukurova University).

Arrangement the floristic list follows the system proposed in the Checklist of the mosses of Europe and Macaronesia (Hill et al., 2006). The situations of identified taxa in Turkey were determined by using new chek-lists for Turkish bryophytes (Kürschner and Erdağ, 2005, Özenoğlu Kiremit and Keceli, 2009). Determinations of the life-form types are based on Mágdefrau (1982)'s criteria, various related literatures (Frey and Kürschner, 1991, During, 1979, Bates, 1998, Kürschner et al., 1998, Kürschner, 1999, Dierben, 2001, Kürschner, 2004) and field observations. For determinations of microhabitat types, the collected number and population position of the each species are used also.

In this paper, the following abbreviations are used: S: Soil, R: Rock, T: Tree, LF: Life-form, Fa: Fan, sT: Short turf: sP: Solitary plants, An: Annual, tT: Tall turf, Ma: Mat; MH: Microhabitat, Xsph: Xero-scioepiphytic, Hsg: Higro-scioepigaeic, Msg: Mezo-scioepigaeic, Xsg: Xero-scioepigaeic, Xsl: Xero-scioepilithic, Xhl: Xero-helioepilithic; Msl: Mezo-scioepilithic, Hsg: Helio-scioepigaeic, Xhsg: Xero-hemiscioepigaeic, Xhg: Xero-helioepigaeic..

4. **Results and discussion**

After the evaluation of 303 specimen envelopes collected from the research area, 9 species of 8 families belonging to Hepaticopsida and 47 taxa of 10 families belonging to Bryopsida species have been identified (In total 56 taxa). The life forms of taxa, substrates and microhabitats are pointed to abbreviations (Table 1).

Table 1. The life-form, microhabitat and substrata types of the Bryophytes in the study area.

Family	**Taxa**	**S**	**R**	**T**	**LF**	**MH**
LIVERWORTS						
Cephaloziellaceae	*Cephaloziella baumgartneri* Schiffn.	+	-	-	Ma	Hsg
Fossombroniaceae	*Fossombronia pusilla* (L.) Nees	+	-	-	Ma	Msg
Arnelliaceae	*Gongylanthus ericetorum* (Raddi) Nees	+	-	-	Ma	Msg
Arnelliaceae	*Southbya tophaceae* (Spruce) Spruce	+	-	-	Ma	Msg
Lophoziaceae	*Leicolea turbinata* (Raddi) H. Buch	+	-	-	Ma	Hsg
Lunulariaceae	*Lunularia cruciata* (L.) Lindb.	+	-	-	Ma	Hsg
Aytoniaceae	*Reboulia hemisiphaerica* (L.) Raddi	+	-	-	Ma	Msg
Ricciaceae	*Riccia glauca* L.	+	-	-	Ma	Xhg
Targioniaceae	*Targionia hypophylla* L.	+	-	-	Ma	Msg
MOSSES						
Funariaceae	*Funaria hygrometrica* Hedw.	+	-	-	sT	Msg
	Funaria muehlenbergii (Turner) Fife	+	-	-	sT	Msg
Grimmiaceae	*Grimmia dissimulata* E.Maier	-	+	-	Cu	Msl
	Grimmia pulvinata (Hedw.) Sm.	-	+	-	Cu	Xsl
Fissidentaceae	*Fissidens crassipes* Wilson ex Bruch & Schimp.	+	-	-	Fa	Hsg
	Fissidens bryoides Hedw.	+	-	-	Fa	Hsg
	Fissidens viridulus (Sw.) Wahlenb.	+	-	-	Fa	Hsg
	Fissidens viridulus (Sw.) Wahlenb. var. *incurvus* (Starke ex Röhl.) Waldh.	+	-	-	Fa	Hsg
Dicranaceae	*Dicranella howeii* Renauld & Cardot	+	-	-	sT	Msg
	Dicranella varia Hedw.) Schimp.	+	-	-	sT	Msg
Ditrichaceae	*Ceratodon purpureus* (Hedw.) Brid.	+	-	-	sT	Xsg
Pottiaceae	*Timmiella barbuloides* (Brid.) Mönk.	+	-	-	tT	Msg
	Gymnostomum calcareum Nees & Hornsch.	+	-	-	sT	Xsg
	Pleurochaete squarrosa (Brid.) Lindb.	+	-	-	tT	Msg
	Tortella flavovirens (Bruch) Broth.	+	-	-	sT	Xsg
	Tortella humilis (Hedw.) Jenn.	+	-	-	sT	Xsg
	Tortella inclinata (R. Hedw.) Limpr.	+	-	-	sT	Xsg
	Trichostomum brachydontium Bruch	+	-	-	sT	Xsg
	Trichostomum crispulum Bruch	+	-	-	sT	Xsg
	Weissia condensa (Voit) Lindb.	+	-	-	sT	Xsg
	Weissia controversa Hedw.	+	-	-	sT	Xsg

Table 1. (Continued)

	Weissia longifolia Mitt.	+	-	-	An	Xsg
	Aloina aloides (Koch ex Schultz) Kindb.	+	-	-	sP	Xsg
	Aloina rigida (Hedw.) Limpr.	+	-	-	sP	Xsg
	Barbula unguiculata Hedw.	+	-	-	sT	Xsg
	Crossidium squamiferum (Viv.) Jur.	-	+	-	sP	Xhl
	Didymodon acutus (Brid.) K. Saito	+	-	-	sT	Xsg
	Didymodon fallax (Hedw.) R. H. Zander	+	-	-	sT	Xsg
	Didymodon rigidulus Hedw.	+	-	-	sT	Xsg
	Didymodon luridus Hornsch. ex Spreng.	+	-	-	sT	Xsg
	Didymodon vinealis (Brid.) R. H. Zander	+	-	-	sT	Xsg
	Didymodon tophaceus (Brid.) Lisa	+	-	-	sT	Xsg
	Microbryum davallianum (Sm.) R.H.Zander	+	-	-	sT	Xsg
	Tortula israelis Bizot & F. Blewsky	-	+	-	sP	Xsl
	Tortula muralis Hedw.	-	+	-	sP	Xhl
	Tortula subulata Hedw.	+	-	-	sP	Xsg
Orthotrichaceae	*Orthotrichum diaphanum* Schrad. ex Brid.	-	-	+	Cu	Xsph
Bryaceae	*Bryum argenteum* Hedw.	-	+	-	sT	Msl
	Bryum capillare Hedw.	+	-	-	sT	Msg
	Bryum dichotomum Hedw.	+	-	-	sT	Msg
	Bryum pallescens Schleich. ex Schwägr.	+	+	-	sT	Msg
	Bryum canariense Brid.	+	-	-	sT	Xsg
Amblystegiaceae	*Amblystegium serpens* (Hedw.) Schimp.	+	-	-	We	Hsg
	Hygroamblystegium tenax (Hedw.) Jenn.	+	-	-	We	Msg
Brachytheciaceae	*Scorpiurium sendtneri* (Schimp.) M. Fleisch.	+	-	-	We	Xsg
	Rhynchostegium megapolitanum (Blandow ex F.Weber & D.Mohr) Schimp.	+	-	-	Ma,We	Xhsg
	Rhynchostegiella litorea (De Not.) Limpr.	+	-	-	We	Xsg

In result 8 different life forms of bryophytes have been determined. Researches on bryophyte communities show that there is a strong relationship among the mosses life and ecological factors which affects the habitat (Mágdefrau, 1982; Frey and Kürschner, 1991; Kürschner et al. 1998; Kürschner, 2004). The light regime, intensity, drought and the period of humidity are the beginning parts of these ecological factors. (Kürschner et al., 1998). Generally, the proportion of tT and Cu life forms are a lot among acrocarpous mosses which show development at xerophytic and heliophytic conditions. However, the proportion of mat, weft, tail and fan life forms are more than the pleurocarpous mosses which grow up in humid conditions (Kürschner, 2004).

The life form spectrum of the mosses in study area is shown in Figure 3. According to this, 46 % of mosses are sT life form. And mat life form follows with the proportion of 14 %. Generally mosses which have short turf life form, grow inside the habitats which have xerophytic and heliophytic features. At the same way, the percentages of the species which have sP life forms spreading through in the xerophytic habitats are at the third rank among the other life forms. This order in the research area is identified by microclimate. However, the percentage of weft and fan life forms are higher and at the fourth and fifth rank because of the humid habitat in the north sides of Seyhan dam lake. The positions of weft and fan life forms in this order are identified by microclimate and microhabitats.

The knowledge that we had from the literature and land observation present some similarities. However, we should not forget that the life forms may change according to ecological factors (During, 1979). In the study area, *Rhynchostegiun megapolitanum* shows mat life forms in the open areas. On the other hand, it shows weft life form at the bottom of the trees because of the increase in the summer temperature and competition of vascular plants.

93 % of the species in the research area are picked over the soil (epigaeic), 6 % are over the rock (epilithic) and 1% is over the trunk (epiphytic). The sample picked from the trunk is *Orthotrichum diaphanum* which is obligate epiphytic.

In terms of relationship among substrate, life form and humidity needs, there is no correlation obviously. On the other hand, it is possible to mention relationship between xerophyte and sT, between mesophyte and Mat, sT, between hygrophyte and We, Mat, Fan. 55.3 % of all mosses in the research area are in the habitats which have xerophytic character. This situation is quite natural for macchia due to the climate.

According to habitat classification system (EUNIS) of the research area macchia is similar to “F5-2” habitat type (Davies and Moss, 2002). When literature knowledge and land research habitats compared 9 microhabitats could be described as shown in Table 1. Among these, the most prevalent microhabitat type is xero-scio-epigaeic (Xsg), mezo-scio-epigaeic (Msg) and higro-scio-epigaeic (Hsg) follows it in turn in order (Figure 4).

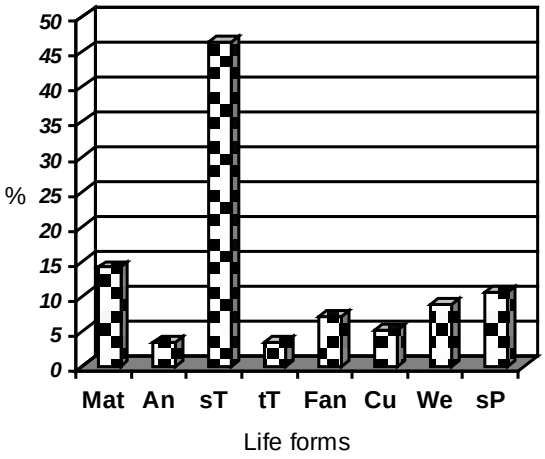

Figure 3. Bryophyte life-form diagram

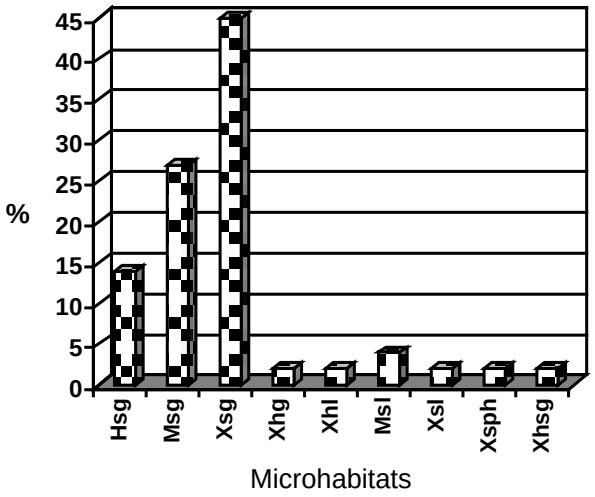

Figure 4. Bryophyte microhabitat diagram

The similar researches, which could be done in identified habitats according to habitat classification systems (EUNIS, CORINE, NATURA 2000, etc.), are going to reveal the spreading and usage of bryophytes at the discrimination of sub-habitat types briefly.

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