

Syntaxonomic analysis of the preforest and forest vegetation in the thermo- and eumediterranean zone around Antalya Gulf, Turkey

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Abstract: The aim of the current study was to reveal the syntaxonomical structure of *Pinus brutia* Ten. forests and the preforest communities in the vicinity of Antalya Gulf. Of the preforest communities, *Dorsytaecho hastatae-Oleatum oleastri* ass. nova is individualized as a paraclimax association. Although little is known about the syntaxonomy of the communities of cliff, rupicolous, and mural communities in the thermomediterranean zone, these are connected with the classes *Asplenieta trichomanis* (Br.-Bl. in Meier & Br.-Bl. 1934) Oberd. 1977 and *Onosmetalia frutescentis* Quézel 1964. In the west of the gulf, *Phlomido bourgaei-Pinetum brutiae* Akman et al. 1998 and its three subassociations were determined: *quercetosum aucheri* subass. nova, *phlomidetosum lyciae* subass. nova, and *iridetosum unguiculariae* subass. nova. The red pine communities in the western side of the gulf are included in *Ceratonio-Rhamnion oleoidis* Barbero and Quézel 1979 of the order *Pistacio lentisci-Rhamnetalia alaterni* Rivas Martinez 1975 belonging to the class *Quercetea ilicis* Braun-Blanq. in Braun-Blanq., Roussine & Nègre 1952. Two new associations, *Phlomido leucophtactae-Pinetum brutiae* ass. nova and *Glycyrrhiza asymetrica-Pinetum brutiae* ass. nova, which are rich in endemics, were determined particularly at the eastern coastal zone of the gulf. These were included in the alliance *Quercion calliprini* (Zohary 1962) Quézel, Barbero & Akman 1978 of the order *Pistacio lentisci-Rhamnetalia alaterni* of *Quercetea ilicis*.

Key words: Syntaxonomy, thermo- and eumediterranean zone, *Pinus brutia* Ten., *Quercetalia ilicis*, Antalya, Turkey

1. Introduction

The present study was carried out to determine and to complete and integrate the vegetational research around Antalya Gulf between the years 2010 and 2012.

In this study, preforest communities characterized by the species *Olea europaea* L., *Ceratonia siliqua* L., *Quercus aucheri* Jaub. & Spach, and mainly *Pinus brutia* Ten. were determined.

The red pine, a relic of Tethys, has a wide distribution in the thermo- and eumediterranean zones in Turkey. Outside Turkey, it extends to Syria, Lebanon, Israel, Cyprus, Crete, the Aegean Islands, Greece, Calabria (Italy), and the Black Sea coasts of Ukraine and Crimea.

Pinus brutia is a widespread species in the Amanus and Taurus ranges in the Aegean and Mediterranean regions of Turkey. There have been local communities of red pine on the distinct mother rocks in the southern parts of Northern Anatolia. From the climatic point of view, *Pinus brutia* extends from the semiarid towards the humid Mediterranean bioclimatic zone (Sakarya Valley, Nallıhan, and Afyon Banaz, annual rainfall of which varies

between 350 and 450 mm) in the districts with climatic characteristics of temperate and cool and annual rainfall of 600–800 mm in the Aegean and Mediterranean regions of Turkey (Atalay et al., 2008).

Pinus brutia, with a wide distribution in Turkey, extends on various mother rocks such as calcareous, marly, schist, flysch, igneous, and ultrabasic (serpentine, gabbro, and basalt) rocks (Atalay et al., 2008).

These climatic and geological peculiarities affect phytosociological composition of red pine communities (Akman et al., 1978). After the anthropogenic destruction of red pine forests it is replaced by *Quercus coccifera* L., *Juniperus* spp., and *Olea europaea* (Barbéro et al., 1976).

While the red pine communities in the thermomediterranean zone in the vicinity of Kemer-Finike have been included in *Ceratonio-Rhamnion oleoidis* Barbéro and Quézel 1979, those extending in the districts of Side and Alanya of Antalya Gulf are included in *Andrachno-Quercion cocciferae* Barbéro and Quézel 1979 belonging to *Quercetea (etalia) ilicis* Braun-Blanq. ex Molin. 1934.

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2. Materials and methods

For the analysis of the vegetation, quadrats were taken and evaluated according to Braun-Blanquet (1964), and the modified scale of Barkman et al. (1964) was used for the combined valuation of abundance and cover.

The sizes of the quadrats were estimated by means of “minimal area” as 400–500 m². The ecological data were placed at the top of each quadrat on the phytosociological tables. Association tables were formed by grouping all the quadrats of identical or very similar floristic composition in one table. Thus, the associations in the study area were differentiated by means of floristic and structural examination. The *International Code of Phytosociological Nomenclature* was followed for naming the new syntaxa (Weber et al., 2000). Moreover, to categorize the syntaxa correctly, the relevant literature was used (Barbero and Quézel, 1976; Akman et al., 1978, 1979a, 1979b; Quézel et al., 1978, 1980, 1992).

2.1. Brief description of the study area

The study area is located on the west (Antalya-Kemer-Finike) and east (Antalya-Manavgat-Alanya) sides of the gulf. It includes thermo- and eumediterranean zones (Figure 1).

2.1.1. The districts on the western side of the gulf: Antalya-Kemer and Finike

The length of the area reaches 60–70 km. The geomorphology of the area covers a range called the Tahtalı Mountains and the front side of Beydağları. This range, the altitude of which rises over 2000 m, has been extended perpendicular to the sea by cutting of various deep valleys from north to south.

This special case allows the thermomediterranean climate to penetrate inwards. Therefore, the red pine forests rise up to 1600 m in this district, that is, on the Tahtalı and Beydağları mountains in Turkey and mix with the cedar forests, whereas these altitudes are occupied normally by only *Pinus brutia* forests. It is determined that the red pines in this district reach an altitude of 1800 m in small patches (Quézel and Pamukcuoglu, 1973). In the region, in the thermo- and eumediterranean even supramediterranean zones, red pines form healthy sites with 90% coverage and grow up to 15–20 m.

The region is dominated by slotted calcareous rocks of Cretaceous age and sometimes by ultrabasic rocks (particularly serpentine) around Kemer (Kalafatçioğlu, 1973).

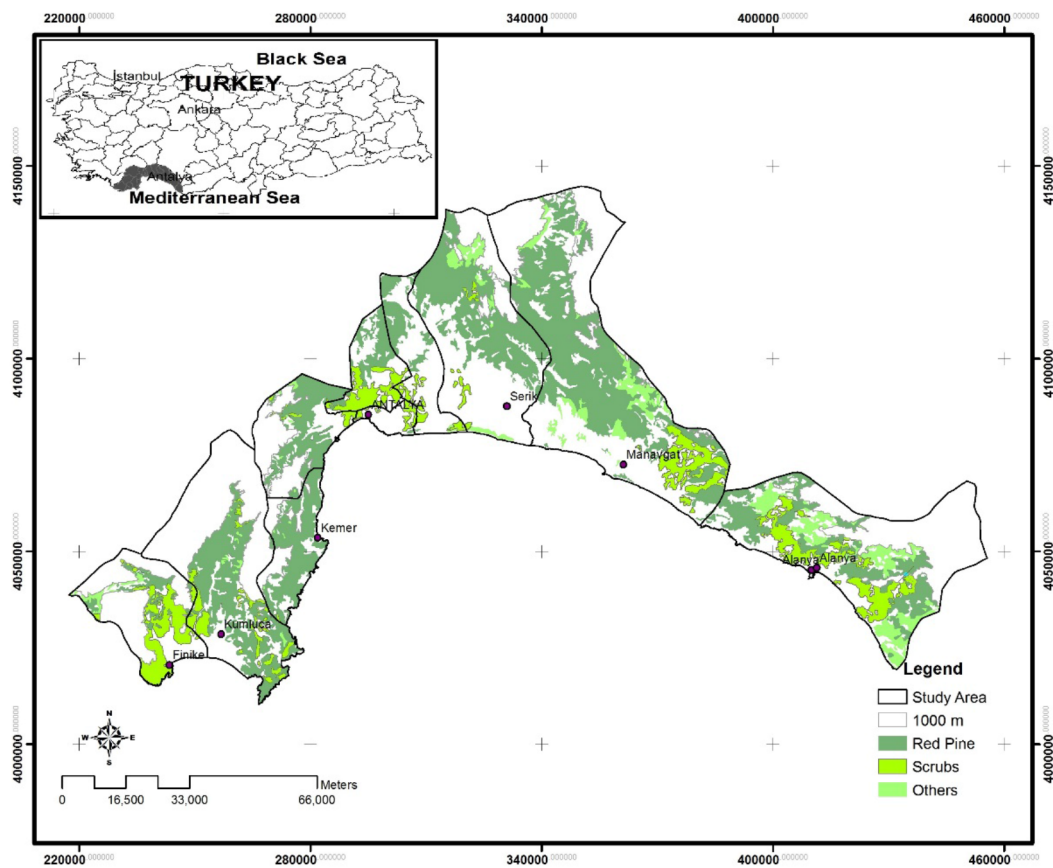


Figure 1. Map of the study area (showing only the altitudes up to 1000 m).

2.1.2. The districts on the eastern side of the gulf: Antalya-Manavgat-Alanya

According to the unpublished geological report by Akay and Uysal in 1985, this district covers an area extending parallel from the east of Antalya towards the coast and generally includes marly and marly calcareous rocks of eosen and neogen age. Some 70%–80% of the district is covered by forests and the rest by garrigue composed of *Cistus creticus* L., *Satureja thymbra* L., and *Calicotome villosa* (Poiret) Link mixed with *Genista acanthoclada* DC., whereas *Cupressus sempervirens* L. occupies an area of 400 ha on the hard calcareous mother rocks in the vicinity of Köprülü Canyon-Beşkonak, at altitudes of 600–500 m in the eumediterranean zone. It exhibits a real forest physiognomy and reaches a height of 20 m.

2.2. TWINSpan classification and detrended correspondence analysis (DCA)

The program JUICE 7.0.97 was used to classify the quadrats. For the cluster analysis and dendrogram, modified TWINSpan classification was applied using the presence/absence data and Sorensen dissimilarity index (Roleček et al., 2009).

For ordination, DCA from the vegan package in R Project (R foundation for statistical computing, R-2.10.1 version, Vienna, Austria) was used on presence/absence data to extract the main gradients in species composition.

2.3. Climate

Seven stations mostly located in the coastal regions were chosen to evaluate the climatic conditions. The stations from east to west were Alanya, Manavgat, Serik, Antalya, Kemer, Kumluca, and Finike. Among these, the stations at Serik, Kemer, and Kumluca record only precipitation data.

At the eastern side of Antalya Gulf, the annual mean precipitation is over 1000 mm (Antalya 1042.9 mm, Serik 1047.6 mm, Manavgat 1288.1 mm, Alanya 1102.7 mm). The precipitation at the western side is less than that at the eastern side (Kemer 818.0 mm, Finike 986.5 mm, Kumluca 1045.8 mm). The precipitation regime at the eastern side is W.A.Sp.Sm. (central Mediterranean regime) while it is W.Sp.A.Sm. (east Mediterranean regime) at the western side of Antalya.

Annual mean temperatures are generally the same, around 23.5–24.0 °C, in the coastal zones of the region. The mean temperatures in winter months do not fall below 10 °C.

The maximum temperature of the hottest months (July–August) is around 31–33 °C at the coastal zone. The minimum temperature of the coldest month (January) shows two variations: one is temperate and cool winter in Antalya (5.8 °C) and Manavgat (6.8 °C), and the other is a variant with warm winters in Finike (7.2 °C) and Alanya (7.7 °C).

These climatic data of the region indicate that the study area is under the effective control of a humid Mediterranean bioclimate with warm, temperate, and cool variants (Akman, 1982).

3. Results and discussion

Based on TWINSpan and DCA results, preforest and forest vegetation units were identified around Antalya Gulf and, following the Braun-Blanquet approach, were classified under five associations and three subassociations.

TWINSpan analysis:

The species were ordered according to their diagnostic value for individual clusters, expressed as fidelity. Using the presence/absence data and Sorensen dissimilarity index for the cluster analysis and dendrogram, modified TWINSpan classification was applied. The data set of 61 quadrats was classified using TWINSpan (pseudospecies cut levels 0-5-25 layers merged).

Three different groups were identified (Appendix Figure 1; on the journal's website).

Group I: *Pinus brutia* communities in the eastern part of Antalya Gulf

1-*Phlomido leucophytae-Pinetum brutiae* ass.

2-*Glycyrrhizo asymetricae-Pinetum brutiae* ass.

Group II: *Pinus brutia* communities in the western part of Antalya Gulf

Phlomido bourgaei-Pinetum brutiae ass.

3-*Quercetosum aucheri* subass.

4-*Iridetosum unguiculariae* subass.

5-*Phlomidetosum lyciae* subass.

Group III: Preforest communities in the western part of Antalya Gulf

6-*Phlomidotum chimerae-lyciae* ass.

7-*Dorystaecho hastatae-Oleetum oleastri* ass.

Ordination:

DCA was performed to determine the relation between the identified vegetation types and the main gradients in species composition (Appendix Figure 2; on the journal's website).

Group I is characterized by *Pinus brutia* communities in the eastern part of Antalya Gulf, Group II is characterized by *Pinus brutia* forest communities, and Group III is characterized by preforest communities in the western part of Antalya Gulf.

3.1. Preforest vegetation

Of the preforest plant groups, *Olea europaea* and *Quercus aucheri* communities, and the cliff, rupicolous, and mural communities were researched for the first time in Turkey.

The climax plant cover of the thermo- and eumediterranean zone is red pine communities (Barbéro et al., 1990; Barbéro et al., 1998). After the destruction of red pine forests, olive and oaks develop as paraclimax communities. The preforest communities around Antalya Gulf are represented by the following associations:

Dorystaecho hastatae-Oleetum oleastri ass. nova (Table 1)

Table 1. Preforest communities of Antalya Gulf.

Quadrat number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Presence	
Altitude (m)	50	40	50	70	80	70	50	50	60	60	60	100	150	30	40	15	15		
Inclination (%)	60	50	60	70	70	60	50	60	70	70	60	35	40	35	30	30	30		
Exposition	S	S	SW	S	SW	S	S	W	S	S	S	S	S	SW	W	SW	SW		
Area of the quadrat (m ²)	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50		
Total coverage (%)	80	85	85	80	85	85	85	85	80	80	85	65	60	50	50	50	50		
Substrat	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	srp		
Characteristic and differential species of the associations																			
<i>Dorystaecho hastatae-Oleetum oleastris</i>																			
<i>Olea europaea</i> var. <i>oleaster</i>	22	33	33	22	23	12	23	22	12	22	22	11	12	.	.	.	.	13
<i>Ceratonia siliqua</i>	11	22	22	22	22	22	23	22	22	22	.	23	22	.	.	.	.	12
<i>Dorstaecho hastata</i>	12	12	12	.	12	11	12	11	12	11	.	.	.	.	.	.	.	9
<i>Quercus aucheri</i>	+1	.	+1	.	11	.	11	12	11	.	.	.	.	.	.	.	.	6
<i>Phlomis chimerae</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
<i>Acantholimon ulicinum</i> ssp. <i>purpurescens</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
<i>Anthemis rosea</i> ssp. <i>carnea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4
<i>Phlomis lycia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3
Cliff Plants																			
<i>Galium canum</i> ssp. <i>antalyense</i>	.	++	11	11	11	12	11	11	.	+1	+1	+1	+1	.	.	.	.	11
<i>Ricotia sinuata</i>	.	.	.	+1	+1	+1	+1	+1	+1	+1	.	.	.	.	.	+1	.	8
<i>Euphorbia hierosolymitana</i>	.	.	.	+1	11	12	12	.	.	.	.	.	.	.	.	.	+1	5
<i>Prilostemon chamaepeuce</i>	.	.	+1	+1	.	.	.	+1	.	+1	.	+1	.	.	+1	.	.	6	
<i>Euphorbia austroanatolica</i>	.	.	.	11	11	12	11	.	.	.	.	.	.	.	.	.	.	4
<i>Hypericum lanuginosum</i> var. <i>pestalozzae</i>	.	+1	+1	.	.	.	.	.	.	.	.	.	.	+1	.	.	.	4
<i>Hypericum pamphylicum</i>	+1	.	.	.	.	+1	+1	+1	.	.	.	.	.	.	.	.	.	4
Rupicol Plants																			
<i>Inula heterolepis</i>	+1	+1	+1	+1	+1	+1	+1	.	+1	+1	.	+1	+1	+1	.	+1	+1	11	
<i>Origanum onites</i>	.	.	.	+1	+1	+1	.	+1	+1	+1	+1	.	.	.	.	.	.	8
<i>Onosma strigosissimum</i>	+1	.	+1	.	+1	.	.	+1	+1	+1	.	.	+1	+1	+1	+1	+1	11	
<i>Hypericum lanuginosum</i> ssp. <i>lanuginosum</i>	.	.	.	.	+1	.	.	.	.	.	+1	+1	.	.	+1	+1	.	5
<i>Stachys aleurites</i>	+1	+1	.	.	.	.	+1	.	+1	.	.	.	.	.	.	+1	+1	6
<i>Nepeta phylloclamus</i>	.	+1	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Murale Plants																			
<i>Cymbalaria longipes</i>	12	11	12	+1	11	.	+1	+1	+1	+1	+1	+1	.	+1	.	.	.	13	
<i>Hyoscyamus aureus</i>	.	+1	.	+1	.	+1	.	.	+1	.	.	.	.	.	+1	.	.	6

C = Calcareous; Srp = Serpentine

Table 1. (Continued).

Characteristic species of the Order <i>Ceratonio-Rhamnion oleoidis</i>																
<i>Phagnalon graecum</i>	+1	+1	+1	+1	+1	11	12	+1	+1	.	11	11	+1	+1	+1	14
<i>Phlomis bourgaei</i>	22	12	11	22	11	11	12	+1	12	11	.	+1	+1	.	.	13
<i>Rubia tenuifolia</i>	+1	.	+1	+1	.	.	+1	.	+1	+1	.	.	.	+1	.	7
<i>Rhamnus oleoides</i> ssp. <i>graecus</i>	.	.	.	.	+1	+1	.	.	.	.	.	.	+1	+1	.	6
Characteristic species of the Order <i>Pistacio-Rhamnietalia aleterni</i>																
<i>Pistacia terebinthus</i> ssp. <i>palaestina</i>	.	.	.	+1	.	+1	.	.	.	11	.	.	.	.	.	5
<i>Piptatherum miliacea</i>	+1	.	+1	+1	+1	.	.	.	.	+1	.	.	11	11	11	8
<i>Myrtus communis</i>	11	11	.	.	.	12	12	.	.	.	.	12	12	.	.	7
<i>Pistacia lentiscus</i>	+1	11	11	.	.	.	+1	+1	.	.	.	.	.	+1	.	7
<i>Clematis circhosa</i>	.	.	.	.	+1	.	.	.	.	.	.	.	.	+1	.	5
Characteristic species of the Class and Order <i>Quercetea (etaitia) iticis</i>																
<i>Euphorbia characias</i> ssp. <i>wulfenii</i>	+1	+1	11	11	12	12	+1	+1	+1	+1	+1	+1	+1	.	.	17
<i>Quercus coccifera</i>	+1	12	12	.	.	.	12	12	.	12	11	12	.	22	22	13
<i>Phillyrea latifolia</i>	.	.	.	22	22	22	11	11	12	.	12	+1	+1	.	12	13
<i>Arbutus andrachne</i>	.	.	11	11	11	.	+1	.	11	11	.	.	11	+1	11	9
<i>Cyclamen percicum</i>	.	.	+1	.	.	.	.	.	.	.	.	+1	.	.	.	5
<i>Smilax aspera</i>	.	.	.	.	.	+1	+1	.	.	11	11	.	.	+1	.	5
Characteristic species of the Class <i>Cisto-Micromerietea</i>																
<i>Calycatome villosa</i>	11	11	11	.	.	.	.	+1	+1	+1	11	.	.	+1	+1	11
<i>Micromeria myrtifolia</i>	.	.	.	.	.	.	.	.	+1	+1	+1	+1	.	.	+1	8
<i>Cistus creticus</i>	.	+1	+1	.	.	.	.	.	.	.	.	+1	+1	.	.	5
<i>Cistus salvifolius</i>	.	+1	+1	.	.	.	.	+1	+1	.	.	.	.	+1	.	5
Characteristic species of the Class <i>Quercetea pubescentis</i>																
<i>Syrax officinalis</i>	.	.	.	.	.	12	12	.	12	.	.	12	12	.	11	7
<i>Rhus cotinus</i>	.	.	.	.	.	11	.	.	.	.	11	.	.	.	.	3
Companions																
<i>Daphne gnidioides</i>	+1	+1	.	.	.	.	+1	+1	.	.	+1	+1	+1	+1	+1	11
<i>Teucrium divaricatum</i>	.	.	.	+1	+1	+1	.	.	.	.	.	.	.	.	.	8
<i>Urginea maritima</i>	.	.	.	.	.	.	+1	+1	.	.	.	.	+1	.	.	4
<i>Teucrium polium</i>	+1	+1	+1	.	.	.	.	.	.	.	+1	+1	.	.	.	6
<i>Satureja thymbra</i>	.	.	.	+1	+1	.	.	.	.	.	+1	.	.	.	.	4
<i>Daphne sericea</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+1	.	3
<i>Sarcopoterium spinosum</i>	.	.	.	.	.	12	12	.	.	.	.	.	.	.	.	3
<i>Coronilla parviflora</i>	.	.	+1	.	.	.	.	+1	+1	.	.	.	.	.	+1	4

Holotypus: Table 1; Quadrat: 5

The wild olive plants occupy the calcareous slopes with an inclination of 35%–70%, and on soils quite poor in organic matter. This type of vegetation is seen on a vast area between Antalya and Finike, in the west coastal zone of Antalya.

This association generally prefers south and southwest slopes at altitudes of 100–150 and 600–700 m.

***Phlomidotum chimerae-lyciae* ass. nova** (Table 1)

Holotypus: Table 1; Quadrat no: 16

The openings of preforest communities are characterized by *Phlomis chimerae* Boissieu, *Phlomis lycia* D.Don, *Acantholimon ulicinum* (Schultes) Boiss. var. *purpurascens* (Bokhari) Bokhari & Edmondson, and *Anthemis rosea* Sm. subsp. *carnea* (Boiss.) Grierson.

Rupicolous groups growing on the calcareous soils are represented by species such as *Galium canum* Req. ex DC. subsp. *antalyense* Ehrend., *Onosma strigosissimum* Boiss., *Euphorbia austroanatolica* Hub.-Mor. & M.S.Khan, *Stachys aleurites* Boiss. & Heldr., and *Nepeta phyllochlamys* P.H.Davis. Other participants belong to upper syntaxonomical units.

The cliff communities developing on the travertines around Antalya are thermophilous and characterized by *Euphorbia hierosolymitana* Boiss., *Ptilostemon chamaepeuce* (L.) Less., *Hypericum lanuginosum* Lam. var. *pestallozuae* (Boiss.) Robson, and *H. pamphylicum* N.Robson & P.H.Davis.

From the syntaxonomical point of view, these cliff, rupicolous, and mural communities at the lower altitudes are connected with *Asplenietea trichomanis* and *Onosmetalia frutescentis*. *Onosma strigosissimum* Boiss. has a close affinity to *O. frutescens* Lam. and is replaced by *O. frutescens* in the study area.

3.2. Forest vegetation

Sylvatic vegetation is in two groups: western and eastern sides of Antalya Gulf.

***Pinus brutia* forests between Antalya-Kemer and Finike at the western side of Antalya Gulf:**

On the montane area extending in the north–south direction in this part of the gulf, *Pinus brutia* forests start to spread in the coastal zone and reach up to 1600 m, where they connect with the *Cedrus libani* A.Rich. forests.

In this part of the gulf, the following associations were determined:

***Phlomido bourgaei-Pinetum brutiae* Akman et al. 1998** (Table 2)

Holotypus: Table 2; Quadrat no: 40

This association firstly was determined around Marmaris and Bodrum by Akman et al. (1998). In the study area it individualizes on the hard calcareous and ultrabasic rocks, particularly on the serpentine at altitudes of 50–100 and 900–1000 m in the warm-humid Mediterranean bioclimatic zone.

The association is characterized by *Phlomis bourgaei* Boiss., *Cupressus sempervirens*, and *Acer sempervirens* L. *Phlomis bourgaei* is a widespread endemic species and extends towards to the presylvatic groups on hard calcareous blocks and serpentine rocks.

Phlomido bourgaei-Pinetum brutiae ass. includes four subassociations around Marmaris and Bodrum. In the study area it includes three subassociations in respect to altitude and the type of mother rock.

***quercetosum aucheri* subass. nova** develops on the shallow terra rossa soils on the hard calcareous blocks of steep slopes (15%–60%) from the south towards the west. This subassociation is differentiated by *Quercus aucheri*, which has a very local distribution only in this region. Central Europe maintains a considerable diversity of dry-mesic oak forests, as their species composition changes along several environmental and geographical gradients (Roleček, 2005).

Holotypus: Table 2; Quadrat no: 40

***phlomidetosum lyciae* subass. nova** individualized as thermophilous subassociation on the ultrabasic mother rocks at Kemer-Finike.

Holotypus: Table 2; Quadrat no: 51

***iridetosum unguiculariae* subass. nova** prefers, apart from the previous ones, the humid and deep brown forest soils at altitudes of 500–550 and 1000–1100 m. It exhibits a mesomediterranean ecology. From the syntaxonomic point of view, *Pinus brutia* Ten. forests are included in the alliance *Ceratonio-Rhamnion oleoidis* of the order *Pistacio lentisci-Rhamnetalia alaterni* of the class *Quercetea ilicis*. Here the red pines develop as a climatic formation in respect to plant dynamism.

Holotypus: Table 2; Quadrat no: 56

The Eastern side of Antalya Gulf

***Glycyrrhizo asymetricae-Pinetum brutiae* ass. nova** (Table 3)

Holotypus: Table 3; Quadrat no: 25

The association localized on the eastern side of Antalya Gulf is characterized by regional endemic species such as *Glycyrrhiza asymmetrica* Hub.-Mor., *Sideritis congesta* P.H.Davis & Hub.-Mor., *Thymus revolutus* Čelak, and *Phlomis lunariifolia* Sm.

In the vicinity of Antalya-Manavgat-İncekum (Alanya), on the sea-facing slopes with brown forest soils derived of marly and marly calcareous rocks at 50–100 and 400–500 m in the warm humid Mediterranean zone, this association was first determined by Ayaşlıgil in 1987 within the boundaries of Köprülü Canyon National Park. The association determined here shows a high similarity ratio, more than 60%, in respect to floristic composition. The study by Ayaşlıgil is a PhD thesis and has not been

Table 2. *Pinus brutia* associations west of Antalya Gulf (around Antalya-Kemer).

	38	39	40	41	42	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	Presence
Quadrat number	38	39	40	41	42	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	
Altitude (m)	60	70	50	20	33	50	70	70	70	75	40	30	20	30	40	40	50	55	50	50	55	55	11	
Inclination (%)	60	50	60	3	15	60	60	50	50	55	40	15	20	40	45	40	5	15	20	40	65	40	30	
Exposition	N	N	S	S	S	S	SW	N	N	NW	S	S	S	S	S	S	N	N	N	N	N	N	N	N
Area of the quadrat (m ²)	40	40	40	4	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Total coverage (%)	0	0	0	00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Substrat	90	90	75	80	80	90	90	90	90	90	85	90	95	80	90	90	90	90	90	90	90	90	90	90
	C	C	C	C	C	C	C	C	C	C	C	srp	srp	srp	srp	srp	C	C	C	C	srp	srp	C	C

Characteristic and differential species of the association and subassociations		<i>Pinus brutia-Phlomis bourgaei (Phlomidio bourgaei-Pinetum brutiae)</i>																								
<i>Pinus brutia</i>		45	44	33	34	44	44	44	44	44	44	44	44	45	44	44	34	44	4	44	44	44	44	44	24	
<i>Phlomis bourgaei</i>		.	.	+	.	+	+	+	+	.	.	+	+	.	4	.	.	.	.	+	+	13
<i>Cupressus sempervirens</i>		11	11	.	.	22	.	11	11	.	.	.	.	.	.	.	.	11	.	.	.	.	.	11	11	8
<i>Asperula antalyensis</i>		.	+	+	.	+	.	+	+	+	10
<i>Acer sempervirens</i>		+	+	.	11	.	.	.	+	+	+	.	.	.	.	.	.	.	1	.	.	.	.	.	.	7
		<i>Quercus aucheri (quercetosum aucheri)</i>												<i>Phlomis lycia (phlomidetosum lyciae)</i>						<i>Iris unguicularis (iridetosum unguiculariae)</i>						
<i>Erica sicula</i> ssp. <i>libanotica</i>		+	.	.	.	+	4
<i>Quercus aucheri</i>		+	+	11	12	+	11	.	11	.	11	.	11	.	.	.	.	.	.	.	.	.	.	.	.	8
<i>Phlomis lycia</i>		6
<i>Iris unguicularis</i>		7

Characteristic species of the Alliance <i>Ceratonia-Rhamnus oleoides*</i> and the Order <i>Pistacio-Rhamnetalia alaterni</i>																											
<i>Myrtus communis</i>		11	22	11	11	22	+	11	23	11	11	.	.	+	22	23	23	.	.	12	.	.	.	.	.	17	
<i>Pistacia terebinthus</i> ssp. <i>palaestina</i>		.	.	12	.	11	12	12	.	.	.	.	11	12	11	11	12	11	+	+	.	.	.	.	.	.	14
* <i>Asparagus acutifolius</i>		.	.	+	+	11	.	+	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	7
<i>Ceratonia siliqua</i>		11	11	12	.	12	.	11	12	.	.	.	12	.	.	.	.	.	.	.	.	.	.	.	.	.	7
<i>Piptatherum miliacea</i>		.	.	12	12	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	6
* <i>Rhamnus oleoides</i> ssp. <i>graecus</i>		+	.	11	11	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	7
<i>Piptatherum coerulescens</i>		.	.	12	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Clematis circhosa</i>		.	.	12	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Rubia tenuifolia</i>		2

Table 2. (Continued).

Characteristic species of the Class and Order <i>Quercetea (etalia) ilicis</i>																			
<i>Smilax aspera</i>	+1	.	11	.	+1	.	+1	+1	.	+1	+1	11	11	+1	.	.	+1	.	15
<i>Quercus coccifera</i>	11	+1	.	12	+1	+1	+1	.	.	.	.	.	+1	.	.	.	11	11	13
<i>Phillyrea latifolia</i>	11	11	22	.	11	11	11	11	11	12	12	12	.	.	.	.	.	.	12
<i>Euphorbia charassias</i> ssp. <i>wulfenii</i>	+1	+1	12	11	11	+1	+1	.	.	.	.	.	.	.	.	.	+1	11	13
<i>Quercus infectoria</i> ssp. <i>boissieri</i>	.	.	.	.	.	.	.	11	11	12	12	11	11	.	.	.	.	.	7
<i>Arbutus andrachne</i>	.	.	12	11	.	.	.	22	22	23	+1	+1	11	11	.	.	+1	.	9
<i>Cyclamen persicum</i>	.	.	.	11	.	.	.	.	.	+1	+1	+1	.	.	.	.	+1	+1	8
<i>Eryngium falcatum</i>	.	.	.	11	.	12	.	.	.	+1	+1	+1	.	.	.	.	.	.	5
<i>Fontenesia phillyroides</i>	.	.	.	.	.	+1	.	.	.	.	.	11	11	11	.	.	+1	+1	9
<i>Pistacia lentiscus</i>	.	.	12	12	.	11	.	12	12	.	.	.	.	.	.	.	.	.	7
<i>Laurus nobilis</i>	.	.	22	11	.	.	.	.	.	.	.	.	11	+1	11	.	.	.	5
<i>Juniperus oxycedrus</i> ssp. <i>oxycedrus</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+1	11	.	+1	+1	6
<i>Ruscus aculeatus</i>	.	.	.	+1	.	11	.	.	.	.	.	.	.	.	.	.	.	.	3
<i>Olea europaea</i> var. <i>oleaster</i>	.	.	.	.	.	.	.	.	11	11	.	.	.	.	.	.	.	.	4
<i>Osyris alba</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	+1	+1	.	.	.	3
Characteristic species of the Class <i>Quercetea pubescentis</i>																			
<i>Syrax officinalis</i>	+1	+1	12	.	.	+1	.	+1	+1	.	.	.	.	.	.	22	.	.	11
<i>Coronilla emeroides</i>	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	+1	.	3
<i>Rhus cotinus</i>	.	.	+1	.	.	.	.	.	.	+1	+1	.	.	.	.	12	.	.	5
<i>Crataegus aronia</i> ssp. <i>aronia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+1	.	2
Characteristic species of the Class <i>Cisto-Micromeretea</i>																			
<i>Cistus salvifolius</i>	+1	+1	.	+1	.	.	.	.	+1	+1	12	12	12	+1	+1	.	.	.	13
<i>Cistus creticus</i>	.	.	11	11	11	+1	.	.	.	.	.	.	.	.	11	.	.	.	6
<i>Teucrium dvaricatum</i>	.	.	+1	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Micromeria myrtifolia</i>	.	.	+1	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Companions																			
<i>Urginea maritima</i>	+1	+1	.	11	11	+1	+1	+1	.	.	.	.	.	.	.	.	.	.	7
<i>Lamyropsis cynaroides</i>	.	.	+1	+1	+1	.	.	.	.	.	.	.	.	.	.	+1	+1	.	7
<i>Origanum onites</i>	+1	.	+1	.	.	+1	+1	.	.	.	.	.	.	.	.	.	.	.	5
<i>Daphne sericea</i>	+1	+1	.	.	+1	.	+1	.	.	.	.	.	.	.	.	.	.	.	7
<i>Calycotome villosa</i>	.	.	11	11	.	.	.	.	.	.	.	.	.	.	+1	.	.	.	5
<i>Spartium junceum</i>	.	.	.	.	.	.	.	.	.	+1	+1	.	.	.	.	.	.	.	8
<i>Ephedra campylopoda</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
<i>Paliurus australis</i>	.	.	.	.	.	.	.	.	.	+1	+1	.	.	.	.	.	.	.	3
<i>Daphne gnidioides</i>	.	.	11	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	2
<i>Fumana thymifolia</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2

C=Calcareous; Srp=Serpentine

Table 3. *Pinus brutia* associations east of Antalya Gulf (around Antalya-Alanya-Beskonak-Köprülü Canyon).

Quadrat number	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Altitude (m)	10	60	50	70	150	150	90	200	220	240	330	350	360	500	520	480	450	100	130	120
Inclination (%)	25	30	20	10	20	10	40	25	35	20	35	30	30	35	35	20	25	35	35	35
Exposition	S	S	SW	S	S	W	W	NW	S	N	S	NW	S	NE	NE	NW	N	SW	W	SW
Area of the quadrat (m ²)	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Total coverage (%)	60	70	75	80	85	60	80	80	90	80	75	80	70	80	75	70	80	75	80	70
Substrat	M	M	M	MC	MC	M	M	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC	MC

Characteristic and differential species of the associations	<i>Pinus brutia-Glycyrrhiza asymmetrica</i> (<i>Glycyrrhiza asymmetrica-Pinetum brutiae</i>)										<i>Pinus brutia-Phlomis leucophacta</i> (<i>Phlomis leucophactae-Pinetum brutiae</i>)											
	<i>Pinus brutia</i>	33	34	34	33	44	44	34	44	44	44	44	44	44	44	44	44	44	44	44	44	20
<i>Verbascum oryzae</i>	+1	.	+1	.	+1	11	.	.	+1	+1	.	+1	.	.	.	.	.	.	.	.	.	8
<i>Sideritis congesta</i>	+1	.	+1	.	+1	+1	.	+1	.	+1	.	.	.	.	.	.	.	.	.	.	.	8
<i>Cupressus sempervirens</i>	+1	+1	+1	.	+1	.	11	11	.	.	+1	11	+1	.	.	.	.	.	.	.	.	9
<i>Phlomis lunariifolia</i>	+1	+1	+1	.	+1	+1	.	11	11	+1	11	+1	+1	.	.	.	.	.	.	.	.	11
<i>Lithodora hispidula</i>	12	12	12	12	.	+1	+1	+1	+1	+1	+1	+1	+1	.	.	.	.	.	.	.	.	12
<i>Glycyrrhiza assyriaca</i>	.	+1	.	.	+1	+1	12	+1	+1	+1	+1	+1	+1	.	.	.	.	.	.	.	.	10
<i>Onobrychis gracilis</i>	12	11	12	11	.	+1	+1	.	+1	.	+1	.	.	.	.	.	.	.	.	.	.	8
<i>Thymus revolutus</i>	+1	+1	11	.	.	+1	+1	+1	.	+1	.	+1	+1	.	.	.	.	.	.	.	.	9
<i>Verbascum nudatum</i> var. <i>nudatum</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
<i>Eromopoa attalica</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	7
<i>Phlomis leucophracta</i>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4

Characteristic species of the Alliance *Quercion calliprini*

<i>Pistacia terebinthus</i> ssp. <i>palaestina</i>	.	.	11	.	.	.	+1	.	+1	.	+1	+1	.	.	.	.	.	.	.	.	.	11
<i>Arbutus andrache</i>	.	.	.	+1	.	.	.	.	.	.	12	11	11	.	+1	.	.	.	.	.	.	9
<i>Eryngium falcatum</i>	+1	+1	.	.	.	.	.	+1	+1	+1	+1	+1	+1	.	.	.	.	.	.	.	.	10
<i>Fontanesia phillyroides</i>	.	.	.	+1	.	.	.	.	+1	+1	+1	+1	.	.	.	.	.	.	.	.	.	7
<i>Rhamnus oleoides</i> ssp. <i>graecus</i>	+1	11	11	.	.	.	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	4

Table 3. (Continued).

Characteristic species of the Order and Class <i>Quercetea (etalia) ilicis</i>	
<i>Quercus coccifer</i>	+1 +1 +1 +1 +1 . . . +1 . . . +1 . . . +1 11 12 12 12
<i>Piptatherum coerulegens</i>	+1 +1 +1 +1 +1 +1 +1 +1 +1 +1 . . 10
<i>Cotinus cogytia</i>	. . . . . +1 +1 +1 +1 +1 . . . 11 +1 . . . 8
<i>Myrtus communis</i>	+1 +1 +1 +1 12 +1 12 +1 8
<i>Asparagus acutifolius</i>	. . . . . +1 +1 +1 +1 +1 6
<i>Olea europaea</i> var. <i>oleaster</i>	. +1 +1 +1 12 +1 +1 +1 6
<i>Osyris alba</i>	+1 +1 . . . +1 +1 +1 . . . +1 6
<i>Quercus infectoria</i> ssp. <i>boissieri</i>	. . . . . +1 11 . . . +1 +1 +1 6
<i>Smilax aspera</i>	. . . . . +1 +1 +1 4
<i>Pistacia lentiscus</i>	+1 . . . +1 12 3
Characteristic species of the Class <i>Quercetea pubescentis</i>	
<i>Syrax officinalis</i>	+1 +1 +1 +1 +1 . . . +1 +1 . . . +1 . . . +1 13
<i>Crataegus monogyna</i>	+1 +1 +1 +1 +1 4
Characteristic species of the Class <i>Cisto-Micromeritetea</i>	
<i>Cistus creticus</i>	+1 +1 +1 +1 22 . . . +1 12 +1 . . . +1 +1 11 +1 . . . +1 . . . +1 15
<i>Micromeria myrtifolia</i>	+1 +1 +1 +1 . . . +1 +1 +1 . . . +1 +1 +1 . . . 11
<i>Genista acanthoclada</i>	22 22 22 12 4
<i>Satureja thymbra</i>	. . . . . 12 +1 +1 +1 4
<i>Teucrium divaricatum</i>	+1 +1 +1 . 3
Companions	
<i>Origanum onites</i>	+1 +1 +1 +1 +1 . . . +1 +1 +1 7
<i>Daphne sericea</i>	+1 . . . +1 +1 +1 +1 +1 6
<i>Fumana thymifolia</i> ssp. <i>thymifolia</i>	+1 +1 +1 +1 +1 . 4
<i>Calycatome villosa</i>	+1 +1 +1 +1 +1 . 4
<i>Sarcopoterium spinosum</i>	11 11 11 . 3
<i>Teucrium polium</i>	+1 +1 +1 +1 +1 . 4
<i>Thymbra spicata</i>	. . . . . +1 . 2

M=Marly; MC=Marly; Calcareous kng=Conglome

published. Due to its invalidity and unpublished position we prefer to name the association composed of our own quadrats as a new one (nomenclatural synonym according to ICPN: article 5 and 19).

***Phlomido leucophytae-Pinetum brutiae* ass. nova** (Table 3)

Holotypus: Table 3; Quadrat no: 32

Pinus brutia also forms infrequent communities between 500 and 1300 m at the eastern side of Antalya Gulf. The coverage rate of community is 60%–70% even though the red pine individuals grow healthily on the easily degradable conglomerates. The diagnostic taxa of the association are *Verbascum nudatum* Murb. var. *nudatum*, *Eromopoa attaica* H.Scholz, and *Phlomis leucophracta* P.H.Davis & Hub.-Mor.

To the north of Manavgat and Alanya, in the vicinity of Akseki at altitudes of 1200–1300 m, this association is replaced by *Phlomido aitidi-Pinetum brutiae* Duran 1997 and the species such as *Rhamnus nitidus* Davis, *Sideritis arguta* Boiss. & Heldr., *Phlomis lunariifolia*, and *P. leucopraeta* P.H.Davis & Hub.-Mor. characterize the association. This association resembles the previous one in respect to floristic composition, but occupies areas of the supramediterranean zone.

It extends on the marly and marly calcareous and sometimes on the conglomerates at the eastern part of the gulf and is attached to the *Quercion calliprini* alliance of the order *Pistacio-Rhamnetalia alaterni* within the class *Quercetea ilicis*.

Within these two associations, the species of *Quercetalia (etea) ilicis* are rich. There have been also the species of *Cisto-Micromerietea* (Oberdorfer 1954) Barbéro-Quézel 1989 and many local endemic species particularly on marly and marly calcareous rocks.

In respect to plant dynamism, although the associations of red pine determined in the study, as in others of the Mediterranean region, reflect the actual climax physiognomy, they seem to develop towards the communities of xerophytic oaks. Xerophytic oaks have a wide distribution across the Mediterranean Basin (almost all xerophytic oak communities are rich in the species of *Quercetalia (etea) ilicis*) (Tsiourlis et al., 2009).

This study was carried out to provide an integrated approach to the work done in the Mediterranean region. The syntaxa determined are as follows:

Class: *QUERCETEA ILICIS* Braun-Blanq. in Braun-Blanq., Roussine & Nègre 1952

Order: *PISTACIO LENTISCI-RHAMNETALIA ALATERNI* Rivas Mart. 1975

Alliance: *Ceratonio-Rhamnion oleoidis* Barbero-Quézel 1979

Association: *Dorystaecho hastatae-Oleetum oleastri* ass. nova

Association: *Phlomido chimerae-lyciae* ass. nova

Association: *Phlomido bourgaei-Pinetum brutiae* Akman et al. 1998

Subassociation: *quercetosum aucheri* subass. nova

Subassociation: *phlomidetosum lyciae* subass. nova

Subassociation: *iridetosum unguiculariae* subass. nova

Alliance: *Quercion calliprini* (Zohary 1962) Quézel, Barbero & Akman 1978

Association: *Glycyrrhizo asymmetricae-Pinetum brutiae* ass. nova

Association: *Phlomido leucophytae-Pinetum brutiae* ass. nova

The vegetation affected by the coastal conditions in the area occupies the thermomediterranean bioclimatic zone with warm winters and annual precipitation of about 1068–1288 mm.

The bioclimatic and geological heterogeneity are general characteristics of the Mediterranean region; therefore, although they are geographically very close, the floristic composition and then the syntaxa may change in very short distances due to the edaphic isolation.

The red pine forests have been included in the alliances *Quercion calliprini* and *Ceratonio-Rhamnion oleoidis* of the order *Pistacio-Rhamnetalia alaterni* belonging to the class *Quercetea ilicis* from the phytosociological point of view.

The *Phlomido leucophytae-Pinetum brutiae*, *Glycyrrhizo asymmetricae-Pinetum brutiae*, and *Phlomido bourgaei-Pinetum brutiae* associations described in the eastern and western parts of Antalya Gulf are different from *Junipero phoeniceae-Pinetum brutiae* Akman et al. 1998 described in Muğla Province and *Rhamno lycioidis-Pinetum brutiae* Konstantinidis et al. 2012 described in Greece and the East Aegean Islands due to the ecological and geographical isolation created by the presence of local indigenous and rare species in the associations described here.

The preforest plant groups are also attached to the *Ceratonio-Rhamnion oleoidis* alliance of the order *Pistacio-Rhamnetalia alaterni* of the class *Quercetea ilicis*. These groups in the Central Mediterranean (Italy) have been represented by *Oleo-Ceratonion* and *Cytision sessilifolii* alliances (Allegrezza et al., 2006).

Within the associations, the characteristic species of *Cisto-Micromerietea* such as *Calycotome villosa*, *Micromeria myrtifolia*, *Cistus creticus*, *C. salviifolius*, *Teucrium polium*, *Satureja thymbra*, and *Sarcopoterium spinosum* are also rich.

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Appendix

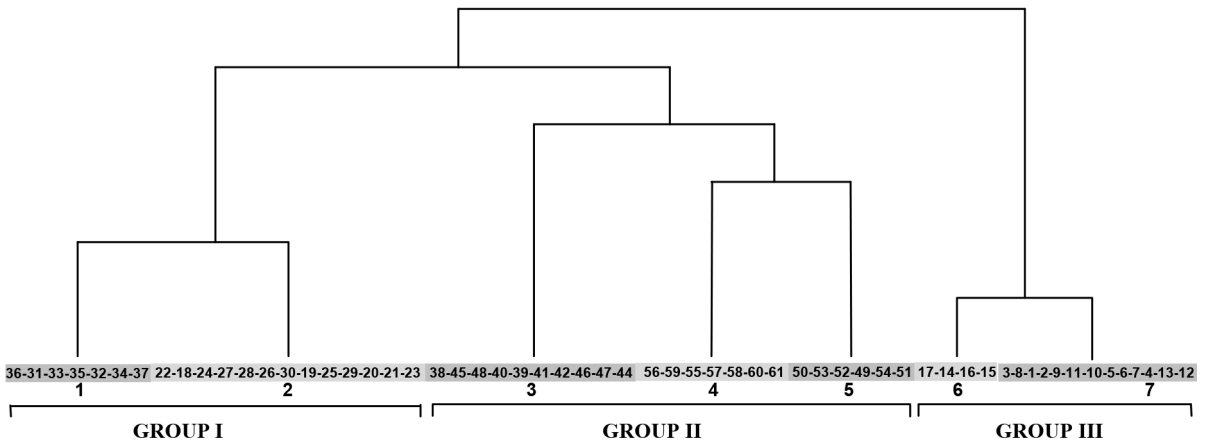


Figure 1. TWINSpan dendrogram of analysis of plant associations. [Group I: *Pinus brutia* communities in the east part of Antalya Gulf (1- *Phlomidio leucophytae*-*Pinetum brutiae* ass., 2- *Glycyrrhizo asymmetricae*-*Pinetum brutiae* ass.), Group II: *Pinus brutia* communities in the western part of Antalya Gulf (3-4-5 *Phlomidio bourgaei*-*Pinetum brutiae* ass. 3- *Quercetosum aucheri* subass. 4- *Iridetosum unguiculariae* subass. 5- *Phlomidetosum lyciae* subass.), Group III: Preforest communities in the western part of Antalya Gulf (6-*Phlomidotum chimerae*-*lyciae* ass. 7- *Dorystaecho hastatae*-*Oleetum oleastri* ass.)].

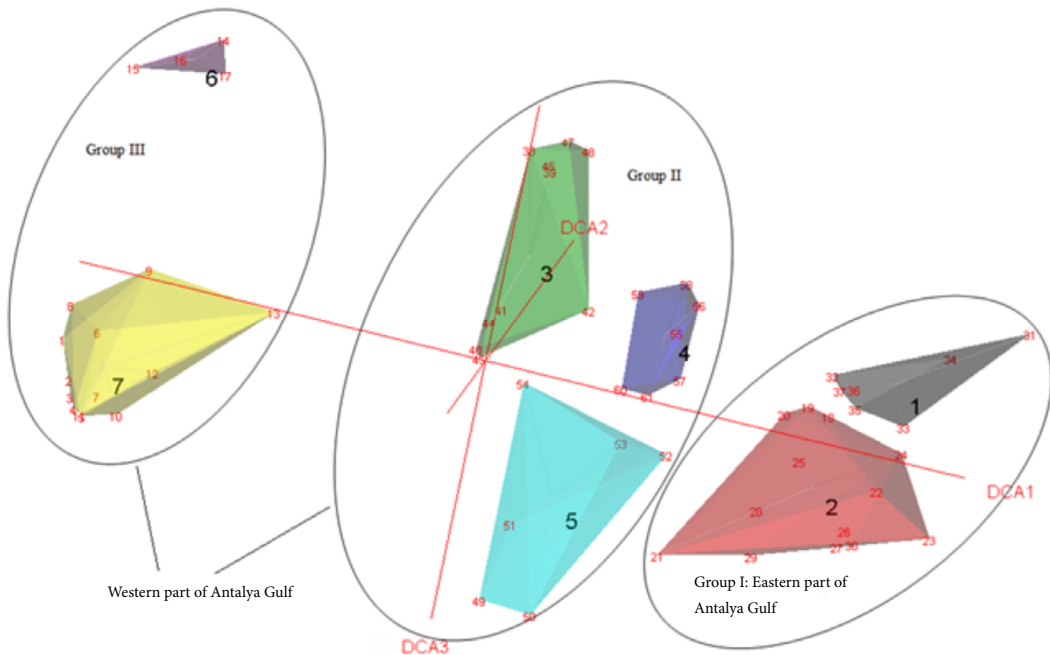


Figure 2. Ordination diagram from detrended correspondence analysis (DCA) showing plant associations [Group I: *Pinus brutia* communities in the eastern part of Antalya Gulf (1- *Phlomidio leucophytae*-*Pinetum brutiae* ass., 2- *Glycyrrhizo asymmetricae*-*Pinetum brutiae* ass.), Group II: *Pinus brutia* communities in the western part of Antalya Gulf (3-4-5 *Phlomidio bourgaei*-*Pinetum brutiae* ass. 3- *quercetosum aucheri* subass. 4- *iridetosum unguiculariae* subass. 5- *phlomidetosum lyciae* subass.), Group III: Preforest communities in the western part of Antalya Gulf (6- *Phlomidotum chimerae*-*lyciae* ass. 7- *Dorystaecho hastatae*-*Oleetum oleastri* ass.)].