An inventory of the vascular plants and bryophytes of Gavdopoula island (S Aegean, Greece) and its phytogeographical significance

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Abstract

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Gavdopoula is an island of 177.5 ha in the S Aegean, near the southeasternmost point of Europe. Based on field excursions in 1998/99 and 2009/10, we provide an annotated floristic catalogue of 186 vascular plant and 13 bryophyte taxa, with a full record of herbarium specimens and field observations, being the first botanical inventory of the island. Species richness in relation to island area is, as shown in a diagram, according to expectations. Among the vascular plants there are six regional (‘Cretan area’) endemics. The Saharo-Arabian-S Mediterranean phytogeographical element is well represented, with several species confined in Greece or even in Europe to the small islands south of Crete. Of these, *Atriplex mollis* occurs in Europe only on Gavdopoula. The moss *Entosthodon commutatus* has not previously been recorded from the E Mediterranean. The vegetation is controlled chiefly by the dry Mediterranean climate, calcareous shallow soils, sea spray and seasonal grazing. It consists of halo-nitrophytic and *Pistacia lentiscus* scrub, two types of phrygana, small-scale ephemeral pastures with winter-annuals on red-loamy soils, and sea-cliff vegetation. The new combination, *Lysimachia arvensis* var. *caerulea*, is published.

Additional key words: Crete, flora, Gavdos, Mediterranean, phytogeography, islet, species-area relation, vegetation

Introduction

The islands of the Aegean are diverse in history and habitats as well as in plant and animal species. They are home to widespread organisms as well as to local and regional endemics, small-island specialists and others confined to the larger islands. Phytogeographically, they connect Europe and Asia, most obviously via the island arc of the S Aegean. The central part of the S Aegean island arc is the ‘Cretan area’. This phytogeographical term is well represented, as in Med-Checklist (Greuter & al. 1984, 1986, 1989; Greuter & Raab-Straube 2008), as comprising Crete and surrounding islands and the Karpathos archipelago. Each Aegean island is distinct in many respects. The flora of the S Aegean islands is particularly remarkable for its affinities to N Africa, and this is nowhere more pronounced in southeastern Mediterranean Europe than on the small offshore islands south of Crete. One of these islets is Gavdopoula, situated in the Libyan Sea about 30 km off the southwestern coast of Crete and 7 km northwest of the southernmost European island, Gavdos.
In the frame of quite different projects, C. Fournaraki, P. Gotsiou, E. Bergmeier and N. Böhling conducted fieldwork on various days in 1998/99, enabling us to make the most of opportunities to survey the plant species of Gavdopoula. Although each of us was granted only a few hours on the island, we believe that our independent yet combined efforts already resulted in a fairly complete inventory. This was proved to be essentially right ten years later when some of us (N. Turland, R. Lansdown and E. Bergmeier with T. Constantinidis, and in 2010 R. Jahn with A. Traxler & al.) took another opportunity to spend a short time on Gavdopoula, and on this occasion also making a collection of bryophytes. Due to the limitations of time and season, however, the bryophyte list presented here is considered preliminary and not intended to be exhaustive.

Until now, there was no botanical inventory for Gavdopoula. In fact, rather surprisingly, to our knowledge this island has not been botanically investigated by others before us. Therefore, the aims of this paper are to bring together our records from Gavdopoula, compile a documentation of the herbarium specimens, provide an annotated list of the vascular plants and bryophytes, and to describe the phytogeographical and ecological significance of the island.

**Geographical background**

Stretched from northwest (34°56′21″N, 23°59′22″E) to southeast (34°55′15″N, 24°00′46″E), Gavdopoula is 3 km long and transversely, from southwest to northeast, broadest at 750 m (Fig. 1). The area of the island is 1.775 km², not 2.6 km² as claimed by various internet sources. The southwestern coastline is an escarpment standing 30–70 m high, whereas towards the northeast the coast is bouldery or rocky. About 85% of the island is a low, gently sloping ridge, plateau-like in the southern part, with no abrupt altitudinal difference, between 40 and 100 m. The maximum elevation is 113 m.

Most of the exposed bedrock on the island belongs to the Pindos-Ethia zone (IGME 1993), a carbonate series consisting of hard crystalline limestones and flysch layers of sandstone with calcitic cementing material, the latter according to IGME (1993) confined to the northwest. A calcareous bank of neogene origin is only represented near the eastern and southeastern coastline (IGME 1993). Soils are calcareous lithic leptosols, chiefly eroded to syrosem or, at best, rendzina, with little organic content except for appreciable amounts of humus accumulation under *Pistacia* shrubs. While the soil in the crystalline limestone area is thin and especially in the south poor in nutrients, the Neogene karst pockets contain brown fertile soil. The entire island is more or less influenced by sea spray.

In the absence of meteorological records from Gavdopoula we can only assume that the climate is very similar to that of Gavdos and the southwestern Cretan coast, i.e. of a frost-free Mediterranean regime. Rainfall is restricted to winter, probably totalling up to c. 400 mm, which renders Gavdopoula and the other islands off the southern coast of Crete among the driest regions in Mediterranean Europe.

Gavdopoula belongs to the historical province (Eparchia) of Selino and to the prefecture (Nomos) of Chania. Together with Gavdos it forms the Natura 2000 site ‘Nisoi Gavdos kai Gavdopoula’ (GR 4340013, Islands of Gavdos and Gavdopoula) (Dimopoulos & al. 2005). The island is also protected by the Greek Forest Law.

Remains of a Minoan settlement have been found in Keramos in the south of the island. Gavdopoula may have been inhabited sporadically from Minoan times until the late 19th century. In former times the island had several other names such as Gkotzòpoulo or Antigkòtzo (Kopaka & al. 2001). Gavdopoula is now uninhabited and lacks freshwater except for ephemeral rainwater pools. The most significant human impact is seasonal livestock grazing. Sheep and goats from southwestern Crete (Sfakia) are taken there in late winter and early spring for foraging.

In 1998, Gavdopoula gained public attention as plans to transform the island into a container storage facility became known. This is why two of us (CF and PG) visited the island to help environmental organisations argue against the plans. Fortunately for the biodiversity of Gavdopoula, the project was turned down in 1999.

**Material and methods**

We collected on Gavdopoula on the following days:

8.4.1998 C. Fournaraki and P. Gotsiou
In the catalogue, families, genera and species are in alphabetical order. Records per species are given in chronological order citing the year (1998, 1999, 2009, 2010) and the type of record, field observation (obs.) and/or herbarium specimen numbers, together with the collectors’ acronyms:

**EB** Erwin Bergmeier

**F&G** Christina Fournaraki & Panagiota Gotsiou

**NT** Nicholas Turland

**RJ** Ralf Jahn

**RL** Richard Lansdown

Collections are deposited in EB’s private herbarium in Göttingen (GOET, kept separate), those of NB in Berlin (B, with duplicates in his private herbarium, UPA and MAIC), those of F&G in Chania (MAIC), those of RJ in his private herbarium (Großschirm, Germany), those of NT in Patras (UPA) and those of RL will be deposited in Edinburgh (E). Family assignation for vascular plants follows APG III (Angiosperm Phylogeny Group 2009) and Stevens & al. (2001+), nomenclature (author citation) follows the available Med-Checklist volumes (Greuter & al. 1984, 1986, 1989; Greuter & Raab-Straube 2008) or else standard floras.

Bryophyte nomenclature follows Grolle & Long (2000) for liverworts (Marchantiophyta) and Hill & al. (2006) for mosses (Bryophyta). All bryophytes listed here were collected by Richard Lansdown (RL) and named by Thomas Blockeel.

**Floristic catalogue**

**Vascular plants**

**Polyphidaceae**

Anogramma leptophylla (L.) Link – 2009: **RL** obs.

**Pinidae**

**Cupressaceae**

Juniperus macrocarpa Sm. – 1999: **EB** obs. (1 plant), **F&G** 5323; 2009: **NT** obs.

Juniperus phoenicea L. – 1999: **EB** obs. (2 plants); 2009: **NT** obs.

**Magnoliidae**

**Aizoaceae**

Mesembryanthemum nodiflorum L. – 1999: **NB** obs., **EB** obs.

**Amaranthaceae** (incl. Chenopodiaceae)


Atriplex mollis Desf. – 1998: **F&G** 4934; 1999: **EB** 99-15, F 5326, **NB** 9535, 9916, 2009: **EB** 09-8, **NT** obs.; 2010: **RJ** s.n.

**Amaryllidaceae** (incl. Alliaceae)

Allium longanum Pamp. – 1998: **F&G** 4960; 1999: **NB** 9513 (det. D. Tzanoudakis), **EB** 99-30


**Anacardiaceae**


**Apiaceae**


**Apocynaceae** (incl. Asclepiadaceae)

Periploca angustifolia Labill. – 1998: **F&G** 4918; 1999: **EB** obs., **NB** 9528; 2009: **EB** 09-7, **NT** obs.; 2010: **RJ** obs.


**Asparagaceae** (incl. Hyacinthaceae)

Asparagus aphyllus subsp. orientalis (Baker) P. H. Davis – 1998: **F&G** 4930; 1999: **F&G** 5327, **EB** obs., **NB** 9508c; 2009: **EB** obs., **NT** 1825; 2010: **RJ** obs.


Bellevalia brevipedicellata Turrill – 1998: **F&G** 4939; 1999: **EB** obs., **NB** 9509/z, 9530, 9947z; 2009: **NT** 1818
Prospero autumnale (L.) Speta (agg.) (= Scilla autumnalis L.) – 1999: F&G photo from cult. plant; NB 9511f, 9934f, 9946z, 9963z; 2009: EB, NT, RL obs.; 2010: RJ & al. living coll. (cultivated at Lentas)

Asteraceae

Taraxacum sp. – 1999: NB obs.

Boraginaceae


Brassicaceae

Capsella bursa-pastoris var. brachycarpa Heldr. – 1999: NB 9525

Campanulaceae

Campanula erinus L. – 1998: F&G 4979

Capparaceae


Caryophyllaceae

Herniaria cinerea DC. – 1999: EB 99-11


S. leucanthemifolius, NT 1839


Senecio vulgaris L. – 1998: F&G 4979
Cistaceae

Colchicaceae
Colchicum cupani (Guss. (s.str.) – 1999: NB 9510; – The gathered bulbs were cultivated in B and produced rather broad-leaved plants which were tentatively assigned to C. coustrieri Greuter. According to Persson (2007: 183), the latter is to be included in C. cupani s.str.
Colchicum pusillum Sieber – 1998: F&G 4985 (photo from cultivated plant was identified as C. pusillum by K. Persson); 1999: EB obs.; 2009: RL obs.

Convolvulaceae

Crassulaceae

Ericaceae

Euphorbiaceae

Fabaceae
Medicago orbicularis (L.) Bartal. – 1998: F&G 4915

Trifolium infamia-porontii Greuter – 1998: F&G 4916
Vicia cretica L. – 1999: EB obs., NB 9931

Gentianaceae
Frankenia hirsuta L. – 1999: EB obs., F&G 5325; 2009: EB obs., NT 1822

Geraniaceae
Erodium neoradifolium Delile – 1999: NB 9499, 9523
Geranium purpureum Vill. – 2009: EB obs.

Iridaceae
Crocus laevigatus Bory & Chaub. – 1999: NB 9945
Crocus tournefortii J. Gay – 1998: F&G (photo from cultivated plant); 1999: NB 9905. – Other Crocus collections from 1999 and 2009 (NB 9512, NT 1821) cannot be assigned with certainty to a species.
Romulea linaresii subsp. graeca Béguin – 1999: NB 9515, 9928z (cf.); 2010: RJ obs. (cf., in fruit)

Juncaceae
Juncus hydridus Brot. – 1999: EB 99-10

Lamiaceae
Ajuga iva (L.) Schreb. – 2010: RJ obs.
Ballota pseudodictamnus (L.) Benth. – 2010: RJ obs.

Teucrium alpestre Sm. – 1999: NB 9532 (cf.); 2009: EB 09-4, NT 1823


Linaceae

Malvaceae
Malva sylvestris L. – 2009: NT 1819

Oleaceae
Olea europaea L. – 1999: EB obs. (1 small-leaved plant, var. sylvestris (Mill.) Lehr)

Orobanchaceae

Plantaginaceae
Plantago squarrosa Murray – 2009: EB obs., NT 1835

Plumbaginaceae
Limonium hyssopifolium (Girard) Rech.f. – 1999: NB 9508a (det. R. Artelari)
Limonium proliferum (d’Urv.) Erben & Brullo, ined. – 1999: F&G 5328 (det. M. Erben). – A paper with the combination used here is currently in prep. by Erben & Brullo (M. Erben in litt.).

Poaceae
Anisantha rubens (L.) Nevski (= Bromus rubens L.) – 1999: EB obs., F&G 5059, NB 9934a (det. H. Scholz); 2009: EB 09-2, NT 1834
Avellinia micheli (Savi) Parl. – 1999: EB 99-25
Castellia tuberculosa (Moris) Bor – 1999: EB 99-17, NB 9961 (det. H. Scholz)
Dactylis glomerata subsp. hackelii (Asch. & Graebn.) Cif. & Giacom. – 1999: NB 9529a, 9533 (det. H. Scholz)
Dactylis glomerata subsp. hispanica (Roth) Nyman – 2010: RJ s.n.
Lolium rigidum Gaudin – 2009: NT 1828
Melica minuta L. – 1999: NB 9960 (det. H. Scholz)
Parapholis incurva L. – 1999: NB 9963 (det. H. Scholz);
2010: RJ s.n.
Parapholis marginata Runemark – 1999: EB 99-9

Poa bulbosa L. (s.l., incl. P. pelasgis H. Scholz) – 1999:
   NB obs.; 2010: RJ obs.

Poa infirma Kunth – 2009: EB obs., NB 9929; RJ s.n.

Poa taiwana (L.) Tzvelev – 1999: F&G 4990; 1999:
   EB obs., NB 9938, 9939 (det. H. Scholz); 2009: RJ s.n.
Rostraria tortilis (Boiss.) Holub – 1999: NB 9949a
   (det. H. Scholz; see also Böhling & Scholz 2003: 73)

Rutaceae

Sulamaceae

Lycium schweinfurthii Dammer – 1998: F&G 4959;

Mandragora officinarum L. (= M. autumnalis Bertol.) –

Urticaceae

   NB 9942; 2009: EB, NT, RL obs.; 2010: RJ obs.

Bryophytes

Marchantiophyta

Fossombroniae

Petalophyllum ralfsii Nees & Gottsche ex Lehm. – 1999:

Lunulariaceae


Bryophyta

Fissidentaceae


Funariaceae

Entosthodon commutatus Durieu & Mont. – RL 44/09
   p.p. – This is a rare and little-known species recently
   elucidated by Brugués & al. (2010) and Brugués &
   Ségro (2010). The material from Gavdopoulou agrees
   in all essential details, especially (1) an erect symme-
   trical capsule, (2) a well-developed exostome of
   16 teeth alternating with very small intercalary proc-
   esses, and a rudimentary endostome, and (3) unbor-
   dered, oblong, shortly acuminate leaves.

Funariella curviseta (Schwägr.) Ségro – RL 39/09 p.p.,

Pottiaceae


Didymodon acutus (Brid.) K. Saito – RL 39/09 p.p.,

Microbryum starckeanum (Hedw.) R. H. Zander (agg.) –
   RL 37/09 p.p., RL 44/09 p.p. – These collections are
   referred here to M. starckeanum s.l., following Ros
   & al. (1996). The spores are nearly smooth, though
   often somewhat irregular in outline, and the capsules
   have a variably developed peristome (which has prob-
   ably been lost partially in many individuals through
   aging of the capsules).

Tortella flavovirens (Bruch) Broth. – RL 37/09 p.p.,


Tortula vahliana (Schultz) Mont. – RL 44/09 p.p. – The
leaves in this collection have hyaline hair-points, in
contrast to the usually shorter greenish-yellow points found in most collections of T. vahliana. However the concept of this species in Flora Brioñtica Ibérica (Cano 2006) includes plants with hyaline hair-points.


In addition to the taxa listed above, a distinctive diminutive species of Tortula of uncertain identity is present in small quantity in RL 45/09. Unidentifiable specimens of senescent Fossombronia (RL 40/09 p.p.) and sterile Bryum (RL 40/09 p.p.) were also collected.

Phytogeography

We found 186 vascular plant taxa on the island of Gavdopoula. This is almost exactly what could be predicted from a species-area curve constructed for the islands surrounding Crete (Fig. 2). At least 22 of the species recorded on Gavdopoula are not known to occur on the nearest and much bigger island of Gadvos (Bergmeier & al. 1997). Of these, the shrubby halophytes Atriplex halimus, A. mollis, Asparagus horridus and Lycium schweinfurthii are species of halo-nitrophytic scrub, a habitat type that is most prominent on small islands and not well represented on Gadvos.

Aegean small-island species are represented on Gavdopoula by Asparagus horridus and Hornungia procumbens. It is known that grazing can be detrimental to non-adapted small-island specialists (Bergmeier & Dimopoulos 2003) and can even eradicate islet populations. On Gavdopoula, A. horridus, apart from being a fairly well-defended species itself on account of its spinose cladodes, occurs not uncommonly in the shelter of Pistacia scrub. Hornungia is a small prostrate low-competitive annual which may profit from sea spray.

The S Mediterranean phytogeographical element is well represented on Gavdopoula. Apart from more widespread species, the following are particularly noteworthy as their distribution reaches its northern limit in Crete and the surrounding islands or, at most, in the S Aegean:

Allium longananum is known otherwise only from Gadvos (Bergmeier & al. 1997), Antikythera (Tzanoudakis & al. 2006, RJ s.n. 1995), Libyan Cyrenaica, the two Cycladic islands of Sirina and Koutzomiti and from northeastern Crete (Stearm 1977).

Asparagus horridus, widespread in coastal N Africa, Mediterranean Spain and along the southeastern Mediterranean, is a small-island species in the Aegean, confined in the Cretan area to islands surrounding Crete and Karpathos (Bergmeier & Dimopoulos 2003).

Atriplex mollis is a N African halophyte with its single European occurrence on Gavdopoula, where it is a common coastal shrub (Bergmeier & al. 1999; see also Fig. 3). Castellia tuberculosa, an annual grass of Macaronesian, S Mediterranean and SW Asian general distribution, has been rarely found in the Cretan area. Apart from Gavdopoula (Böhling & Scholz 2003) there are three previous records from eastern Crete: in 1973 on a sandy beach 3 km S of Agios Nikolaos (Greuter & al. 1985: 32), in 1996 near Myrtos W of Ierapetra (Jahn 1996) and E of Ferma on the E side of the valley of Agia Fotia (35°01'33''N, 25°52'34''E), roadside bank, 50 m, 5.5.1994, Jahn s.n.

Chlamydophora tridentata, a southeastern Mediterranean annual composite of halophytic habitats, is known in Greece only from Rodos and the islands S of Crete (Bergmeier & al. 2001).

Erodium neuradifolium, a S Mediterranean annual extending into the Saharo-Arabian region, is known off the southern coast of Crete otherwise on the island of Koufonisi (Bergmeier & al. 2001). It also occurs scattered in Crete and the Karpathos island group.

Frankenia corymbosa, a small shrubby halophyte of chiefly N African distribution, is known in Greece only from Gavdopoula and Koufonisi (Böhling & al. 1999; Bergmeier & al. 2001) and Gadvos, where RJ collected it in 2010 (s.n.) at several locations between Potamos beach and Lavrakas beach, opposite to Gavdopoula.

Periplaca angustifolia, a species of coastal scrub in the S Mediterranean-Saharan region, occurs in Greece only on the islands S of Crete: Chrisi, Gadvos and Gavdopoula (Bergmeier & al. 1997, 2001). On Gavdopoula, it is a common plant.

Entosthodon commutatus is a rare species previously known only from the W Mediterranean region (Algeria, Morocco and Spain) and Macaronies (as E. krausei
Besch.). It is new to the Cretan area and to Greece, and the occurrence on Gavdopoula represents a large eastern extension of its range.

Endemics of the Cretan area occurring on Gavdopoula are:

*Bellevia brevipedicellata* is a narrowly endemic geophyte of southwestern Crete, Gavdos and Gavdopoula (Turland 1995; Bergmeier & al. 1997; Bareka 2010).

*Crepis cretica* is an annual occurring abundantly throughout the Cretan area.

*Crepis tybakiensis* is an annual widespread in the Cretan area including some of the surrounding islands and is locally common in stony phrygana habitats.

*Muscari spreiztenhoferi* is widespread in Crete and the surrounding islands, ranging from sea level to the high mountains (e. 2100 m).

*Ononis verae* is an annual scattered in western and central Crete (Turland & al. 1993; Fielding & Turland 2005) and occurring also on Gavdos (Bergmeier & al. 1997) and Gavdopoula.

*Teucrium alpestre* is a subshrub endemic to Crete with an altitudinal range similar to that of *Muscari spreiztenhoferi*, from sea level to 2200 m. Apart from Gavdopoula, it is not known to occur on the islands surrounding Crete.

**Vegetation**

The vegetation of Gavdopoula is shaped by drought, wind, sea spray and grazing and is not particularly diverse. The most extensive type of vegetation is the E Mediterranean phrygana formation, a mosaic of low shrubs and open ground with herbs in between. There are two types of phrygana on Gavdopoula. Both are commonly dominated by *Thymbra capitata* (*Coridothymus capitatus*) and very low windshorn shrubs of *Pistacia lentiscus*. Other common shrubs and subshrubs of the more extensive type of phrygana on crystalline limestones are *Convolvulus oleifolius*, *Periploca angustifolia*, *Teucrium brevifolium* and *T. capitatum*. The other type of phrygana is restricted to extremely karstic limestones almost without soil found in the south of the island. It is characterised by *Anthyllis hermanniae*, *Erica manipuliflora* and *Fumana thyminifolia*. Both types of phrygana are known with similar species composition from Gavdos, Chrisi and Crete.

The bryophyte flora also shows the influence of prolonged desiccation and wind. Only acrocarpous mosses and three species of liverwort were recorded, the mosses dominated by the *Pottiacaeae*, particularly in the flat interior part of Gavdopoula, with other families limited to the coastal cliffs and slopes. The presence and growth form of shrubs appears critical to bryophytes, most plants of which grow in the shade of the larger and denser bushes, as well as occasionally in the shade of the largest rocks.

The most frequent species in these habitats are *Aloina aloides* and *Trichostomum brachydontium*, both of which also occur in open rocky areas between shrubs and on bare rock. Moist, shaded habitats also support small populations of *Fossombronia*, all plants of which were senescent at the time of survey and could therefore not be identified to species.

Where red or brown clayey soil has accumulated between rock outcrops or as alluvium in slight depressions, vascular plant species densities of 20–30 species per m² were found. This is sheep-grazed vegetation chiefly composed of annual plants such as *Crepis cretica*, *Geranium molle*, *Lagoecia cuminoides*, *Medicago monspeliaca*, *Plantago lagopus*, *P. weldenii* and *Sherardia arvensis*. These areas also provide the only really suitable habitat for a diverse bryophyte flora in the more open areas of the flat terrain. *Trichostomum brachydontium* is again widespread, with *Aloina aloides* and some *A. ambigua*. Where the thin soil is periodically wet and the clay swollen, additional species such as *Trifolium tomentosum* and, rare on Gavdopoula, *Crepis pusilla*, *Filago cretensis* and *Trifolium suffocatum* occur with a greater diversity of mosses, including *Microbryum starckeanum*, *Tortella flavovirens* and *Tortula pallida*.

Dense patches of *Pistacia lentiscus* scrub of 10–50 m² and 1–2 m tall occur chiefly in the east of Gavdopoula immediately where the terrain drops to the coastline and in the southeastern and south-central part, which is in places more sheltered from the prevailing winds. Apart from *Pistacia*, typical species include *Lycium schweinfurthii*, *Periploca angustifolia*, *Prasium majus* and both *Asparagus* species.

Although not as extensive as phrygana, the most striking vegetation type of Gavdopoula is halo-nitrophytic scrub. As such, it is common along the coasts of many of the Aegean islands, particularly the minor ones, but the kind occurring on Gavdopoula is unique in species composition from a European perspective, with the N African species *Atriplex mollis* and *Frankenia corymbosa*, together with the more widespread *A. halimus*, being the dominant and characteristic taxa. Halo-nitrophytic shrub vegetation occurs on and between coastal rocks chiefly but not exclusively along the northern and eastern coasts, also sheltered below cliffs on the southern coast. In the northwestern part, which is particularly exposed to the strong sea-spray-laden winds, *Pistacia lentiscus-Atriplex mollis-Atriplex halimus* scrub extends considerably inland and occurs from near sea level to about 50 m. As a result of sea spray blown all over the island, a typical feature of small islands is the occurrence of species of halonitrophytic scrub far inland in otherwise non-halophytic vegetation: on Gavdopoula *Frankenia corymbosa* may be found in phrygana and *Atriplex mollis* in *Pistacia* scrub.

The large boulders on the eastern cliffs create the only permanently humid microhabitats on the island, as well as supporting the main breeding population of Cory’s shearwater (*Calonectris diomedea diomedea*). This combination results in moist clays which are locally kept
Fig. 3. Halo-nitrophytic scrub with *Atriplex mollis* on Gavdopoula in its single European locality, with gull’s nest (*Larus michahellis michahellis*). – Photo by N. Turland, April 2009.
clear by trampling by birds and enriched by guano. They support the only pteridophyte recorded, Anogramma leptophylla, as well as the most diverse bryophyte flora on the island. The most abundant mosses are similar to those in the wet pans, such as Tortella flavovirens and Microbryum starceanum. However, this habitat also supports the only populations of Entosthodon commutatus, Fissidens incurvus, Funaria curviflora and Tortula vahliana recorded, as well as two of the three liverwort species recorded: Lunularia cruciata and Petalophyllum ralfsii.

Finally, in cliff situations along the western coast, a species-poor vegetation with the pendulous shrub Capparis orientalis and sometimes with Cardiunculus maritimum can be found. On the western coast, near the southern end of the island, due to intense sea spray, the sharply eroded karstic limestone slopes are free of plants up to several metres above sea level.

During the late winter months until about Easter the islet Gavdopoula becomes a natural enclosed area for sheep. This typical Greek-Aegean habitat of shepherd-less ‘island transhumance’ has clearly affected the vegetation of Gavdopoula through grazing and browsing but only very few species were found that seem to be allochthonous, originating from the main island of Crete and accidentally transported to Gavdopoula with the sheep. Philomis fruticosa, Ballota pseudodictamnus, Capsella bursa-pastoris, Galium aparine and Malva sylvestris may belong to this group of species of more or less recent casual introductions.

We found the potentially tall shrubs (or low trees but for the wind) Juniperus macrocarpa and Olea europaea on Gavdopoula only as one or two small shrubs at the northwestern or southeastern end, respectively. J. phoenicea was also present with only two low shrubs. Clearly, they represent rare established introductions from Gavdos or southwestern Crete where juniper wood- and scrubland is common. There is a small breeding colony of yellow-legged gulls (Larus michahellis michahellis) on Gavdopoula (Fig. 3) and olive seeds were found from the gulls’ regurgitated pellets. So the gulls are very likely the source of the single olive shrub on Gavdopoula, and perhaps of the junipers too.

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