



The genus *Gonocytisus* (*Fabaceae*) in Greece

Kit Tan¹, Kostas Giannopoulos² & Naim Berisha³

¹ Institute of Biology, University of Copenhagen, Universitetsparken 15, DK-2100 Copenhagen Ø, Denmark, e-mail: kitt@bio.ku.dk
(author for correspondence)

² Dabaki 15, Pyrgos, Ilias 271 00, Greece

³ Faculty of Mathematics and Natural Sciences, Department of Biology, University of Prishtina, St George Bush 31, 10 000, Prishtina, Kosovo

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Abstract

Gonocytisus dirmilensis (*Fabaceae*) was originally described from SW Anatolia, Turkey. It occurs disjunct in south and south-central Greece where it is the sole representative of its genus. The Greek plants from south-central Greece were recently named *G. graecus*. Principal component analysis (PCA) reveals that the morphological variation between *G. dirmilensis* and *G. graecus* is limited and there is no justification in treating the Greek populations as a separate species. *Gonocytisus graecus* is thus relegated to synonymy of *G. dirmilensis*. A description of the species in Greece, its ecology and distribution together with a map of total distribution are provided.

Key words

Gonocytisus, Greece, distribution, taxonomy, Turkey

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Introduction

Gonocytisus Spach comprises three species occurring in Greece and the eastern Mediterranean (Turkey, W Syria, Israel and Lebanon). The genus is distinct in the *Genistaceae* on account of its ciliate-barbate anthers, a feature also present in *Spartium*; the spathaceous calyx is likewise split adaxially almost to base. *Gonocytisus dirmilensis* Hub.-Mor. was described from collections made in 1948 from the Altınyayla (Dirmil) district of Burdur province in Turkey (Huber-Morath 1965). It was considered endemic to Turkey. In 2006, the species was reported from Sterea Ellas in south central Greece (Tan & al. 2006), and also from the Peloponnese (Giannopoulos & al. 2011; Zarkos & al. 2018) which showed its geographical disjunction is similar to that of some other taxa occurring in Europe and SW Asia such as *Juniperus drupacea* Labill., *Macrotomia densiflora* (Nordm.) J.F. Macbr., *Podocytisus caramanicus* Boiss. & Heldr. and *Solananthus stamineus* (Desf.) Wettst. *Gonocytisus angulatus* (L.) Spach is a species from NW, W

& S Anatolia; it differs from *G. dirmilensis* by its smaller flowers and proportionately broader leaves. Reports of this species from northern Greece (Gibbs 1970: 22) have never been confirmed and are probably erroneous. The third species, *G. pterocladus* (Boiss.) Spach with angular-winged branches (hence the epithet), is restricted to S Anatolia (Amanus region), W Syria, Israel and Lebanon; it does not occur in Greece.

The Greek plants from Sterea Ellas, south central Greece were recently described by Şentürk & al. (2024) as belonging to a new species, *G. graecus* Şentürk & Yıldırım. This is stated to differ from *G. dirmilensis* in Turkey by its larger flowers and fruit, orbicular-reniform seeds with finely reticulate surface, as well as smaller subprolate pollen. In the abstract provided in that publication it is written that *G. graecus* shares dehiscent fruits with *G. dirmilensis*, in contrast to the indehiscent fruits of *G. angulatus* and *G. pterocladus*. This is a typographical error as the fruits of *G. dirmilensis* are indehiscent and those of *G. pterocladus* clearly dehiscent (Fig. 1).

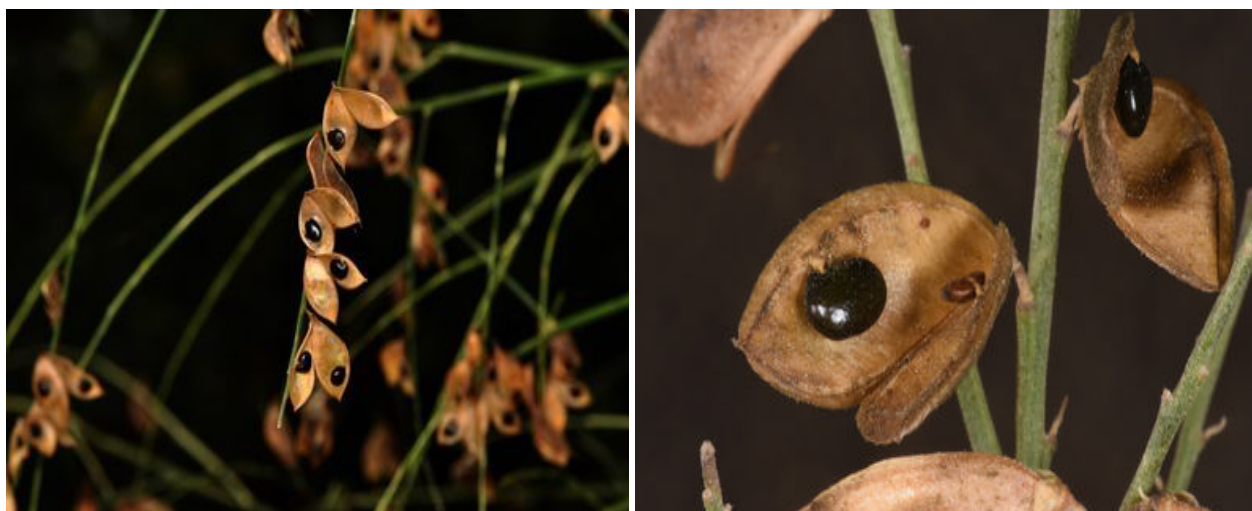


Fig. 1. *Gonocytisus pterocladus* fruits (as displayed in POWO 2025).

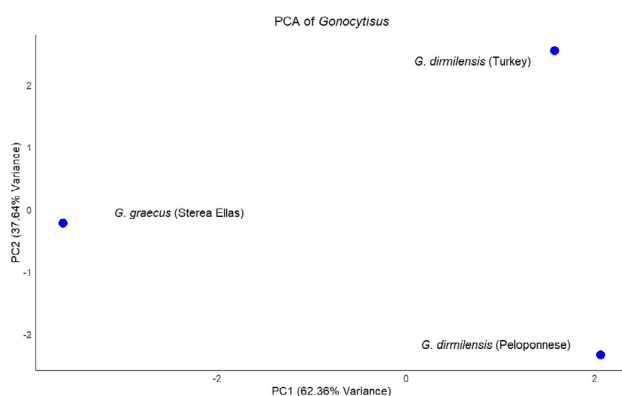


Fig. 2. Principal Component Analysis (PCA) diagram for *Gonocytisus*.

We decided to carry out a *Principal Component Analysis* (PCA) to see if there were any distinct morphological differences which could clearly separate the Greek populations from the Turkish ones.

Material and methods

The plant populations of *Gonocytisus dirmilensis* in the Peloponnese have never been seen by Şentürk & al. who only examined the plants from Sterea Ellas as their basis for the description of *G. graecus*. We visited the plant populations in the Peloponnese on several occasions and at different times of the year (June to October) between 2011 and 2023. Photographs and specimens were taken to document their occurrence. The same set of morphological characters in Table 1 of Şentürk & al. (2024) were selected for *G. graecus* (the Greek populations from Sterea Ellas), scored for *G. dirmilensis* (the Greek populations from the Peloponnese), and compared with the data of *G. dirmilensis* from SW Anatolia. The results were tabulated and the measurements obtained used to create a PCA diagram.

Results

Table of characters (Table 1)

The measurements for all characters of *G. dirmilensis* (Peloponnese) and *G. dirmilensis* (Turkey) show complete overlap, indicating the close similarity of the two populations.

The corolla in *G. graecus* (Stereia Ellas) is larger than that of *G. dirmilensis*, also most of the fruits, otherwise there is also complete overlap in measurements of characters. The seeds in *G. graecus* (Stereia Ellas) were described as orbicular-reniform, green and smooth, differing from the oblong-reniform, blackish-brown, finely reticulate seeds of *G. dirmilensis*.

PCA diagram (Fig. 2)

The PCA plot obtained based on the measured characters provides a visual overview of the morphometric differences between *G. graecus*, *G. dirmilensis* (Peloponnese) and *G. dirmilensis* (Turkey).

Axes and variance

PC1 (62.36% variance): the first principal component accounts for 62.36% of the variance of the dataset. It represents the main axis of variation between species and is determined by the most 'important' or 'influential' morphometric traits.

PC2 (37.64% variance): the second principal component is responsible for 37.64% of the variance. It represents the secondary axis of variation and captures the differences that are not explained by PC1.

Together (PC1 and PC2) they explain 100% of the variance in the data set, which means that the plot accurately represents the differences between the species.

Morphological separation of species and its taxonomic significance

In Fig. 2, *G. graecus* is clearly positioned to the left indicating morphometric features that separate it from the *G. dirmilensis* groups (Peloponnese and Turkey) along the PC1 axis. The features responsible for this separation include those with high loadings on PC1 such as the size of corolla and fruits.

Gonocytisus dirmilensis (Peloponnese) and *G. dirmilensis* (Turkey) are near each other along the PC1 axis, but are separated along the PC2 axis. This indicates that the two populations have very close morphological similarity, sharing similar traits along the primary axis (PC1) but differ in traits that influence PC2. Population-level variability could be explained by adaptation to local environmental conditions or genetic differences due to geographical separation.

Discussion

Principal component analysis (PCA) optimally describes variance in a single dataset. The results of our PCA plot reveal that the morphological variation between *G. graecus* and *G. dirmilensis* is limited and largely confined to a single axis (PC1), which accounts for >60% of the observed variance (Fig. 2). The largest variances are caused by flower and fruit size. Characters such as leaflet size, flower number, pedicel length, calyx and seed size exhibit substantial overlap. The relatively low level of meaningful variability along the second axis PC2 (37.64% variance) indicates the absence of any significant multidimensional differentiation between the two taxa. Tomović & al. (2007) noted that ripe capsules are always largest in specimens of

Table 1. Morphological characters of *Gonocytisus graecus* and *G. dirmilensis*.

Characters	<i>Gonocytisus graecus</i> (Stereia Ellas)	<i>Gonocytisus dirmilensis</i> (Peloponnese)	<i>Gonocytisus dirmilensis</i> (Turkey)
Habit	ascending virgate, 1-2 m	ascending virgate, 1-3 m	ascending virgate, 1-1.5 m
Stems (annual)	sparsely to densely strigillose	sparsely to densely strigillose	sparsely to densely strigillose
Leaves	trifoliolate, late caducous	trifoliolate, late caducous	trifoliolate, late caducous
Terminal leaflets	1.9-4.5 × 0.75-4.8 mm	10-45 × 0.5-5 mm	2.3-50 × 0.5-6.9 mm
Lateral leaflets	1.2-4.1 × 0.4-4 mm	2.9-30 × 1.6-4 mm	1.5-4.6 × 0.4-6.7 mm
Inflorescence	leafless raceme	leafless raceme	leafless raceme
Number of flowers	14-35	8-45	(7-)15-35 (-50)
Pedicel length	0.1-1.3 mm	1-2.5 mm	0.8-1.0 mm
Pedicel indumentum	sparsely patent-strigillose	strigillose	strigillose
Calyx	3.5-3.9 × 2.0-2.3 mm	3-5 × 1.7-2.4 mm	3.2-4.5 × 2.15-2.25 mm
Calyx tube/calyx length	1/3	1/4-2/3	1/4-2/3
Corolla colour	golden yellow	golden yellow	golden yellow
Standard	11.0-11.5 × 7-8 mm	7.1-10 × 6-7 mm	9.5-10.2 × 5.5-7.0 mm
Claw length	2.3-2.5 mm	2.3-2.5 mm	2.2-2.5 mm
Wing petals	10.2-10.5 × 3.1-3.5 mm	6.3-7.5 × 2-2.5 mm	7.5-9.9 × 1.5-2.25 mm
Claw length	3.6-3.7 mm	2.5-3 mm	2.5-2.8 mm
Keel petal	11.5-12 × 3.2-3.4 mm	8.5-10.5 × 2.6-3.5 mm	9.9-11.3 × 2.6-3.1 mm
Claw length	3.5-3.8 mm	3.5-3.7 mm	3.75 mm
Standard to keel length	standard shorter than keel	standard shorter than keel	standard shorter than keel
Stamens	monadelphous	monadelphous	monadelphous
Basifixed anther length	0.7-0.9 mm	0.83-1.0 mm	0.7-1.4 mm
Dorsifixed anther length	0.4-0.5 mm	0.5-0.66 mm	0.4-0.7 mm
Filament tube length	5.5-6 mm	5.0-6.1 mm	6.5-7 mm
Style length	7-8 mm	8-12 mm	10-12 mm
Legume length	indehiscent, 13-23 mm	indehiscent, 11-14 mm	indehiscent, 8.6-15.8 mm
Surface	sparsely to densely strigillose	sparsely to densely strigillose	sparsely strigillose
Ovule number	4-5	1-5	3-4
Number of seeds in legume	1(-2)	1-3 (-4)	1-2 (-3)
Seed	3.3-4.1 × 3-3.75 mm	4.5-5.5 × 3.0-3.5 mm	2.7-5.34 × 2.5-3.4 mm
Seed shape	orbicular-reniform (unripe)	oblong-reniform	oblong-reniform
Seed colour	green (unripe)	blackish-brown	blackish-brown
Seed surface	smooth, becoming finely reticulate	smooth, becoming finely reticulate	smooth, becoming finely reticulate

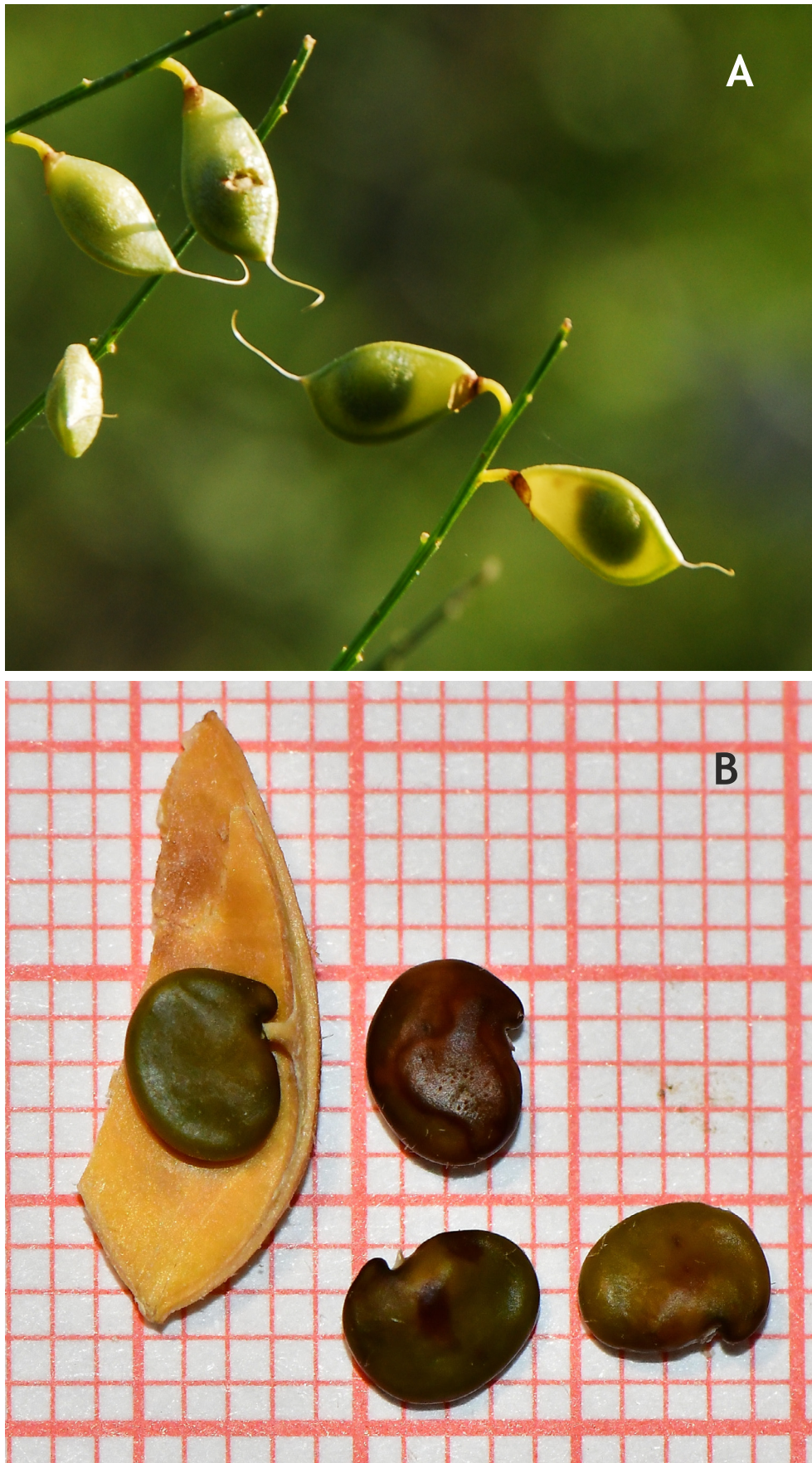


Fig. 3. A, *Gonocytisus dirmilensis* fruits with green, orbicular-reniform unripe seeds; **B**, *Gonocytisus dirmilensis* blackish-brown, oblong-reniform mature seeds.

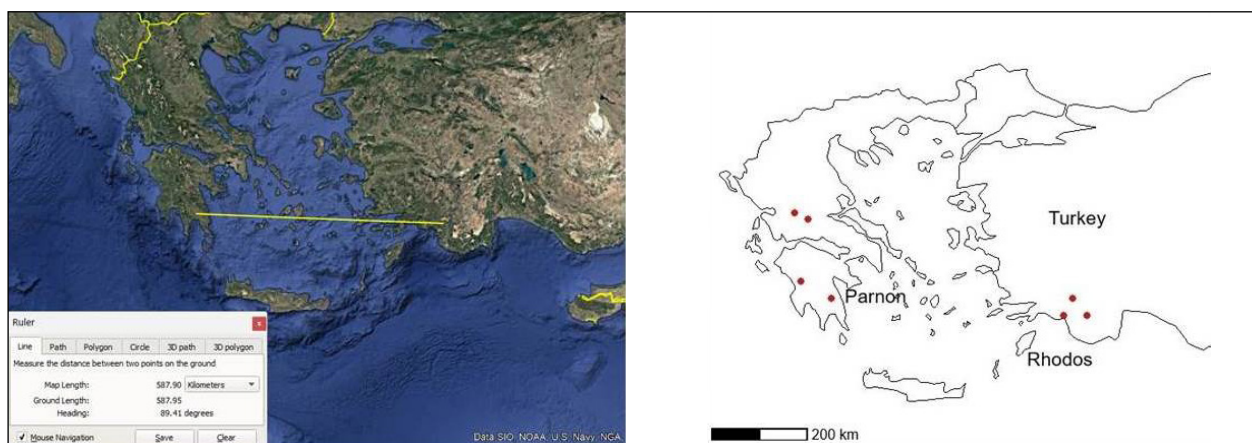


Fig. 4. Distribution of *Gonocytisus dirmilensis* in Greece and Turkey.

northern populations of *Fritillaria montana* W.D.J. Koch in Serbia, while individuals from the southern populations have capsules only half as long. The differences result from ecological conditions (substrate, moisture, temperature) and genetic differences. Thus flower and fruit size may not be good characters for delimiting species.

The only taxonomic character of note separating *G. graecus* from *G. dirmilensis* is the seed. In the description of *G. graecus* (Şentürk & al. 2024: 282) it is stated that the legume is indehiscent and the seeds orbicular-reniform, green with a smooth surface. However, the Greek plants we examined have seeds which are orbicular-reniform, green with a smooth surface when immature, even up to late August (Fig. 3A), but become oblong-reniform, blackish-brown with a finely reticulate surface when fully developed in late September and October (Fig. 3B), just as in the Turkish plants. Thus this feature also cannot be used as a distinguishing character of the two taxa since the fruits of *G. graecus* examined by Şentürk & al. are not fully mature.

As regarding pollen shape whether prolate or subprolate, this character has little diagnostic value due to the limited sampling. The pollen measurements of $20 \times 12 \mu\text{m}$ for *G. graecus* without maximal or minimal ranges are perhaps taken from a single flowering plant.

The accuracy of the data presented in Şentürk & al. (2024) is not in doubt as the same results were obtained by Tan & al. (2006) based on a single specimen, the holotype of *G. graecus*. It is the interpretation of the data that is disputed. The description of *G. graecus* was based on a very small sample size, viz., two herbarium collections from Sterea Ellas with unripe fruits (*Strid* 33809, *Strid* & *Hartvig* 59506) and probably one or two living plants from near the locality of *Strid* 33809 (Şentürk & *Yildirim* EGE 44068), also with unripe fruits. No material from the Peloponnese has been examined which would reveal that the Peloponnese plants have very close similarities to the Turkish plants. Even within this small sample size of *G. graecus* it is interesting that variation in quantitative measurements of morphological characters was found. This aligns with our opinion that *G. graecus* and *G. dirmilen-*

sis do not represent distinct species but shows variation between individual specimens rather than between geographical populations. We thus relegate *G. graecus* to synonymy of *G. dirmilensis*.

With a disjunction of ca. 580 km as the crow flies from S Peloponnese to the type locality of *G. dirmilensis* in SW Anatolia (Fig. 4), some morphological variation in the Greek plants is naturally expected, and is found, e.g., in the larger flowers of the plants from Sterea Ellas which populations are at the northernmost margin of the distribution range. However, variation from Turkish plants was not marked in plants from S Peloponnese, they are very similar. Mt Parnon in S Peloponnese is ca. 150 km from the type locality of *G. graecus* in Sterea Ellas and ca. 580 km from the type locality of *G. dirmilensis* in SW Anatolia. Reconstruction of Aegean-W Anatolian tectonics shows that at one point the distance between SW Peloponnese and the island of Rhodos (near SW Anatolia) was a mere 100 km 25 Ma (million years) ago in the middle Miocene before the ancient landmass continuous from Turkey to Greece fragmented (van Hinsbergen & Schmid 2012). This distance is less than the distance of ca. 150 km separating the southern and northern Greek populations.

A description of the species in Greece, its ecology and distribution, together with maps of distribution in Greece and total distribution are provided.

Description of species (Figs. 5 & 6)

Gonocytisus dirmilensis Hub.-Mor. in *Bauhinia* 2: 297 (1965). – Type: [Turkey C2 Burdur] distr. Tefenni, *Pinus pallasiana* -Wald, 8 km nördlich Dirmil, 1050-1100 m, 30 June 1948, *Huber-Morath* 9411 (holo. herb. *Huber-Morath*, now transferred to BAS).

= *Gonocytisus graecus* Şentürk & *Yildirim* in *Phytotaxa* 666 (4): 278 (2024). – Nomos & Eparchia Evritanias: 2 km from Mikro Chorio to Prousos, 600 m, 30 July 1992, *Strid* 33809 (holo. UPA; iso. G, herb. *Strid*).

Erect-ascending, much-branched, non-spiny shrub 1-3 m tall. Young stems and older branches slender, virgate, 1-4 mm in diam., angular-striate becoming \pm terete, green, adpressed-strigillose or glabrescent. Stipules ab-

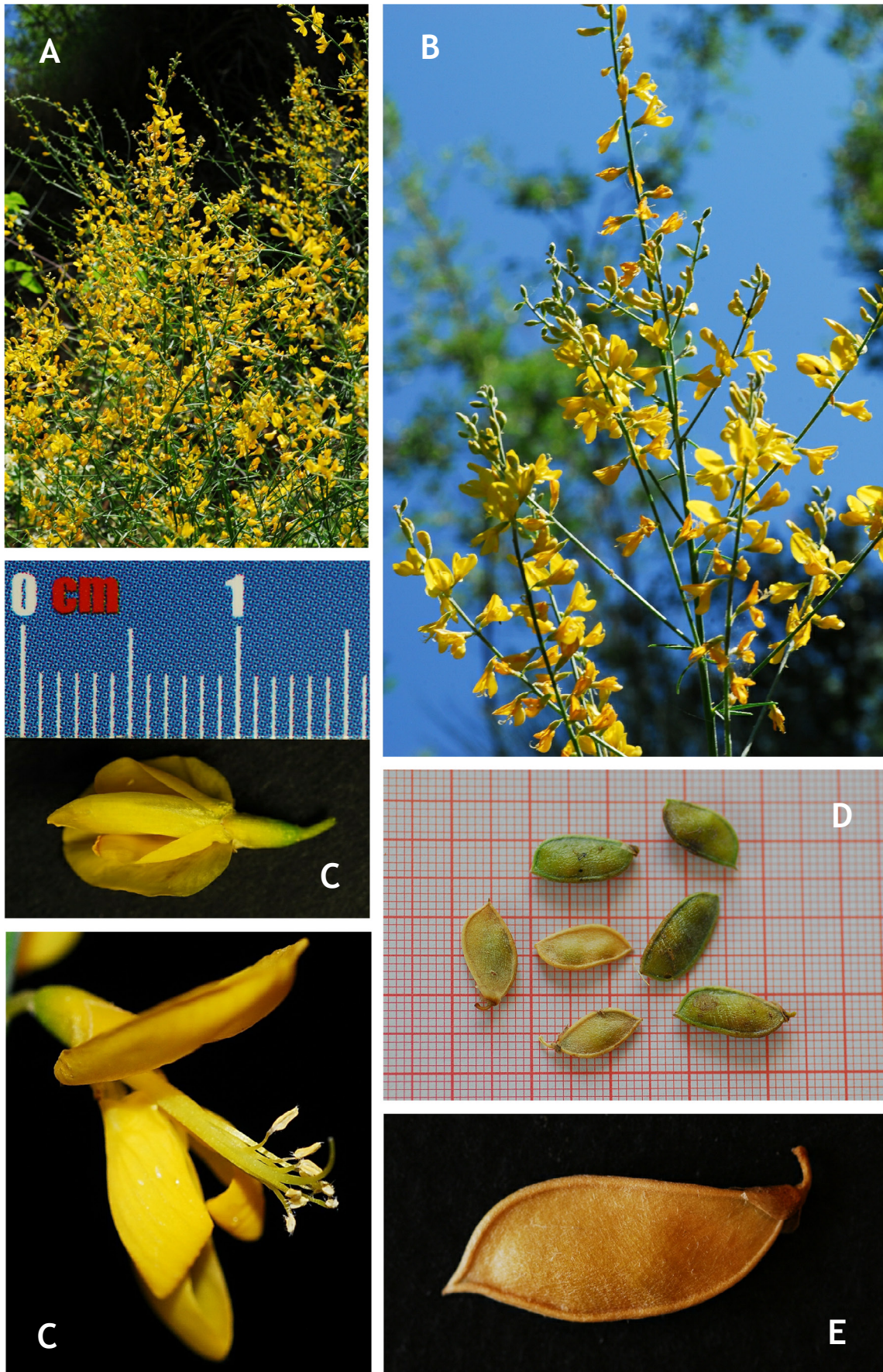


Fig. 5. *Gonocytisus dirmilensis* in Greece: **A**, flowering shrub; **B**, flowering stems; **C**, flowers (each division = 0.83 mm); **D**, immature fruits; **E**, legume showing thickened dorsal and ventral sutures.

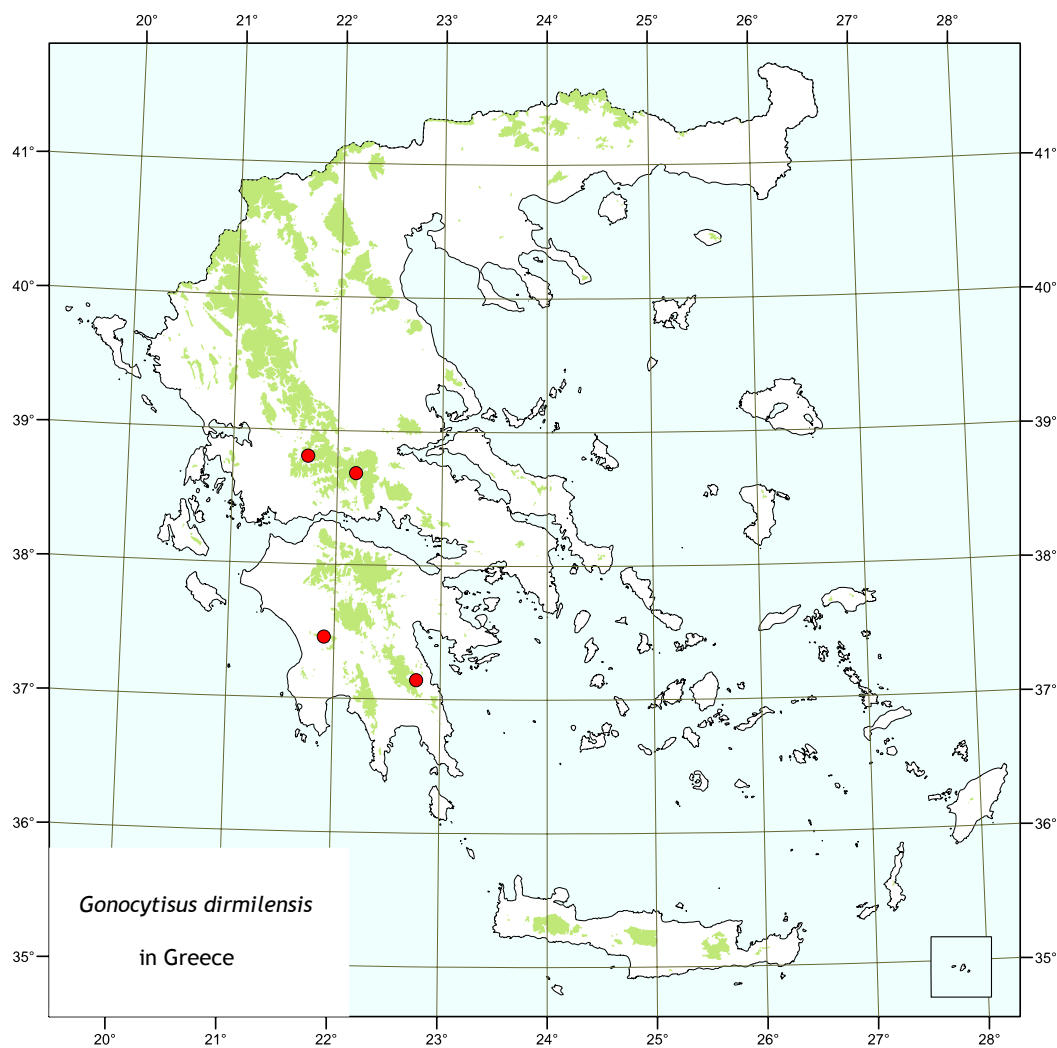


Fig. 6. Distribution of *Gonocytisus dirmilensis* in Greece.

sent. Leaves 3-foliolate, upper ones unifoliolate, subsessile. Leaflets with 1.0–1.5 mm petiolules, elliptic-linear to linear-oblong, 10–45 × 0.5–5.0 mm (leaflets at base of plant up to 60 mm long), acute, green, sparsely adpressed-hairy on both surfaces or glabrous above. Flowers in lax, erect, terminal racemes 4–30 cm long and 8–45-flowered. Bracts early caducous; bracteoles 2, at base of calyx, small, linear, caducous. Pedicels 1.0–2.5 mm, puberulous. Calyx campanulate, 3–5 mm, puberulous, persistent; upper lip split adaxially with two diverging, broadly triangular, ca. 1 mm teeth; lower lip shortly 3-toothed, ciliolate. Corolla 8.5–13.0 mm, caducous. Standard golden to orange-yellow, reflexed in vivo, orbicular-ovate, emarginate; lamina 7–10 mm at anthesis, shorter than keel, glabrous; claw 2.0–2.5 mm. Wings orange-yellow, lamina 6.3–10.0 mm. Keel obtusely beaked, lemon-yellow, ventrally sericeous-pubescent one-third to halfway from claw. Stamens monadelphous; basifixed anthers linear-oblong, 0.7–1.0 mm, longer than dorsifixed ones, extrorse, apiculate, white-barbate at base and apex; filament tube 5–6 mm, weakly pilose. Ovary ovoid-oblong, 1–5-ovulate, white-strigillose; style 8–12 mm, glabrous except in lower third, becoming

deflexed; stigma terminal, subcapitate. Legume ovoid becoming reddish-brown and rhomboidal-oblong or rhomboidal-elliptic at maturity, unwinged, 11–23 × 5–9 mm, sparsely or densely white-strigillose, thickened and indurated at both dorsal and ventral sutures, indehiscent, apiculate with remains of style. Seeds 1–3 (–4), orbicular-reniform becoming oblong-reniform at maturity, 3.5–5.5 × 3.0–3.75 mm, dull olive-green, smooth, becoming blackish-brown and finely reticulate.

Habitat and ecology

In openings of vegetation along road, roadsides in *Abies* woodland, gravelly slopes, damp places by river, 600–950 m. Flowering June to August (rarely to mid-September); fruiting till late October.

The fruits are unwinged, with thickened and indurated dorsal and ventral sutures and remain indehiscent on the leafless stems for a long time, even up to late October and November. Although unwinged, their rhomboidal shape allows transfer by strong wind once detached from the stem. There were no fruits or seeds lying below or near the plants in early January. Dispersal and spread is mainly

by wind and rain wash which is why young plants are often found at the side of asphalt roads where the runoff is particularly heavy in autumn. There was at least 3.4 km distance along the road from the first populations noted in 2011 to more recent ones in the same area.

Distribution in Greece

This species, once considered endemic to SW Anatolia, was first collected in Greece in 1992, and known from only one locality and a single gathering in Sterea Ellas, south-central Greece (Nomos & Eparchia Evritanias, *Strid* 33809). The plant was growing in openings of maquis-like vegetation 50–100 m from the river and in full flower. The habitat was not a particularly unusual or noteworthy one. It was with some surprise that it

was found growing in the Peloponnese nearly 20 years later (Nomos Ilias, Eparchia Olimbias, *Kit Tan, G. Vold & Giannopoulos* 31063, 31113, 32233; also from Nomos Arkadias, Eparchia Kinourias, *Kit Tan, G. Vold & Giannopoulos* 33033; first observed by G. Zarkos in 2018). Unless flowering, the shrub with its slender virgate branches is not particularly conspicuous and is easily overlooked. However, when flowering, it is also “camouflaged” to some extent by *Spartium junceum* and other yellow-flowered shrubs in the vicinity. Plants were more recently found in Sterea Ellas (Nomos Fokidos, Eparchia Parnassidos, *Strid & Hartvig* 59506), ca. 40 km away from the first discovery, and the species is probably more widespread in south central Greece and the Peloponnese than as reported.

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