

An update on the non-native flora of Crete (Greece)

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Abstract. Based on fieldwork in May and June 2024, a number of alien taxa are reported as new to Crete (or even to Greece in general): *Bidens subalternans*, *Commelina erecta*, *Datura wrightii*, *Dimorphotheca ecklonis*, *Euphorbia cyathophora*, *Leucaena leucocephala*, *Oenothera rosea*, *Paraserianthes lophantha*, *Senecio angulatus* and *Washingtonia robusta*. For a number of other alien taxa that have only recently been known from Crete (*Cenchrus longisetus*, *Euphorbia hypericifolia* and *Vachellia farnesiana*), new locations are presented and/or their degree of naturalization is updated. Taking into account previous experiences in climatically similar regions, almost all of these species have the potential to become invasive in Crete in the near future.

Key words: alien plants, Crete, fieldwork, Greece, invasive, naturalization

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Introduction

The flora and vegetation of Greece in general and of Crete in particular have been studied very well and for a very long time, especially with regard to the rich native and endemic flora. The recently published *Flora Cretica* (Muer & al. 2024) presents current knowledge of the island's flora, native, as well as introduced. However, as for the alien species of Greece, knowledge is more limited and focuses mainly on naturalized and invasive species (e.g. Arianoutsou & al. 2010, 2023).

Despite the fact that the Cretan flora has been well studied in the past, interesting plant discoveries can still be made, even in well-researched areas. Especially in regions with high anthropogenic pres-

sure (densely populated, subject to intense economic activities or tourism), the flora is permanently changing: new alien species are constantly being introduced, whether intentionally or not. It is also interesting to monitor the behavior of species that are already present: their status (ephemeral => naturalizing => naturalized => invasive) can change quickly. Ornamental plants that have been deliberately introduced in the past may begin to escape from cultivation, which could be the first step toward an incipient future invasion. Also, increased knowledge regarding some difficult species groups (including the application of genetic research) may shed new light on the identity of some taxa.

It is with this approach that fieldwork was carried out in the early summer of 2024 in Crete,

mainly in the central northern part of the island. This article discusses the observations that resulted from this.

Material and methods

All data presented in this article are the result of a fieldwork session by the author between 24 May and 7 June 2024. In the course of those efforts, numerous localities have been explored in the central northern part of Crete, i.e. in the area between Heraklion and Agios Nikolaos, especially along the coast and in the lowland areas. The main focus was on riparian and anthropogenic, often urban habitats (such as roadsides, parks, etc.), agricultural fields, etc.

Voucher specimens were collected for most taxa and these were deposited in the herbarium of Meise Botanic Garden, Belgium (BR). Specimens deposited in BR will be made available online in due course at <https://www.botanicalcollections.be/#/en/home>. Furthermore, photos were taken. All records (including the photographs) were registered on the online platform <https://observation.org/> and the data were subsequently also included in GBIF (Global Biodiversity Information Facility – <https://www.gbif.org/>).

The presence or absence of the species recorded in Crete was verified in various recent online databases and literature references: Arianoutsou & al. (2010), Dimopoulos & al. (2013, 2016), Arianoutsou & al. (2023), the Euro+Med Plantbase (2024), the Flora of Greece Web (2024), and Muer & al. (2024).

In order to verify a possible earlier presence of a species at the recently discovered locations, images from Google Streetview were checked (if possible, from multiple recording moments). In this regard, it should be noted that not all locations were covered by Google and/or that some images were not clear enough to identify the species on them.

The nomenclature in this paper usually follows Plants of the World Online (POWO 2024), except for the genus *Washingtonia* H. Wendl. All plant photos are taken by the author (F. Verloove).

Results

Bidens subalternans DC., Prodr. 5: 600 (1836) (Asteraceae)

New to Crete and Greece.

Herbarium: Greece, Crete: Chersonisos, old village, close to drive-out of A90 motorway, in roadside ditch, a single individual, 29.05.2024, F. Verloove 15038 (BR).

Observation:

<https://observation.org/observation/312073701/>.

This South American weed is naturalized in several West Mediterranean countries. In Southeast Europe, it is less frequent and probably only known from Cyprus (Hand 2010), North Macedonia (Vladimirov & al. 2019) and Serbia (Bogosavljević & Zlatković 2015). A single vegetative plant has been seen in Crete. Unless the species is more widespread elsewhere on the island, it is probably a casual alien, although it is often considered invasive in its secondary range.

From Greece (East Aegean Islands), a similar Asian species is known, *B. bipinnata* L. (Flora of Greece Web 2024). Compared to that species, the leaf segments in *B. subalternans* are narrower and more pointed and ligules are usually absent.

Cenchrus longisetus M.C. Johnst., Sida 1: 182 (1963) (Poaceae)

Confirmed for Crete.

Observations:

<https://observation.org/observation/313026450/>;
<https://observation.org/observation/313331734/>.

This species from Northeast Africa and Arabia is widely cultivated as an ornamental and readily escapes wherever introduced, to the extent that it is often considered invasive (numerous online references).

In Greece, it is known from the Ionian Islands, Northeast Greece, the Peloponnisos and Sterea Ellas (Flora of Greece Web 2024). *Cenchrus longisetus* has been only recently reported for the first time from Crete, under the illegitimate name *C. villosus* (Fresen.) Kuntze (Muer & al. 2024); it was reportedly known from a single location.



Fig. 1. *Commelina erecta* on Milatos Beach, 31.05.2024.

During recent fieldwork, two small populations have been discovered between Heraklion and Hersonissos. Considering the behavior of the species elsewhere in the Mediterranean, this is a precursor to a wider naturalization on the island.

Commelina erecta L., Sp. Pl.: 41 (1753) (*Comelinaceae*) (Fig. 1)

New to Crete and Greece.

Herbarium: Greece, Crete: Agios Nikolaos, Thémistokleous, on rocks, near restaurant, 28.05.2024, F. Verloove 15027 (BR); Milatos Beach, main street, on pavement, plantation weed, etc., many dozens, 31.05.2024, F. Verloove 15037 (BR).

Observations:

<https://observation.org/observation/311973314/>;
<https://observation.org/observation/312364254/>;
<https://observation.org/observation/312500955/>;
<https://observation.org/observation/312500919/>.

Commelina erecta is a pantropical weed that seems to be expanding recently in the Mediterranean region. It has been reported first from Spain (e.g. Gómez-Bellver & al. 2019; Verloove & Aymerich 2020), and subsequently also from Italy (Rosati & al. 2020), Malta (Mifsud 2022a) and Egypt (Heneidy & al. 2024). Here, it is reported from various locations in Crete (Agios Nikolaos, Hersonissos and Milatos). It

looks established at least in the two latter localities.

From Greece, only *C. communis* L. has been so far known (Flora of Greece Web 2024). Both species look somewhat similar, mainly because they both have flowers with a small, white lower petal. *C. erecta* is readily distinguished by spathes with margins that are connate basally (vs free to base). Furthermore, it is a perennial (vs annual) and its capsules are 2-seeded, with one seed per locule (vs 4-seeded, with two seeds per locule).

Datura wrightii Regel, Gartenflora 8: t. 260 (1859) (*Solanaceae*)

New to Crete.

Herbarium: Greece, Crete: Gournes Gouvon, Nik. Kazantzaki, on rough ground in front of houses, ca. 10 individuals, 05.06.2024, F. Verloove 15047 (BR).

Observations:

<https://observation.org/observation/311820910/>;
<https://observation.org/observation/313183300/>.

This species is native from the Southwest and South Central U.S.A. to North Mexico. Like the similar-looking *D. innoxia* Mill., it is grown as an ornamental and easily escapes from cultivation, wherever introduced. In South Europe, both species have been confused with each other for a long time (see Verloove 2008, where distinguishing features are discussed and illustrated).

Datura wrightii was first reported from Greece (Limnos) by Bergmeier (2021) and subsequently was also recorded from Peloponnese, Ionian Islands (Kerkira, Paxi, Kefallinia), Kiklades (Milos), North Central and North Aegean Islands (comm. Kit Tan). Records of *D. innoxia* from Greece and the Aegean should be critically re-examined. During recent fieldwork in Crete, both species were observed, particularly *D. innoxia* (e.g. in various locations in Hersonissos, Elounda and Stalída). *D. wrightii* was recorded twice, in Hersonissos and in Gournes. Based on recent observations alone, the degree of naturalization of the species can hardly be assessed with certainty. However, it seems that, similarly to *D. innoxia*, it is naturalized in Crete, at least locally.



Fig. 2. *Dimorphotheca ecklonis* in Hersonissos, 26.05.2024.

Dimorphotheca ecklonis DC., Prodr. 6: 71 (1838) (*Asteraceae*) (Fig. 2)

Syn.: *Osteospermum ecklonis* (DC.) Norl.

New to Crete and Greece.

Herbarium: Chersonisos, Irinis, in dried-out riverlet, small population, near the beach, 26.05.2024, F. Verloove 15028 (BR).

Observations:

<https://observation.org/observation/311820833/>;
<https://observation.org/observation/312217620/>.

This perennial herb is endemic to the Cape in South Africa. It is widely grown as an ornamental for its showy flowers (African Daisy) and rather easily escapes from cultivation. It is naturalized in regions with a Mediterranean climate, such as California or parts of Australia, and is occasionally considered an

environmental weed, for instance on the Australian Far South Coast (*Weeds of Australia* 2024).

A related species is known from Greece, *D. barberae* Harv. (Flora of Greece Web 2024), although it is only known there as a cultivated species.

The genus is taxonomically complex and several species are grown as ornamentals. The plants recently found in Crete are characterized as follows: fruits are all identical, rays white above, bluish below and disc flowers are blue. These features point at *D. ecklonis* (Norlindh 1943).

Euphorbia cyathophora Murray, Commentat. Soc. Regiae Sci. Gott. 7: 81 (1786) (*Euphorbiaceae*) (Fig. 3)

New to Crete and Greece.

Herbarium: Greece, Crete: Agios Nikolaos, near Minos Beach Hotel, at foot of a wall, escaped from



Fig. 3. *Euphorbia cyathophora* on Milatos Beach, 31.05.2024.

gardens, ca. 10 individuals, 28.05.2024, F. Verloove 15049 (BR).

Observations:

<https://observation.org/observation/311973305/>;

<https://observation.org/observation/312364235/>.

The native range of this species stretches from Central U.S.A. to North Argentina. It is valued as an ornamental plant for its bright red spotted upper leaves. In this respect, the species superficially resembles *Euphorbia pulcherrima* Willd. ex Klotzsch, which however is a shrub, not an annual herb. More than an ornamental, *E. cyathophora* is considered an annoying weed.

In the Mediterranean area, the species is documented from Israel (Euro+Med Plantbase 2024) and Tunisia (El Mokni 2023) and for a long time it has also been known from the Canary Islands (Biota Canarias 2024).

In Crete, *E. cyathophora* was recorded in two localities in 2024, both in the wide Agios Nikolaos area. Interestingly, there were several observations of this species from Crete registered in iNaturalist. It is difficult to judge whether they are cultivated or wild plants. Therefore, it remains to be seen whether the species has become established in Crete.

Euphorbia hypericifolia L., Sp. Pl.: 454 (1753) (*Euphorbiaceae*)

Confirmed for Crete.

Herbarium: Greece, Crete: Stalida, E090 road, at roadside, near gardens, locally, 26.05.2024, F. Verloove 15030 (BR); Chersonisos, Agiou Vasiliou, on rough ground, three individuals, 01.06.2024, F. Verloove 15039 (BR); Chersonisos, Petinaki, urban weed (on pavement), 01.06.2024, F. Verloove 15040 (BR);



Fig. 4. *Leucaena leucocephala* in Malia, 01.06.2024.

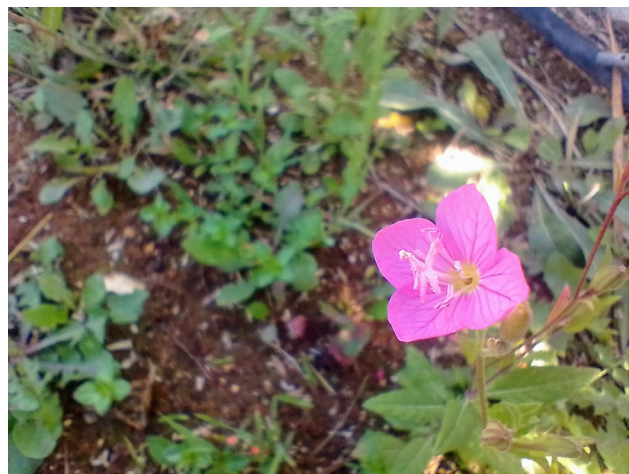


Fig. 5. *Oenothera rosea* in Hersonissos, 02.06.2024.

Gouves, Athanasiou Diakou, roadside weed, several dozens, 05.06.2024, F. Verloove 15048 (BR); Agios Nikolaos, Akti Koundourou, plantation weed, scattered, 28.05.2024, F. Verloove 15050 (BR).

Observations:

<https://observation.org/observation/311820820/>;
<https://observation.org/observation/311973326/>;
<https://observation.org/observation/311973312/>;
<https://observation.org/observation/312500939/>;
<https://observation.org/observation/312500912/>;
<https://observation.org/observation/312674979/>;
<https://observation.org/observation/313183312/>;
<https://observation.org/observation/313183282/>;
<https://observation.org/observation/313331795/>;
<https://observation.org/observation/313331704/>.

This American weed has been recently greatly expanding in the Mediterranean area. In Greece, it is known from the East Aegean Islands, the Kikladhes and Crete, and Karpathos (Flora of Greece Web 2024). It has been first reported from Crete by Gregor & Meierott (2013) and is currently known from a few locations in the eastern part of the island (Muer & al. 2024).

Based on recent field research, the species appears to be more widespread and clearly established in several places, in particular in the area between Heraklion and Agios Nikolaos. According to recent data from iNaturalist, *E. hypericifolia* also occurs around Chania and Plakias and is also known from the Imbros and Kartero gorges (comm. Kit Tan).

Leucaena leucocephala (Lam.) de Wit, Taxon 10: 54 (1961) (*Fabaceae*) (Fig. 4)

New to Crete and Greece.

Observations:

<https://observation.org/observation/311820926/>;
<https://observation.org/observation/311820728/>;
<https://observation.org/observation/311973330/>;
<https://observation.org/observation/311973307/>;
<https://observation.org/observation/312501138/>;
<https://observation.org/observation/312674971/>;
<https://observation.org/observation/312674968/>.

This shrub is native from Mexico to Central America, but is widely grown as an ornamental in the subtropics. The species produces abundant fruits and grows prolifically from seeds. Therefore, it is an increasing weed problem (e.g. Sharma & al. 2022; Marifatul & al. 2024), in the Mediterranean too (Dana & al. 2003; Badalamenti & al. 2020; Mifsud 2022b).

Although *L. leucocephala* is widely grown as an ornamental in Crete, its escape from cultivation apparently has not yet been documented. The species actually reproduces from seed almost everywhere it is planted. Young, spontaneous individuals grow in the vicinity of plantations, usually in urban environments, on fallow land, at roadsides, etc. It is only a matter of time before the species will spread, e.g. via dried-out riverbeds, a preferred habitat for the species. Its large-scale and short-term naturalization on the island is almost inevitable. The species is po-



Fig. 6. *Paraserianthes lophantha* in Hersonissos, 29.05.2024.

tentially very invasive, as was experienced on other Mediterranean islands, such as Malta (Mifsud 2022b) or Sicily (Badalamenti & al. 2020).

During the author's fieldwork, escaped plants (or even populations) were observed in various localities between Gouves and Agios Nikolaos. In iNaturalist, the species is listed for a several dozen locations but most clearly referred to plantations. However, at least in Zakros (2022), the easternmost part of Crete, the species also seems to have been found as an escape.

Oenothera rosea L'Hér. ex Aiton, Hort. Kew. 2: 3 (1789) (*Onagraceae*) (Fig. 5)

New to Crete and Greece.

Herbarium: Greece, Crete: Chersonisos, El. Venizelou, plantation weed, ca. a dozen individuals, 02.06.2024, F. Verloove 15045 (BR).

Observation:

<https://observation.org/observation/312675005/>.

This American species has become a rather frequent weed in Southwest Europe. In the eastern part of the Mediterranean, however, it appears to be only known from Israel (Euro+Med Plantbase 2024). The species is often considered invasive (e.g. Frean & al. 1997).

During recent fieldwork, a small population was found as a weed in an ornamental plantation in Hersonissos.

The species should not be confused with *O. speciosa* Nutt., also with pink flowers and often planted on Crete. The latter is a procumbent plant that has much larger (and often paler pink) flowers and is, therefore, more suitable as an ornamental plant. *O. rosea* is an erect weed with small flowers.



Fig. 7. *Senecio angulatus* in Sisi, 01.06.2024.

Paraserianthes lophantha (Vent.) I.C. Nielsen, Bull. Mus. Natl. Hist. Nat., B, Adansonia 5: 326 (1983) (*Fabaceae*) (Fig. 6)

New to Crete and Greece.

Herbarium: Greece, Crete: Chersonisos, near drive-out of A90 motorway, in roadside ditch, three escaped individuals (not seen planted), 29.05.2024, F. Verloove 15035 (BR).

Observation:

<https://observation.org/observation/312073706/>.

Native distribution of this species ranges from Sumatera to the Lesser Sunda Islands and in South-west Australia. It is grown as an ornamental tree across the subtropics and reproduces prolifically from seed. It is often considered a very noxious invader, for instance in South Africa and Hawaii

(Le Roux & al. 2011). In the Mediterranean area, *P. lophantha* is an increasing weed on several islands, including Sardinia, Sicily (Ruggero & al. 2024) and Malta (Mifsud 2022c).

During recent fieldwork, three self-sown specimens were observed in a dried-out roadside ditch in Hersonissos. The species was not found planted in the immediate vicinity, so it was unclear how it has arrived at this location. The degree of naturalization in Crete remains also uncertain until more plants or populations are found.

Senecio angulatus L. f., Suppl. Pl.: 369 (1782) (*Asteraceae*) (Fig. 7)

New to Crete.

Observation:

<https://observation.org/observation/312501130/>.



Fig. 8. *Washingtonia robusta* in Malia, 29.05.2024.

This climbing shrub is native to the Cape Province in South Africa, but it is widely cultivated as an ornamental in the subtropics. The species grows very quickly and is soon considered a nuisance, after which it is dumped as garden waste. In no time, it starts spreading where it was once dumped and is soon considered invasive.

In Greece, *S. angulatus* has been so far known from Rhodos, Tilos and Symi (comm. K. Tan). It is reported here for the first time from Crete. A small population has been observed in Sisi, at the Palm Bay. The species closely resembles some other senecioid lianas from South Africa, in particular *S. tamoides* DC. Interestingly, from the westernmost part of Crete (Gazaro, Mousoures) naturalized populations of the latter species have been known since 2022 (comm. A. Strid). However, based on the photographs presented, these

plants also belong to *S. angulatus*: ligules are about 2-3 times as long as wide ($7,7-11 \times 2,6-4,3$ mm) whereas they are much longer and narrower in *S. tamoides* ($17-20 \times 2,3-3,5$ mm) (Calvo & Aedo 2019).

Vachellia farnesiana (L.) Wight & Arn., Prodr. Fl. Ind. Orient. 1: 272 (1834) (*Fabaceae*)
Syn.: *Acacia farnesiana* (L.) Willd.

Confirmed for Crete.

Herbarium: Greece, Crete: Milatos, at roadside, scattered escaped individuals, 31.05.2024, F. Verloove 15025 (BR).

Observations:

<https://observation.org/observation/312364259/>;
<https://observation.org/observation/313026459/>.

This American shrub is widely cultivated as an

ornamental in the warm-temperate regions across the world, including the Mediterranean. It easily escapes and establishes itself, in particular in dried-out riverbeds and creeks. In an increasing number of regions it is considered invasive, for instance in Australia, the Canary Islands or South Africa (e.g. Naranjo Cigala & al. 2009; Cheek & Boon 2019).

In the Mediterranean area, *V. farnesiana* is known from its western (Spain, France, Italy) and eastern (Israel/Palestine, Lebanon, Syria) parts (Euro+Med Plantbase 2024).

Although the species is also widely planted in Greece, until recently it has apparently not been observed in the wild, when it was reported as occasionally escaping in Crete by Muer & al. (2024). During recent fieldwork, the species was indeed observed in the wild in two locations. In Gouves, it was seen in a dried-out riverbed, the preferred habitat of this species.

The species was identified according to Clarke & al. (1989).

Washingtonia robusta H. Wendl., Gart.-Zeitung (Berlin) 2: 198 (1883) (*Arecaceae*) (Fig. 8)

New to Crete and Greece.

Observations:

<https://observation.org/observation/311820920/>;
<https://observation.org/observation/311820838/>;
<https://observation.org/observation/311820752/>;
<https://observation.org/observation/311973275/>;
<https://observation.org/observation/312073683/>;
<https://observation.org/observation/312364185/>;
<https://observation.org/observation/312501032/>;
<https://observation.org/observation/313026404/>;
<https://observation.org/observation/313026400/>.

This ornamental tree is native to Mexico and widely planted in warm-temperate and subtropical regions across the world. It propagates readily from seed, aided by berry-eating birds, and successfully invades disturbed areas and urban landscapes wherever it is introduced. It also colonizes more natural habitats, like dried-out streambeds and creeks, and is increasingly considered an unwanted invader, for instance, in Hawaii or Florida (Meyer & al. 2008).

According to Turland (2023), the species is known only as cultivated in Greece. However, during the recent fieldwork, *W. robusta* has been recorded regularly as an escape from cultivation. At least in Malia, the species also seems to be in the process of local naturalization in the coastal grasslands.

Muer & al. (2024) have reported the closely similar *W. filifera* (T. Moore & Mast.) H. Wendl. ex de Bary as naturalized in Crete. Unless that species is accepted in broader terms by those authors (as including *W. robusta*), the plants that are currently found in the wild seem to belong mostly (or exclusively) to *W. robusta*. Leaf stalks are sharply toothed throughout their length and the fan-shaped leaves are bright green, not greyish green.

Discussion

During a two-week fieldwork session on Crete, ten non-indigenous plant species were recorded that were not yet known in the wild on the island. For three more species, new chorological data were gathered that confirm their recent local incipient naturalization. The degree of naturalization of the newly reported alien species varied: some appeared to be well established, at least locally, while others may still be considered ephemeral. What they did have in common, however, was that they have shown invasive behavior elsewhere in the world, in regions with a climate similar to the Mediterranean. It could reasonably be assumed that eventually they would also become established on Crete and, in a worst-case scenario, would become invasive. More than half of these species were initially introduced deliberately, mainly as ornamental plants. Although the flora of Crete, especially compared to other Mediterranean islands, is still relatively intact and plant invasions are still limited, the present results give food for thought. A better screening of the species introduced through the ornamental horticultural trade seems advisable. During the author's fieldwork, it has been found that even *Cenchrus setaceus* (Forssk.) Morrone, a species of EU concern, is still planted and the invasion of the island by that species has recently started (Verloove, submitted).

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