



Action Plan for the long term conservation of *Bupleurum gaudianum* on the island of Gavdos

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MEDITERRANEAN ISLANDS COLLECTIVE PROJECT

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Introduction

The Action Plan for *Bupleurum gaudianum* was created in the framework of the project “Mediterranean Islands Collective: Collaborating to Protect Nature in Mediterranean islands”, Pilot action “Gavdos Island – Crete – Ultra-threatened plant recovery project” (2021-2022).

The project is implemented by the Mediterranean Plant Conservation Unit of CIHEAM Mediterranean Agronomic Institute of Chania (MPCU-MAICh) in cooperation with the IUCN/SSC/Mediterranean Plant Specialist Group and the Municipality of Gavdos.

The annual plant *B. gaudianum* is the only endemic plant of Gavdos island and is characterized as Vulnerable (VU) in the IUCN Red List of Threatened Species, mainly due to the small area where its subpopulations are limited. The plant was first described in 1985 and has since been recorded in various locations on the island. Since 2000, the MPCU-MAICh has contributed to the complementary *ex situ* conservation of the species.

This Action Plan aims to address any threats to the population of *B. gaudianum* by long term monitoring of the plant population and suggests a practical protocol for its population reinforcement in case it is needed in the future.

1. Description and Evaluation of the current situation

1.1 The island of Gavdos

The island of Gavdos is located 21 miles south of the southwest Cretan coast and forms the southernmost edge of Greece and Europe. The area of Gavdos is around 30 km² and the maximum altitude is 362 m.

Geologically the island consists of limestone of upper Cretaceous (Pindos zone). Also, there are metamorphosed rocks and extensive neogene deposits with marine fossils. In the east side, between the settlements Karave and Kastri, there are also late Pleistocene deposits (psammitic) with well conserved land snail fossils. Although Gavdos is not characterized by a high altitude, it has several valleys and seasonal streams.

The climate of Gavdos is typical Mediterranean. The average annual rainfall in Gavdos is only 311 mm, but it shows strong yearly variations since during the period 1992 to 2003, the measured values ranged from 130 mm (2001-2002) to about 550 mm (1995-1996). The wet season of the year is from November to March (87% of the annual rainfall) while during the 3 summer months there is no rain at all. December is the wettest month, followed by January and November. Prolonged rainlessness often exceeds 100 days.

The temperature in Gavdos is particularly high almost all year round and varies from 13 °C in the months of January and February to 28 °C in the months of July and August. The average monthly value falls slightly below 15 °C only 3 months a year (January, February and March), while for more than 5 months it is higher than 20 °C.

Concerning the flora of Gavdos, 490 plant taxa have been recorded until today, one of which (*Bupleurum gaudianum*) is endemic to the island. Furthermore, 8 plants are endemic to Crete & Gavdos (phytogeographic region of Cretan area), and 14 plants are endemic to Greece. About 70% of the plants of Gavdos are also present in Cyrenaica of Libya (Bergmeier et al. 1997). Last, 30 plants of Gavdos are protected by the Greek legislation (PD 67/81) and 10 plants are included in the Red Data Books of Rare and Threatened Plants of Greece (Phitos et al. 1995, Phitos et al. 2009).

The vegetation of Gavdos consists of maquis, forest (mainly pine forest of *Pinus brutia*) and phrygana, and there are extensive sand dunes with *Juniperus* spp. on the north side of the island. Also, there are many abandoned cultivated fields and terraces which have been converted to forest or phrygana.

The wealth of natural resources of Gavdos attracted people from as early as the Palaeolithic period. Today, the Municipality of Gavdos, which is the smallest Municipality in Greece, has 151 inhabitants and no more than 100 people live on Gavdos permanently throughout the year (Gavdopoula islet is uninhabited). In the summer months, the general population of the island, due to tourists, can reach 3,500, with most of them being campers. The inhabitants are mainly engaged in livestock farming, fishing and tourism.

1.2 *Bupleurum gaudianum* Snogerup

1.2.1 Description

Annual, 2-7 cm or sometimes taller, pseudodichotomously branched from near the base, with up to 15 umbels (Photo 1), last formed umbels often depauperate. First leaves long-petiolate with lanceolate lamina 2-4 x 1.0-1.5 mm, upper ones narrowly linear. Umbels with peduncle 20-10 mm, very unequal, bracts 3. Bractlets normally 4, 2-4 x 0.5-1.5 mm, lanceolate to ovate with a sharply pointed tip, 3-veined, herbaceous between the veins, scarious outside the lateral ones. Umbellules 2-5 flowered. Petals yellowish, often drying white, 0.5-0.6 x 0.4-0.6 mm, broadest above, inflexed lobe inconspicuous, only c. 0.2 x 0.1 mm, tapering to a sharp point, vein very thin, continuing to point of lobe. Anthers 0.2-0.3 mm, filaments 0.4-0.5 mm. Ripe fruit, c. 1 mm, dark brown, smooth with filiform ridges, without papillae (Photo 3).

According to Snogerup (1995) this species is of interest for further studies of the infrageneric taxonomy and differentiation of the genus *Bupleurum*. From its morphology it stands out as taxonomically isolated. The species was placed in the section *Aristata* and subsection *Aristata* (Snogerup and Snogerup 2001).

Distinguished from its close relatives by the unusual form of the inflexed petal lobe, and also by the combination of 4 bracteoles with their sharply distinguished herbaceous and scarious parts. In Gavdos, it can be confused with *Bupleurum semicompositum*, also present in Gavdos, from which it is distinguished by the fruits. The fruits of *B. semicompositum* are larger, lighter brown in colour, and with small whitish papillae. (Photos 2 & 3).

Furthermore, the original description of the species does not mention the color of the petals (Snogerup 1985) and neither does the description of the plant in the Red Data Book of Threatened Plants of Greece (Snogerup 1995). Later, in a publication by Snogerup and Snogerup (2001), it is mentioned that the color of the petals of *B. gaudianum* is purplish as that of the species *B. semicompositum*. Also, in the same publication it is noted that the

color of the petals is often drying white. Photographs taken during the flowering period do not confirm that the petal color is purplish; they are yellowish in contrast to *B. semicompositum* whose petal color is clearly purplish (Photo 4). We suggest that experts review this morphological feature of the species.



Photo 1. *Bupleurum gaudianum* plant in flowering



Photo 2. Dry specimens of *Bupleurum gaudianum* (left) and *B. semicompositum* (right) from the Herbarium of MAICH



Photo 3. Fruits of *Bupleurum gaudianum* (left) and *B. semicompositum* (right)



Photo 4. Plant of *Bupleurum gaudianum* (left) and *B. semicompositum* (right) in flowering
(Photos by Louis-Marie PREAU).

1.2.2 Biology & Ecology

Flowering period: April-May

Fruiting period: June-July

Habitat: *Bupleurum gaudianum* grows in low phrygana and open pinewoods on neogene sediments and sandstone, in openings between the dominating shrublets, among other short-lived, mostly early flowering annuals, altitude 0-300 m. The vegetation is, at least in most of its area, maintained by heavy grazing from domestic animals, mainly sheep and goats (Photo 5).



Photo 5. Habitat of *Bupleurum gaudianum*.

Seed germination and dormancy:

In the context of the study of the germination of the seeds of *Bupleurum gaudianum*, the effect of three constant temperatures (10, 15, 20 °C) was investigated. The species grows well at low temperatures while the final percentage of germination decreases at 20 °C. Final germination rates are high at the three temperatures tested, over 90%. Germination started on the 3rd day after the start of soaking and was completed in about 10 days. A slight delay in the onset of germination was observed at low temperatures (10 °C).

White light significantly affects the germination of *B. gaudianum* seeds and inhibits their germination at all temperatures tested (Figure 1). Very low rates of final germination are observed under the influence of white light compared to darkness as well as a lower rate of germination at all temperatures (Figure 1).

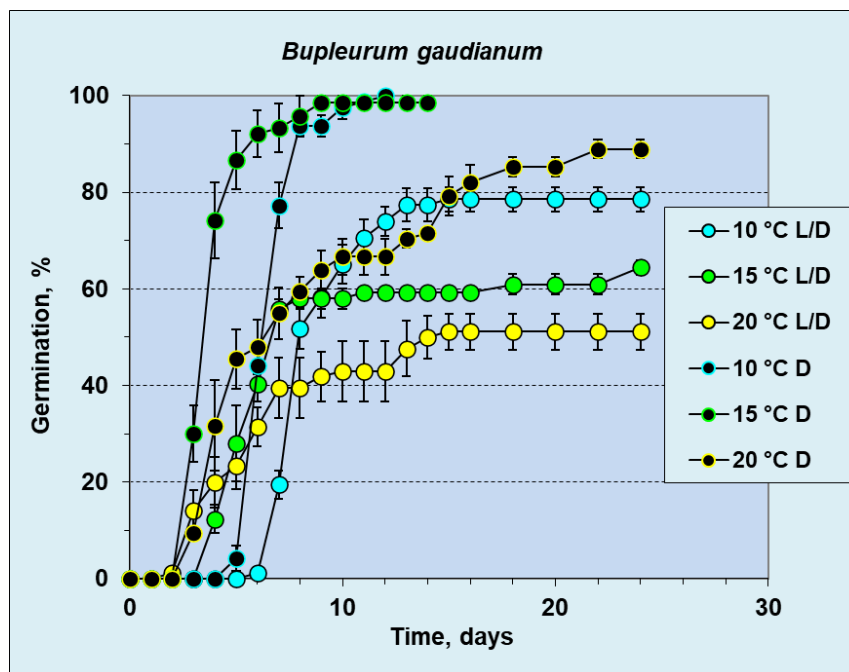


Figure 1. Time course of *Bupleurum gaudianum* seed germination at 10, 15 and 20 °C in light/dark (L/D) (12 h/12 h) and total darkness (D)

The seed dormancy of the species was studied by Fournaraki (2010). The seeds of the plant are characterized by physiological dormancy as they do not germinate immediately after collection and also by morphological dormancy as they have a small embryo compared to the endosperm. This means that the seeds of *B. gaudianum* are characterized by a combination of morphological and physiological dormancy (morphophysiological dormancy). Physiological dormancy is removed by storing the seeds in a dry environment (after-ripening), while the development of the embryo and therefore the removal of the morphological dormancy is observed in a short period of time after placing them in conditions suitable for germination.

1.2.3 Distribution

Bupleurum gaudianum is a steno-endemic plant. It is the unique endemic plant of Gavdos island. It is found at several localities: along the path from Vatsiana to Korfos and to Tripiti, Metochi Pateridon to Korfos, Ai Stratigos to Vatsiana, and generally in the south part of the island. (Map 1).

According to Bergmeier et al (1997) the plant is found in more areas in the northern part of the island as well as in the western part, but during this project it was not possible to confirm these locations.

A detailed record of the plant on the island is needed since it coexists in many places with *B. semicompositum* and in many cases it is difficult to distinguish between them in the field. Locations recorded by simple observation in the field should be re-examined.



Map 1. Distribution of *Bupleurum gaudianum* on Gavdos island.

1.2.4 Legal status

As an endemic plant of Greece, *Bupleurum gaudianum* is protected by the Greek Legislation (Greek “Biodiversity” law Article 11 of Law No 3937/31-03-2011, Presidential Degree 67/81). The habitat of *B. gaudianum* is within the NATURA 2000 site GR4340013.

1.2.5 Conservation status / Geographical scope

Global, Mediterranean & Europe (IUCN Red List): *Bupleurum gaudianum* is listed as Vulnerable under criteria B1ab(iii)+2ab(iii) (Version 3.1) - last assessed in 2021

Greece (Red Data Book of Rare and Threatened Plants of Greece): *B. gaudianum* is listed as Vulnerable (1995).

1.2.6 Threat(s)

Bupleurum gaudianum as an annual occurring in a small area of vegetation kept open by traditional management namely by grazing from sheep and goats or probably in areas with soil erosion and high-water stress. It will be very susceptible to any management changes, especially if these lead to an alteration in the type of plant communities (Snogerub 1995). Moreover, it grows in open areas among *Pinus brutia* trees which are threatened by forest fires. Last, intensive grazing and trampling by animals appears to negatively affect the population size of the plant.

1.3 Past and Current studies and Conservation actions for *Bupleurum gaudianum*

1.3.1 *Ex situ* conservation

Genetic material of *Bupleurum gaudianum* (seeds) is conserved at the Seed Bank of MAICH. The genetic material conserved is from seed collections that took place by the Mediterranean Plant Conservation Unit of MAICH in the years 2000 (Fournaraki 2010) and 2018 (Montmollin B. de et al. 2019).

Moreover, the seeds of *B. gaudianum* are characterized by orthodox storage behaviour, as they were stored for about a year at -20 °C in the Cold Room of the Seed Bank of MAICH and remained viable (unpublished data, MPCU-MAICH).

1.3.2 Establishment of permanent monitoring plots

In the context of management measures to address the threats, it is necessary to improve our knowledge on both the biology and ecology of the plant, to assess the trend of subpopulations and to record the threats they face. For this purpose, for long-term monitoring of the population of *Bupleurum gaudianum* 3 permanent plots (10 m² each) were established (Photo 6).



Photo 6. First recordings of *Bupleurum gaudianum* plants at the permanent monitoring plots established on 26 March 2022

1.3.3 Elaboration of a practical translocation protocol for *Bupleurum gaudianum*.

Based on the experimental study of the seed germination of *Bupleurum gaudianum*, a practical plant translocation (reintroduction and/or reinforcement) protocol is proposed. The optimum conditions for germination of *B. gaudianum* seeds in the laboratory are at a temperature of 10 to 15 °C in total darkness (Figure 1). In these conditions it takes 8-10 days to reach a germination rate of 100%. Practically, this means that *B. gaudianum* seeds in their natural environment will have their highest germination rate in the winter period when they are well covered with soil. The rain period in Gavdos is from November to March. December is the wettest month, followed by January and November. Moreover, during this period the temperatures are appropriate for the germination of the species. Taking the above into account, the end of November or the beginning of December seems to be the most suitable period for planting the seeds as the rainy season follows which will ensure the survival of the seedlings.

Moreover, immediately after collection and under laboratory conditions, the dormant seeds of *B. gaudianum* cease to be dormant after about 6 months when stored in dry conditions (after-ripening) (Fournaraki 2010). In other words, the dormant seeds collected in May-June will not be dormant at the end of November to beginning of December when they are planted in the field.

Therefore, the method proposed for the translocation of *B. gaudianum* is by sowing seeds directly at the site during the winter period. Sowing seeds is preferred instead of planting seedlings in order to avoid the expenses for preparing the seedlings in a nursery and transporting them to the site but also because there is no risk of accidentally introducing alien species or other harmful organisms in the wild by transferring them with the plant substrate.

In order to be able to monitor the action, the seeds will be sown in fixed positions within metal grids which will be fixed to the ground (Photo 7). The locations will be recorded with GPS and they will be mapped and photographed in order to easily be located for monitoring.

The translocation will be monitored once yearly at the beginning of April. The first monitoring of the plants in the grids will show how successful the plant establishment from seeds is. Since *B. gaudianum* is an annual plant, it is expected that new plants will be established in the following year from the seeds produced. Monitoring will be repeated in the next years both within the grids and in additional monitoring plots which will be

established near the grids (1 additional plot 10 m² for each grid), as described above for the permanent monitoring plots.



Photo 7. Example of a metal grid fixed to the ground

1.3.4 Public awareness and sensitization actions

An **information day** took place on 10 April 2022. It was a dissemination event targeting residents, visitors, representatives of relevant authorities and other stakeholders (total 43 participants) (Photo 8 & 9). The theme of the event was “The environmental and cultural heritage of Gavdos” and it was co-organised by MAICH, the Municipality of Gavdos, the IUCN, the Management Unit of Samaria National Park and the Protected Areas of Western Crete of the Natural Environment and Climate Change Agency, and the Forest Directorate of Chania. The conservation of *Bupleurum gaudianum* was one of the main issues presented and discussed during this event.

Also, as the plant is the only endemic of the island and it was in its flowering period, many participants were interested in getting to know it in the field. For this reason, a small visit was organized a short distance south of the event site to see the plant in its natural environment.

The event ended with a consultation with the participants in order to elaborate proposals for the protection of the environmental and cultural heritage of Gavdos. Concerning *B. gaudianum* and other important plants of the island, all participants agreed that they should be protected and several residents expressed their interest to voluntarily participate in conservation actions under scientific guidance.



Photo 8. Dissemination event in Gavdos, 10 April 2022. Photo: Louis-Marie PREAU



Photo 9. Group photo from dissemination event in Gavdos, 10 April 2022. Photo: Louis-Marie PREAU

Creation of an information booklet in English and Greek. A booklet was produced to inform visitors about the significant flora of the island and the threatened plant species. The booklet is published (Photo 10) in Greek and English (250 GR and 250 EN copies) and is available in digital form on the Municipality website: (<https://gavdos.gr/getting-to-know-the-important-plants-of-gavdos-and-gavdopoula/>). This edition aims to inform and raise awareness among the residents and visitors of Gavdos and Gavdopoula about the important biodiversity of the islands, and specifically about the rare, threatened and protected plants that are found in the area.

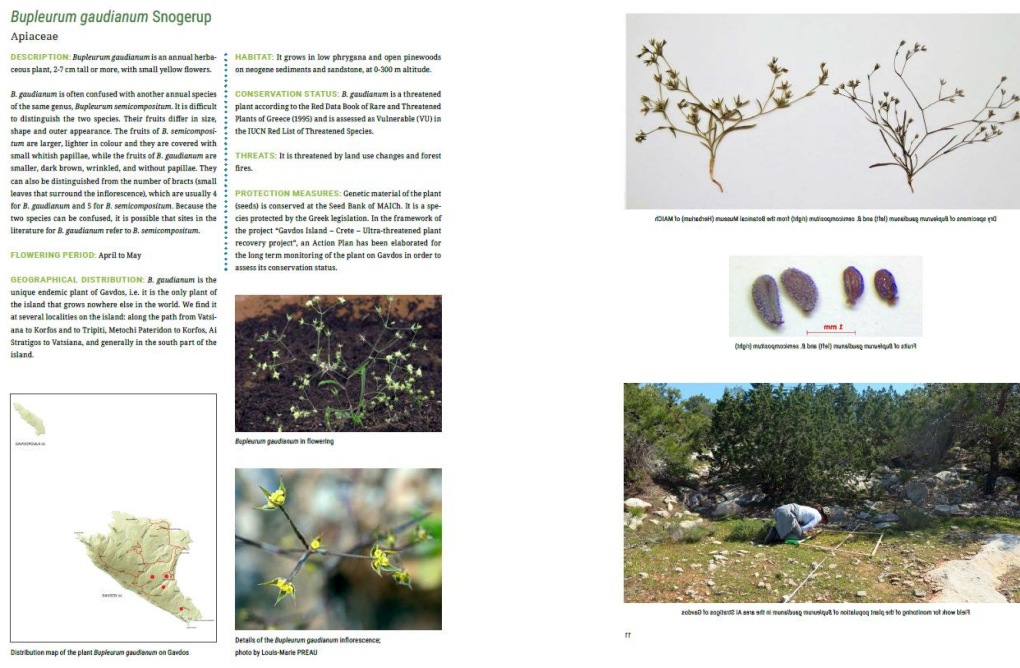


Photo 10. Information leaflet about the flora of Gavdos and Gavdopoula - the information for *Bupleurum gaudianum*

Design and production of T-shirts and canvas bags. Creation of designs (Figure 2) with the threatened plants of Gavdos *Callitriche pulchra* and *Bupleurum gaudianum* and production of 440 T-shirts and 120 canvas bags (Photos 11). The T-shirts and bags were offered to the participants of the dissemination event in Gavdos and to the Municipality of Gavdos for distribution to inhabitants and visitors of the island.



Figure 2. The design created for *Bupleurum gaudianum* by George Avgeros



Photo 11. T-shirts of *Callitriche pulchra* and *Bupleurum gaudianum*.

2. Future Actions proposed for the conservation of *Bupleurum gaudianum*

2.1 Monitoring of *Bupleurum gaudianum* populations (after the current project)

The monitoring of permanent plots will be repeated the following year at around the same period of time, at the beginning of April, depending on the weather conditions and the accessibility to the island, by researchers of MAICH. This activity cannot be implemented by residents on the island as it is difficult for non-specialists to distinguish *Bupleurum gaudianum* from *B. semicompositum*. The plan is to implement the monitoring for two consecutive years in each 5-year period. By monitoring for two consecutive years, it will be possible to detect fluctuations in population size of this annual species due to different climatic conditions from year to year. In case a decrease in population size is recorded, the translocation protocol established in this project can be implemented in the winter season of the year that follows.

2.2 Future *ex situ* actions

According to the international standards for seed storage in Seed Banks (ENSCONET and GENMEDA networks), seed samples for *ex situ* conservation should be tested for their viability **every 5 years**.

After the last seed collection of 2018 for seed banking at MAICH installations, the viability of the seed samples will be tested in the next year (2023) through germination experiments. If the viability goes below 80%, then seed collection for seed banking should be renewed via a new collection. In addition, further duplication of the seedlots, in another seed bank other than that of MAICH is recommended for safety reasons.

2.3 Actions for public awareness and sensitization

➤ The Municipality of Gavdos in collaboration with scientists and research centres, could organize information days for the biodiversity of the island (and include the specific plant species *Bupleurum gaudianum* and its habitat) on a regular basis, e.g. once per year or every 2 years, and preferably during summer when most visitors and inhabitants are on the island.

- Communication material such as banners, posters, info kiosks, etc., with detailed information and photos of the unique endemic plant of Gavdos could be prepared and installed in various places of the island for the visitors, for example at the new information centre that will be created.
- The leaflet that was produced during the current project will be accessible via the Municipality website; the hard copies in English and Greek have been given to the Municipality for distribution to the visitors and tourists of Gavdos.
- Social networks of the Municipality of Gavdos and other groups could be used for the promotion of the information on the threatened plant species and its habitat.

2.4 Actions of cooperation for the sustainability of conservation actions

- The cooperation between **the Municipality of Gavdos, CIHEAM- MAICH and the IUCN - Mediterranean Plants Specialist Group** in matters related to **protection of biodiversity on the island** will continue. A Memorandum of Agreement for this purpose is proposed to be signed by all entities and take into account the present ACTION PLAN.
- **The Mediterranean Plant Conservation Unit** of CIHEAM - MAICH will continue the actions that were initiated in the context of the current project by seeking to raise appropriate funds.
- The **expected Management Plan** for the Natura 2000 site of Gavdos and Gavdopoula from the Greek Ministry of Environment will provide the directions for the protection of biodiversity on the two islands to all stakeholders, management authorities and decision makers.

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