INCORPORATING BIOGEOGRAPHICAL PRINCIPLES IN HORTICULTURE: DESIGN AND CREATION OF THE IONIAN ISLANDS UNIQUE ROCK GARDEN IN THESSALONIKI, GREECE

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ABSTRACT

The design and creation of the Ionian Islands Unique Rock Garden (IIURG), an innovative plant display in Thessaloniki, Greece, is described. This includes seven naturalistic rock gardens hosting twenty-two plant taxa of conservation priority. The unique nature of the IIURG is based on two features: the emulation of the natural geographic characteristics of the Ionian Islands (Greece) and the integration of the endemic elements of the islands' native flora, focusing on the biogeographical significance of each. In this way, the IIURG represents an innovative concept in the horticulture of botanic gardens which embodies the natural biogeography and its basic concepts such as 'islands', 'native' and 'endemism'. In aesthetic terms the garden looks like a natural sculpture and functions as a focal point. It is a carefully constructed plant display using environmentally sustainable principles with low levels of maintenance and irrigation required. The aim is that the IIURG should be used as a useful tool for awareness-raising on the conservation of prioritised plants.

BIOGEOGRAPHY AND ENDEMISM IN GREECE

Biogeography addresses questions related to where organisms occur across space and time as well as why certain species occur in given areas and why others do not (Norris, 2011). Phytogeography is the branch of biogeography that is concerned with the distributions of plant taxa and the factors that contribute to those distributions (Lomolino *et al.*, 2006). Island biogeography seeks to understand the generation of biodiversity on island archipelagos in relation to geographical isolation and dispersal abilities of taxa. Although islands are defined as isolated pieces of land surrounded by water, in biogeography an insular environment (or 'island') is actually any area of habitat suitable for a specific ecosystem, surrounded by an expanse of unsuitable habitat. This concept can be applied to natural habitats surrounded by human-altered landscapes such as a rocky formation surrounded by agricultural land. If this concept is transferred to the horticultural practice applied in human-made botanic gardens, the description 'island' may even

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be applied to an artificially created habitat, for example a rock garden, which is designed to resemble natural habitats within a matrix of human-managed landscape.

Although ecological planting styles, i.e. *geographic* (aiming to recreate vegetation types or their essential characteristics from areas around the world) or *physiognomic* (aiming to recreate natural characteristics/patterns and vegetation function, but with little regard to the geographic origin of the component species) have been present in garden design for about 200 years (Flynn, 2009), horticulture and biogeography in common practice still seem to be an odd couple (Norris, 2011). However, inferences from biogeography can lead horticulturists to make regionally adapted selections for cultivation and utilise genetic resources from a particular geographic area (native plants) to enhance the productivity or adaptability of cultivated plants (Norris, 2011).

Native plants are defined as taxa that have originated in a given area without human involvement or that have arrived in a given area without intentional or unintentional intervention by humans from a region in which they are native (Pyšek *et al.*, 2004). These indigenous plants are the foundations of natural ecosystems in every geographical unit. In horticulture and landscape design, the selection of native plants according to biogeographical principles can help to create designed landscapes that will thrive and sustain themselves in the long term, at the same time celebrating their region and coherently fitting into the general landscape matrix (Beck, 2013).

Among native plants, the endemic taxa (species and subspecies) are those that thrive only in a specific geographical area which may range from a particular continent to a single country (national endemics), or a specific region within a country. Such plants include the unique elements in the flora of a given geographical area and sometimes these endemic elements are treated as 'national living treasures'. In fact, their value is also acknowledged at an international level in the frame of the implementation of the Nagoya Protocol. This introduces the principle that "[s]tates have sovereign rights over natural resources found within their jurisdiction and the authority to determine access to their genetic resources" (see EU Regulation 511/2014). Greece is a biodiversity hotspot, with high rates of endemism in relation to surface area (Krigas *et al.*, 2010). Several Greek endemic plants are quite restricted in geographic scope and are found exclusively on specific mountains (mountain endemics) or on particular islands (island endemics).

INTRODUCTION TO THE PROJECT

Previous studies indicate that rare Greek endemic plants are well represented in the world's botanic gardens and seed banks (Krigas *et al.*, 2016) and they are highly appreciated in the international horticultural industry (Krigas *et al.*, 2014). The Balkan Botanic Garden of Kroussia (BBGK), Institute of Plant Breeding and Phytogenetic Resources, Hellenic Agricultural Organisation Demeter has been a pioneer in prioritising native plants and local Greek endemics in horticulture, landscape design and sustainable utilisation (Maloupa *et al.*, 2007; Krigas & Maloupa, 2008; Maloupa *et al.*, 2008). Currently, several botanic gardens include native plant areas displayed at their

grounds (Rhizopoulou *et al.*, 2010; Schulman & Lehvävirta, 2011; Hood & Reaney, 2013).

Environmental awareness focusing on the utilisation of native and endemic plants in the urban environment is of major importance for the scope of a botanic garden. At the same time, new ways of creating fascinating and unique plant displays that attract visitors in botanic gardens is an essential tool for raising environmental awareness. New design approaches of plant displays in botanic gardens are useful for establishing stronger relationships between people, plants and associated environmental issues (Villagra-Islas, 2011), thus enabling botanic gardens to positively influence visitors' environmental attitudes (Sanders, 2007; Williams *et al*., 2015).

It was within this framework that the Ionian Islands Unique Rock Garden (IIURG) project was undertaken by the BBGK. The initial aim was to make a naturalistic and biogeographically accurate plant display in order to demonstrate to the public the precious and unique elements of the native flora of the Ionian Islands in south-west Greece (Fig. 2). The Ionian Islands include six major islands (from north to south: Corfu, Paxi, Lefkada, Cephalonia, Ithaca and Zante), several smaller islands and islets (Antipaxi, Atokos, Kalamos, Kastos, Meganisi, Pontikonisi, Skorpios, Sparti (Lefkada) and Strofades) and three small archipelagos: Diapontia (largest islands: Othonoi, Ereikoussa, Mathraki), Echinades (largest islands: Petalas, Oxeia, Drakonera) and Oinousses (largest islands: Schiza, Sapientza). This biodiversity-rich area has been targeted by earlier efforts at *ex situ* conservation in the BBGK (Krigas *et al.*, 2010). The inspiration to create a realistic rocky plant display came mostly from the Crevice Garden (Jardin de Crevasses) of Montreal Botanical Garden and the Davies Alpine House and Rock Garden of the Royal Botanic Gardens, Kew. After bibliographical research and an internet survey the preliminary plans of IIURG were drawn and a proposal was prepared to attract funds for the project's implementation. In 2014, the IIURG project was awarded funding by the Stanley Smith (UK) Horticultural Trust.

METHODOLOGY: DESIGN, MATERIALS AND CONSTRUCTION

In order to select an adequate location for the construction of the IIURG several issues had to be addressed: first, the IIURG had to be easy to access and maintain. Second, the site had to be level and weed-free. Third, it needed to be close to a big urban centre to attract visitors. Such a location existed in the grounds of the Botanic Garden of Environmental Awareness in Thermi, metropolitan Thessaloniki, Greece (Fig. 1). In this garden, a flattened, almost weed-free area of approximately 200m^2 which did not need special site preparation was selected and covered with a permeable landscape fabric.

Based on the preliminary plans and the selected construction site (Fig. 1), the final design was drawn into the right scale and proportion using computer-aided design software according to a high-resolution map of the Ionian Islands downloaded from the Flora Ionica website (https://floraionica.univie.ac.at/) (Fig. 2). In order to fit the dimensions of the site Corfu Island had to be relocated and was transferred 4m to the right

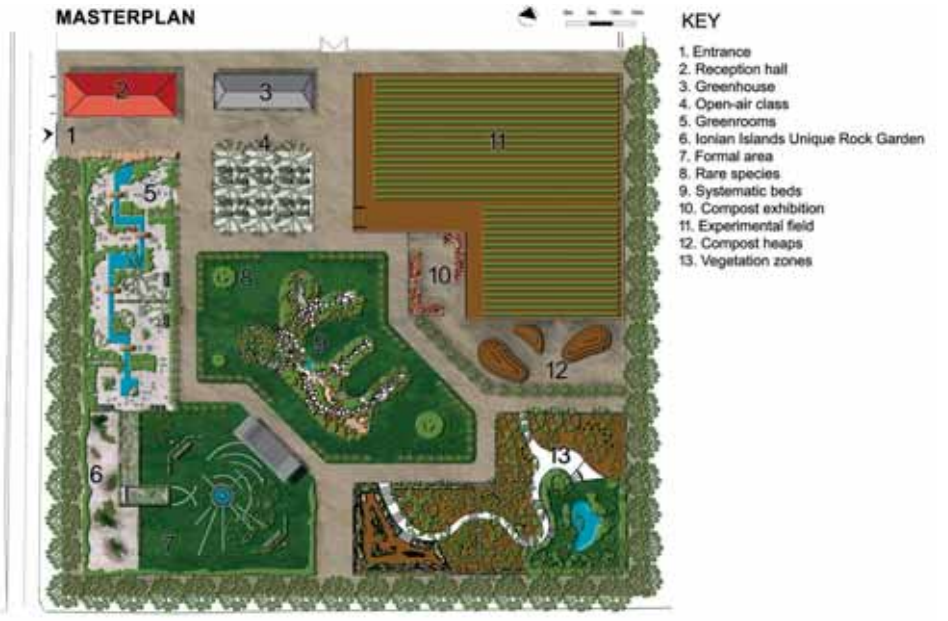

Fig. 1 Map of the Botanical Garden of Environmental Awareness (Maloupa *et al.*, 2007) showing the position of the Ionian Islands Unique Rock Garden (no. 6). This suburban botanic garden belongs to the Laboratory for Conservation & Evaluation of Native & Floricultural Species, Institute of Plant Breeding & Genetic Resources, Hellenic Agricultural Organisation Demeter and is located in Thermi, metropolitan Thessaloniki, northern Greece. Plan: Marina Panagiotidou.

from its original position. Two scales for measurement were used: (1) a horizontal one to the scale of 1:10,000 in order to imprint the natural perimeter (coastline) of each of the Ionian Islands and (2) a vertical one to the scale of 1:2,000 in order to demonstrate their landform (plateaus, cliffs and mountain peaks). For example, the actual area of Lefkada, 302.5km^2, was designed on site to be shown as 3m^2 and its highest mountain peak (Mt Stavrota), 1,182m, was designed as 60cm high (Fig. 2).

At the same time all landscape materials were sourced and the necessary slate (traditional Kavala stones), rocks, pebbles, sand and soil mixture (well drained, yet moisture-retentive) were selected and delivered to the construction site. This was a time-consuming operation which involved the use of heavy machinery. The exact amount of materials ordered for this project were: 60m^2 of slate, 8m^3 of sand, 15m^3 of small pebbles, 140kg of blue pebble-glass and 6m^3 of garden soil.

The shape of the islands was transferred onto the site using a red marker spray for the creation of a 50cm × 50cm canvas (Fig. 3). The canvas was used as a guideline to help draw the perimeter of each island. For example, Cephalonia and Ithaca were drawn using one canvas of 20m^2 (4m × 5m) (Fig. 3). Over the trace of the red marker, a rope wrapped around several 8cm long nails was installed on the ground marking the islands' shapes.

Fig. 2 Scaling of the natural perimeter designed (left) according to the geography of the major Ionian Islands: Corfu or Kerkyra (Kérkira), Paxi-Antipaxi, Lefkada (Lefkádha), Ithaca (Itháki), Cephalonia (Kefaloniá) and Zante (Zákinthos), Greece (right). The map of the Ionian Islands and their archipelagos is reproduced with the permission of the Flora Ionica team (Institute of Botany, University of Vienna, Austria). Plan: Marina Panagiotidou.

The next step was to cut the permeable landscape fabric along the line created by the rope. It was then removed from the site and the space left was dug out to create a base 30cm deep which was filled with gravel and sand for essential drainage and stone stability (Fig. 4). Then, slate was set vertically into sand and in-filled with more washed sharp sand, grit and small pebbles (Fig. 4). In this way, the crevices and plateaus of the natural landform of each of the Ionian Islands were emulated.

The first stages were completed in autumn and winter of 2014–2015, when the rock gardens of Cephalonia, Ithaca and Lefkada were constructed. The second stage was completed in the winter of 2015–2016 when the project was completed with the establishment of the rock gardens of Corfu, Paxi-Antipaxi and Zante.

Fig. 3 Transfer of basic design (left) on the site by creating a 50 × 50cm canvas on the ground with red marker in order to imprint and establish the natural shape of Cephalonia (middle) and Lefkada Island (right). Dimensions are shown in metres. Plan and photos: Marina Panagiotidou.

PLANT SELECTION, PROPAGATION AND PLANTING

For planting in the IIURG, species were selected on the basis that their range was restricted, that they occur on the Ionian Islands and that they would offer uniqueness to the plant display (Table 1). These include local island endemics such as *Campanula garganica* subsp. *cephallenica*, *Centaurea paxorum*, *Limonium damboldtianum* (all assessed nationally as rare and/or threatened; see Phitos *et al.*, 1995; 2009), regional Greek endemics such as *Cerastium candidissimum*, *Delphinium hellenicum*, *Thymus holosericeous*, range-restricted local Balkan endemics such as *Erysimum microstylum*, or other plants rare in Greece such as *Hypericum aegypticum* subsp. *webbii*. These taxa either represent plants of higher altitudes to be positioned in the upper parts of the Rock Gardens or lowland plants to be positioned in the lower parts (see Table 1).

The display was designed to be an ecologically representative abstraction of the rocky areas of the Ionian Islands, Greece. In this way, it was easier to select the plants required and to explore how they would fit together. For this, the thorough records of wild field collections which are maintained at BBGK were exploited (Maloupa *et al.*, 2008; Krigas & Maloupa, 2008) and endemic, rare and/or threatened Ionian plants that usually grow on rocky substrates were selected (Krigas *et al.*, 2010). For the plant displays, only indirect wild origin natural source material was used, meaning that this material was propagated sexually or asexually in the nursery facilities at BBGK (Krigas *et al.*, 2010).

After the development of species-specific propagation and cultivation protocols (see Krigas *et al.*, 2010) and the construction of the small rock gardens representing each of the major Ionian Islands, planting work was next. At the beginning, all the propagated plants were positioned between the rocks while still in their pots according to the planting plan (Fig. 5; Table 1). Then, the extra grit surrounding each pot was removed and a suitable soil mixture (compost mix) was firmly packed under, behind and in between each piece of rockwork in order to eliminate any spaces where frost might penetrate. The plants were planted firmly in the compost mix while they were raised approximately 3cm above the surrounding compost (Fig. 7). The 3cm gap under the cushion or rosette was packed tightly with a top dressing of small pebbles and grit in order to ensure that each cushion or rosette had appropriate drainage underneath it (a mandatory requirement) and yet ensuring that the surrounding soil would maintain an adequate moisture level. Most of the plants in the IIURG established well in their new artificial habitats (Table 2).

Finally, sand and small blue glass pebbles were laid out around the islands' perimeter to demonstrate the coastline and the Ionian Sea, while the rest of the area was covered with grey pebbles (Fig. 8).

Overall the construction of the IIURG along with the site preparation took twenty days of eight working hours per day, with two trained technicians and a landscape designer involved. All plantings were made during November and early December 2014 as well as in February and November of 2016, always in cool and humid

Fig. 4 Basic construction steps followed for the creation of the Ionian Islands Unique Rock Garden: (a): Cutting off the permeable landscape fabric. (b): Setting slate stones of different sizes according to the actual geographical terrain of the Ionian Islands (here Cephalonia). (c): Digging the base for slate. (d): Creation of a base for slate (c. 30cm deep). (e) and (f): Setting slate vertically to simulate the actual geographical relief of each island i.e. Cephalonia (e) and Ithaca (f) (Photos: Marina Panagiotidou).

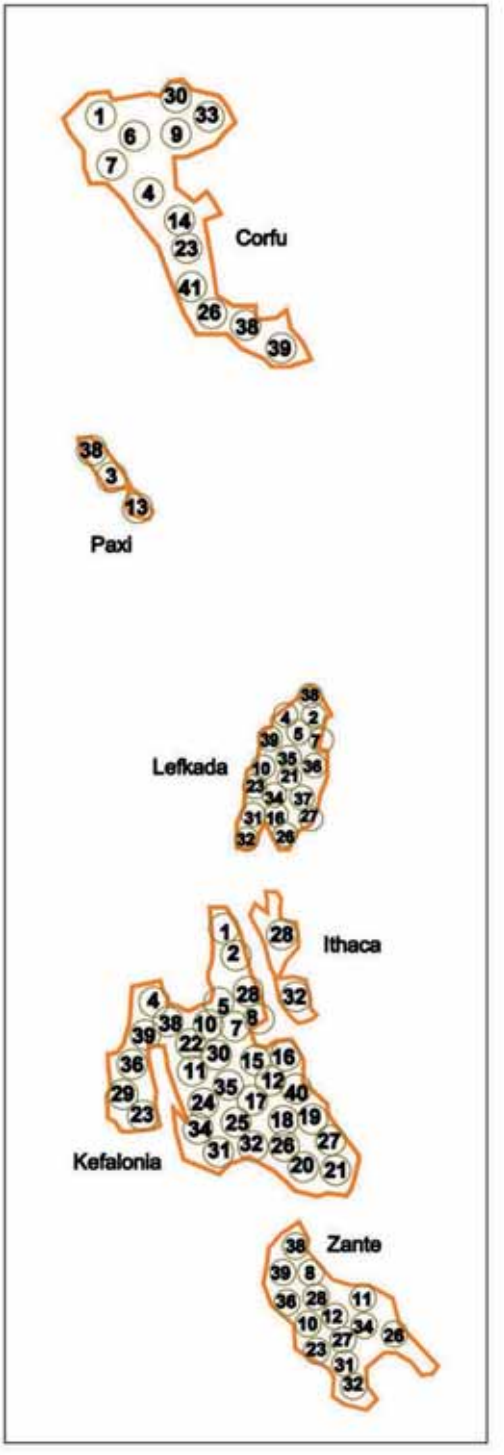

Fig. 5 Basic planting plan of the Ionian Islands Unique Rock Garden indicating their diversity of plants important for conservation (for numbering of taxa, see Table 1), including 15 taxa for Cephalonia, 2 taxa for Ithaca, 9 taxa for Lefkada, 13 taxa for Corfu, 3 taxa for Paxi-Antipaxi and 14 taxa for Zante. Plan: Marina Panagiotidou.

Fig. 6 Irrigation system and preliminary plant positioning in the Rock Garden according to the planting plan (top), plant labelling and covering with grey and blue pebbles for configuration of the island's natural shoreline (bottom). Photos: Marina Panagiotidou.

weather. In spring, when temperatures rose, a drip irrigation system was created for each plant.

RESULTS AND DISCUSSION

During the IIURG project seven isolated rock gardens were created, each representing one of the major Ionian Islands (from north to south: Corfu, Paxi, Antipaxi, Lefkada, Cephalonia, Ithaca, Zante), with their natural coastline and landform emulated to scale and to fit the construction site (Fig. 8). Locally endemic and other plants of conservation concern occurring on each of the Ionian Islands were planted and labelled (Figs 6, 7 & 8) in each of these rock gardens.

The uniqueness of the IIURG lies in the emulation of the geographic characteristics of the Ionian Islands in the construction, and the integration of the endemic elements

Fig. 7 Planting firmly in the compost mix (left) and creation of artificial habitats at the rock garden of Lefkada Island for the range-restricted local Balkan endemic *Centaurea alba* subsp. *subciliaris* and the local Ionian endemic *Campanula garganica* subsp. *cephalenica* (right) which is assessed as Vulnerable in the national Red Data Book (Phitos *et al*., 2009). Photos: Marina Panagiotidou.

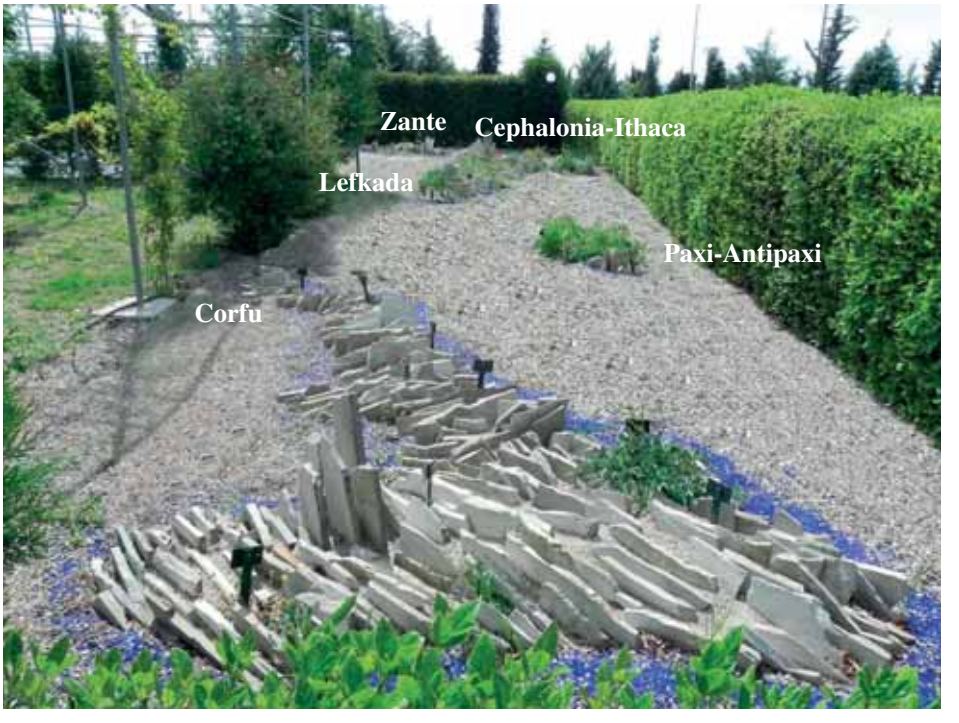

Fig. 8 View of the Ionian Islands Unique Rock Garden as constructed in the Garden of Environmental Awareness, Laboratory for Conservation & Evaluation of Native & Floricultural Species, Institute of Plant Breeding & Genetic Resources, Hellenic Agricultural Organisation Demeter in Thermi, metropolitan Thessaloniki, Greece. Photo: Marina Panagiotidou.

Number	Family	Scientific name of selected plant	Ionian Islands	Position
1	Lamiaceae	**Ajuga orientalis* subsp. *aenesia*	CORFU, CEPHALONIA	Higher
2	Fabaceae	**Astragalus sempervirens* subsp. *cephalonicus*	CEPHALONIA, LEFKADA	Higher
3	Asteraceae	*Centaurea spruneri*	CEPHALONIA, LEFKADA, CORFU	Higher
4	Asteraceae	*Centaurea alba* subsp. *subciliaris*	CEPHALONIA, LEFKADA	Higher
5	Caryophyllaceae	**Cerastium brachypetalum* subsp. *corcyrense*	CORFU	Higher
6	Caryophyllaceae	**Cerastium illyricum* subsp. *illyricum*	CEPHALONIA, LEFKADA, CORFU	Higher
7	Brassicaceae	*Erysimum microstylum*	CORFU	Higher
8	Asteraceae	**Leontodon graecus*	CEPHALONIA, ZANTE	Higher
9	Dipsacaceae	*Pterocephalus perennis* subsp. *bellidifolius*	CEPHALONIA	Higher
10	Lamiaceae	**Stachys parolinii*	CEPHALONIA	Higher
11	Apiaceae	*Trinia glauca* subsp. *pindica*	CEPHALONIA	Higher
12	Veronicaceae	**Veronica glauca* subsp. *peloponnesiaca*	CEPHALONIA, LEFKADA	Higher
13	Caryophyllaceae	**Cerastium candidissimum*	CEPHALONIA	Higher
14	Poaceae	**Poa cephalonica*	CEPHALONIA	Higher
15	Lamiaceae	****Scutellaria rupestris* subsp. *cephalonica***	CEPHALONIA	Higher
16	Lamiaceae	**Thymus holosericeus*	CEPHALONIA, ZANTE, LEFKADA	Higher
17	Campanulaceae	****Campanula garganica* subsp. *cephallenica***	CEPHALONIA, ZANTE, ITHACA	Higher
18	Rubiaceae	**Galium circae*	CEPHALONIA, CORFU	Higher
19	Veronicaceae	**Veronica chamaedrys* subsp. *chamaedryoides*	CORFU	Higher

Table 1 Annotated list of plants proposed for planting in the Ionian Islands Unique Rock Garden, arranged alphabetically according to scientific name in two sections (plants of higher altitudes to be positioned in the upper parts of the rock gardens and lowland plants to be positioned in the lower parts). Plants marked with an asterisk are Greek endemics; the others are either Balkan endemics or other rare plants found in Greece (distribution, endemism and nomenclature according to Dimopoulos *et al.*, 2013). Plants appearing in bold are assessed as nationally rare and/or threatened (Phitos *et al.,* 1995; Phitos *et al.,* 2009).

Number	Family	Scientific name of selected plant	Ionian Islands	Position
20	Paeoniaceae	***Paeonia corsica***	CEPHALONIA, LEFKADA, ZANTE	Higher
21	Veronicaceae	**Cymbalaria microcalyx* subsp. *minor*	CEPHALONIA, LEFKADA	Higher
22	Paeoniaceae	*Paeonia peregrina*	LEFKADA	Higher
23	Asteraceae	***Centaurea paxorum***	PAXI, CORFU	Lower
24	Ranunculaceae	**Delphinium hellenicum*	CEPHALONIA, ZANTE	Lower
25	Apiaceae	**Heptaptera colladonioides*	CEPHALONIA, LEFKADA, ZANTE	Lower
26	Hypericaceae	*Hypericum aegypticum* subsp. *webbii*	CEPHALONIA, ZANTE	Lower
27	Plumbaginaceae	***Limonium antipaxorum*	PAXI-ANTIPAXI	Lower
28	Plumbaginaceae	**Limonium arcuatum*	CORFU	Lower
29	Plumbaginaceae	**Limonium cephalonicum*	CEPHALONIA	Lower
30	Plumbaginaceae	***Limonium damboldtianum***	CEPHALONIA, LEFKADA	Lower
31	Apiaceae	**Scaligeria moreana*	CEPHALONIA	Lower
32	Lamiaceae	**Teucrium halacsyanum*	CEPHALONIA, CORFU, LEFKADA, ZANTE	Lower
33	Rubiaceae	**Gallium peloponnesiacum*	CEPHALONIA	Lower
34	Dipsacaceae	*Lomelosia crenata* subsp. *dellaportae*	CEPHALONIA, LEFKADA, ZANTE	Lower
35	Lamiaceae	**Stachys ionica*	CEPHALONIA, LEFKADA, ZANTE, ITHACA	Lower
36	Caryophyllaceae	**Dianthus fruticosus* subsp. *occidentalis*	CEPHALONIA, LEFKADA, ZANTE	Lower
37	Brassicaceae	*Brassica cretica* subsp. *aegaea*	CEPHALONIA, LEFKADA, ZANTE, PAXI, CORFU	Lower
38	Iridaceae	*Crocus boryi*	CEPHALONIA, LEFKADA, ZANTE, CORFU	Lower
39	Lamiaceae	*Satureja cuneifolia*	CEPHALONIA	Lower
40	Lamiaceae	*Stachys arvensis*	CORFU	Lower

Table 1 (*conitnued*)

Taxon	Ionian Islands	Acclimatisation	Growth	Flowering	Fruiting
Astragalus sempervirens subsp. *cephalonicus*	CEPHALONIA,LEFKADA	Good	Good	Yes	Yes
Brassica cretica subsp. *aegea*	CEPHALONIA, LEFKADA, ZANTE, PAXI, CORFU	Intermediate	Intermediate	Yes	No
Campanula garganica subsp. *cephallenica*	CEPHALONIA, ZANTE, ITHACA	Good	Good	Yes	No
Centaurea paxorum	PAXI, CORFU	Good	Good	Yes	Yes
Centaurea alba subsp. *subciliaris*	CEPHALONIA, LEFKADA	Good	Good	Yes	Yes
Centaurea spruneri	CEPHALONIA, LEFKADA, CORFU	Intermediate	Intermediate	Yes	Yes
Cerastium illyricum subsp. *illyricum*	CEPHALONIA, LEFKADA, CORFU	Intermediate	Intermediate	No	No
Dianthus fruticosus subsp. *occidentalis*	CEPHALONIA, LEFKADA, ZANTE	Good	Good	Yes	Yes
Erysimum microstylum	CORFU	Intermediate	Intermediate	No	No
Galium circae	CEPHALONIA, CORFU	Good	Good	No	No
Galium peloponnesiacum	CEPHALONIA	Good	Good	No	No
Hypericum aegypticum subsp. *webii*	CEPHALONIA, ZANTE	Good	Good	Yes	Yes
Leontodon graecus	CEPHALONIA, ZANTE	Good	Good	Yes	No
Limonium arcuatum	CORFU	Bad	Bad	No	No
Limonium damboldtianum	CEPHALONIA, LEFKADA	Bad	Bad	No	No
Lomelosia crenata subsp. *dellaportae*	CEPHALONIA, LEFKADA, ZANTE	Good	Good	Yes	Yes
Poa cephalonica	CEPHALONIA	Good	Good	Yes	Yes
Satureja cuneifolia	CEPHALONIA	Good	Good	Yes	Yes
Stachys ionica	CEPHALONIA, LEFKADA, ZANTE, ITHACA	Good	Good	Yes	Yes
Teucrium halacsyanum	CEPHALONIA, CORFU, LEFKADA, ZANTE	Good	Good	Yes	Yes
Thymus holosericeus	CEPHALONIA, ZANTE, LEFKADA	Good	Good	Yes	Yes
Veronica glauca subsp. *peloponnesiaca*	CEPHALONIA, LEFKADA	Good	Good	Yes	No

Table 2 Selected plants important for conservation (22 taxa, arranged alphabetically) that were propagated at the Balkan Botanic Garden of Kroussia (Krigas *et al.,* 2010) and were then planted in the Ionian Islands Unique Rock Garden with notes on their acclimatisation, growth, flowering and fruiting in their new artificial habitats.

of the Ionian Islands' flora; the Garden thus focuses on the biogeographical significance of each of the Ionian Islands. In this way, the IIURG represents an innovative concept in horticulture within botanic gardens which brings biogeography into the display and incorporates the biogeographical concepts of 'islands', 'native' and 'endemism' ('uniqueness'). In the rock gardens of the IIURG (Fig. 8), 22 locally endemic species and those important for conservation were selected, planted and labelled (Table 2). The Cephalonia rock garden hosted most of the selected plants (19 taxa, Table 2), followed by Lefkada (12 taxa, Table 2), Zante (9 taxa, Table 2) and Corfu (8 taxa, Table 2). In the smaller Ionian Islands, Paxi-Antpaxi and Ithaca rock gardens, we planted *Brassica cretica* subsp. *aegaea* and the vulnerable Ionian endemic *Centaurea paxorum* (Paxi-Antipaxi) and *Stachys ionica* and the vulnerable *Campanula garganica* subsp. *cephallenica* (Ithaca). With the exception of *Limonium arcuatum* and *L. damboltianum*, all the plants selected for this display acclimatised well in their artificial habitats and produced flowers and fruits (Table 2).

A rock garden can provide several different microhabitats accommodating various plants with different needs, even in quite a small area. Rocks can be placed so that plants thrive in a sunny spot, whereas a shade-tolerant plant can nestle in the north-facing shadow of the same rock, keeping the root system cooler in summer and warmer in winter, and moisture is used more efficiently. These features were exploited in the design. However, due to the small space of the construction site not all plants from the proposed planting list (Table 1) were planted. The largest plants such as *Paeonia* sp. were excluded, as were those for which only limited propagation experience exists. For the latter, more investigation into their lifecycle and propagation requirements are needed prior to inclusion in the proposed planting plan (Table 1).

EVALUATION AND IMPROVEMENTS TO THE DESIGN

Based on the results achieved during the implementation of the IIURG project, a new design has been proposed which will be more appropriate for the individual rock gardens of the Ionian Islands and will enhance the positive aspects, resolve the problems encountered and overall improve the project's realisation.

The new design proposes that the scale of the IIURG be enlarged to double the size of the rock gardens of the Ionian Islands (Fig. 9) from the initial plan and using the same construction methods (Figs 2–7). Again, two scales for measurement will be used for the construction of the Ionian Islands Unique Rock Garden: (1) a horizontal one to the scale of 1:5,000 in order to imprint the perimeter of the islands and (2) a vertical one to the scale of 1:1,000 in order to demonstrate landform (plateaus, cliffs and mountain peaks). In this way, for example, the area of Lefkada, which was previously designed as $3m^2$, will now be designed as $6m^2$, while the highest mountain peak, which was 60cm, will now be displayed as 1.2m. The area dedicated to the construction of the IIURG is estimated to increase to at least $800m^2$.

Fig. 9 Photorealistic representation of Lefkada Island according to the new design proposed for the creation of the Ionian Islands Unique Rock Garden with duplication of construction scales (horizontal scale 1:5,000; vertical scale 1:1,000) and raised rocky substrate allowing planting of more plant individuals per taxon. Photorealistic view: Marina Panagiotidou.

The other significant change proposed is that different construction materials will be used. Each of the Ionian Islands will be built as low dry-stone walls (30–45cm high) forming the islands' perimeter (like raised rock gardens); on top of this structure, the IIURG will be established using the same methodology as previously described in detail (Fig. 9).

By doubling the islands' size sufficient space will be created to accommodate all the species on the indicative planting list (Table 1), and more than one individual could be planted. This will make a more engaging and spectacular display. It will also be easier for the public to look around and interact with the structure (Fig. 9).

Following the logic of ecological plantings (Flynn, 2009), the original thought behind this endeavour was that this display will bring visitors to the botanic garden into contact with the most unique elements of the flora of this specific region of Greece. Some may not have the opportunity to visit this area and will never come across all of these endemic, rare or threatened plants. In this way, through the creation of naturalistic rock displays with unique plant components that are emotive representations of specific ecosystems, people will be able to experience the feeling of visiting these areas without

ever having actually been there. By creating these displays in tandem with appropriate biogeographic interpretation, the sensation of being in these different places will come alive and the understanding of the role of geographic isolation in shaping the uniqueness of the Islands' flora will become evident. At the time of writing different methods of interpretation are being considered, because it is known that the installation of clearly marked interpretation schemes that tell biogeographical or ecological stories enables visitors to take home some of the important conservation messages that go with them (Flynn, 2009).

CONCLUSION

Education and the creation of an aesthetically pleasing environment are the two main principles behind botanic gardens, reiterated through many mission statements from various gardens (Flynn, 2009). On the other hand, ecological plantings and plant displays with well-documented native and/or endemic plants offer both educational and conservation benefits (Flynn, 2009).

The results of the IIURG project show that this is a very promising project which displays native endemic plants with conservation priority in a highly unique man-made environment while alluding to the scenery where the plants naturally occur in the wild. Additionally, it incorporates basic concepts of biogeography into horticulture (island, native, endemism). The allocation of funds to appropriate construction materials (size of rocks and type of stones) has led to a satisfactory result, and one which provides a useful tool for raising awareness of environmental issues in botanic gardens. Other gardens are invited to consider applying this horticultural experience to their master plans and priorities and to exploit the experience gained by the staff at the Balkan Botanic Garden Kroussia during the implementation of the Ionian Islands Unique Rock Garden project.

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