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The role of a gene bank as an impact mitigation tool in the Alqueva dam (Portugal)

Abstract

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The construction of the Alqueva dam in Portugal will result in a large-scale habitat fragmentation and ecosystem alterations that adversely affect both terrestrial and aquatic biodiversity. As an impact-minimization action and help for future restoration programs 1200 plant specimens (over 300 species) are now preserved in the "Antonio Luis Belo Correia Gene Bank" of Lisbon University Botanical Garden. After the flooding, several actions of restoration and impact compensation of the area will be implemented, some of which are illustrated in this paper.

Introduction

The construction of the Alqueva dam in Portugal will result in the loss of 25000 ha of Mediterranean river ecosystems as well as surrounding rocky areas. The habitat fragmentations will involve either reduction/loss of habitat or a decrease in habitat connectivity that will adversely affect both terrestrial and aquatic biodiversity. Due to the direct impact on plant populations and future changes in land use, the "Antonio Luis Belo Correia Gene Bank" of Lisbon University Botanical Garden has developed a conservation project (2001-2004) focused on the collection, storage and long-term conservation of germplasm from the area affected by the Alqueva dam. In order to achieve the aims of the project it was necessary to reorganize the existing gene bank facilities. New laboratories were designed to assure (1) the plannification of seed sampling, (2) the characterization of the germplasm collected and (3) the long-term preservation of seeds. During the first two years, the gene bank staff was trained in collection protocols and seed preservation, while in the last two years the massive efforts were focused to the collection of the target species. The long-term conservation method adopted was that proposed by Gómez-Campo (2001).

The conservation project consists of a mitigation action aiming at: i) minimising the loss of genetic resources that will cause the construction of the dam, and ii) becoming a tool for further conservation actions (habitat re-establishment, re-introductions, re-inforcements...) in the area. The fact that a global action plan was defined previously allowed an adequate collecting effort before the flooding. This remarkable particularity ensures the use of

autochthonous germplasm in the future mitigation actions that are expected to facilitate its success (Falk & al.1996).

Seed preservation of the plants affected by the Alqueva dam

Considering the deep transformation of the affected area and its surroundings, the impact of the Alqueva dam would have consequences at all levels of the trophic web. The main alteration of vegetation involves changes in primary biological productivity of ecosystems including effects on riparian plant-life and on down-stream habitats. Another feature of the same problem is the repercussion on fauna due to changes on herbivorous behavior and population dynamics that may also affect the carnivorous composition.

Due to the size of the area to be flooded, and the short time (2001-2002) available to collect, a collecting strategy was defined based on a previous eco-geographical survey of the flooded area (Draper & al. 2003). The main goal of this survey was to detect different ecological conditions that may affect the genetic adaptation on these particular ecological profiles since collecting in completely different profiles may ensure a wide genetic diversity. The characterization of the original ecological profile will also be used in the future actions to select the most accurately seed samples to be used in each place. This collecting strategy was followed during the project resulting in a total number of 1200 specimens from over 300 species, covering most ecological niches which would be destroyed or modified by the dam construction (Fig. 1). These species represent 58 plant families and 60% of the plant diversity present in the area (Fig. 2).

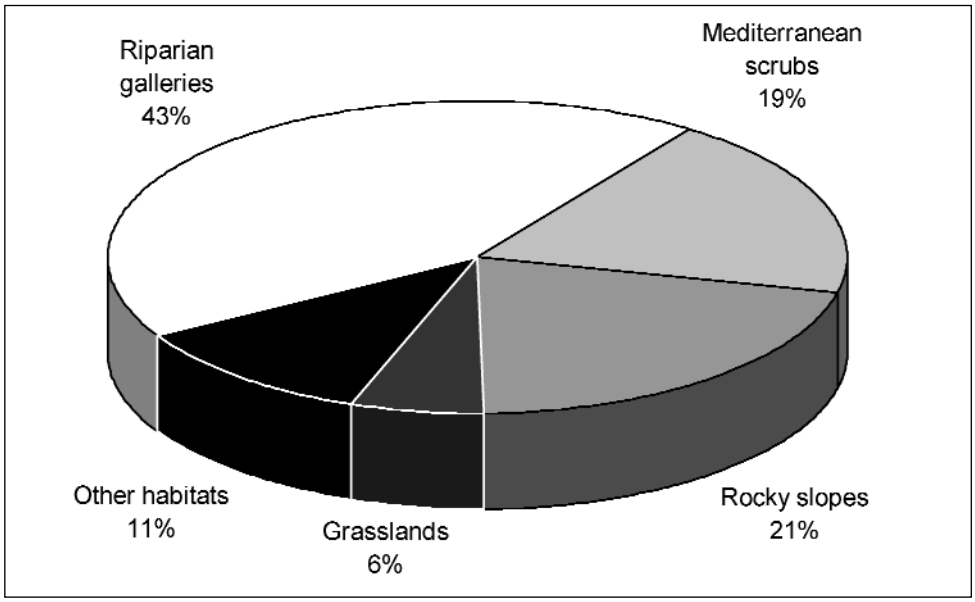

Fig. 1. Distribution of collected samples by ecological niches (n=1200 samples).

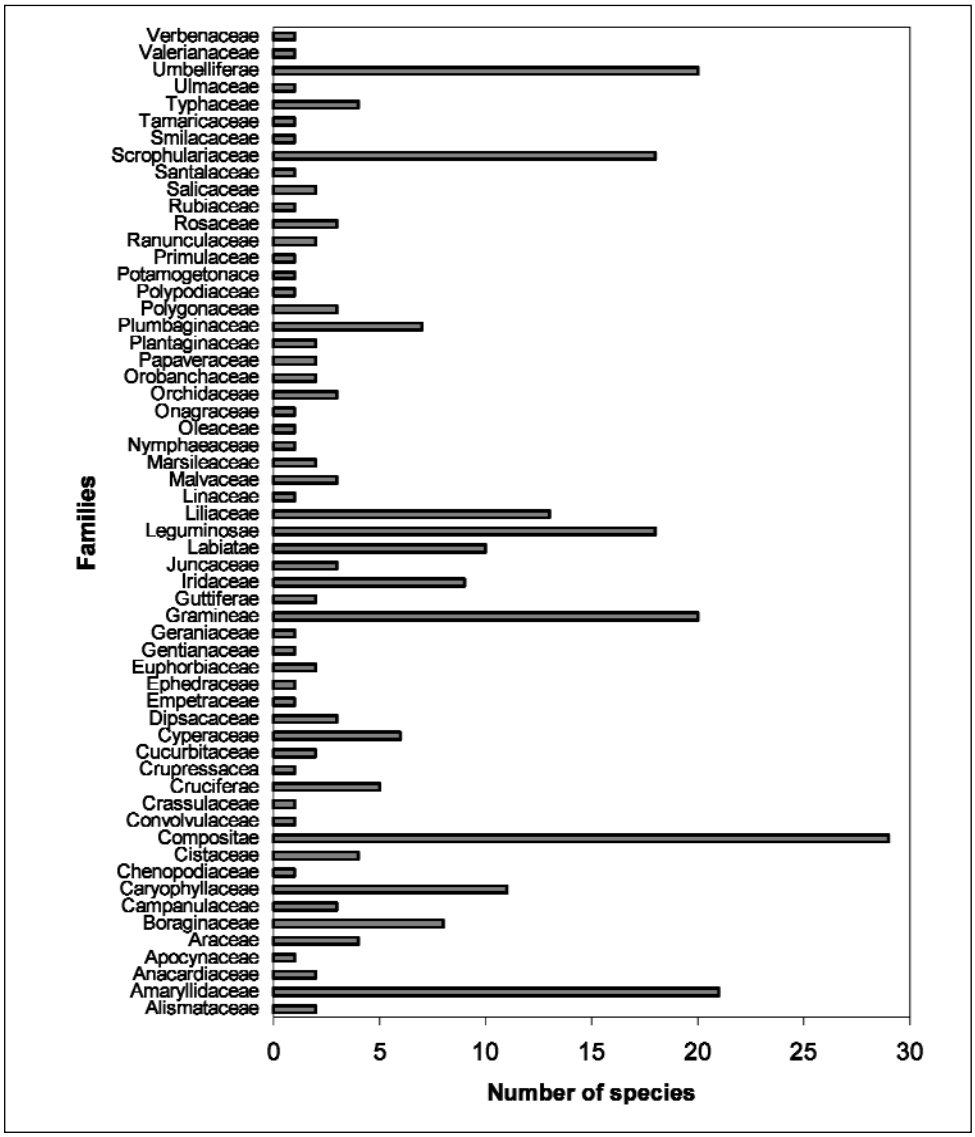

Fig. 2. Number of species (by plant family) preserved in the Alqueva gene bank.

The future utilization of the preserved material is conditioned by the knowledge of its characteristics and its viability (Jaramillo & Baena 2000). Thus, in order to determine the germplasm potential use, it was important to characterize all the material held in the gene bank. The characterization of the Alqueva germplasm includes herbarium vouchers, field information, germination profiles, patterns of drying behavior, viability status, relation between the number of seeds, its weight and volume, and cytogenetic data.

Main restoration actions

In the context of this project, the *ex situ* conservation of native species acts as a 'back-up' providing the possibility to undertake future actions to minimize the lost of the existent genetic diversity. The restoration actions may be summarized as follows.

Re-inforcement of remaining riparian populations and habitats

This action will consider the creation of new riparian galleries segments as well as the recovery of the remaining ones. The aim of this restoration is to ensure plant population dynamics but also to feed, hide, and provide nesting conditions to several groups of animals. The target plant species for this action were:

Agrostis stolonifera
Alisma plantago-aquatica
Amaranthus albus
Asparagus aphyllus
Aster squamatus
Bryonia craetica subsp. *dioica*
Carthamus lanatus subsp. *lanatus*
Crataegus monogyna
Cynodon dactylon
Cynosurus echinatus
Cyperus longus
Cyperus longus subsp. *badius*
Cytisus scoparius
Dittrichia viscosa subsp. *viscosa*
Echinochloa crus-galli
Epilobium hirsutum
Epilobium tetragonum
Flueggea tinctoria
Foeniculum vulgare
Foeniculum vulgare subsp. *piperitum*
Fraxinus angustifolia
Juncus acutus
Lactuca serriola
Lythrum salicaria
Marsilea batardae
Mentha suaveolens
Nerium oleander
Olea europaea var. sylvestris
Osyris alba
Panicum repens
Paspalum paspalodes
Phragmites australis
Picris echioides
Piptatherum miliaceum
Pistacia lentiscus
Polygonum amphibium
Polygonum equisetiforme
Polygonum monspeliensis
Populus deltoides
Pulicaria paludosa
Rubus ulmifolius
Salix salvifolia
Schoenoplectus mucronatus
Scirpoides holoschoenus
Silybum marianum
Smilax aspera
Tamarix africana
Typha latifolia

Increase of connectivity between riparian galleries and sclerophyllous pasturelands

The creation of an artificial new shoreline has generated a sharp break in communities and landscapes. Thus, this action aims to increase the ecotone area suitable for the establishment and migration of animal populations. Specific habitat restoration will be done focusing some priority mammals such as *Microtus cabrerae* (Habitat Directive 92/43/EEC) that lives in open rush meadows or close to temporary ponds. The use of different plants will create areas suitable not only for their nesting but also for refuge and feeding. The considered species were:

Aristolochia baetica
Aristolochia paucinervis
Asparagus acutifolius
Asparagus albus
Calamintha baetica
Centranthus calcitrapae
Cistus albidus
Cistus monspeliensis
Coronilla glauca
Crataegus brevispina
Cynodon dactylon
Daphne gnidium
Elaeoselinum foetidum
Euphorbia nicaensis
Hyacinthoides hispanica
Hypericum perfoliatum
Jasminum fruticans
Lavandula sampaiana
Lonicera implexa
Olea europaea var. sylvestris
Osyris alba
Phillyrea media
Pistacia lentiscus
Quercus coccifera
Retama sphaerocarpa
Rhamnus alaternus
Rhamnus oleoides
Rubia peregrina
Rubus ulmifolius
Ruscus aculeatus
Scirpus holoschoenus
Smilax aspera
Smyrnium olusatrum
Teucrium fruticans
Teucrium lusitanicum
Urginea maritima
Viburnum tinus

Adaptation of artificial structures for aquatic fauna

Several plant species will be used taking into consideration the importance of this structure in the colonization of riverbanks as well as their role as bridges between shorelines, refuge and protection of aquatic birds, amphibians and fishes. The proposed species were:

Alisma lanceolatum
Alisma plantago-aquatica
Baldellia ranunculoides
Carex hispida
Ceratophyllum demersum
Cynodon dactylon
Cyperus eragrostis
Cyperus longus
Cyperus longus subsp. *badus*
Elatine macropoda
Eleocharis palustris
Epilobium hirsutum
Epilobium tetragonum
Equisetum ramosissimum
Equisetum telmateia
Eryngium corniculatum
Eryngium galioides
Glinus lotoides
Hypericum undulatum
Iris pseudacorus
Isoetes histrix
Isoetes velatum
Juncus acutiflorus
Juncus acutus
Juncus fontanesii
Juncus inflexus
Juncus maritimus
Juncus pygmaeus
Lythrum hyssopifolia
Lythrum junceum
Lythrum salicaria
Marsilea batardae
Mentha cervina
Mentha pulegium
Mentha suaveolens
Narcissus jonquilla
Nuphar luteum
Phragmites australis
Potamogeton nodosus
Ranunculus bullatus
Ranunculus ololeucos
Ranunculus peltatus
Rubus ulmifolius
Scirpoides holoschoenus
Typha domingensis
Typha latifolia
Veronica anagallis-aquatica

Re-inforcement of existing plant populations and establishment of new patches of endangered species

Specific actions will be performed for the endangered taxa *Marsilea batardae*, *Narcissus cavanillesii* and *Digitalis purpurea* subsp. *heywoodii*. New populations of some aquatic macrophytes becoming extinct in the area will be re-established, e.g., *Nuphar luteum*, *Potamogeton nodosus*.

A multidisciplinary approach including zoologists, botanists and foresters is expected to ensure the success of these actions.

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