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Insular endemism in the Mediterranean vascular flora: the case of the Aeolian Islands (Sicily, Italy)

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ABSTRACT The present paper briefly provides the state of the art of the knowledge on vascular plant endemism in the oceanic ("thalassogenous") Aeolian Archipelago (Sicily). Preliminary analysis of distribution areas and review of recent literature on biosystematics of endemic species revealed that: (a) Aeolian strictly endemic taxa are just 6, i.e. about the 0.7 % of the local vascular flora; among them, just 4 can be considered (with doubt) derived from in situ evolution. (b) The other 18 endemics are taxa occurring in wider areas, so they cannot be generally considered "locally evolved" but relicts. This preliminary analysis confirms that not only continental ("chersogenous") but all Mediterranean islands are primarily conservative rather than evolutionary active systems.

KEY WORDS speciation; evolutionary refugia; dispersal; island biota.

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INTRODUCTION

Islands and archipelagoes have long fascinated biologists, primarily because of their unique and somewhat unusual faunas and floras (Thomson, 2005). The emersion of the Aeolian Archipelago (Fig. 1), a volcanic arc separated from Sicily and Italian Peninsula by sea channels of about 1,000-2,000 m depth (Allen & Morelli, 1971), began about 500,000 years b.p. (Calanchi et al., 2007). Despite its relatively "young" age, but maybe thanks to its continuing isolation during the Pleistocene falls in sea level, a fair number of endemic plant and animal species occurs on one or more islands (Lo Cascio & Sparacio, 2010).

Endemism has multiple causes and a diversity of factors can influence variation in range size. Endemic plants are commonly distinguished in two main categories: relicts or newly formed. These two categories are commonly referred to as palaeo-endemic and neo-endemic taxa, respectively (Favarger & Contandriopoulos, 1961), or as Zohary (1973) preferred, primary (active) and secondary (relict) endemism. In the Mediterranean region, islands are for the most part fragments of land that have become isolated due to their separation from continental areas; the few exceptions include the islands originated from submarine volcanic activity, such as the Aeolian Islands. The former are usually known as "continental islands", the latter "oceanic islands", even if a different terminology was proposed by Greuter (1979): namely, "chersogenous" for the former, "thalassogenous" for the latter ones.

In thalassogenous islands, initially, "empty space offers itself for a few newcomers to expand and adapt. The chersogenous islands, to which all Mediterranean islands of an appreciable size belong, already carried their own, fully adapted and diversified flora when they became insular. No empty space could they offer, no special challenges

to new colonists, no new horizons (…). They are conservative systems, remarkably well buffered against the effects of climatic and evolutionary change" (Greuter, 2001). According to this view, the endemic species, occurring nowadays on the thalassogenous Aeolian Islands, are expected to be derived from in situ evolutionary processes. Aim of this paper is to briefly provide the state of the art of the knowledge on vascular plant endemism in this archipelago.

MATERIALS AND METHODS

The current available list of Aeolian vascular plant endemic taxa (Mazzola et al., 2001; Lo Cascio & Pasta, 2004) was verified, according to the more recent available literature (Brullo & Minissale, 2002; Peruzzi & Passalacqua, 2003; Cristofolini & Troia, 2006; Euro+Med, 2006-; Ferro, 2009; Peruzzi & Vangelisti, 2009; Kadereit & Freitag, 2011; Hilpold et al., 2011; Bacchetta et al., 2012), mainly to assess the taxonomic status and the actual distribution area of each taxon. Taxa of doubtful taxonomic value or not endemics were excluded from the revised list.

The resulting strictly endemic taxa were tentatively assigned to one of the two categories: primary (active) or secondary (relict) endemics, these categories better defining the origin of the endemism regardless of its age.

RESULTS

An up-to-date list of the endemic plant taxa occurring in Aeolian Islands was achieved, distinguishing the ones strictly endemic of the archipelago (Table 1) from those endemic of wider areas (Table 2).

Anthemis aeolica Lojac., generally considered a synonym of *A. maritima* L. (Pignatti, 1982; Giardina et al., 2007) but preliminary accepted in some recent works (Greuter, 2006-2009; 2008), was included in Table 1. It was described as an annual plant, occurring just in few small islets near the Panarea island (Lojacono, 1902-1903; Lo Cascio & Navarra, 2003). Considering that in annual *Anthemis* "prevailing mode of speciation (...) is allopatric speciation and local (founder effect) speciation is usually encountered" (Oberprieler, 1998), and that a local endemic species with a similar micro-insular habitat occurs in Aegean area (Georgiou et al., 2006), certainly this taxon of doubtful taxonomic value deserves more attention and further studies.

DISCUSSION AND CONCLUSIONS

The oceanic island ecosystems offer great opportunities for the study of evolution and have for a long time been recognized as natural laboratories for studying evolutionary processes involved in diversification owing to their discrete geographical nature and diversity of species and habitats (Emerson, 2002).

Preliminary analysis of distribution areas and review of recent literature on biosystematics of endemic Tyrrhenian taxa revealed that:

- Aeolian strictly ("narrow") endemic taxa are just 6 (Table 1); considering that Aeolian vascular flora consists of approximately 900 taxa (Pasta, 1997; Privitera et al., 2008; unfortunately, a complete published checklist of the Aeolian flora does not exist), the strictly endemic taxa are just the 0.7 % of the local flora.

- Of these few strictly endemic taxa, just 4 can be considered (with doubt) derived from in situ evolutionary processes.

- Most of the "endemics" (sensu lato) are species occurring in wider areas, or at least in another place outside the archipelago (Table 2); this is a clear clue to consider them secondary endemics. Considering their biology and taxonomic/phylogenetic relationships (but also the young age of the islands, and their relative proximity to other landmasses), it is reasonable to think that - in general - they are not new taxa, evolved in the studied archipelago and then spread outside, but they colonized these islands from other nearby populations; this happened, in one case at least (*Cytisus aeolicus*, Fig. 2, cf. Conte et al., 1998), also for the nowadays strictly endemic species.

- If all the endemics (24 taxa, Tables 1 and 2) are considered, the percentage of plant endemism in the archipelago becomes ca. 2.7 %, a low value but comparable with others concerning Mediterranean islands such as Malta (2.3 %), Balearic Islands (6.5 %) (Médail & Quézel, 1997) or Egadi Islands (5.9 %) and Pelagian Islands (6.1 %) (Mazzola et al., 2001).

- As to Greuter's (2001) view, mentioned in the introduction, both palaeo- and neo- endemics occur

in the thalassogenous/oceanic Aeolian Islands, probably according to random factors related to the biology of the species and the geological history of their habitat.

After this preliminary survey and waiting for further investigations, some conclusions can be made:

1) As already implicitly suggested by Greuter (2001), not only chersogenous but all Mediterranean islands are primarily conservative systems.

Verlaque et al. (1997) also observed that palaeoendemic species may be more prevalent in the endemic flora of Mediterranean islands compared to continental areas. This observation suggests that geographic isolation may be important not just because it promotes genetic differentiation and the

Figure 1. A view of the Aeolian archipelago as seen from the East (from an airliner). Below, the Calabria (Italy). On the left, after the Messina Straits, Sicily with its 3,330 m high Etna volcano. On the right, all the seven main Aeolian islands can be distinguished (photo A. Troia). Figure 2. *Cytisus aeolicus* Guss. It is a palaeoendemic small tree, whose wild populations occur only in the Aeolian archipelago. To stress its isolated taxonomic position, it was put in a monotypic section (sect. *Dendrocytisus*) within its genus (see Cristofolini & Troia, 2006) (photo A. Troia). Figure 3. Strombolicchio, near the island of Stromboli, is one of the several "minor" islets of the Archipelago. "Minor" is said with reference to their size, but they often house very interesting animal and plant species. For example, Strombolicchio houses the only Aeolian population of *Eokochia saxicola* (Guss.) Freitag & G. Kadereit, occurring also (and only) in the Campanian islands of Capri and Ischia (here extinct) and in two recently discovered sites in mainland Campania, near Cape Palinuro (Santangelo et al., 2012); photo A. Troia.

evolution of endemism, but also because it reduces immigration of common species and thereby favours the persistence of endemic species on islands (Thomson, 2005).

2) Geographic distances separating Aeolian Islands from other nearby landmasses may be (and may have been) too small to guarantee an effective "perfect" isolation (cf. Troia et al., 2012); this, cou-

Anthemis aeolica Lojac.	Primary endemic (?)
Centaurea aeolica Guss. ex Lojac. subsp. *aeolica*	Primary endemic (?) (*)
Cytisus aeolicus Guss.	Secondary endemic
Erysimum brulloi Ferro	Primary endemic (?)
Genista tyrrhena Vals. subsp. *tyrrhena*	Primary endemic (?) (*)
Silene hicesiae Brullo & Signorello	Secondary endemic (?)

Table 1. Strictly endemic taxa of Aeolian Islands.
(*) The presence of the same species in two different archipelagoes (Aeolian and Pontine Islands) contradicts its in situ evolution; assuming that the subspecific differences are significant, each subspecies (strictly endemic of a different archipelago) can be considered locally evolved.

ENDEMIC TAXA OF AEOLIAN ISLANDS AND NEAR (N-E) SICILY

- *Dianthus rupicola* subsp. *aeolicus* (Lojac.) Brullo & Minissale
- *Limonium minutiflorum* (Guss.) O. Kuntze

ENDEMIC TAXA OF AEOLIAN ISLANDS AND WESTERN SICILY

- *Ranunculus spicatus* subsp. *rupestris* (Guss.) Maire
- *Seseli bocconi* Guss. subsp. *bocconi*

ENDEMIC TAXA OF AEOLIAN ISLANDS AND TYRRHENIAN AREA

- *Bellis margaritifolia* Huter, Porta & Rigo
- *Carlina hispanica* subsp. *globosa* (Arcang.) Meusel & Kästner
- *Carlina sicula* Ten. subsp. *sicula*
- *Eokochia saxicola* (Guss.) Freitag & G. Kadereit (Fig. 3)
- *Helichrysum litoreum* Guss.
- *Heliotropium suaveolens* subsp. *bocconei* (Guss.) Brummitt
- *Matthiola incana* subsp. *rupestris* (Raf.) Nyman
- *Micromeria graeca* subsp. *consentina* (Ten.) Guinea
- *Ranunculus pratensis* C. Presl

ENDEMIC TAXA OF AEOLIAN ISLANDS AND CENTRAL-WESTERN MEDITERRANEAN

- *Daucus carota* subsp. *rupestris* (Guss.) Heywood
- *Glandora rosmarinifolia* (Ten.) D.C. Thomas
- *Hyoseris lucida* subsp. *taurina* (Martinoli) Peruzzi & Vangelisti
- *Iberis semperflorens* L.
- *Silene turbinata* Guss.

Table 2. Not-strictly endemic taxa of Aeolian Islands.

pled with the relatively young age of the islands and their volcanic instability, may have prevented local (in situ) speciation.

3) Further studies on Aeolian flora are needed.

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