Biodiversity Journal, 2012, 3 (4): 401-406

Biodiversity and evolution of the dendroflora in the Mediterranean

Pasquale Marino[1], Giuseppe Castellano[1] & Rosario Schicchi[2]

[1]Dipartimento di Scienze e Tecnologie Biologiche, Chimiche e Farmaceutiche, Università degli Studi di Palermo, via Archirafi 38 90123 Palermo, Italy
[2]Dipartimento di Scienze Agrarie e Forestali, Università degli Studi di Palermo, via Archirafi 38 - 90123 Palermo, Italy
*Corresponding author:

ABSTRACT Sediment The main old representatives of the Mediterranean dendroflora, their origin and distribution are treated. Relevant threats and strategy for in situ and ex situ conservation are also discussed here.

KEY WORDS Biogeography; dendroflora; endemism; insularity.

Received 11.05.2012; accepted 21.12.2012; printed 30.03.2013
Proceedings of the 1st International Congress "Insularity and Biodiversity", May 11th-13th, 2012 - Palermo (Italy)

INTRODUCTION

The Mediterranean basin is one of the 25 biodiversity hotspots identified at a global level to which the storage is of essential importance (Myers et al., 2000). It is rich in islands of all extensions, from Sicily with its 25,700 square kilometres down to the pebble size of those; other large islands are Sardinia (24,090 sq km), Cyprus (9253 sq km), Corse (8748 sq km), Crete (8258 sq km), Baleares (4,996 sq km), Malta (316 sq km). This basin represents the remnant of the ancient Tethys Sea, a Mesozoic ocean that underwent profound changes during the Alpine orogeny, beginning in the Middle Cretaceous, about 100 Ma (Gradstein & al., 2004), and extending to the late Miocene, about 7 Ma. Palaeoclimatic researchers studying the late Miocene (Messinian, 7.2-5.3 Ma) have identified an event of regional aridity, during which most of the Mediterranean Sea became a marsh (Kovar-Eder et al., 2008). Thereafter, during the Pliocene (5.3-1.8 Ma), the Mediterranean seasonality and the regional cooling accentuated around 4.5, 3.6, 3.2, 2.8 and 2.4 Ma (Suc, 1984; Kovar-Eder et al., 2008; Jost et al., 2009). These climatic oscillations, ending with the Pleistocene glaciations, resulted in the cumulative loss of several thermophilic species from the European continent, as well as in episodic expansions of xerophytic communities (Pignatti, 1978; Suc, 1984; Palamarev, 1989). Palaeoclimatic analysis suggests the establishment of the current Mediterranean climate seasonality, characterized by two intra-annual stress periods for plant growth, in summer and in winter, during at least three climatic crises dated to 3.2, 2.8 and 2.4 Ma (Suc, 1984; Fauquette et al., 1999, 2007; Bruch et al., 2006). By 10,000 BP coniferous forests dominated by Pine and Juniper species were occurring; by 5000 years BP deciduous trees of oak, elm, hornbeam beech etc., were becoming dominant (Willis & McElwain, 2002).

THE MEDITERRANEAN DENDROFLORA: A FOCUS ON ANCIENT WOODY SPECIES

Cupressaceae. This family appeared in the Triassic (200 Ma) with the genus Wriddingtonia that at now only in South Africa occurs. During Eo-

cene (55 Ma) Tetraclinis and *Cupressus* emerged in the Mediterranean dendroflora (Palamarev, 1989). *Tetraclinis articulata* (Vahl) Mast. is the only one taxon of the Callitroideae subfamily that is spread in the northern hemisphere, in Morocco, Southern Spain, and Malta (Fig. 1). The genus *Cupressus* includes *C. atlantica* Gaussen and *C. sempervirens* L. The former occurs in Morocco (High Atlas), the latter in Cyprus, Greece and in the Balkan coasts.

Pinaceae. This family, which appeared in the Mesozoic, about 150 Ma, includes several genera that are among the most important in the forestal Mediterranean landscape: *Abies*, *Cedrus* and *Pinus*. Nine species, one natural hybrid and several varieties of Fir (Vidakovic, 1991) belong to the Mediterranean dendroflora. Palaeoecological studies based on fossil pollen and plant macrofossils show that during the Pliocene (c. 5 Ma) the Mediterranean Basin was covered by vast forest ecosystems, presumably including a common ancestor of the current Mediterranean Firs (Pignatti, 1978; Meyen, 1987; Palamarev, 1989). From this common ancestor, migrations and subsequent population fragmentation led to smaller, isolated Fir forests around the current Mediterranean Basin (Farjon & Rushforth, 1989) (Fig. 2).

The genus *Abies* appears to have undergone significant morphological differentiation that does not necessarily imply reproductive isolation. Infact long-term Mediterranean Basin dryness along a south-eastern to north-western gradient may have started a Miocene-Pliocene speciation sequence. Pleistocene glacial cycles probably forced migrations leading to repeated contact between Fir species in glacial refugia (Linares, 2011). In this context is *A. nebrodensis* (Lojac.) Mattei, very rare with only twenty-four mature individuals (Fig. 3).

Figure 1. Formations with *Tetraclinis articulata* Mast., High Atlas, Morocco.

Speciation of the genus *Cedrus* dates back about 58 Ma. Recent phytogeographic studies have revealed several sites of refuge in the Mediterranean mountains during the Pleistocene (2 Ma) (Svenning & Skov, 2005; Comes, 2004; Hellwig, 2004). Three species belong to the Mediterranea dendroflora:

- *Cedrus atlantica* (Endl.) G. Manetti ex Carrière (Middle Atlas, Morocco) (Fig. 4)
- *Cedrus libani* A. Rich. (Lebanon and Turkey)
- *Cedrus brevifolia* Elwes & Henry (Cyprus)

The genus *Pinus*, the the richest in species among all conifers, was already established in the Cretaceous (145-66 Ma); in the Mediterranean it includes:

- *Pinus halepensis* Mill. (widespread in the basin) (Fig. 5)
- *Pinus nigra* Aiton
- subsp. *nigra* (Central Italy and Balkan area)
- subsp. *calabrica* (Loud.) A. E. Murray (Sicily, Calabria, Corse) (Fig. 6)
- subsp. *salzmannii* (Dunal) Franco (Spain, France)
- subsp. *dalmatica* (Vis.) Franco (Dalmatia)
- subsp. *pallasiana* Lamb. Holmboe (Romany, Greece, Turkey)
- *Pinus pinaster* Aiton
- subsp. *atlantica* Villar (Atlantic coastlands of Spain, France and Portugal)
- subsp. *hamiltonii* (Ten.) Villar. (Pantelleria and Southern Spain)
- subsp. *renoui* (Morocco)

Angiosperms. Angiosperms, of prevalent Tertiary origin, represent the largest group in the world. In the Mediterranean basin they play a very important role in forest and secondary shrub communities showing high levels of specific diversity (e.g. *Acer*, *Quercus*, *Pyrus*, *Malus*, *Ulmus*). Many of these taxa are of remarkable interest. Among these several very remarkable paleoendemics are included, such as *Zelkova sicula* Di Pasquale, Garfì et Quézel, which is confined in two very restricted localities of Sicily (Marino & Spadaro, 2012) (Fig. 7).

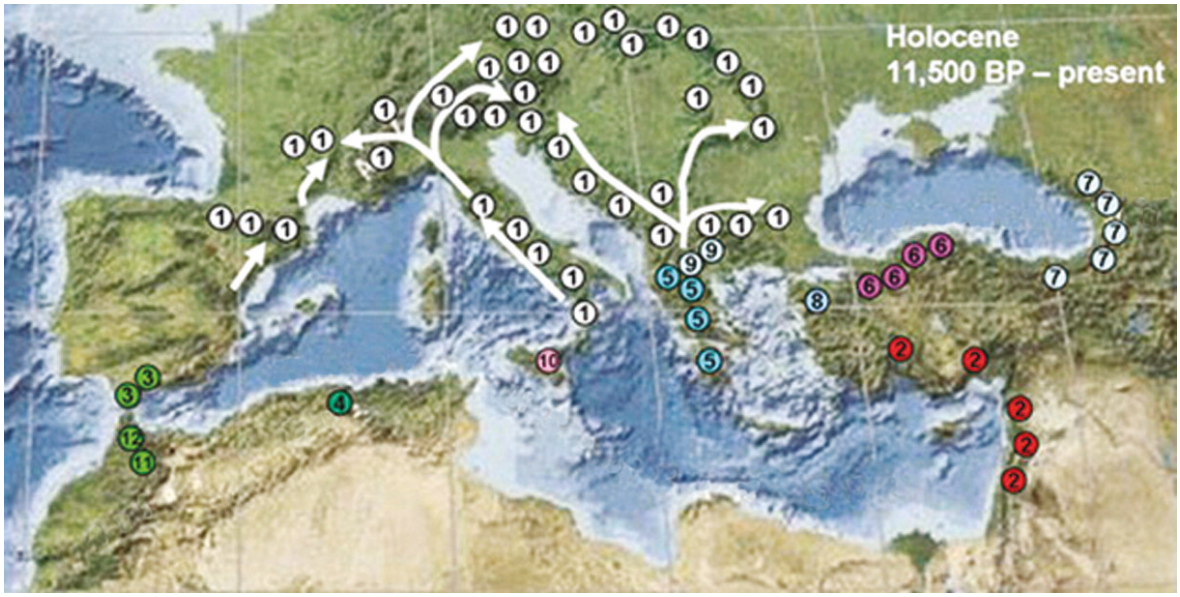

Figure 2. Hypothetical post-glacial expansion of *A. alba* based on molecular data and fossil records, and present distribution and diversity of the Mediterranean *Abies* species (Linares, 2011). 1) *A. alba*; 2) *A. cilicica*; 3) *A. pinsapo*; 4) *A. numidica*; 5) *A. cephalonica*; 6) *A. bornmuelleriana*; 7) *A. nordmanniana*; 8) *A. equi-trojani*; 9) *A. borisii-regis* (*A.* • *borisii-regis* = *A. alba* • *A. cephalonica*); 10) *A. nebrodensis*; 11) *A. pinsapo* var. *maroccana*; 12) *A. pinsapo* var. *tazaotana*.

THREATS

Fire, pasture and invasion of alien plants are the main traits affecting the Mediterranean dendroflora (Table 1). Inclusion of congeneric taxa to the native ones in reforestation projects is the most serious threat of biological pollution and represents an important factor in the genetic erosion (e.g. *Fraxinus excelsior* subsp. *siciliensis* Ilardi et Raimondo and *Abies nebrodensis* in Sicily) (Schicchi & Marino, 2011).

Exotic fauna is another factor dangerous for the wood renoval. A boar of Balkan and its cross in Sicily represent a very threat for biodiversity conservation like in main protected areas.

From the phytopathological point of view the introdution of alien species can be identified as an imprtant source of diseases for the native populations (Schicchi et al., 2008).

DISCUSSION

Mediterranean Islands possess ancient taxa dating back to Triassic (over 200 Ma) since Eocene (55 Ma); these are mainly Gymnosperms like *Abies*, *Cedrus*, *Cupressus*, *Pinus* and *Tetraclinis*. This group suffers the highest risk, due the ecological competition and human threats. A relevant example is represented by *Abies nebrodensis* that in Sicily is located in a restricted area dominated by *Fagus sylvatica* and where several exotic firs were introduced in the past.

Cenozoic flora, also known as Terthiary flora, represent for the Mediterranean area a biggest group of woody species that dominate from the level of sea to the high mountains. *Acer*, *Ulmus*, *Fagus*, *Quercus* are the most important genera. Other taxa are *Pyrus*, *Malus*, *Sorbus* that grow in shrubby vegetation.

Preservation of Mediterranean dendroflora is of vital importance for the future of biodiversity. Human activity has shaped these biological resources but tourism especially can result in destructive deteriorattion. In addition, changing agricultural policies, especially the EU ones, are likely to alterate rural landscapes further.

Conservation strategies of specific habitats on a regional scale is required to preserve biodiversity. In the Mediterranean Islands, strategies for in situ and ex situ conservation are widely shared trough collection of seeds and plants. An important role, improuving conservation strategy, is played by seed

3

4

Figure 3. *Abies nebrodensis* in the native area, Madonie Mountains, Sicily.
Figure 4. A huge *Cedrus atlantica* tree, Middle Atlas, Morocco.

Figure 5. Natural Reserve "Pino d'Aleppo" the only one indigenous station of *Pinus halepensis* in Sicily.

Figure 6. A monumental tree of *Pinus nigra* subsp. *calabrica* in the southern slope of Etna volcano (Sicily).

Figure 7. *Zelkova sicula* in the locus classicus, Iblei Mountains, Sicily.

ISLANDS	AREA (KM^2)	MAIN ENDEMIC ENDANGERED TAXA	THREATS
SICILY	25708	*Abies nebrodensis* *Zelkova sicula*	Pasture, alien sp., fire
SARDINIA	24090	*Pinus pinea*	Fire, human activities
CYPRUS	9253	*Cupressus sempervirens* *Cedrus brevifolia*	Fire, pasture
CORSE	8748	*Pinus nigra* subsp. *calabrica*	Fire
CRETE	8258	*Zelkova abelicea*	Fire, pasture
BALEARES	4996	*Pinus pinaster* subsp. *renoui*	Fire, pasture
MALTA	316	*Tetraclinis articulata*	Fire, pasture

Table 1. Examples of Mediterranean dendroflora taxa and their main threats.

banks and Botanic gardens in the main Islands. These living collections consist centuries of know-how and expertise that now means they play a key role in plant conservation. Many of these activities contribute to ex situ conservation, but botanic gardens also play an important role in in situ conservation.

ACKNOWLEDGEMENTS

University of Palermo Funds are gratefully acknowledged.

REFERENCES

Airoldi Bruch A.A., Utescher T., Mosbrugger V., Gabrielyan I. & Ivanov D.A., 2006. Late Miocene climate in the circum-Alpine realm a quantitative analysis of terrestrial palaeofloras. Palaeogeography Palaeoclimatology Palaeoecology, 238: 270-280.

Comes H.P., 2004. The Mediterranean region - a hotspot for plant biogeographic research. New Phytologist, 164: 11-14.

Farjon A. & Rushforth K.D., 1989. A classification of Abies Miller (Pinaceae). Notes of the Royal Botanical Garden of Edinburgh, 46: 59-79.

Fauquette S., Suc J.-P., Guiot J., Diniz F., Feddi N., Zheng Z., Bessais E. & Drivaliari A., 1999. Climate and biomes in the West Mediterranean area during the Pliocene. Palaeogeography Palaeoclimatology Palaeoecology, 152: 15-36.

Fauquette S., Suc J.-P., Jiménez-Moreno G., Micheels A., Jost A., Favre E., Bachiri-Taoufiq N., Bertini A., Clet-Pellerin M., Diniz F., Farjanel, G., Feddi N. & Zheng Z., 2007. Latitudinal climatic gradients in Western European and Mediterranean regions from the Mid-Miocene (!15 Ma) to the Mid-Pliocene (!3.6 Ma) as quantified from pollen data. Deep time perspectives on climate change: marrying the signal from computer models and biological proxies (ed. by M. Williams, A.M. Haywood, F.J. Gregory and D.M. Schmidt), pp. 481-502. The Micropaleontological Society/The Geological Society of London, London.

Gradstein F., Ogg J., Smith A., Bleeker W. & Lourens L., 2004. A new Geologic Time Scale, with special reference to Precambrian and Neogene. Episodes, 27: 83-100.

Hellwig F.H.A., 2004. Centaureinae (Asteraceae) in the Mediterranean-history of ecogeographical radiation. Plant Systematic and Evolution, 246: 137-162.

Jost A., Fauquette S., Kageyama M., Krinner G., Ramstein G., Suc J.P. & Violette S., 2009. High resolution climate and vegetation simulations of the Late Pliocene, a modeldata comparison over western Europe and the Mediterranean region. Climate of the Past, 5: 585-606.

Kovar-Eder J., Kvacek Z., Martinetto E. & Roiron P., 2006. Late Miocene to Early Pliocene vegetation of

southern Europe (7-4 Ma) as reflected in the megafossil plant record. Palaeogeography Palaeoclimatology Palaeoecology, 238: 321-339.

Linares C.J.J., 2011. Biogeography and evolution of Abies (Pinaceae) in the Mediterranean Basin: the roles of long-term climatic change and glacial refugia. Biogeography, 38: 619-630.

Marino P. & Spadaro V., 2012. Due casi di rarità estrema nella flora siciliana. In: Giardina G. Piante rare di Sicilia (2th Edition). Università degli Studi di Palermo, DAB, pp. 289-291. ISBN 978-88-903108-9-8.

Meyen S.V., 1987. Fundamentals of palaeobotany. Chapman and Hall, London.

Myers N., Mittermeier R.A., Mittermeier C.G., Da Fonseca G.A.B. & Kent J., 2000. Biodiversity hotspots for conservation priorities. Nature, 403: 853-858.

Palamarev E., 1989. Paleobotanical evidences of the Tertiary history and origin of the Mediterranean sclerophyll dendroflora. Plant Systematic and Evolution, 162: 93-107.

Pignatti S., 1978. Evolutionary trends in Mediterranean flora and vegetation. Plant Ecology, 37: 175-185.

Schicchi R., Bazan G., Castellano G., Ilardi V., Marino P. & Surano N., 2008. Piano di Gestione Monti Madonie - Strategie gestionali. Università degli studi di Palermo, CIRITA.

Schicchi R. & Marino P., 2011. Taxa relitti della flora forestale siciliana e problemi di conservazione. Biogeographia, 30: 141-150.

Svenning J.-C. & Skov F., 2005. The relative roles of environment and history as controls of tree species composition and richness in Europe. Journal of Biogeography, 32: 1019-1033.

Suc J.P., 1984. Origin and evolution of the Mediterranean vegetation and climate in Europe. Nature, 307: 429-432.

Vidakovic M., 1991. Conifers, morphology and variation. Zdravko Zidovec, Zagreb, 88 pp.

Willis K.J. & McElwain J.C., 2002. The evolution of plants. Oxford University Press, Oxford, New York, 392 pp.