Summary

Forest Isles of the Campiña of Cádiz (Southern Spain): A floristic approach

The province of Cádiz, located in the southernmost tip of the Iberian Peninsula (SW Europe) separated by the Gibraltar Strait from North Africa, is one of the richest landscapes that may be found in Spain. From the enchanting beauty of the mountain Nature Reserves of Grazalema and the Alcornocales, where the Spanish fir (*Abies pinsapo*) and traces of relict flora of the tertiary period find their last resorts to the thriving and diverse coastal formations (marshes and bays) the province has been extensively studied by scientists for many centuries. But still in our days, part of this countryside, mainly the Campiña that lies between the mountains and the coast, remains partially unknown and may hide similar treasures.

The Campiña landscape is formed by dales and small hills and smooth slopes with an average altitude of 200 to 300 m above sea level, the highest point being the mount Gibalbín (408 m) and the lowest in the flats of the basin of the Guadalquivir river (2 to 4 m) in the east of the province. The geology of the Campiña is mainly composed by tertiary sediments from the Eocene, Oligocene and Miocene with recent alluvial incorporations from the rivers Guadalete, Barbate and Guadalquivir. Many types of soils have developed on these materials, which together with the smooth topography have induced an intense use and transformation of the territory by man. Agriculture, principally cereals, cotton, beetroot, olive and vines, and traditional extensive cattle exploitations, milk and meat cows and the famous bulls of the bullfights, are the actual uses of the Campiña resources. The climate of the area is typically *Csa* Mediterranean with hot dry summers and mild wet winters. Mean annual rainfall range from 600 to 1000 litres and mean annual temperature is between 17 and 19 °C (winter lowest mean temperatures are between 4 and 10 °C). The climax vegetation in this area would be composed mainly by cork oak woodlands (*Quercus suber*) in those sites where the soil tends to be acid and wild olive tree (*Olea europaea* subsp. *sylvestris*) formations where soils are chalky, alkaline and compact.

"Forest isles", fragments of woodlands surrounded by hostile and different environments, remain as interesting pieces of long lost ecosystems which maintain the necessary conditions for the survival of plant and animal species that otherwise would have also disappeared. Their value is increased by the fact that they can serve as passages or ecological corridors, together with the riverside forests, that allow the connection and movements of species from one existing Nature Reserve to another. The aims of this book were to know the location and size of the forest isles as well as the riparian forests still remaining in the countryside of Cádiz, and to make a floristic approach of them paying special attention to the endemic and/or endangered flora that find refuge in them. Complementarily, the fitosanitary state, the capacity of regeneration of the woods and the assessment of some biodiversity indexes were taken into account.

To carry out this project we counted with previous information contained in the vegetation Landcover Map of the Environmental Council (1995 version), from where the fragments with >50% tree cover were selected; a number of record cards filled in by the wardens of the Environmental Council containing brief information about the forest isles that could be found in their counties were also useful. Based on this information, fieldwork was carried out between February and October of 1999 visiting once or twice each fragment cited by the wardens or selected from the Landcover Map. For each type of vegetation a number of 20 m line intercept samples were taken to obtain the objective measures of woody shrub species coverage that allow the assessment of several biological diversity indexes. All this information was recorded in a Data Base at the Environmental Council.

The riparian forests, out of which 32 different sites were visited, presented just a few in good conservation state composed by natural and typical riverside vegetation. The majority of the riverbanks were transformed, reduced or occupied by crops or introduced trees such as *Eucalyptus* plantations. Only the gallery forests of the streams Chapatal and Soto de Castellar, in the West of the province, and the elm woods of the stream Azaden, in the North, can be pointed out for their value.

As many as 263 forest fragments were selected or recorded by the wardens. Out of these, 26 were too small or inaccessible and were eventually ruled out. Another 78 were discarded as they were considered transformed or had disappeared, becoming gardens, suburbs, crops, shrublands or *Eucalyptus* plantations. The remaining 159 fragments were considered forest isles.

Attending to the surface covered by the different types of vegetation, cork oak (*Quercus suber*) forests were the most extensive covering a total of 2007 Ha followed by the pine forests (*Pinus pinea* and *P. halepensis*) with 1815 Ha and the olive tree (*Olea europaea*) forests with 1267 Ha. Mixed forests of cork oak, pine and olive tree, with no predominance of one on other, totalled 356 Ha, holm oak (*Quercus ilex* subsp *ballota*) forests covered 250 Ha and lusitanian oak (*Quercus faginea*) forests presented the lowest surface with only 30 Ha. On the other hand, the pine forests showed the highest number of fragments found (54) followed by patches of cork oak (46), olive tree forests (45), mixed forests (7), holm oak (6) and lusitanian oak (1).

The results of the fieldwork, mainly the line intercept sampling data, allowed the calculation of biological diversity indexes, such as the species diversity, the Shannon-Wiener index, the grade of endemism (GE) and the taxonomic singularity (ST) of the types of vegetation of the forest fragments. A total of 105 line intercept transects were done in the six types of vegetation formations: 51 in the cork oak forests, 33 in the pine woods, 6 in the holm oak forests, 6 in the olive tree formations and 9 in mixed forests.

The holm oak forests showed higher mean values of species diversity (11,83 ±1,94) than the cork oak forests (8,66 ± 2,55) (p=0,01), the olive tree forests (7,8 ± 2,22) (p=0,01) and the pine forests (7,18 ± 1,72) (p=0,001), but the reduced number of samples, due to the scarcity of holm oak fragments, should make these results be approached cautiously. The mean value of Shannon-Wiener index found for all the formations was 1,51 ± 0,3 and no significant differences were found amongst the different formations. The highest value for the grade of endemism (GE) was achieved again by the holm oak forests, with a mean value of 1,8, followed by the pine forests (0,63) and the cork oak forests (0,49). The lowest value was found in the olive tree forests. The taxonomic singularity was similar in all types of formations, the lowest value found for cork oak forests (0,37 ± 0,09) and the highest for the olive tree forests (0,51 ± 0,06). The mean height of the shrubs was negatively correlated to the species richness (r = -0,20, p=0,041), thus the communities with higher number of different species present lower shrubs. On the other hand, there was a positive correlation between the height of the shrubs and the taxonomic singularity (ST) (r =0,32, p= 0,001) which means that the small shrub communities are composed by genera containing many species (i.e. *Thymus, Teucrium, Cistus*), while the tall shrub communities would be composed by genera which contain a small number of different species (i.e. *Pistacia, Arbutus, Phyllirea*).

Although there was a great floristic homogeneity among the different types of vegetation, the ordination by correspondence analysis (CA) of the line intercept transects demonstrated that certain differences can be found related mainly to the type of soil they grow on. The holm oak and cork oak forests would be placed on the positive CA 1 axis although separated due to the composition of the undergrowth (calcicolous in the case of the holm oak woods and silicicolous with more or less abundance of heathers and *Cistus* in the cork oak forests). The olive tree forests would stand between the two previous forests, as they share part of the woody shrubs of either of them, but are more thermophyllous and have more abundance of *Pistacia lentiscus.* Mixed forests and pine forests are on the negative end of the CA 1 axis, as they develop principally on sands and sandstones. Pine forests would present a higher floristic similarity with cork oak woods, with some differences caused by the coastal influence. But in fact, they spread along the whole gradient of the axis CA 1 which may be interpreted as the result of pine woods substituting ancient domains of both, cork oak and holm oak woodlands. These results are in accordance with other studies which relate the distribution pattern of vegetation to environmental variables, where the nature of soils and altitude also were considered the main factors in the determination of the floristic composition, at least in some plant communities in southern Spain.

In absolute values, the township with higher surface covered by forest isles was Vejer de la Frontera with 958 Ha, followed by Arcos de la Frontera (885 Ha), Medina Sidonia (741 Ha) and Jerez de la Frontera (616 Ha). But in relative values, taking into account the surface of the township, although Vejer de la Frontera is still first, townships such as San José del Valle, Puerto Real, Chiclana or San Roque showed higher values than Arcos de la Frontera, Medina Sidonia or Jerez de la Frontera.

The floristic results of the fieldwork revealed the existence of many threatened, vulnerable and rare plant species that found refuge in these forest fragments. Part of the valuable information gathered in the project are the list of endangered taxa collected: seven threatened or endangered (*Arenaria algarbiensis, Ononis leucotricha, Ononis azcaratei, Eryngium corniculatum, Thymus albicans, Linaria munbyana* var. *munbyana* and *Anthemis bourgaei*) and fourteen vulnerable ones (*Juniperus oxycedrus* subsp. *oxycedrus, Juniperus phoenicea* subsp. *turbinata, Armeria macrophylla, Biscutella lyrata, Xolantha commutata, Xolantha echioides, Fumana juniperina, Drosophyllum lusitanicum, Frangula alnus* subsp. *baetica, Sideritis perezlarae, Gallium concatenatum, Centaurea aspera* subsp. *scorpiurifolia, Hymenostemma pseudoanthemis* and *Klasea monardii* ; and seven rare species, *Limonium echioides, Armeria hirta, Pistorinia brevifolia, Stauracanthus genistoides* subsp. *genistoides, Mercurialis elliptica, Guillonea scabra* and *Scrophularia laxifolia*).

Also three taxa found in the forest isles, *Thymelaea pubescens* subsp. *elliptica, Antirrhinum graniticum* subsp. *onubensis* and *Sparganium erectum* subsp. *neglectum* were found for the first time in the province of Cádiz and a high number of species, known to the coasts and mountains of Cádiz, were also cited for the first time to this countryside of the Campiña.

Amongst the 159 studied forest isles some should be pointed out, from a floristic point of view, as they are sites that shelter these endemisms and threatened taxa or they hold plant communities in a relatively pristine state (number in brackets refers to identification in the maps): La Cañada de Manzanete (192), La Herradura (193), Libreros (186) and Las Cabañas (221) in the township of Vejer de la Frontera; Pinar de Miguel Guerra (202) in Chiclana de la Frontera; La Guita (97) and the pine forest nº 96 in Jerez de la Frontera; Pinar del Rey (208) and Guadalquiitón (209) in San Roque; Dehesa de las Yeguas (54), Los Ojuelos (87) and the fragment nº 56 in Puerto Real; Dehesa de Malduerme (107 y 109) in San José del Valle; El Hundido (139) in Medina Sidonia; la Huerta del Lobo (6) in Arcos de la Frontera; and Loma de los Castillejos (31 y 32) in Villamartín and Prado del Rey.