Challenges to the conservation of biodiversity on small islands: the case of the Maltese Islands

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Abstract

The conservation of biodiversity on small islands is fraught with challenges, most of which do not apply to mainland areas, and which are borne of characteristics unique to islands. These include a disproportionate coastal extent, anomalously high rates of endemicity and species richness, high degrees of genetic distinctiveness exhibited by biota as a result of their physical isolation. This is coupled to a high degree of anthropogenic disturbance facing island biota and to the high economic importance of coastal-based tourism on islands. This combination in turn translates in a pronounced fraction of island biota being considered as endangered and in islands being considered as biodiversity priorities. The Maltese Islands are located in the Mediterranean Basin, which in itself is already considered as a biodiversity hotspot, and present a case study of intense anthropogenic impacts on a rich biodiversity.

Keywords: Biodiversity, islands, conservation, Mediterranean

Introduction

The challenges and needs faced by small island developing states (SIDS) in pursuing sustainable development are widely recognised. It has been on the international agenda since the early 1990s, beginning with the United Nations Conference on Environment and Development or the Earth Summit at Rio de Janeiro in 1992. Ever since the signing of the Convention on Biological Diversity (CBD) at the Rio Earth Summit in 1992, the dire need for conservation of biodiversity has gained traction, transcending the conventional confines of scientific study and appeals and receiving international attention. An example of the degree of international exposure that the issue is receiving is the declaration of 2010 by the United Nations as the International Year for Biodiversity, in the wake of the 188 CBD contracting parties pledging, on the 19th April 2002 at The Hague in the Netherlands, to the 2010 Biodiversity Target. This target, which contemplates a reduction in the rate of biodiversity loss, was incorporated in 2007 in the Millenium Development Goals.

One outcome of CBD that specifically address to islands is the Global Island Partnership (GLISPA) that "assists islands in addressing one of the world's greatest challenges: to conserve and utilize the invaluable island natural resources that support people, cultures, and livelihoods in their island homes around the world". At its COP7 in Kuala Lumpur in February 2004, it was decided to establish a thematic programme of work on Island Biodiversity, with an ad hoc technical expert group in Canary Islands (Spain) in December 2004 (Orueta, 2009). Subsequently, the Island Biodiversity Programme of Work, aiming to implement the CBD objectives on islands, was adopted at COP8 in Brazil, March 2006. As of 2004, the IUCN Regional Office for pan-Europe hosts the

Countdown 2010 Secretariat which facilitates and encourages action, promotes the importance of the 2010 Biodiversity Target and assesses progress towards its realization. Chapter 17 of Agenda 21, encapsulates the challenges faced by SIDS in conserving their natural resources by stating that “Small island developing States have all the environmental problems and challenges of the coastal zone concentrated in a limited land area.”

Ever since the publication in the 1960’s of the theory of island biogeography by McArthur and Wilson, biodiversity assets on islands have received increasing attention. The global island human population is estimated to constitute ca. 10% of the world’s population (UNEP Island Directory), with 169 islands having a population of over 100,000, of which 15 have a population of over 1 million (various population censuses). In Europe alone, there are around 500 islands larger than 20 km^2, which add up to more than 70000 km^2, which in turn is equivalent to 7% of the total surface of Europe. With almost 5000 islands and islets, the Mediterranean comprises one of the largest group of islands in the world (Delanoe et al., 1996). Strategically located at the very centre of this sea, the Maltese Islands can be considered as the quintessential Mediterranean archipelago, reflecting in microcosm many of the human-biodiversity relations observed elsewhere in the Basin. Ever since their human colonisation ca. seven thousand years ago (Cassar, 1997), the biodiversity assets of the Maltese Islands have been subjected to unrelenting anthropogenic pressure, first in the form of clearance of natural habitats for agricultural and grazing purposes, and subsequently in the form of expansion of human settlements which led to progressive urbanisation. This predicament is acknowledged in the Island Directory, compiled by UNEP, is one of the few global initiatives (along with the GIN – Global Island Network – which includes partners such as the IUCN and the CBD) aiming to quantify biodiversity assets and anthropogenic pressures on islands. The same directory (which is grossly outdated, being last updated in 1990) ranks the Maltese Islands, along with Bermuda, Mauritius and New Caledonia, as one of the SIDS where natural resources are most at risk, as a consequence of a high Human Impact Index Value and a high Terrestrial Conservation Importance Index.

This study aims to compile a comprehensive list of challenges specifically facing the conservation of biodiversity on small islands, adopting the Maltese Islands as a case study.

Results and Discussion

Small islands are generally repositories of high species richness and endemism counts, mainly borne out of their physical isolation from the mainland which renders them ideal crucibles for novel adaptation strategies by biotic populations which in turn is a well-recognised speciation factor. An additional cause for such anomalous richness of biodivesity on islands could be the habitat heterogeneity posed by small islands, with different habitats juxtaposed within relatively small areas. Using the Maltese Islands as an example, the protected area of Dwejra on the island of Gozo covers a miniscule area – 8km^2 – but features shingle beaches, a watercourse and associated valley ecosystem, a freshwater wetland, coastal garigue, rupestral assemblages along cliffs, rocky shores and a whole suite of infralittoral biocoenosis ranging from submarine caves to vertical walls to sciaphilic assemblages and seagrass meadows.

Small islands cover just 5% of the global land area; yet around one-third of all the world's threatened mammals, birds and amphibians are found only on islands. Not surprisingly, islands represent from one-quarter to one-half of all biodiversity conservation priorities, depending on the measure used (da Fonseca et al., 2006). Roughly 20% of all the world's vascular plant diversity and 15 percent of all the world's mammals, birds, and amphibians are found only on islands (Conservation International, 2006). Citing a few specific examples, the Seychelles are home to the highest number of endemic amphibians in the world, ca. 90% of Hawaiian biota is endemic to the archipelago and more than 8,000 endemic species have been recorded from the island of Madagascar alone (du Puy, 2004).

In view of its high species richness counts and rates of endemism, the Mediterranean was listed amongst one of the world's first 25 Global Biodiversity Hotspots (Myers et al., 2000). In fact, the Basin is estmated to house ca. 22,500 vascular plant species, which equals four times the number of similar species found in the rest of Europe (Sustainable Forestry Initiative, 2010). Of these, ca. 11,700 species are though to be endemic. 2 out of 3 amphibian species are endemic, as well as half of the crabs and crayfish, 48% of the reptiles, a quarter of mammals, 14% of dragonflies, 6% of sharks and rays and 3% of the birds (IUCN reference). Ca. 19% of all vertebrates and dragonflies are considered to have a threatened status and at least 16 endemic species have gone extinct from the Mediterranean Basin (Cuttlelod et al., 2008). More than 8500 species of macroscopic marine organisms have been recorded from the Mediterranean Sea, corresponding to somewhat between 4% and 18% of the world marine species. Despite covering less than 1% of the world's ocean surface area and less than 0.5% of the world's ocean volume, the Mediterranean is endowed with ca. 18% of the global number of marine macrophytes (Bianchi & Morri, 2000). Likewise, Mediterranean islands are a hotspot for many plants and invertebrates. In the Canary Islands, up to 70% of some taxa, like coleopters, are endemic (Machado 1998). Almost 12% of Corsican flora is endemic and endemic plants constitute 10% and 7% of the flora in Crete and Cyprus respectively.

The skewed biodiversity assets on islands and the long history of human colonisation of the same islands translates itself in an overtly high percentage of species on islands which are threatened or endangered. One-fifth of the world's threatened amphibian fauna (348 species), one-quarter of the world's threatened mammals (279 species), and more than one-third of all the world's threatened birds (462 species) are endemic to island biodiversity hotspots (Mittermeier et al., 2004). It is estimated that 30% of known threatened plant species are endemic to such islands, and 23% of bird species found on these islands are threatened (Nurse *et al.*, 2001). A total of 115 floral and 28 faunal species are reported as extinct from the Maltese Islands, with an additional 260 floral species being considered as endangered, rare or vulnerable (Schembri et al., 2002). The figures for specific habitats are even more sobering. For example, in the Maltese Islands, only 24% of sand dune-specific plant species are considered to be frequent, with a staggering 94% of the same species being on the decline (Stevens, 2001).

The biodiversity prowess of small islands is acknowledged in the Barbados Declaration, adopted in 1994 by States participating in the Global Conference on the Sustainable Development of Small Island Developing States. The Declaration states that ˝Their (Small Island Developing States – SIDS) biodiversity is among the most threatened in the world and their ecosystems provide ecological corridors linking major areas of biodiversity around the world. They bear responsibility for a significant portion of the world's oceans and seas and their resources." The Declaration was adopted, along with the Barbados Programme of Action (BPOA), at the 22nd Special Session of the United Nations, with the latter recommendations for small developing island states in fourteen fields, including biodiversity. In the wake of the BPOA, the South Pacific Applied Geoscience Commission (SOPAC) developed an Environmental Vulnerability Index (EVI) which was presented to the Mauritius International Meeting on 12 January 2005, and within which different biodiversity measures are entrenched. Chapter 17 of Agenda 21 also pays tribute to the rich biodiversity on islands, by stating that "Their (SIDS') geographic isolation has resulted in their habitation of a comparatively large number of unique species of flora and fauna, giving them a very high share of global biodiversity.' Conservation efforts, or at least their pledge, also take stock of the biodiversity richness on islands. In fact, globally, 31% of priority areas for protected area expansion are sited on islands (Rodrigues *et al*., 2004). Priorities for biodiversity conservation on islands suffer however from a skewed distribution. In fact, for biodiversity hotspots, one of the ten island hotspots is in the Neotropics (Caribbean) and another in Africa (Madagascar and the Indian Ocean Islands), but all the remaining eight are situated in the Asia-Pacific region (de Fonseca et al., 2006), with none being sited in the Mediterranean region.

The Maltese Islands harbour 23 endemic floral species and ca. 60 endemic faunal plant species (Schembri, 1994). The total number of non-marine species described to date from the islands totals around 2,400, although the total number of such species on the islands is expected to be in the region of 5,000 species (Schembri, 2006; Schembri et al., 1999, 2002). The total number of floral species from the islands hovers around 1,200 species (Schembri et al., 1999, 2002).

Geographic isolation of archipelagii also translates itself into a higher proportion of endemic monotypic genera – i.e. genera characterised by a single species – two of which, *Cremnophyton* and *Palaeocyanus*, are known from the Maltese Islands. These genera are, in most cases, relics of the pre-glacial period, better known as paleoendemics. The detachment of island biotic populations from mainland ones can be viewed as a form of allopatric speciation, in which the single mother population becomes fragmented into a number of small ones between which genetic drift is restricted. This process results in progressively higher degress of genetic distinctiveness amongst island biotic populaitons and thus bestows upon these populations a higher conservation importance. In fact, islands are useful in biogeography since represent a 'worst-case' scenario for habitat fragmentation in view of their being isolated for far longer periods of time and by greater distances than most mainland habitats fragmented by human activities. Additionally, water barriers present a greater obstacle to immigration by terrestrial inhabitants, intensifying the effective isolation of an island compared to similar distances between mainland fragments (Rubinoff & Powell, 2004).

In addition to the well documented case of Darwin's finches from the Galapagos Islands, several other cases from the Mediterranean have been recorded, including those of shrew, killifish and mollusc species. The extinct Pleistocene shrew species, *Crocidura esuae*, predated human occupation of the Maltese Islands (Schembri, 1994), which eventually gave rise to two separate shrew species – *Suncus etruscus* and *Crocidura sicula.* The latter is a Siculo-Maltese endemism, with the Maltese population being identified as the sub-species *calypso* in view of its distinct morphological characteristics. Studies (e.g. Tigano et al., 2006) have shown that Maltese populations of the killfish *Aphanius fasciatus* are morphologically and genetically distinct from their Sicilian and North African counterparts. The biogeographic affinities of a number of clausilliid (gastropod) species are a further example of the complex population fragmentation opportunities posed by islands. Different tectonic events, resulting in dramatic changes in regional sea level over time, resulted in the Maltese Islands, the Pelagian Islands and Sicilty being alternatively joined as a one landmass and being disjointed as separate islands. This resulted in different episodes of colonisation by door snail species, such as those belonging to the *Muticaria* genus, which eventually developed in isolation from the parent population, giving rise to three separate species – *Lampedusa lopadusae* (endemic to the islands of Lampedusa and Lampione), *L. imitatrix* (endemic to the islands of Malta and Filfla) and *L. melitensis* (endemic to the island of Malta) – all derived from the single invading *Muticaria* species (Thake, 1985; Giusti, 1995).

Such a fragmentation also occurs between populations dispersed across different islands of an archipelago. Examples demonstrating this phenomenon include the Maltese Everlasting – *Helichrysum melitense* – which is endemic to cliffs along the western coastline of the island of Gozo only, within the Maltese archipelago – and the Maltese wall lizard – *Podarcis filfolensis* – which species endemic to the Maltese archieplago and the the Pelagian islands of Linosa and Lampione but for which four different sub-species exist on different islands and islets of the Maltese archipelago.

Islands, as dictated by their physical physiognomy, are endowed by disproportionately long coastal stretches. The coastline of the Maltese Islands stretches for 271km, resulting in a coastline/terrestrial area ratio of 0.86. The corresponding figures for Cyprus (a significantly larger island than those of the Maltese archipelago) and for Spain (whose terrestrial extent dwarfes the Maltese archipelago) are 0.07 and 0.01, respectvely, underpinning the fact that the smaller the island, the higher the relative fraction of coastal extent. Coasts are considered by ecologists are ecotones, defined as transition zones between two adjacent biomes. Consequently, coasts are bequeathed with a high conservation importance in view of the heterogenous suites of species and habitats they harbour. The preponderance of coastal habitat on islands in turn translates itself in a high susceptibility to climate changes impacts, including erosion and inundation of low-lying areas which might constitute areas of conservation importance, such as turtle nesting beaches, coastal vegetated wetlands and mangroves (Mimura et al., 2007).

Climate change has been evoked in the mediation of a number of other biodiversity-related impacts, including the spread of pathogens affecting particular species (including coral and oyster species – Harvell et al., 2002) and the facilitated spread of alien (non-indigenous species). The spread of invasive alien species (IAS) beyond their native ranges has been identified as one of the most pressing threats to global biodiversity. In fact, the IMO (International Maritime Organisation) lists the environmental impact of invasive marine species as one of the four major threats to the world's oceans (IMO, 2000-2007). The IUCN ranks such a threat on the same footing as habitat degradation and EU is considering adopting a pan-European strategy on IAS. Biodiversity on small islands exhibits a higher susceptibility to being outcompeted by invasive, non-indigenous species. This is attributable to the fact that islands present a number of features which are highly congenial for spread of alien species, including (1) the absence of natural enemies and (2) the presence of an ecological niche which is not fully occupied (Di Castri, 1990). For example, many island endemics have reduced behavioural defenses relative to their ancestral continental forms, including the loss of ability to fly, reduced aggressiveness, and ground nesting (Diamond, 1991).

In the Maltese Islands 18 percent of the plant species so far identified may be classified as alien. Of these, approximately 3% are possibly native, 1% was introduced more than 500 years ago, while approximately 3% are known to be invasive (MEPA, 2006a). Of these, a number of insidious alien floral species have colonized vast terrestrial swathes of the Maltese Islands, with some of these species being introduced willfully by man whilst others were introduced accidentally. These include the Cape Sorrel (*Oxalis pes-caprae*), introduced accidentally in the beginning of the nineteenth century from South Africa (Henslow, 1891), and which carpets steppic, abandoned agricultural and rubble wall sites, having spread to date along the entire Atlantic coastline of Europe up to the UK; *Aster squamatus*, probably the most successful "weed" species in the Maltese Islands, introduced towards the 1930's (Schembri & Lanfranco, 1996) and preferring sheltered and humid soils such as those found along watercourses; the Castor Oil Plant (*Ricinus officinalis*), introduced willfully for ornamental purposes and highly invasive within riparian (valley) ecosystems; the tobacco plant (*Nicotiana glauca*), also introduced for ornamental purposes and currently synonymous with disturbed habitats and mounds of rubble.

The Maltese Islands and the Mediterranean region in general have a long history of human-mediated biotic introductions. Archeophytes are defined as floral species introduced willfully by man for agricultural or ornamental purposes in antiquity (i.e. predating 1492, the discovery of the Americas) and which have become naturalized, with examples including the prickly pear (*Opuntia ficus-carica* – native to Mexico), the carob tree (*Ceratonia siliqua* – native to the Middle East) and the giant reed (*Arundo donax* – native to Turkey). Generally, undisturbed ecosystems are inherently resistant to invasion by exotics (Di Castri, 1990). However, this capacity is severely reduced in ecosystems which are disturbed, especially if the disturbance is rapid and frequent (Di Castri, 1990). The promulgation of non-indigenous species on the Maltese Islands can thus be considered as symptomatic of the high degree of human disturbance on the islands.

Different islands adopt different strategies with respect to the introduction of non-indigenous species. Differences in assessing the ecological impact of *Carpobrotus edulis*, commonly known as the hottentot fig or the iceplant, a native of South Africa and considered as an alien species in many parts of the world, including Australia and Europe, is a case in point. *C. edulis* forms impenetrable mats and competes aggressively with native species, threatening rare and endangered species. This prompted the European Commission in 2001 to approve the LIFE Nature proposal for the *Conservation of areas with threatened flora in the island of Minorca,* whose main objective was the eradication of the exotic plant species from the island. Conversely, on the island of Malta, landscape consortia still strenuously defend the planting of the species along roadsides and in public gardens, which has resulted in the species establishing itself in the wild such as within rupestral communities along cliffs.

Human well-being on most small islands is heavily reliant on ecosystem services such as amenity value and fisheries (Wong et al., 2005). On islands subject to a general dearth of natural resources, such as most Mediterranean islands, including those of the Maltese archipelago, a greater economic reliance on service industries, such as tourism, is evident. The higher economic dependance of small islands states than larger states on tourism (Ellul, 1999; McElroy & Olazarri, 1997; Liu & Jenkins, 1995; Hein, 1990 and UNCTAD, 1990) might stem from the comparative advantage that islands tend to have in tourism-related activities. (Briguglio & Brigulio, 1996). Mediterranean islands face a greater gauntlet from tourism by virtue of their location within a basin which the world's leading tourism destination. In fact, international tourist arrivals in the basin totalled 220 million, with the figure set to mushroom to 350 million, according to some estimates, by 2020 (WTO, 2001). Tourist receipts in 1999 surpassed the 130 million US$, which is equivalent to 1/3 of global tourism receipts.

The two island states of Cyprus and Malta are the only two European countries where tourism accounts for more than 20% of export earnings (Hoti et al., 2007) and the top two European countries in terms of tourism intensity (i.e. the number of nights in collective tourist accommodation divided by the number of inhabitants) for the share of national employment in tourist accommodation (Eurostat, 2007). With over 1 million annual tourists, the Maltese Islands experience one of the highest tourist arrival densities in the world. Most of the tourism pressure on small islands is exerted along the narrow coastal fringe. Statistics from the Maltese Islands amply testify to this statement. For example, in 2009, 37% of all tourist arrivals in the Maltese Islands were concentrated during just the three summer months (July-September – National Statistics Office [NSO] 2009 data), which corresponds to the main bathing season; of these tourists, 85% stated that they frequent coastal areas, namely sandy beaches and/or rocky shores (Ministry of Tourism, 2001). 96% of the accessible coastline in the Maltese Islands is developed, dominated by tourism, shipping or other industries (Anderson & Schembri, 1989), whilst 21% of the total coastline of the islands no longer retains its natural features (MEPA, 2006b).

Reference will be made to two ad hoc biodiversity conservation strategies from the Maltese Islands which give an insight to the caveats facing conservation of biodiversity on small islands and on the lack of circumscribed action taken in this sense. The parasitic plant *Cynomorium coccineum* (Malta fungus) is a red plant which derives nourishment from the roots of a number of leguminous plants and which is distributed along the North African coast, the Middle East and Central Asia. The plant is known from just one site in the Maltese Islands – Fungus (or General's) Rock and it enjoyed the status of a highly prized commodity, by virtue of its putative medicinal properties, since the sixteenth century. The Knight of St. John presented the plant to dignitaries visiting the island and guarded jealously the plant from marauders by posting permanent surveillance on the nearest mainland in form of stationed soldiers and imposed stiff penalties on defaulters, including a prescribed period of forced labour on galleys of the Order.

A precious coral industry existed in the Maltese Islands ever since the first century BC (Busuttil, 1971), with coral fragments being unearthed in Phoenician remains known as Tas-Silg dating back to the same period (Quercia, 2002). Different precious coral species have been fished over the millenia from Maltese waters but stangely no scientific stock assessment data and accurate distribution data on populations of the same species in Maltese coastal waters exists. Despite this, black (*Antipathes* spp.) and red (*Corallium rubrum)* coral is stricly protected in the Maltese Islands, suggesting that such conservation is mainly motivated by precautionary action rather than scientific data.

Whilst most historical extinctions have taken place on islands, leading to the near-complete extermination of some island's biodiversity (Easter Island is an infamous example), most species currently facing high extinction risk are continental (Ricketts et al., 2005). Hence, island biodiversity conservation projects can provide hindsight to address biodiversity conservation challenges on the mainland.

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