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THE MALTESE ISLANDS: CLIMATE, VEGETATION AND LANDSCAPE

by

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Abstract

The Maltese Islands, situated in the central Mediterranean, occupy an area of only some 316 km^2. The climate is typically Mediterranean: the average annual rainfall is c.530mm of which some 85% falls during the period October to March; the mean monthly temperature range is 12-26°C, and the islands are very windy and sunny. Although small, the Maltese Islands have a considerable diversity of landscapes and ecosystems which are representative of the range and variety of those of the Mediterranean region.

The islands are composed mainly of limestones, the soils are young and are very similar to the parent rocks, and there are no mountains, streams or lakes, but only minor springs; the main geomorphological features are karstic limestone plateaux, hillsides covered with clay taluses, gently rolling limestone plains, valleys which drain runoff during the wet season, steep sea-cliffs on the south-western coasts, and gently sloping rocky shores to the Northeast. The main vegetational assemblages are maquis, garigue and steppe; minor ones include patches of woodland, coastal wetlands, sand dunes, freshwater, and rupestral communities; the latter are the most scientifically important in view of the large number of endemic species they support. Human impact is significant. Some 38% of the land area is cultivated, c.15% is built up, and the rest is countryside.

The present landscape is a result of the interaction of geology and climate, coupled with the intense human exploitation of the environment over many thousands of years, which has altered the original condition of the vegetation cover, principally through the diversion of vast tracts of land to cultivation, the construction of terraces, water catchment devices, irrigation channels and drainage ditches, the grazing of animals on uncultivated land, and the development of land for buildings and industry. The scantiness of the soil, combined with the erratic rainfall and the periodic disturbance of the vegetation cover, has resulted in extensive erosion. As a consequence it is now difficult for the original vegetation to reassert itself, affecting the landscape drastically and permanently. Much of the original native flora has been lost or marginalised and the present day non-urban landscape is now dominated by vegetation consisting mainly of ruderal and introduced species. As the population increases, and human pressure on the environment mounts, such trends are likely to continue and it is only very recently that some important initiatives have been taken to manage the environment and halt the deterioration of the landscape.

Introduction

Climate, vegetation and landscape are inextricably linked to each other. Plant growth depends primarily on the availability of light, water, carbon dioxide and mineral nutrients, all of which are under the control of climate. Climate, therefore, has a profound effect on the development of vegetation. At one level, it determines which species grow where, on the basis of their physiological tolerances to physico-chemical factors. At another level, it interplays with such biotic factors as competition, grazing pressure and other forms of predation, and mutualistic interactions, to shape the species composition of individual community types. In turn, the vegetation is an important component of the landscape.

Climate also has a direct effect on the landscape since it affects both erosion and deposition, while these processes determine which types of plant life can occur in a given area since they give rise to the physical medium in which the plants grow. The relationship between climate, vegetation and landscape is particularly well illustrated in the Mediterranean area. This region has a characteristic climate usually defined as being extra-tropical, with seasonal and daily photoperiodicity, with rainfall concentrated in the cold or relatively cold seasons of the year, and with a hot, dry summer (Emberger, 1954); other definitions exist, however (see Quézel, 1985). This type of climate is not confined to the Mediterranean region but also occurs in other parts of the world, namely: California, southern Chile, the Cape Province region of South Africa, parts of southern Australia, parts of western Pakistan and the Caspian Sea (Nahal, 1981). In all these places the vegetation is more severely limited by the availability of water than any other factor, and especially by the pronounced seasonality in the distribution of rainfall, which is probably more important than the actual amount of rain falling in any given year. This climatic regime results in a vegetation that has a more or less similar structure in all regions with the Mediterranean type of climate, although of course, different species are involved. For this reason some phytogeographers recognise a distinct Mediterranean biome characterised by evergreen trees and shrubs with thick-skinned leaves adapted to reduce water loss.

In the Mediterranean region itself, this type of vegetation is known as sclerophyllous scrub. It is the highest type of vegetation that can exist in equilibrium with the climate and is the end product of a well defined successional series. This series consists of highly characteristic seral communities with a very rich assortment of evergreen trees and shrubs, lianas, herbaceous perennials and annuals, whose main growth occurs in autumn and in spring, the two periods of the year when there is adequate water and the temperature is neither too hot nor too cold (Polunin & Walters 1985). The Mediterranean flora comprises some 25,000 different species (Quézel, 1985). The flora is so diverse because the climatic climax is actually present in only very few places. In much of the region, a variety of natural and anthropic factors result in a whole series of seres, subclimaxes, edaphic climaxes and disclimaxes (Ruiz de la Torre, 1985). Agriculture adds another suite of vegetational assemblages ranging from completely anthropogenic to semi-natural ones (Pons, 1978). Natural and agricultural assemblages intergrade as some wild plant species have come to form an integral part of agro-ecosystems. In most Mediterranean countries, therefore, the landscape is a rich and complex mosaic of different types of vegetational assemblages. Within each, a multitude of regional and local variants exist such that it is practically impossible to give a general account of Mediterranean vegetation; indeed, the term 'Mediterranean', whether applied in its geographical, climatic or floristic sense is somewhat misleading since it implies unity, whereas in practice it is very difficult to define (Quézel, 1985). On the other hand, given their position in the central Mediterranean, the Maltese Islands provide a good example of the range and variety of the Mediterranean vegetation, both that forming part of the climatic successional sequence, as well as that associated with particular environmental conditions. The rest of this article will describe the Maltese vegetation and its relationship with the landscape.

The Maltese Islands: geography, geology and geomorphology

The Maltese Islands are a group of small, low islands aligned in a NW-SE direction and located in the central Mediterranean approximately 96 km from Sicily and 290 km from North Africa. The Maltese archipelago consists of three inhabited islands: Malta (245.7 km^2), Gozo (67.1 km^2) and Comino (2.8 km^2) together with a number of small uninhabited islets (each less than 10 ha). Further information on the geography of the Maltese Islands may be found in the works of Bowen Jones et al. (1961), Nehring (1966), Biagini (1974), Miossec (1980) and Ransley & Azzopardi (1988).

The geology of the Maltese Islands has been extensively studied and good reviews are provided by Hyde (1955), House et al. (1961), Felix (1973), Pedley et al. (1976, 1978) Zammit Maempel (1977), Bosence et al. (1981) and Bosence (1990). The islands are composed almost entirely of marine sedimentary rocks, mainly limestones of Oligo-Miocene age (30-5 million years BP). There are also some minor Quaternary deposits of terrestrial origin. The geology of the islands is overall quite simple, consisting of five main types of rocks in a basic layer-cake arrangement as follows (in order of decreasing age):

> Lower Coralline Limestone which is exposed to a thickness of 140m. This is the oldest exposed rock type in the Maltese Islands and it started being laid down between 30 and 25 million years ago.
>
> Globigerina Limestone which is exposed to a thickness ranging from 23m to 207m and is subdivided into three units (Lower, Middle and Upper Globigerina Limestones) by two ubiquitous nodule beds.
>
> Blue Clay which is exposed to a thickness of up to 65m.
>
> Greensand which is exposed to a maximum thickness of 12m, but in most places this formation only attains a thickness of some 1m.
>
> Upper Coralline Limestone which is exposed to a thickness of 162m. This formation is a complex association of limestones. In some areas, the uppermost parts show evidence of an intertidal or even supratidal depositional environment and probably represent the point at which Malta first became dry land, late in the Miocene, some 10 million years ago.

Localised Quaternary deposits of Pleistocene age occur and comprise palaeosols, fluvial gravels, coastal conglomerates and breccias, dunes and infillings of caves and fissures [see Trechmann (1938) and Hunt (this volume) for details]. The Pleistocene sediments and their faunas have traditionally been interpreted as indicating an overall wetter climatic regime than that at present. They also indicate that after a brief period of connection with the Sicilian/Italian mainland, during which there was an influx of European fauna and flora, the land connection between Malta and Sicily was severed and the islands underwent a period of isolation sufficiently long for an endemic island biota to evolve. Much of this biota became extinct before the end of the Pleistocene, most probably as a result of changes in the climate. At present there is no very strong evidence for a land connection with the North African mainland.

Maltese soils are characterised by their close similarity to the parent rock material, their relatively young age, the ineffectiveness of the climate in producing soil horizon development, and the great importance of human activities in modifying them (Lang, 1960; Bowen Jones et al., 1961; Sivarajasingham, 1971). Maltese soils have been classified by Lang (1960) using the Kubiëna system, into three main types:

> Terra Soils (or Red Mediterranean Soils) which are relic soils formed during the Pleistocene probably under Mediterranean woodland or scrubland and which are little affected by the present climate. They are mature and extensively weathered, have a low calcium carbonate content, and are also low in organic matter. Terra soils develop on karstland.
>
> Xerorendzinas which are immature soils with a high calcium carbonate content and low in organic matter. These develop on weathered Globigerina Limestone and on valley deposits.
>
> Carbonate Raw Soils which are also immature and which have a very high calcium carbonate content and are very low in organic matter. These develop on weathered

Quaternary sandstones, Greensand, the lower beds of the Upper Coralline Limestone, Blue Clay and on Globigerina Limestone.

Saline soils and alluvial soils also exist in some areas. In addition there are soil complexes formed through human agency: either by mixing of powdered rock with already existing soil at the time fields were laid out, or by addition of rock debris to soil during reclamation of disused quarries, or by mixing domestic waste with soil for use in land reclamation, or by mixing of different soil types transported from different localities.

Geomorphology

The geomorphology of the Maltese Islands has been discussed by House et al. (1961), Vossmerbäumer (1972), Guilcher & Paskoff, (1975), Paskoff & Sanlaville (1978), Ellenberg (1983), Reuther (1984) and Alexander (1988). Erosion of the different rock types gives a characteristic topography. Lower Coralline Limestone forms sheer cliffs which bound the islands to the West; inland this rock type forms barren grey limestone-platform plateaux on which karstland develops. The Globigerina Limestone, which is the most extensive exposed formation, forms a broad rolling landscape. Blue Clay slumps out from exposed faces to form taluses, sometimes with slopes of up to 45°, over the underlying rock. Upper Coralline Limestone forms massive cliffs and limestone-platforms with karstic topography similar to the Lower Coralline Limestone.

Both main islands are tilted seawards to the Northeast. There are no mountains, the highest point is 253m above sea level. There are also no lakes, rivers or streams but only minor springs.

The islands are riven by normal faults grouped in two main families: those trending NE-SW which predominate, and those trending NW-SE. The principal faults of the NE-SW system are the Great Fault on mainland Malta and the South Gozo Fault. Between these two master faults block faulting gives rise to a sequence of horsts and grabens. The principal member of the family of NW-SE trending faults is the Maghlaq Fault along the southern coast of mainland Malta. This fault shows a vertical throw of some 250m. South of the Great Fault, much of the Upper Coralline Limestone, Greensand and Blue Clay strata have been eroded away, leaving the Globigerina Limestone exposed. Here, large scale gentle folding is an important structural feature and this gives southern Malta its characteristic topography of plains and shallow depressions separated by low hills. South of the Great Fault, it is only in the Rabat-Dingli plateau that all five strata still remain. Much of the surface of this plateau is typical karstic limestone-pavement.

Topographically, Gozo consists of a series of hills, each topped by an Upper Coralline Limestone plateau, and separated by low-lying plains where the rock has been eroded down to the Globigerina Limestone. The plateaux are karstic, the hillsides are covered with clay taluses, and the plains between the hills roll gently.

Characteristic topographic features of particular importance are the rdum and widien (singular wied). Rdum are near vertical faces of rock formed either by erosion or by tectonic movements. Their bases are invariably surrounded by screes of boulders eroded from the rdum edges. Because of the shelter they provide and their relative inaccessibility, the rdum sides and boulder screes provide important refuges for many species of Maltese flora and fauna, including many endemics. Widien are drainage channels formed either by stream erosion during a previous (Pleistocene) much wetter climatic regime, or by tectonism, or by a combination of the two processes. Most widien are now dry valleys and only carry water along their watercourses during the wet season; a few widien drain perennial springs and have some water flowing through them throughout the year, attaining the character of miniature river valleys. By virtue of the shelter provided by their sides and their water supply, widien are one of the richest habitats on the islands; they are also extensively cultivated.

Climate

The climate of the Maltese Islands has been analysed by Mitchell & Dewdney (1961) who also review previous work on the subject. Chetcuti et al. (1992) have extended and updated Mitchell & Dewdney's work.

The climate of the Maltese Islands is typically Mediterranean with characteristic mild, wet winters and hot, dry summers. Table 1 gives the mean monthly values of selected climatic parameters (from Chetcuti et al., 1992).

Table 1 Mean values of climatic parameteres for the Maltese Islands. (Source: Meteorological Office of the Department of Civil Aviation, Governmennt of Malta)

Month	Rainfall (mm)	Max.Temp. (°C)	Min.Temp. (°C)	Sunshine (h)
January	86.4	14.9	10.0	5.3
Febuary	57.7	15.2	10.0	6.3
March	41.8	16.6	10.7	7.3
April	23.2	18.5	12.5	8.3
May	10.4	22.7	15.6	10.0
June	2.0	27.0	19.2	11.2
July	1.8	29.9	21.9	12.1
August	4.8	30.1	22.5	11.3
September	29.5	27.7	20.9	8.9
October	87.8	23.9	17.7	7.3
November	91.4	20.0	14.4	6.3
December	104.3	16.7	11.4	5.2

The average annual precipitation is 530mm. Rainfall is highly variable from year to year; some years are excessively wet while other are extremely dry (extreme minimum for period 1854-1995, 191.3mm, extreme maximum for period, 1031.2mm). The seasonal distribution of rainfall defines a wet period (October to March with c.85% of the total annual rainfall) and a dry period (April to September). Air temperatures are moderate (mean annual temperature 18.6°C; mean monthly range, 12.3-26.3°C) and never fall too low for adequate plant growth (Haslam, 1969). Grass temperatures may fall below zero during the period December to April. During the summer months, grass temperatures may reach values in the upper 40s (Haslam, 1969).

Relative humidity is consistently high throughout the year, being mostly in the range 65-80%. The Maltese Islands receive a great deal of sunshine all the year round (mean 8.3h of bright sunshine per day). The islands are windy, only some 8% of the days of the year are calm. The predominant wind is the North-westerly which on average blows on 19% of windy days. The other winds are all nearly equally represented.

The climate of the Maltese Islands is therefore strongly biseasonal, particularly in terms of water availability. The standard way of illustrating this biseasonality is to plot pluvio-thermic climate diagrams (Gaussen, 1954). Such a climate diagram has been constructed by Chetcuti et al. (1992). That region where the precipitation curve passes below the temperature curve, is said to define the arid period. On the basis of this definition, the arid period for the Maltese Islands extends from approximately the last third of March to the first third of September, with peak aridity being reached between June and August. This pattern is typical of the central Mediterranean area. Here, plant life has to be greatly adapted to excess water during the wet season and to drought and heat in the dry season. Plants, such as many crops, which are not so adapted, find it difficult to grow in such a climatic regime without careful husbandry. In the Maltese Islands, where winter temperature may be quite mild, some plants continue growing throughout winter (Haslam, 1969; Haslam et al., 1977), and it is the dry, hot summer that is really hostile to plant growth. This is reflected in the landscape, which is green throughout the wet period, but mostly bare of vegetation during the dry period.

Vegetation

The terrestrial vegetational assemblages of the Maltese Islands may be grouped in three categories: (i) major communities that are part of the successional sequence towards the climatic climax; and, (ii) minor communities which are either specialised to occupy particular habitats, or occupy habitats that are rare on the islands, or are relics from a previous ecological regime, now surviving in a few refugia; and (iii) vegetational assemblages of disturbed habitats, which are those occupying land subject to periodic disturbance, usually related to anthropic activities. Descriptions of Maltese vegetational assemblages have been given by Haslam (1969), Lanfranco (1984), Lanfranco & Schembri (1986), Anderson & Schembri (1989), Schembri (1991; 1993), and Lanfranco (1995).

Major assemblages

Woodland

It is thought that before humans colonised the Maltese Islands, large areas were covered with Mediterranean Sclerophyll Forest. In the central Mediterranean this forest is characterised by Holm Oak (Quercus ilex) and Aleppo Pine (Pinus halepensis) with an undergrowth of smaller trees, shrubs and climbers. The early settlers cut down the trees for their wood and to clear the land for agriculture and buildings. Additionally, they introduced sheep and goats, whose grazing and browsing causes some damage to mature trees but more importantly prevents them from regenerating. In the Maltese Islands, the native forest is all but extinct and only remnants persist at four localities, all on the island of Malta. These forest remnants take the form of small copses of Holm Oak where the total number of trees on average is less than thirty. Some of these trees are estimated to be between 600 and 900 years old.

Buskett (Malta) was originally planted by man (Borg, 1990) but is now self-regenerating and has the character of the natural climax community and may be described as a semi-natural woodland. Here the wood is dominated by Aleppo Pine with various other trees being sub-dominant (e.g. Olive, Carob, Holm Oak) and there is an extensive undergrowth of shrubs (e.g. Lentisk, Buckthorn and Hawthorn), herbs and climbers. This semi-natural wood is very important since it represents the only woodland ecosystem in the islands and consequently harbours a large number of woodland plants and animals which, because of the lack of suitable wooded habitats in the islands, are locally very rare.

Many other tree-covered areas exist on the islands, however, all are man-made (e.g. public/private gardens, plantations, orchards etc.) (Borg 1990) and do not possess the character of the native climax forest ecosystem nor are they self-maintaining and self-regenerating, and therefore do not qualify as semi-natural woodlands.

Maquis

The Maltese maquis is an impoverished scrub community resulting from degeneration of the climax woodland due to cutting, grazing and the resultant erosion of the soil.

A semi-natural maquis survives in relatively inaccessible sites such as the sides of steep valleys and at the foot of inland cliffs (rdum), while an artificial maquis develops round trees, mainly olives and carobs, planted by man.

The local maquis is characterised by a number of small trees and large shrubs, principally Carob (Ceratonia siliqua), Olive (Olea europaea), Lentisk (Pistacia lentiscus), Olive-leaved Buckthorn (Rhamnus oleoides), Yellow Germander (Teucrium flavum), White Hedge-nettle (Prasium majus), Mediterranean Honeysuckle (Lonicera implexa), Sarsaparilla (Smilax asper), Bear's Breeches (Acanthus mollis) and others.

Garigue

This is the most characteristic natural vegetation type present. Some garigue communities are natural, others result from degradation of forest and maquis, particularly where removal of the original vegetation cover has caused such extensive soil erosion that large tracts of the limestone bedrock have become exposed and only patches of stony soil still occur. Garigues are typical of such rocky ground and are especially common on the flat karstic limestone platforms of western Malta and the Gozitan hills.

Garigues are characterised by low shrubs such as Mediterranean Thyme (Coridothymus capitatus), Yellow Kidney Vetch (Anthyllis hermanniae), Olive-leaved Germander (Teucrium fructicans), Mediterranean Heath (Erica multiflora), and the endemic Maltese Spurge (Euphorbia melitensis), accompanied by numerous geophytes and therophytes. Many subtypes exist.

Steppes

These are dominated by grasses, umbellifers, thistles and geophytes. Steppes are widespread and result from degradation of the maquis and garigue, mainly due to grazing and browsing (goats are capable of cropping plants very close to their base thus destroying them, and are also able to chew and eat spiny xerophytic vegetation), but also in response to other factors, for example, continued soil erosion due to the short but heavy rainstorms which are characteristic of the islands. Some steppic communities are, however, climactic or semi-climactic with Esparto Grass (Lygeum spartum) on clay slopes, or with Beard Grass (Hyparrhenia hirta) and Andropogon distachyus. Other steppes are characterised by False Brome (Brachypodium retusum) or, rarely, by Canary Grass (Phalaris truncata). The more degraded steppes are characterised by Steppe Grass (Stipa capensis) and Goat Grass (Aegilops geniculata) and a variety of thistles (for example, Carlina involucrata, Notobasis syriaca, Galactites tomentosa) and geophytes (e.g. Branched Asphodel Asphodelus aestivuus, and Seaside Squill Urginea pancration). Steppic communities may also develop on abandoned agricultural land.

Minor ecosystems

Coastal communities

Saline marshlands form an interface between the marine, freshwater and terrestrial environments. Maltese coastal marshes are characterised by a muddy substratum on which a pool of brackish water collects in the wet season. During the dry season this water becomes progressively more brackish until it disappears completely, leaving the marsh dry until the following wet season. Because of these harsh conditions, saline marshlands support a highly specialised flora and fauna which is only found in this type of habitat. Although several of these plants and animals are common to all local marshlands, each site has its own peculiar habitat characteristics and suite of species (Schembri et al., 1987).

Some coastal wetlands are transitional between freshwater wetlands and saline marshlands in the sense that the communities they support consist of species typical of both freshwater and saline habitats. There are only very few such sites in the Maltese Islands (Anderson & Schembri, 1989) and hardly any studies on this habitat type have been made (Lanfranco & Schembri, 1995).

Many local sandy beaches were backed by dune systems, but at present only very few still persist and even these have been much degraded due mainly to human activities connected with beach development for touristic purposes and with recreational use (Anderson & Schembri, 1989; Schembri & Lanfranco, 1993). Sand dunes are thus amongst the rarest and most threatened of local ecosystems. Those local dunes which are still vegetated harbour typical Mediterranean dune communities dominated by the dune grasses Sand Couch (Elytrigia juncea) and Sporobolus arenarius, and, until recently, also by Southern Marram Grass (Ammophila australis) which has now been totally extirpated (Lanfranco, 1989).

On gently sloping rocky shores, halophytic vegetation grows in isolated patches in the shallow saline soil which accumulates in pockets in the rock. The species present are typical of this type of habitat. Two endemic plants are found only in this community type and a third also occurs although it is not exclusive to low-lying maritime rock. The former are Zerapha's Sea-lavender (Limonium zeraphae) and Maltese Sea-camomile (Anthemis urvilleana); the latter is

Maltese Dwarf Garlic (Allium lojaconoi) (Lanfranco, 1989). Other characteristic plants of scientific importance include: Pignatti's Fern-grass (Desmazeria pignattii) and Pygmy Groundsel (Senecio pygmaeus) which are Hybleo-Maltese endemics, and Hymenolobus revelieri subsp. sommieri, a Pelago-Maltese endemic which in the Maltese Islands is confined to the island of Comino.

Rupestral assemblages

These grow on cliff faces and high walls. The South, Southwest and West coasts of Malta consist of vertical cliffs rising from the sea to heights of c.70-130m. In the Dingli Cliffs area, these cliffs give way to a steeply sloping substratum. This sloping ground is terraced and partly under cultivation. Further inland there is a second tier of vertical cliffs (rdum). The South and Southwest coasts of Gozo consist of sea-cliffs similar to those of southern Malta. Because of the shelter they provide and their relative inaccessibility, both the sea-cliffs, and the second tier of rdum with the boulder screes which form beneath them, provide important refuges for many species of Maltese flora and fauna, including many endemics.

Cliff-side communities are dominated by shrubs and are especially significant due to the presence of a large number of endemic plant taxa including Maltese Rock-centaury (Palaeocyanus crassifolius and Maltese Cliff-orache (Cremnophyton lanfrancoi), both of which are monotypic species (that is, the genus too is endemic). Other important cliff-side plants are Maltese Salt-tree (Darniella melitensis), Maltese Hyoseris (Hyoseris frutescens), Maltese Sea-lavender (Limonium melitense), Maltese Fleabane (Chiliadenus bocconei), and Maltese Everlasting (Helichrysum melitense), all which are endemic; Maltese Stocks (Matthiola incana subsp. melitense), an endemic subspecies; Egyptian St.John's Wort (Triadenia aegyptica), Rock Crosswort (Crucianella rupestris), Wolfbane (Periploca angustifolia) and White Snapdragon (Antirrhinum siculum), all of which have a restricted Mediterranean distribution; and Cliff Carrot (Daucus cf. rupestris), which is possibly a subendemic (Lanfranco, 1987; 1989).

Freshwater assemblages

During the wet period, rainwater collects in natural depressions and hollows on coralline limestone karstland to form temporary rainwater pools. These pools are usually very transient and rapidly dry up especially with the onset of the hot season. These natural freshwater pools house many freshwater species which are overall rare in the Maltese Islands, including such plants as Sanicle-leaved Water-crowfoot (Ranunculus saniculaefolius), Starwort (Callitriche truncata), Waterwort (Elatine gussonei) Mediterranean Starfruit (Damasonium bourgei), Water Stonecrop (Crassula vaillantii), the freshwater alga Tolypella glomerata, and a number of freshwater animals, mainly crustaceans and some insects. A few pools, which form in natural depressions, are more or less permanent either because of their physical size or because they receive water from sources other than rain, usually from springs. These pools are of great local interest since they represent the only natural standing water bodies on the islands. Because of the dearth of freshwater in the islands, freshwater plants and animals are overall rather rare, and this is especially true for those species which require a more or less year-round supply of water.

The bulk of Maltese plants and animals associating with freshwater live in the widien watercourse when these are filled with water during the wet season. Most watercourses are dominated by the Great Reed (Arundo donax) together with Galingale (Cyperus longus), Clustered Club-rush (Holoschoenus vulgaris), Southern Reed-mace (Typha domingensis) and others. The submerged vegetation consists mainly of Stoneworts (Chara species) and Thread-leaved Water-crowfoot (Ranunculus trichophyllus) (Lanfranco & Schembri, 1986).

The few remaining permanent springs support a distinctive flora and fauna, many species of which, since they require a perennial supply of running freshwater, are limited to this habitat type and are therefore very rare and have a restricted distribution (Lanfranco & Schembri, 1986). Along a few watercourses there are still remnants of broad-leaved deciduous woodlands with White Poplar (Populus alba), Mediterranean Willow (Salix pedicellata), Grey

Elm (Ulmus canescens) and sometimes accompanied by Bay Laurel (Laurus nobilis), which is also a component of maquis assemblages.

Assemblages of disturbed ground

Given the islands' high human population and extensive land use, these assemblages have a considerable coverage. They are dominated by a variety of plant species, many of which are aliens. Many subtypes occur, for example in used and abandoned fields, along roadsides, and in disturbed seaside habitats.

Climate, vegetation and landscape in the Maltese Islands: a synthesis

The Maltese landscape consists of three key components: built-up areas, agricultural land and the natural countryside. A significant proportion of the land area of the islands is given over to buildings and roads. Built-up areas (residential, industrial, airport and roads) now occupy c.16% of the land surface of the island of Malta and c.10% of that of Gozo (Ministry for Development of Infrastructure, 1988). During the past 40 years the trend has been for the built-up area to increase at the expense of both cultivated land and the natural countryside. Agriculture, a mainstay of the Maltese economy since antiquity, has progressively diminished in importance, particularly since the 1950s, as successive Governments promoted the tourism and service industries, and as farming became increasingly less attractive to the younger generation; agriculture (together with fisheries) accounted for 5.6% of the Gross Domestic Product in 1954 and now accounts for some 3%, rising to a maximum of only 7% during this period (King, 1979; Mizzi, 1994). As a consequence of diminishing agricultural activity, registered agricultural land fell from c.56% of the islands' area in 1957 to c.45% in 1968 to the present figure of 38% (Meli, 1993).

The corresponding figures for the natural countryside are 39%, 49% and 46% (Ministry for Development of Infrastructure, 1988). Although at first sight it would appear that while the proportion of built-up to non-built-up land, while high, is not excessive, these figures must be interpreted with care. Human occupation of the islands has been for such long periods of time (at least 7000 years; Blouet, 1984), and human pressure on the natural environment so intense, that there is nowhere on the islands that can be said to be completely natural, and even the most remote areas show evident signs of anthropic activities. The ‘natural’ countryside is therefore at best a semi-natural one.

Apart from the increased diversion of land to development, two other trends are evident in the agricultural and natural landscape. One is the increasing soil erosion which is causing very significant changes in the vegetation, and therefore in the landscape, in some areas. The other is a development of the vegetation from lower to higher stages in the successional sequence.

Much agricultural land is on sloping ground which is terraced with retaining walls made of limestone rubble. With the abandonment of agriculture, many of these dry-stone walls have fallen into disrepair, with a concurrent increase in soil erosion. Most of the agricultural land is not irrigated, which leaves the soil bare of vegetation during the dry period of the year, leading to accelerated erosion. Additionally, during the transition from the dry to the wet season, short but very heavy rainstorms are common; these lead to increased runoff and erosion. Loss of soil through runoff is accentuated due to the large number of roads which provide an unimpeded channel to the sea for storm water.

Sheep and goats were introduced into the Maltese Islands in antiquity (Boessneck & Küver, 1970). As in other Mediterranean countries (e.g. Pons & Quézel, 1985), these animals have had a profound effect on the natural vegetation, being responsible for degrading the landscape, impoverishing the flora (and consequently the fauna), and increasing runoff and erosion due to their grazing and browsing activities. The goat in particular is a highly adapted browser with a remarkable agility, flexible diet, a relatively low water need, and a specialised digestive tract which allows it to thrive on low-quality browse, on which cattle or sheep would not be able to survive (Le Houérou, 1981). With the changing socio-economic situation in the Maltese Islands during the past fifty years, goat herding has become much less important, and is now virtually inexistent. This has had a beneficial effect on the vegetation which is regenerating in over-browsed areas, and in others is developing from steppe to garigue or maquis (Schembri & Lanfranco, 1993).

On the macroscopic level, the Maltese Islands are generally regarded as having an impoverished landscape, in part resulting from the limited topographical variety and the poor soil cover, and in part from the arid environment which supports a patchily distributed specialised vegetation very different from the temperate forests and grasslands of higher latitudes. Superimposed on these is the influence of man, who through his activities, mainly urbanisation, agriculture and deforestation, has had a profound and frequently negative effect on the landscape.

In spite of this, however, the Maltese Islands harbour a surprising diverse range of habitat types and biota which add variety to the landscape, particularly when viewed on the micro-level. To give but one example, the island of Comino, a mere 2.8 km^2 in area, has two sandy beaches, gently sloping rocky shores, cliff coasts with rupestral vegetation, tracts of karstland with steppic and garigue vegetation, two or three small widien, cultivated fields, abandoned fields in various stages of reversion to a natural vegetation cover, tamarisk scrub, small patches of secondary maquis, as well as a small hamlet, a large pig-farm and two hotels and their associated anthropophilic biotic assemblages. Apart from this spatial heterogeneity, there is also a temporal one as the vegetation changes with the season.

This spatial and temporal variety in the landscape is not generally appreciated for two main reasons. One is that many habitats occur in very small and widely separated patches, as already discussed; a second is that the biota, especially the vegetation, is adapted to the biseasonal climate and many species survive adverse conditions in a dormant state, when they are not at all obvious.

During the very stressful arid period some plants survive in a state of reduced activity or dormancy, in the form of underground perennating organs (tubers, bulbs etc.) or in the form of seeds, all aerial parts of the plant dying and drying. Other plants are evergreen, but have numerous adaptations to reduce water loss by transpiration and to avoid overheating during the arid period, foremost amongst which is sclerophylly, that is, the leaves have a thickened cuticle and are often reduced in size and scale-like, thus limiting transpiration.

The biseasonality of the climate imposes a biseasonality in the landscape, particularly the steppes and garigues growing on the limestone karstlands. Here, vegetation becomes very sparse during the dry period as the land desiccates and the landscape becomes an expanse of bare rock with patches of soil and occasional thorny bushes. In complete contrast, during the wet period, every patch of earth and shallow pocket of soil amongst the rocks become covered with a large carpet of green, as the dormant vegetation resumes growth. The peak blooming period for the Maltese vegetation as a whole is between March and June (Haslam 1969), so the colour provided by flowers adds further to the contrast with the landscape during the dry period.

Agriculture adds further complexity to the landscape. In the Maltese Islands, traditional agriculture is influenced primarily by the availability of water, and this defines three types: dry farming, where the only source of water is rainfall; semi-irrigated farming, where some water for irrigation is available but not in sufficient quantities to allow irrigation throughout the whole of the dry period; and, irrigated farming, where there is a more or less permanent supply of irrigation water and farming can continue throughout the dry period (Bowen Jones et al., 1961; Busuttil, 1993). In effect, irrigated agriculture is only found where there are perennial springs, that is, where the Blue Clay layer is present. On the island of Malta, this is towards the North, on the Rabat-Dingli uplands. In summer, there is a stark contrast between the irrigated fields in this area, which are more or less green, and the exposed soil of the fields to the South, where little irrigation water is available and consequently hardly any crops can grow during the dry period. This picture is now changing somewhat, as in 1983 a sewage treatment plant located in the South of the island started providing some irrigation water to traditionally dry-farmed areas (Gauci, 1993). In Gozo, Blue Clay is widespread throughout the island and consequently it is only in those areas remote from Upper Coralline outcrops underlain by Blue Clay that large tracts of agricultural land are bare of vegetation during the dry season; for the most part, the island is a pleasing mosaic of vegetated, semi-vegetated and bare fields lying in close proximity to one another. For this island, Jones & Hunt (1994) have demonstrated that the multiple strategies used by Gozitan farmers to address the problems of aridity and soil erosion, and the relationships between farming practices and the physical features of the environment, have contributed to the complexity and micro-regional variation in the landscape. Moreover, the cultural landscape is polyphase since different generations of water and soil management structures are apparent (Jones & Hunt, 1994). There is no reason to believe that the situation on the island of Malta is any different.

Chetcuti et al. (1991) have attempted to correlate vegetational communities with the spatial distribution of rainfall and the amount of water infiltrating into the soil. They found no clear correlation between the two. The reason is that, as for the rest of the Mediterranean (Pignatti, 1978; Pons, 1981, Pons & Quézel, 1985), human influence is far more important in controlling the present vegetation than is the climate. Any regional differences in vegetation type due to climatic effects, which, given the size and the topography of the Maltese Islands, are expected to be small in any case, are more than swamped out by anthropic influences, which are large. Most of the vegetational communities of the Maltese Islands are not climactic, but rather are at different degredational stages from the climatic climax, or are edaphically controlled. In turn, most present endaphic conditions result from an interaction of human activities with natural processes, primarily erosion, which has accelerated, due to removal of much of the protective vegetation cover (Schembri, 1991; Schembri & Lanfranco, 1993). In some cases, biotic communities may be recovering from man's influence and progressing upwards in the successional sequence as already discussed (Schembri & Lanfranco, 1993), however, it is doubtful whether the climactic climax will ever be attained, as much of the original soil cover has now eroded away, leaving only patches of shallow soil, separated by areas of stony ground and exposed bedrock, which are not suitable for regrowth of the original climax forest, for edaphic reasons.

While not as important a limiting factor as water, temperature also exerts some control over vegetation growth. In this respect, ground temperature is a more important limiting factor than air temperature, particularly for seedlings and plants with buds or shoot apices at or just below ground level (hemicryptophytes and cryptophytes, respectively). Thus, poor seedling survival is probably a far more important agent of degradation of the Mediterranean climax forest than damage to the mature trees. In the absence of biotic factors (e.g. grazing), seedling survival depends largely on the climatic regime, particularly the microclimate at ground level. Although ground temperatures in the Maltese Islands frequently drop below zero during the wet period (Chetcuti et al., 1991), such freezing temperatures never last longer than a few hours. Most plants can withstand short periods of freezing without sustaining any permanent harmful effects, so freezing ground temperatures are not considered to have any great impact on most plants, beyond a general slowing down of growth. While the lethal temperature for adult plant parts is usually above 50°C, young plant parts and seedlings are killed by temperatures in excess of 38°C (Haslam 1969). Such temperatures are frequently exceeded and very few plants exposed to the full force of the sun germinate or grow shoots during the dry period.

The windy nature of the Maltese Islands and the regular strong winds and occasional gales which occur, have important impacts on the local vegetation. Thus, trees growing in wind-exposed areas tend to be stunted and to grow hugging the ground. An example of this is the so called 'Israel Grove' at Ghajn Tuffieha where Aleppo Pines (Pinus halepensis), planted between 1969 and 1971 (Borg, 1990), are barely 2m high. Some vegetational communities, particularly those growing on north-westerly-facing ground, may be strongly influenced by the wind. An extreme example is provided by the San Dimitri area of Northwest Gozo. Here, Golden Samphire (Inula crithmoides) and other halophytes, normally characteristic of coasts, are found growing several kilometres inland. This is probably a result of the prevailing north-westerly winds, blowing sea-spray and salt-laden air large distances inland, across the flat exposed Globigerina limestone plains of this area.

Winds also have a significant impact on agriculture. Fruit trees have to be planted in sheltered valleys or protected by high stone walls or other windbreaks, and crops grown in very exposed areas have to be similarly protected. Blouet (1962) suggests that many of the Islands' field walls were built to shelter crops from the prevailing wind of the region. Prickly Pear (Opuntia ficus-indica) is often planted along field walls to act as a windbreak, while in Gozo, palisades built of the stems of the Great Reed (Arundo donax), bound together, are commonly used as windbreaks to protect low-growing crops.

Conclusion

Although small in size, the Maltese Islands have a considerable diversity of landscapes and ecosystems. These result from interaction of natural and anthropic factors: the former mainly the complex geomorphology, itself a result of the interaction of geology and climate, and the latter the intense human exploitation over thousands of years which has greatly altered the original condition of the vegetation cover, principally through the diversion of vast tracts of land to cultivation, the construction of terraces, water catchment devices, irrigation channels and drainage ditches, the grazing of animals on uncultivated land, and the development of land for buildings and industry.

The present landscapes are therefore a legacy of the intense human use of the environment and form a continuum between those where human influence dominates, for example, urban landscapes where no or little natural vegetation is evident, to those where human activities have greatly modified the landscape, but where elements of the original vegetation still persist, for example, the karstlands with their garigues and the scarp-foot boulder screes with their maquis. The most pristine are the rupestral habitats where human interference has been at a minimum. For this reason, from the scientific point of view at least, the sea-cliffs, steep valley sides and rdum, with their rupestral assemblages, are the most valuable contemporary landscape elements of the Maltese Islands.

The centuries of environmental mismanagement have had serious consequences for the natural environment. This process started with the conversion of woodlands to arable land and overgrazing by domesticated sheep and goats. Successive cycles of cultivation and neglect, due to the vagaries of the climate and to periods of strife, followed. In more recent times there has been overdevelopment of some areas, resulting in further displacement of soil and abandonment of agriculture. The scantiness of the soil, combined with the erratic rainfall and the periodic disturbance of the vegetation cover, has resulted in extensive erosion. As a consequence it became more and more difficult for the original vegetation to reassert itself. All of these factors have affected the landscape drastically and permanently. Much of the original native flora has been lost or marginalised. Much of the present day non-urban landscape is now dominated by banal weedy vegetation and by introduced species.

As the population increases, and human pressure on the environment mounts, such trends are likely to continue or even become worse and there is increasingly reason for concern about the future of the natural landscapes of the Maltese Islands. Very recently, some important initiatives have been taken with the enactment of the Environment Protection Act of 1991 and the Development Planning Act of 1992, but the situation is still far from optimistic. Effective environmental management must involve the co-ordinated co-operation of many and only time will tell if the recent awareness of the precarious state of the Maltese landscape will result in the required collaboration between the various sectors of Maltese society in order to halt if not reverse the present deterioration.

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