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Physical Geography and Ecology of the Maltese Islands: A Brief Overview

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Abstract. *The Maltese archipelago, occupying an area of c.316 km² and situated in the central Mediterranean, consists of the inhabited islands of Malta and Gozo and a number of uninhabited islets and rocks. The islands are composed mainly of limestone of Oligo-Miocene age. Soils are young, show little horizon development, and are very similar to the parent rocks. There are no mountains, streams or lakes, but only minor springs. The main geomorphological features are karstic limestone plateaux, hillsides covered with clay taluses, and gently rolling limestone plains. The southwest coast is mainly steep sea-cliffs and the land tilts gently seawards to the northeast. The islands are riven by valleys which drain runoff during the wet season. The average annual rainfall is c. 530 mm of which some 85% falls during the period October to March. The mean monthly temperature range is 12-26°C. The islands are very windy and sunny. Natural water resources depend on percolating rainwater which collects in limestone aquifers. The flora and fauna are rich with c. 2,000 species of plants and more than 3,000 species of animals recorded to date; a relatively large number of species are endemic. The main ecosystems are maquis, garrigue and steppe. Minor ones include patches of woodland, coastal wetlands, sand dunes, freshwater and rupestral communities and those of caves. Human impact is significant. The resident population density is 1,140 per km². Some 38% of the land area is cultivated and c.16% is built up. Environmental problems include accelerated soil erosion, quarrying, disposal of waste, high levels of chlorides and nitrates in the water supply, and loss of habitats and wildlife. The most important environmental issue at present is the rational use of land, a problem which is only now being tackled by the Maltese Government.*

Titre. Géographie physique et écologie des îles maltaises, une brève présentation.

Résumé. L'archipel maltais, d'une superficie d'environ 316 km², est situé dans la Méditerranée centrale. Il est composé de deux îles habitées, Malte et Gozo, et d'un certain nombre d'îlots inhabités. Les îles sont principalement composées de roches calcaires de l'oligo-miocène. Les sols sont jeunes, les horizons sont peu épais et les sols sont très proches des roches-mères. Il n'y a pas de montagne, pas de rivière et pas de lac, mais seulement quelques sources peu abondantes. Les principales caractéristiques géomorphologiques sont : des plateaux karstiques, des reliefs collinaires avec des talus argileux et des plaines calcaires légèrement ondulées. La côte sud-ouest est essentiellement composée de falaises vives abruptes alors que celle du nord-est meurt lentement dans la mer. Les îles sont quadrillées de vallées qui drainent les eaux de pluies pendant la saison humide. La moyenne des précipitations annuelles est d'environ 530 mm, dont 85% tombent pendant la période octobre-mars. L'écart maximum des températures mensuelles se situe entre 12° et 26°. Les îles sont très ventées et ensoleillées. Les ressources naturelles en eau dépendent de la percolation des eaux de pluie qui sont collectées dans les nappes phréatiques. La faune et la flore sont riches de quelque deux mille espèces de plantes et trois mille espèces d'animaux recensés à ce jour ; une partie relativement importante de ces espèces sont endémiques. Les principaux écosystèmes sont : le maquis, la garrigue et la steppe ; les autres sont des bosquets, des marais côtiers, des dunes de sable, des écosystèmes liés aux rochers ou aux mares d'eau douce et des écosystèmes cavernicoles. L'influence humaine est importante. La densité de la population résidente est de 1.140 habitants au km². Environ 38% de la superficie est cultivée et 16% construit. Les problèmes environnementaux principaux sont : une rapide érosion des sols, la multiplication des carrières, le traitement des déchets, la forte présence de chlorure et de nitrate dans l'eau, la disparition des habitats et de la vie sauvage. Le problème d'environnement le plus important aujourd'hui est l'utilisation rationnelle des terres qui vient seulement d'être pris en compte par le gouvernement maltais.

Keywords. Maltese Islands – Environment – Geography – Ecology – Geology – Soils – Geomorphology – Climate – Water resources – Flora – Fauna – Habitats – Ecosystems – Human impact.

I. – Introduction : Position and Size

The Maltese Islands are a group of small, low islands aligned in a NW-SE direction and located in the central Mediterranean at:

latitude: 35°48’28” – 36°05’00” North
longitude: 14°11’04” – 14°34’37” East

They are situated on a shallow shelf, the Malta-Ragusa Rise, part of the submarine ridge which extends from the Ragusa peninsula of Sicily southwards to the African coasts of Tripoli and Libya. Geophysically, the Maltese Islands and the Ragusa peninsula of Sicily are generally regarded as forming part of the African continental plate. The islands lie approximately:

96 km from Sicily (Italy)
290 km from North Africa
1836 km from Gibraltar
1519 km from Alexandria (Egypt)

The sea between the islands and Sicily (the Sicilian Channel) reaches a maximum depth of not more than 200 m and is mostly less than 90 m; that between the islands and North Africa (the Malta Channel) is much deeper, in places reaching more than 1,000 m (Morelli *et al.*, 1975).

The Maltese Archipelago consists of three inhabited islands: Malta, Gozo (in Maltese *Ghawdex*), and Comino (in Maltese *Kemmuna*) and a number of small uninhabited islets: Cominotto (in Maltese *Kemmunett*), Filfola (better known by its Maltese name *Filfla*), St. Paul’s Islands (in Maltese *Il-Gzejjer ta’ San Pawl*, also known as Selmunett Islands), Fungus Rock (also known as General’s Rock; in Maltese *Il-Hagra tal-General* or *Il-Gebla tal-General*), and a few other minor rocks. The land area of the various islands is:

Malta: 245.7 km^2
Gozo: 67.1 km^2
Comino: 2.8 km^2
St. Paul’s Islands: 10.1 ha
Cominotto: 9.9 ha
Filfla: 2.0 ha
Fungus Rock: 0.7 ha

An early general account of Maltese geography is given by Murray (1890) while a more recent detailed account is given by Bowen Jones *et al.* (1961). Ransley and Azzopardi (1988) provide a more elementary description.

II. – Physical Geography

1. Geology

Hyde (1955) reviews earlier literature on Maltese geology while modern general accounts are given by House *et al.* (1961) and Pedley *et al.* (1976, 1978). Zammit Maempel (1977) gives a more popular outline.

Geologically, the islands are composed almost entirely of marine sedimentary rocks, mainly limestones of Oligo-Miocene age. There are also some minor quaternary deposits of terrestrial origin. The five main rock types are (in order of decreasing age):

- **Lower Coralline Limestone** which is exposed to a thickness of 140 m. This is the oldest exposed rock type in the Maltese Islands and started being laid down between 30-25 million years ago.
- **Globigerina Limestone**, exposed to a thickness ranging from 23 m to 207 m and subdivided into three units (Lower, Middle and Upper Globigerina Limestones) by two pebble beds.
- **Blue Clay**, exposed to thicknesses of up to 65 m.
- **Greensand**, exposed to a maximum thickness of 12 m.
- **Upper Coralline Limestone**, exposed to a thickness of 162 m. This formation is a complex association of limestones. Deposition of these marine sediments stopped some 10 million years ago when the seabed rose above sea level.

Localised quaternary deposits of Pleistocene age (1.9-0.01 million years ago) occur and comprise “fossil” soils (palaeosols), fluvial gravels, coastal conglomerates and breccias, dunes and infillings of caves and fissures, see Trechmann (1938) for details.

2. Soils

The soils of the Maltese Islands have been studied by Lang (1960).

Maltese soils are characterized 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. Using the Kubiena classification system, Maltese soils are of three main types:

- **Terra Soils** which are relic soils formed during the Pleistocene 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.

Moreover, 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 the 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.

3. Geomorphology

The geomorphology of the Maltese Islands is described by House *et al.* (1961) and by Vossmerbäumer (1972) while coastal geomorphology is treated by Paskoff and Sanlaville (1978) and Ellenberg (1983). Reuther (1984) discusses the tectonics of the Maltese Islands and reviews previous literature on the subject.

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 c. 45° taluses 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 at Ta' Zuta on Dingli Cliffs (SW Malta) which is 253 m above sea level; the highest point on Gozo is at Dbiegi (191 m). 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 in Malta and the South Gozo Fault. The Great Fault bisects the island of Malta perpendicular to its long axis from Fomm ir-Rih on the southwest coast to Madliena on the northeast coast. The South Gozo Fault runs parallel to the Great Fault and crosses the island of Gozo from Ras il-Qala on the east coast to Mgarr ix-Xini on the southeast. Between these two master faults is a system of ridges and valleys. The principal member of the family of NW-SE trending faults is the Maghlaq Fault along the southern coast of Malta. 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 platform.

Block faulting north of the Great Fault gives rise to a sequence of horsts (ridges) and grabens (valleys) which, proceeding from the Great Fault are: the Bingemma Basin, Wardija Ridge, Pwales Valley, Bajda Ridge, Mistra Valley, Mellieha Ridge, Ghadira Valley and Marfa Ridge. The next graben in the sequence is inundated by sea water and forms the South Comino Channel separating Malta from the island of Comino. The highest part of the next horst is exposed above sea level as the island of Comino and the next graben is again under water and forms the North Comino Channel.

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 stratum. The plateaux are karstic, the hillsides are covered with clay taluses and the plains between the hills roll gently.

Characteristic topographic features of particular ecological 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 refuge 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, that is, they 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.

4. Climate

An analysis of the climate of the Maltese Islands is given by Mitchell and Dewdney (1961) who also review previous work on the subject. Chetcuti (1988) and Chetcuti *et al.* (1992) have extended and updated Mitchell and Dewdney's work.

The climate of the Maltese Islands is typically Mediterranean with characteristic mild, wet winters and hot, dry summers. *Table 1* below gives the mean monthly values of selected climatic parameters (from Chetcuti, 1988).

Table 1. Mean monthly values of Main Climate Parameters

Month	Rainfall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Sea Temp. (°C)	Sunshine (h)
Jan	86.4	14.9	10.0	14.5	5.3
Feb	57.7	15.2	10.0	14.5	6.3
Mar	41.8	16.6	10.7	14.5	7.3
Apr	23.2	18.5	12.5	16.1	8.3
May	10.4	22.7	15.6	18.4	10.0
Jun	2.0	27.0	19.2	21.1	11.2
Jul	1.8	29.9	21.9	24.5	12.1
Aug	4.8	30.1	22.5	25.6	11.3
Sep	29.5	27.7	20.9	25.0	8.9
Oct	87.8	23.9	17.7	22.2	7.3
Nov	91.4	20.0	14.4	19.5	6.3
Dec	104.3	16.7	11.4	16.7	5.2

The average annual precipitation is 530 mm (mean for period 1951-1990). Rainfall is highly variable from year to year; some years are excessively wet while others are extremely dry (extreme minimum for period 1854-1990, 191.3 mm, extreme maximum for period, 1031.2 mm). 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 for period 1951-1990, 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 forties (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 for period 1951-1990, 8.3 h 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 northwesterly which on average blows on 19% of windy days. The other winds are all nearly equally represented.

5. Water resources

Numerous studies on the hydrology and water resources of the Maltese Islands have been made. The main ones are those of Chadwick (1884), Zammit (1931), Morris (1952) and Newbery (1968). Works on Maltese geology frequently refer also to local hydrology (*e.g.*, Rizzo, 1932; Hyde, 1955; House *et al.*, 1961; Zammit Maempel, 1977).

The islands' natural water resources depend entirely on rainwater percolating through the porous limestone rock and accumulating in aquifers from where it either seeps out or is pumped by man. It has been estimated that between 16% and 25% of the annual rainfall infiltrates to recharge the aquifers (Morris, 1952; Newbery, 1968; Chetcuti, 1988; Chetcuti *et al.*, 1992). The largest aquifer is the Main Sea-level Aquifer which consists of a lens of freshwater floating on denser saline water in limestone rock at sea level. The other aquifers of importance are the Perched Aquifers, which consist of rainwater trapped in the permeable Upper Coralline Limestone due to the underlying layer of impermeable Blue Clay.

Water seepage from the Perched Aquifers, wherever the Upper Coralline Limestone/Blue Clay interface is exposed, gives rise to so-called High Level springs which drain into *widien* watercourses. Many of these springs used to flow all year round, albeit with much reduced flow in the dry period; however, most are now tapped by farmers for irrigation. Over the years there have been a number of programmes of small dam construction across the *widien* watercourses, aimed at reducing flow along these and at retaining water in the *widien* for longer periods to allow increased infiltration and to supply water for irrigation.

III. – Ecology

1. Flora and Fauna

The Maltese Islands are popularly regarded as having an impoverished flora and fauna. In actual fact, the islands harbour a very diverse array of plants and animals, especially when considering the relatively small land area, the limited number of habitat types and the intense human pressure.

Table 2 gives estimates of the number of species of plants and animals which occur in the Maltese Islands.

Table 2. Main Species of Plants and Animals in Malta

Plants	
Algae	c. 150
Large Fungi	c. 150
Lichens	c. 300
Bryophyta (mosses and relatives)	c. 130
Pteridophyta (ferns and relatives)	11
Gymnospermae (conifers)	two indigenous species
Angiospermae (flowering plants)	c.1000
Animals	
Mollusca (snails and slugs)	c. 60
Arachnida (spiders and relatives)	not studied; at least 200+ species
Isopoda (woodlice)	c. 45
Decapoda (crabs)	one freshwater species
Odonata (dragonflies)	c. 10
Orthoptera (grasshoppers and relatives)	c. 48
Coleoptera (beetles)	c. 600 recorded; probably 2,000+ occur
Lepidoptera (butterflies and moths)	c. 590
Diptera (flies)	not studied; probably 500+ species
Hymenoptera (bees, wasps and ants)	c. 150 recorded; probably 500+ occur
Diplopoda (millipedes)	c. 12
Chilopoda (centipedes)	c. 15
Amphibia (frogs)	one species
Reptilia (reptiles)	nine species
Aves (birds)	c. 13 resident (c. 57 regular visitors and c. 112 regular migrants also recorded)
Mammalia (mammals)	c. 21 species

Only terrestrial and freshwater species are considered. In some cases the numbers given are only estimates as the groups concerned have not been adequately studied (Adapted from Schembri, 1988).

The Maltese Islands support a number of species of plants and animals which are found in the Maltese Islands only and nowhere else in the world. The number of such endemic species from those groups which have been adequately studied are given in *Table 3*.

Table 3. The number of endemic species occurring in the Maltese Islands

Group	No. of endemic species	% endemic of total occurring in Maltese Islands
Tracheophyta (higher plants)	21	2.10
Bryophyta (mosses and relatives)	2	1.54
Mollusca (snails and slugs)	17	28.33
Pseudoscorpiones (false scorpions)	3	12.50
Palpigradi (micro-whipscorpions)	1	100.00
Isopoda (woodlice)	4	9.52
Decapoda (crabs)	1	100.00
Thysanura (silverfish)	1	10.00
Orthoptera (grasshoppers and relatives)	1	2.08
Heteroptera (bugs)	1	0.88
Coleoptera: Staphylinidae (rove beetles)	4	2.33
Coleoptera: Elateridae (click beetles)	1	16.67
Coleoptera: Tenebrionidae (darkling beetles)	5	14.71
Coleoptera: Curculionidae (weevils)	2	2.06
Lepidoptera (butterflies and moths)	17	2.88
Hymenoptera: Formicidae (ants)	2	4.55
Hymenoptera: Mutillidae (velvet ants)	1	6.67
Reptilia (reptiles)	1	11.11

Only those groups which have been adequately studied taxonomically are included and only freshwater and terrestrial species are considered (Source: Schembri and Sultana, 1989).

2. Ecosystems

The terrestrial ecosystems of the Maltese Islands may be grouped in two categories: (i) major communities that are part of the successional sequence towards the climatic climax; and, (ii) minor communities which either are specialized to occupy particular habitats, or occupy habitats that are rare in the islands, or are relics from a previous ecological regime, now surviving in a few refugia. Descriptions of Maltese ecosystems have been given by Haslam (1969), Lanfranco (1984), Lanfranco and Schembri (1986) and Anderson and Schembri (1989). Schembri (1991, 1992) provides a systematic classification and description based mainly on vegetation.

A. Woodland

It is thought that before man colonized the Maltese Islands, large areas were covered with Mediterranean Sclerophyll Forest, which is the highest type of vegetation that can develop in the Mediterranean climate regime. In the Central Mediterranean this forest is characterized by Holm Oak (*Quercus ilex*) and Aleppo Pine (*Pinus halepensis*) with an undergrowth of smaller trees, shrubs and climbers. When man colonized the islands, trees were cut for their wood and to clear the land for agriculture and buildings. Additionally, the early colonizers introduced sheep and goats to the islands, whose grazing 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 remain 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 is less than thirty. Some of these trees are estimated to be between 500 and 900 years old.

Buskett (Malta) was originally planted by man 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 (*Pinus halepensis*) with various other trees being sub-dominant (*e.g.*, Olive, Carob, Holm Oak) and there is an extensive undergrowth of shrubs (*e.g.*, Pistacia, 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 habitats in the islands, are locally very rare. Many other wooded areas exist in the islands; however, all are man-made (*e.g.*, public/private gardens, afforestation areas, orchards, etc.) and do not possess the character of the native climax forest ecosystem, nor are they self-maintaining and self-regenerating. Therefore they do not qualify as semi-natural woodlands.

B. Maquis

A semi-natural maquis develops 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 characterized by a number of small shrubs principally *Ceratonia siliqua*, *Olea europaea*, *Pistacia lentiscus*, *Rhamnus oleoides*, *Teucrium flavum*, *Prasium majus* and others.

C. Garrigue

This is the most common natural vegetation type present. Some garrigue communities are natural, others result from degradation of forest and maquis. Garrigues are typical of rocky ground and are characterized by such species as *Coridothymus capitatus*, *Anthyllis hermanniae*, *Teucrium fructicans*, *Erica multiflora* and the endemic *Euphorbia melitensis*, accompanied by numerous geophytes and therophytes. Many subtypes exist.

D. Steppic grasslands

These are dominated by grasses, umbellifers, thistles and geophytes. Steppic grasslands are widespread and result from degradation of the maquis and garrigue, mainly due to grazing (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. Some steppic communities are, however, climactic or semi-climactic with *Lygeum spartum* (on clay slopes) or with *Hyparrhenia pubescens* and *Andropogon distachyus*. Other steppes are characterized by *Brachypodium retusum* or *Phalaris truncata*. The more degraded steppes are characterized by *Stipa capensis*, *Aegilops geniculata* and a variety of thistles (*e.g.*, *Carlina involucrata*, *Notobasis syriaca*, *Galactites tomentosa*) and geophytes (*e.g.*, *Asphodelus aestivuus*, *Urginea pancration*). Steppic communities may also develop on abandoned agricultural land.

E. Communities of disturbed ground

Given the islands' high human population and its considerable land use, this community type has a large coverage. It is dominated by a variety of plant species, many of which are aliens. Subtypes occur in abandoned fields, along roadsides and in disturbed seaside habitats.

F. Coastal communities

Saline marshlands form an interface between the marine, freshwater and terrestrial environments. Maltese coastal marshes are characterized 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

becomes hypersaline and finally disappears completely, leaving the marsh dry until the following wet season. Because of these harsh environmental conditions, saline marshlands support a highly specialized 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).

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 (Schembri *et al.*, 1987; Anderson and Schembri, 1989). Sand dune ecosystems are thus amongst the rarest and most threatened of local ecosystems. Local dunes are dominated by the dune grasses *Elymus farctus* and *Sporobolus arenarius*, and, until recently, also by *Ammophila australis* which has now been totally extirpated.

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 and mainly form part of the Mediterranean vegetational community called the *Crithmo-Limonietum*.

G. Rupestral communities

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. 70-130 mm. 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 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 refuge 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 two belonging to monotypic genera: *Palaeocyanus crassifolius* (the National Plant of Malta) and *Cremnophyton lanfrancoi* (Lanfranco, 1989a, b).

H. Freshwater communities

During the wet season, 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 dry season. These natural freshwater pools house many freshwater species which are overall rare in the Maltese Islands (Lanfranco and Schembri, 1986). 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 rainwater, usually from springs. These pools are of great local interest since they represent the only natural standing water bodies in 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 associated with freshwater live in the *widien* watercourses when these are filled with water during the wet season. Apart from freshwater species, watercourses support a rich fauna of terrestrial organisms associated with the luxuriant vegetation that grows along them (Lanfranco and Schembri, 1986). The few remaining permanent springs support a distinctive flora and fauna, many species of which, since they require a year-round supply of running freshwater, are limited to this habitat type and are therefore very rare and have a restricted distribution. Along a few watercourses are still remnants of broad-leaved deciduous woodland with *Populus alba*, *Salix pedicellata*, *Ulmus canescens*, and sometimes accompanied by *Laurus nobilis*.

I. Caves

In spite of being made up almost exclusively of limestone, the Maltese Islands have surprisingly few deep caves. It is only recently that the biology and ecology of Maltese caves have started being investigated. These studies have shown that Maltese caves are inhabited by organisms which are adapted to live in such habitats and therefore have a very restricted distribution. The best known cave-dwellers are bats but there are many other species, particularly invertebrates. Moreover, a number of these species are endemic to the Maltese Islands and therefore of great scientific interest. They are also highly vulnerable, both because of the limited habitat available and because of their poor dispersive ability.

IV. – Human Impact

Summaries of the effect of man on the natural environment of the Maltese Islands are given by Haslam (1969, 1989), Industrial Council for Bird Preservation (Malta) (1975), Baldacchino (1988), and Schembri and Lanfranco (1990).

The Maltese Islands have been settled since Neolithic times (c. 7000 BP, Blouet, 1984). At present, the islands' total population has topped 360,000 and the overall population density is 1140 per km^2. The growth rate is 0.9% per year (1985 statistics). The resident population is augmented by substantial tourist arrivals which have tended to increase over the years and in 1992 topped the 1 million mark. It is hardly surprising therefore that human influence is a key feature of the islands' ecology.

The first settlers on the islands cleared the land for agriculture and introduced sheep and goats which prevented the trees from regenerating through their grazing activities. This process of deforestation has continued and has resulted in the almost total destruction of the native forests and most indigenous trees. Much of the land area of the islands is given over either to agriculture or to buildings and roads. Agricultural land is being diverted to other uses, mainly for buildings (registered agricultural land fell from c. 56% of the islands' area in 1957 to c. 45% in 1968 to c. 38% in 1985). Built-up areas (residential and industrial) now occupy c. 16% of the island of Malta and c. 10.1% of the island of Gozo (1985 statistics). There are some 1,518 km of roads (1988 statistics).

Globigerina Limestone is quarried for use as a building stone while Coralline Limestone is quarried for use as spalls. Many of the old quarries have been worked out and abandoned, some without any reclamation. New quarries are being established, in some cases in ecologically sensitive areas, such as in *widien* and on coastal cliffs. Another problem is disposal of domestic, building and industrial waste, which is currently deposited in a number of official land-fill sites. However, many unofficial dumps also exist.

Much agricultural land is on sloping ground which is terraced with retaining walls made of limestone rubble. Many of these rubble walls have fallen into disrepair with a concurrent increase of 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. There is no problem of contamination of water sources by industrial pollutants, however there are problems with high levels of chlorides (from overpumping) and nitrates (from fertilizers).

The intense human pressure on the natural environment over the years has resulted in the loss of habitats and in a number of indigenous species of wildlife becoming extinct; others are threatened in various ways (Schembri and Sultana, 1989).

V. – Conclusion

As with most densely populated small islands elsewhere, the environment of the Maltese Islands is shaped by a complex interaction of geological, climatic and anthropic factors. That the Maltese people and the State of Malta exist at all today, is mainly an accident of geology and climate: the many natural freshwater springs resulting from seepage of rainwater stored in limestone aquifers sealed by an impermeable clay stratum is very probably what attracted man to settle on the islands in the first place. There are many small central Mediterranean islands with no, or only a small, indigenous population. Most of these have very limited water resources, mostly due to their geological structure.

Having settled on the Maltese Islands, man had a profound effect on the subsequent environmental development, initially through his agricultural activities, and more recently, because of increasing industrialization and urbanization. The present landscape of the islands is entirely shaped by man, and human activities are the single most important factor affecting the environment, a trend which will almost certainly continue in the future.

Of these anthropic factors, the most important is, doubtlessly, land-use. The Maltese environment has been subject to great pressures from a variety of development-related activities. This is understandable given the size, population density and standard of living. Since independence in 1964, development in Malta has been largely uncoordinated. As far back as the mid-forties, various reports, proposals and pieces of draft legislation relating to land-use, in particular building development, have been prepared, but no integrated national plan was ever drawn up (Malta. Ministry for Development of Infrastructure, 1988). The result has been haphazard, piecemeal, unregulated development leading to urban sprawl, abandonment of agricultural land, increased soil erosion, deforestation, increased quarrying activity, loss of countryside, loss of habitats and wildlife, and problems of contamination of water resources, pollution and waste disposal (Schembri and Lanfranco, 1990).

It is only recently that there has been an active awareness of the need of protecting and conserving the islands' environment, of maintaining environmental quality and of controlling development. The most important initiative in this respect is the preparation of a Structure Plan for the Maltese Islands. Legislation enacted in 1988 *inter alia* requires the drafting of a Structure Plan formulating a national planning policy and general proposals in respect of the development and other use of land. The Structure Plan has as its basic objective "the optimal physical use and development of land which respects the environment and at the same time ensures that the basic social needs of the community are, as far as is practical, satisfied" (Malta. Ministry for Development of Infrastructure, 1988). Implicit in the whole Structure Plan process is the understanding that, ultimately, the country's most scarce resource is land and that there will therefore continue to be fierce competition for its use. A more intelligent and environmentally-sensitive management of land use within the Maltese Islands will hopefully result in an acceptable blending of developmental needs and the preservation of the islands' traditional agricultural landscape as well as conservation of the countryside and of the natural and cultural heritage of the country.

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References

Anderson, E. W., and P. J. Schembri (1989). Coastal zone survey of the Maltese Islands report. Planning Services Division, Works Department, Floriana.

Baldacchino, A. E., ed. (1988). *State of the Environment Report 1985: A comparative aid to the state of the environment today*. Valletta: Din l-Art Helwa/Men of the Trees/The Ornithological Society/Society for the Study and Conservation of Nature.

Blouet, B. (1984). *The Story of Malta*. Valletta: Progress Press.

Bowen Jones, H., J. C. Dewdney, and W. B. Fisher, eds. (1961). *Malta: A background for development*. Durham: Durham University Press.

Chadwick, O. (1884). Report on the water supply of Malta.Valletta: Government Printing Office.

Chetcuti, D. (1988). The climate of the Maltese Islands. Unpublished B.Ed. (Hons.) dissertation, University of Malta.

Chetcuti, D., A. Buhagiar, P. J. Schembri, and F. Ventura (1992). *The climate of the Maltese Islands: A review*. Msida: Malta University Press.

Ellenberg, L. (1983).Die Kusten von Gozo. *Essener Geogr. Arb*. 6:129-160.

Haslam, S. M. (1969). *Malta's Plant Life*.

—— (1989). The influence of climate and man on the watercourses of Malta. *Toxic. Env. Chem*. 20-21:85-92.

House, M. R., K. C. Dunham, and J. C. Wigglesworth (1961). Geology and structure of the Maltese Islands. In *Malta: A background for development,* eds. H. Bowen Jones, J. Dewdney and W. B. Fisher, pp. 25-47, Durham: Durham University Press.

Hyde, H. P.T. (1955). *Geology of the Maltese Islands.*

Industrial Council for Bird Preservation (ICBP) (1975). Prospect and review of ecological problems concerning the Maltese natural environment, unpublished memorandum presented to the Director of Agriculture and the Food and Agriculture Orgnisation (FAO) General Agricultural Advisor, Valletta.

Lanfranco, E. (1984). Guida alle escursioni a Malta. Societa Botanica Italiana, sezzione Siciliana. Mimeo.

—— (1989a). Il-Pjanti Vaskulari Endemici tal-Gzejjer Maltin [The endemic vascular plants of the Maltese islands]. In *L-Identita Kulturali ta' Malta* [The cultural identity of Malta], ed.T. Cortis, pp.141-164. Valletta: Department of Information.

—— (1989b). The Flora. In *Red Data Book for the Maltese Islands,* eds. P. J. Schembri and J. Sultana, pp. 5-70, Valletta: Department of Information.

Lanfranco, E., and P.J. Schembri (1986). Maltese wetlands and wetland biota. *Potamon* 15:122-125.

Lang, D.M. (1960). *Soils of Malta and Gozo.* London: Her Majesty's Stationery Office (HMSO). Colonial Research Series, 29.

Malta. Ministry for Development of Infrastructure. Town Planning Division, Floriana (1988). Structure Plan brief.

Mitchell, P. K., and J.C. Dewdney (1961). The Maltese climate and weather. In *Malta: A background for development*, eds. H. Bowen Jones, J. C. Dewdney and W.B. Fisher, pp. 48-82, Durham: Durham University Press.

Morelli, C., G. Gantar, and M. Pisani (1975). Bathymetry, gravity and magnetism in the Strait of Sicily and in the Ionian Sea. *Boll. Geof. Teor. Appl.* 17:39-57.

Morris, T. O. (1952). The water supply resources of Malta. Valletta: Government Printing Office.

Murray, J. (1890). The Maltese Islands with special reference to their geological structure. *Scottish Geogr. Mag.* 6:449-488.

Newbery, J. (1968). The perched water table in the upper limestone aquifer of Malta. *J. Inst. Water Eng.* 22:551-570.

Paskoff, R., and P. Sanlaville (1978). Observations géomorphologiques sur les côtes de l'archipel maltais [Geomorpholocial observations on the coasts of the Maltese archipelago]. *Zeitschrift fur Geomorphologie* 22(3): 310-328.

Pedley, H. M., M. R. House, and B. Waugh (1976). The Geology of Malta and Gozo. In *Proceedings of the Geologists' Association* 87(3): 325-341.

— (1978). The Geology of the Pelagian Block: the Maltese Islands. In *The Ocean Basins and Margins,* eds.A. E. M. Nairn, W. H. Kanes and F.G. Stehli. *The Western Mediterranean*, vol. 4B, pp. 417-433, London: Plenum Press.

Ransley, N., and A. Azzopardi (1988). *A Geography of the Maltese Islands*. 4th ed. Birkirkara: St. Aloysius College Publishers.

Reuther, C. D. (1984). Tectonics of the Maltese Islands. *Centro* 1:1-20.

Rizzo, C. (1932). Report on the geology of the Maltese Islands including chapters on possible ground-water tables and prospecting for mineral oil and natural gas. Valletta: Government Printing Office.

Schembri, P. J. (1988). Conservation of the Maltese fauna. In *State of the Environment Report 1985: A comparative aid to the state of the environment today*, ed. A. E. Baldacchino. Valletta: Din l-Art Helwa/Men of the Trees/The Ornithological Society/Society of the Study and Conservation of Nature.

—— (1991). Ekologija tal-Gzejjer Maltin: Harsa Generali [Ecology of the Maltese Islands: A general overview]. In *Oqsma tal-kultura Maltija* [Aspects of the Maltese culture], ed. T. Cortis, pp. 5-37, Floriana: Ministry of Education and the Interior.

—— (1992). Report of survey: Natural resources In *Malta Structure Plan Technical Report*. Floriana: Planning Services Division.

Schembri, P. J., and E. W. Anderson (1991). Land-use competition in Malta. Paper presented at International Conference on Islands and Small States. Foundation for International Studies, Valletta, May 23-25, 1991. Mimeo.

Schembri, P. J., and E. Lanfranco (1990). The effects of development on the natural environment of the Maltese Islands. Paper presented at Conference on Small Island Development. Foundation for International Studies, Valletta, March 24-28, 1990.Mimeo.

Schembri, P. J., E. Lanfranco, P.Farrugia, S. Schembri, and J. Sultana (1987). Localities with conservation value in the Maltese Islands. Floriana: Environment Division, Ministry of Education.

Schembri, P.J., and J. Sultana, eds. (1989). *Red data book for the Maltese Islands.* Valletta: Department of Information.

Trechmann, C. T. (1938). Quaternary Conditions in Malta. *Geog. Mag.* 75:1-26.

Vossmerbäumer, H. (1972). Malta, ein Beitrag zur geologie und geomorphologie des Zentralmediterranen Raumes. *Wurzburger Geogr. Arb*. 38:1-213.

Zammit, T. (1931). *The water supply of the Maltese Islands*. Valletta: Government Printing Office.

Zammit Maempel, G. (1977). *An outline of Maltese geology*.

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