Published as:
Schembri, P.J. (1994) Natural heritage. In: Frendo, H. & Friggieri, O. (eds) *Malta culture and identity.* pp. 105-124; Valletta, Malta: Ministry of Youth and the Arts; ix + 272pp.

MALTA'S NATURAL HERITAGE

by

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INTRODUCTION

Malta[1] is justifiably renowned for its rich archaeological, historical and cultural heritage. However, the islands are generally thought of as having little to offer in terms of natural history, that is, natural objects and events, including plant and animal life, fossils, rocks, landscape features and climate. This is far from the truth. In spite of their small size, the Maltese Islands are endowed with a variety of habitat types, a diverse fauna and flora, and an interesting geology. These constitute the natural heritage of the Maltese Islands, which is just as worthy of study and preservation as the rest of the nation's patrimony.

Apart from their local importance, some elements of Malta's natural heritage have a wider regional importance. For example:

- A number of Maltese endemic (i.e. found only in a particular region and nowhere else) plants and animals are relics from the pre-glacial Mediterranean flora and fauna and some have no close relatives anywhere else in the world.

- Numerous endemic species and subspecies of plants and animals have been described from the Maltese Islands and these are of evolutionary and biogeographical interest.

- Numerous species of Maltese flora and fauna have a restricted Mediterranean distribution. Some locally relatively common species are endangered on a European scale.

- The island of Filfla situated some 4.5km south off the southern coast of mainland Malta, supports one of the largest known breeding colonies of the Storm Petrel *Hydrobates pelagicus* in the Mediterranean.

- The Mediterranean is divided into two major subregions, the East Basin and the West Basin, each with its own characteristic species. Additionally, there are differences in species diversity between the northern (European) shores and the southern (North African) shores of the Mediterranean. Being situated in the centre of the Mediterranean, the Maltese Islands are at the meeting point of these four regions, and therefore the marine biota of the islands is of biogeographical interest.

- The Maltese Islands include the only part of an extensive central Mediterranean rift system (the Pantelleria Rift) currently to be exposed and as such provide an insight into the processes associated with development of this rift.

[1] In this work, Malta means the Republic of Malta as a whole, while the island of Malta is referred to as 'mainland Malta'.

This article briefly reviews the main elements of Malta's natural heritage and discusses their cultural and scientific importance. There exists an extensive literature on Maltese natural history, however, there are very few synthetic works. For reasons of space, it was not possible to include a full bibliography, therefore, the works listed in the Bibliography were selected mainly on the basis of their seminality and availability, and on whether they summarise previous work and include extensive bibliographies. Preference was given to books and book chapters, however, a fair number of primary research papers published in learned journals had to be included as, in many cases, these represent the only available works on the subject.

GEOGRAPHY, GEOLOGY AND PALAEONTOLOGY

Geography

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 Tunisia and Libya. Geophysically, the Maltese Islands and the Hyblean Plateau of southeastern 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 reaches a maximum depth of not more than 200m and is mostly less than 90m; that between the islands and North Africa is much deeper, in places reaching more than 1000m.

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:

mainland 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

Geology and palaeontology

Geologically, the islands are composed almost entirely of marine sedimentary rocks, mainly limestones of Oligo-Miocene age (30-5 million years BP). In many respects these resemble the mid-Tertiary limestones occurring in the Ragusa region of Sicily, in the Pelagian Islands, and in the Sirte Basin of Libya, suggesting that all these localities formed part of the same unit during their formation. There are also some minor Quaternary deposits of terrestrial origin. Although the geology of the Malta is overall quite simple in that it consists only of sedimentary rocks in a basic layer-cake arrangement, yet in detail it is remarkably complex. Because of the very good exposures available, the Maltese strata have been the subject of numerous studies by geologists and are frequently the subject of field-trips organized by learned societies and educational institutions.

The five main rock types are (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. The coralline algae *Lithothamnium* and *Archaeolithothamnium* (from which the formation gets its name) are locally abundant, and corals, bivalves and gastropods are characteristic fossils. The upper part of the formation consists of a c.1m thick bed especially rich in fossils of the sea urchin *Scutella* and is thus often referred to as the Scutella Bed.

■**Globigerina Limestone** 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 pebble beds. Apart from microfossils (e.g. the foraminiferan *Globigerina* from which the formation gets its name), common fossils of the Globigerina Limestone include bivalves, gastropods and sea urchins. Remains of turtles, crocodiles, a sirenian, and a seal have also been found. The pebble beds are rich in fossil bivalves, gastropods, sea urchins,
corals and shark teeth (e.g. of the giant shark *Carcharodon megalodon*, estimated to have attained a length of some 25m).

■**Blue Clay** is exposed to thicknesses of up to 65m. The upper reaches of this formation are rich in fossils of cephalopods (cuttlefish), bivalves, gastropods, sea urchins and corals. Vertebrate remains including fish teeth, cetaceans and sirenians have also been found.

■**Greensand** is exposed to a maximum thickness of 12m, however, in most places this formation only attains a thickness of some 1m. The name derives from the abundant dark green grains of the iron mineral glauconite. This horizon is very rich in fossils, especially foraminifera (e.g. the giant *Heterostregina*, sometimes so abundant as to give a 'Heterostregina Limestone'), gastropods, bivalves and sea urchins.

■**Upper Coralline Limestone** 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 (1.9-0.01 million years BP) occur and comprise 'fossil' soils (palaeosols), fluvial gravels, coastal conglomerates and breccias, dunes and infillings of caves and fissures.

The more ancient deposits (such as those of the lower beds in the Ghar Dalam Cave sequence) have yielded the remains of hippopotami (*Hippopotamus*), dwarf elephants (*Palaeoloxodon*), bats, swans (*Cygnus*) and other birds. Younger deposits have yielded copious remains of deer (*Cervus*). Other fossils found in this and other cave and fissure infills from various parts of the islands include dormice (*Leithia, Eliomys*), voles (*Pitymys*) shrews (*Crocidura*), bats (*Rhinolophus*), an otter (*Nesolutra*), a bear (*Ursus*), a fox (*Vulpes*), a wolf (*Canis*), a small horse (*Equus*) as well as various bird, turtle, toad and lizard remains.

Many Quaternary deposits, especially the younger red-coloured ones (so coloured by the oxidation products of iron minerals) are rich in the fossil and subfossil remains of brackish water, freshwater and terrestrial molluscs.

The Pleistocene sediments and their faunas indicate 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.

Soils

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. Using the Kubiëna classification system, Maltese soils are of 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 (see below).

■**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

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. Karst is a terrain created by the solution of limestone rock and is characterised by a series of surface hollows, depressions and fissures and a subterranean drainage network. 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. This is interpreted as being a result of upwelling which started in late Miocene times as a result of formation of the Pantelleria Rift. There are no mountains, the highest point is at Ta' Zuta on Dingli Cliffs (SW mainland Malta) which is 253m above sea level; the highest point on Gozo is at Dbiegi (191m). 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. 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. In places, the vertical throw of the Great Fault is between 90m and 180m, and produces steep escarpments. 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 there is a system of ridges and valleys (see below). 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 and slickensides (polished and scratched surfaces at the fault plane produced by friction between the opposing sides of the fault) are very evident (e.g. at Ix-Xaqqa).
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 mainland 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 mainland 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 importance are the *rdum*, *widien* (singular *wied*), and solution subsidence structures. *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, 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.

Changes in sea level have submerged the mouths of some of these *widien* where they exit on the coast, giving rise to headlands, creeks and bays. This is especially evident on the northeastern coasts because of the islands' seawards tilt in this direction. Especially important are the systems of drowned valleys which form the creeks of Malta's two main harbours: Marsamxett Harbour and Grand Harbour, separated by the Valletta headland. Important examples of inundated river valleys in Gozo include Mgarr ix-Xini Bay and Xlendi Bay.

A solution subsidence structure results when the surface collapses into a circular crater-like hollow due to removal by solution of the underlying limestone. There are two families of such structures in the Maltese Islands: those formed underwater due to seafloor collapse during the Miocene, and those formed on land during the Quaternary. The former are only found in Gozo, and the best examples are Dwejra Bay and Qawra (the 'Inland Sea'). The terrestrial structures are termed dolines and result from cavern roof collapse following enlargement of an underground cavern by groundwater. The best known example of this type of structure is Il-Maqluba on the outskirts of Qrendi on mainland Malta.

One particular feature of regional importance is the Upper Coralline Limestone outlier located in the Ghar Lapsi area on the southwestern coast of mainland Malta. An outlier is an outcrop of rock occurring in a detached location from the main body of similar rock. In the case of the Ghar Lapsi outlier, the nearest outcrop of Upper Coralline Limestone occurs some 1km to the northwest. This outlier is the only part of the extensive Pantelleria Rift system which is currently exposed above sea level and as such it provides a unique opportunity for study of the syntectonic depositional processes associated with rift development; additionally, the younger parts of the deposit record a Late Miocene emergence of the Maltese Islands better than that seen in any other Maltese locality.

Climate

The Maltese climate is characterised by moist winters during which the bulk of the annual rainfall is deposited, air temperatures which never fall below zero, and a long hot and dry summer. This climatic regime is typical of the central Mediterranean. The table below gives the mean monthly values of selected climatic parameters (based on data from the Meteorological Office of the Department of Civil Aviation).

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	9.5	27.7	20.9	25.0	8.9
Oct	7.8	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 530mm (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, 191.3mm; extreme maximum for period, 1031.2mm). However, no trend in the annual rainfall appears to exist. 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). Even within the wet period, rain is not evenly distributed. A large amount of rain may fall in a short period of time during a single storm, and the mean annual rainfall may in fact represent three or four short torrential downpours. The most intense outbursts occur during the often violent storms which characterise the transition from the dry to the wet period.

Air temperatures are moderate (mean annual temperature for period 1951-1990, 18.6°C; mean monthly range, 12.3-26.3°C). The reduced temperature difference between the warmest and the coldest months of the year is due to the moderating effect of the sea coupled with the lack of very high ground on the islands. The islands are small enough for the influence of the sea to be felt strongly even in inland sites. Temperatures never fall too low for adequate plant growth. Grass temperatures may fall below zero for a few hours at night during the period December to April. During the summer months, grass temperatures may reach values in the upper 40s.

Because of the maritime nature of the islands, relative humidity is consistently high throughout the year, being mostly in the range 65-80%. The high relative humidity even during the hot, dry period results in heavy dewfalls when the temperature falls slightly during the night. These dewfalls are of extreme importance as they represent the only reliable source of water for numerous biota during the arid summer months. The Maltese Islands receive a great deal of sunshine all the year round (mean for period 1951-1990, 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 northwesterly which on average blows on 19% of windy days. The other winds are all nearly equally represented. Southwesterly winds (known locally as *Xlokk*) bring damp oppressive weather and often copious red dust from the Sahara.

The climate of the Maltese Islands has a profound influence on the vegetation, and consequently, on the islands' fauna, landscape and ecology, including that of the human population. The hot, arid summer months are very stressful to plant growth and the natural vegetation is therefore characterised by evergreen trees and shrubs which resist the adverse summer heat and drought, and a very large number of herbaceous plants which grow and flower during the wet period, but which spend the dry period in the form of seeds or perennating organs (e.g. bulbs, rhizomes etc.) below ground. The main periods of plant growth are autumn and spring, when temperature and rainfall are optimal.

FLORA AND FAUNA

The Maltese Islands are popularly regarded as having an impoverished flora and fauna. This view was probably handed down by casual visitors in colonial times who, more accustomed to northern latitudes and mainland biotas, drew wrong conclusions about the totally different environment of the central Mediterranean. In actual fact, the Maltese 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.

The table below gives estimates of the number of species of selected groups of plants and animals which occur in the Maltese Islands.

The number of species of representative groups of plants and animals in the Maltese Islands. 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.

PLANTS	
Algae	**c.150**
Large Fungi	**c.150**
Lichenes (lichens)	**c.300**
Bryophyta (mosses and relatives)	**c.130**
Pteridophyta (ferns and relatives)	**11**
Gymnospermae (conifers)	**2 indigenous species**
Angiospermae (flowering plants)	**c.1000**
ANIMALS	
Hydrozoa (hydras)	**1 species recorded**
Turbellaria (flatworms)	**at least 10 species**
Annelida (earthworms and leeches)	**at least 15 species**
Mollusca (snails and slugs)	**c.67**
Arachnida (spiders and relatives)	**at least 200+ species**
Branchiopoda (fairy shrimps, water-fleas and relatives)	**at least 10 species**
Ostracoda (seed shrimps)	**at least 7 species**
Amphipoda (sandhoppers and beach-hoppers)	**c.9 recorded**
Isopoda (woodlice)	**c.49**
Decapoda (crabs)	**one freshwater species**
Odonata (dragonflies and damselflies)	**c.10 recorded**
Dictyoptera (mantises and cockroaches)	**c.11**
Orthoptera (grasshoppers and relatives)	**c.48**
Coleoptera (beetles)	**c.600 recorded; probably 2000+ occur**
Heteroptera (true bugs)	**113 recorded; more occur**
Lepidoptera (butterflies and moths)	**c.590**
Neuroptera (lacewings)	**c.12 recorded**
Diptera (flies)	**c.200 recorded; probably 500+ occur**
Hymenoptera (bees, wasps and ants)	**c.150 recorded; probably 500+ occur**
Diplopoda (millipedes)	**c.14**
Chilopoda (centipedes)	**c.15**
Amphibia (frogs)	**1 species**
Reptilia (reptiles)	**9 species**
Aves (birds)	**c.13 resident (c.57 regular visitors and c.112 regular migrants)**
Mammalia (mammals)	**c.20 species**

As might be expected, the main affinities of the Maltese biota are with Sicily, the closest landmass of any size. However, the Maltese biota is not merely an appendage to that of Sicily. To illustrate this let us consider vascular plants (Tracheophyta) which are much better known than any other group. The bulk of Maltese vascular plants also occur in Sicily, and indeed some species are Siculo-Maltese endemics, that is, they are found only in Sicily and Malta, for example: Sicilian Squill (*Scilla sicula*), Sicilian Iris (*Iris sicula*), Pygmy Groundsel (*Senecio pygmaeus*), Pignatti's Fern-grass (*Desmazeria pignattii*) and Late Spider-orchid (*Ophrys oxyrrhyncos*). Nevertheless, several Maltese species are absent from Sicily, for example: Aleppo Spurge (*Euphorbia aleppica*) and Olive-leaved Bindweed (*Convolvulus*

oleifolius). The Maltese Islands' position in the centre of the Mediterranean results in the presence both of western elements such as Mediterranean Willow (*Salix pedicellata*), African Tamarisk (*Tamarix africana*) and Sandarac Gum Tree (*Tetraclinis articulata*, the national tree of Malta), and of eastern elements such as Thorny Burnet (*Sarcopoterium spinosum*) and Olive-leaved Bindweed (*Convolvulus oleifolius*). There is also a fairly strong North African element represented by such species as Egyptian St.John's Wort (*Triadenia aegyptica*), Rock Crosswort (*Crucianella rupestris*) and perhaps such Pelago-Maltese endemics (i.e. found only in Malta and the neighbouring Pelagian Islands) as Cliff Carrot (*Daucus rupestris*), Maltese Toadflax (*Linaria pseudolaxiflora*) and Maltese Waterwort (*Elatine gussonei*). Similar patterns of biogeographical affinity are also shown by certain animal groups, although for these the data are still incomplete.

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

The number of endemic species occurring in the Maltese Islands. Only those groups which have been adequately studied taxonomically are included and only freshwater and terrestrial species are considered.

Group	**Number of endemic species**
Tracheophyta (higher plants)	**21**
Bryophyta (mosses and relatives)	**2**
Mollusca (snails and slugs)	**8**
Pseudoscorpiones (false scorpions)	**3**
Palpigradi (micro-whipscorpions)	**1**
Isopoda (woodlice)	**5**
Decapoda (crabs)	**1**
Thysanura (silverfish)	**1**
Orthoptera (grasshoppers and relatives)	**1**
Heteroptera (true bugs)	**1**
Coleoptera: Staphylinidae (rove beetles)	**4**
Coleoptera: Elateridae (click beetles)	**1**
Coleoptera: Tenebrionidae (darkling beetles)	**5**
Coleoptera: Curculionidae (weevils)	**2**
Lepidoptera: (butterflies and moths)	**17**
Hymenoptera: Formicidae (ants)	**2**
Hymenoptera: Mutillidae (velvet ants)	**1**
Reptilia (reptiles)	**1**
Mammalia (mammals)	**1**

Endemic species are of great cultural and scientific importance. Culturally they are important because such species are unique to the Maltese Islands and therefore a valuable part of the national heritage. Scientifically they are important because of their intrinsic interest with respect to phylogeny, biogeography and evolution of their group, and for the wider evolutionary processes they demonstrate. Three cases will suffice to show this: the endemic vascular plants, the endemic lizard, and the endemic shrew of Gozo.

Some of the endemic plants of the islands are relics from the pre-glacial Mediterranean flora (these are called palaeoendemics) and have no close relatives anywhere else in the world. The principal palaeoendemics are Maltese Cliff-orache (*Cremnophyton lanfrancoi*), Maltese Rock-centaury (*Palaeocyanus crassifolius*, the national plant of Malta), Maltese Salt-tree (*Darniella melitensis*), Maltese Fleabane (*Chiliadenus bocconei*), Maltese Hyoseris (*Hyoseris frutescens*), and Maltese Dwarf Garlic (*Allium lojaconei*). The genera *Cremnophyton* and *Palaeocyanus* are monotypic, that is, represented by a single species only, and therefore, these are also endemic to the Maltese Islands. *Palaeocyanus* is most closely related to the genus *Centaurea* but is more primitive than this and related genera. *Cremnophyton* is related to the ancestors of *Atriplex*. These species are therefore of interest from the evolutionary point of view since they throw light on the evolution of certain plant groups. Other endemic plants evolved more recently, following final separation of the Maltese Islands from the Sicilian and European mainlands (these are called neoendemics). The neoendemics include Maltese Sea-lavender (*Limonium melitense*), Zerapha's Sea-lavender (*Limonium*

zeraphae), Maltese Pyramidal Orchid (*Anacamptis urvilleana*), and Maltese Sea-chamomile (*Anthemis urvilleana*). These are closely related to mainland species but differ due to their reproductive isolation. Such species therefore illustrate evolutionary processes at work.

These processes are also illustrated by the endemic lizard and the shrew of Gozo. The Maltese Wall Lizard, *Podarcis filfolensis*, is a species endemic to the Maltese Islands and the Pelagian Islands of Linosa and Lampione. Four races have been named from the various islands of the Maltese group (*filfolensis* from Filfla; *maltensis* from mainland Malta, Gozo and Comino; *kieselbachi* from St.Paul's Islands; and *generalensis* from Fungus Rock) and one race from the Pelagian Islands (*laurentiimuelleri*). *Podarcis filfolensis* is closely related to *Podarcis sicula*, a southern European species, and to *Podarcis melisellensis*, a species of the East Adriatic coast.

Two species of shrew currently occur in the Maltese Islands: the Pygmy Shrew (*Suncus etruscus*) which is known to have been introduced into the islands in historic times and a White-toothed Shrew (genus *Crocidura*) which is only found on Gozo and which has been assigned different names by different workers. Another species of White-toothed Shrew (equated with the extinct Pleistocene *Crocidura esuae* of Sicily by some workers) pre-dated human occupation of the islands. A recent re-evaluation of the living Maltese *Crocidura* species has shown that this is actually *Crocidura sicula*, a Sicilian species. The present day Sicilian and Maltese species evolved from the Pleistocene *Crocidura esuae* and the only real difference between the two is a reduction in size. *Crocidura sicula* is a Siculo-Maltese endemism and one of the few survivors of the Pleistocene fauna of the region. The Gozitan population has been named as an endemic subspecies, *calypso*; the other living subspecies are *C.s. sicula* of Sicily and *C.s. aegatensis* of the Egadi Islands. According to some workers, *Crocidura sicula* is closely related to North African species of the genus.

In passing one can mention that many endemic species have been named after the Maltese naturalists who discovered them. In this way Maltese pioneers of the study of the natural history of Malta, such as Stefano Zerafa, Gavino Gulia, Giovanni Gulia, Giuseppe Mamo, Antonio Schembri, Alfredo Caruana Gatto, Giuseppe Despott, Carmelo De Lucca and Anthony Valletta, are commemorated.

BIOCOENOSES

Biocoenosis is a general ecological term for any naturally occurring group of organisms inhabiting a common environment. The terrestrial biocoenoses 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 are either specialised 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 biocoenoses are based mainly on vegetation.

■ Woodland

It is thought that before man colonised 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 characterised by Holm Oak (*Quercus ilex*) and Aleppo Pine (*Pinus halepensis*) with an undergrowth of smaller trees, shrubs and climbers. The early settlers cut the trees for their wood and to clear the land for agriculture and buildings. Additionally, these colonisers 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 (mainland 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. Lentisk, Buckthorn and Hawthorn), herbs and climbers. This semi-natural wood is very important since it represents the only woodland ecosystem on the islands and consequently harbours a large number of woodland plants and animals which, because of the lack of suitable habitats in Malta, are locally very rare. Particularly important woodland species are fungi which are symbiotic with trees, insects which feed, breed or live in trees and dead wood, and leaf-litter inhabiting invertebrates.

Many other wooded areas exist in the islands, however, all are man-made (e.g. public/private gardens, afforestation sites, orchards, etc.) 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

Maquis is a more or less dense, mostly evergreen shrub community where the individual shrubs reach a height of between 1m and 3m. In Malta, 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 a secondary maquis develops round trees, mainly olives and carobs, planted by man.

The local maquis is characterised by a number of small shrubs principally Carob (*Ceratonia siliqua*), Olive (*Olea europaea*), Lentisk (*Pistacia lentiscus*), Buckthorn (*Rhamnus oleoides*), Yellow Germander (*Teucrium flavum*), Hedge Nettle (*Prasium majus*) and others.

■ Garigue

Garigue is a community of low (less than 1m) scattered, often spiney and aromatic shrubs with a herbaceous undergrowth. This is the most common natural vegetation type present in Malta. Some garigue communities are natural, others result from degradation of forest and maquis. Garigues are typical of rocky ground, particularly karstland, and are characterised by such species as Mediterranean Thyme (*Coridothymus capitatus*), Yellow Kidney-vetch (*Anthyllis hermanniae*), Evergreen Germander (*Teucrium fructicans*), Mediterranean Heath (*Erica multiflora*) and the endemic Maltese Spurge (*Euphorbia melitensis*), accompanied by numerous geophytes (herbs with perennating buds below soil level) and therophytes (herbs which survive the unfavourable season as seeds). Many subtypes of garigue exist.

■ Steppic grassland

This is a treeless grassland dominated by grasses, umbellifers, thistles and geophytes. Steppic grasslands are widespread and result from degradation of the maquis and garigue, 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 spiney xerophytic vegetation), but also in response to other factors. Some steppic communities are, however, climactic or semi-climactic, for example, those dominated by Esparto Grass (*Lygeum spartum*) which develop on clay slopes. The more degraded steppes are characterised by Common Awn-grass (*Stipa capensis*), Aegilops (*Aegilops geniculata*) and a variety of thistles (e.g. Clustered Carline Thistle *Carlina involucrata*, Horse Thistle *Notobasis syriaca*, Mediterranean Thistle *Galactites tomentosa*) and geophytes (e.g. Asphodel *Asphodelus aestivuus*, Seaside Squill *Urginea pancration*). Steppic communities may also develop on abandoned agricultural land.

■ Communities of disturbed ground

Given the islands' high human population and its considerable land use, this biocoenosis 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.

■ 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 finally disappears completely, leaving the marsh dry until the following wet season. Because of these harsh environmental conditions,

saline marshlands support a highly specialised biota which is only found in this type of habitat. Although several species are common to all local marshlands, yet each site has its own peculiar habitat characteristics and suite of species.

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. 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 Southern Marram Grass (*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*. In the Maltese variants of this biocoenosis, 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-chamomile (*Anthemis urvilleana*); the latter is Maltese Dwarf Garlic (*Allium lojaconoi*). Other characteristic plants of scientific importance include: Pignatti's Fern-grass (*Desmazeria pignattii*) and Pygmy Groundsel (*Senecio pygmaeus*), which are Hybleo-Maltese endemics. Although the fauna of low-lying coastal rock is much less well known, several species seem to be more or less exclusive to this habitat type.

■ Rupestral communities

These grow on cliff faces and high walls. The south, southwest and west coasts of mainland 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.

The fauna of coastal cliffs includes some of the rarest of Maltese animals; for example, the endemic Maltese Door-snail (*Lampedusa melitensis*) occupies a very precarious habitat of a few tens of square metres only on the southwest cliffs of mainland Malta, while two other rare endemic snails are found in a few cliffside localities only. Cliff-side communities are dominated by shrubs and are especially significant due to the presence of a large number of endemic plant taxa including the two (*Palaeocyanus crassifolius* and *Cremnophyton lanfrancoi*) belonging to monotypic genera already mentioned.

■ 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 onset of the dry season. These natural freshwater pools house many freshwater species which are overall rare in the Maltese Islands. 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 associating with freshwater are found in *widien* watercourses when these are filled with water during the wet season. One of the most conspicuous species of these habitats is the Painted Frog (*Discoglossus pictus*), Malta's only amphibian. Apart from freshwater species, watercourses support a rich fauna of terrestrial organisms associated with the luxuriant vegetation that grows along the *widien*. 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. One such species is the endemic local race of the Mediterranean Freshwater Crab (*Potamon fluviatile lanfrancoi*). Along a few watercourses there are still remnants of broad-leaved deciduous woodland with White Poplar (*Populus alba*), Mediterranean Willow (*Salix pedicellata*), and Grey-leaved Elm (*Ulmus canescens*), sometimes accompanied by Bay Laurel (*Laurus nobilis*).

■ 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 has 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. Additionally, many caves have deposits of Quaternary age, study of which is expected to throw light on the islands' palaeoenvironment and biogeography. One cave, that at Ghar Harq Hamiem at St.Georges Bay (mainland Malta) is unique in that it houses a deep pool of freshwater, the only such body known in the Maltese Islands.

■ Marine biocoenoses

The marine biocoenoses of the Maltese Islands are mostly similar to those found in other parts of the Mediterranean. Only the most interesting locally occurring ones of the shore and shallow water off it are discussed below.

Supralittoral biocoenoses are those which occur high up on the shore where the substratum is only wetted by sea spray and the very highest waves. Supralittoral communities of rocky substrata are by far the commonest given that most of the islands' coastline is of this type. Those of soft substrata are to be found on the few sandy beaches, however, these communities have been little studied locally. A very distinctive supralittoral biocoenosis is that of the so called "banquettes", consisting of masses of drying and decaying plant debris deposited on the shore by wave action. These specialised communities are composed of an assortment of semi-terrestrial marine species and semi-aquatic terrestrial species.

Mediolittoral biocoenoses are those which occur in that part of the shore continuously covered and uncovered by the sea. One such type of biocoenosis which is considered valuable on a Mediterranean scale and which also occurs locally, is the vermetid/coralline algal "trottoir" (or 'rim'). This consists of dense aggregations of vermetid gastropods (*Dendropoma* sp.) whose uncoiled shells are cemented to the rocky substratum and to each other, and where the interstices are filled by the coralline alga *Neogoniolithon*. A second type of threatened trottoir, that formed by the coralline alga *Lithophyllum lichenoides* may also occur.

Infralittoral biocoenoses are those occurring under the sea, from mean sea level down to a depth where there is sufficient light for photosynthesis. In the Maltese Islands this is down to a depth of c.70m. The main community developing on infralittoral rocky substrata is that dominated by attached macroalgae. Many subtypes are known, depending on shelter, light penetration, nature of the substratum, water movement etc. The most widespread are those dominated by species of the brown seaweed *Cystoseira* which grow on exposed rocky shores starting from very shallow water. Another type of *Cystoseira* community grows in deep water and is based on the species *Cystoseira spinosa*, *Cystoseira dubia*, and *Cystoseira zozteroides*. Most of the Mediterranean species of *Cystoseira* are endemic to the region.

Sea-grass meadows are perhaps the most important sublittoral biotic communities in the Mediterranean. Sea-grass meadows are highly productive ecosystems on which a large number of other ecosystems, and individual species, depend; for example, many fish and cephalopods use these meadows as breeding and nursery grounds. Although common and widespread round the Maltese Islands, sea-grasses are very sensitive to pollution and habitat

modification. In many parts of the Mediterranean, these meadows have regressed and eroded away, leaving in their place much impoverished thanatocoenoses (i.e. communities based on dead or dying organisms). The same is likely to happen to Maltese sea-grass meadows in enclosed or semi-enclosed coastal areas receiving a variety of effluents or subject to certain activities (for example, dredging, dumping, aquaculture operations etc.). Several types of sea-grass meadows exist. In deeper water these are formed mainly by Neptune Grass (*Posidonia oceanica*), a species endemic to the Mediterranean. In more sheltered localities and in shallow water, the meadows are based on Lesser Neptune Grass (*Cymodocea nodosa*), Red Sea Grass (*Halophila stipulacea*) and the alga *Caulerpa prolifera*.

ACKNOWLEDGEMENTS

I wish to thank Mr Edwin Lanfranco (Department of Biology, University of Malta) for his help and advice during the preparation of this article, particularly concerning botanical matters. I thank also Mr John A. Schembri (Mediterranean Institute, University of Malta), Mr Stephen Schembri (Mediterranean Institute, University of Malta) and Professor Frank Ventura (Faculty of Education, University of Malta) for their help with various aspects of this work, and the Meteorological Office of the Department of Civil Aviation for supplying meteorological data. I am grateful to the University of Malta for supporting my research on the faunistics and ecology of the Maltese Islands.

BIBLIOGRAPHY

Alexander, D. (1988) A review of the physical geography of Malta and its significance for tectonic geomorphology. *Quaternary Science Reviews* 7: 41-53.

Anderson, E.W. & Schembri, P.J. (1989) *Coastal zone survey of the Maltese Islands report*. Beltissebh, Malta: Planning Services Division, Works Department; xii + 121pp. + 100 hand-drawn colour maps + 19 synoptic maps.

Bacetti, B. (1972) Notulae orthopterologicae XXX. Gli ortotteroidei dell'arcipelago Maltese. *Lavori della Societa' Italiana di Biogeografia* n.ser., 3: 605-608.

Baldacchino, A.E.; Dandria, D.; Lanfranco, E. & Schembri, P.J. (1993) Records of spiders (Arachnida: Araneae) from the Maltese Islands (Central Mediterranean). *The Central Mediterranean Naturalist* 2(2): 37-59..

Baldacchino, A.E.; Lanfranco, E. & Schembri, P.J. (1990) *Discovering nature in the Maltese Islands.* Blata l-Bajda, Malta: Merlin Library Ltd.; 104pp.

Bannerman, D.A. & Vella Gaffiero, J.A. (1976) *Birds of the Maltese archipelago.* Valletta, Malta: Museums Department; xxi + 550pp. + map.

Beckmann, K.H. (1987) Land- und Süβwassermollusken der Maltesischen Inseln. *Heldia* 1 (suppl.): 1-38.

Biagini, E. (1974) *Le isole maltesi.* Genova: Accademia Ligure di Scienze e Lettere; 223pp.

Borg, John (1927) *Descriptive flora of the Maltese Islands.* Valletta, Malta: Government Printing Press; 846pp. [reprinted 1976 as *Floras of the world* Vol.2 by Otto Koeltz Science Publishers, Germany]

Borg, Joseph (1990) *The public gardens and groves of Malta and Gozo.* [3rd ed.] Malta: [the author]; xii + 149pp.

Borg, P. (1932) *The scale insects of the Maltese Islands*. Malta: Government Printing Office; 67pp.

Bosence, D.W.J. [ed.] (1990) *Field guide to the Cenozoic platform carbonates of the Maltese Islands.* Nottingham: International Sedimentological Congress 1990; 111pp.

Bosence, D.W.J.; Pedley, H.M. & Rose, E.P.F. (1981) *Field giude to the mid-Tertiary carbonate facies of Malta.* London: The Palaeontological Association; 88pp.

Bowen Jones, H.; Dewdney, J.C. & Fisher, W.B. [eds] (1961) *Malta, a background for development.* Durham: Durham University Press, 356pp.

Busuttil, S.; Lerin, F. & Mizzi, L. [eds](1993) *Malta: food, agriculture, fisheries and the environment.* [Options Méditerranéennes ser.B: Etudes et Recherches Nº7] Paris, France: CIHEAM (Centre International de Hautes Etudes Agronomiques Méditerranéennes); 192pp.

Cameron, M. & Caruana Gatto, A. (1907) The Coleoptera of the Maltese Islands. *Transactions of the Entomological Society of London* 59: 383-403.

Caruana Gatto, A. (1894) *Common beetles of the Maltese Islands*. Malta: G. Muscat; 14pp.

Caruso, D. & Lombardo, B.M. (1982) Isopodi terrestri delle Isole Maltesi. *Animalia* 9: 5-52.

Chetcuti, D.; Buhagiar, A.; Schembri, P.J. & Ventura, F. (1992) *The climate of the Maltese Islands: a review.* Msida, Malta: Malta University Press; vi + 108pp.

Cilia, J.L. (1989) Coleoptera. In: Schembri, P.J. & Sultana, J. [eds] *Red data book for the Maltese Islands* pp. 105-128; Valletta, Malta: Department of Information.

Ellenberg, L. (1983) Die küsten von Gozo. *Essener Geographische Arbeiten* 6: 129-160.

Enghoff, H. & Schembri, P.J. (1989) The millipedes of the Maltese Islands (Central Mediterranean) (Diplopoda). *Bollettino della Societa' Entomologica Italiana* 120: 164-173.

Felix, R. (1973) *Oligo-Miocene stratigraphy of Malta and Gozo.* Medeelingen Landbouwhogeschool Wageningen Nederlands 73 (20); 104pp.

Francini Corti, E. & Lanza, VB. (1972) XVIII Congresso della Societa' Italiana di Biogeografia: note conclusive sulla storia del popolamento animale e vegetale delle isole circumsiciliane. *Lavori della Societa' Italiana di Biogeografia* n.ser., 3: 911-918.

Giusti, F.; Manganelli, G. & Schembri, P.J. (in preparation) *The recent and fossil non-marine molluscs of the Maltese Islands.* Torino, Italy: Museo Regionale di Storia Naturale.

Grimm, R. (1986) Tenebrionidae vom Maltesischen Archipel (Insecta: Coleoptera). *Stuttgarter Beitraege Naturkundliche* ser. A, 392: 1-17.

Guilcher, A. & Paskoff, R. (1975) Remarques sur la geomorphologie littorale de l'archipel maltais. *Bulletin de l'Association Géographique de France* 427: 225-231.

Gulia, G. (1914) Uno sguardo alla zoologia delle 'Isole Maltesi'. *IX° Congrès International de Zoologie [Monaco, 1913]* sect. 4: 545-555, Rennes, France.

Haslam, S.M. (1969) *Malta's plant life.* Malta: [Dr S.M. Haslam], viii + 129pp.

Haslam, S.M. & Royle, P.Y. (1968) *Buskett and its natural history.* Msida, Malta: Malta University Press; 52pp.

Haslam, S.M.; Sell, P.D. & Wolseley, P.A. (1977) *A flora of the Maltese Islands.* Msida, Malta: Malta University Press; lxxi + 560pp + plates I-LXVI.

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

Hutterer, R. (1990) Temporal and geographical variation of shrews of the Sicilian-Maltese archipelago since the Pleistocene. *Vie Milieu* 40: 213-217.

Hutterer, R. (1991) Variation and evolution of the Sicilian shrew: taxonomic conclusions and description of a possibly related species from the Pleistocene of Morocco (Mammalia: Soricidae). *Bonner zoologische Beitraege* 42: 241-251.

Hyde, H.P.T. (1955) *Geology of the Maltese Islands*. Malta: Lux Press, 135pp.

Lanfranco, E. (1984) *Guida alle escursioni a Malta; Aprile 1984*. Societa Botanica Italiana sezzione Siciliana; 10pp. [mimeographed]

Lanfranco, E. (1987) Jewels of the Maltese flora: plants endemic to the Maltese Islands. *Spectra, New Lyceum Science Magazine* (Malta) 5: 2-11 + cover.

Lanfranco, E. (1989a) Il-pjanti vaskulari endemici tal-Gzejjer Maltin. In: Cortis, T. [ed.] *L-identita kulturali ta' Malta*. pp.141-164; Valletta, Malta: Departiment ta' l-Informazzjoni. [in Maltese]

Lanfranco, E. (1989b) The flora. In: Schembri, P.J. & Sultana, J. [eds] *Red data book for the Maltese Islands*. pp. 5-70; Valletta, Malta: Department of Information.

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

Lanfranco, G.G. (1969) *Maltese mammals*. Valletta, Malta: Progress Press; 28pp. + plates 1-8.

Lanfranco, G.G. (1969) *Field guide to the wild flowers of Malta.* Valletta, Malta: Progress Press; viii + 83pp. + plates 1-65.

Lanfranco, G.G. (1974) *A complete guide to the fishes of Malta (Central Mediterranean).* Valletta, Malta: Progress Press; 96pp. + plates 1-42.

Lanfranco, G.G. & Schembri, P.J. (1989) Vertebrates other than birds. In: Schembri, P.J. & Sultana, J. [eds] *Red data book for the Maltese Islands* pp. 129-137; Valletta, Malta: Department of Information.

Lang, D.M. (1960) *Soils of Malta and Gozo*. [Colonial Research Studies 29] London: Her Majesty's Stationary Office; 112pp.+ map.

Lanza, B. (1972) Gli anfibi e i rettili delle isole circumsiciliane. *Lavori della Società Italiana di Biogeografia* n. ser., 3: 755-804.

Lorenz, C. & Mascle, G. (1984) Le point sur la géologie de l'archipel maltais. *Revue de Géologie Dynamique et Geographie Physique* 25: 63-68.

Mahnert, V. (1975) Pseudoscorpione von den Maltesischen Inseln. *Fragmenta Entomologica* 11: 185-197.

Matic, Z.; Darabantu, C. & Clichici, M. (1967) Contributo alla conoscenza dei Chilopodi di Spagna e di Malta. *Bollettino delle Sedute della Accademia Gioenia di Scienze Naturali in Catania*, ser. 4, 9: 175-199.

Micallef, H. & Evans, F. (1968) *The marine fauna of MAlta.* Malta: Biology Department, The Royal University of Malta; vi + 26pp.

Miossec, J.M. (1980) L'archipel maltais. *Bulletin de la Sociétè Languedoc. de Géographie* 14: 43-96.

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

Murray, J. (1890) The Maltese Islands, with special reference to their geological structure. *Scottish Geographical Magazine* 6: 449-488 (+ plates I and II).

Nehring, B. (1966) Die maltesischen Inseln. *Tübinger Geograph. Stud.* 19: 1-172.

Paskoff, R. & Sanlaville, P. (1978) Observations geomorphologiques sur les cotes de l'archipel maltais. *Zeitschrift für Geomorphologie* N. F., 22: 310-328.

Pedley, H.M. (1974) Miocene seafloor subsidence and later subaerial solution subsidence structures in the Maltese Islands. *Proceedings of the Geologists' Association* 85: 533-547.

Pedley, H.M. (1980) The occurrence and sedimentology of a Pleistocene travertine in the Fiddien Valley, Malta. *Proceedings of the Geologists' Association* 91: 195-202.

Pedley, H.M. (1987a) Controls of Cenozoic carbonate deposition in the Maltese Islands: review and reinterpretation. *Memorie della Società Geologica Italiana* 38: 81-94.

Pedley, H.M. (1987b) The Ghar Lapsi limestones: sedimentology of a Miocene intra-shelf graben. *Centro* (Malta) 1 (3): 1-14.

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

Pedley, H.M., House, M.R. & Waugh, B. (1978) The geology of the Pelagian Block: the Maltese Islands. In: Nairn, A.E.M.; Kanes, W.H. & Stehli, F.G. [eds] *The ocean basins and margins. Vol 4B the western Mediterranean.* pp. 417-433; London: Plenum Press.

Poggi, R. (1980) Appunti su alcuni Pselaphidae e Scydmaenidae di Malta (Coleoptera). *Bollettino della Società Entomologica Italiana* 112: 167-170.

Ransley, N. & Azzopardi, A. (1988) *A geography of the Maltese Islands* [4th. ed.] Malta: St. Aloysius College Publ., x + 150pp.

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

Riccardi, R. (1943) Aspetti geografici di Malta. *Bollettino della Regia Società Geografica Italiana* 7/8: 193-207.

Rieger, C. (1986) Wanzen aus Malta (Insecta, Heteroptera). *Carolinea* 44: 87-90.

Sabatinelli, G. & Schembri, S. (1990) Gli scarabeidi floricoli delle Isole Maltesi (Coleoptera Scarabaeidae). *Bollettino della Società Entomologica Italiana* 122: 31-36.

Sammut, P.M. (1984) A systematic and synonymic list of the Lepidoptera of the Maltese Islands. *Neue Entomologische Nachrichten* 13; 124pp.

Sammut, P.M. (1989) Il-Lepidoptera Maltija. In: Cortis, T. [ed.] *L-identità kulturali ta' Malta*. pp. 117-139; Valletta, Malta: Department of Information. [in Maltese]

Sammut, P.M. & Valletta, A. (1989) Lepidoptera. In: Schembri, P.J. & Sultana, J. [eds] *Red data book for the Maltese Islands* pp. 97-104; Valletta, Malta: Department of Information.

Savona Ventura, C. (1984) The fossil herpetofauna of the Maltese Islands; a review. *Naturalista Siciliano* ser.4, 8: 93-106.

Schembri, P.J. (in press) The fauna of the Maltese Islands: a review and analysis.

Schembri, P.J. (1991a) *Report of survey: natural resources*. [Malta Structure Plan Technical Report 5.4] Colin Buchanan and Partners/Generale Progetti SpA/Planning Services Division, Government of Malta; vii + 138pp.

Schembri, P.J. (1991b) Ekologija tal-Gzejjer Maltin: harsa generali. In: Cortis, T. [ed.] *Oqsma tal-kultura Maltija*. pp. 5- 37; Beltissebh, Malta: Ministeru ta' l-Edukazzjoni u ta' l-Intern. [in Maltese]

Schembri, P.J. (1993) Physical geography and ecology of the Maltese Islands: a brief overview. In: Busuttil, S.; Lerin, F. & Mizzi, L. [eds] *Malta: food, agriculture, fisheries and the environment.* [Options Méditerranéennes ser.B: Etudes et Recherches Nº7] pp. 27-39; Paris, France: CIHEAM (Centre International de Hautes Etudes Agronomiques Méditerranéennes).

Schembri, P.J.; Lanfranco, E.; Farrugia, P.; Schembri, S. & Sultana, J. (1987) *Localities with conservation value in the Maltese Islands.* Beltissebh, Malta: Environment Division, Ministry of Education; iii + 27pp.

Schembri, P.J. & Sultana, J. [eds] (1989) *Red Data book for the Maltese Islands.* Valletta, Malta: Department of Information; viii + 142pp. + plates I-VIII.

Schembri, S. (1980) Vespoidea from the Maltese Islands (Hymenoptera Aculeata). *Bollettino della Società Entomologica Italiana* 112: 90-93.

Schembri, S. (1982) Recent records of Hymenoptera Apoidea from the Maltese Islands. *Bulletin of the Amateur Entomologists' Society* 41: 25-30.

Schembri, S. (1985) The Vespoidea of the Maltese Islands: remarks and additions (Hymenoptera Aculeata). *Bollettino della Società Entomologica Italiana* 117: 15-116.

Schembri, S. (1989) Insects excluding Coleoptera and Lepidoptera. In: Schembri, P.J. & Sultana, J. [eds] *Red data book for the Maltese Islands* pp. 90-96; Valletta, Malta: Department of Information.

Schembri, S. (1991) Sphecid wasps of the Maltese Islands: a review (Hymenoptera Spechidae). *Bollettino della Società Entomologica Italiana* 122: 175-184.

Schembri, S. (1991) The Anthicidae of the Maltese Islands (Coleoptera). *Bollettino della Società Entomologica Italiana* 123: 32-38.

Schembri, S. & Collingwood, C.A. (1981) A revision of the myrmecofauna of the Maltese Islands (Hymenoptera, Formicidae). *Annali del Museo Civico di Storia Naturale, Genova* 83: 417-442.

Schembri, S. & Ebejer, M.J. (1983) A review of the Tettigoniidae of the Maltese Islands. *Bollettino della Società Entomologica Italiana* 115: 135-138.

Schembri, S. ; Gatt, P. & Schembri, J.L. (1991) Recent records of flies from the Maltese Islands (Diptera). *Memorie della Società Entomologica Italiana* 70: 255-277.

Schembri, S. & Sama, G. (1986) The Cerambycidae of the Maltese Islands (Coleoptera). *Bollettino della Società Entomologica Italiana* 118: 93-100.

Schembri, S. & Schembri, J.L. (1978) A preliminary report on the Dermaptera of the Maltese Islands. *Annali del Museo Civico di Storia Naturale, Genova* 82: 329-332.

Schembri, S. & Schembri, J.L. (1982) Recent records of Coleoptera Staphylinidae from the Maltese Islands. *Lavori della Società Veneziana di Scienze Naturali* 7: 45-53.

Sivarajasingham, S. (1971) *The soils of Malta.* [UNOP/SF Project MAT/5, Water disposal and water supply] Rome: Food and Agriculture Organization of the United Nations; 82pp.

Sommier, S. & Caruana Gatto, A. (1915) *Flora Melitensis nova*. Firenze, Italy: Stab. Pallas; viii + 142pp.

Soós, L. (1933) A systematic and zoogeographical contribution to the mollusc fauna of the Maltese Islands and Lampedusa. *Archiv für Naturgeschiche* 2: 305-353.

Storch, G. (1970) Holozäne Kleinsäugerfunde aus der Ghar Dalam-Höhle, Malta (Mammalia: Insectivora, Chiroptera, Rodentia). *Senckenbergiana Biologica* 51: 135-145.

Strumia, F. (1981) Imenotteri crisididi delle Isole Maltesi (Hymenoptera Chrysididae). *Bollettino della Società Entomologica Italiana* 113: 167-168.

Sultana, J. & Gauci, C. (1979) *L-aghsafar.* Valletta, Malta: The Ornithological Society; 190pp.

Sultana, J. & Gauci, C. (1982) *A new guide to the birds of Malta.* Valletta, Malta: The Ornithological Society; 205pp.

Tamanini, L. (1966) Eterotteri delle Isole Maltesi (Hemiptera, Heteroptera). *Bollettino delle Sedute della Accademia Gioenia di Scienze Naturali in Catania* ser. 4, 8: 679-697.

Thake, M.A. (1985) The biogeography of the Maltese Islands illustrated by the Clausiliidae. *Journal of Biogeography* 12: 269-287.

Thake, M.A. & Schembri, P.J. (1989) Mollusca. In: Schembri, P.J. & Sultana, J. [eds] *Red data book for the Maltese Islands*. pp. 79-89; Valletta, Malta: Department of Information.

Trechmann, C.T. (1938) Quaternary conditions in Malta. *Geological Magazine* 75: 1-26 (+ plates I and II).

Valletta, A. (1971) *The butterflies of the Maltese Islands.* Valletta, Malta: Giov. Muscat; 64pp.

Valletta, A. (1973) *The moths of the Maltese Islands.* Valletta, Malta: Progress Press; 118pp.

Vogel, P.; Schembri, P.J.; Borg, M. & Sultana, J. (1990a) The shrew (*Crocidura* sp.) of Gozo, a probable survivor of the Pleistocene fauna of Mediterranean islands. *Zeitschrift für Säugetierkunde* 55: 357-359.

Vossmerbäumer, H. (1972) Malta, ein Beitrag zur Geologie und Geomorphologie des Zentralmediterranen Raumes. *Würzburger Geographische Arbeiten* 38: 1-213.

Zammit Maempel, G. (1977) *An outline of Maltese geology.* Malta: Dr G. Zammit Maempel; 44pp.

Zammit Maempel, G. (1989) *Ghar Dalam cave and deposits.*
Malta: Dr G. Zammit Maempel; 74pp.

Zammit Maempel, G. (1989) *Pioneers of Maltese geology.* Malta: Dr G. Zammit Maempel; 302pp.