Francis Dov Por

Biogeography of "Mediterraneis" a province moulded by Humans

Abstract

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This is an attempt to characterise the Mediterranean region in biogeographic-historic terms, and not the usual climatic ones. "Mediterraneis "is a province contained between the Sahara and the Alpine mountain ridges, with the Mediterranean Sea , the only remnant of the Mesozoic Tethys as its core. The fauna and flora of the province is composed of Palearctic and some Ethiopian biota which evolved during the late Neogene, in the refuges of the sea shore and on the many islands. There has been a tight relation with the hydrological evolution of the Mediterranean sea, culminating with the paroxysm of the Messinian event. Information on floristics and faunistics is being compared. Characteristically for. this province, early seafaring co-existed already with post-Glacial climate fluctuations and tectonic conflagrations Peculiar circum-Mediterranean distribution areas resulted from prolonged human impact. Cycles of frequent and sudden alternations of humid to arid climates, jointly with the anthropic impact moulded this province. The modern Suez Canal and river-damming have also radically changed marine life.

This lecture paper is dedicated to the memory of
Prof. Clara Heyn,
eminent Israeli botanist and faithful friend.

Looking from different geographical directions at the "Mare Nostrum" and being to different degrees heirs of the Mediterranean culture, the term "Mediterranean" is a household word which we easily and often indiscriminately use, mixing true biogeographical notions with geopolitical realities. Mediterranean floras include all of France and often even countries along the Black Sea. Gustav de Lattin, one of the big, already classical zoogeographers, uses the term "*Mediterraneis*", but avoids to define it. In an old paper (Por 1967), I suggested that all the circum-mediterranean distribution patterns are consequences of anthropic action and that consequently there is no Mediterranean biogeographic entity at all. This impression is indeed strengthened by the maps which are delimiting Mediterraneis merely as the area where olive trees grow in this part of the world, the "Olive Tree Line" of UNEP.

In actuo-ecological terms some more confusion might result. There exists a well defined Mediterranean climate, warm-temperate to subtropical, with rainy winters and sub-arid summers. It is found in the several other "Mediterranean" regions of the globe (Australia, California, Chile, South Africa). These are situated on the west coast of the continents, as opposed to the east coasts that have a so-called "Cotton belt" climate. Bailey's (1958) well known "effective precipitation index" is useful in defining them. Koppen's maps of "Cs" climates are of lesser use. Superficial comparisons can go a little farther: Mediterranean lands are coastal land stripes situated behind rain-shading mountains, and near a desert. All of them are characterised by sclerophyllous vegetation. Wine, olive and other plant growers of all the continents have used these climatic similarities and so had the "Medfly", *Ceratitis capitata* and many other animal pests. A flora and an adventive fauna, already symbiotic with the classical Mediterranean farmers, easily spread to all the adequate climates of the globe. Among the fauna, snakes, lizards, scorpions and other arachnids, land isopods, some beetle families, and gastropod mollusks are prevalent in the Mediterranean climates. Convergent features exist also among the bird fauna. Rivers are usually short and intermittent and temporary rain pools are frequent, with their specific crustacean fauna. Such convergences between the different Mediterranean regions were extensively reviewed by di Castri & Mooney (1973).

Unlike other such climatic regions, Mediterraneis is not a geographically limited longitudinal continental West coast area, but occupies an extended latitudinal belt and is also one of the three biogeographic transition areas between the realm of Holarctis, the old Laurasia ,and the tropical realms of old Gondwana, in our case the Ethiopian realm. In the other two transition areas, the Central American isthmus and South-Eastern China the transition is more or less smooth and ongoing. In Mediterraneis the transition is today almost entirely obstructed by the broad Saharian belt , the Alpine system ridges in the North and by the Mediterranean sea in between. *Thus contained in the middle, the Mediterranean and its shore lands came to be a biogeographical entity of its own, permanently stressed because its intermediate, transitional position.* The stage is a relatively narrow strip of land and marine shelf, which extends over many thousands of kilometres. To set more precise limits would be impossible, if one takes into account all the constituents of the biodiversity and if one considers the frequent changes wrought by climatic fluctuations and first of all by ephemerous human action. Relics, refugees and expatriates from the two bordering realms have produced along the shores surrounding the sea and on its islands, a special set of biota .This living world is intimately dependent on the hydrological history of the "Mare Nostrum". A wealth of islands and of intermittent land bridges, of closing and opening seaways, as well as well as the agency of the stone-age navigators and their successors have further increased the specific homogeneity of this circum-Mediterranean world. As the saying goes, "the sea does not separate but unites". Historical biogeography of Mediterraneis and not the above-mentioned instances of convergences will be the main subject of my presentation. I shall try to limit myself to new data and of course to marine and terrestrial zoological information, possibly new to this audience.

The Mediterranean, especially its Eastern basin, is the only surviving legacy of the Mesozoic Tethys Sea (Por 1989).The Western basin is tectonically very much modified. Tropical climates prevailed along the Tethys shores, while the seas itself was rich in coral reefs and mangrove. Few relics of this period are still around, although this name is often being excessively used. Among the plants we can speak of *Ceratonia, Olea, Laurus, Myrtus*. Among the terrestrial animals, the painted frogs, the Discoglossidae, with their many endemics on the Mediterranean islands are probable Tethys relics. Definitely relics are also several taxa of subterranean crustaceans, the Thermosbaenacea, the Cirolanid isopods and the prawn genus *Typhlocaris*, with disjunct endemics all around the Mediterranean basin and no representatives in the open sea.

The closure of the Tethys in the Middle East of today started with different intermittent episodes in the Burdigalian stage of the Miocene, 17-18 m.y. ago. Known to the palaeozoologists as the "Proboscidean Datum", it initiated the spread of the African mammals to Eurasia. This datum should be, in my opinion, used also for the expansion of the African tropical flora.

As the Tethyan bottoms gradually emerged, the lithology of Mediterraneis emerged too. Its rocks are mainly Mesozoic chalks deposited in the tropical sea and the terra-rossa soils that resulted from them.

The gradual closure of this Paleo-Mediterranean in the Miocene, through the northward movement of the African plate, caused the alpine orogenesis and most important for our subject, provoked the aridisation of our region. The West-East and South- North gradient of increasing dryness prevalent in our area till today, came into being. It would become steeper or milder as a result of general climatic fluctuations , but it existed ever since. Correspondingly the hydrology of the Mediterranean Sea was to establish a similar and permanent W-E salinity and temperature gradient. For the hydrologist, it is a huge "negative estuary"

In the Messinian end stage of the Miocene, the ongoing process of aridisation attained a short and dramatic climax, the much discussed "Messinian Salinity Crisis" which lasted for less than 1 million years (Fig.1). The sea broke-up into a series of hypersaline lagoons intermittently fed by influx of water from the Atlantic and/or from the "lago-mare" of the Pannonian Paratethys. Between 5.80 and 5.32 million years ago the drying-out was maximal. A two thousand meters thick salt layer carpeted the floor of the Western Mediterranean, three thousand meter thick in the East. Geologists are still discussing the dynamics of this outstanding event, its hydrology, its different sub-phases, its tectonic effects and local variations.

It is however evident that there has never been a total cut-off from the Atlantic, since deposition of salt layers as thick, needed a fairly continuous "trickle" supply of oceanic water. To accommodate the thick salt layers, the Mediterranean sea floor subsided correspondingly by orogenic and epeirogenic movements. Consequently, there has never been an empty basin, thousands of meters below sea level and no gigantic Gibraltar waterfall, when the salinity crisis ended.

The Messinian marked the height of the establishment of the arid biota around the Mediterranean. Greuter (1979) is right when he considers the Messinian to be a "key period" for Mediterranean phytogeography and the cradle of the Mediterranean non-arborescent flora. Many of the halophytes of the Mediterranean lagoons originate from those times, as well as the circum-mediterranean *Aphanius-Cyprideis* fauna of the lagoons of Por & Dimentman (1985).

The active tectonics that started in the Miocene is still continuing at present and this is perhaps another peculiarity of Mediterraneis. Tectonics took care that the Siculo-Tunisian

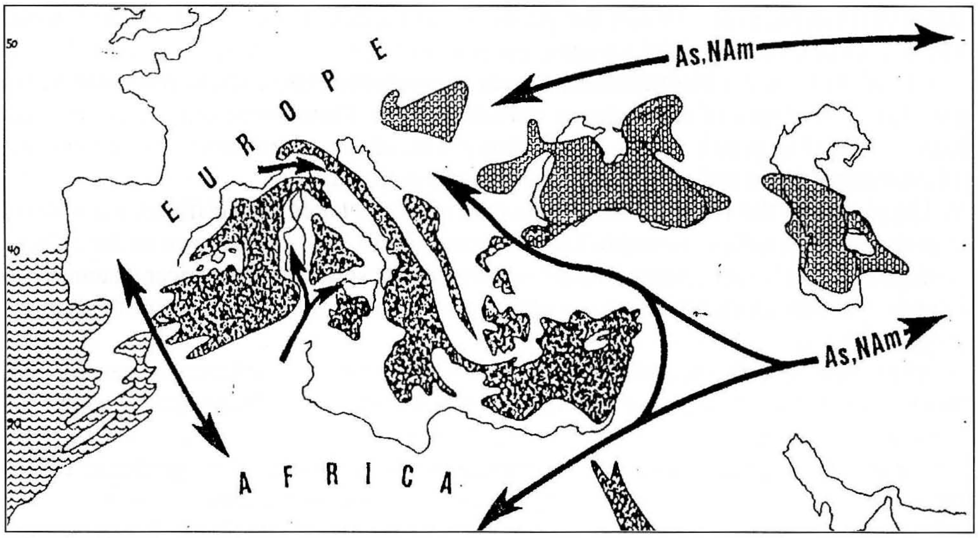

Fig. 1. The Messinian Mediterranean and Paratethys, showing terrestrial faunal exchanges (after Rogl & Steininger 1983).

strait was never laid dry, and that finally the present Straits of Gibraltar broke open and led to the Atlantic re-flooding of the Mediterranean basin.

This event, 5,4 million year ago, marked the start of the Pliocene. While it was generally considered that the Pliocene was a cool period, Tchernov (1988) even mentions a general decrease of 18° C, today it is considered that the Pliocene of our area, was generally warmer and definitely wetter than today. Eurasian arborescent flora of *Picea* and *Quercus* spread to Mediterraneis and even reached North Africa. Closed forests were established. Also elements of a limited Eurasian small mammalian fauna spread to the North African shores.

During two successive Pliocene transgressions, the newly established Mediterranean flooded tens and hundreds kilometres deep into the river valleys carved down to the low Messinian sea level, such as the Rhone or the Nile valleys. In Israel, the newly formed Dead Sea rift valley was invaded by the Pliocene sea. Tchernov (1988) considers that evolutionary regional fragmentation occurred because of these perpendicular watery obstacles. On a much larger scale, the Red Sea basin was invaded by the Indian Ocean waters, heralding a future re-colonisation of the Mediterranean sea by tropical biota.

There are proofs that during the Pliocene there were already considerable cyclic oscillations in aridity and temperature (Foucault & Melieres 1998) in response to the three "Milankovitch Cycles", the changes of Earth's position in the orbit with amplitudes from 21,000 to 100,000 years.

The start of the Pleistocene Ice Ages is now dated at 2.4 million years ago. The complex and profound sequential Glacial fluctuations critically influenced the narrow shore biota delimited by the sea and by the mountain ranges in the back, though glaciers never came close and at the worst, cool and dry steppes prevailed. Raven (1973) considers that the present environmental framework of Mediterraneis became established in the Pleistocene as an area of climatic stress.

Our views about Pleistocenic climate fluctuations have changed considerably lately. We have now a much more fine-grained view on the many and often very sudden climate fluctuations. Falsifying the basic scheme of four Glacials, based on alpine moraine records, micropaleontologists analysing marine cores came up with as many as 10 Glaciations. Today, combining a whole series of methods and first of all palynological data, there seems to be a consensus for 7 world-wide major Glaciations.

For many years it has been considered that the *Glacials* of the temperate zone were faithfully accompanied in the tropics by "*Pluvials*", wet climate periods. Today it is accepted that the climate of the tropics, during the Glacials was dryer than today, dryer and cooler. The Pluvials were in fact only short episodes of increased humidity, often also regionally limited, especially when defined only by higher levels in the lakes in certain basins.

In the sea, especially in the Eastern Mediterranean, pluvial episodes were associated with high river discharge and consequent short-lived estuarine saline stratification and anaerobism.

These were the so-called "*Sapropelic Events*", for the high organic content of the dark sapropel sediments deposited in the anaerobic deep waters. Reflecting non-synchronic regional climates, sapropelic events could be caused either by the discharge of the Nile or of the East European rivers. The significance of these events for the marine flora was minimal, though it may explain some local absences. The last such event occurred 8,000 years ago With the Nile dammed in Asswan and the Ukrainian barrages in place, there will be no future sapropelic events.

Much more important were the changes of the sea level during the Pleistocene. The old concept of very high Interglacial sea levels, up to 50-60 m in the Tyrrhenian Interglacial, is today totally rejected. The high terraces around the Mediterranean are due to tectonic uplifting. Probably high sea levels never surpassed + 4 m. The rest was due to orogeny and epeirogeny. Real sea level was however very much lower during the Glacials. During the last two of them, the sea level fell as much as 150 m. The biogeographical consequences were extremely important: The northern half of the Adriatic fell repeatedly dry. Corsica linked up with Sardinia and Malta with Sicily. In the East, Rhodes became connected to Anatolia and the huge alluvial fan of the Nile included the coasts of Israel. In the small confined basins of the Mediterranean, the flooding events were surprisingly sudden and those of reflux, probably much slower. After the last Glaciation the sea rose at a rate of 5 m per 200 years. In the Persian Gulf the sea advanced over the land no less than 100-200 m per year. More famous is the recent finding that 7,500 years ago when the Mediterranean broke through the tectonically lowered sill of the Bosphorus, the Black Sea filled up to level in one year and the waters encroached on the land at a rate of 1 km per day.

This event is considered to have given rise to the legend of the Diluvium. But there were probably many smaller-sized Noah's among the people of the Greek archipelago, who witnessed such sudden flooding events in this complex network of basins and bays. Also, since in Mediterraneis the tectonic convulsions never stopped, there could have been many Deukalion's, who escaped from catastrophic land-slides and several Atlantises that were swept by tsunamis or collapsed into the sea.

The slightly higher Interglacial sea levels and the maximal level 5,000 years ago, narrowed the Suez isthmus separating the Mediterranean from the Red Sea, to a few kilometres of intermittently flooded swamp land. High seas or intrepid navigators of the Pharaonic times might have passively carried some tropical biota into the Mediterranean.

The climatic history of the Last Glacial and of the recent deglaciation is today much better known. New methods are being used in order to locate climatic events more precisely on the time-scale. Radio carbon years are today calibrated and translated into "calendar years". Recent work on Greenland ice cores supplied detailed palaeo-climatic data. Subfossil beetle elytrae and analysis of sub-recent bird populations supply data on short-term and local climate fluctuations which sometimes cannot be discerned by the more "coarse-grained" pollen composition profiles. And as yet, for the understanding of the fluctuations of the Mediterranean biota, the data are still too few. Whereas over mainland Europe advance and retreat of the biota occurred over a wide front, in Mediterraneis survival and resettlement can only be understood assuming the persistence of populations in many small-sized, even micro-climatic pockets, such as protected valleys and quiet bays. Perhaps on the general background of more arid conditions in the past 150,000 years, the low sea-level contacts were more important than the opportunities offered by the short climatic improvements.

The paradigmatic scheme of a continuous glaciation lasting around 100,000 years followed by an interglacial lasting around 10,000 years has also been falsified recently. The Milankovitch cycles are superposed and complicated by shorter frequency cycles, such as the cycles of the "*Heinrich events* ", which seem to have a 1,500 year frequency and by even shorter cyclic changes resulting from ocean circulation changes. Complicating the stately sequence of Glacials and Interglacials of old, a variety of "*stadials*" and of "*interstadials*" has been discerned. It now also appears that the radical climatic changes were also very abrupt, in the range of centuries or even decades (Adams & Faure 2000).

The "Eemian", the last Interglacial, was generally 4-5 °C warmer than today at its peak around 125,000 yr and some Mediterranean plants, such as the maple *Acer monspessulanum* and water chestnut *Trapa* reached North Europe. Mediterraneis was covered by a more arid vegetation with *Olea* and with evergreen oaks. Velichko and Isaeva (1992) however, consider that the Mediterranean climate was slightly cooler than today. The Eemian was interrupted by at least one known cold climate event of about 5,000 yr duration.

A rapid cooling around 110,000 yr initiated the last Glacial But already 105,000 ago there has been a short return to warmer climate. There have been in the following several "stadials", cold phases corresponding to Heinrich events. To date 6 or 7 such cold stadials are on register. Twice during the last Glacial, temperatures attained minima, namely in the period between 75,000-58,000 yr and between 22,000-14,000 yr ago (Fig. 2). Under those circumstances, all ice-free Europe was covered by steppes and forests were limited to a few pockets in the South. Whereas the stadials had a relatively longer duration, the warm interstadials, also called "*Dansgaard-Oeschger events*" were much shorter: lasting a few centuries up to 2,000 yr. Transitions took only a few decades. There were some 24 such warm interstadials. As shown by Rossignol-Strick & Planchais (1989), during the interstadials the arboresecent vegetation expanded in Mediterraneis: oaks returned to Sicily and mixed tree open forests with *Picea* and *Juniperus* covered Spain, Italy and Greece. Some interstadials were however so short that trees did not have the time to return from the southern refuges.

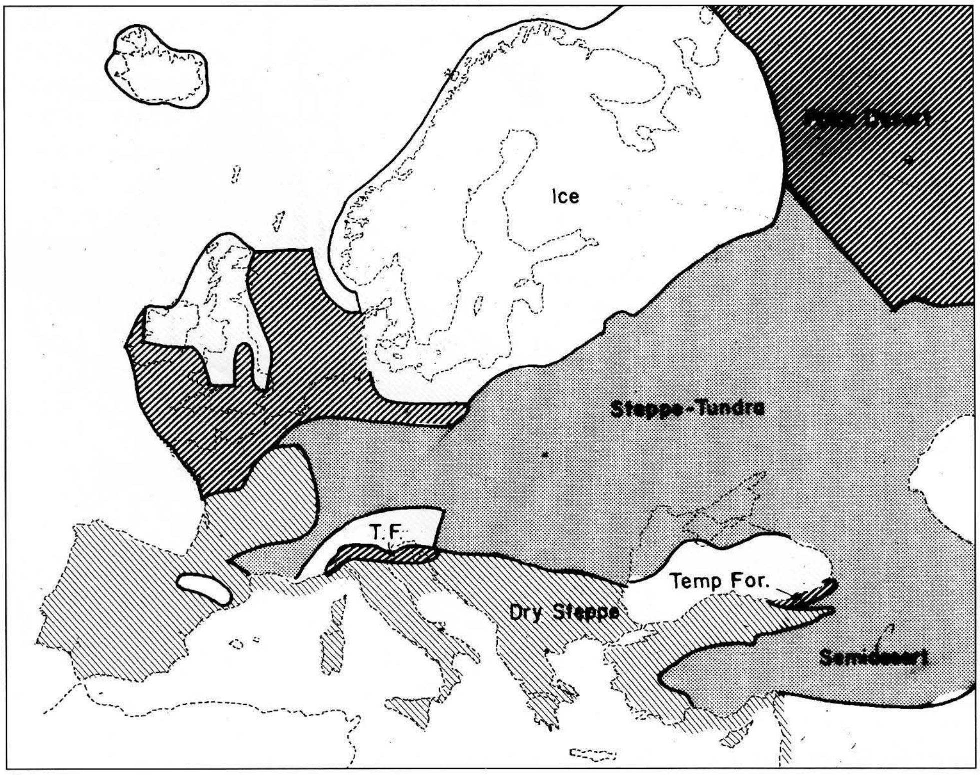

Fig. 2. Vegetational Map of Europe, 22,000-14,000 ^{14}C years ago, during the last Glacial Maximum (after Adams & Faure 1997).

A sudden warming-up to temperatures higher than at present heralded 13,000 yr ago the end of the Last Glacial. It was so short a period of about 500 yr that again, only coleopteran populations could document. A more consistent warm period followed between 12,000–11,000 yr ago. In Mediterraneis, *Quercus rotundifolia* accompanied by *Artemisia* and Chenopodiaceae, were found in Southern Spain, closed forest spread in Italy, whereas in Greece deciduous oaks, and pine accompanied an *Artemisia* steppe (Fig. 3).

The climatic improvement was harshly interrupted by a return to Glacial conditions, during the so-called Younger Dryas, which lasted only for two millennia, between 10,800 and 10,000 yr ago. While the ice cap expanded again over Northern Europe, aridity returned in Mediterraneis. According to Rossignol-Strick (1995), conditions in Greece and Anatolia were even dryer than during the Glacial maxima (Fig. 4). Recent data indicate that this short glacial return was felt also in the Southern hemisphere.

The "climatic" termination of the Younger Dryas took only 75 years, but it took about 1,000 years for the vegetation to recover and expand again. During the ensuing "Holocene Optimum", humidity was higher than today and real Mediterranean-type maquis was at times limited only to Crete. The rest of Mediterraneis was covered by closed forests of

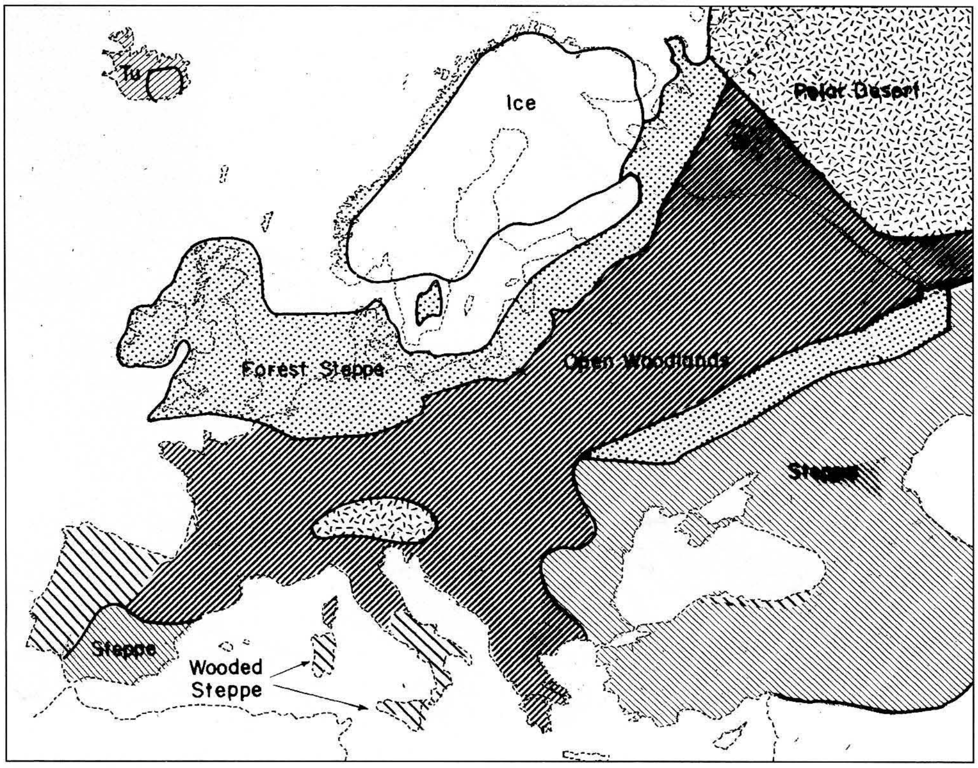

Fig. 3. Vegetational Map of Europe 12,000-11,000 ^{14}C years ago, during the first significant deglaciation spell (after Adams & Faure 1997).

Carpinus and deciduous oaks or by open woodlands with *Amygdalus* and *Pistacia*. The period between 7,000 and 5,000 yr ago, seems to have been the warmest. It was probably 2-3 °C warmer than today and significantly wetter in Mediterraneis.

In part, the climatic fluctuations were provoked by the North-South oscillations of the Intertropical Convergence, which limits the northward extension of the winter monsoons. These oscillation were especially important for Northern Africa. Where the interstadial oscillations there generally corresponded with the European ones. For our subject there is some interest in the fact that conditions moister than today, were present in the Sahara with some fluctuations during the period 9,000-4,000 BP. During these times savannah's expanded over the Sahara and the North African rim enjoyed also more amiable climate. Whereas savannah mammals, elephants and giraffes abounded in the Sahara, Mediterranean flora reached as far as the Tasili and Hoggar mountains, with the cypress *Cupressus dupreziana*, the wild olive *Olea lapperinei* and the myrtle *Myrtus nivelii*. Present dryness started since 4,000 yr ago, (Fig. 5) with some reprieve between 3,800-3,500 yr ago. The last 2000 yr were the worst.

By 7,000 BP, burning of forests starts to be reported in Mediterraneis, as intimated by the spread of the fire resistant *Quercus suber* in Spain. Olive and cereal pollen also spread all over. Anthropic influence started to put its mark more and more on the living world of

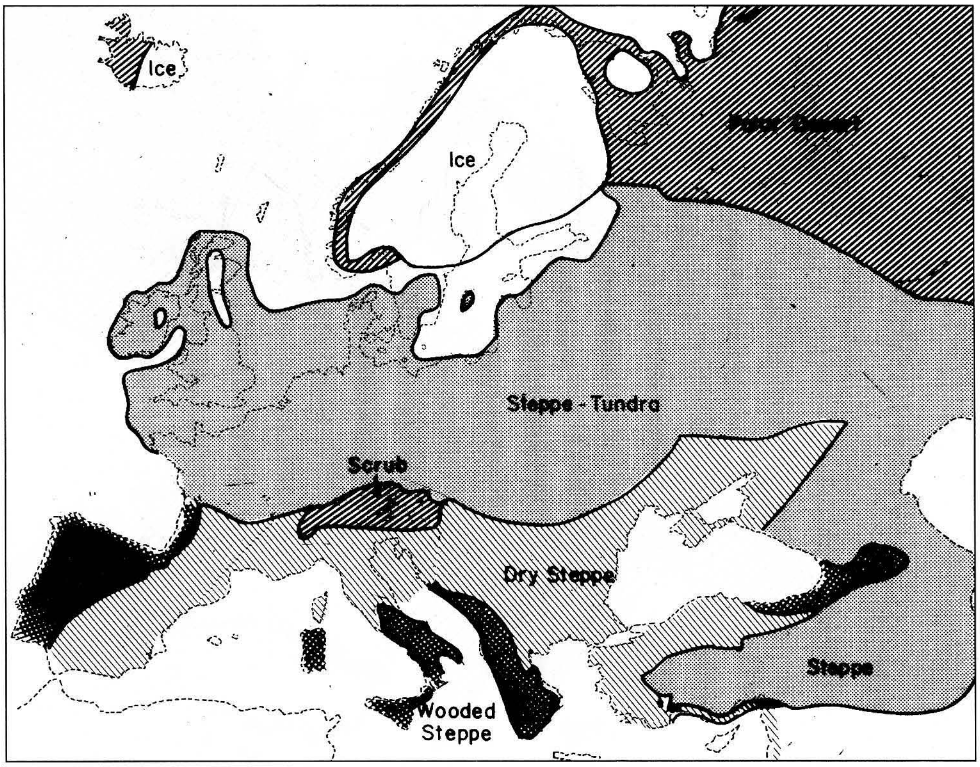

Fig. 4. Vegetational Map of Europe , during the cold spell of the Younger Dryas 11,000-10,000 ^{14}C years ago (after Adams & Faure 1997)

Mediterraneis. But before dealing with this subject, let us have a look at the biogeographic heritage of the Pleistocene in our area.

I shall not dwell too much on phytogeography, since in this field I am only an interested layman, but rather make some comparisons with the distribution of the animals and try to reach also some general conclusions. In doing this, I am conscious that I am treading on a very flimsy and uncharted ground.

Among the plants there are several notable cases of palaeo-endemics, genera surviving since Miocene times, such as *Platanus, Olea, Laurus, Ceratonia, Nerium* or *Cercis.* In the animal world we have such palaeo-endemics only among small invertebrate fauna, especially land molluscs. The tropical vertebrate fauna which invaded Europe in the Miocene, evolved during the ensuing colder climates into local species and genera, like the cave-dwelling and woolly mammals of the mainland, and the Mediterranean dwarf island endemics.

Animals evolve perhaps more rapidly and certainly are more dynamic in their distribution. Greuter (1979) is right when he emphasised this basic differences between the biogeography of the two kingdoms of organisms. De Lattin (1967) a zoogeographer based on the distribution of butterflies, considers his Mediterraneis, chiefly as a complex of three glacial refugia

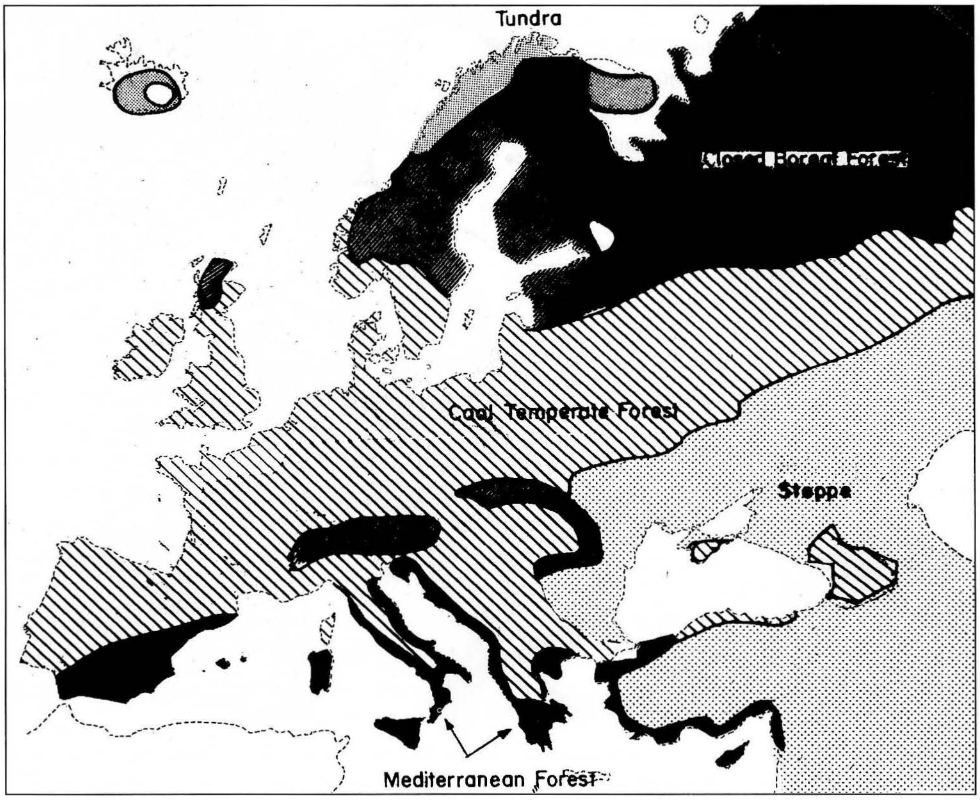

Fig. 5. Potential Present Vegetational Map of Europe since 4000 ^{14}C years ago (after Adams & Faure 1997).

of temperate woodland species that take and took shelter along the sea and according to the climatic shifts re-colonized mainland Europe to different degrees and extent. This is correct, since the majority of the Mediterranean fauna is "arboreal" and of Palaearctic origin.

However, there exists also an important "eremic", desert component. These are species that originated in the Saharian-Arabic belt, reptiles, rodents, and various arthropods. Por (1975) considered that the deserts of the Old World, with their near-continental extension and old and uninterrupted history, were an independent centre of supra-specific animal evolution. In a mirror-image of de Lattin's "europocentric" view, Mediterraneis contains pockets of such eremic, Saharo-Arabian animal species expanding or even re-colonising the region from the Saharan cradle, each time when more arid conditions return. In the plant world this aspect is reflected in the persistence of steppe and arid land species in the open environments and especially on islands (Greuter 1979). Perhaps also the dwarf palm *Chamaerops humilis* of the garrigue of Spain and Morocco and eventually also Crete's endemic date palm *Phoenix theophrasti* belong to this category.

Fresh water fauna in Mediterraneis has been much influenced by influx from the Pliocene brackish Paratethys. Under the present inter-stadial conditions, like their terrestrial counterparts, many fresh water species reoccupied the European space. On the islands, except those like Rhodes which had Pleistocene continental contact, there are no typical freshwater animals, except aquatic insects and of course estuarine organisms.

Neo-endemism, resulting from recent instances of isolated evolution, is frequent in Mediterraneis, especially on the islands. However, because of relatively recent isolation, endemism did not exceed, as a rule, the species level. This might appear as a somewhat bold generalisation, but taxonomic practice has been often too generous in designating new genera.

In many instances, endemic areas encompass a whole group of islands, indicating past connections. This means according to Greuter (1979) that in many cases evolution of endemics occurred before most recent fragmentation events. Crete an isolated and large island, harbours an important endemic contingent, nearly 10% of its flora. Corsica has also a very rich endemic flora. The island faunas are no match to this, with the notable exception of the endemism of terrestrial molluscs and aquatic insects. Corsica and nearby Sardinia, repeatedly connected in the past, share some of their endemics. Mobility of the animals and frequent anthropic transport and activity have obliterated probably much of the original diversity. This was notably the case with the demise of the remarkable endemic pygmy elephants, hippopotamuses and giant rodents and insectivores of the islands.

Much more frequent are the cases of regional vicariance of congeneric species between the eastern and the western parts of Mediterraneis. The classic in this case may be the vicariance of the *Quercus* species, but there are many more cases among the flora of our region. Vicariance in floral distribution can often be suggested or on the contrary masked by local edaphic and climatic factors. On the contrary, vicariance in animal distribution is as a rule the pure result of evolutionary segregation. Perhaps for this reason the zoogeographers seem to be more inclined to draw comparative distribution maps than the botanists. Resuming an overlay of areas of distribution, de Lattin (1967) separates the three Meiterranean terrestrial "secondary centres", namely the Atlanto-Mediterranean, the Adriato-Mediterranean and the Ponto-Mediterranean secondary centres. He adds three such centres for the islands and two respectively for Cyrenaica and for the Mauretanian island. Many other authors simply use a separating line between West- and East Mediterranean, at the head of the Adriatic sea.

However, what is most remarkable about biotic distribution in Mediterraneis, is the disproportionate role played by the "circum- or holomediterranean" species (Fig.6). The only way in which such a pattern of distribution could have been achieved was passive transport by birds, but first of all, by voluntary and involuntary transport by humans. For instance Greuter (1979) found that one third of the plant species on Crete are "anthropophytes" and on the island of Psara even 45%. Among the animals there are many cases of circum-mediterranean distribution. Kugler (1988) for example found that 10% of the ant fauna of Israel are holomediterranean species. One cannot avoid implying here a human agency. Of the 93 species of Lepidoptera reported on *Quercus* in Israel, many are holomediterranean. Cultivated Mediterranean plants took their specific butterflies and moths with them around the sea. Olive tree associates, such as the tephritid fly *Dacus oleae* or the bark-living crab spider *Xysticus*, spread with their host. Many dipteran pests such as the medfly *Ceratitis capitata* or the vectors *Phlebotomus papatacii* or *Simulium mediterraneum* are also holomediterranean. Human vectors are responsible also for some circum-mediterranean reptiles, the gecko *Hemidactylus turcicus*, the lizard *Chalcides ocellatus* and the tortoise *Testudo graeca*. The gecko *Tarentola mauretanica* must have used human

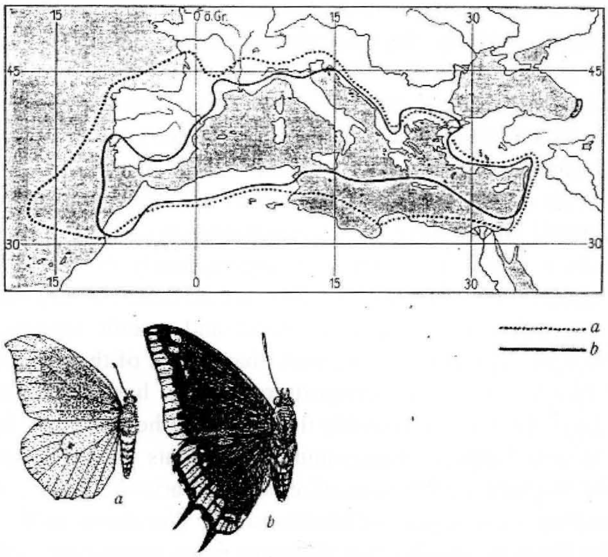

Fig. 6. Holomediterranean distribution of the butterflies *Goniopteryx cleopatra* (1) and *Charaxes.jasius* (2) (from de Lattin 1967).

transport to reach its Afro-Sicilian distribution, much like the lizard *Psammodromus algirus*. Several birds are circum-mediterranean and first of all songbirds like the warbler *Sylvia conspicillata*. Besides the mammalian pests ,the bat *Rhinolophus mehelyi* is found all around the Mediterranean (Table 1).

How old is this impressive human activity in the biogeographical sense? When did the Mediterranean become more of a bridge than a barrier? The Neanderthals never expanded and colonized the islands. Some Paleolithic sites are found only on the Aegean islands which had continental connection during the later Pleniglacial. Strangely, recent data show that the Iberian, Italian and Balkan peninsulas served as refuges for the Neanderthals up to something like 28,000 yr ago. There, with their back to the Mediterranean, they coexisted with the modern humans of the European mainland for more than 10,000 yr.

The earliest indication of human activity on the islands was the overseas trade with obsidian from the Island of Melos around 12,000 BP. Lately a late Paleolithic-Mesolithic site at Akrotiri in Cyprus dated at 10,000 has been found jointly with an assemblage of butchered pygmy hippopotamuses *Phanorius minutus* and of the pygmy elephant *Elephas cypriotes*. Today we know of 12 East Mediterranean islands which had an endemic mammalian fauna. In the West, Malta and Sicily had pygmy elephants. Masseti & Darlas (1999) discuss the role of the humans in the extinction of the endemic island mammals and admit the possibility of overseas hunting expeditions who did the killings, even before permanently settling on the islands.

Table 1. A selection of holomediterranean animal species.

Lepidoptera:

Charaxes lasius on *Arbutus*
Gonopteryx cleopatra on *Crataegus*
Limnetis anonyma on *Lonicera*
Marumba querci on *Quercus*
Lithocolletis platani on *Platanus*
Colias croceus on *Ceratonia*

Diptera (anthropophilous):

Dacus oleaea on *Olea*
Ceratitis capitata "Medfly"
Phlebotomus papateci
Simulium mediterraneum
Heteronychia fertoni

Reptiles:

Hemidactylus turcicus (gecko)
Chalcides ocellatus (scincid lizard)
Testudo graeca (tortoise)

Birds:

Serinus serinus (canary)
Sylvia conspicillata (warbler)
Oenanthe hispanica (wheater)

Mammals:

Rhinolophus mehelyi (bat)

The present configuration of the sea shore stabilised after the Younger Dryas and the many bays and protected channels in this tide-less sea, made shore settlement and regular navigation possible. Perhaps the rapid and drastic climatic changes served as an incentive for many Noah arcs. Of right, Mediterranean is considered as the cradle of sea-faring. In the following Post-Glacial Climatic Maximum, the wave of settlement of the islands started. Byblos, later to become an important port was settled by 8,000 BP, Crete was permanently settled by 8,000 BP and Malta by 7,000 BP. Obsidian from the Lipari Islands was traded by 5,000 BP. No doubt that longer trips, for instance between the African and the European shore were started also in Neolithic times. As mentioned above, it was this the period when the first indications of large-scale burning started on the continent.

Land burning in Mediterraneis has been according to Kozlowski (1974) of no lesser importance for the shaping of the ecosystems than climate and soils. The same author considers nostalgically, that fire has been a most beneficial tool in the hands of "our Mediterranean ancestors", unlike the modern wildfires. However, fire must have been lethal to endemic faunas especially on islands and confined peninsulas, and there is no parallel to the pyrophytes among the Mediterranean animal world. As is well known to botanists and the public at large, pigs and goats took also their important share in shaping the modern floristic picture of our area. It should be emphasised here, that both these domestic animals, jointly with cats, dogs and slightly later ,with rats, had their role also in savagely culling the local animal diversity and promoting the holomediterranean faunal homogeneity.

But, returning now to the sea, human activity had the most impressive influence on the Mediterranean marine diversity. As mentioned above, during the Post-Glacial climatic maximum, as the sea level rose to + 2 m, the Mediterranean and the Gulf of Suez shores came in close vicinity. Around 3,300 BP, during the Middle Kingdom of Egypt a navigable canal was dug between the two seas. Probably a few tropical species used the old connections in order to invade the Mediterranean, if they did not do it so, even before. Such were the sea grass *Halophila stipulacea,* one or two green algae of genus *Caulerpa* and remarkably, the pearl oyster *Pinctada radiata*. The canal functioned with various phases of disrepair till 1,300 BP. When the engineers of Napoleon started the measurements for a new canal, the old canal was 3 meters above sea level. Finally in 1867 Ferdinand de Lesseps dug and opened the present canal of Suez. Since this date many hundreds of Red Sea species, "Lessepsian migrants", have invaded the Mediterranean, especially fishes, molluscs and crustaceans. The algae *Hypnea esperi, H. valentiae, Cladophoropsis zollingeri* are among these Lessepsian Migrants (Por 1978) (Table 2). Firmly established in the East were they constitute already more than 20% of the species inventory, the migrants reach today a limit on the shores of Sicily, carving out a new marine biogeographic province (Fig. 7). Many of the newly invading families and genera are known as fossils from the Mesozoic Mediterranean segment of Tethys. This is by far the major biogeographic change replicated by modern technology. Future paleontologists will perhaps define a new geological horizon and possibly muse about its genesis.

Intensive shipping, urban and industrial development along the shores caused recent preoccupation with the pollution of the Mediterranean. Although locally and especially in nea-shore bays and ports pollution might be often heavy, there is little chance that in our environment-aware age the deep and oligotrophic Mediterranean will sensibly suffer in its totality. Nothing compared to the predicament of the Baltic Sea is in sight.

The environments most endangered are the Mediterranean wetlands that are encroached by development and polluted by sewage input and oil spills. Intensive conservation measures are being taken in this field by the MedWet co-operative programme. Many marine species, other than the Lessepsian migrants, have invaded the Mediterranean, purposely brought for the developing mariculture, or inadvertently introduced. CIESM is busy in preparing a data base with a long list of them. The green alga *Caulerpa taxifolia* recently spreading in the Western Mediterranean, is the most recent and famous example. But like the terrestrial world of Mediterraneis which for millennia has undergone anthropic intervention and accommodated hundreds of exotic plants and their associate fauna, the sea will

Table 2. Lessepsian or eventually Leassepsioan marine algae in the Mediterranean.

Presumed before 1869 Suez Canal :

Acanthophora delillei
Acanthophora najadiformis
Hypnaea valentiae
Hypnaea nidifica
Halophila stipulacea

Suez Canal migrants, "Lessepsian Migrants":

Acetabularia calyculus
Acetabularia moebii
Cladophoropsis zollingeri
Caulerpa racemosa
Hypnaea esperi
Rhodymenia erythraea
Sarconema filiforme
Sarconema furcellatum
Sollieria dura
Spatoglossum variabile

Circum-tropical species, doubtful migrants:

Caluerpa mexicana
Caluerpa scalpelliformis
Hypnaea cornuta
Hypnaea nidifica
Gracillaria arcuata
Kylinia spathoglossi
Lophocladia lallemandii
Padina gymnospora

also follow suit and turn into a human-moulded environment. Avoiding excesses, this process can be handled.

During more than ten millennia, the Mediterranean people have unwittingly adapted their activities, in response to the often sharp and rapid post-Pleistocenic climate fluctuations They build Noah arcs when the sea invaded, they escaped from the drought to the flesh pots of the Nile, called "The Sea People", they fled to the more hospitable shores of Etruria and of Filistia and thus contributed to the spread and genesis of the resilient flora and fauna that characterise Mediterraneis. Now however, for the first time, we possess the tools of scientific prevision. The recent drought in Mediterraneis has been identified as an effect of the positive phase of the newly discovered North Atlantic Oscillation (NAO) which has a frequency of a few decades and the consequent displacement of the Intertropical Convergence. There exists a concrete possibility to foresee the evolution of these NAO cycles (Stephenson 1999).We know now, that a decade or two are often

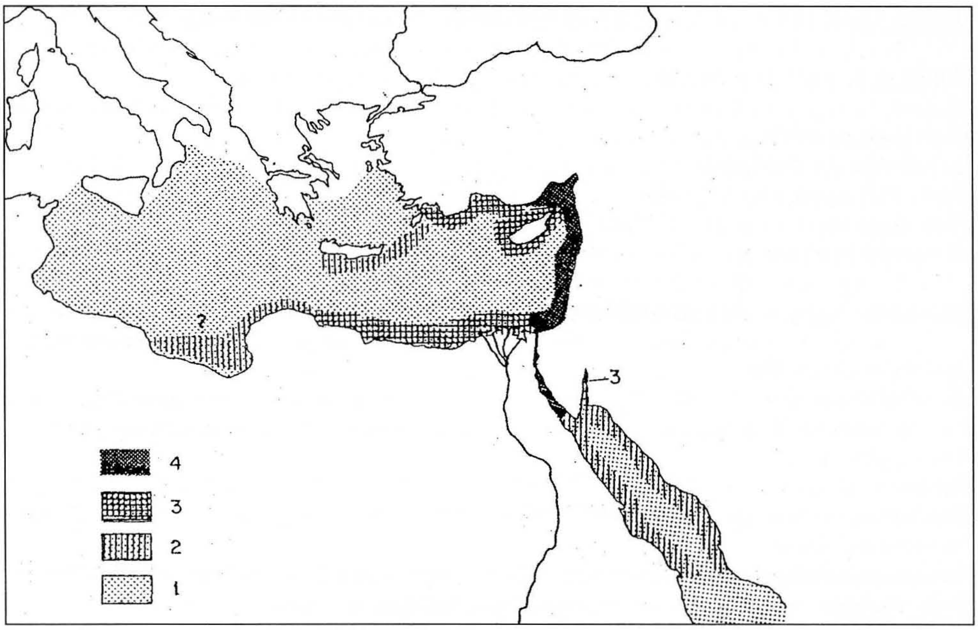

Fig. 7. The marine Lessepsian Province in contemporary Mediterranean (from Por 1990). Shades indicate degree of presence of the migrants in the Mediterranean, respectively their differential recruitment in the Red Sea.

enough to bring about a new stadial or a new interstadial. The experience with the Kyoto Protocol shows however. In the case of the perhaps wrongly incriminated carbon dioxide, that concerted world-wide action is slow to materialise. Perhaps in Mediterraneis, this self-contained, thoroughly "humanised" environment, more efficient mechanisms of co-operative action could eventually be expected. Despite all the political vagaries, MedPlan started by the Barcelona Convention in 1976, is surprisingly active.

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Address of the author:
F. Dov Por, Hebrew University Jerusalem, Department of Evolution, Systematics and Ecology, 91904 Jerusalem, Israel.
E-mail: por@vms.husi.ac.il.