Omaggio a G. E. Hutchinson

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GROUND BEETLE COENOSES IN THE LANDSCAPE OF THE NEBRODI MOUNTAINS, SICILY (*Coleoptera, Carabidae*)

SUMMARY

Carabid beetle coenoses harboured by different biotopes in the Nebrodi mountains were studied, starting from evergreen forests (Cork oak) of the lower altitudes to deciduous temperate forests (beech, turkey oak) of the tops. At the same time carabids on several types of open formations, as pastures and *Calicotome* shrubs, were trapped.

The 114 species collected were subdivided in nine ecological groups, according to their distribution in bioclimate and vegetation belts. A group of mediterranean forest-dwellers preferring humid / subhumid macroclimate and highly oceanic conditions in mountain fog belt has been related to the colchian vegetation belt (colchian paleoecological indicators). Interpretation (gradient analysis) of the vegetation (ecosystem) series and ecological succession (seres) is discussed in detail. Recent formation of the fauna and the history of its diversity are dealt with on the light of Hutchinson's niche concept and of the « law of Franz ».

RIASSUNTO

Le cenosi di Carabidi nel paesaggio dei Monti Nebrodi in Sicilia. È stato effettuato un campionamento metodico delle cenosi di Carabidi in differenti ambienti dei Nebrodi, e precisamente nei boschi sempreverdi di Quercia da sughero delle quote più basse, nelle faggete e cerrete delle zone più elevate, ed ancora nei pascoli e negli ambienti arbustivi a *Calicotome*. In totale sono state censite 114 specie di Carabidi, a loro volta suddivise in nove gruppi ecologici, sulla base della loro distribuzione bioclimatica e vegetazionale. In modo particolare viene individuato un gruppo di specie di foreste legate al macroclima umido/subumido e alle condizioni tipicamente oceaniche delle aree nebbiose dei Nebrodi. Esso viene considerato un indicatore della vegetazione colchica secondo la classificazione di Pignatti (1979).

Viene inoltre discussa l'analisi de'le cenosi lungo gli habitat rappresentativi del gradiente vegetazionale e della successione ecologica. Infine è analizzata la possibile storia della fauna carabidologica dell'area oggetto dello studio e della sua diversità, alla luce del concetto di nicchia di Hutchinson e della legge di Franz.

STUDY AREA

Nebrodi Mountains are placed in Northeastern Sicily, rising as a chain of about 80 km closely along the Tyrrhenian coast. The highest elevation of the range is Mt. Soro (1847 m. a. s. l.), and the entire crestline rarely drops under 1300 m. The area studied belongs to the Province of Messina, and the stands sampled can be subdivided into two major groups or « series » localized in different landscape units, which are also somewhat different from the biogeographical and ecological point of view.

The Mt. Soro-series (symbol: S) includes all the biotopes around Mt. Soro and the stands of the valley of the river Caronia, between the villages of Cesarò, Mistretta and S. Agata di Militello.

The Malabotta series (symbol: M) includes the samples in and around the Malabotta forest, the most impressive remnant of the ancient forest landscape of Sicily, 30 km East of Mt. Soro, near Montalbano Elicona. Geographically speaking, this locality has to be assigned to the Peloritani Mts.

The areas studied have been included in a Nature Reserve project, the limits of which have been drawn by the Sicilian zoologist Pietro Alicata.

Climate. Nebrodi Mts are a typical « coastal range », and the dominant NW-winds ensure high yearly rainfalls of about 800-1400 mm, with a maximum in autumn and winter, and a marked dry season in summer. At lower altitudes (0-750 m) the climate is true mediterranean and vegetation belongs to the biome of sclerophylls (evergreen hard-leaved woods). At higher elevation (above 700 m) the summer dryness is not so pronunced (at least on the seaward slope of the chain), and deciduous trees become dominant in the landscape (oak, beech). Here the climate can be defined as mediterranean-montane (Walter & Lieth) and subhumid.

The Malabotta landscape unit (locality: Floresta) seems to be more oceanic and rainy than Mt. Soro; moreover, precipitations decrease rapidly from the Nebrodi crestline towards the Sicilian mainland. Thus, the Nebrodi range is quite asymmetric in its bioclimate structure.

Geology and soils. The bedrocks of Mt. Soro series are mostly cretaceous « Flysch » (marls and sandstones), the Malabotta unit develops on more recent flysch formations (Flysch of Capo d'Orlando, Oligocene-Miocene). The soils are mostly very rich in clay and with good water retention power. Around Malabotta and Floresta they share impressive humus layers, which are probably the evidence of past pluvial periods.

Vegetation. Potential vegetation (climax forests) belongs to two very different biomes: a) temperate deciduous forests and b) sclerophyll forests.

Deciduous temperate forests: the forests of this « european » biome can be subdivided into two altitudinal belts: beech forests (colchian and subatlantic belts of PIGNATTI, 1979) and deciduous oak belt (samnitic belt of PIGNATTI, 1979).

The beech formations have been assigned to association *Aquifolio-Fagetum*, i.e. the « warmer » beech woods of the Apennine (RONSISVALLE & SIGNORELLO, 1977). They are peculiar for the presence of some evergreen plants like the Holly (*Ilex aquifolium*), *Daphne laureola* and others that are inherited from Tertiary warm-temperate forests of the mediterranean area (colchian elements of PIGNATTI, 1979).

The *Quercus* formations are mostly of Turkey oaks (*Quercus cerris*) or of Pubescent oaks (*Quercus pubescens* species group, more thermophilous), and show very variable microclimates and water balance, the grass layer is marked by *Doronicum orientale* and, often, by the Butcher's broom *Ruscus aculeatus*. The ecoclimate of the stands sampled seems intermediate between that of *Q. cerris* and *pubescens*, but sometimes with more pronounced summer aridity. At lower altitudes the summergreen oaks build large ecoclines or ecotones with the evergreen cork-oak forests.

The open formations of the Nebrodi have been studied by BRULLO & GRILLO (1978). They belong mostly to the mesic or humid *Molinio-Arrbenateretea*. Above 1300 m (Mt. Soro, Portella di Femmina Morta) the pasture is called *Genisto - Potentilletum calabrae*, at lower elevations we sampled the *Cynosuro-Leontodontetum siculi.*

An intermediate clearing formation, favourished by overgrazing, is the *Calicotome* shrub, very abundant in the oceanic Malabotta unit.

Sclerophyllous evergreen forests: the evergreen forests of the mediterranean biome are represented mostly by Cork oak woods (*Quercus suber*) or by degraded « *macchia* », evergreen shrubs. A high-trunked Cork oak stand has been studied in the valley of the river Caronia. The majority of the areas occupied by this biome are today overgrazed pastures or abandoned cropland, especially on the southern slope of the Nebrodi, wich faces the arid mainland of Sicily.

ZOOSOCIOLOGIC TABLE AND ECOLOGICAL GROUPS

Table 1 orders 114 carabid species on 17 stands. From left to right S2... M2 are forests (*Fagetum* and *Quercetum*), M3 and M3a *Calicotome* shrub formations, M4a a pasture with well preserved humus layer and ferns,

S1 ... S7 pastures with degraded soil and scattered vegetation. Waterside ecosystems are not included.

A careful analysis of the habitat affinity and of previous literature allowed us to separate nine ecological groups:

1) *Mediterranean forest dwellers of humid/subhumid macroclimate*, which prefer highly oceanic conditions and mountain FOG BELTS (german: *Nebelzonen*). One species, *Pseudomasoreus canigouensis*, is restricted to deciduous and evergreen oak forests and avoids beech wood (see also VIGNA TAGLIANTI *et al.*, 1988).

We find in this group typical « historical » or paleoecological indicators, inherited from ancient Tertiary mediterranean warm-temperate forest. All these species are endemic of Sicily (*C. planatus*) or of the westmediterranean area (« *old forest dwellers* » see BRANDMAYR & PIZZOLOTTO, 1988), and they appear to crowd in the so-called COLCHIAN BELT vegetation as it has been defined by some botanists: PIGNATTI, 1979), in other words on the sea-facing slopes of coastal ranges, and at the more fog-rich altitudes.

2) *Eurytopic in mediterranean and temperate forests.* The habitat of *Percus strictus* needs further investigation.

3) *European forest dwellers* of the atlantic Europe. Most species are tied to very oceanic climates, some of them are very common in lowland forests of Central and Western Europe. *C. lefebvrei* is a southern ecological substitute of *C. intricatus.*

4) *Stenotopic in beech woods (Fagion)*, at least in Southern Italy.

5) *Thermophilous and mesophilous in temperate forests or clearings*, secondarily often in open lands. *Bembidion lampros* should perhaps belong to this group.

6) *Eurytopic in open lands of temperate Europe and/or mediterranean highlands*, sometimes only in oceanic countries (*Apristus subaeneus*), or markedly thermophilous (*Cymindis variolosa, Harpalus oblitus*, etc.), but able to overcome cold winters.

7) *Thermoxerophilous species in open lands of the mediterranean biome* (sclerophylls). These species show often some preference for a given soil type, as *Licinus* for limestone, or *Bembidion rectangulum, Siagona europaea* and others for clayey soil, but not as much as those of the following group. Their presence in forests is mostly indicative of the canopy opening or the degradation by overgrazing (the same is true for group 6).

8) *Stenotopic species of clayey/loamy, often polygonal, soils.* These ground beetles are thermophilous and hygrophilous, and more or less bond to the microenvironments of soil cracks which appear in loam and clay after partial desiccation. The majority are mediterranean, many also live

on watersides. The group position of *Harpalus cupreus* and *Nebria psammodes* in uncertain.

9) *Highly thermophilous species of the arid parts of the mediterranean biome.* They need a very dry summer and humid, mild winters, and are closely linked to open formations. *Broscus politus* is a well known « *winter breeder* » (PAARMANN, 1979).

GRADIENT ANALYSIS, SERIES AND SERES

Our working group till now updated data elaboration of 20 stands, three of which are not reported in table I: Ce, Su and CS, respectively a turkey oak, a cork oak forest and an ecocline between these two types. Community data can be arranged for the reconstruction of vegetation (ecosystem) series and ecological successions (seres), using as descriptor parameter the species characteristics, like habitat preferences, wing features, distribution areas and so on. The two series studied are practically cross sections of the Nebrodi chain, showing changes in carabids from the mainland slope (SE) to the seaward one (NW).

Climax forest series of Mt. Soro landscape unit

The series comprises one stand (*Quercetum*) on the southern slope, an five on the tyrrhenian side: S2 - Su (Fig. 1). Beech stand S2a is particularly interesting because its SW exposure makes it warm enough and at the same time quite fog-rich. In this stand we found the highest density of *Carabus planatus*, in our opinion the most typical « colchian indicator ». Also the colchian beetle *Calathus montivagus* shows the maximum density in the biome of deciduous forests, but it is by far more eurytopic. The colchian elements *Pseudomasoreus canigouensis* and *Laemostenus algerinus* concentrate in summergreen and evergreen oak woods, latter being known also from beech stand M1.

The overall species number is decreasing with the altitude, as far as the number of group 3 (species of european forests). Colchian historical indicators are moderately increasing towards the mediterranean biome, but we should remember that non-degraded Cork oak woods are certainly more humid than holm oak forests (*Quercus ilex*), where a very low number of ground beetles has already been recorded by BRANDMAYR *et al.*, (1983).

The number of species able to fly is high in deciduous biome stands, and continuously decreasing along the coenocline, a minimum being found under Cork oaks. The percentage of flying species reflects here the increase

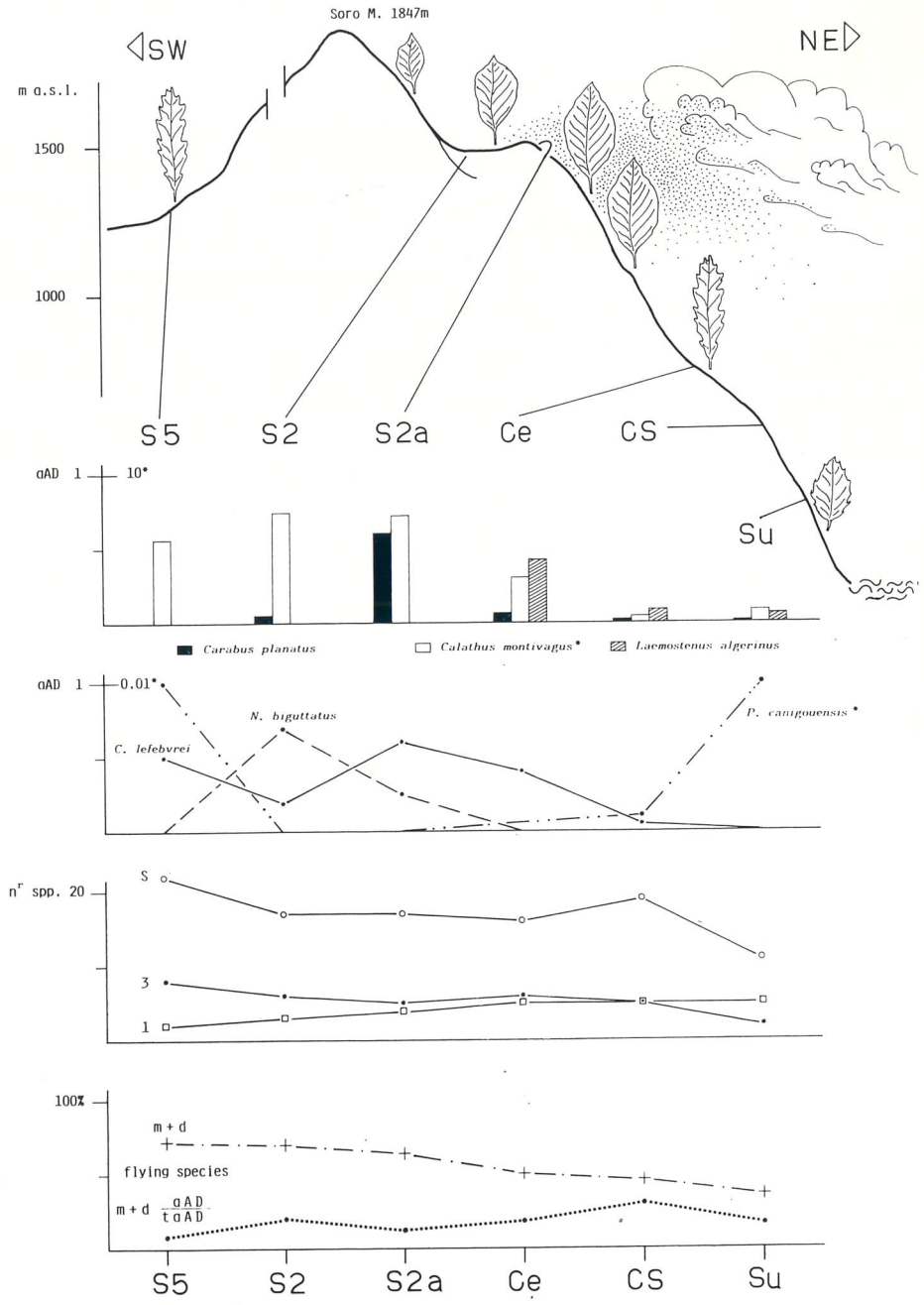

Fig. 1 — Climax forest series of the Mt. Soro landscape unit. Symbols of sample sites: Su = Cork-oak wood; CS = Cork-oak/Turkey-oak ecocline; Ce and S5 = Turkey-oak; S2 and S2a = Beech-wood. aAD = annual Activity Density; s = species diversity; 1 = ecological group 1; 3 = ecological group 3 (see text). In the last diagram is reported the qualitative (above) and quantitative (below) importance of flying species (macropterous + dimorphic species).

Table 1

Zoosociologic table of ground beetles on Nebrodi Mts. Sample site symbols refer to Mt.Soro (S and N) and Malabotta (M) landscape units and are grouped in: beech and oak-forests, Calicotome *shrubs and pasture vegetation. Species are ranked according to the nine groups reported in the text. Figures are the annual Activity Density (aAD), i.e. the yearly mean of specimens collected per trap within the standard period of ten days (cf. BRANDMAYR & PIZZOLOTTO 1989). Asterisks (*) = aAD less than 0.01; + = «hand collection». On the right are reported the* wing size *(ws) and* chorology *(choro) of species according to the following abbreviations: wing size - b* = brachypterous; *m* = macropterous; *d* = dimorphic; *chorology - I* = Sicilian endemisms; *II* = endemisms of Italian Apennines; *III* = European species in the widest meaning *(capital letter refers to the cardinal point;* m = *restricted to Mediterranean basin;* am = *atlanto-mediterranean); IV* = Euroasiatic, eurosiberian; *V* = Palearctic, holarctic.

sample site	S2	S2a	M1	M1a	S5	M2	M3	M3a	M4a	S1	S1a	S3	S4	M4	N	M5	S7		
altitude (meters a.s.l.)	1460	1475	1215	1300	1290	1185	1200	1200	1335	1840	1840	1580	1265	1295	200	800	1000		
exposure	N-NE	SSW	WNW	W	NE	W	WNW	WNW	ENE	ENE-E	NE	S	SE	S	NE	S	S		
vegetation cover (%)	95	80	75	95	85	85	90	50	80	40	50	45	40	30					
slope (°)	20	10	20	20	15	18	5	5	12	10	10	15	10	35	5	8	20		
vegetation type	(---------- Beech ----------)				(- Oak -)		Calicotome		(---------- P a s t u r e s ----------)									ws	choro
1c *Calathus montivagus*	7,43	7,35	3,13	4,80	5,73	6,27	0,53	0,09	*	0,01	-	-	-	-	-	-	-	b	II
1c *Carabus planatus*	0,05	0,61		-	-	-	-	-	-	-	-	-	-	-	-	-	-	b	I
1c *Laemostenus barbarus*	0,02	0,02	0,01	-	-	0,01	-	-	-	-	-	-	-	-	-	-	-	m	IIIWm
1c *Leistus crenatus*	-	-	0,02	-	-	-	0,01	-	-	-	-	-	-	-	-	-	-	m	IIIWm
1c *Laemostenus algerinus*	-	-	0,19	-	-	0,16	0,11	0,04	0,04	-	-	-	*	0,01	-	-	-	b	IIIWm
1c *Pseudomasoreus canigouensis*	-	-	-	-	0,01	0,04	0,01	-	-	-	-	-	-	-	-	-	-	m	IIIWm
1c *Leistus sardous*	-	(+)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	m	IIIWm
2 *Platyderus canaliculatus*	-	0,01	0,20	0,16	-	0,96	0,07	0,09	-	-	-	-	-	-	-	-	-	b	II
2 *Percus strictus*	-	-	-	-	-	0,10	-	-	-	-	-	-	-	-	-	-	-	b	I
3c *Nebria brevicollis*	1,22	0,04	-	-	0,01	-	0,06	0,01	-	-	-	-	-	-	-	-	-	m	III
3 *Trechus obtusus*	0,24	0,04	*	-	0,08	0,15	-	-	-	-	-	0,41	-	-	+	-	+	b	III
3c *Leistus spinibarbis*	0,02	-	0,04	-	0,01	+	0,01	-	-	0,01	0,02	-	-	+	-	-	-	m	IIIam
3 *Carabus lefebvrei*	0,19	0,60	1,69	1,64	0,51	0,74	0,06	0,01	0,01	0,01	0,02	-	-	-	-	-	-	b	III
3 *Philorhyzus brandmayri*	0,01	-	*	-	0,01	-	-	-	-	-	-	-	-	-	-	-	-	m	I
3c *Leistus fulvibarbis*	0,01	-	0,03	0,04	*	0,01	-	-	-	-	-	-	-	-	-	-	-	m	IIIam
3c *Philorhizus vectensis*	-	0,01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	m	IIIam
3 *Pterostichus nigrita*	-	0,01	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	m	IV
3 *Notiophilus rufipes*	-	-	0,21	0,74	0,14	0,18	0,01	-	-	-	-	-	-	-	-	-	-	m	III
3 *Calosoma sycophanta*	-	-	-	-	0,03	-	-	-	-	-	-	-	-	-	-	-	-	m	V
3 *Dromius agilis*	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	m	IV
3 *Dromius quadrimaculatus*	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	m	III
3c *Argutor (Bothriopterus) angustatus*	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	m	III
3 *Harpalus atratus*	-	-	*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	d	III
3c *Leistus rufomarginatus*	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	d	III
4 *Notiophilus biguttatus*	0,69	0,25	0,13	1,15	-	0,01	-	-	-	-	-	-	-	-	-	-	-	d	III
5 *Pterostichus melas*	5,01	2,43	3.43	6,49	5,18	0,16	0,06	0,01	-	0,29	0,08	0,34	0,02	0,02	+	-	+	b	IIISE
5c *Nebria andalusiaca*	0,25	-	0,02	0,04	0,01	-	0,08	0,01	-	0,07	0,03	0,01	0,30	-	+	+	+	m	IIIWm
5 *Harpalus tardus*	0,01	0,04	0,07	-	-	0,16	-	-	0,01	-	-	-	-	-	-	-	-	m?	IV
5 *Ophonus rufibarbis*	-	-	0,02	-	-	0,01	-	-	-	-	-	-	-	-	-	-	-	m	III
5 *Synuchus nivalis*	-	-	0,08	-	-	-	0,01	-	-	-	-	-	-	-	-	-	-	m	III
5 *Trechus quadristriatus*	-	-	0,01	-	0,30	-	-	-	-	-	-	-	0,08	-	-	-	+	m	V
5 *Brachinus italicus*	-	-	-	-	0,03	-	-	-	-	-	-	-	-	-	-	-	-	b?	II
5 *Amara eurynota*	-	-	-	-	0,01	0,01	0,01	-	-	-	0,03	-	-	-	-	-	-	m	IV
5 *Amara similata*	-	-	-	-	-	0,24	-	-	-	-	-	-	-	-	-	-	-	m	IV
5 *Amara anthobia*	-	-	-	-	-	0,04	-	-	-	-	-	-	-	-	-	-	-	m	III
5 *Carabus convexus*	-	-	-	-	-	0,02	-	-	-	-	-	-	-	-	-	-	-	b	IV
5 *Harpalus rubripes*	-	-	*	-	-	0,02	0,40	0,08	0,30	-	-	-	-	-	-	+	-	m	IV
5 *Masoreus wetterhalli*	-	-	-	-	-	0,01	0,04	-	0,10	-	-	-	-	-	-	-	-	d	V
5 *Calathus solieri*							0,04	0,03										m	IIIWm

5	*Calathus solieri*	-	-	-	-	-	-	0,01	0,01	-	-	-	-	-	-	-	-	-	m	IIIWm
5	*Notiophilus quadripunctatus*	-	-	-	-	-	-	0,01	0,11	*	-	-	-	-	-	-	-	-	m	IIIam
5	*Carabus morbillosus*	-	-	-	-	-	-	0,11	0,11	0,01	-	-	-	*	-	-	-	+	b	IIIWm
6	*Harpalus serripes*	0,01	0,01	-	-	-	-	0,02	-	0,04	-	-	0,01	-	-	-	-	-	m	IV
6	*Calathus mollis*	0,01	0,06	-	-	-	0,18	0,30	0,28	0,86	1,79	4,04	0,05	*	-	-	-	+	d	III
6	*Brachinus crepitans*	0,01	-	-	-	-	-	-	-	0,01	-	-	0,05	0,19	-	-	-	+	d	IV
6	*Calathus fuscipes*	1,01	1,15	0,09	0,49	0,53	2,43	3,82	5,88	7,88	11,93	10,36	2,86	0,78	0,36	-	-	+	d	III
6	*Ophonus cribricollis*	-	-	-	-	-	0,01	-	-	0,02	-	-	-	-	-	-	-	-	m	IIIS
6	*Harpalus rufitarsis*	-	0,01	-	-	*	0,01	0,04	0,50	0,32	0,05	0,03	-	-	0,01	-	-	-	m	III
6	*Cymindis variolosa*	-	-	-	-	-	0,02	0,03	-	0,10	0,04	-	1,62	0,42	0,30	-	-	-	d	IIIS
6	*Harpalus impressipennis*	-	-	-	-	-	0,01	0,06	0,20	0,07	1,25	0,66	0,01	-	-	-	-	-	m	IIINWm
6	*Harpalus sulphuripes*	-	-	-	-	-	-	0,06	0,24	0,46	0,45	0,08	-	*	-	-	-	-	d	IIIam
6	*Synthomus obscuroguttatus*	-	-	-	-	-	-	0,01	-	-	-	-	0,15	0,07	-	+	-	-	?	III
6	*Bembidion lampros*	-	-	-	-	-	-	0,01	-	-	0,04	0,15	0,07	0,01	-	-	-	-	d	IV
6	*Amara aenea*	-	-	-	-	-	-	0,01	0,03	0,80	0,18	1,61	0,04	0,02	-	-	-	-	m	V
6	*Amara sicula*	-	-	-	-	-	-	0,05	0,01	0,12	-	-	-	-	0,29	-	-	-	m?	II
6	*Synthomus impressus*	-	-	-	-	-	-	0,02	0,14	0,42	-	-	-	-	+	-	-	-	?	IIIEm
6	*Ophonus azureus*	-	-	-	-	-	-	0,01	-	*	-	-	-	-	0,01	+	-	-	d	III
6	*Licinus silphoides*	-	-	-	-	-	-	0,01	0,01	*	-	-	-	-	0,01	-	-	-	m	IIINEm
6	*Ophonus puncticeps*	-	-	-	-	-	-	-	-	0,02	-	-	0,10	*	-	+	-	-	m	III
6	*Cicindela campestris*	-	-	-	-	-	-	-	-	0,01	-	-	-	-	-	-	-	-	m	V
6	*Microlestes fulvibasis*	-	-	-	-	-	-	-	-	0,01	-	-	-	-	-	-	-	-	d?	V
6	*Lebia crux-minor*	-	-	-	-	-	-	-	-	0,01	0,01	-	0,04	0,01	0,02	-	-	-	m	V
6	*Notiophilus pusillus*	-	-	-	-	-	-	-	-	-	1,23	1,30	0,41	*	-	-	-	-	m	III
6	*Harpalus distinguendus*	-	-	-	-	-	-	-	-	-	0,33	0,37	0,01	-	-	-	-	-	m	IV
6	*Ophonus parallelus*	-	-	-	-	-	-	-	-	-	-	-	0,02	-	-	-	-	-	m?	III
6	*Harpalus oblitus*	-	-	-	-	-	-	-	-	-	-	-	0,01	-	-	-	-	-	m	III
6	*Poecilus cupreus*	-	-	-	-	-	-	-	-	-	-	-	0,01	-	-	-	-	-	m	IV
6	*Brachinus sclopeta*	-	-	-	-	-	-	-	-	-	-	-	0,01	-	-	-	-	-	m	IIIS
6	*Apristus subaeneus*	-	-	-	-	-	-	(+)	-	-	-	-	-	-	-	-	-	-	m	IIINm
6	*Dromius linearis*	-	-	-	-	-	-	-	-	*	-	-	-	*	-	-	-	-	d	III
6	*Philorhizus crucifer*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	?	IIIm
7	*Microlestes negrita*	-	-	-	0,04	*	-	0,01	-	0,17	0,01	0,02	0,19	0,07	0,02	-	-	-	d	IIIm
7	*Microlestes luctuosus*	-	-	*	-	-	-	0,10	0,05	0,27	0,01	0,10	0,03	0,04	0,37	+	+	+	d	IIISm
7	*Ophonus subquadratus*	-	-	-	-	-	-	0,02	-	0,02	-	-	0,01	-	0,06	+	-	-	m	IIIam
7	*Acinopus picipes*	-	-	-	-	-	-	0,01	-	-	-	-	-	-	0,02	-	+	-	d	IIISE
7	*Olisthopus glabricollis*	-	-	-	-	-	-	0,01	-	-	-	-	0,01	0,01	-	+	+	+	d?	IIINm
7	*Harpalus attenuatus*	-	-	-	-	*	-	-	0,04	0,03	-	-	-	*	0,02	-	-	-	m?	IIIam
7	*Microlestes laevipennis bedeli*	-	-	-	-	-	-	-	-	0,09	-	-	-	0,07	0,02	+	+ +	+	b	IIIWm
7	*Microlestes abeillei brisouti*	-	-	-	-	-	-	-	-	0,04	-	-	-	-	0,14	-	-	+	d	IIIWm
7	*Ditomus sphaerocephalus*	-	-	-	-	-	-	-	-	0,01	-	-	-	-	0,27	-	-	-	m	IIIWm
7	*Carterus rotundicollis*	-	-	-	-	-	-	-	-	-	-	0,02	0,01	-	-	+	-	+	m	IIIWm
7	*Carterus dama*	-	-	-	-	*	-	-	-	*	-	-	0,01	0,02	0,01	-	+	-	m	IIIm
7	*Lebia trimaculata*	-	-	-	-	-	-	-	-	-	-	-	0,01	-	-	-	-	-	m	IIIS
7	*Bembidion rectangulum*	-	-	-	-	-	-	-	-	-	-	-	-	0,06	-	-	-	-	d	IIIWm

7	*Brachinus fulviventris*	-	-	-	-	-	-	-	-	-	-	-	-	0,04	-	+	-	-	m	IIINm
7	*Ophonus sabulicola*	-	-	-	-	-	-	-	-	-	-	-	-	0,01	-	-	+	-	m	III
7	*Acinopus baudii*	-	-	-	-	-	-	-	-	-	-	-	-	-	0,10	-	-	-	b?	II
7	*Acinopus megacephalus*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	m	IIINEm
7c	*Brachinus immaculicornis*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	d	IIIWm
7	*Bembidion hypocrita*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	m	IIIS
7	*Licinus punctatulus*	-	-	-	-	-	-	(+)	-	*	-	-	-	*	-	+	-	-	m	IIIam
7	*Notiophilus geminatus*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	m	IIIWm
7	*Siagona europaea*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	m	V
7	*Ophonus incisus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	m	IIIS
7	*Ophonus similis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	m	III
8c	*Notiophilus substriatus*	-	-	-	-	0,02	-	-	0,01	0,01	-	-	0,07	0,14	0,01	-	-	-	m	IIIam
8	*Bembidion lunulatum*	-	-	-	-	-	-	-	-	-	-	-	0,06	0,08	-	-	-	-	m	III
8	*Dinodes decipiens*	-	-	-	-	*	-	-	-	-	-	-	0,01	-	-	-	-	-	m	III
8	*Tachys bistriatus*	-	-	-	-	-	-	-	-	-	-	-	+	0,06	-	+	-	-	m	III
8	*Microlestes mauritanicus*	-	-	-	-	-	-	-	-	-	-	-	-	0,04	-	-	-	+	d?	IIISm
8	*Bembidion escherichi subatratum*	-	-	-	-	-	-	-	-	-	-	-	-	0,01	-	-	-	-	m	IIIS
8	*Poecilus (Angoleus) crenatus*	-	-	-	-	-	-	-	-	-	-	-	-	0,01	-	+	+	-	m	IIIWm
8	*Polystichus fasciolatus*	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	m	IIIm
8	*Acupalpus puncticollis*	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	m?	IIISE
8	*Chlaenius chrysocephalus*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	m	IIIWm
8	*Harpalus cupreus*	-	-	-	-	-	-	-	-	*	-	-	-	-	-	-	-	-	m	III
8	*Bembidion callosum*	-	-	-	-	-	-	-	-	-	-	-	-	*	-	-	-	-	m	IIIWm
8	*Nebria psammodes*	-	-	-	-	-	-	(+)	-	-	-	-	-	-	-	-	-	-	m	IIISW
9	*Calathus circumseptus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	m	IIIm
9	*Ditomus clypeatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	m	III
9	*Broscus politus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	m	II
9	*Carterus cordatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	m	IIIm
9	*Bembidion tethys*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	m	IIIm
9	*Ophonus pumilio*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	m	IIIWm
9	*Ophonus rotundatus*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	m	IIIWm
	number of species	17	17	25	10	22	30	40	23	38	18	18	32	40	22	18	13	21		114
	total aAD	16,2	12,6	9,4	15,6	12,6	12	6,2	8	12,3	17,7	19	6,6	2,6	2	—	—	—		
	m + d	12	11	19	6	16	22	32	16	32	15	15	29	35	17	14	12	16		
	m + d%	70,5	64,7	76	60	72,7	73,3	80	69,5	84,2	83,3	83,3	90,6	87,5	77,2	77,7	92,3	76,1		

in Table

0 — 500 — 1000 — 1500 — 2000 m a.s.l.

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of hydric stability (BRANDMAYR, 1983) in mediterranean summerarid forests.

The small peaks of Activity Density (AD) of winged species (percentage of total annual AD) reflects local conditions of hydric (S2) or dynamic instability (CS is surrounded by clearings). It indicates no great differences of dynamic stability within the series.

Anthropogenic pasture series in the Mt. Soro unit

Pasture sequence (Fig. 2) ranges from c. 200 to 1840 m (Mt. Soro). *Calathus fuscipes* was selected as indicator species for ecological group 6 (open lands of temperate Europe). This carabid is very abundant in the fresh terms of *Plantaginion cupanii* (*Genisto-Potentilletum calabrae*), and is disappearing below 1000 m, towards the true mediterranean open land. *Harpalus distinguendus*, *Notiophilus pusillus*, *Brachinus crepitans*, *Harpalus rufitarsis* give to these « higher » pastures an european character. *Harpalus*

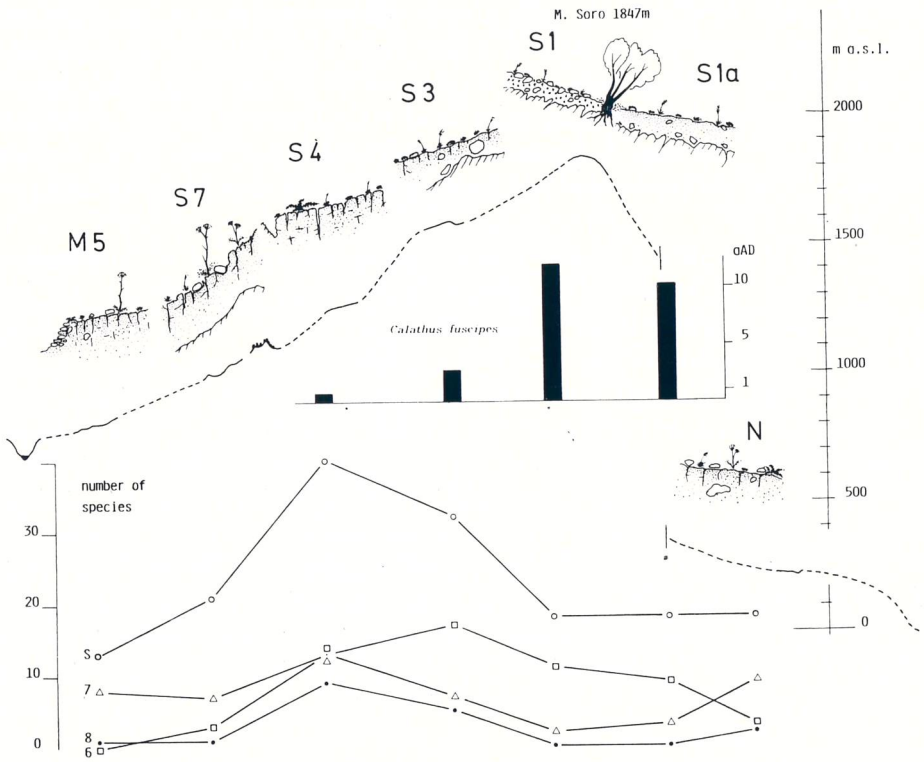

Fig. 2 — Anthropogenic pasture series in the Mt. Soro unit. Symbols of sample as in Table 1. Numbers 7, 8, 6 refer to ecological groups.

impressipennis, mediterranean in its distributions area, shows also an exclusive preference for highland pastures.

Mediterranean open land species (group 7) behave in the opposite way, and this holds true even more for group 9 (see table 1).

The high species diversity of S4 is also explained by the importance of group 8 in the stand; *Chlaenius chrysocephalus*, *Poecilus (Angoleus) crenatus*, *Bembidion escherichi* and *B. callosum* are true « crack-dwellers » in clayey soils. In S3 a similar condition is underlined by presence of *Dinodes decipiens* and *Polystichus fasciolatus*, but erosion phenomena are not so developed. Species diversity in M5, S7 and N is probably underestimated (hand collectings).

The sere (ecological succession) of the Malabotta unit

The landscape unit of Malabotta (Fig. 3) offered the best conditions for the study of community changes in ecological successions; indeed shrub formations and soil profiles are here not so deeply modified by grazing. The M1-M4 alignment is at least in part merely conventional: both *Fagetum* and *Quercetum* should be considered « final steps » at different altitudes and exposures, and M1a is only the crestline facies of the same beech forest. Species diversity is greater in open land (this characteristic is commonly found among carabids). A minimum is observed in the very dark crestline *Fagetum*, where no open land nor clearing-stragglers have been checked (see list of M1!).

Mediterranean open land species are numerous only if temperature favourishes onset stages (M4), while european open land dwellers are largely prevailing when some humus layers are present or fern and bush growth becomes thicker.

Grazing indicators like *Cymindis variolosa* or *Amara sicula*, very abundant in mesic and dry pastures, are turnovered in *Calicotome* -shrubs by ground beetles of mesic, oceanic clearings and heaths: *Notiophilus quadripunctatus*, *Masoreus wetterhalli*, and by *Calathus solieri*, tied to mountain shrubs and humus-rich bush formations of the westmediterranean mountains. In the quite mesic/humid conditions of the *Quercus cerris* forest M2 they are replaced by some species preferring mesophilous and eutrophic conditions, as *Amara eurynota*, *similata* and *anthobia*. Here also an isolated population of *Percus strictus* was found (a rare, sedentary Molopine). In forest stands *Carabus lefebvrei* and many colchian elements appear with increasing abundance.

Dispersal power of turnovering populations is represented in the lower part of Figure 3. The lowest percentage of winged species is found

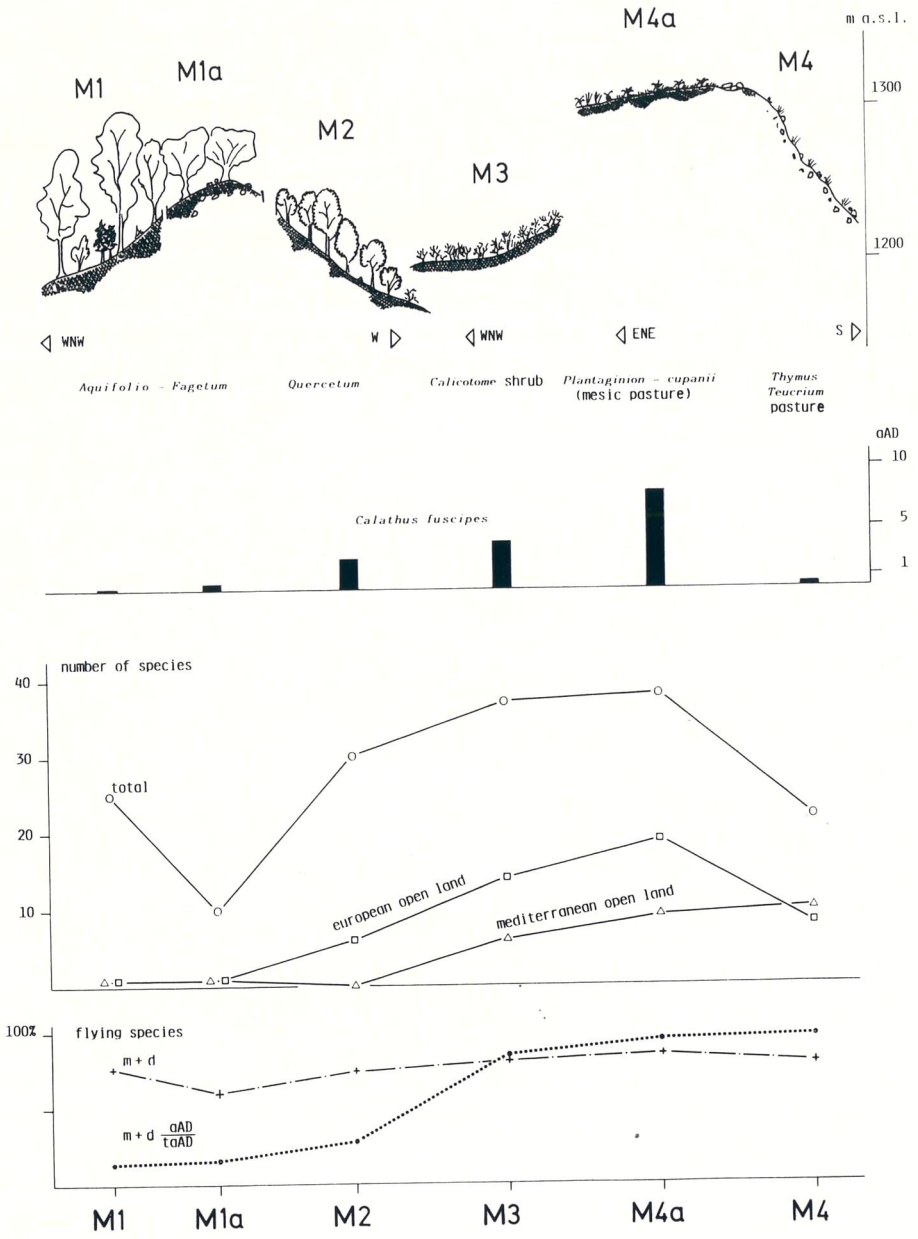

Fig. 3 — Ecological succession of the Malabotta unit. Symbols of sample sites as in Table 1. Lower diagram as in Fig. 1.

in forests, but the difference against open land is not outstanding (see the following paragraph).

The increase of dynamic stability along the succession is better expressed by the yearly abundance amount of flying species (m+d aAD/taAD, i.e. the annual activity of macropterous and dimorphic species as a percentage of the entire annual catches).

ZOOGEOGRAPHY AND HISTORY OF FAUNAL DIVERSITY

Landscape units share 114 species of ground beetles (160 species, if we add waterside habitats). The most abundant chorotypes are mediterranean (IIIm, 39%) and european in the widest meaning (III, 35%). Only 18% of the beetles are widespread over larger geographical areas (IV, V) and 8% are restricted to small areas, notably 3% are Sicily endemites, and 5% are Sicily + Maghreb or Sicily + Southern Italy species.

Column IIIm of Figure 4 is particularly interesting: almost half of the « mediterranean » species are indeed W-mediterranean, often « tyrrhenian ». W-mediterranean or with W-mediterranean relatives are the « *colchian* » forest dwellers *Leistus crenatus*, *L. sardous*, *Laemostenus barbarus*, *Lae-*

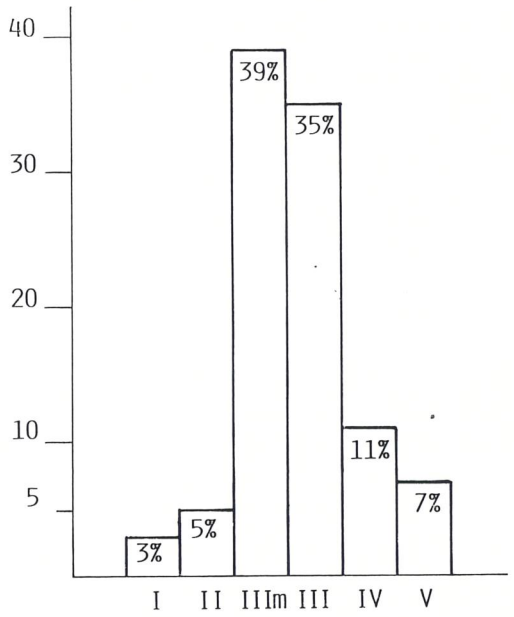

Fig. 4 — Percentage of species per each chorotype, that is chorological spectrum of the Carabid beetle faunula on Nebrodi Mts. Symbols as in Table 1.

mostenus algerinus, *Pseudomasoreus canigouensis*, but also *Carabus planatus* belongs to the W-mediterranean subgenus *Macrothorax*. Another fraction of this chorologic group are the atlantomediterranean beetles (IIIam).

Table 2 shows the distribution of chorotypes within the different habitats. Endemites are more frequent in forest (I, II), mediterranean species crowd in xeric pastures.

Species structure of communities and faunal history of the Sicilian mountain forests, especially of beech woods, appear to be noteworthly different from those of continental Italy. Beech and deciduous oak forests of Nebrodi Mts. are:

1) Poor of endemic ground beetles.

2) Poor of petrophilous carabids (exception are *C. planatus*, *Percus strictus*, *Platyderus* ?).

3) Rich of colchian elements, some of which in common with North-african (Maghrebian) forests: *L. crenatus*, *P. canigouensis*, *L. algerinus*.

4) Dimorphic and macropterous carabids are more numerous here than on the Apennines; percentages of about 70% (see Fig. 1) are usually too high for climax forest; also on marls or sandstones (e.g.: according to BRANDMAYR, 1983 on marls and sandstones of the Eastern Alps only c. 30% of species are able to fly).

5) Many of these winged species are tied to very oceanic climates and their colonisation of Sicily probably dates back to Quaternary. Sicily indeed was not affected by ice masses and glacial phases, but whole island was probably exposed to the temporary pluvial periods. In Calabrian beech forests we found at least 10-12 petrophilous species, and the brachypterous form is largely prevailing within the community structure (BRANDMAYR & PIZZOLOTTO, 1988).

We believe that at least a part of the old mountain forest fauna has become extinct in Sicily at the end of the Neogene period (Pliocene, Quaternary), when possibly elevation of Nebrodi and Madonie Mts. was not enough to preserve cool-moist and mesic forest types. On the other hand, even if the Messina channel was dried out during some glacial periods, petrophilous beetles of the Apennines were not able to pass it, probably being not able to settle alluvial soils. During Quaternary, only good flyers and non-petrophilous carabids, as *Carabus coriaceus, C. convexus, Pterostichus melas* and others, reached the so called « Sicilian Apennine ». *Notiophilus biguttatus* (dimorphic species) may be considered a recent arrival, being known in Calabria and Sicily virtually only its winged morph (BRANDMAYR & PIZZOLOTTO, 1988). The time length of Quaternary period was too short to consent the evolution of a new petrophilous fauna.

Table 2

Number and percentage of species belonging to different chorotypes recorded in each sample site. Abbreviations as in Table 1

		S2	S2a	M1	M1a	S5	M2	M3	M3a	M4a	S1	S1a	S3	S4	M4	N	M5	S7	spp tot
Number of species	I	2	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	1	3
	II	1	2	2	2	2	2	3	3	2	1	0	0	0	2	0	0	0	6
	IIIm	4	3	7	3	8	6	18	12	17	6	8	10	22	15	10	7	12	45
	(IIIWm)	2	1	4	1	2	4	7	5	6	2	3	3	10	4	4	4	6	21
	III	7	8	11	5	8	14	13	6	10	7	6	15	13	6	7	5	6	40
	IV	3	3	3	0	1	6	4	1	4	2	3	5	2	0	0	1	1	12
	V	0	0	1	0	2	1	2	1	5	2	1	2	3	1	1	0	1	8
% of species	I	12	6	4	0	5	3	0	0	0	0	0	0	0	0	0	0	5	3
	II	6	12	8	20	9	7	8	13	5	6	0	0	0	9	0	0	0	5
	IIIm	24	18	28	30	36	20	45	52	45	33	44	31	55	68	56	54	57	39
	(IIIWm)	12	6	16	10	9	13	18	22	16	11	17	9	25	18	22	31	29	18
	III	41	47	44	50	36	47	32	26	26	39	33	47	32	27	39	38	29	35
	IV	18	18	12	0	5	20	10	4	11	11	17	16	5	0	0	8	5	11
	V	0	0	4	0	9	3	5	4	13	11	6	6	8	5	6	0	5	7

At the same time (late Pliocene, Quaternary), the « new » biome of the sclerophylls arose from the impoverished old evergreen warm-temperate forest of the mediterranean basin, following the Neogene climate variation from subtropical (with summer precipitations) to « mediterranean » (with winter rains and summer drought) (AXELROD, 1973). Many hygrophilous forest dwellers disappeared or emigrated, others found a refugium habitat in mountain *Fagetalia* or in mesic Turkey oak woods. Today no carabid is known to be tied to Sicilian sclerophyll forests; according to the « law of Franz » (1939), this is an interesting evidence of the youth of this evergreen, summer-dry ecosystem type.

HUTCHINSON (1959), to whom this issue is dedicated, accounted for the diversity of bird communities by means of small differences in the multidimensional niche of coexisting bird species. According to FRANZ (1939) the more unaltered is a biotope during the time, the richer in species and stable is its fauna. Its law seems a more comprehensive rule; indeed it includes not only the coevolutionary aspects of diversity problems within an ecosystem, but also the adaptation opportunity of some species to « eco-climate » features in a given ecosystem type.

During Quaternary, the spread of the sclerophyll biome, with its unusual combination of soil dryness and darkness under the canopy, represented an unexpected « ecophysiological barrier », that is to say a sudden change.

In conclusion, on the ground of the law of Franz, the low species diversity of soil fauna harboured by sclerophyll vegetation types is accounted for by ecosystem « history ».

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