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Department of Biology, University of Crete, Iraklion, Greece

Phenology and patterns of activity of ground Coleoptera in an insular Mediterranean ecosystem (Cyclades, Greece)

A. Trihas and A. Legakis

With 5 Figures

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1. Introduction

Mediterranean ecosystems are some of the less well known areas of the world. This fact applies especially to the eastern mediterranean region and in particular to the ground fauna of these ecosystems. The majority of the existing data concern faunistic and systematic studies carried out during short collecting trips. Ecological studies in the field are difficult to carry out mainly because of the heterogeneity of the environment (di Castri & Vitali-di Castri, 1981) and also because of the lack of tradition in ecological research in countries like Greece. From other studies on the soil fauna, it is evident that the Coleoptera are one of the most diverse groups in size, in number of species and in the number of different ecological roles that they have. They include coprophagous species (some Scarabaeidae), detritivores (some Staphylinidae), herbivores (Curculionidae, Chrysomelidae), carnivores (Carabidae) and omnivores. The size ranges from 2 mm up to 3 cm.

The present study concerns the seasonal variation of the populations and the spatial and temporal patterns of activity of ground Coleoptera of an insular mediterranean ecosystem situated on the island of Naxos in the Cyclades group of islands. This study is part of a research project "Structure and energy flow in Aegean insular ecosystems" carried out by the Sect. of Ecology and Taxonomy of the Univ. of Athens in collaboration with the Ecole Normale Superieure of Paris and partly financed by the EEC. Sorting, identification and analysis were carried out in the Dept. of Biology of the Univ. of Crete.

2. Site description

The ecosystem under study is situated in the eastern part of Naxos island, 5 km south of the village of Moutsouna. The study site is on a hill of an altitude between 100 and 200 m above sea level. The slope is 30° (19%) facing east. The distance from the sea is appr. 1250 m.

The substrate is calcareous composed mainly of rocks of medium to large size. The soil is not rich and is most deep in the rock cavities or between rocks.

The vegetation is dominated by the phoenician juniper, *Juniperus phoenicea* (37% cover, average height 2.5 m). Other important species are the olive tree. *Olea europaea silvestris* L. (8% cover) and the lentisc, *Pistacia lentiscus* (7% cover). A large proportion (47%) is open ground containing various herbaceous species including a large population of the sea squill *Urginea maritima* .

Human activities in the study area include grazing by herds of goats. The area has a long history of grazing as in most Greek islands and its effects are evident on the vegetation.

The climate of Naxos can be considered as temperate to maritime. The annual range of temperatures is 13 °C (12.3 °C in January to 24.9 °C in July and August). The mean annual rainfall is 390 mm which means that the climate of Naxos belongs to the drier part of mediterranean type climates. Maximum rainfall is in January and minimum in July. The relative humidity is around 71%. There are about 130–150 sunny days during the year. The variations of climatic conditions between years are significant (Matsakis *et al.*, in press).

3. Materials and methods

Forty pitfall traps (6 cm ∅, 8 cm depth) were placed throughout the ecosystem as they are an efficient way to estimate coleopteran migration activity (GREENSLADE, 1964). Ten were placed under *J. phoenicea*, ten under *O. europaea*, ten under *P. lentiscus* and ten in the open ground. The traps under the trees were placed in pairs (at diametrically opposing positions) under five different individuals of each species. The fixing medium was ethylene glycol which is colorless, odorless and not volatile. The contents of the traps were collected each month from April 1982 up to April 1983 and sorted. The results were expressed as numbers of animals per 30 days per trap.

Quantitative sampling included (a) three to five 25 cm × 25 cm samples of litter from under each dominant tree species placed in Berlese-Tullgren funnels, (b) three samples of approximately 1 m^2 each of animals under stones, under each tree, each month. These results were transformed to individuals per 1 m^2 per month). (c) five 1 m^2 quadrats of open ground (the quantitative sampling took place from December 1982 up to March 1984).

The identification of Coleoptera was carried out to species level wherever possible and at least to genus level.

4. Results

4.0. General notes

Quantitative sampling produced 21 species from 9 families: Carabidae (4 spp.), Staphylinidae (4 spp.), Lathridiidae (1 sp.), Anobiidae (1 sp.), Ptinidae (1 sp.), Tenebrionidae (2 spp.), Scarabaeidae (2 spp.), Chrysomelidae (2 spp.) and Curculionidae (4 spp.).

Pitfall traps produced 66 species from 25 families: Carabidae (8 spp.), Histeridae (2 spp.), Leiodidae (2 spp.), Scydmaenidae (1 sp.), Staphylinidae (9 spp.), Pselaphidae (1 sp.), Melyridae (3 spp.), Cleridae (2 spp.), Elateridae (1 sp.), Buprestidae (1 sp.), Dermestidae (1 sp.), Nitidulidae (1 sp.), Cucujidae (1 sp.), Cryptophagidae (1 sp.), Lathridiidae (1 sp.), Anobiidae (1 sp.), Ptinidae (1 sp.), Oedemeridae (1 sp.), Anthicidae (1 sp.), Meloidae (2 spp.), Tenebrionidae (5 spp.), Scarabaeidae (6 spp.), Chrysomelidae (3 spp.), Bruchidae (1 sp.) and Curculionidae (10 spp.).

The dominant families in terms of numbers of species are Carabidae, Staphylinidae, Tenebrionidae, Scarabaeidae and Curculionidae. Also the families Melyridae, Antihicidae and Ptinidae, although poor in species, have a very high number of individuals during some months. Not all species of the above mentioned families have high population densities. Table 1 shows the dominant species in each family.

Table 1. List of dominant species of the main families.

Carabidae: *Carabus coriaceus cerisyi* DEJEAN, 1826; *Carterus calydonius* (ROSSI, 1970); *Acinopus subquadratus* (BRULLÉ, 1932); *Microlestes sp.*
Staphylinidae: *Oxytelus spp.; Xantholinus sp.; Mycetoporus sp.*
Melyridae: *Dasytes graminicola* (KIESENWETTER, 1859); *Danacaea sp.*
Anthicidae: *Anthicus sp.*
Tenebrionidae: *Dailognatha quadricollis* (BRULLÉ, 1832); *Raiboscelis cf. azureus* (BRULLÉ, 1832); *Helops sp.*
Scarabaeidae: *Epicometis hirta* (PODA, 1761); *Typhoeus fossor* (WALTL, 1838); *Trox sp., Geotrupes intermedius* A. COSTA, 1827;
Curculionidae: *Brachycerus sp., Otiorhynchus spp.*

4.1. Spatial distribution

The quantitative results show that there is a preference for litter microhabitats especially during winter (fig. 1). However, the small number of samples taken as the study was concentrated on the ground arthropoda in general, does not permit to arrive at conclusions for the spatial preferences of individual species.

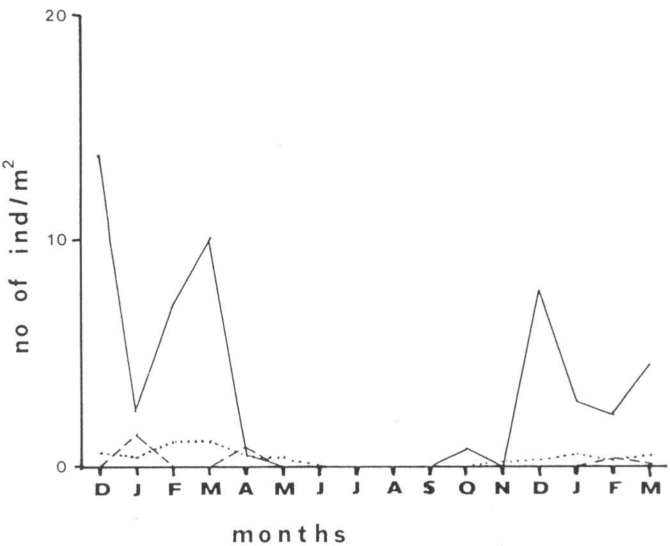

Fig. 1. Annual variation of Coleoptera in various microhabitats. Continuous line: litter, dashed line: stones, dotted line: open ground.

Looking at the spatial patterns of activity during the whole year, it seems quite clear that a migration takes place from one microhabitat to another as climatic conditions change. This is most obvious in the cases of Carabidae and Tenebrionidae. As is evident from fig. 2, Carabidae move from the drier open ground and *Olea* microhabitats to the more humid *Juniperus* and *Pistacia* as temperatures increase and humidity drops from April to June. This is more evident in the case of *C. calydonius* (fig. 3). Tenebrionidae and in particular *D. quadricollis*, seem to have the same trend (figs. 2 and 3). During the high temperatures of June, they are most active under the dense *Pistacia* shrubs while in May they are more active under *Olea*. It is evident that these two families prefer open surfaces (both *Juniperus* and *Pistacia* have thick litter and rich undergrowth) in order to find their food more easily. However, they are forced under cover when conditions become harsh. The other families do not show a particular preference for a microhabitat during spring (although one must be cautious due to the small number of individuals belonging to these families).

The same trend is obvious with Carabidae, Curculionidae and Staphylinidae during October and November. However, their migration under cover during the subsequent months is due now to the lower temperatures of winter.

Finally, Melyridae and Anthicidae appeared mainly in the open ground and under *Olea* during their short presence in May.

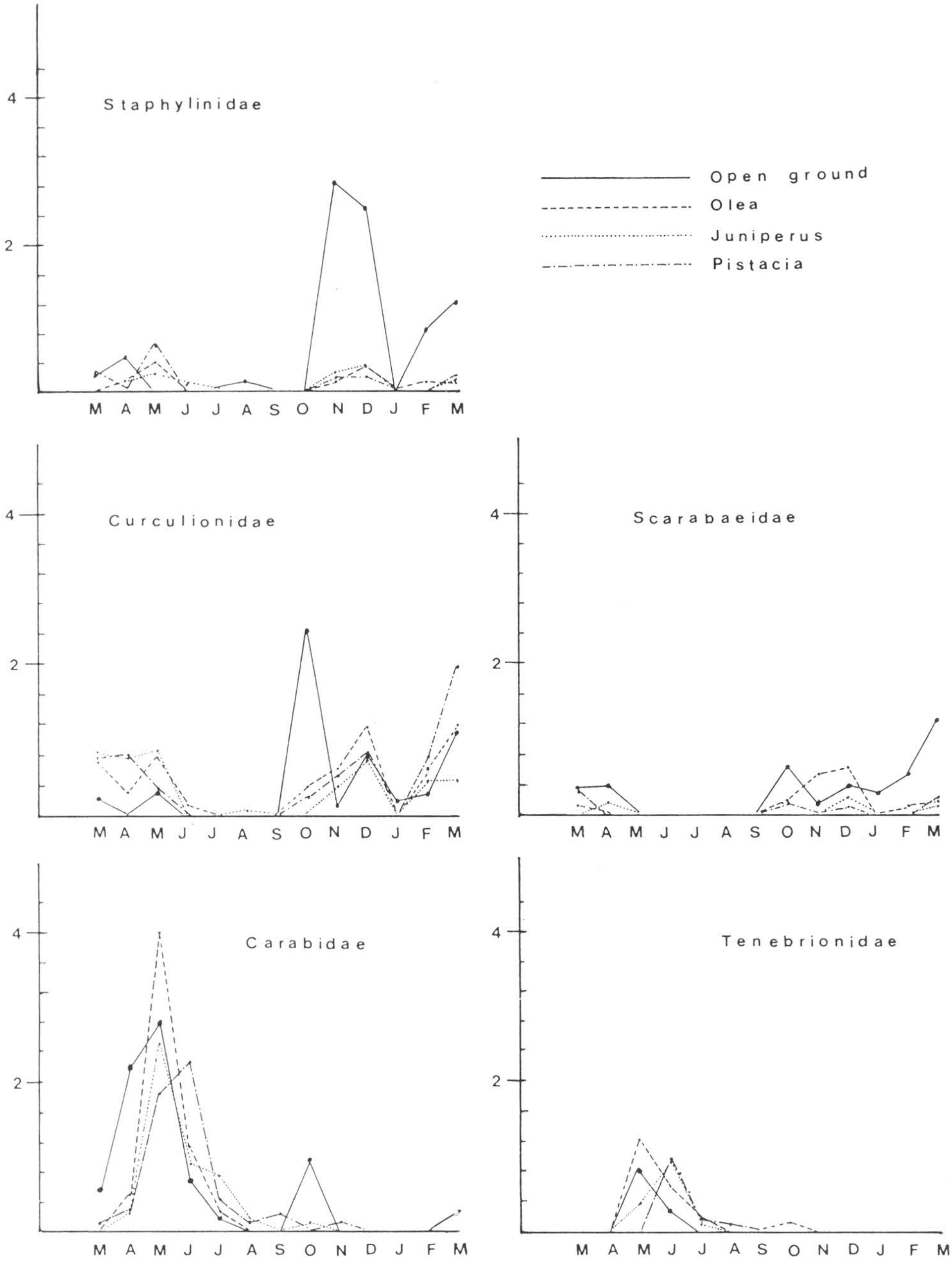

Fig. 2. Annual variation of activity of the families (x-axis: months, y-axis: no of ind./trap/month).

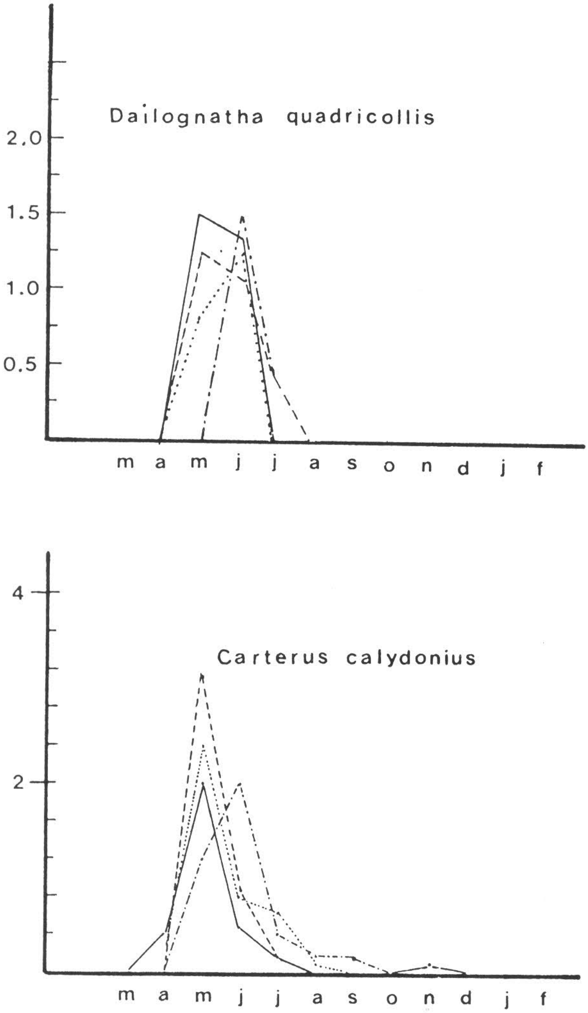

Fig. 3. Annual variation of *D. quadricollis* and *C. calydonius* activity (x-axis: months, y-axis: no of ind./trap/month).

4.2. Seasonal variation

The quantitative results show one period of high densities from December to March and one period of low densities from April to October (fig. 1). This is consistent with the results obtained with the total number of soil arthropods (KARAMAOUNA *et al.*, 1991). Most abundant Coleoptera in the quantitative samples are Curculionidae and especially *Otiorhynchus* which follows the general rule.

As it appears in fig. 4, the greatest number of individuals caught in traps occurred during spring and in the middle to late autumn. This general trend is expected since these two periods offer the most mild climate, not exceedingly high or low temperatures and a sufficient level of humidity.

In particular, Carabidae have a high number of individuals in May. The two most dominant species during this period are *C. calydonius* and *A. subquadratus*. A second peak

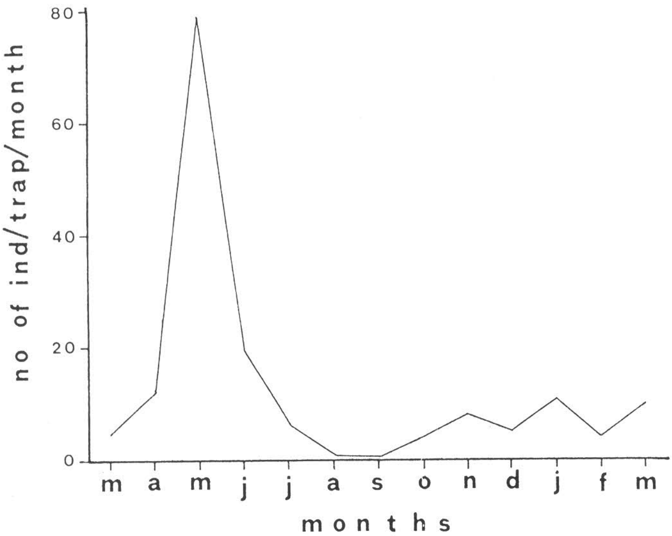

Fig. 4. Annual variation of activity of all Coleoptera.

in October is caused by the presence of only the second species. It must be noted that these two species constituted 86% of the total number of Carabidae. *C. calydonius* is more thermophilous and appears between April and September, while *A. subquadratus* appears from March to June and in October.

Tenebrionidae appeared to be active during a longer period in spring between May and June. The dominant species here was *D. quadricollis*. Unlike Carabidae, this family did not show a significant peak during the autumn. Of the dominant genera, *Helops* is the most thermophilous.

Curculionidae had a long period of activity both in spring and in the autumn. Their highest density occurred between October and December. These ground living Curculionidae like *Brachycerus* and *Otiorhynchus* seem to prefer the fresh leaves of new plants that appear after the summer drought.

Scarabaeidae had two totally different peaks. The first occurred during early spring and was caused by high populations of *E. hirta* and *T. fossor*, mainly the former. *E. hirta* is a flower pollinator and therefore it is associated with the major flowering season. *T. fossor* is coprophagous and its high activity during spring can be explained by the increased number of goats that are led to graze the fresh leaves of spring at the study area. The second peak of Scarabaeidae occurs in late autumn. The October samples contain almost exclusively *G. intermedius*, another coprophagous species that takes advantage of the presence of goats grazing the new autumn leaves. The November and December samples contain high numbers of both *G. intermedius* and *T. fossor*.

Staphylinidae have a long but low activity during spring and apear in high numbers in November and December. The samples consist almost exclusively of one genus, *Oxytelus*.

Of particular interest was the high population number of Melyridae *(D. graminicola)* and Anthicidae *(Anthicus sp.)* during May and their almost total absence during the rest of the year. This can be explained by the preference of these species for flowers.

The same is true of Ptinidae which do not reach such high numbers as the other families. Of the other families, mention must be made of Histeridae, in which the genus *Platysoma* appears almost exclusively during summer and Meloidae and Dermestidae with a somewhat larger number in May and June.

Looking at the temporal distribution of all the dominant genera, five groups can be distinguished (fig. 5). One appears both in spring and autumn from March till June and

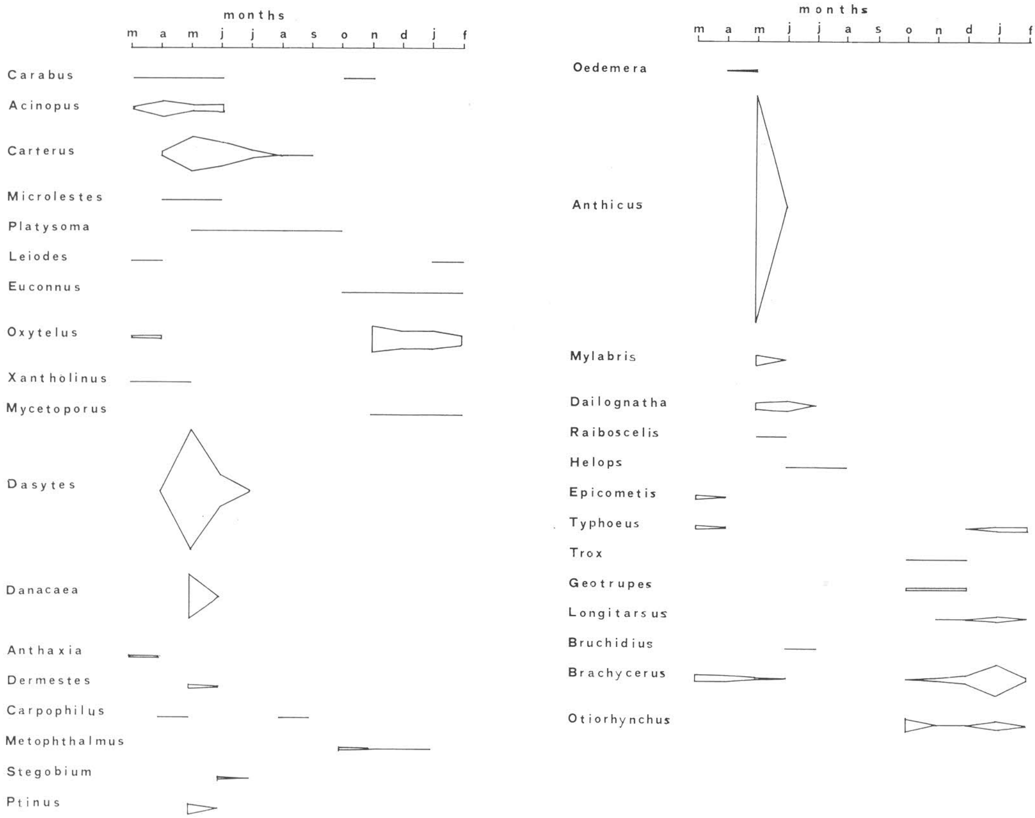

Fig. 5. Annual variation of activity and phenology of dominant genera.

from October till November. It contains *Carabus*, *Acinopus* and *Raiboscelis*. The second group appears only in spring from March till June. It contains *Anthaxia*, *Epicometis*, *Microlestes*, *Dasytes*, *Danacaea*, *Dermestes*, *Ptinus*, *Anthicus*, *Mylabris*, *Dailognatha* and *Oedemera*. The third group apears only in the autumn and early winter from October till February. It contains *Euconnus*, *Mycetoporus*, *Trox* and *Geotrupes*. The fourth group appears from the autumn till spring and contains *Leiodes*, *Oxytelus*, *Xantholinus*, *Typhoeus*, *Brachycerus*, *Otiorhynchus*, *Metophthalmus* and *Longitarsus*. Finally, the fifth group appears mainly during the summer and contains *Carterus*, *Platysoma*, *Helops*, *Bruchidius* and *Stegobium*.

5. Conclusions

The first thing that has to be pointed out as one looks at the ground fauna of mediterranean insular ecosystems in general, is the lack of detailed information and published results. Especially the surface living fauna (epigaion) appears sporadically and fragmentarily in works that deals with the soil fauna. Most such works treat Coleoptera as a group and do not analyse them further, although they are one of the most numerous in terms of species and ecological roles. In a more detailed work, SAIZ (1977) compared the ground fauna of Coleoptera in Chile and California. In both regions, four families are dominant: Carabidae. Curculionidae, Staphylinidae and Tenebrionidae. These results are comparable to our own. It is also impossible to analyse the insular character of the Coleopteran fauna of our study area since there are no similar studies on mainland Greece.

Our mediterranean-type ecosystem can however be compared with other types of ecosystems such as temperate coniferous and deciduous forests. Such ecosystems were recently studied (TRIHAS, 1985) on Mount Avala near Belgrade in Yugoslavia. Using the same methods – pitfall trapping – some characteristic differences are clearly evident. For example the Carabidae (with *Abax carinatus* as the dominant species in both forests) of the coniferous forest had a very similar activity with the mediterranean ecosystem from May to October. However, the Carabidae of the deciduous forest had lower activity in the autumn. It is possible that the increase in activity after the summer drought in mediterranean ecosystems is not present in deciduous forests because climatic conditions are more constant and the activity is more spread throughout the year.

Staphylinidae show a totally different activity pattern in the autumn. In the temperate forests they reach a peak as early as October. In our study area however, October is still quite warm and Staphylinidae appear later, between November and December.

The Tenebrionidae and Scarabaeidae are more thermophilous and xerophilous families showing maximum diversity and population density in the tropics. It is not surprising therefore that they are more frequent in our study area than in the temperate forests. Tenebrionidae however, are not as dominant in Naxos as in California. The ecosystem under study is more similar as far as Tenebrionidae is concerned, to the Chilean mattoral than to the Californian chaparral where this family represents 90% of the biomass of the ground beetles (SAIZ, 1977).

Ground living Curculionidae are also very rare in temperate forests. Most of those falling into traps drop from the branches of the trees and are not associated with the ground.

In general, the seasonal peaks of activity for Coleoptera as a group in the study area seem to agree with other works on the meso- and macro-fauna of the mediterranean shrublands (MARCUZZI, 1968). Peaks of activity always appear in spring and/or autumn and are at a minimum during the summer. This is a general characteristic of semi-arid and subhumid regions (DI CASTRI, 1973).

The observed seasonal migration between microhabitats corroborates the hypothesis of interhabitat turnover towards more humid areas which was shown to exist in mediterranean ecosystems of Chile (DI CASTRI, 1973).

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Synopsis: *Original scientific paper*

TRIHAS, A., & A. LEGAKIS, 1991. Phenology and patterns of activity of ground Coleoptera in an insular Mediterranean ecosystem (Cyclades, Greece). Pedobiologia **35**, 327–335.

The fauna of ground Coleoptera of an insular mediterranean ecosystem of Greece was studied quantitatively and qualitatively over a period of one year. Sixty six species were identified. Dominant families were Carabidae, Staphylinidae, Tenebrionidae, Scarabaeidae and Curculionidae. The variations of climatic conditions of the area cause a migration of many species from one microhabitat to another. In general, litter under trees is prefered. The highest population densities are observed in winter and early spring but activity is more pronounced in spring and early summer. Five groups of species can be distinguished according to their phenology.
Keywords: Mediterranean ecosystem, Coleoptera, pitfall traps, migration activity, abundance.

Address of the corresponding author: Dr. A. LEGAKIS, Department of Biology, University of Crete, Iraklion, GR-71409, Greece.