

BIOLOGY, POPULATION DYNAMICS AND ZOOGEOGRAPHY OF SOME CAVERNICOLOUS CARABID BEETLES (INSECTA, COLEOPTERA) - A PROPOSAL FOR A BIOSPELEOLOGICAL RESEARCH IN GREECE

By

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ABSTRACT

Biospeleological ecological investigations in Greece are very few; the cave fauna has been studied mostly from systematical and biogeographical point of view. Therefore, comprehensive research projects including basic research as well as site surveys and evaluations for the monitoring and management are of great interest. In this context a proposal for a long-term investigation on cavernicolous carabids (Insecta, Coleoptera) is presented. Combining various methods of biological research, ranging from zoogeographical distribution and systematics to biology, population ecology and genetics, we intend to realize a detailed research project on the *Laemostenus*-genus (subgenus *Actenipus*) as a good example of such complex studies on insects.

Using the same methodology like in a research project on *Laemostenus schreibersi* (subgenus *Antisphodrus*) living in the Eastern Alps (Austria), an equivalent comparison between two eucavernicol subspecies can be made: *Laemostenus schreibersi* - living in a region affected by glaciation periods and *Laemostenus vignai* located in the Mediteranean area. Special attention will be accorded to the differences in biology, behaviour and population dynamics. Problems which are to be considered concern the factors which have determined the evolution to a cavernicolous life, the adaptive characters to this environment as well as the zoogeography of the species.

Greece is a country with one of the greatest number of caves in the world. Until now, more than 7,500 caves all over Greece are registered. A great part of them have been studied from touristical and scientific point of view (geology, paleontology, archaeology, climatology, anthropology, biology). They are part of the Greek national heritage and under legal protection by the state. Therefore, comprehensive site surveys and evaluations for their monitoring and management are of special interest.

Biospeleological research began in the middle of the 19th century, with the discovery of the first cavernicolous animal of Greece: the carabid beetle *Duvalius krueperi* (CASALE & GIACHINO, 1994). In more recent times biospeleologists investigated several caves of Greece on the continental parts as well as on the islands.

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The fauna of the Greek caves has been studied only sporadically and from a systematical and biogeographical point of view. Unfortunately, biospeleological long-term investigations have not been carried out. Another problem is that numerous caves of Greece are suffering from various uncontrolled human activities and it is very possible that a serious reduction in the biodiversity of the cave fauna will be effected before anything is known about the biology, ecology, genetics of the cavernicolous species and before any precaution and protection measures can be taken.

In the following a proposal for a comprehensive research project on cave beetles (Coleoptera, Carabidae) in Greece is presented. The study will be carried out in collaboration with Prof. LEGAKIS from the Zoological Museum, Department of Biology of the University of Athens.

Combining various methods of biological research, ranging from zoogeographical distribution and systematic, to biology, population ecology and genetics, we intend to realize a detailed research project on cavernicolous carabids. In this context we propose to investigate carabids beetles of the genus *Laemostenus* as a good example of such complex studies on insects (for a revision of the genus see CASALE, 1988).

Carabids of the *Laemostenus* group are in particular useful for investigations of evolutionary biology, because this genus includes species - each with subspecies - ranging from epigean to hypogean forms, which colonized the subterranean habitat independently from each other. Problems of research concern on the one hand the factors which have determined the evolution to a cavernicolous life and on the other hand the different adaptive characters to this particular environment.

For a better survey of the problems to be studied and the methods of investigation, I'll make a short presentation of a similar study on a species of *Laemostenus*: *Laemostenus (Antisphodrus) schreibersi* living in the "Eggerloch"-cave near Villach in Carinthia (Austria).

Laemostenus schreibersi is considered as an "eucavernicol" species (in the sense of VIGNA-TAGLIANTI, 1982), which inhabits caves and cave-like cavities, as well as the superficial underground compartments. The distribution area of this species covers the southern part of the Eastern Alps, from Northern Italy to Carinthia, Styria, Slovenia and Croatia (Fig. 1).

The investigations were carried out in the cave called "Eggerloch" near Villach (Austria), located at 565 m above sea-level in the triassic carbonates of the Villacher Alpe-mountains. The total length of the whole cave-system is 650 m and the vertical high amounts to 119 m. According to the topography of the cave, we distinguish the cave mouth region and four cave-compartments.

The investigations cover meanwhile a period of nine years: 1986 -1994 (13 seasons of investigation with a duration of 18 days to 2 months). A number of 35 traps were exposed along the cave gallery in which the beetles were baited with meat. The carabids were individually marked with notches in the elytra by a small drill and released again nearby the trap they were caught in.

By applying the mark-recapture method it was possible to estimate population size and to describe the different patterns of movement inside the cave. Other investigated aspects are concerned with: daily and seasonal activity, spatial distribution inside the different cave-compartments, longevity, sex-ratio, seasonality of breeding and

development, reproduction-rate. All the data obtained were tested for their significance on the base of the exact statistical methodology. Measurements of climatic parameters like temperature, relative humidity and ventilation complemented the biological investigations (for a detailed description of methods see RUSDEA, 1992). A part of the results of this longterm investigation has been already published (RUSDEA, 1994; 1995).

Using this methodology we have found out that *Laemostenus schreibersi* revealed a seasonal periodicity of activity. During winter months no animals were caught inside the cave. The first beetles were found in the pitfalls at the end of May. They were caught regularly during summer and autumn; at the end of October their number decreased. The beetles seem to leave the cave and retire into the surrounding fissure-system, where they mix with other beetles of the (meta)population. Obviously, this behaviour is an adaptation to a seasonal change of climatic factors: appearance and disappearance of the beetles inside the cave correspond very well to the change of ventilation direction in April/May and October/November.

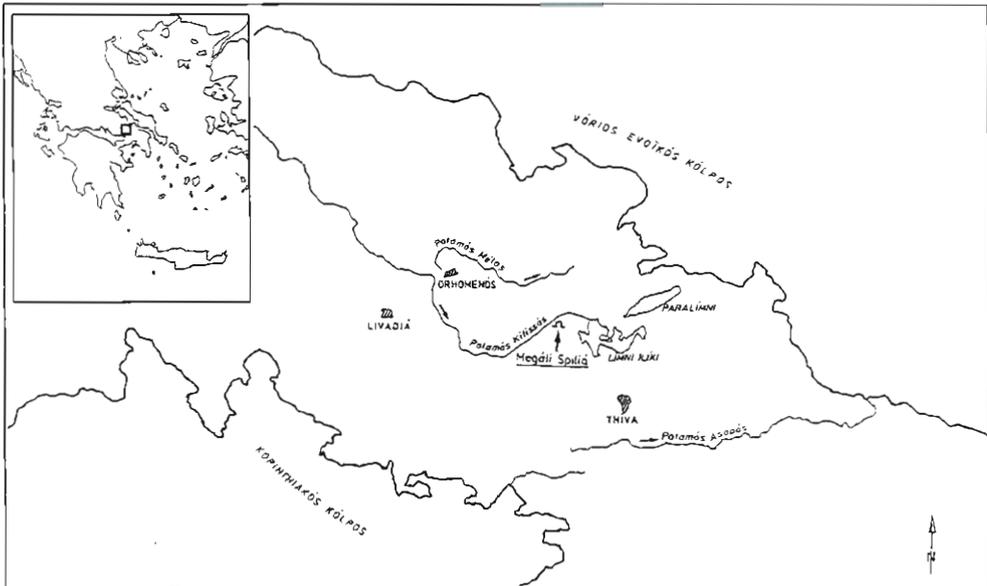
Spatial distribution inside the cave is not uniform. In the cave mouth region (the first 20 m from the entrance) no carabids were caught. The beetles concentrate in the anterior cave-compartments I and II (20 - 90 m from the entrance). More rarely beetles were found in the posterior compartments III and IV (95 - 331 m from the cave entrance). Migrations from one compartment to the other were observed.

During the investigation period from 1986-1994 a total number of 533 carabids was individually marked. Population size is small but rather constant: between 50 and 110 individuals.

The probability of staying in the explored cave-area was rather high. From the total number of 1422 captures 63 % represent recaptures. 64 % of the beetles were captured more than once, one beetle was caught for 18 times. The existence of more compartments nearby inhabited by the beetles, but inaccessible for man, is also proved by the fact that some beetles were recaptured after they had been missing inside the cave during one or more seasons. Some individuals "skip" usually one or two seasons; two beetles were missed for 5 consecutive seasons. Obviously, some individuals survive for a long period of time (from 5 to 9 seasons).

Concerning the age structure of the population living in the Eggerloch, larvae of *Laemostenus schreibersi* were captured only in the autumn: in August, September and October. The teneral beetles (which had not completed postecdysial ripening) were not equally distributed over the year: in the spring seasons their portion is very small (1 % - 3 %) comparing with the autumn seasons (15 % - 46 %). From the seasonal occurrence of larvae and teneral adults it can be concluded, that the population of *Laemostenus schreibersi* from the Eggerloch exhibits a seasonality of reproduction and development. It seems, that the beetles breed during spring/early-summer (spring-breeder).

According to the first capture and to the several recaptures during the seasons of investigation, it was possible to estimate the age of the beetles. Life-span of *Laemostenus schreibersi* in its natural habitat can be very large. Some beetles attained the remarkable age of 6,5 to 7 years. The survival time of adult beetles throughout some years is known from several carabid species, but such an extreme longevity has not been reported before.



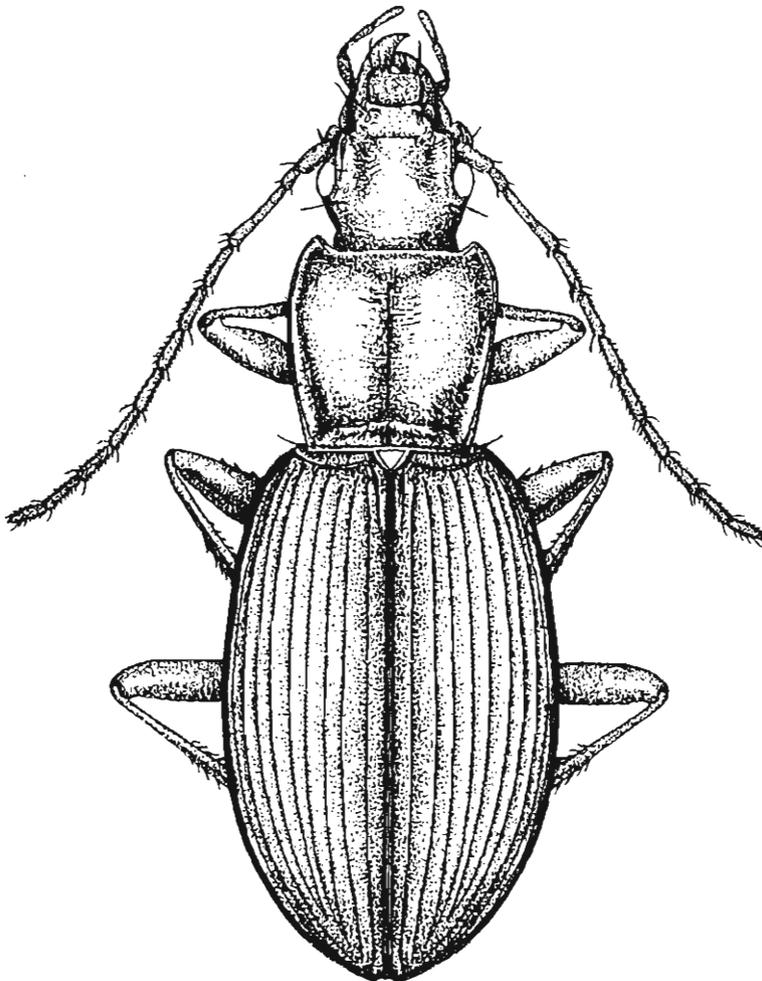
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Fig. 1: Geographical distribution of some *Laemostenus*-species:

- subgenus *Antispodrus*: 1 = *Laemostenus schreibersi*;
- subgenus *Actenipus*: 2 = *Laemostenus vignai*;
- 3 = *Laemostenus peloponnesiacus*;
- 4 = *Laemostenus krueperi*;
- 5 = *Laemostenus thessalicus*;
- 6 = *Laemostenus plasoni* (after CASALE, 1988).

Fig. 2: *Laemostenus (Actenipus) vignai* from a cave near Orhomenos; size: 1,7 - 1,9 cm (after CASALE, 1988).

Fig. 3: Area of the former Copaide Lake with position of the Megali Spilia (Beotia, Central Greece) (after BERTOLANI & ROSSI, 1983).



Sex-ratio demonstrates a predominance of the females (58 % females comparing to 42 % males). The probability of the recapture was identical for females and males; that means the sexes did not differ with respect to activity behaviour.

In conclusion: the population of *Laemostenus schreibersi* living in the Eggerloch-cave in Austria is part of a larger metapopulation, which comprises also groups living in the inaccessible compartments of the fissure-system of the massif. The number of the trapped animals in the Eggerloch is rather constant. The size of the population seems to be relatively stable. Individual longevity could be a factor which stabilises the individual number in the Eggerloch and also the number of the larger metapopulation.

In the proposed research project in Greece we intend to realize a similar investigation on another related subspecies of the *Laemostenus*-genus localized in Greece. From Greece there are reported five species of *Laemostenus* belonging to the subgenus *Actenipus* (CASALE, 1988). Some of them are epigeic species living in the woodlands, other species inhabit the superficial underground compartment beneath embedded stones in the mountains as well as caves - being considered as orophile, troglophile respectively eucavernicol species. Within the mentioned subgenus four species belong to the Aegean group: *Laemostenus krueperi*, *L. vignai*, *L. peloponnesiacus*, *L. thessalicus* and one specie, *Laemostenus plasoni* has a north-Aegean distribution (Fig. 1).

The exact zoogeographical range of this genus in Greece will be studied using baited pitfalls and by hand-collecting. Special attention will be accorded to the vicariant sister species *Laemostenus krueperi* and *Laemostenus vignai*. Biology and population dynamics of one eucavernicol species will be studied in detail - for example *Laemostenus vignai* (Fig. 2), known from a cave near Orchomenos (Beotia). This cave called "Megali Spilia" is located on the southern part of the former Copaide Lake (Fig. 3) at 100 m above sea-level. A description of the cave is given by BERTOLANI (BERTOLANI & ROSSI, 1983), who investigated the caves of this area during 5 expeditions (1969 - 1975). The total length of the cave is 1370 m. In our research, the methods of investigation will be the same like those used in the project on *Laemostenus schreibersi* in the cave of the Eastern Alps. During a period of at least two years, field observations will cover several seasons of investigation inside the cave. The beetles will be trapped in pitfalls and individually marked. The main aspects of the research will deal with: seasonal and spatial distribution inside the cave, patterns of locomotion activity, population-size, sex-ratio, longevity and mortality, seasonality of reproduction. At the same time measurements of the climatic factors (like temperature, relative humidity, cave-ventilation) and their seasonal changes will be carried out. In this manner an equivalent comparison between two species of the same genus can be made: one living in a region affected by glaciation periods (*Laemostenus schreibersi*) and the other located in the Mediterranean area (*Laemostenus vignai*). The biological study will be complemented with the evidence of other faunistic genera and species in the mentioned cave and with the formulation of proposals for its management.

The importance of the proposed project consists in following: using various methods of investigation for different aspects of biological study (biogeography, population dynamics, ecology) this proposed research project represents an essential contribution to basic research not only in Greece, but to biospeleology in general. Some the methods used may be applied, both for research and for monitoring and management of the other caves in Greece. At the same time, the collaboration in

fundamental research science between the Member States of the European Union will be promoted.

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