THE PSEUDOSCORPIONS OF DOBROGEA: FROM ORIGINS TO THE PRESENT AND PERSPECTIVES

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BALKAN FRAME

The Mediterranean region is the vast intercontinental zone comprising the Mediterranean Sea which separates two great blocks of the Ancient World, the Eurasiatic and the Indoafrican, and is situated at the meeting-point of the two climatic and biogeographic zones. There are many particular zones which distinguished the Mediterranean region from the continental masses surrounding it. First of all, the zone contains a great mass of mesozoic sediments accumulated in the depression of the ancient Tethys and where the calcareous sediments largely predominate. It is the zone of the great Alpine Orogeny which gave birth to the mountain chains encircling the Inner Sea: The Pyrenees, the Alps, the Carpathians, the Balkans, the Caucasus at the north; the Riff and the Atlas, the Apennines and the Dinaro-Tauric Arc at the south. It has therefore been an unstable and disturbed zone from remote ages up to our time. Its geological history is full of varied and violent events which followed one another without interruption, especially during the Tertiary, forming a tormented relief full of contrasts, with a great variety of morphological and architectural shapes. The Mediterranean is a zone of great faultings. It is due to these faultings also that the Mediterranean relief is so broken, with the general configuration of the coasts extremely chiselled in parts, and with a high degree of intimate interpenetration of sea and land such as is rarely witressed elsewhere. To this should be added the effect of erosion which has scooped out deep furrows, sculptured the protrusions and is manifesting itself, on calcareous ground, also in the special forms of the karstic relief.

Situated in the eastern part of the Mediterranean region and occupying the area between the Adriatic Sea at the west and the Black Sea at the east, the Balkan Peninsula faces Asia Minor, with which it formed, till in the Pleistocene, an uninterrupted continental mass (ancient Aegeis). Nowhere else in the Mediterranean region is the relief of the land more complicated than in the Balkan Peninsula. Several great geotectonic units exist there: first, the great range of Rhodopes mountains should be distinguished as the ancient crystalline nucleus of the Hercynian age. This resistant nucleus of the Peninsula, formed mainly of crystalline schists with intrusions of eruptive rocks, has been greatly broken and disrupted by faultings in a number of depressions and isolated blocks some of which reach 2,900 m in altitude and represent the highest summits of the Peninsula. The

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Rhodopes range is succeeded in the north by the ancient Pannonian mass, deeply subsided and covered with the Neogene sea and lake deposits. On the south-east, the link of the Rhodopes range with the ancient block of Asia Minor is disrupted by the sinking of the Aegean Sea. All these ancient blocks, however, played the part of an intermediary mass during the Alpine evolution (CONSTANTINESCU, 1989; LASCU, 1989; MORARU *et al.*, 1966).

In fact, two branches of the great Alpine orogeny run around the ancient mass of the Peninsula: the Carpatho-Balkanic Arc in the east and north and the Dinarides in the west and south. The Balkan Penninsula thus constituted is an essentially mountainous land. The South Carpathians have advanced in great overthrusts toward the south beyond the Danube penetrating the Peninsula (East Serbia), to be continued to the east by the Balkan range. This mountain chain represents a backbone of the Peninsula and separates, on the north, the great Danubian platform. South of this mountain chain lies a long series of tectonic depressions.

With the exception of the great Pannonian Plain and the Danubian Platform in the north, the flat fround is limited especially to the numerous great tectonic depressions. They bear witness to violent tectonic activity, particularly during the Tertiary. In fact, the relief of the region is extremely broken by numerous fractures. A set of basins run along the central axis of the Peninsula, from the Danube in the north to the Aegean Sea in the South. This is the great longitudinal depression, now followed by the rivers Morava and Vardar (Axiós). Another longitudinal depression (ancient Thrace) is now followed by the river Marica.

The tormented relief influences the climate of the Peninsula, much more than its geographical position in South Europe. The Mediterranean climate is felt in the Greco-Aegen region and along the Adriatic coast as well as on the islands. The mountain ranges of the interior part prevent the further penetration of this climate. Most of the Peninsula is however largely open to the influence of the central European climate, while the eastern part is under the influence of the Pontic climate. The result is a series of climatic wheels, where the different climatic influences prevail.

ROMANIA: GEOGRAPHICAL TRAITS

The geological past of Romania was a tormented one; in its soil, very ancient fixed shields combine with more recent earths, formed by sedimentation in the pre-Tertiary and Tertiary Seas (as those in Northern Dobruja), with young lofty mountains, which form most of the Carpathian mountain ranges. The volcanic activity, in more remote or more recent times, which raised the chain of volcanoes in Eastern Transylvania and the isolated cones in the Western Mountains and elsewhere, as well as the erosion brought by the Quarternary glaciers, the gradual descent of the running waters into the valleys, the unloosing of the lateral gradients, the formation of the new (dry) land in the flood plains, and the advance of the Danube Delta towards the sea, have completed the details of the hilly regions and plains.

In the centre of Romania lies the Transylvanian Plateau. Encircling it are the arcs of the Eastern, Southern and Western Carpathians, which allow connecting gateways between the intra- and peri-Carpathian zone either along valleys, or through summit passes, a result of the tectonic breaking-ups and their subsequent moulding.

The Carpathian arc offers the most varied aspects, whose peculiar characteristics differentiate it both from the Alps and the Balkan mountains, in spite of being a part of the same Alpine (Dinaric-Carpathian-Balkan) system. The highest altitude reaches 2,500 m (the Bucegi, Făgăraş, Parîng, Retezat massifs). The maximum width of the Carpathian massif is 100 km; at the bend of this arc the width extends to 130 km.

The Eastern Carpathians stretch from the northern border down to the Prahova Valley. The southern slopes of this land mass are the Wooded Carpathians (The Maramureş). This part of the country also includes the depression of the Dornas, the Căliman Massif (where the volcanic eruptions were of great proportions), the Moldova mountains and the Braşov Depression.

The Southern Carpathians, situated between the Prahova Valley to the east, and the two tectonic corridors (Timiş-Cerna and Bistra-Strei) to the west and north-west are divided into four great groups: the Bucegi group, Piatra Craiului, the Făgăraş mountains, and the Parâng group. Geomorphologically, the region includes also: the Olt Valley, the Petroşani Depression, and the Retezat-Godeanu group of mountains and hills.

The Western Carpathians close the western side of the great Transylvanian depression – the largest part of the central sinking of the Carpathians. They stretch from the Danube up to the Barcău Valley being clearly separated from the Southern Carpathians by wide corridors, along which flow the Timiş, the Bistra and the Cerna and by the wide depression of the Haţeg Country. The Western Carpathians are thus constituted by the Banat Mts., by the Poiana Ruscă massif and by the Apuseni Mts.; the widely spread limestone produces extremely varied karst forms there.

Two main categories of relief may be differentiated within the hilly regions: the sub-Carpathians hills and the tableland hills. The first group encompasses: the sub-Carpathians from the Suceava to the Moldova rivers; those between the Moldova and the Trotuş rivers; then, the sub-Carpathians between the Trotuş and the Dâmboviţa rivers; and the Getic sub-Carpathians. The tableland territories are characterized by a relief generally less ruffled, with horizontal or slightly sloping layers of rocks, and only irregularly, displaying wide, difficultly discerned undulations. Among the tablelands, the largest are: the Transylvanian Plateau (inside the great depression of the Carpathian arc), the Someş Plateau in the north-west, the Moldavian and Dobrujan Plateaus in the east, and the Getic Plateau in the south.

The next region of the country relief is constituted by the plains and floodlands and is enclosed by the Prut River, the sea coast, the Danube and the ancient meandering zone of the Tisza River. The plains occupy a third of the Rumanian surface. The only uneven mass on the ground are wide valleys and the man-made tumuli or mounds, vestiges of the long since past times of the migratory peoples.

The climate of Romania is temperately continental with a transitional character.

DOBRUJA: AN OUTLOOK

The Dobruja Plateau comprises two distinct parts: the northern part, "root of some very old mountains, heavily eroded to the dimensions of mere hills, and the southern part, of lower altitude and more even relief".

Northern Dobruja, limited by the Danube on the north and by the line Topalu-Taşaul on the south, is a remainder of the Hercynian Mountains, folded in the primary period, reduced by the continuous action of external factors to be a true platform, whose maximum altitude hardly reaches 467 m at the Ţuţuiatul Peak of the Pricopan top. Thus, the retrographical complexity asserts itself in the intensely developed relief only through the loftier forms resulting from the weathering of the granites. Hard rocks (granite, limestone, schists) predominate, some being used as building stones.

The Tableland of Southern Dobruja is lower and from the viewpoint of the constitutive rocks is an integral part of the pre-Balkan Platform. The superficial geological formation (Sarmatian sediments, with predomination of limestone, and the covering layer of loess), tabularly arranged, account for the monotonous relief forms, for the canyon-like valleys, the depressions of the Negru Vodă Tableland, as well as for the cliffs of the Black Sea coast, or the steep bank of the Danube.

The mouths of the tributaries of the Danube widen to form depressions which harbour fluviatile lagoons (Oltine, Gârliţa, Mârleanu, Vederoasa, Limpezişu, Cochirleni, etc.). In general, the altitude of this tableland does not rise above 200 m.

Therefore, Southern Dobruja is a platform consisting of Archaic-Proterozoic metamorphic basement overlain by Paleozoic, Mesozoic and Tertiary sedimentary rocks. Following the end of the Proterozoic, the region underwent only vertical movements by slight west or eastward swinging, resulting in aproximately horizontal layers affected by large undulations and a system of fractures trending NW-SE. The last transgression is assigned to the Sarmatian, when the lumachelle limestone deposited in the brackish epicontinental sea covering the southern Dobruja. At the same time, the plutonic volcanic activity was intenified and was followed by the basement uplifting and the initiation of hydrothermal activity in Southern Dobruja.

By the end of the Miocene the sea receded definitely from Southern Dobruja leaving behind a vast calcareous plateau which linked the northern Dobrujan orogeny surrounded by water to the large African-Aegean-Pontic land. This configuration and the warm and wet climate have favoured the spreading in South Dobruja of fauna typical of the tropics. Such environmental condition pre vailed till the mid-Pontian, the entire Paratethys passed through the so-called Messinian effect. Subsequently to the draining of the Mediterranean Sea, the waters from the Paratethys basin flew westwards in order to compensate for its massive water loss which resulted in the division and limitation of the Paratethys.

According to HSÜ *et al.* (1977), the Black Sea level lowered by several hundred metres during several hundreds of thousands years. Consequently, Southern Dobruja (being, as a part of the epicontinental platform, freed from waters) extended more eastwards and lay suspended by at least several hundred of metres above the base level. This strong lack of equilibrium reactivated the relief energy along its platform. It is therefore assumed that rejuvenated streams had cut deep canyons into continental slope; although the slopes are now submerged, some of these canyons can still be seen in sea floor profiles.

It is not easy to analyse the origin and history of endemic forms of the Dobrujan subterranean habitats, because they represent an adaptive and selected fauna. The colonisation of the Dobruja underground milieux must have begun a long time ago, and have passed through successive stages during different geological times, together with the development of different karstic phenomena. It is therefore possible to distinguish in each faunistic group several historical lineages, their exact ages being difficult to establish (GUÉORGUIEV, 1977; ĆURČIĆ, 1988a). We have every reason to assume that the fauna evolved from the ancient Mediterranean fauna, its origin to be sought in the Balkan Peninsula. There the underground milieux have succeeded each other in a continuous manner up to the present time. More ancient caves disappeared, while new caves formed, thus favouring the survival of their fauna. The continuity of subterranean habitats has certainly played an outstanding part in the preservation of some ancient faunistic elements (FURON, 1950, 1959).

However, the large and rapid climatic subversion at the end of the Miocene epoch (ĆURČIĆ, 1988b), which brought aridity to the Mediterranean area, rendered it uninhabitable by humidity-dependent species. The Balkan Peninsula (Romania, Serbia, and Bulgaria) where sufficient moisture was preserved offered a shelter for the retreating and hygrophilic fauna. Among the main causes which have affected the history of soil and cave invertebrates in the Balkan Peninsula, one should emphasize the effects of the karstification process (ĆURČIĆ, 1988c). This process is very little known as yet; hence its interpretation must be more or less hypothetical. It is evident that the Balkan (and the Dobrujan) karst was not developed at one time; thus its colonization had to have occurred progressively (GAVRILOVIĆ, 1989; ĆURČIĆ *et al.*, 1997, 2001; HSÜ, 1977).

Table 1

List of pseudoscorpions inhabiting Dobruja, with their evolutionary status.
The junior author was kind enough to borrow to the senior author, for scientific investigations, a collection of pseudoscorpions both from Dobruja and other regions in Romania. A thorough study has yielded some 14 species new to science and a couple of (probably) new subgenera and genera; the results of this study are to be published in due time.
Georgescu & Capuşe (1996) are certainly wrong in their claim that the original label of the finding place of *N. biharicum* Beier (The Movile Cave) was probably incorrect. Due to the relevant information received from Dr. Serban Sarbu (otherwise the collector of all pseudoscorpions from the cave), the label is definitely correct

Genus and species	Status
CHTHONIIDAE	
Chthonius (Chthonius) decoui Georgescu & Capuşe	Endemic
Chthonius (Chthonius) ionicus (Beier)	Not endemic
Chthonius (Chthonius) monicae Boghean	Endemic
Chthonius (Chthonius) motasi Dumitrescu & Orghidan	Endemic
Chthonius (Epphiochthonius) scythicus Georgescu & Capuşe	Endemic
Chthonius (Ephippiochthonius) tetrachelatus (Preyssler)	Not endemic
Chthonius (Globochthonis) vandeli Dumitrescu & Orghidan	Endemic
NEOBISIIDAE	
Acanthocreagris callaticola (Dumitrescu & Orghidan)	Endemic
Neobisium biharicum Beier	Not endemic
Roncus ciobanmos Ćurčić, Poinar & Sarbu	Endemic
Roncus dragobete Ćurčić, Poinar & Sarbu	Endemic
ATEMNIDAE	
Atemnus politus (Simon)	Not endemic
CHEIRIDIIDAE	
Apocheiridium ferum (Simon)	Not endemic
CHELIFERIDAE	
Hysterochelifer meridianus (Koch)	Not endemic
CHERNETIDAE	
Allochernes sp. n. (Georgescu & Capuşe 1996)	Endemic ?
GARYPIDAE	
Larca lata (Hansen)	Not endemic

It is pertinent to note that faunal exchange between Dobrujan caves and those found elsewhere has been very limited, especially in the advanced phases of karstic evolution (HADŽI, 1941). This is due to their geographical position, and to the adaptation of their inhabitants to specific life conditions. Thus, cave invertebrates have evolved to compete successfully with new immigrants. However, the living conditions in caves must be considered as relative. These conditions have certainly changed during existence of the caves, but not in a manner to have provoked the disappearance of the majority of relicts. In addition, such changes have favoured the divergent differentiation of soil- and cave-inhabiting pseudoscorpions there.

FUTURE DIRECTIONS

In several areas of evolutionary ecology the study of cave animals can play increasingly important role. But to consider possibilities, some mention must be made about the direction evolutionary ecology is likely to take in the next several decades. A mature science of ecology will not have a thousand more or less unrelated models, each designed for a particular small group of organisms or habitats. On the other hand, models that have formal, logical structure (usually mathematical) should play a central role. That is, there are general patterns and processes that are important for a large subset of species, communities, and habitats, although clearly we do not know what these patterns and processes are (JUBERTHIE & DECU, 1994).

There is an equally important question that has received less attention. Are complex systems, such as the tropics or organisms with complex life histories, the appropriate situations in which to test the models? In retrospect, the answer is no (LEVINS, 1966). A more appropriate place to test many ecological models is in relatively simple situations like caves. To reiterate, cave communities are simple, allowing more detailed examination of interactions; there are many replicate communities and natural occurrences of species additions and removals; and at least some assumptions of the models, such as near-equilibrium conditions, are more likely to be satisfied in caves than in more complex systems. But there have been weaknesses in the use of caves as model systems. The first is the virtual absence of experimental manipulations that would provide stronger tests of the theory. The second is the absence of long-term studies on fluctuations in age, structure, population size, or species composition. These kinds of data are critical for the examination of underlying assumptions of equilibrium and steady state. The third weakness, which has been all too evident throughout different studies, is the lack of sufficient data to make a strong test of a hypothesis.

Suppose we take an optimistic look at the future and assume that the major ecological processes and patterns of cave faunas can be described and predicted by realistic, general models. Is there any reason to believe that this is also a step toward explaining more complex communities? We really do not know. Perhaps highly diverse communities such as those in the tropics have a completely different mode of organization, involving more mutualisms, higher-order interactions, and the like. But it seems equally, or even more, likely, that complex communities consist of relatively small subsets of strongly interacting species. Cave communities may then serve as a paradigm for a strongly interacting subset of species. First, long-term studies of population size and age structure could indicate the validity of some assumptions of the models and help sort out alternative explanations for the evolution of such phenomena as increased longevity and delayed reproduction. Second, perturbation experiments, especially species additions, could serve as a rigorous test of the species interaction models used. Third, monitoring of species turnover in caves could provide one of the best tests of island biogeography theory.

The population genetics side of evolutionary ecology presents a different picture. Both the experimental and the theoretical work in population genetics is more sophisticated, but also less interrelated, than it is in ecology. For topics on complex genetic systems, such as linkage disequilibrium and the evolution of recombination, the number of theoretical papers greatly exceeds the number of experimental papers. Although experimental and theoretical population genetics need to be reconnected, it is highly unlikely that work on cave populations will play any role in most of this (VANDEL, 1964).

However, work on cave organisms may be important in reforging the connection between population genetics and adaptation. Since the use of gel electrophoresis to detect genetic variation, modern population genetics has become increasingly unconcerned with the phenotype above the level of enzymes. In the meantime, the study of morphological and physiological adaptation has, with some notable exceptions, fallen into decline because it no longer appears "modern". Both fields would benefit from a closer connection. A genetic analysis, using either the classical techniques of quantitative genetics or the modern techniques of gel electrophoresis, could begin to address problems of how much genetic change accompanies morphological and physiological changes within the context of well-defined morphological variation. It is an unsatisfactory state of affairs when adaptation and genetic variation are treated as wholly separate – as they are in this study and in the work of nearly all cave biologists.

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In conclusion, the Balkan karst is inhabited by a great member of endemic and relict cave animals pertaining to the Paleo-Mediterranean, Laurasian, Paleo-Aegean, and South- or North-Aegean (or Proto-Balkan) phyletic series (FURON, 1950, 1959).

The major causes of the extraordinary variety of the troglobitic fauna of this region include: (i) the varied epigean fauna populating the Proto–Balkans in the remote past; (ii) continuity of continental phases in different areas of the Balkans; (iii) presence of mighty limestone beds and the subsequent evolution of the underground karst relief; (iv) succession of suitable climatic conditions favouring the colonization of subterranean habitats; and (v) divergent differentiation of different lower and higher taxa in numerous isolated niches underground.

Study of the cave inhabitants of the Balkan karst has offered further proof of their great ages and different origins. These species and genera represent the last vestiges of an old fauna, which found shelter in the underground domain of the Balkans and its adjoining regions.

Apart from this, it is apparent that specific aspects of geomorphological and climatic events in the Balkans, together with peculiarities in the historical development of the fauna there, caused the Peninsula to become the main center of dispersion and colonization of species and groups of species, *i.e.*, the main source for the revitalization and genesis of biological diversity, not just in the Mediterranean region, but throughout all of Southeast Europe (WALLWORK, 1972)..

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