ON AN ANIMAL ACTIVITY STRUCTURE PRODUCED BY THE *CICINDELA* (COLEOPTERA) IN THE SAND OF *THE SF. GHEORGHE BEACH (DANUBE DELTA)*

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Abstract. The paper described a gravitational collaps biogene sedimentary structure produced by the *Cicindela* (Coleoptera) in the sand of Sf. Gheorghe beach (Danube Delta). The collapse structure produced by *Cicindela* as an adult suggests the manifestation of a noncharacteristic sheltering behaviour.

Key words: Athropoda, insecta, *Cicindela*, collapse structure, neoichnology.

INTRODUCTION

Biogene sedimentary structures, both present ones and fossils produced generally by arthropodae and especially by insects have been recently one of the main subjects under study of the ichnology. This interest is due to the high potential of the structures produced by these animals to determine the environmental conditions in which the non-marine deposits came into being. Their use with this end is based on the following characteristics: their small size, the great number and the morphological and behaviouristic variety. The diversity of the traces produced by the terrestrial arthropodae and the fresh water ones reflects, according to Donovan (1994) the interaction organism-substratum (e.g. traces, galleries), organism-organism interaction (e.g. insects-plants: borings in wooden substratum, mines and worns in and on leaves) and the building of the structures as nests, by using the raw anorganic matter (=aedificichnia, *sensu* Bown & Ratcleffe, 1988).

Protescu (1912) was the first researcher to have made the first attempt in Romania of using the insects traces (*Gryllotalpa*) for explaining the formation of the hieroglyphs. Later on, Givulescu (1984) brought indubitable proofs of the insects-plants interaction describing and showing mines and worns in the leaves material in the Upper Miocene at Chiuzbaia (Maramures). In time, traces of isopodae (*Oniscoidichnus miocenicus* – Alexandrescu et al., 1986) and of amphipoda (*Talitrichnus panini* – Brustur & Alexandrescu, 1993) were described in the Lower Miocene molasse. Brustur et al. (in press) has recently discussed the possible paleobiogeographical and biostratigraphical implications of the present-day faecal pellets of *Trachelipus troglobius* (troglobiont isopoda) in the Movile Cave. Biogene structures (tunnels and burrows) produced by crustaceans are reported by Brustur (1995) in Eocene in Sotrile facies (*Ophiomorpha*) and in Tarcău Sandstone Formation (*Thalassinoides*). *Thalassinoides* were quoted by Neagu et al. (1997) in the Valanginian at Cernavodă. The presence of *Ophiomorpha* and *Thalassinoides* is reported by Brustur (in prep.) in the Cenomanian from Cerna (North Dobrogea), and *Thalassinoides* was identified in the Eocene of the Preluca Area, north of Poiana Blenchii and in the Upper Sarmatian from Buleta, west of Râmnicu Vâlcea (Brustur, in prep.). Except the taphonomic study owed to Marinescu (1973), the neoichnological researches on the arthropoda traces on the Romanian Black Sea coast belong to Brustur (1996).

GEOLOGICAL AND GEOMORPHOLOGICAL DATA

The geological and geomorphological evolution of the Danube Delta – the most recent Romanian land – represents the result of some depositional, biochemical and ecostructural processes having a very complex dynamic (Panin, 1997). The rhythm and intensity of these processes have been and are still controlled by the three distributaries – Chilia, Sulina and Sf.Gheorghe – through which the water and the sediments carried by the Danube flow into the Black Sea. The three distributaries are the ones to have determined Danube Delta formation and development in different stages along the last 12,000 years (Panin, 1997). The activity of the Sf. Gheorghe branch carried out in two stages, had a special importance in the structure and evolution of the Danube Delta. The first delta of the Danube was formed in the first stage (Sf.Gheorghe Delta I), especially due to to the littoral drift of the sediments brought from the Ukraine rivers mouths. Later on, the reactivation of the Sf.Gheorghe distributary, after cca. 5,000 years, when the main deltaic distributary was the Sulina branch, led to the formation of Sf.Gheorghe II Delta. Without getting into the details reported by

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Panin in the synthesis drawn up (1997), we mention that the Sf.Gheorghe II Delta is made up of two wings: a northern one, represented by the Saraturile accumulation formation and another southern one with littoral belts and belt sets whose material came from Sf.Gheorghe branch. These accumulation deposits have their correspondent in the divergent stuctures of the Sărăturile Formation in the norther wing, formed of the alluvial deposits coming from the Sulina delta. The most important littoral coordinates within the Sărăturile Formation are Câsla Vădanei, Sărăturile, Iepurilor and Sf. Gheorghe and in the south the belt sets Frasin, Plopilor, Palade and Flămânda as well as the littoral belt under formation of the Sakhalin Island (Fig.1).

The present day deposits of the Black Sea coast belong to two categories: fine quartz sands spread in the northern area (Sulina-Constanta) and calcareous-organogene sands, dominant in the south area, between Constanta and Vama Veche (Panin, 1967). The main morphological element in the northern area of the back-shore zone is represented by 2-3 beach terraces. Their structure results from the ratio between the granulometric and mineralogic nature of the marine-littoral deposits, the amplitude and the types of the oscillations of the sea level and of the waves characteristics (Panin, 1967). Except the marine deposits, along the beaches there are eolian sands accumulations, especially at the base of the microcliff. The sand brought about by wind and deposited on the wet beach is usually less compact due to the air among the grains. The release of the air with swash leads to the modification of the sand lamination (Panin, 1967).

OCCURRENCE AND DESCRIPTION

An extremely intersting trace, noticed in the summer of 1996 on the Sf. Gheorghe beach (Fig.1), belongs to the *Cicindela* coleopera (Fig.2A). This carnivorous coleopteran frequently met on the beaches of the Black Sea, is small in size (14-17 mm length) and it is very active.

The larva, very greedy, hides during the day in vertical pipes dug in the sand, where from it catches its prey (Panin, 1951). The adult leaves a very fine characteristic moving trace as a slope on the fine sand.

The particular type of trace produced by *Cicindela* is represented by a series of small depressions having a circular aspect (diameter = ca. 8 mm), one after the other on the slope of a fine eolian sand dune (Fig.2C).

The forming mechanism of this trace type can be explained like this (Fig. 2D): the animal makes its way, advancing very quickly in the microdune sand (Fig.2D, a) taking an underground route parallel with the slope, closely to the surface (Fig.2D, b). As it advances (Fig.2D, c), right behind it, the sand collapses gravitationally (Fig.2D, d), the phenomenon repeating all along the underground burrow length (Fig.2D, e). This type of trace, generated by this mechanism, may be attributed to a collapse structure, which has not been reported so far in the neoichnological literature. The fact that not all the entrances of the animal in the sand lead to the formation of this type of structure suggests the manifestation of a noncharactersitic sheltering behaviour.

DISCUSSION AND CONCLUSIONS

The traces of the nonmarine aquatic animals (invertebrates and vertebrates) are abundent and diverse from a morphological point of view. Many invertebrates build sheltering structures, produce resting traces or moving ones or feeding burrows (Chamberlain, 1975; Tevesz & McCall, 1982). Some of them, especially the insects, leave traces of the pupal chambers, of the growing up of the progenies or of hibernation and estivation. In the same way, many of the vertebrates leave the trace of the hibernation rooms and of nests. In the fresh water environments there live about 30 groups of invertebrates, from protozoa to mollusca, the most numerous traces which rank among the main ethotological chategories belonging to arthropoda and partially to mollusca (Chamberlain, 1975).

Referring strictly to the cicindelidae coleoptera, we should mention that these produce sheltering structures (the grubs) and pupal chambers for breeding the progenies and for hibernation/estivation (the adults) (Chamberlain, 1975). The larvas build a simple vertical tube in the wet lands on the river banks and lake shores (Shelford, 1937 in Chamberlain, 1975). The tubes, several mm in diameter, go as deep as 15 cm. Ratcliffe & Fagerstrom (1980) show that the larvas of *Cicindela* can dig curved burrows too, extending to a depth of 1.25 m.

The American *Cicindela* species dig their burrows in varied lands from dry sands; claysh soils to the muds at the edge of the rivers and salt or alkaline lakes (Wallis, 1961 in Chamberlain, 1975). The adults dig little deep burrows during the night or day, when the warmth becomes suffocating.

Entrances in such galleries made in the sand of the eolian microdunes probably made for a temporary shelter, can be frequently noticed on the beach at Sf. Gheorghe (Fig.2C). Chamberlain (1975) mentioned that the *Cicindela* larva tubes, together with the *Heterocerus* (Coleoptera) galleries and the *Gryllotalpa* or *Tridactylis* (Orthoptera) ones are characteristic to the traces along the river banks and lake shores. In Romania, Băcescu (1942) noticed on the sandy beach with

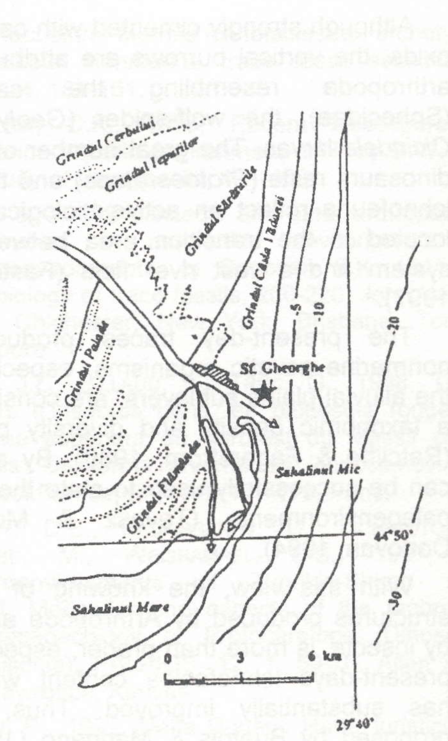

Fig. 1 The skech of the Sf. Gheorghe branch flowing area (Găstescu, 1992, simplified) locating the trace of *Cicindela* (asterisk).

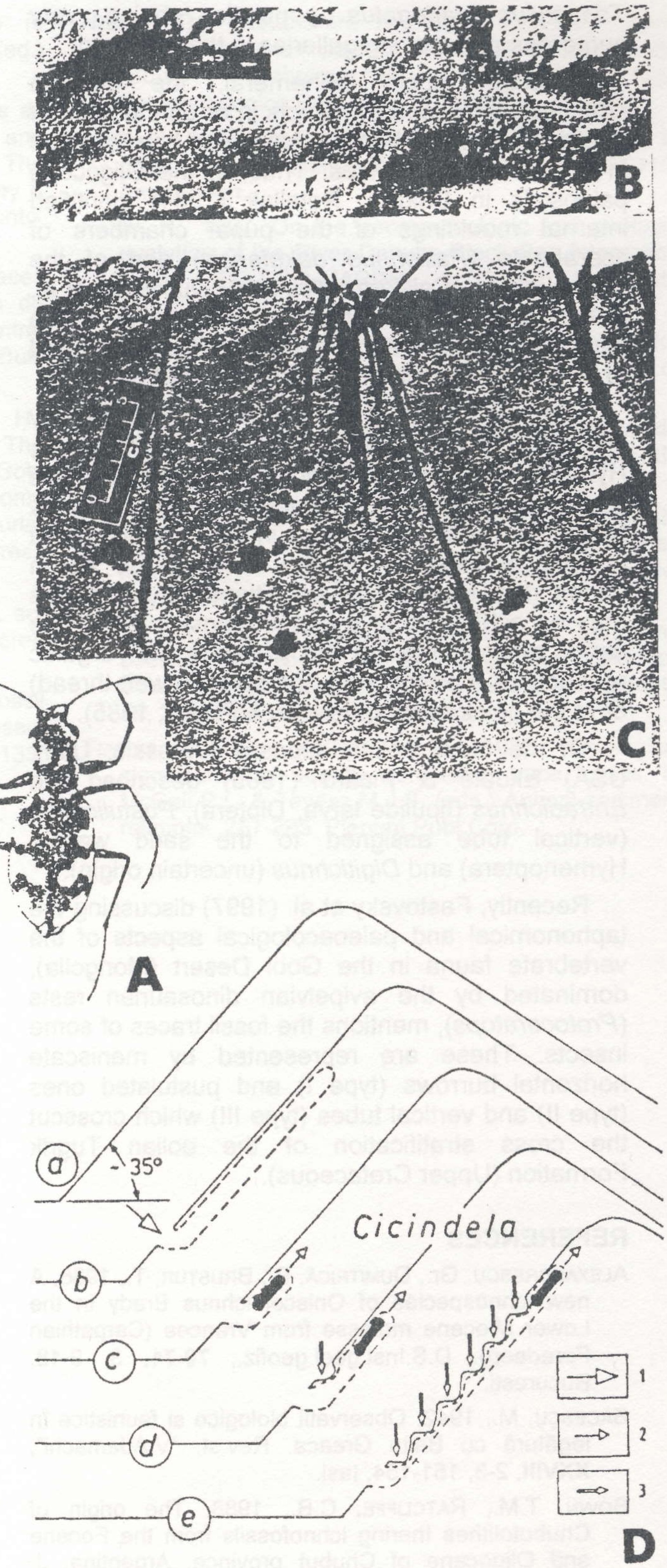

Fig. 2 Collapse structure produced by Cicindela (2A, *Cicindela hybrida*, according to Panin, 1951; 2B, locomotion trace produced by *Cicindela* on the Mamaia beach, according to Brustur, 1996; 2C, entrance holes and the collapse structure produced by *Cicindela*; 2D, schematic draft of the way the collapse structure takes place: 1, entrance hole; 2, moving sense; 3, gravitational collapse).

much mud of the former Greaca swamp a special arthropod fauna (myriapods, Coleoptera, Dermaptera, staphilinida, Orthoptera) the *Tridactylus variegatus* population being very numerous and making galleries in the wet sand.

Although mostly ephemeral, the biogene structures produced by insects in or on the sand of the beach, land and eolian dunes can be preserved in special circumstances. Thus, in the Oligocene paleosoils in Dakota, Retallak (1984) identified internal mouldings of the pupal chambers of scarabeida (*Pallichnus dakotensis*) and of the wasps' nests (*Celliforma ficoides*). Ducreaux et al. (1988) describe from the Upper Miocene of the central Massif in France, ovoidal traces considered to be bee larval cells (*Celliforma arvernensis*).

The fossil nests of the building wasps are very interesting (*Chubutolithes gaimanensis,* Hymenoptera, fam. Sphecidae) supposed to have come from Argentina's Paleogene, which Bown & Ratcliffe (1988) integrate in the aedificichnia ethological category. In the case of the eolian dunes, the fossilization conditions of the traces may be achievend in a certain consistancy of the sand, of consolidating the galleries with organic products of a proteic (e.g. the spider's web thread) or of the quick burying (Ekdale & Picard, 1985).

Of the fossil eolian deposits (Jurassic, Utah, USA) Ekdale & Picard (1985) described the *Entradichnus* (tipulide larva, Diptera), *Pustulichnus* (vertical tube assigned to the sand wasps, Hymenoptera) and *Digitichnus* (uncertain origin).

Recently, Fastovsky et al. (1997) discussing the taphonomical and paleoecological aspects of the vertebrate fauna in the Gobi Desert (Mongolia), dominated by the avipelvian dinosaurian rests (*Protoceratops*), mentions the fossil traces of some insects. These are represented by meniscate horizontal burrows (type I) and pustulated ones (type II) and vertical tubes (type III) which crosscut the cross stratification of the eolian Tugrik Formation (Upper Cretaceous).

Although strongly cimented with calcite and iron oxids, the vertical burrows are attributed to some arthropoda resembling the sand wasps (Sphecidae), the wolf-spider (*Geolycosa*) or to *Cicindela* larvas. The great number of herbivorous dinosaurs rests (*Protoceratops*) and the rich fossil ichnofauna reflect an active biological ecosystem located in the transition area between a desert system and a vast river field (Fastovsky et al., 1997).

The present-day traces produced by the nonmarine acvatic organisms, especially those in the alluvial plains sublayers, are considerable from a taxonomic density and diversity point of view (Ratcliffe & Fagerstrom, 1980). By analogy, they can be successfully used to state the depositional paleoenvironments (Tevesz & McCall, 1982; Donovan, 1994).

With this view, the knowing of the biogene structures produced by Arthropoda and especially by insects, is more than proper, especially that the present-days ichnofacies content with *Scoyenia* has substantially improved. Thus, the model proposed by Buatois & Mangano (1995) assigns the *Scoyenia*, *Termitichnus* and *Mermia* ichnofacies an equal hierarchical rank. In sedimentological terms, the ichnofacies with *Termitichnus* characterizes the terrestrial media, the one with *Scoyenia* is typical to the nonmarine terrestrial/aquatic transition realm and the *Mermia* ichnofacies show the proper nonmarine aquatic deposits.

Concluding, the collapse structure due to the *Cicindela* (Coleoptera) enriches the inventory of the arthropoda traces which are more and more he often used for completing the *Scoyenia, Termitichnus* and *Marmia* ichnofacies, which can be of real help for stating the environmental conditions in which the fossil nonmarine deposits were formed.

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