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A supplementary account on the echinoids from the Korytnica Basin (Middle Miocene; Holy Cross Mountains, Central Poland)

ABSTRACT: A new sifted material considerably supplements the knowledge of the Middle Miocene (Badanian) echinoids from the Korytnica Basin (Holy Cross Mountains, Central Poland). The occurrence of such genera as *Psammechinus*, *Scutella* (? *Parascutella*), *Clypeaster*, and *Echinolampas* is reported for the first time. Shortly discussed is the whole assemblage, which comprises 13 genera of seven orders, and thus is the richest among coeval assemblages occurring in the Miocene deposits of the Fore-Carpathian Depression.

INTRODUCTION

The aim of the present paper is to supplement a former report (MĄCZYŃSKA 1977) on the echinoids occurring in the Middle Miocene (Badenian) deposits of the Korytnica Basin, developed on the southern slopes of the Holy Cross Mountains, Central Poland (*see* BAŁUK & RADWAŃSKI 1977, 1979; ALI & MĄCZYŃSKA 1986). The new material was collected by sifting and sieving the Korytnica Clays. It consists primarily of isolated plates, fragments of tests, spines, and numerous elements of the Aristotle's lanterns, whereas more or less complete tests appear to be very scarce.

The investigated collection is housed at the Museum of the Earth (Polish Academy of Sciences) in Warsaw, and kept under the Catalogue Numbers *MZ VIII Ee 1238—1260*, and *1266—1290*.

DESCRIPTIVE ACCOUNT

In the investigated material, the order **Cidaroida** is represented by the genera *Cidaris*, *Cyathocidaris*, and *Plegiocidaris*. A more complex fragment, composed of several plates of two ambulacral rows (Pl. 1,

Fig. 4), belongs to *Cyathocidaris avenionensis* (DESMOULINS), the species recently revised and reported from the Miocene deposits of the Rhone Basin (PHILIPPE 1984). Ambulacral plates of this species (Pl. 1, Figs 5—7 and Pl. 2, Fig. 1) are very scarce, while its interambulacral plates (Pl. 1, Fig. 3) are quite common, as are also those (Pl. 1, Fig. 2) of *Plegiocidaris peroni* (COTTEAU). Spines of *Cidaris zeamais* SISMONDA are also common (Pl. 1, Fig. 1 and Pl. 8, Fig. 3).

The order **Diadematoida** is documented by the presence of its spines. Besides the formerly reported (MĄCZYŃSKA 1977) species *Centrostephanus calarensis* COTTEAU, *C. rhodanicus* (MAYER-EYMAR) has also been presently noted.

Of the order **Temnopleuroida,** special attention is paid to the genus *Arbacina,* which was formerly known (MĄCZYŃSKA 1977) to be represented only by fragmented tests of *A. monilis* (DESMAREST). In the newly collected material, a complete test (Pl. 2, Fig. 3) of *A. catenata* (DESOR) and specifically undeterminable spines, designated as *Arbacina* sp. (Pl. 2, Fig. 4), are recovered.

The order **Echinoida** is represented primarily by the genus *Psammechinus,* the presence of which was formerly unknown in the Korytnica Basin. The complete tests of *P. dubius* (L. AGASSIZ), one to a few millimeters in diameter (Pl. 2, Figs 6—7 and Pl. 3, Figs 1—7), belong to juvenile specimens. Fragments of larger (adult) tests are specifically unrecognizable, and they are herein reported (Pl. 2, Fig. 5) as *Psammechinus* sp. The juvenile specimens of *P. dubius* (L. AGASSIZ) are most similar to those reported from the Miocene of Spain (*see* MONTENAT & ROMAN 1970) and the Rhone Basin (*see* PHILIPPE 1984). This species has also been recently noted in the Middle Miocene (Badenian) deposits of Budapest area in Hungary (MIHÁLY 1985). Another genus of this order, *Parasalenia,* is represented by the species *P. fontannesi* COTTEAU which was formerly documented by complete tests (MĄCZYŃSKA 1977). In the newly collected material, only two juvenile specimens and one isolated ambulacral plate (Pl. 2, Fig. 2) have been found.

The order **Clypeasteroida** is represented by relatively rich material, especially of the genus *Echinocyamus.* The species *E. pusillus* (O. F. MÜLLER), known from the previous report (MĄCZYŃSKA 1977), occurs also in localities Karsy and Chomentów (Pl. 4, Figs 1—4). The genus *Clypeaster,* formerly unknown in the Korytnica Basin, is now documented by a massive fragment of a rather large test (Pl. 4, Fig. 6). The occurrence of a representative of the genus *Scutella* (or? *Parascutella)* is evidenced by a marginal part of the test (Pl. 3, Fig. 8).

The taxonomic assignement of the discussed scutellid fragment is unclear. According to DURHAM (1953, 1955), the genus *Parascutella,* established by him in 1953, occurred only in the Paratethys, while the genus *Scutella* was typical of the

Tethys, more precisely the western Mediterranean. Recently, MIHÁLY (1985) described two new species from the Middle Miocene (Badenian) deposits of Budapest area and attributed them to the genus *Scutella*. The identity or separateness of these two genera seems to be therefore an open question (*see also* ALI & MĄCZYŃSKA 1986).

The order **Cassiduloida** is represented by the genus *Echinolampas*, test fragments of which (Pl. 4, Fig. 5 and Pl. 5, Fig. 1) are fairly common in some samples.

Numerous, large test fragments belong to the order **Spatangoida** (Pl. 5, Fig. 2 and Pl. 6, Fig. 2) and seem to be diverse at the genus level. Only two tests which were formerly reported (MĄCZYŃSKA 1977) as *Schizaster ventiensis* LAMBERT, and another one illustrated by GUTOWSKI (1984, Pl. 3, Fig. 2a—2b) as *S. karreri* LAUBE can be determined to the generic and specific ranks. Fragmented apical systems, precisely the sets of united genital plates (Pl. 6, Fig. 1), spines of various kind (Pl. 7, Fig. 1), and isolated labral plates (Pl. 7, Figs 3—4) are also attributable to the Spatangoida.

ISOLATED LANTERN PLATES

The abundant material of isolated plates of the Aristotle's lanterns is very diverse (*see* Pl. 7, Fig. 2 and Pl. 8, Figs 1—2). Its taxonomic potential is very limited, and only some elements may be determined more or less precisely. As compared to the previous report (MĄCZYŃSKA 1977, p. 194 and Pl. 2), the demipyramids are mostly of non-cidaroid type, and only some are attributable to the Cidaridae; on the other hand, the rotules are largely identical with those of the Echinidae (*see* Pl. 8, Fig. 1). Recognized for the first time are the epiphyses (*see* Pl. 7, Fig. 2).

ECHINOID ASSEMBLAGE OF THE KORYTNICA BASIN

The assemblage of the echinoid taxa, representatives of which have once lived in the Korytnica Basin, may be regarded as relatively rich and diverse, although the majority of genera and species have occurred in very limited numbers (*see* KOWALEWSKI 1930, MĄCZYŃSKA 1977, GUTOWSKI 1984; *cf. also* ALI & MĄCZYŃSKA 1986). This is particularly true of large forms which are usually preserved in small fragments, sufficient for taxonomic identification at the generic rank — as exemplified by such forms as *Clypeaster* sp., *Scutella* (or? *Parascutella*) sp., *Echinolampas* sp., and *Spatangus* sp. — but too poor to recognize their specific attribution.

The present analysis of new materials allows to supplement the previous report (MĄCZYŃSKA 1977) and indicates that the echinoid assem-

Echinoid taxa occurring in the Middle Miocene (Badenian) deposits of the Korytnica Basin, as recognized in the present study (supplementary to the previous report, MĄCZYŃSKA 1977)

Taxonomy	Material
Order **Cidaroida** CLAUS, 1880 Family **Cidaridae** GRAY, 1825 Genus *Cidaris* LESKE, 1778	
1. *Cidaris desmoulinsi* SISMONDA, 1842 . .	Spines
2. *Cidaris zeamais* SISMONDA, 1842	Spines
Genus *Cyathocidaris* LAMBERT, 1910	
3. *Cyathocidaris avenionensis* (DESMOULINS, 1837)	Plates, test fragments
Genus *Plegiocidaris* POMEL, 1883	
4. *Plegiocidaris peroni* (COTTEAU, 1877) . .	Plates
Order **Diadematoida** DUNCAN, 1889 Family **Diadematidae** GRAY, 1855 Genus *Centrostephanus* PETERS, 1855	
5. *Centrostephanus calarensis* COTTEAU, 1905	Spines
6. *Centrostephanus rhodanicus* (MAYER-EYMAR, 1910)	Spines
Order **Temnopleuroida** MORTENSEN, 1942 Family **Temnopleuridae** A. AGASSIZ, 1872 Genus *Arbacina* POMEL, 1869	
7. *Arbacina monilis* (DESMAREST, 1822) . .	Tests, fragments
8. *Arbacina catenata* (DESOR, 1847)	Tests, fragments
9. *Arbacina* sp.	Spines
Order **Echinoida** CLAUS, 1876 Family **Echinidae** GRAY, 1825 Genus *Psammechinus* L. AGASSIZ & DESOR, 1846	
10. *Psammechinus dubius* (L. AGASSIZ, 1840)	Juvenile tests
Family **Parasaleniidae** MORTENSEN, 1903 Genus *Parasalenia* A. AGASSIZ, 1863	
11. *Parasalenia fontannesi* COTTEAU, 1888 . .	Tests, fragments
Order **Clypeasteroida** A. AGASSIZ, 1872 Family **Clypeasteridae** L. AGASSIZ, 1835 Genus *Clypeaster* LAMARCK, 1801	
12. *Clypeaster* sp.	Fragments of tests
Family **Fibulariidae** GRAY, 1855 Genus *Echinocyamus* van PHELSUM, 1774	
13. *Echinocyamus pusillus* (O. F. MÜLLER, 1776)	Tests
14. *Echinocyamus pseudopusillus* COTTEAU, 1895	Tests
15. *Echinocyamus circularis* CAPEDER, 1906	Tests
16. *Echinocyamus linearis* CAPEDER, 1906 . .	Tests
Family **Scutellidae** GRAY, 1825 Genus *Scutella* LAMARCK, 1816 (? *Parascutella* DURHAM, 1953)	
17. *Scutella (? Parascutella)* sp.	Marginal plates of tests
Order **Cassiduloida** CLAUS, 1880 Family **Echinolampadidae** GRAY, 1851 Genus *Echinolampas* GRAY, 1825	

18. *Echinolampas* sp.	Fragments of tests
Order **Spatangoida** CLAUS, 1876	
Family **Schizasteridae** LAMBERT, 1905	
Genus *Schizaster* L. AGASSIZ, 1836	
19. *Schizaster ventiensis* LAMBERT, 1906 . .	Two tests
20. *Schizaster karreri* LAUBE, 1871	One test
Family **Spatangidae** GRAY, 1825	
Genus *Spatangus* GRAY, 1825	
21. *Spatangus* sp.	Fragments of tests

blage from the Korytnica Basin comprises 13 genera of seven orders. The list of species contains 16 items plus 5 items specifically undeterminable.

The whole assemblage of the Korytnica echinoids is dominated by irregular forms, primarily those of the order Clypeasteroida (genera *Clypeaster, Echinocyamus, Scutella* or *Parascutella*). Fairly common are representatives of the order Spatangoida, particularly those of the family Spatangidae, evidenced by numerous fragments of tests, apical systems, and diverse but delicate spines. Among the regular forms, the commonest are the Cidaroida (genera *Cidaris, Cyathocidaris, Plegiocidaris*) and Echinoida, the latter represented mainly by juvenile individuals of the genera *Psammechinus* and *Parasalenia.*

COMPARATIVE REMARKS

The echinoid assemblage from the Korytnica Basin, rather closely resembles in its taxonomic composition, both at the genus and the species levels, the Miocene assemblages of the Rhone Basin (*see* LAMBERT 1910, 1912, 1913; PHILIPPE 1984), Sardinia (*see* CAPEDER 1906, LAMBERT 1907), Spain (*see* MONTENAT & ROMAN 1970), and Hungary (*see* VADÁSZ 1907, 1915; SZÖRÉNYI 1950; MIHÁLY 1985).

In the Middle Miocene (Badenian) deposits of the Fore-Carpathian Depression in Poland (*see* BAŁUK & RADWAŃSKI 1977, Text-fig. 1*B*), echinoids belong to relatively rare fossils, and only some lithofacies in a few localities have thus far yielded any materials (*see* ALI & MĄCZYŃSKA 1986, Text-fig. 3).

Along the southern slopes of the Holy Cross Mountains, echinoids are reported from the detrital red-algal/bryozoan limestones (*Leithakalk* type of the Vienna Basin) exposed at Pińczów and its environs, 15 kms south of Korytnica. Of a few genera (*Psammechinus, Clypeaster, Scutella*) noted therefrom by KOWALEWSKI (1930, p. 54), the occurrence

of the genus *Clypeaster* is worth special attention (*see* BAŁUK & RADWAŃSKI 1977, p. 115).

Along the south-eastern and eastern slopes of the Holy Cross Mountains, echinoids are encountered in some sandy facies where they may occur gregariously, in great numbers of individuals, as exemplified by *Psammechinus* sp. in the section exposed at Świniary (*see* RADWAŃSKI 1973, p. 395, Text-fig. 6*B* and Pls 6—7). The echinoid assemblage of this region is presently subject to investigation (MĄCZYŃSKA, *in press*).

In the Roztocze region (Lublin Upland) in eastern Poland, sandy deposits exposed in several localities (*see* ALI & MĄCZYŃSKA 1986, Text-fig. 3) yield a relatively abundant assemblage. It is dominated (*see* MĄCZYŃSKA 1979) by the genus *Spatangus*, however, and only some species of the genera *Arbacina*, *Psammechinus*, and *Echinocyamus* are in common with the Korytnica Basin.

A small assemblage of echinoids is known (GOŁĄB 1932) from the sandy and/or organodetrital (mostly red-algal) limestones exposed at Niechobrz near Rzeszów at the Carpathian margin (*see* ALI & MĄCZYŃSKA 1986, Text-fig. 3). This assemblage consists of four species of the genera *Psammechinus*, *Parasalenia*, *Clypeaster*, and *Echinolampas*, all of which are reported herein from the Korytnica Basin, although only one species, *Parasalenia fontannesi* COTTEAU, occurs in both these regions.

Another species, *Clypeaster scillae* DESMOULINS, may also be in common for the two discussed regions. At Niechobrz, it was first recorded by GOŁĄB (1932) and subsequently discussed by KALABIS (1949, pp. 35 and 61). One of the specimens collected by GOŁĄB (1932) has recently been offered to the Museum of the Earth and is now kept under the Catalogue Number *MZ VIII Ee 1265*. The investigated *Clypeaster* remains from the Korytnica Basin (*see* Pl. 4, Fig. 6) are specifically indeterminable, but their attribution to the discussed species can not be excluded.

The occurrences of the genus *Clypeaster* in the Middle Miocene (Badenian) deposits of the Fore-Carpathian Depression are of special interest because of the ecological requirements of this genus. The genus *Clypeaster*, typical primarily of modern tropical zones, has long been regarded as a good indicator of paleoclimate and hence commonly used in paleobiogeographical reconstructions (*see* KALABIS 1949, p. 61; BAŁUK & RADWAŃSKI 1977, p. 115). Its occurrence in the Korytnica Basin indicates the northernmost site of its distribution in the Miocene seas of Europe as well as the whole world (*see* KALABIS 1949, Text-fig. 16). The paleogeographical distribution of this genus through the Cenozoic era has recently been studied by ALI (1983), who documented its maximum spread in the Middle Miocene. On the other hand, PODDUBIUK & ROSE (1985) indicated an ecostratigraphic value of this genus in the whole Neogene sequence.

Another important genus is *Echinolampas*, herein first recorded from the Korytnica Basin. It was widely distributed (about 100 species) in the Miocene all over the world, the Indo-Pacific bioprovince including (*see* ROMAN 1965).

A recent comparative analysis of the Middle Miocene echinoid spectra from Poland and Egypt (ALI & MĄCZYŃSKA 1985, 1986) indicates that these assemblages, representative of the Paratethys and Tethys, respectively, are surprisingly similar to each other, being dominated by the same genera and closely related species.

In the intermediate areas, rich echinoid assemblages were studied by MARCOPOULOU-DIACANTONI (1974) from the Middle Miocene deposits of Greece. These assemblages, including such thermophilic forms as *Clypeaster* and *Echinolampas* as well as abundant *Schizaster*, are comparable to those of Yugoslavia, Italy, France, and Hungary, and all are indicative of tropical and/or subtropical climatic conditions.

All these data evidence good seaway connections at Middle Miocene time between the Paratethyan (Poland, Hungary, Yugoslavia) and Tethyan basins (Greece, Italy, Egypt). More distant connections of the Miocene echinoid faunas have recently been considered by ALI & CHERIF (1985) who recognized their further migrations from the Mediterranean to the Indian Ocean and Western Pacific regions.

To summarize, the investigated assemblage of echinoids from the Korytnica Basin comprises widely distributed forms. Their ecological requirements, however, indicate warmer seas, the tropical zone including, and well-marked affinities with the Indo-Pacific bioprovince. This assessment is consistent with the conclusions based on ecological and paleobiogeographical analysis of the associated fauna (*see* BAŁUK & RADWAŃSKI 1977, 1979), as recently documented *i. a.* by the studies on inarticulate brachiopods (RADWAŃSKA & RADWAŃSKI 1984) and bony fish otoliths (RADWAŃSKA 1984).

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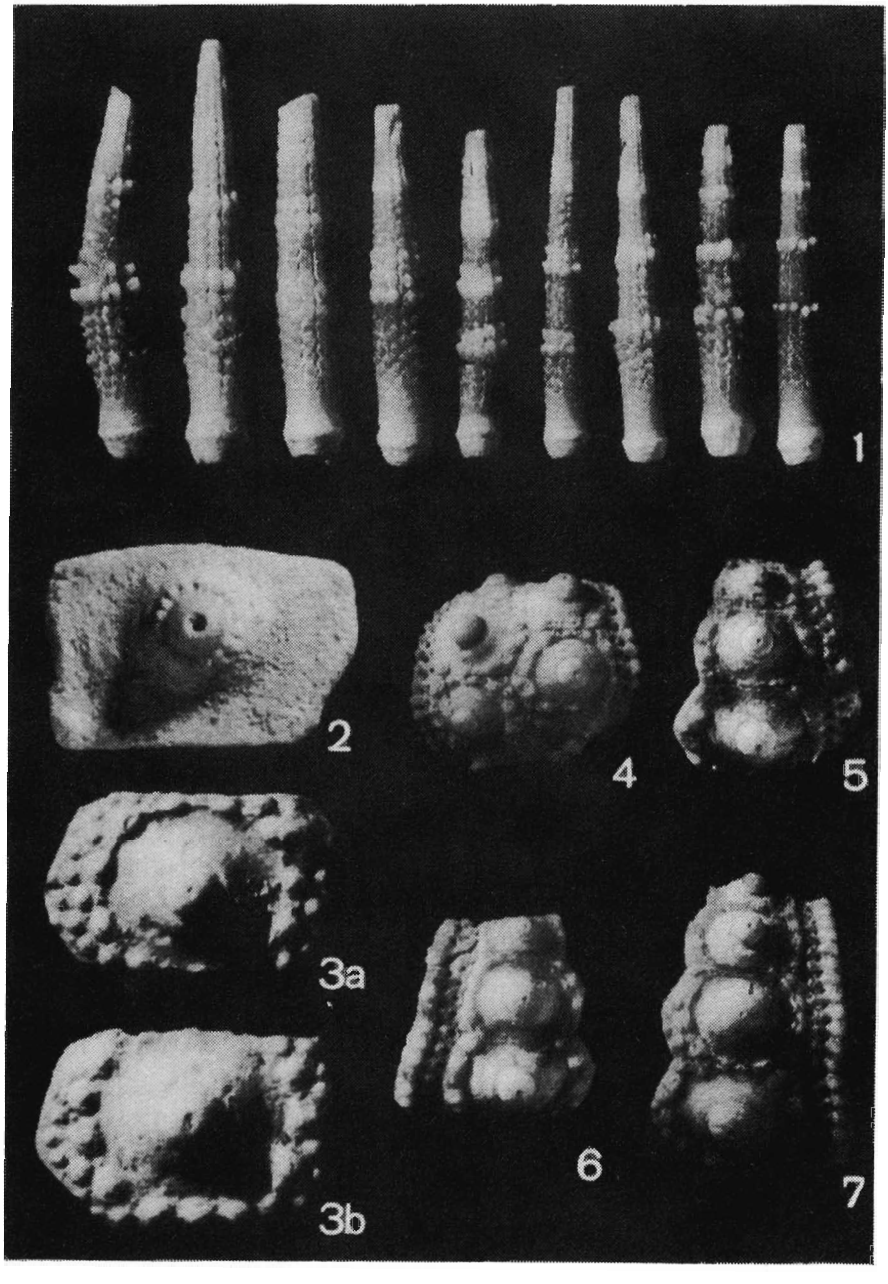
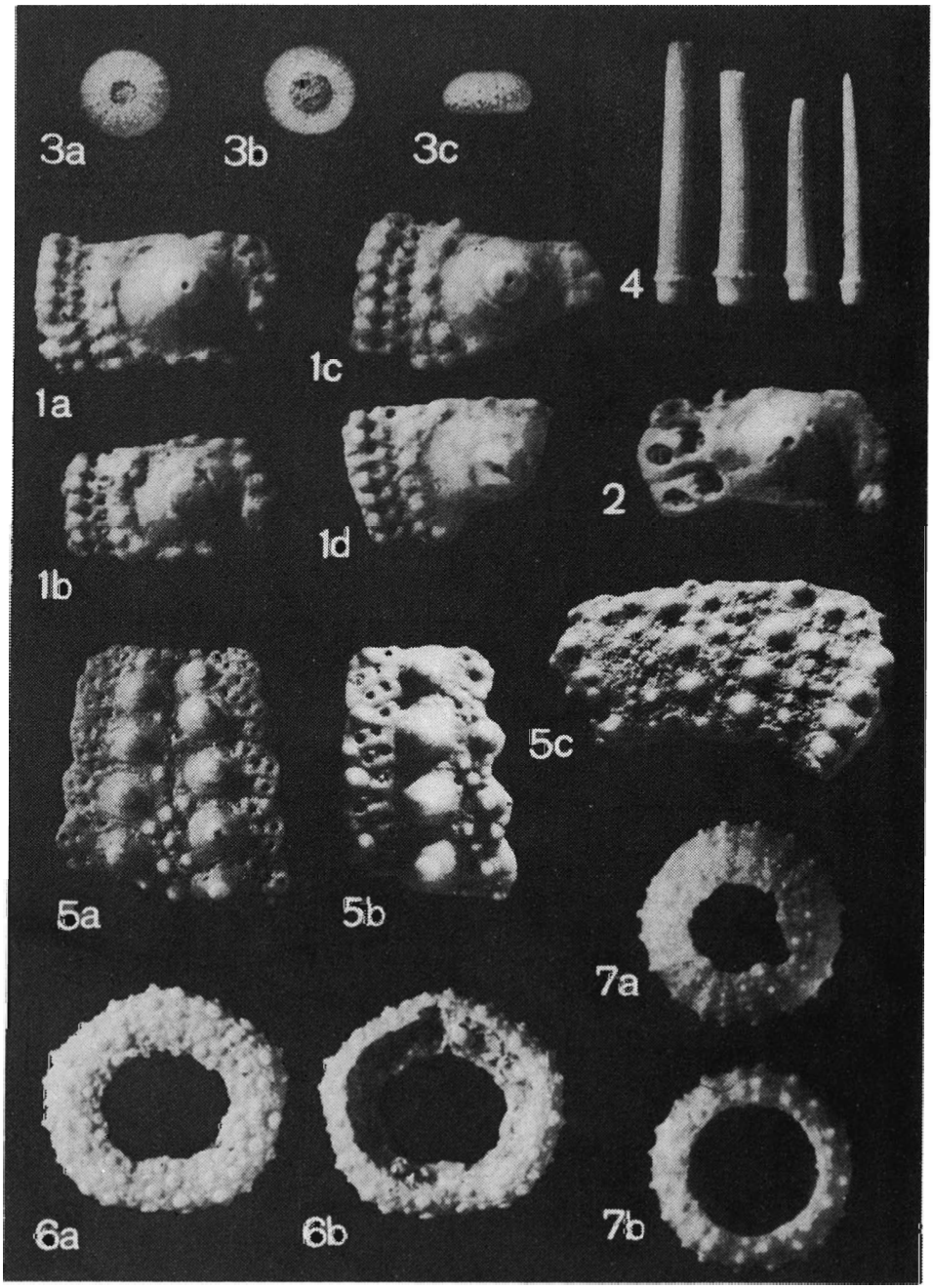
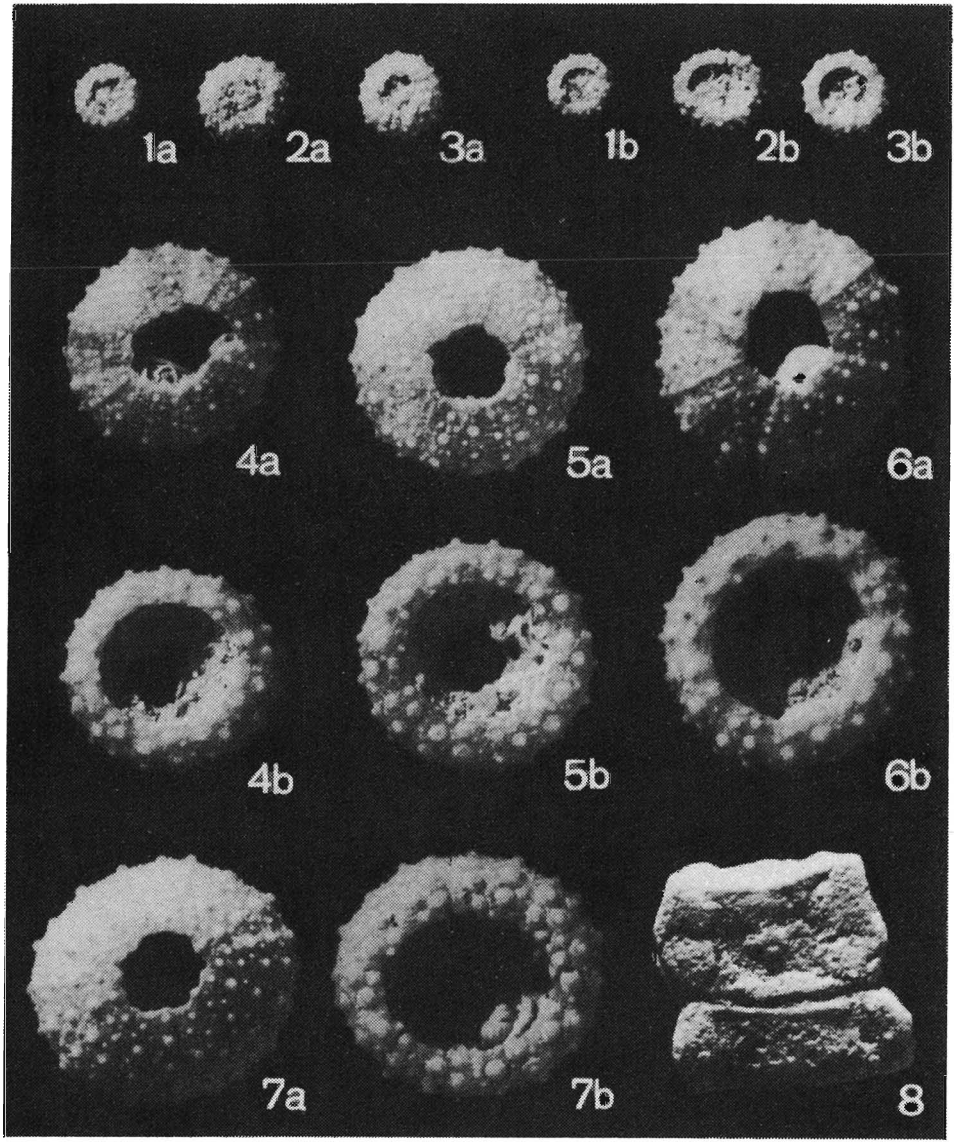


1 — *Cidaris zeamais* SISMONDA; spines (specimens No. Ee 1248), ×6
2 — *Plegiocidaris peroni* (COTTEAU); isolated interambulacral plate (specimen No. Ee 890), ×7 [reported as *Cidaris* sp. by MĄCZYŃSKA 1977, Pl. 1, Fig. 16]
3-7 — *Cyathocidaris avenionensis* (DESMOULINS): 3a-3b — Isolated interambulacral plates (specimens No. Ee 1249), ×7; 4 — Fragment of the test, ambulacral area (specimen No. Ee 1271), ×2; 5-7 — Joined ambulacral plates (specimens No. Ee 1272), ×2

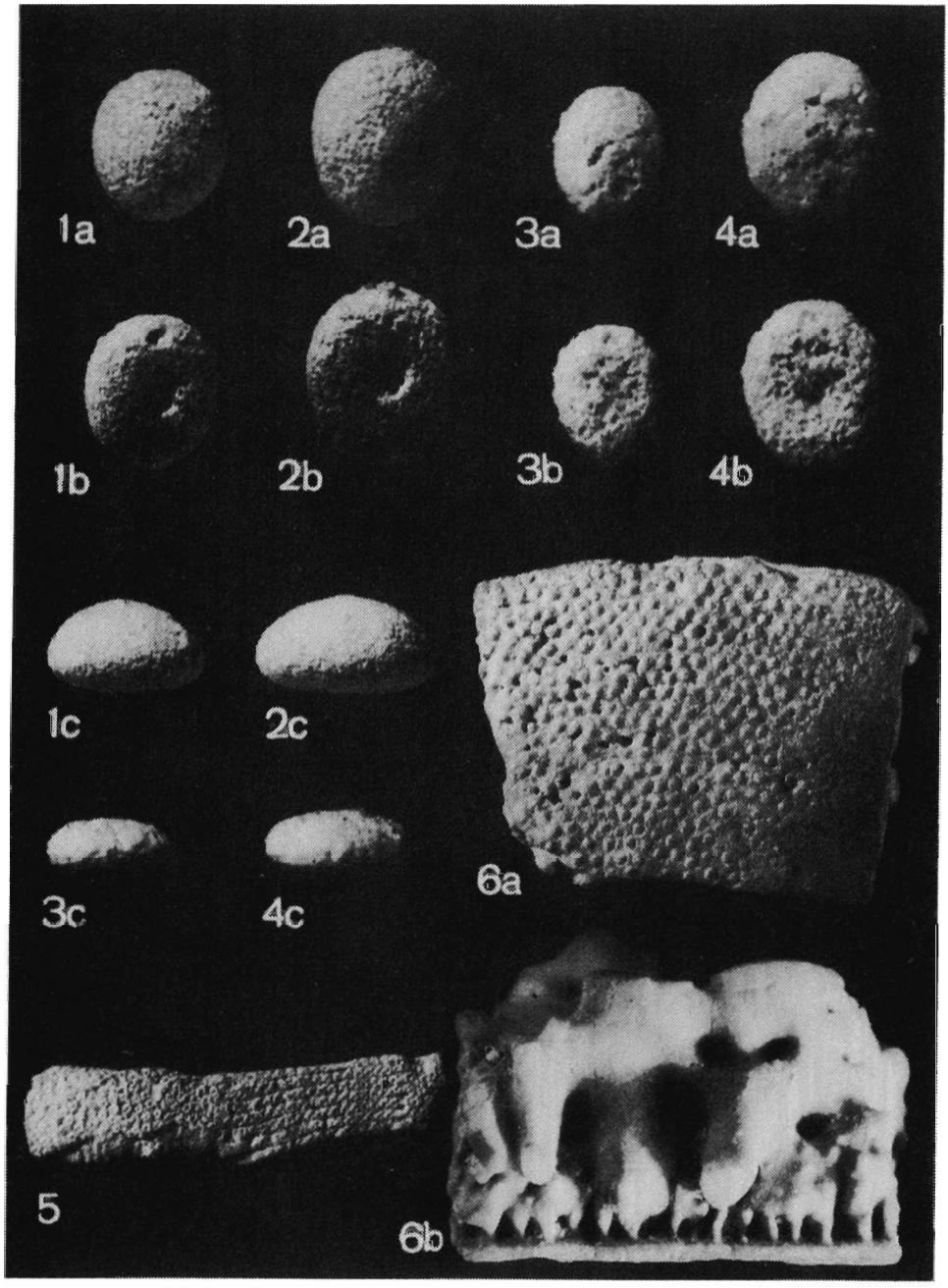


1a-1d— *Cyathocidaris avenionensis* (DESMOULINS); isolated ambulacral plates (specimens No. Ee 1250), ×7
2— *Parasalenia fontannesi* COTTEAU; specimen No. Ee 1251, ×7
3— *Arbacina catenata* (DESOR): *3a* aboral, *3b* adoral, *3c* lateral views (specimen No. Ee 1245), nat. size
4— *Arbacina* sp.; spines (specimen No. Ee 1246), ×5
5— *Psanunechinus* sp.; *5a* ambulacral area, *5b* joined ambulacral plates, *5c* fragment of the test (specimens No. Ee 1273), ×6
6-7— *Psammechinus dubius* (L. AGASSIZ); *6a 7a* aboral, *6b, 7b* oral views (specimens Nos Ee 1240 and 1241), ×6



1-7 — *Psammechinus dubius* (L. AGASSIZ); specimens varying in size (No. Ee 1243), *a* aboral, *b* oral views; ×7

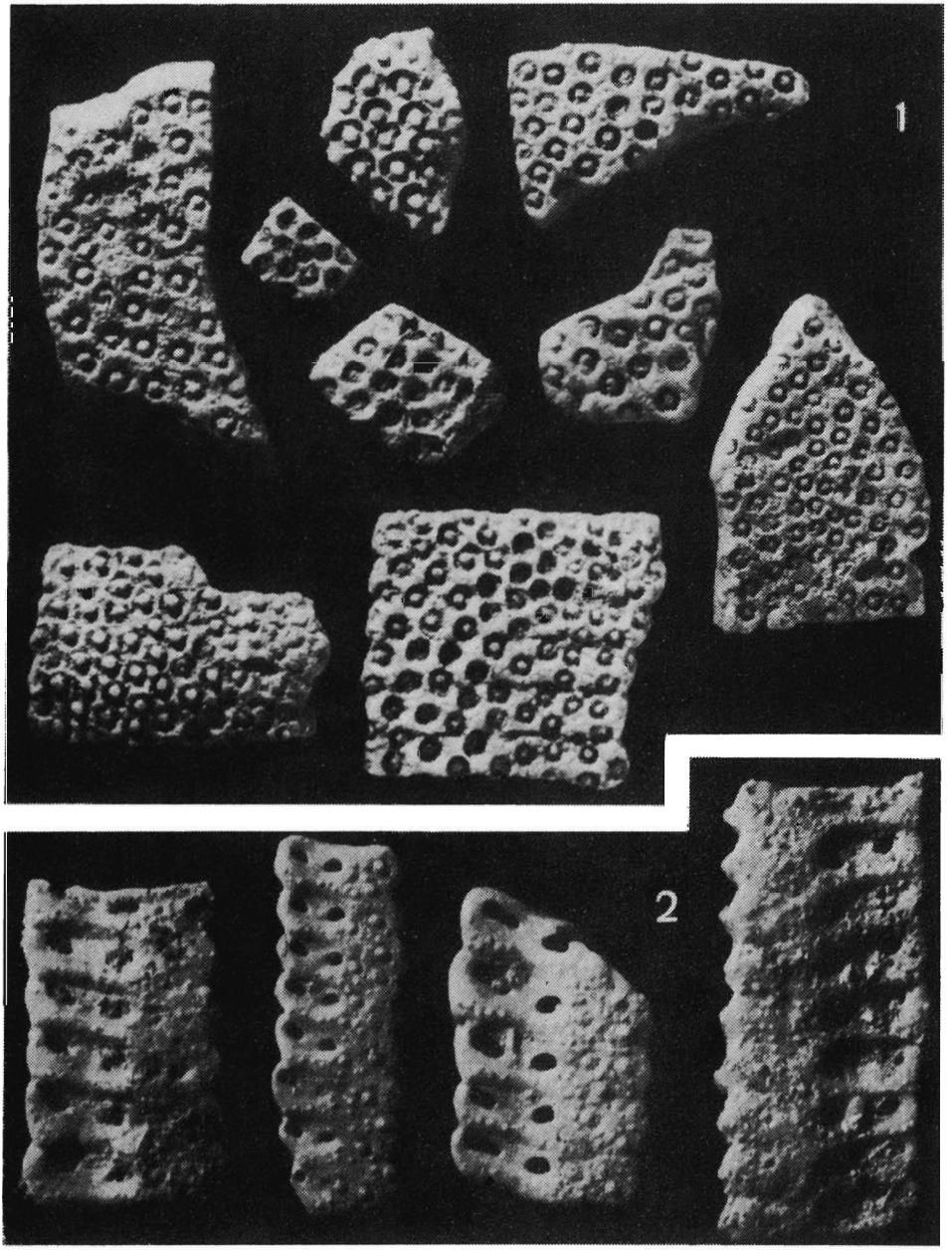
8 — *Scutella* (?*Parascutella*) sp.; fragment of the test (specimen No. Ee 1247), ×6



1-4 — *Echinocyamus pusillus* (O. F. MÜLLER): 1-2 — specimens from Karsy (No. Ee 1238), 3-4 — specimens from Chomentów (No. Ee 1239); *a* aboral, *b* oral, *c* lateral views; ×6

5 — *Echinolampas* sp.; fragment of the test with ambulacral and interambulacral areas (specimen No. 1258), ×3

6a-6b — *Clypeaster* sp.; fragment of the test (specimen No. Ee 1259, from Karsy), ×3



1 — *Echinolampas* sp.; fragments of the test (specimens No. Ee 1253), ×6
2 — Ambulacral plates of the Spatangoida (specimens No. Ee 1254), ×6

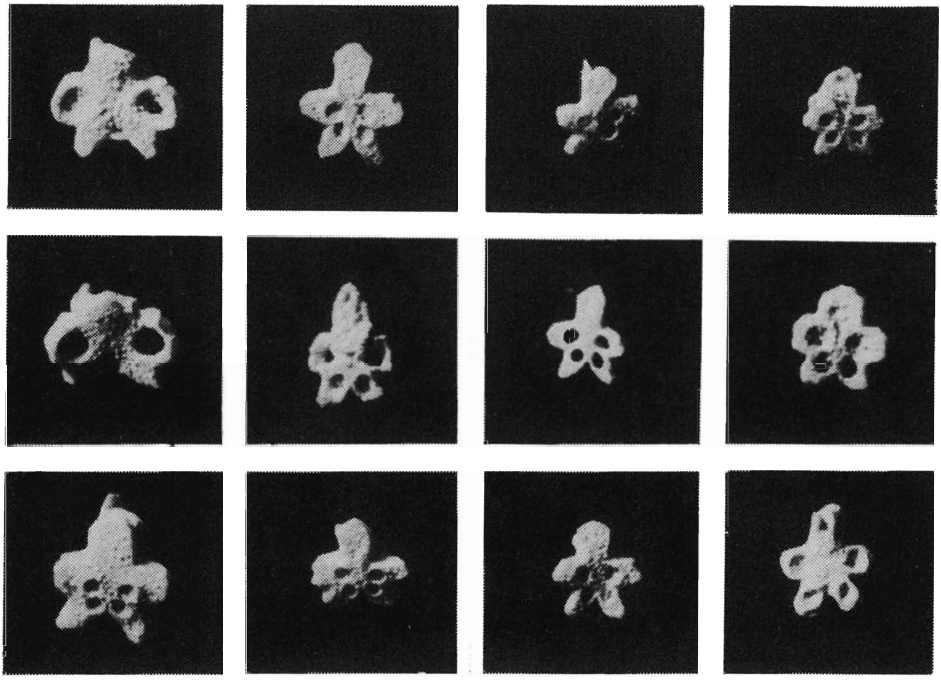


Fig. 1. Apical systems of the Spatangoida (specimens No. Ee 1255), ×6

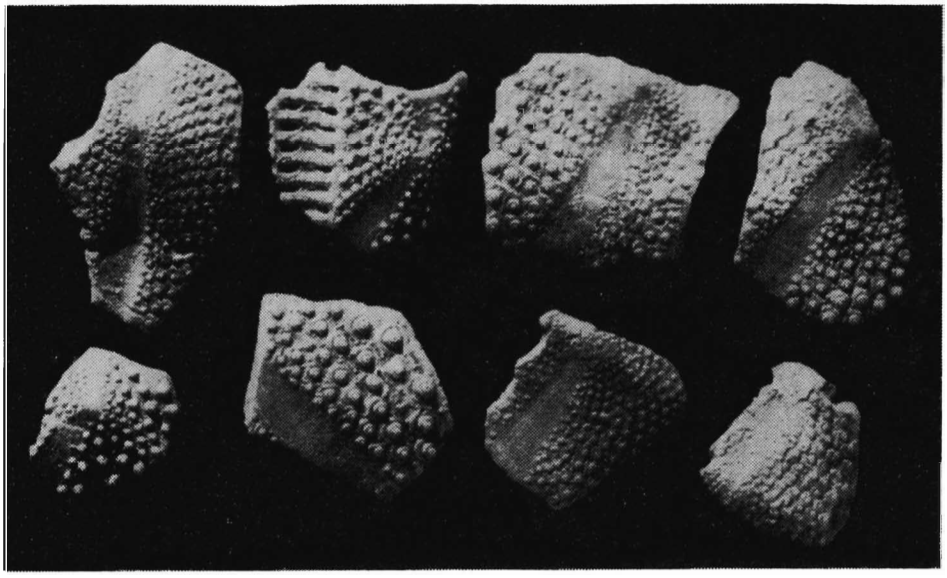
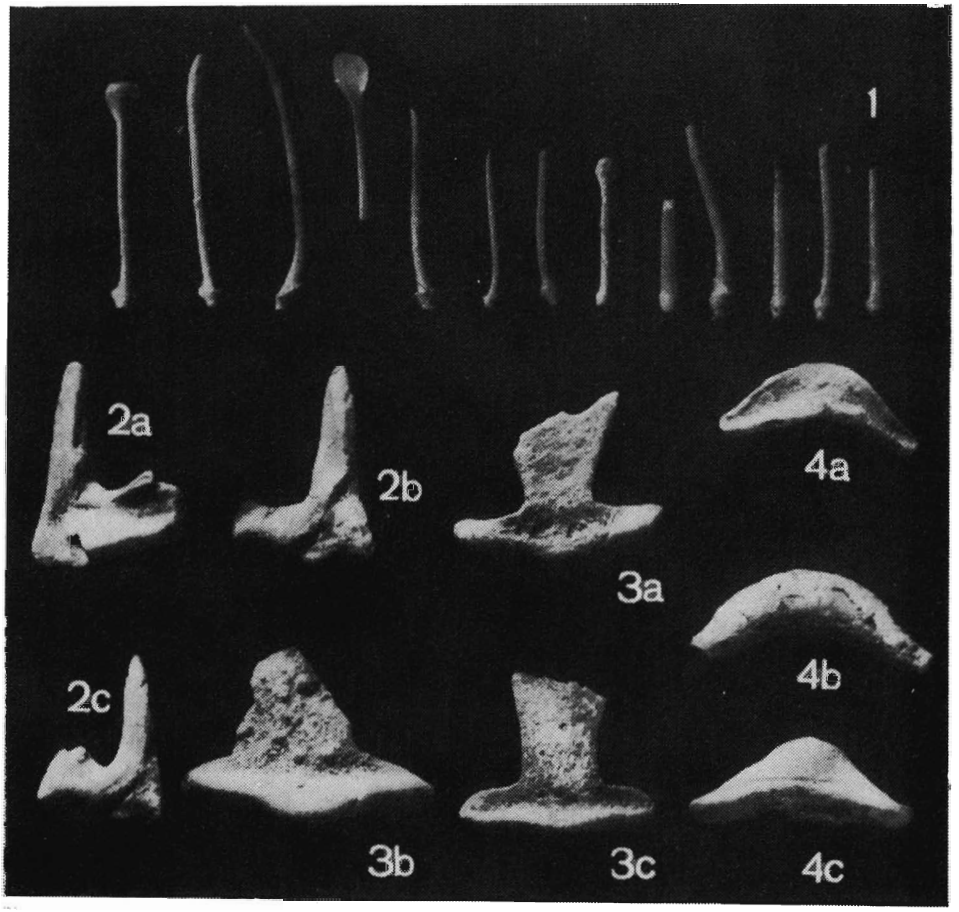
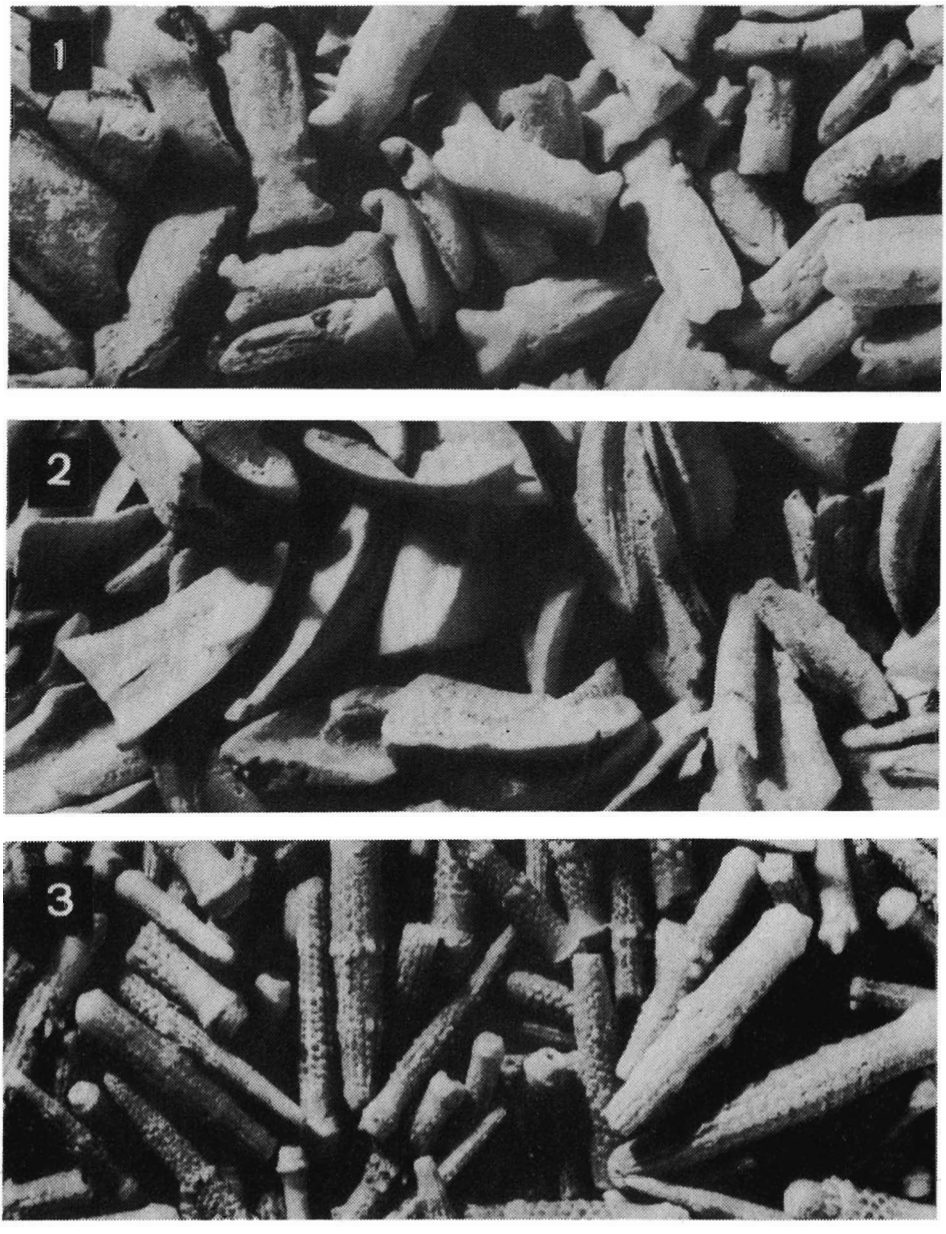


Fig. 2. Test fragments of the Spatangoida, with parts of the fasciole (specimens No. Ee 1256), ×6



1 — Spines of the Spatangoida (specimens No. Ee 1257), ×5
2a-2c — Epiphyses from the Aristotele's lanterns (specimens No. Ee 1268), ×4
3-4 — Labral plates of the Spatangoida (specimens No. Ee 1260), ×4
5 — Sifted material with epiphyses and labra (specimens No. Ee 1260 and 1268), ×4



Sifted material with: **1** — Rotules from the Aristotle's lanterns (specimen No. Ee 1269); **2** — Demipyramids from the Aristotle's lanterns (specimen No. Ee 1270); **3** — Spines (specimen No. Ee 1248); abundantly, those of *Cidaris zeamais* SISMONDA are visible; all taken ×5

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S. MĄCZYŃSKA

NOWE DANE O SZCZĄTKACH JEŻOWCÓW Z BASENU KORYTNICY

(Streszczenie)

Przedmiotem pracy jest omówienie nowego materiału szczątków jeżowców z Basenu Korytnicy (*patrz* pl. 1—8), które uzyskano w wyniku szlamowania iłów korytnickich (przeszlamowano około 1.000 kg iłu). W wyniku znalezienia licznych fragmentów pancerzy (lub pojedynczych jego płytek) oraz kolców i luźnych elementów latarni Arystotelesa, stwierdzono występowanie zespołu znacznie bogatszego niż znany był tutaj poprzednio (*patrz* MĄCZYŃSKA 1977). Po raz pierwszy napotkano fragmenty pancerzy osobników z rodzajów: *Psammechinus* L. AGASSIZ & DESOR, *Scutella* LAMARCK (? *Parascutella* DURHAM), *Clypeaster* LAMARCK oraz *Echinolampas* GRAY. Cały zespół jeżowców reprezentowany jest przez 13 rodzajów należących do 7 rzędów.

Analiza ekologiczna zespołu jeżowców z Basenu Korytnicy wskazuje na występowanie w nim wielu rodzajów charakteryzujących się znacznym rozprzestrzenieniem geograficznym oraz zasiedlaniem stref płytkomorskich ciepłych, a nawet tropikalnych.
