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Lower Kimmeridgian echinoids of Poland

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ABSTRACT:

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A rich assemblage of echinoids, primarily regular ones, is reported from the Lower Kimmeridgian part of an over 1km thick Upper Jurassic carbonate sequence, developed over cratonic (epicontinental) areas of Poland (Holy Cross Mountains in Central Poland, and Western Pomerania in NW Poland). The echinoids, either underestimated or even overlooked in the former literature, appear to be significant components of ubiquitous organic assemblages contained in various deposits of the bahamite type of facies. The most diversified taxonomically are the echinoids from Małogoszcz in the Holy Cross Mountains (22 species, of which 4 dominate: *Rhabdocidaris orbignyana*, *Hemicidaris intermedia*, *Gymnocidaris agassizi*, *Holectypus corallinus*). The richest numerically is the collection from Czarnogłowy in Western Pomerania (13 species, of which only 2 dominate: *Hemicidaris hoffmanni* and *Nucleolites letteroni*).

The systematically accounted forms, totalling over 2,000 specimens, represent 31 species of 20 regular genera, and 10 species of 5 irregular genera. Of these, four species are new to science, viz. *Pseudosalenia malogostiana* sp.n., *Pseudocidaris sanctacrucensis* sp.n., *Trochotiara kongieli* sp.n., and *T. suleiovense* sp.n. The well preserved specimens, although usually devoid of spines and apical plates, display the SEM-recognizable features of the tests (*i.a.* pore-pairs morphology, tubercle arrangement) substantial for a functional analysis of 14 more commonly occurring species. This analysis stimulated a paleobiologic interpretation focused on the behavioral and environmental (very shallow up to subtidal) conditions under which the studied echinoids lived and were buried, *i.a.* by such catastrophic events as storm-induced and mass-movement deposition.

A separate, short section of the paper concerns the grazing traces of regular echinoids [classified in ichnology as *Gnathichnus pentax* BROMLEY, 1975], caused by browsing the epibionts, and preserved in the studied sequence on various organic (shelly) substrates, the other echinoid tests including.

Key words: Echinoidea, taxonomy, paleoecology, Upper Jurassic, Poland.

Contents

REFERENCES

INTRODUCTION

The subject of the present paper is a monographic description of a part of the Upper Jurassic echinoids from Poland. Selected to this description are Lower Kimmeridgian echinoids, whose ubiquitous tests typify that very interval of the Upper Jurassic sequence of Poland. This interval has been selected since its facies development, as a sequence of shallow-marine carbonates, involved a rise of the mosaic pattern of diverse biotope conditions especially favorable for the echinoids, to live profusely and to proliferate. In comparison with other invertebrates, primarily ammonites, brachiopods, and some bivalves, commonly known from these Lower Kimmeridgian strata, the echinoids have, however, virtually been neglected in the former literature.

The studied Lower Kimmeridgian interval is a part of an over 1km thick Upper Jurassic carbonate sequence, developed over cratonic (epicontinental) areas of Poland (*see* KUTEK 1994).

A general paleogeographic framework of Poland at Early Kimmeridgian time, as recognized by KUTEK, MATYJA & WIERZBOWSKI (1984), was accentuated by the development of a carbonate platform that embraced the major parts of Eastern and Central Poland, the Holy Cross Mountains including (*see* Text-fig. 1); this platform is herein called the *Holy Cross Platform*. At that time the shallow-marine clastics and carbonates developed also in northwestern Poland, where the echinoids have been known since the early years of this century, primarily from the classic locality Czarnogłowy (*Zarnglaff* in German literature) near Szczecin in Western Pomerania (*see* Text-fig. 1); the region of this facies is herein called the *Pomeranian Platform.*

The carbonates of the Holy Cross Platform correspond to those of the present-day Great Bahama Bank typified by huge oolite shoals (*see* Kutek 1969). A common occurrence of blue-green-algal onkolites (*see* Kutek & Radwański 1965, 1967; Kutek 1969), and hardgrounds (*see* Kutek & Radwański 1967; Kaźmierczak & Pszczółkowski 1968; Kutek 1969; Gruszczyński 1979, 1986), the both commonly bored by rock-borers, and developed locally at a coral patch-reef (*see* Roniewicz & Roniewicz 1968), speaks clearly of a very shallow to extremely shallow-marine sedimentary environment.

Within the Holy Cross Mountains, the facies favorable for the echinoids' life had been established primarily in the region being now the Mesozoic margins that formed due to erosion subsequent to the Laramide folding and uplift of the Holy Cross tectogen composed (*see* Kutek & Głazek 1972) of the Variscan core and the post-Variscan (Permian – uppermost Cretaceous) cover.

Of the two Mesozoic margins of the Holy Cross Mountains, the northeastern and the southwestern (*see* Text-fig. 2), the more fossiliferous are sequences of the SW margin, where the deposits of the discussed carbonate platform (*see* Text-fig. 3) have been widely exposed since the mid-seventies of this century in the huge quarry at Małogoszcz. A situation of the Małogoszcz section within the platform and relation of the latter to older carbonates of the Upper Jurassic sequence, totalling over 1 km in thickness (*see* Text-fig. 3), indicates an almost uniform development of the bahamite-type lithofacies throughout the whole area of the present-day southwestern margin of the Holy Cross Mountains, as formerly recognized by Kutek (1968; *see also* Kutek 1994). The area of the present-day northeastern Mesozoic margin of the Holy Cross Mountains, as studied recently by Gutowski (1992, 1998), yielded the facies development distinctly less favorable for the echinoids.

The deposits of other facies of Early Kimmeridgian age, developed outside the Holy Cross Platform and the Pomeranian Platform (*see* Text-fig. 1) have not hitherto been recognized to yield well preserved echinoids. Such deposits are exposed at the surface only in some parts at the Polish Jura (*see* PJ in Text-fig. 1).

Less favorable for the echinoids, because of deeper marine facies, were all the older, that is Oxfordian, parts of the Upper Jurassic carbonate sequence of Poland. The much dispersed, through facies and time, occurrences of the Oxfordian echinoids in cratonic areas of Poland, little known from the literature (Pusch 1837, Roemer 1870, Siemiradzki 1893, Lewiński 1912, Świdziński 1931, Samsonowicz 1934, Wiśniewska-Żelichowska 1971), need a separate study.

Treated in this study are thus the Lower Kimmeridgian echinoids from the Holy Cross

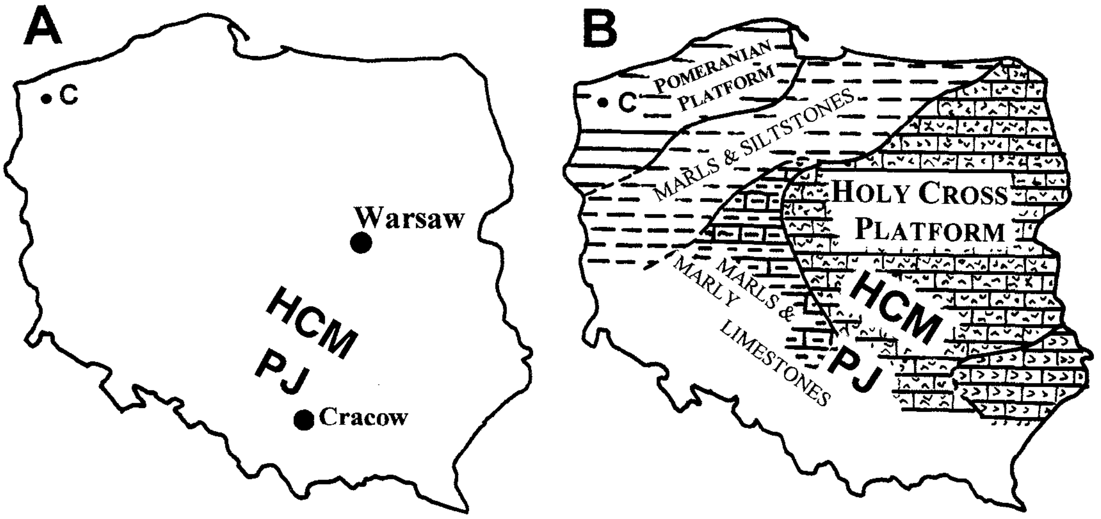


Fig. 1. Location of the Lower Kimmeridgian echinoid-bearing deposits in Poland; **A** – General map of Poland, to locate regions in which the Lower Kimmeridgian strata are exposed: HCM – Holy Cross Mountains, PJ – Polish Jura, C – Czarnogłowy; **B** – Paleogeographic map of Poland at Early Kimmeridgian time (*adopted from*: Kutek, Matyja & Wierzbowski 1984, Fig. 1)

Mountains, Central Poland, and from Czarnogłowy and neighboring localities in Western Pomerania, NW Poland.

STRATIGRAPHIC AGE OF THE ECHINOID-BEARING SEQUENCE

The stratigraphic age of the echinoid-bearing sequence of the carbonate platform in the southwestern margin of the Holy Cross Mountains is precisely dated by ammonites (*see* KUTEK 1968, 1994; KUTEK, MATYJA & WIERZBOWSKI 1984, 1992; MATYJA & WIERZBOWSKI 1996) as the two Lower Kimmeridgian zones, Ataxioceras hypselocyclum and Katroliceras divisum, with a notation that the lower members (Lower Oolite, and Banded Limestones) may still belong to the Sutneria platynota Zone of the lowermost Kimmeridgian.

In the northeastern Mesozoic margin, the same two ammonite zones, Ataxioceras hypselocyclum and Katroliceras divisum, were recognized by GUTOWSKI (1992, 1998), to classify the age of the echinoid-bearing sequence.

At Czarnogłowy, the Lower Kimmeridgian age of the echinoid-bearing part of the section is indicated by ammonites monographed by WILCZYŃSKI (1961; *see also* CHERCHI & SCHROEDER 1992, pp. 6-8).

PROVENANCE OF THE MATERIAL STUDIED

The majority of the echinoids from the Holy Cross Mountains have been collected by the present author herself since the late seventies in localities known to yield these echinoderms. Such localities, apart from those mentioned in older references (LEWIŃSKI 1912, ŚWIDZIŃSKI 1931, SAMSONOWICZ 1934), have been recognized through the activity of the scientific staff of the Faculty of Geology, University of Warsaw, and performed since almost forty years primarily by Professor Dr. J. KUTEK and

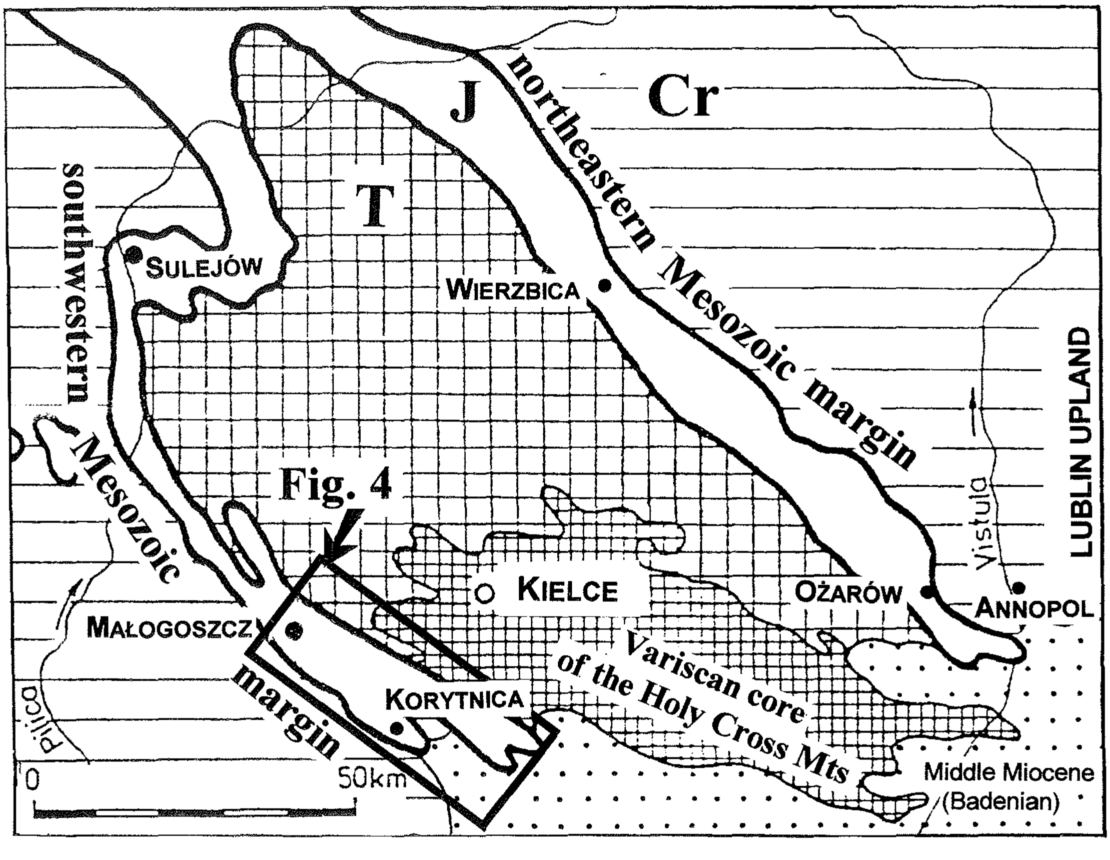


Fig. 2. Geologic map of the Holy Cross Mountains, Central Poland, to show the main structural units – the Variscan core, and the post-Variscan (Permian; *and* Mesozoic: T – Triassic, J – Jurassic, Cr – Cretaceous) margins; indicated is also the extent of the Middle Miocene (Badenian) transgressive deposits abutting on the rocky shoreline; rectangled is the area presented in Text-fig. 4
(Adopted from: KUTEK, MATYJA & WIERZBOWSKI 1992, Fig. 1)

Professor Dr. W. Barczyk, their students and collaborators. The echinoid-bearing strata were then included, besides the published theses (Barczyk 1961; Kutek 1968, 1969) and field-guides (Matyja 1985, 1991; Kutek, Matyja & Wierzbowski 1992, 1996; Kutek, Matyja, Radwański & Wierzbowski 1992), into many unpublished reports, some Ph.D. theses (Gutowski 1992) and M.Sc. theses (Skompski 1976, Gruszczyński 1977, Machalski 1983, Pastusiak 1987) including. To the truth, very few echinoid taxa were mentioned in the afore-listed items, and illustrations were supplied only by Barczyk (1961) in his monograph of the Upper Jurassic sequence of Sulejów, and by Jesionek-Szymańska (1988) in her brief account to the Upper Jurassic echinoids of Poland.

The present-author's own research was initiated when the echinoid-bearing strata had been exposed in the Małogoszcz Quarry in the mid-seventies, when they yielded a rather paramount assemblage of diverse echinoids, containing now 22 taxa. The coeval echinoid-bearing strata, have then been recognized by the present author in the famous region of Korytnica, during her faunistic study of the Miocene seashores (Radwańska 1982) – the seashores built just by the Lower Kimmeridgian echinoid-bearing sequence.

The material collected personally in the Holy Cross Mountains has been supplemented by some specimens kindly offered by former and present-day students, collaborators, or staff members of the Faculty of Geology, University of Warsaw. First, it is the whole material collected by Professor Dr. W. Barczyk and described in his monograph (Barczyk 1961). Second, there are some specimens collected by Dr. S. Skompski from Górki, Dr.

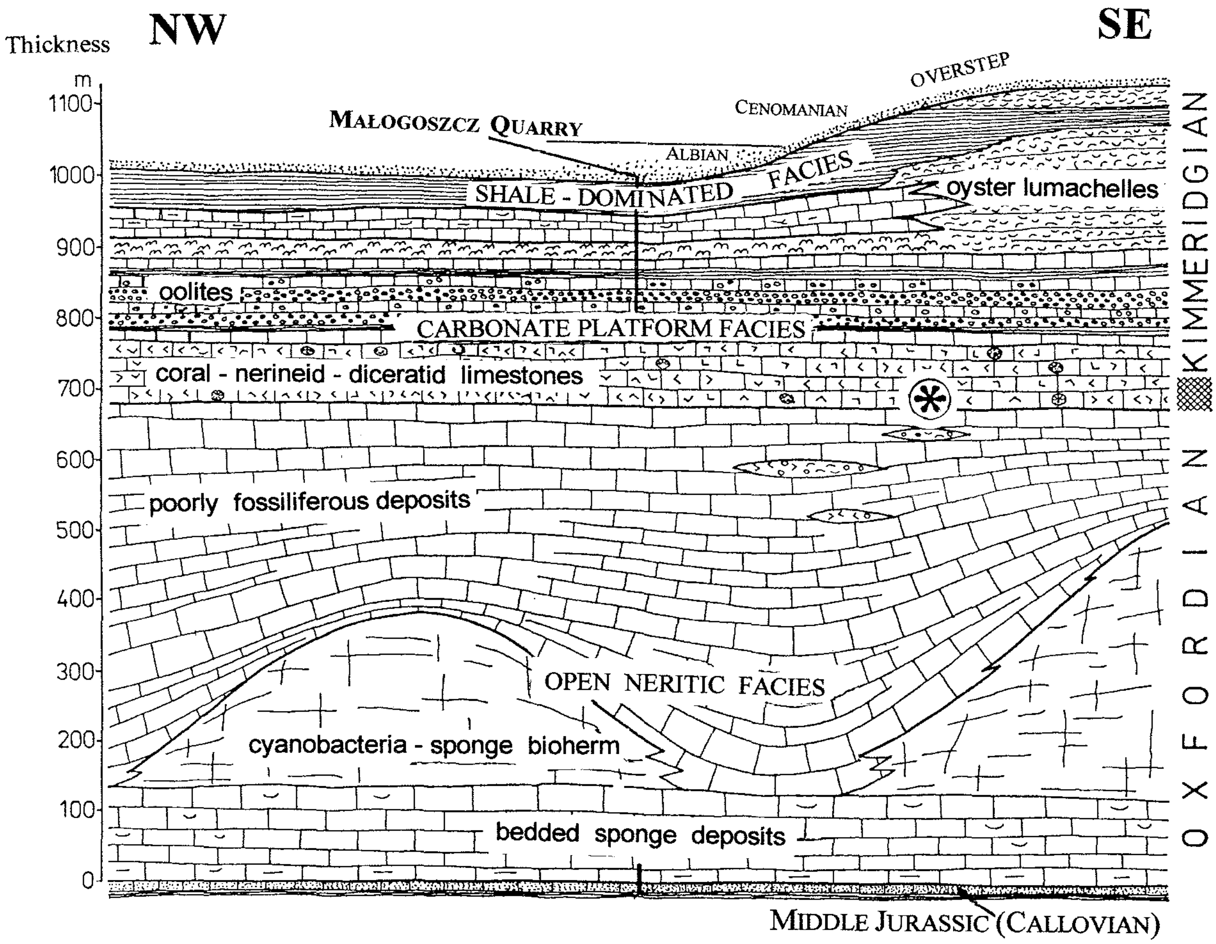


Fig. 3. Diagrammatic sketch of the Upper Jurassic (Oxfordian through Kimmeridgian) sequence of facies in the southern part of the southwestern margin of the Holy Cross Mountains (*after* Matyja 1985, Fig. 38 = 1991, Fig. 38; *adopted from* Kutek, Matyja & Wierzbowski 1992, Fig. 3); indicated is the range of the section exposed at the Małogoszcz Quarry, and the location (*asterisked*) of the echinoid-bearing strata exposed at Sobków-Wierzbica

M. MACHALSKI from Karsy, Mr. J. GUBAŁA from Niziny, as well as Professor Dr. B.A. MATYJA, Mr. A. SOCHACZEWSKI, Mr. A. KIN, Mr. T. PRASZKIER, and Mr. S. ROGULA from Małogoszcz.

Some specimens from Wierzbica have kindly been loaned by Professor Dr. J. DZIK of the Institute of Paleobiology, Polish Academy of Sciences in Warsaw, and those from Sulejów have been donated by Professor Dr. J. MASZEWSKI, of the University of Łódź.

As concerns the echinoids from Czarnogłowy, and neighboring Świętoszewo (yielding a few specimens), the whole material comes from older collections, as the exposures are presently not accessible. First, it is the original collection of the late Professor Dr. R. KONGIEL, upon which he based his monograph (KONGIEL 1957). This collection, owned by the Geological Survey of Poland, and kept in the Museum of that Institution in Warsaw, has kindly been made available due to the courtesy of Professor Dr. S. SPECZIK, the Director of the Survey.

Included in the present study was also the subsequent collection from Czarnogłowy, of Professor R. KONGIEL, now kept in the Museum of the Earth in Warsaw, as well as some additional collections gathered by Dr. W. JESIONEK-SZYMAŃSKA and Professor Dr. J. DZIK for the Institute of Paleobiology of the Polish Academy of Sciences in Warsaw. All these collections have been made accessible to the present author by the Managements of these Institutions.

The author's own material from Czarnogłowy comes from private collections, generously donated by Professor Dr. W. BARCZYK, the late Professor Dr. H. MAKOWSKI, and the late Dr. A. WILCZYŃSKI.

A general list of the studied species (Table 1) comprises 41 taxa, of which 3 (of the genera *Psephechinus, Glypticus,* and *Collyrites*) are determined to the genus level, and 4 (of the genera *Pseudosalenia, Pseudocidaris,* and *Trochotiara*) are new to science.

The frequency of particular species within the collection, totalling over 2,000 specimens, is much variable, with some very common species but also rarities represented by one specimen only (*see* Table 1).

REGIONAL SETTING OF THE ECHINOID-BEARING LOCALITIES

Southwestern margin of the Holy Cross Mountains, Central Poland

The studied echinoids from the southwestern margin of the Holy Cross Mountains come from a number of localities of a much variable state of access at present. These are both natural exposures along the embankments and/or structural steps, as well as roadsides, local trenches (some of them military from the 1*st* World War), rural excavations and pits and/or quarries of various size, usually abandoned (*see* Text-fig. 6). The larger quarries, still at work, are only those of Sulejów and Małogoszcz (*see* Text-fig. 6*A*). The echinoids were systematically collected from those localities in which the present state of exposure promised a successful search.

Along the southwestern Mesozoic margin of Holy Cross Mountains such exposures were thus accessible at Sulejów and in the area stretching from Gruszczyn

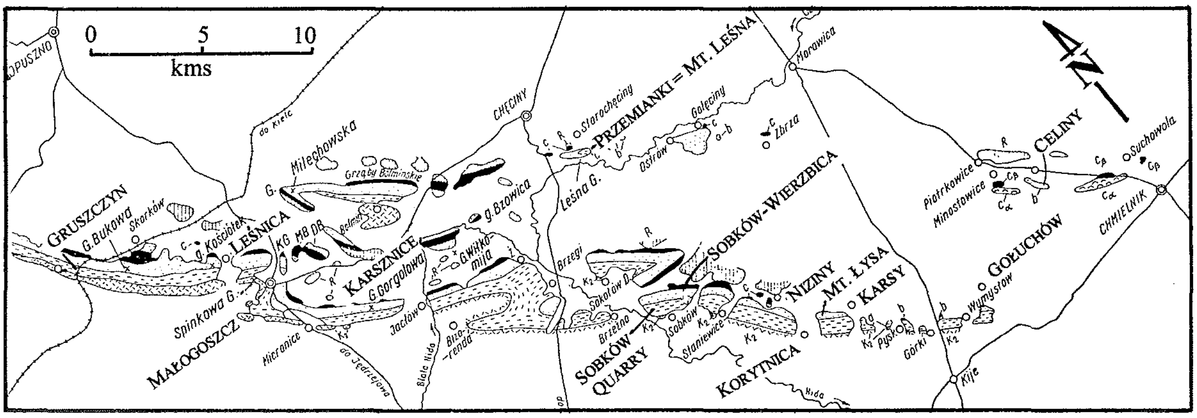


Fig. 4. Location of the studied echinoid-bearing sections (capitalized, bold; *see* Text-fig. 5) in the southern part of the southwestern margin of the Holy Cross Mountains (*see* rectangled area in Text-fig. 2), plotted against the original map presented by KUTEK (1968, Table 1), to facilitate their setting in the field; for all stratigraphic and lithologic explanations *see* KUTEK (1968, Table 1)

Table 1

Frequency of specifically determined specimens of the studied echinoids

SPECIES	SULEJÓW	GRUSZCZYN	LEŚNICA	MAŁOGOSZCZ	KARSZNICE	SOBKÓW*	NIZINY	KORYTNICA	KARSY	GOŁUCHÓW	CELINY	WIERZBICA	OŻARÓW	ANNOPOL	CZARNOGŁOWY
Rhabdocidaris nobilis				2		6									
Rhabdocidaris orbignyana	3			215					13	9	3				
Rhabdocidaris sp.				1											
Paracidaris smithi				4								17			
Plegiocidaris crucifera				10											
Pedina sublaevis				3							1				
Pseudodiadema tetragramma														2	
Acrosalenia angularis	3			6		1		6	12						1
Pseudosalenia malogostiana sp.n.				2											
Hemicidaris gresslyi	30														
Hemicidaris hoffmanni															560
Hemicidaris intermedia	8	1	3	80	7	10	1		9	24		15	6	1	90
Hemicidaris mitra							1								
Hemitiaris stramonium															1
Pseudocidaris mammosa		1													2
Pseudocidaris thurmanni							7								
Pseudocidaris sanctacrucensis sp.n.				4								2			
Trochotiara kongieli sp.n.	7	1	1	14					25	3		1	2	4	42
Trochotiara suleiovense sp.n.	1														
Tetragramma planissimum							1					2			
Tetragramma pomeraniae				2											1
Phymosoma douvillei				1					1						
Phymosoma supracorallinum				1											26
Stomechinus gyratus				7					3						
Stomechinus semiplacenta	14												2		
Polycyphus distinctus				7					8						
Psephechinus sp.															1
Gymnocidaris agassizi	1		1	205					11	1					
Acropeltis aequituberculata						1*									
Glypticus sp.						1*									
Orthopsis pomeraniae															3
Pygaster morrisi	1			41		2			2						
Pygaster tenuis				36					1			1			
Holectypus corallinus		4		259				1	109	9	5			1	25
Pygurus blumenbachi				4					2			4			
Pygurus costatus	1														
Pygurus jurensis				2		1							1		1
Nucleolites brodiei							20								
Nucleolites letteroni												1	7		300
Nucleolites truncatus											15				
Collyrites sp.									1						

*Asterisked in this column are the two items coming from locality Sobków-Wierzbica (*see* the text).

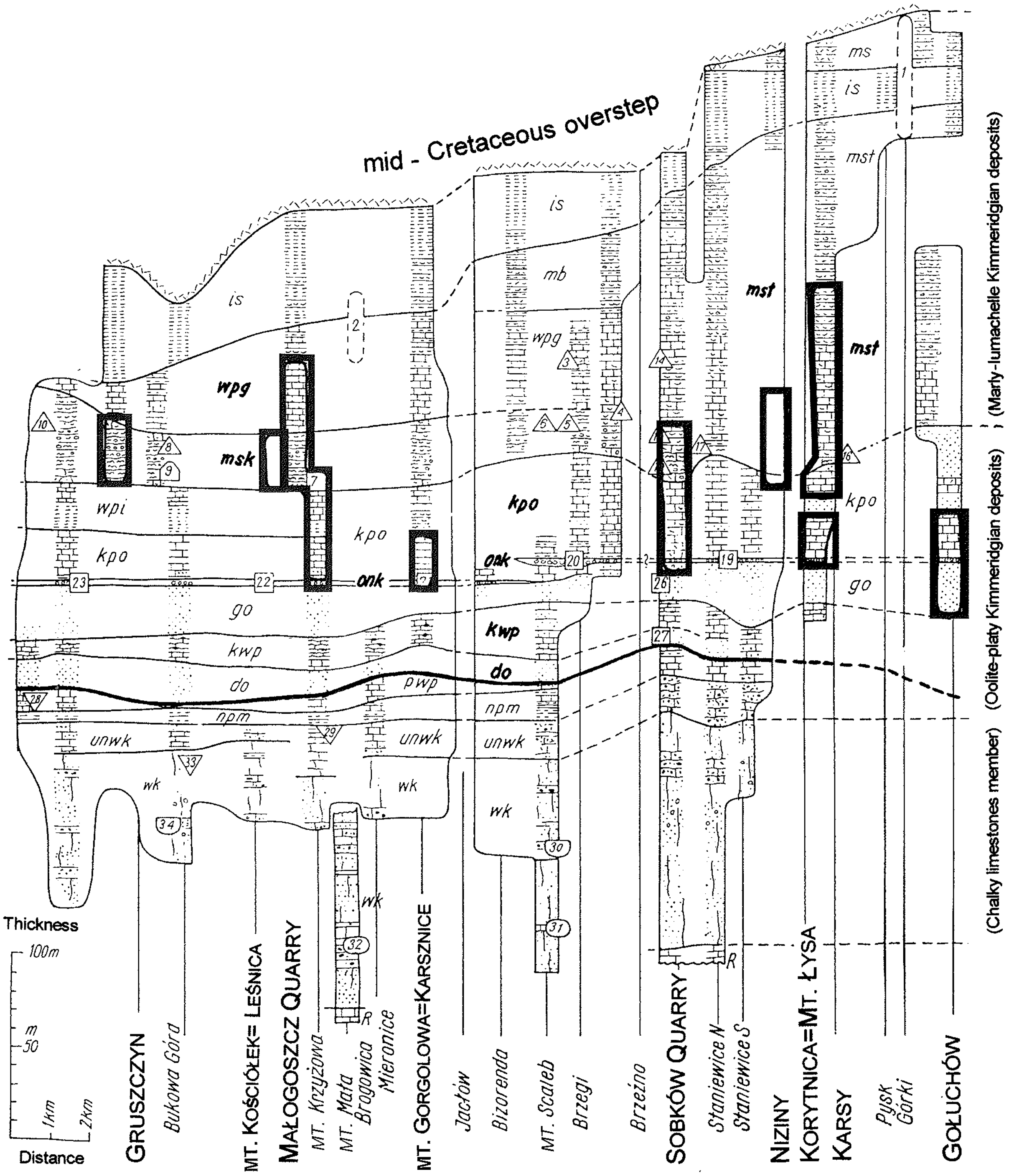


Fig. 5. The studied sections (capitalized, the echinoid-bearing parts framed in bold) in the southern part of the southwestern margin of the Holy Cross Mountains (for location *see* Text-fig. 4), plotted against a part of the original sketch presented by KUTEK (1968, Table 2). The lithostratigraphic units of KUTEK (1968, Table 2), wherefrom the echinoids were collected, are abbreviated in their stratigraphic succession as follows:

do – Lower Oolite, **kwp** – Banded Limestone member, **go** – Upper Oolite, **onk** – Onkolite horizon, **kpo** – Oolite-Platy member, **msk** – Skorków Lumachelle, **wpg** – Upper Platy Limestones, **mst** – Staniewice Lumachelle

In this sketch, as a horizontal key horizon *the Onkolite horizon* (**onk**) is used; to compare with the diagram presented in Text-fig. 3, where *the Lower Oolite* is used as the base of the carbonate platform succession, that very base is marked herein with a heavy line in NW, through Gołuchów and Celiny in SE (*see* Text-fig. 4). In all the successive localities, the echinoid-bearing strata represent a relatively narrow interval of the local lithostratigraphic column, established by KUTEK (1968), that is several members (*see* Text-fig. 5) composing a sequence of the "Oolite-platy Kimmeridgian deposits" and "Marly-lumachelle Kimmeridgian deposits" (*see* KUTEK 1968, Table 2; partly re-figured herein as Text-fig. 5).

The lithofacies in which the echinoids occurred, are pure limestones (primarily oolites) grading into marlstones, locally even into soft marls; the limestones range in their structural variability from almost micritic, through various biocalcarenites to shell-hash and/or pure ostreid coquinas forming extensive shellbeds.

The ostreid coquinas in the lower part of the shellbed sequence are composed of shells of the genus then called *Alectryonia*, and so referred by KUTEK (1968, p. 507; 1969) and PUGACZEWSKA (1971), and later as *Lopha* by KUTEK (1994, p. 187), but which has recently been identified as *Actinostreon* by MACHALSKI (1998). Coquinas of the higher part of the shellbed sequence are composed of the shells of *Exogyra* (*Nanogyra*) *nana* and/or *Exogyra* (*Nanogyra*) *virgula*.

Some of the localities listed below from the southern part of the southwestern Holy Cross margin, were studied earlier, prior to KUTEK (1968, 1969), by the recognized authors of former generations: by LEWIŃSKI (1912) those framed from Gruszczyn to Gołuchów, and by ŚWIDZIŃSKI (1931) those framed from Małogoszcz to Sobków.

Several echinoid taxa reported by these authors (LEWIŃSKI 1912, ŚWIDZIŃSKI 1931), as well as those noted still earlier (PUSCH 1837; ZEUSCHNER 1868a, b) are to remain bibliographical items. All their collections have been destroyed through the winds of the World Wars, and thus the actual taxonomic position cannot be verified.

Sulejów: Large abandoned quarry, south at the great lime-kiln, in which only a part of the sequence is exposed, and from which the echinoids were monographed by BARCZYK (1961), at time when a series of small quarries were at work.

Gruszczyn: Railroad section, described by LEWIŃSKI (1912; *see also* GRUSZCZYŃSKI 1977).

Leśnica: Small exposures in the cropland and in local trenches and pits on the slopes of Mt. Kościółek (*see* location of the section *in* KUTEK 1968, Table 2; and herein Text-fig. 5). Two echinoids, one *Hemicidaris* species (*see* synonymy) and *Holectypus corallinus* D'ORBIGNY, were illustrated by JESIONEK-SZYMAŃSKA (1988, Pl. 174, Fig.1 and Pl. 175, Fig. 2).

Małogoszcz: Huge quarry, opened in the mid-seventies, exposing the section (*see* Text-fig. 6*A*) through almost the whole sequence studied by KUTEK (1968: section situated between Mt. Kościółek and Mt. Krzyżowa; *see* herein Text-fig. 5). The section (*see* Text-fig. 3) is presented in the referenced papers (KUTEK, MATYJA & WIERZBOWSKI 1992, Fig. 5; *see also* RADWAŃSKI 1995, Fig. 1 *and* MATYJA & WIERZBOWSKI 1996), as are the ubiquitous fossils (*see* SEILACHER, MATYJA & WIERZBOWSKI 1985; RADWAŃSKI 1995; MACHALSKI 1998), of which the echinoids were mentioned by KUTEK, MATYJA, RADWAŃSKI & WIERZBOWSKI (1992, p. 32).

Karsznice: Small exposures in the cropland and in rural pits on the slopes of Mt. Gorgolowa where the Pea-Grits are exposed (*cf.* Text-figs 4-5).

Sobków: Large, abandoned quarry on Mt. Galicowa, with the echinoid-bearing part of the exposed sequence being mainly the Pea-Grits (*cf.* Text-figs 4-5; *see also* PASTUSIAK 1987).

Under the same name of Sobków (*see* Table 1, asterisked) are listed two specimens of the two rare genera *Acropeltis* and *Glypticus* coming from a sister-quarry known as **Sobków-Wierzbica**, whose section was studied in detail by MATYJA, GUTOWSKI & WIERZBOWSKI (1989). The horizon of the echinoid occurrence, the oldest of all those studied, belongs to the basal part of the Holy Cross Platform (*see* Text-fig. 3, asterisked).

Niziny: Small field exposures noted by LEWIŃSKI (1912, p. 530) who recognized an occurrence site of the genus *Nucleolites* (called then *Echinobrissus*).

Korytnica: Section on the slopes of Mt. Łysa, along which the Miocene seashores with ubiquitous fossils developed (*see* RADWAŃSKI 1969, BAŁUK & RADWAŃSKI 1977), formerly studied *i.a.* by the present author (RADWAŃSKA 1982). First report on two echinoid taxa was given by ZEUSCHNER (1868a, b).

Karsy: Abandoned, small rural quarry, the exposed sequence of which represents a unique, very fossiliferous layer (*see* MACHALSKI 1983) of marly shell-hash limestones (*see* Text-fig. 6*D*) yielding the whole assemblage from this locality (*see* Table 1).

Górki: Small, local trenches (*see* SKOMPSKI 1976).

Gołuchów: Larger, now abandoned quarry (*see* Text-fig. 6*B*), the section of which was briefly noted by KUTEK (1968), and which has long been known due to the Miocene abrasion platform with ubiquitous borings of littoral echinoids (RADWAŃSKI 1969, pp. 81-82 and Pl. 30, Figs 1-2; *see also* SKOMPŚKI 1976).

Starochęciny = Przemianki = Mt. Leśna: Exposures over a cropland, from which one *Pygaster* species (*see* synonymy) was illustrated by JESIONEK-SZYMAŃSKA (1988, Pl. 175, Fig. 1).

Celiny: Small, abandoned quarry in the sequence of the Upper Oolite, one layer of which is profusely echinoid-bearing (*see* Text-fig. 6*C* and Table *1*), and from which a hardground truncating the Upper Oolite, and overlain by the Onkolite Horizon, was formerly described by KUTEK & RADWAŃSKI (1967).

Northeastern margin of the Holy Cross Mountains, Central Poland

Along the northeastern Mesozoic margin of the Holy Cross Mountains the echinoid-bearing strata are best exposed in two huge quarries of the cement plants, Wierzbica and Ożarów, as well as in a remote exposure at Annopol-on-Vistula, on the eastern bank of the Vistula, that is outside the Holy Cross region, already constituting the westernmost tip of the Lublin Upland. As studied recently by GUTOWSKI (1992, 1998), all the echinoid-bearing strata belong to the local lithostratigraphic units corresponding well to those established by KUTEK (1968) and listed above, as well as to the same ammonite zones, that is the Ataxioceras hypselocyclum Zone and the Katroliceras divisum Zone.

The lithofacies in which the echinoids were contained are similar to those occurring along the southwestern margin of the Holy Cross Mountains. These are more or less marly limestones, ranging from biocalcarenites through oolites and shellbeds to marlstones; in all those lithofacies the marl content is much greater, but the frequency of echinoids much lesser than in the former area.

Wierzbica: Huge quarry, with well exposed, very fossiliferous strata supplying diverse fossils (*see* GUTOWSKI 1992, 1998) of which special attention has hitherto been paid to terebratulid brachiopods (DZIK 1979) and ostreid bivalves (DZIK 1982; SEILACHER, MATYJA & WIERZBOWSKI 1985; MACHALSKI 1989, 1998).

Ożarów: Huge quarry, exposing the same strata as at Wierzbica; their faunal content may be referred to that known from older regional description of the area (SAMSONOWICZ 1934; *see also* GUTOWSKI 1992, 1998).

Annopol-on-Vistula (formerly known as **Rachów**): Small exposures, along the roadsides and city diggings or trenches, of marly oyster-hash conquinas, reported formerly by SAMSONOWICZ (1925, 1934). These Lower Kimmeridgian strata (*see* SAMSONOWICZ 1925, p. 55), covered by those not dated precisely (*see* SAMSONOWICZ 1925, 1934, p. 41; GUTOWSKI 1998), underlie here the well known mid-Cretaceous (Albian-Cenomanian) transgressive sequence with phosphorites (SAMSONOWICZ 1925, 1934; *see also* MARCINOWSKI & RADWAŃSKI 1983, pp. 72-73 and Fig. 6; MARCINOWSKI & WIEDMANN 1990, Fig. 4).

Western Pomerania, NW Poland

The famous, very fossiliferous sequence exposed at **Czarnogłowy** (in German literature: *Zarnglaff*) and nearby **Świętoszewo** (in German literature: *Schwanteshagen*) near Szczecin in Western Pomerania is known since 18*th* mid-century. All early reports (BRÜGGEMANN 1779-84, GUMPRECHT 1846, BOLL 1846, WESSEL 1851; *see* SCHMIDT 1905) were briefly reviewed by SCHMIDT (1905) who first noted the presence of the echinoids within a very rich faunistic assemblage of Czarnogłowy and other localities of Western Pomerania (*see* SCHMIDT 1905, pp. 94-127) containing 415 taxa of almost all animal phyla, plus one peculiar, but common plant, a dasycladacean *Goniolina*. Of these localities, besides Czarnogłowy and Świętoszewo, the echinoids referenced in the present paper were reported from **Trzebieszewo** (in German literature: *Tribsow*) and **Kłęby** (in German literature: *Klemmen bei Gülzow*), both situated near Szczecin, as well as from **Bardo** near Kołobrzeg (in German literature: *Bartin bei Kolberg*).

Extensive quarrying at Czarnogłowy since 1903 (*see* SCHMIDT 1905, p. 44; CZEKALSKA 1957,

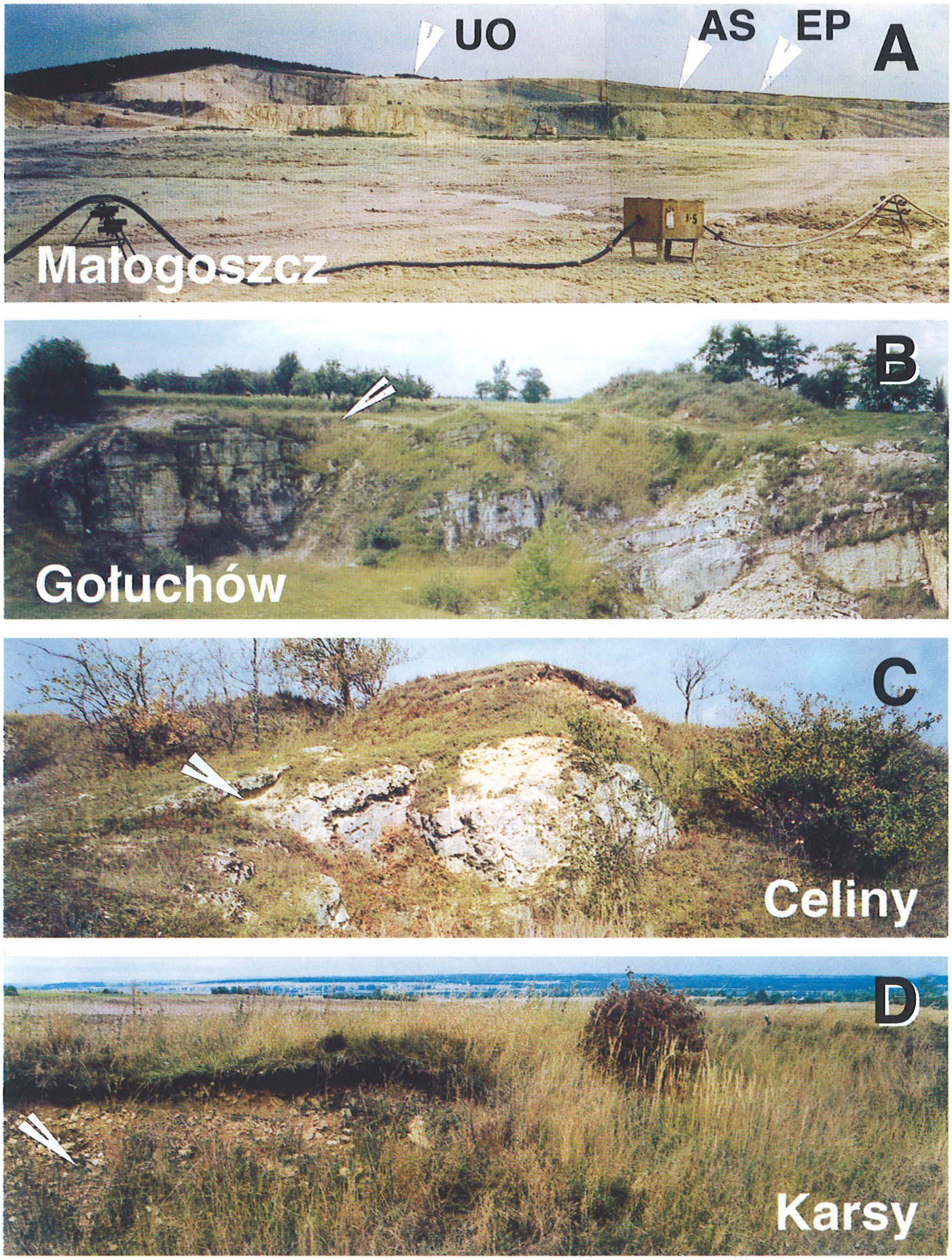


Fig. 6. Examples of the Lower Kimmeridgian echinoid-bearing exposures along the southwestern margin of the Holy Cross Mountains, Central Poland; detailed explanation in the text: **A** – Huge, working quarry at Małogoszcz; arrowed are the best echinoid-bearing strata of the Upper Oolite (*UO*), *Actinostreon* shellbeds (*AS*), and *Exogyra* marls with pea-grits (*EP*); **B** – Abandoned larger quarry at Gołuchów; arrowed is a layer of the echinoid-bearing marly pea-stone; **C** – Abandoned small quarry at Celiny; arrowed is a layer of the echinoid-bearing marly oolite; **D** – Abandoned small rural quarry over a cropland at Karsy; arrowed is a layer of the echinoid-bearing marly shell-hash limestone

p. 346) has soon made an access to ubiquitous fossils, the collections of which are still an unexhausted source of highly valuable material at a time when all the quarries have been abandoned after the 1960s.

The echinoids, primarily from SCHMIDT's original collection, were re-investigated by BEURLEN (1937), and subjected to a thorough monographic description by KONGIEL (1957).

Other monographs concern the ammonites (DOHM 1925, WILCZYŃSKI 1961), gastropods (DMOCH 1970), some bivalves, primarily ostreids (DMOCH 1970, PUGACZEWSKA 1971, DZIK 1982), brachiopods (DZIK 1979), and the above-indicated dasycladacean alga, *Goniolina hexagona* D'ORBIGNY, 1850, recently re-studied by CHERCHI & SCHROEDER (1992, 1993).

The lithofacies in which the echinoids were contained, are marls, marly limestones, ostreid marly shellbeds, and marly oolites; the latter are locally very poorly cemented, almost loose to form an oolitic sand, quite peculiar within the Lower Kimmeridgian bahamite sequence of the Pomeranian Platform.

SYSTEMATIC ACCOUNT

General characteristics of the accounted material

The systematically studied echinoid material, described below, is represented generally by emptied tests. In majority, the collected specimens are preserved relatively excellent as concerns the sculpture of the emptied test, but not as it does the rest of the skeleton. The state of the whole corona, with or without apical plates, lacking peristomial and periproctal plates, spines, and Aristotle's lantern realizes in almost all, except of about ten specimens (that is about 0.5% of the total). This state of preservation corresponds to the stage classified as (*b*) by SMITH (1984, p. 17 and Fig. 2.6*d*), as (*4*) by KIDWELL & BAUMILLER (1990, p. 249 and Fig. 2), or as illustrated in figure (*B*) by ZIEGLER (1998, Fig. 630). Generally, it is thus rather far from that recently recognized by the present author in the Eocene La Meseta Formation of the Seymour Island, Antarctica (RADWAŃSKA 1996).

In literature, an estimation of the length of time needed the test to be freed of spines, Aristotle's lantern and/or apical plates is much diversified. SMITH (1984, p. 17) speaks about the months, while seasons are claimed by KIDWELL & BAUMILLER (1990) who also indicated the rate of decomposition being dependant on temperature.

For the whole studied material, the timespan after the echinoids' death and before burial of their tests may be generally estimated as not very long, comparable to that indicated above as measured in months rather than seasons. This is inferred from a very low frequency of specimens encrusted by shelly epibionts, that need a few seasons to grow, although the grazing traces suggest the presence of non-skeletal overgrowths, most likely of algal origin (*see* a separate chapter). None of the specimens studied were encrusted and/or bored to an extent displayed by those illustrated by HESS (1975, Pl. 39, Fig. 11) or by SMITH (1984, Fig. 2.6*c*). On the other hand, it also happens that an overgrowth by ostreids *Exogyra* has been sufficiently fast to protect a *Rhabdocidaris* specimen from the lost of its apical-disc plates (*see* Pl. 3, Figs 3-3a).

In majority of occurrences, the collected echinoids are the adult individuals, and the juveniles and/or dwarfish specimens were recognized in one locality only (Czarnogłowy).

It is also to report that almost all studied specimens are regarded to be well-grown, healthy individuals of echinoids lacking any biogenic malformations and/or injuries caused by physical agents, or by predatory attacks (not uncommon in other echinoid assemblages; *see* SMITH 1984, pp. 11-14).

Diagenetic damages

Diagenetic damages in the collected material are manifested primarily by the compactional fracturing and/or partial compression of thin-walled tests. Of the irregular echinoids, this may concern either the phenotypic variants of one species (*e.g.* of *Pygaster tenuis* at locality Małogoszcz, as remarked hereafter) or the whole population recognized in one locality (*e.g. Nucleolites truncatus* at Celiny). In the regular echinoids this is displayed by the whole material of *Paracidaris smithi*, regardless its occurrence site, although it is advanced to a variable extent (vertical squeezing and collapse of the test at Wierzbica, disintegration into columnar fragments at Małogoszcz).

Within the grained sediments, especially in some sparry biocalcarenites and oolites, the collected echinoid tests (*e.g.* of *Nucleolites*) are "armored" by fine clasts due to pressure-solution (pitting) processes that develop in any matrix-free, grained deposits (*see* RADWAŃSKI 1965).

The Systematics used

The whole systematic scheme of the Class ECHINOIDEA Leske, 1778, used in this paper is of cladistic nature, to follow the successive attempts presented by Smith (1984) and Smith & Wright (1989, 1990, 1993, 1996). The systematics used in the *Treatise of Invertebrate Paleontology* (Durham 1966, Fell 1966), still of common use, is incoherent in many aspects, what has already been announced by the authors (*see* Durham 1966, pp. *U*281-*U*283).

The cladistic systematics seems to be much more clearly motivated and documented, although in some clads a further advance should certainly be postulated. This concerns primarily the clads rooted in the Jurassic period, because the scheme used by Smith (1984) and Smith & Wright (1989, 1990, 1993, 1996) is based mostly on the data yielded by the Cretaceous echinoids subjected to their thorough analysis. The Jurassic echinoids, especially of groups which dominated at that time, *e.g.* all regular ones (*see* Kier 1977), evidently bear an important potential for any systematics, and they should clearly be settled in the used scheme. At present, some genera of the regular echinoids studied, e.g. *Trochotiara*, *Gymnocidaris*, cannot be accommodated in definite families accepted by the cladistic systematics.

Repositories

Most of the echinoid material described hereafter is housed at the collection of the Department of Paleontology, Faculty of Geology, University of Warsaw. It is kept under the collection numbers preceded by the character **E** (echinoids), followed by lettered symbols of particular localities (*see* Table 1), as follows:

Sl – Sulejów, **Gr** – Gruszczyn, **Le** – Leśnica,
Ma – Małogoszcz, **K** – Karsznice,
So – Sobków *and* Sobków-Wierzbica,
Ni – Niziny, **Ko** – Korytnica, **Ka** – Karsy,
Go – Gołuchów, **Ce** – Celiny,
Wi – Wierzbica, **Oz** – Ożarów,
An – Annopol, **Cz** – Czarnogłowy.

The loaned specimens are indicated by the collection numbers of their mother institutions, as follows:

ZPAL – Institute of Paleobiology, Polish Academy of Sciences, Warsaw;

MUZ P.I.G. – Museum of the Geological Survey of Poland, Warsaw.

Descriptive abbreviations used

Throughout the systematic description of the species, in *Tables of dimensions*, the following abbreviations are used:

hd – horizontal diameter of the test,
vd – vertical diameter of the test,
∅Ad – diameter of the apical disc,
∅Pm – diameter of the peristome,
∅Pe – diameter of the periproct,
l – length (antero-posteriorly) of the test,
w – width of the test,
h – height of the test.

Class **ECHINOIDEA** Leske, 1778
Subclass **PERISCHOECHINOIDEA** M'Coy, 1849

Order **Cidaroida** Claus, 1880

REMARKS: The systematics of the order Cidaroida has been treated controversially by successive authors. Its historical account has recently been presented by Smith & Wright (1989) who offered a cladistic approach to classification of the Cidaroida (*see* Smith & Wright 1989, p. 12). Simultaneously, however, there also appeared two papers, published in a local journal by Vadet (1988, 1991) who undertook a revision of the Jurassic (Dogger, Oxfordian, Kimmeridgian) cidaroids of Europe. Based on a detailed biometry of tests and spines, Vadet (1988) established a series of new taxonomic families and genera, *i.a.* the new families Polycidaridae and Nenoticidaridae, to which the studied specimens from Poland could be assigned. Unfortunately, instead of hopeful intention of that author (Vadet 1988), his diagnoses of the families are very chaotic and unprecise because they encompass the features shared by the two above-indicated families; moreover, some of these features, *e.g.* the presence of plates arranged in two columns in the interambulacrum, are so basic that they may occur in many families. On the other hand, the diagnoses of the genera and their keys contain numerous (? typographic) errors and unclear statements that make the classification given by Vadet (1988, 1991) difficult for practical use. Such difficulties are exemplified by the generic assessment of the species *smithi* of Wright (1855), as discussed hereafter, in the description of the genus *Paracidaris* Pomel, 1883.

Family **Rhabdocidaridae** LAMBERT, 1900
Subfamily **Rhabdocidarinae** LAMBERT, 1900

Genus *Rhabdocidaris* DESOR, 1855

Rhabdocidaris nobilis (MÜNSTER, 1826)
(Pl. 1, Figs 1a-1b)

1826. *Cidarites nobilis* MÜNSTER; G. MÜNSTER, p. 117, Pl. 39, Figs 4a-4e; ? Figs 4f-4i.

?1840b. *Cidaris nobilis* MSTR.; L. AGASSIZ, p. 65, Pl. 21a, Fig. 21.

1847. *Cidaris nobilis* MÜNST. *in* GOLDF.; L. AGASSIZ & E. DESOR, p. 28.

1855. *Rhabdocidaris nobilis* MÜNSTER *in* GOLDFUSS; E. DESOR, p. 40, Pl. 8, Fig. 10.

1929. *Rhabdocidaris Desori* nov.spec.; A. JEANNET, pp. 26-28, Text-figs 13-14.

1929. *Rhabdocidaris* cfr. *Desori* nov.spec.; A. JEANNET, p. 28, Text-fig. 4, Pl. 3, Fig. 10.

1929. *Rhabdocidaris nobilis* MÜNSTER (*Cidarites*); A. JEANNET, pp. 30-35, Pl. 2, Figs 8-10; Pl. 4, Figs 3-4 and 13; Pl. 5, Figs 19-24.

1929. *Rhabdocidaris Orbignyiformis* nov.spec.; A. JEANNET, pp. 35-37, Pl. 4, Figs 5-6; Pl. 5, Figs 28-30 and 37-39.

1929. *Rhabdocidaris Cotteaui* nov.spec.; A. JEANNET, pp. 37-39, Text-fig. 17 and Pl. 4, Figs 7-9; Pl. 5, Figs 31-33 and 41-43.

1929. *Rhabdocidaris rauraca* nov.spec.; A. JEANNET, pp. 39-40, Pl. 4, Figs 10-12; Pl. 5, Figs 16-18.

1929. *Rhabdocidaris Stingelini* nov.spec.; A. JEANNET, p. 41, Pl. 2, Fig. 11; Pl. 5, Figs 34-36.

1971. *Rhabdocidaris nobilis* (MÜNSTER); M. WIŚNIEWSKA-ŻELICHOWSKA, p. 57, Pl. 33, Figs 10-13 and Pl. 34, Figs 1a-1b.

1975. *Rhabdocidaris nobilis* (MÜNSTER); H. HESS, p. 88, Pl. 30, Fig. 4.

?1988. *Rhabdocidaris nobilis* (MÜNSTER, 1826); A. VADET, pp. 134-136, Pl. 22, Figs 1-3.

MATERIAL: 6 broken tests from Sobków, 2 well preserved tests from Małogoszcz.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
EMa/1	57	28	21.5	—	Pl. 1, Figs 1a-1b
EMa/94	52	29	23.5	24.0	—

DESCRIPTION: **The tests** are circular, moderately high, flattened above and below (*see* Pl. 1, Figs 1a-1b).

The ambulacra (*see* Pl. 1, Fig. 1a) are slightly sinuate. The interporiferous zone is a bit wider than the pore zone. Marginal series of tubercles are regular, contiguous; the bosses of the tubercles slightly flattened and concave at the contact with the pore zone. Each plate carries one or two tubercles, about half size of the marginal one; these tubercles form a fairly distinct inner, second series placed near the perradial suture. The median space is furnished with one or two tubercles. These tubercles form the third regular, longitudinal series. Below the inner pores, there are three or four, crowded, small tubercles. The pores are conjugate, connected by a distinct furrow. The pores are large and equal in size; they both are amygdaloid in outline. Pore pairs are surrounded by a distinct wall; sometimes, at the lower edge of this wall one or two small tubercles are developed.

The interambulacra (*see* Pl. 1, Fig. 1a) are wide, the plates numbering 6-7 in a series; the areoles are large and shallow, well separated, nonconfluent, circular in outline, except of the lowermost ones, slightly transverse-oval. The perforate tubercles are moderately large, the bosses are distinctly crenulate. The scrobicular tubercles (*see* Pl. 1, Fig. 1a) are not very prominent; the adapical and adoral miliary zones are present, and the miliary zone is especially well developed at the uppermost plates (*see* Pl. 1, Fig. 1a). The admedian zone is wide and closely covered by very fine miliary tubercles decreasing in size towards the sutures (*see* Pl. 1, Fig. 1b).

The apical disc (*see* Pl. 1, Fig. 1b) is moderately large, 37% of the test diameter, circular in outline.

The peristome is subpentagonal in outline, nearly as large as the apical disc.

REMARKS: The studied specimens have all the features diagnostic of the species *Rhabdocidaris nobilis* (MÜNSTER, 1826), namely fine ornamentation, inconspicuous scrobicular tubercles, wide subapical and admedian miliary zones, and wide interporiferous zone with 6 rows of tubercles. The species *Rhabdocidaris nobilis* (MÜNSTER, 1826) is close to the type species of the genus, *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840). Both species have similar test shape, general ornamentation and proportion between interambulacral and ambulacral zones. However, *Rh. nobilis* (MÜNSTER, 1826) differs from *Rh. orbignyana* mainly by its fine ornamentation, inconspicuous scrobicular rings, wider miliary zones, and by an interporiferous zone with 6 rows of tubercles.

The synonymy of the species includes numerous species established by JEANNET (1929) as new: "*Rh. desori, Rh.* cf. *desori, Rh. orbignyiformis, Rh. cotteaui, Rh. rauraca,* and *Rh. stingelini*". It is worth to note that all these species were established on very scare material (often on one specimen) and, in the present author's opinion, differences in height of the test or density of ornamentation, indicated by JEANNET (1929), fall into intraspecific variability. On the other hand, JEANNET's (1929) interpretation of the ambital interporiferous zones of the species *Rhabdocidaris desori*, *Rh.* cf. *desori*, and *Rh. cotteaui* (*see* JEANNET 1929, Text-figs 1 *and* 4; Pl. 5, Fig. 32) is in the present author's opinion, erroneous, because there are six ranges of tubercles instead of four or two detected by JEANNET.

VADET (1988) in his revision of the two *Rhabdocidaris* species, *Rh. orbignyana* and *Rh. nobilis*, took into account only a part of the material described by the former authors; his revision therefore remains incomplete and, in some cases, highly unclear. This particularly concerns the material monographed by JEANNET (1929); to exemplify, in the synonymy of the species *Rh. nobilis*, VADET (1988, p. 134) included only one of the specimens (complete test) of the species *Rh. orbignyiformis* illustrated by JEANNET (1929, Pl. 4, Fig. 6), without any comment on the other one (*see* JEANNET 1929, Pl. 4, Fig. 5) and, of the drawings of the ambulacral zone, he included only the detail of the non-commented specimen (*see* JEANNET 1929, Pl. 5, Figs 28-30), but omitted that (*see* JEANNET 1929, Pl. 5, Figs 37-39) of the test just-taken into synonymy [sic!].

The specimens illustrated by VADET himself (1988, Pl. 22, Figs 1 *and* 3) as *Rh. nobilis* (MÜNSTER) are herein put into synonymy with a question mark, because they deviate from the diagnosis of the species, accepted by VADET (1988, p. 135); they have conspicuous scrobicular tubercles, a narrow admedian miliary zone, and an undeveloped ambital miliary zone.

Finally, with a question mark included in the synonymy is the specimen figured as a line-drawing by AGASSIZ (1840b), and re-figured in the form of a photo by JEANNET (1929, Text-fig. 15); the latter photographic illustration shows a damaged specimen, superficially corroded, the diagnostic specific features of which cannot be recognized with certainty.

This species has already been illustrated from Poland, by WIŚNIEWSKA-ŻELICHOWSKA (1971), from the Oxfordian of Rudniki near Częstochowa (Polish Jura).

Rhabdocidaris orbignyana (L. AGASSIZ, 1840)
(Pl. 1, Figs 2-4 and Pls 2-4)

1840a. *Cidaris Orbignyana* AG.; L. AGASSIZ, p. 10.
1847. *Cidaris Orbignyana* AGASS.; L. AGASSIZ & E. DESOR, p. 28.
1855. *Rhabdocidaris Orbignyana*; E. DESOR, p. 40, Pl. 1, Fig. 3 and Pl. 8, Figs 7-9.
?1869. *Rabdocidaris caprimontana*, DESOR; E. DESOR & P. DE LORIOL; p. 65, Pl. 9, Figs 5-11.
1872. *Rabdocidaris caprimontana* DESOR; E. DESOR & P. DE LORIOL; p. 393, Pl. 61, Fig. 1.
1890. *Rhabdocidaris orbignyana* (AGASSIZ) DESOR; P. DE LORIOL, p. 34, Pl. 4, Figs 5-17.
1910. *Rhabdocidaris Orbygnyi* AGASSIZ; J. LAMBERT & P. THIÉRY, p. 136.
1926. *Rhabdocidaris Orbignyi* AGASSIZ; J. LAMBERT, pp. 755-759, Pl. 29, Fig. 1.
1929. *Rhabdocidaris Orbignyi* AGASSIZ; A. JEANNET, p. 19, Text-figs 2-3 and 10-12, Pl. 3, Figs 1-6; Pl. 5, Figs 1-9, 13-15, 51-57.
1961. *Rhabdocidaris orbignyi* AG.; W. BARCZYK, p. 69, Pl. 4, Fig. 1.
1975. *Rhabdocidaris orbignyana* (AGASSIZ); H. HESS, p. 88, Pl. 29, Figs 1a-b and Pl. 30, Figs 1-2.
1988. *Rhabdocidaris orbignyana* AGASSIZ *in* DESOR, 1856; A. VADET, p. 132, Pl. 21, Figs 1-2; ?Pl. 22, Fig. 4; Pl. 23, Figs 1-3, and Pl. 24, Fig. 2.

MATERIAL: 215 well preserved tests from Małogoszcz, 13 from Karsy, 9 from Gołuchów, 3 from Sulejów, and 3 fragments from Celiny.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	*∅Pe*	Figured in:
EMa/15	74.2	46.1	31.0	30.0	—	Pl. 2, Fig. 11
EMa/13	60.0	35.4	26.5	25.0	—	Pl. 2, Fig. 9
EMa/16	54.2	33.7	25.8	24.2	—	Pl. 3, Figs 1a-1c
EMa/4	52.0	33.4	21.7	21.0	—	Pl. 1, Figs 4a-4b
EMa/18	50.8	31.8	24.5	21.4	12.0	Pl. 3, Figs 3-3a
EMa/2	40.0	23.8	18.0	18.0	—	Pl. 1, Figs 2a-2c
EMa/17	42.3	26.0	17.6	18.0	—	Pl. 3, Figs 2a-2b
EMa/14	33.5	19.0	13.5	—	—	Pl. 2, Figs 10a-10c

DESCRIPTION: **The tests** are circular, high, flattened above and below, with strongly swollen interambulacra.

The ambulacra (*see* Pl. 1, Figs 2c, 3a, 4b, *and* Pl. 3, Figs 1b, 2b) are slightly sinuate. The interporiferous zone is (*see* Pl. 4, Figs 1a, 1c, 2, 3a) as wide as the pore zone. Marginal series of tubercles are regular; the bosses of these tubercles are slightly flattened and concave at the contact with the pore zone. Each plate carries one or two small tubercles (*see* Pl. 4, Figs 1a, 1c, 3b), about half the size of the marginal one; these tubercles form a fairly distinct inner second series placed near the perradial suture. Even in the largest specimens (*see* Pl. 4, Fig. 2) there appears no distinct third longitudinal series. Tubercles of these series are very small and placed near the adapical and adoral sutures of each plate. Below the perradial pores, there are two or three, crowded, small tubercles (*see* Pl. 4, Figs 3b, 1c). The conjugate pores represented by *C1* isopores (*see* Pl. 4, Figs 1b, 1c, 1d, 1e), are connected by the narrow furrow. The pores are relatively large and slightly unequal in size; the perradial ones are circular in outline, the adradial ones are slightly larger and amygdaloid in outline.

The interambulacra (*see* Pl. 1, Fig. 2a) are wide, the plates numbering 6-8 in a series; the areoles are large and shallow, well separated, nonconfluent, circular in outline, except of the lowermost ones transverse-oval. The perforate tubercles are moderately large, the bosses are distinctly crenulate. The scrobicular tubercles (*see* Pl. 1, Figs 2a, 2c *and* Pl. 3, Fig. 2b) are conspicuous; the adapical and adoral miliary zones are not developed, only at the uppermost plates the miliary adapical zone is weakly developed (*see* Pl. 1, Figs 2b, 3b, 4a; Pl. 2, Figs 9-11, *and* Pl. 3, Figs 1a, 2a). The admedian zone is moderately wide and closely covered by miliary tubercles decreasing in size towards the sutures.

The apical disc (*see* Pl. 3, Fig 3-3a) is flat, large, 51% of the test diameter, dicyclic, slightly pentagonal in outline. Periproctal opening is large. The ocular plates are exsert. The genital plates are large, with genital pores fairly distant from the outer edge. The whole of the apical disc is closely covered with tubercles of uniform size.

The peristome is subpentagonal in outline, nearly as large as the apical disc (*see* Pl. 3, Fig. 1c).

The primary spines (*see* Pl. 2, Figs 1-8 *and* Figs 10a-10c) are large, and spatulate (bladed). The shaft is flattened (from one side more strongly), and ornamented by longitudinal, distinct rims, and longitudinally arranged granules. The neck is short, and marked with fine longitudinal striations; the collar is shorter than the neck; the milled ring is distinctly developed.

REMARKS: The studied specimens, due to their ornamentation (conspicuous scrobicular tubercles, weakly developed adapical and admedian miliary zones), as well as four rows of tubercles on the interporiferous zone, fit well into diagnostic features of the species *Rhabdocidaris orbignyana* (AGASSIZ, 1840). It is noteworthy that all the studied, very rich material, is represented by small, or moderately sized, specimens (the largest attains 74mm of diameter).

Within the studied material one specimen from Małogoszcz (*see* Pl. 3, Figs 3-3a) retains its apical disc in position (all ocular and genital plates are preserved); to the present author's knowledge this is the first report on the apical disc of this species, and of the genus *Rhabdocidaris*.

Moreover, one of the specimens (*see* Pl. 2, Figs 10a-10c) contains a part of its spine-coat *in situ*; there are primarily secondary spines, associated with four small primary spines on the oral side. Primary spines preserved *in situ* have so far been demonstrated only by JEANNET (1929, Pl. 3, Fig. 4).

In the synonymy of the species *Rh. orbignyana* (AGASSIZ,1840), should certainly be included the specimens described by DESOR & DE LORIOL as "*Rabdocidaris caprimontana* DESOR". The tests of this latter species have already been included in the species *Rh. orbignyana* by JEANNET (1929, p. 20). The specimens illustrated by DESOR & DE LORIOL (1869, Pl. 9, Figs 5-11) are herein put into the synonymy with a question mark, because their preservation does not allow to precise their specific assignment.

This species has already been reported from Poland, firstly by ROEMER (1870) who figured only one primary spine, as "*Rhabdocidaris caprimontana*", from the Oxfordian of Bzów in the Polish Jura (*see also* SIEMIRADZKI 1893), and secondly by BARCZYK (1961, Pl. 4, Fig. 1) from the studied locality Sulejów.

Rhabdocidaris sp.
(Pl. 49, Figs 1a-1b)

MATERIAL: One test from Małogoszcz.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	Figured in:
EMa/94	27.0	12.6	13.3	Pl. 49, Figs 1a-1b

DESCRIPTION: **The test** is small, circular in outline, low, flattened aborally and adorally (*see* Pl. 49, Fig. 1a).

The ambulacra are strongly sinuate (*see* Pl. 49, Fig. 1a). The interporiferous zone is somewhat wider than the pore zone. There are four rows of tubercles, the marginal ones of which are contiguous, and somewhat larger than the inner ones. Close to the adoral sutures, there are small, two or three granules. Pores are conjugate, relatively small and equal in size; both are circular in outline.

The interambulacra are wide, and composed of four large plates in a series only; the areoles are nonconfluent, circular in outline, large and shallow. The primary tubercles are perforate and strongly crenulate. At the ambitus, scrobicular rings are composed of 13 widely spaced and not very prominent scrobicular tubercles. The adapical and adoral miliary tubercles are well developed, especially on the uppermost plates. The admedian zone is narrow and covered by sparse, elongated miliary tubercles.

The apical disc is not preserved (*see* Pl. 49, Fig. 1b).

REMARKS: The studied specimen is close to those of the species *Rhabdocidaris orbignyana* (AGASSIZ, 1840), from which it differs by its lower test, less numerous interambulacral plates per column (only 4), and the more sinuous ambulacra. The very limited material justifies its assignment to the genus level only.

Such a form has not hitherto been reported from Poland.

Subfamily **Histocidarinae** MORTENSEN, 1928
Tribe **Histocidarini** MORTENSEN, 1928

Genus *Paracidaris* POMEL, 1883

Paracidaris smithi (WRIGHT, 1855)
(Pl. 5, Figs 1-5a)

1855. *Cidaris Smithii*, WRIGHT, nov.sp.; T. WRIGHT, p. 50, Pl. 2, Figs 1a-1e, and Pl. 4, Figs 5a-5e.

1855. *Cidaris boloniensis*, WRIGHT; T. WRIGHT, p. 53, Pl. 12, Figs 5a-5b.

1884. *Rhabdocidaris bononiensis*, COTTEAU, 1868; G. COTTEAU, p. 816, Pl. 491, Figs 6-11.

1890. *Cidaris blumenbachi* MÜNSTER; P. DE LORIOL, p. 18, Pl. 3, Figs 2-3.

1988. *Nenoticidaris smithii* (WRIGHT 1857); A. VADET, p. 111, Text-figs 23-25 and Pl. 6, Figs 1-2; Pl. 7, Figs 1-4.

1989. *Nenoticidaris smithii* (WRIGHT); A. VADET, pp. 50-52.

MATERIAL: One broken, flattened test (without apical part) from Wierzbica, 16 loose interambulacral plates (one with associated ambulacral plates) from Wierzbica; four fragments of interambulacra, three of which are with ambulacral plates, from Małogoszcz.

DESCRIPTION: **The test** is circular, moderately high, fragile.

The ambulacra (*see* Pl. 5, Figs 1-2) are almost straight. Interporiferous zone wider than the pore zone of the plate, at the ambitus; pores are moderately large, nonconjugate, separated by large, conspicuous rim; this rim is longer than the diameter of the pore (*see* Pl. 5, Figs 5-5a). In the pore pair the inner pore is round in outline, but the outer one is oblong. One pore pair is alternately associated with one, large tubercle, or with four small tubercles; these tubercles give characteristic, regular ornamentation on the interporiferous zone of the ambulacra. The adoral ambulacral tubercles, numbering about 10, are slightly perforate. There are 13 ambulacral plates to each interambulacral plate at the ambitus (*see* Pl. 5, Fig. 5).

The interambulacra are wide, the plates numbering 8-9 in a series; areoles (*see* Pl. 5, Figs 2-4) are large, moderately deep, oval in outline, conspiciously lower than broad; adapical and ambital areoles are contiguous, adoral (3-4 proximal ones), become almost confluent, and more oval in outline; scrobicular ring of tubercles is very narrow (*see* Pl. 5, Fig. 4). The primary tubercles are small, perforate, distinctly crenulate. Scrobicular tubercles are small and bear very small mamelons. Secondary tubercles are circular in outline and decreasing in size towards the sutures. Miliaries are developed only on the admedian and adradial part of the plates (*see* Pl. 5, Fig. 4), and they are wedged between the scrobicular and secondary tubercles. Admedian part of the plate is narrow. Admedian sutures are slightly incised.

REMARKS: The studied specimens are concordant with the syntypes of the species, illustrated by WRIGHT (1855, Pl. 2, Figs 1a-1e; *see also* VADET 1988, Pl. 7, Figs 3-4). The only, indinstinct, difference concerns the width of the interradial zone, which is smaller in the studied specimens; however, this certainly results from their smaller size.

A more important problem lies in the generic assessment of the discussed species. LAMBERT &

THIÉRY (1925) assigned it to genus *Paracidaris* POMEL, 1883, whereas VADET (1988) accommodated it into his new genus *Nenoticidaris* VADET, 1988. When a relatively very low diagnostic potential of the test and primary spine parameters in the cidaroid echinoids is taken into account, these two traits need a discussion.

If the genus *Paracidaris* POMEL, 1883, is treated widely, to include the species with circular and oval areoles, nonconfluent throughout or almost confluent adorally, scrobicular tubercles of variable size (from these of a diameter near that of the secondary ones, to those distinctly larger), and primary spines relatively long with fine thorns in longitudinal rows, or fusiform with small granules, then the species *smithi* falls well into this very genus. In such a way, *Paracidaris smithi* should be regarded, within that genus, as an extreme species, bearing oval areoles almost confluent adorally, small scrobicular tubercles not much larger than the others on a plate, and long primary spines ornamented with fine thorns in longitudinal rows. [Due to these features, the discussed species is close to those of the genus *Histocidaris* MORTENSEN, 1928]. The opposite extreme of the genus *Paracidaris* POMEL, 1883, should thus be recognized in its type species, *Paracidaris florigemma* (PHILLIPS, 1835), with areoles evidently nonconfluent throughout, relatively large scrobicular tubercles, and fusiform primary spines. The transitional forms should consequently be indicated in specimens constituting the species *Paracidaris blumenbachi* (MÜNSTER, 1826).

On the other hand, if the genus *Paracidaris* POMEL, 1883, is treated as a taxon of small variability range (of scrobicular-tubercle size, shape of spines), then the recognition of the genus *Nenoticidaris* VADET, 1988, is justified, to comprise all the species with small scrobicular tubercles, and long primary spines with longitudinal rows of fine thorns.

In the present author's estimation, the assignation of the species *smithi* WRIGHT, 1857, to the genus *Paracidaris* POMEL, 1883, as originally proposed by LAMBERT & THIÉRY (1925), is well substantiated.

Such very treatment is supported by the analysis of test and spine characters in the present-day species of the genus *Histocidaris* MORTENSEN, 1928. As given by MORTENSEN (1928, pp. 70-102), a relatively high variability is demonstrated both by the tests (overall shape and depth of areoles, size of scrobicular tubercles), and by the primary spines (straight elongated, or short fusiform). It is therefore apparent that none of these features are of diagnostic value, to distinguish separate taxa at the genus level. Consequently, the systematics proposed by VADET (1988, 1991) is regarded to concern the morphological categories (morphotypes) and not the taxonomic ranks.

In the present author's opinion, the basic features of tests in all species of the genus *Paracidaris* POMEL, 1883, indicate that it should be classified close to the genera *Histocidaris* MORTENSEN, 1928, and *Plegiocidaris* POMEL, 1883, and it should be included in the subfamily Histocidarinae MORTENSEN, 1928. The subfamily Histocidarinae MORTENSEN, 1928, is herein accommodated within the family Rhabdocidaridae LAMBERT, 1900, to follow the treatment by SMITH & WRIGHT (1989), and not within the family Cidaridae GRAY, 1825, as formerly proposed by FELL (1966).

Histocidarinae, gen. et sp. indet.
(Pl. 5, Figs 6-11)

MATERIAL: 30 fragments of spines from Wierzbica, one spine from Małogoszcz.

The primary spines (*see* Pl. 5, Figs 6-11) represent three morphological types: (1) long cylindrical, (2) long slightly flattened, (3) or relatively short, distinctly flattened. On the long cylindical spines the shaft is ornamented with short, obliquely set and loosely spaced thorns, associated with longitudinally arranged granules (*see* Pl. 5, Figs 6-7). On the long, slightly flattened spines the shaft is ornamented with closely spaced thorns arranged in longitudinal rows (*see* Pl. 5, Figs 8-9). On the distinctly flattened spines (?oral primaries) the shaft is ornamented with a double series of strong serration (developed on both sides of the shaft), and between these serrations there are five longitudinal rows of spines (*see* Pl. 5, Figs 10-11). The inner side of the shaft, directed towards the peristome, may be smooth in some specimens. The neck is moderately long, and marked by longitudinal striations. The milled ring is well developed, and the base is relatively short.

REMARKS: The studied fragments, due to their ornamentation, overall shape and proportions, fit well into the features of primary spines of cidaroids of the subfamily Histocidarinae MORTENSEN, 1928.

As stated above, the collected material comprises three types of primary spines, the different shape of which was probably induced by their function. The long, cylindrical or slightly flattened, primary spines indicate an adapical position on the test, the distinctly flattened ones an adoral position.

Such different types of the primary spines on one test are observable (*see* MORTENSEN 1928, pp. 70-102) in many present-day species of the genus *Histocidaris* MORTENSEN, 1928.

Nevertheless, since all the studied spines were found isolated, they cannot be assigned to a definite species, or group of species. Moreover, their attribution to the species *Paracidaris smithi* (WRIGHT, 1855) cannot be proven, as the few illustrations hitherto presented (*see* WRIGHT 1855, Pl. 4, Figs 5a-5e; VADET 1988, Pl. 6, Fig. 1 *and* Pl. 7, Fig. 2) show different forms.

Tribe **Poriocidarini** MORTENSEN, 1909

Genus *Plegiocidaris* POMEL, 1883

Plegiocidaris crucifera (L. AGASSIZ, 1840)
(Pl. 6, Figs 1-4 and Pl. 7, Figs 1-3)

1840a. *Cidaris crucifera* AG.; L. AGASSIZ, p. 10.
1840b. *Cidaris crucifera* AG.; L. AGASSIZ, p. 61, Pl. 21, Figs 1-4.
1840b. *Cidaris cervicalis* AG.; L. AGASSIZ, p. 77, Pl. 21a, Fig. 10.
1988. *Plegiocidaris crucifera* (AGASSIZ, 1840); A. VADET, pp. 122-128, Pls 15-17, and Pl. 18, Figs 1-3.
1996. *Plegiocidaris crucifera* (AGASSIZ 1840); A. VADET, P. NICOLLEAU & J.P. PINEAU, p. 26, Pl. 5, Text-figs 33-34 and Pl. 5, Figs 1a-1c, 2.

MATERIAL: Six well preserved tests, four test fragments, and one broken spine; all from Małogoszcz.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
EMa/26	37.0	21.6	17.0	17.0	Pl. 6, Figs 2a-2b
EMa/27	35.5	20.0	18.5	16.5	Pl. 6, Figs 3a-3c
EMa/25	22.0	11.6	11.5	11.0	Pl. 6, Figs 1a-1c

DESCRIPTION: **The tests** are circular, moderately high (*see* Pl. 6, Figs 1-3).

The ambulacra (*see* Pl. 6, Figs 1a, 3b, 4) are strongly sinuate. The interporiferous zone is twice as wide as the pore zone of the plate (*see* Pl. 6, Fig. 4 *and* Pl. 7, Fig. 2). The large primary tubercles form regular, marginal series; the bosses of these tubercles are large and swollen, mamelons are flat and positioned eccentrically on the bosses. Each ambulacral plate carries one or two secondary tubercles (*see* Pl. 6, Fig. 4 *and* Pl. 7, Fig. 2), about of the half a size of the marginal one; these tubercles form distinct inner second series placed near the perradial suture. Wedged between marginal and inner tubercle is the third, small tubercle. All interporiferous tubercles are crowded together. The pores (*see* Pl. 6, Fig. 4a *and* Pl. 7, Fig. 2a) are nonconjugate, separated by a conspicuous rim, which decreases in size towards the apical and adoral side. Pores are large, circular in outline; below the inner one the neuropore is developed (*see* Pl. 7, Fig. 2a). The pore pair represents isopores of the type P1, distinguished by SMITH (1978, p. 764). There are 18 ambulacral plates to each interambulacral plate at the ambitus.

The interambulacra (*see* Pl. 6, Fig. 2b) are wide, the plates numbering 5 in a series; areoles are circular in outline, moderately deep. Primary tubercles are very large, perforate and noncrenulate. Scrobicular ring of tubercles is conspicuous; scrobicular tubercles are large, bearing (*see* Pl. 7, Fig. 1) very well developed mamelons. Secondary tubercles are large, but smaller than the scrobicular ones; they decrease in size towards the interradial suture. Miliaries are dispersed between the secondary tubercles. The interradial sutures are incised.

The apical disc (*see* Pl. 6, Figs 1b, 2a, 3a) is large, about 55% of the test diameter.

The peristome (*see* Pl. 6, Figs 1c, 3c) is large, subpentagonal in outline, about 48% of the test diameter.

The primary spine (*see* Pl. 7, Figs 3a-3b) is relatively short, cylindrical, and roundly pointed; the shaft (this part is preserved only) is ornamented with longitudinal, densely arranged granules or very short spines.

REMARKS: The studied specimens belong evidently to the genus *Plegiocidaris* POMEL, 1883, within which new taxonomic criteria have recently been established by VADET (1988). According to these criteria the studied specimens are assigned to *Plegiocidaris crucifera* (AGASSIZ, 1840). The synonymy of this species is however far from clear, because the criteria used by VADET (1988) for the distinction of test features (*e.g.* the presence of isopores of the types *P1* or *P2* at the ambitus, the size of scrobicular mamelons) can hardly, if ever, be recognized in older illustrations. The herein presented synonymy is therefore much abbreviated, and includes only the specimens illustrated by the author of the species, that is AGASSIZ (1840), as well as those discussed by the thorough revisor (of the species), namely VADET (1988, pp. 122-128), to whose paper the readers are addressed.

The two species commonly reported from various European countries, *e.g.* from the Swiss Jura by HESS (1975), *Plegiocidaris cervicalis* (AGASSIZ, 1840) and *Plegiocidaris propinqua* (MÜNSTER, 1826) are considered by VADET (1988) to be synonyms of *Plegiocidaris crucifera* (AGASSIZ, 1840).

Subclass **Euechinoidea** BRONN, 1810
Infraclass **Acroechinoidea** SMITH, 1981
Cohort **Diadematacea** DUNCAN, 1889
Order **Pedinoida** MORTENSEN, 1939
Family **Pedinidae** POMEL, 1883

Genus *Pedina* L. AGASSIZ, 1838

Pedina sublaevis L. AGASSIZ, 1840
(Pl. 7, Fig. 4 and Pl. 8, Figs 1-2)

1840a. *Pedina sublaevis* AG.; L. AGASSIZ, p. 9.
1840a. *Pedina aspera* AG.; L. AGASSIZ, p. 9.
1840b. *Pedina sublaevis* AG.; L. AGASSIZ, p. 34, Pl. 15, Figs 11-13.
1840b. *Pedina aspera* AG.; L. AGASSIZ, p. 34, Pl. 15, Figs 8-10.
1847. *Pedina sublaevis* AGASS.; L. AGASSIZ & E. DESOR, p. 66.
1855. *Pedina sublaevis* AGASS.; E. DESOR, p. 101, Pl. 16, Figs 11-13.
1872. *Pedina sublaevis*, AGASSIZ; E. DESOR & P. DE LORIOL, p. 238, Pl. 40, Figs 1-4.
1872. *Pedina aspera* AG.; W. DAMES, p. 617, Pl. 22, Fig. 2.
1884. *Pedina sublaevis*, AGASSIZ, 1840; G. COTTEAU, p. 646, Pls 431-434.
1937. *Pedina sublaevis* AGASSIZ; K. BEURLEN, p. 37, Text-figs 3-4.
1975. *Pedina sublaevis* AGASSIZ; H. HESS, p. 90, Pl. 31, Fig. 1.
1996. *Pedina sublaevis* AGASSIZ, 1840; A. VADET, P. NICOLLEAU & J.P. PINEAU, p. 48, Text-figs 55-56 and Pl. 12, Figs 1-2.

MATERIAL: Three well preserved tests from Małogoszcz, one from Celiny.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
EMa/32	57.0	25.0	13.0	14.0	Pl. 8, Figs 2a-2b
EMa/30	38.0	17.0	10.0	10.0	Pl. 7, Figs 4a-4c
EMa/31	33.0	17.0	9.0	9.0	Pl. 8, Figs 1a-1c

DESCRIPTION: **The tests** are circular (rotular) in outline, depresssed and wheel-shaped in profile (*see* Pl. 7, Fig. 4b *and* Pl. 8, Figs 1b, 2c).
The ambulacra are stright, tapering both adapically and adorally, but adapically much more. Ambulacral plates are all trigeminate, with all three elements reaching the perradial suture. Pore pairs are arranged in arcs, most prominently from the ambitus to the peristome. Each compound plate bears a single, noncrenulate, perforate primary tubercle of different diameter. Primaries are arranged in characteristic order, every third plate with its primary tubercle larger than two following; however, at the ambitus, only one small primary tubercle separates two large ones. Primary tubercules are large and occupy most of the plate, but areoles are separated. Primary tubercles decrease in size gradually towards the apex and the peristome. Primaries are surrounded by small scondary tubercles.
The interambulacra are three times as wide as the ambulacra, and are much less tapered both adapically and adorally. Primary tubercles which are noncrenulate and perforate, as in the ambulacra, decrease in size gradually towards the apex and the peristome. Primary tubercles are small and positioned just above on the adoral plate suture, and near the adradial suture. Smaller secondary tubercles form two additional columns, one near the interradial suture, and the other near the adradial suture. Secondary tubercles occur both on the oral and aboral side of the test, but on the ambital and adoral plates they are much better developed. The latter plates carry an assortment of small tubercles and miliaries.
The apical disc (*see* Pl. 7, Fig. 4a *and* Pl. 8, Figs 1a, 2a) is small, dicyclic. Periproct is circular, large, positioned centrally. Genital plates are broad, covered by 3 or 4 well developed tubercles surrounding the periproct. Ocular plates are small, narrow and distinctly separated from the periproct.
The peristome is small, about 24-27% of the test diameter. Buccal slits are shallow, but well formed (*see* Pl. 7, Fig. 4c *and* Pl. 8, Figs 1c, 2b).

REMARKS: The studied specimens are concordant with those given in the synonymy. To the synonymy of the species included are, to follow a treatment of former authors (DESOR & DE LORIOL 1871, COTTEAU 1884), the specimens discussed by L. AGASSIZ, who first (1840a) distinguished them as *Pedina aspera*, but soon after (AGASSIZ 1840b, pp. 34-35) doubted their specific separateness from *Pedina sublaevis*.

Cohort **Echinacea** Claus, 1876
Superorder **Stirodonta** Jackson, 1912
Family **Pseudodiadematidae** Pomel, 1883

Genus *Pseudodiadema* Desor, 1855

REMARKS: The genus *Pseudodiadema* was established by Desor (1855) and included numerous species (*see* Wright 1855-1859, Cotteau 1880-1885), which were afterwards transferred (*see* Fell & Pawson 1966, Smith & Wright 1993) to other genera, such as i.a. *Polydiadema*, *Tetragramma*, and *Trochotiara*.

In the present author's opinion, the species described below, *tetragramma* of Agassiz (1840a), with its dicyclic apical disc, uniserial pore zone, crenulate and perforate tubercles, should be retained in the genus *Pseudodiadema*, according to the first assignment by Desor (1855).

Pseudodiadema tetragramma (L. Agassiz, 1840)
(Pl. 8, Figs 3-4 and Pl. 9, Figs 1a-1h)

1840a. *Diadema tetragramma* Ag.; L. Agassiz, p. 8.
1840b. *Diadema tetragramma* Ag.; L. Agassiz, p. 15, Pl. 17, Figs 39-43.
1847. *Diadema tetragramma* Agass.; L. Agassiz & E. Desor, p. 46.
1855. *Pseudodiadema tetragramma* Agassiz; E. Desor, p. 69.
1871. *Pseudodiadema tetragramma*, Agassiz; E. Desor & P. de Loriol, p. 144, Pl. 23, Fig. 6.
1882. *Pseudodiadema tetragramma* (Agassiz) Desor; G. Cotteau, p. 309, Pl. 346, Figs 1-8.

MATERIAL: Two tests from Annopol.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
EAn/98	10.5	4.4	3.0	4.0	Pl. 8, Figs 3-3a *and* Pl. 9, Figs 1a-1h
EAn/99	10.6	4.4	3.0	—	Pl. 8, Fig. 4

DESCRIPTION: **The tests** are small, circular in outline, flattened below ambitus (*see* Pl. 8, Figs 3-4 *and* Pl. 9, Fig 1a-1b).

The ambulacra are straight, tapering both adapically and adorally (*see* Pl. 8, Fig. 3a). Ambulacral plates all trigeminate (diadematoid type), and all elements reaching the perradial suture (*see* Pl. 9, Figs 1c-1f). Ambulacral primary tubercles are flat, perforate, crenulate and diminishing very gradually in size adapically. Bosses of these tubercles cover two elements of the plate, but areoles appear on all three elements, and they are nonconfluent (*see* Pl. 9, Figs 1c, 1e). On every third element there are three or four small tubercles in horizontal series (*see* Pl. 9, Figs 1c, 1e). Pore zones are uniserial, only at the peristome they are somewhat widened, and pore-pairs are placed more obliquely (*see* Pl. 9, Figs 1f, 1h).

The interambulacra are slightly more than twice the width of ambulacra. Interambulacral plates are wide and very low. Every plate bears one, relatively small, perforate and crenulate primary tubercle in the middle of the plate (*see* Pl. 9, Fig. 1g). Close the adapical sutures there are smaller secondary tubercles lying on both sides of the primary tubercle (*see* Pl. 9, Fig. 1g). The primary tubercles decrease in size gradually towards the apical disc. However, on the four plates closest to the apex the tubercles near the interradial suture diminish sharply in their size. The primary tubercles are surrounded by regular scrobicular rings composed of a few, scattered tubercles. Areoles are not confluent. The secondary tubercles are surrounded by regular circles of small tubercles too.

The apical disc is not preserved. As suggested by the opening, its structure may be estimated as dicyclic.

REMARKS: The studied specimens are concordant with those described by L. Agassiz (1840b) as "*Diadema tetragramma*", the species included by Desor (1855) to the newly established genus *Pseudodiadema*.

Family **Acrosaleniidae** Gregory, 1900

Genus *Acrosalenia* L. Agassiz, 1840

Acrosalenia angularis (L. Agassiz, 1840)
(Pl. 10, Figs 1-5)

1840a. *Hemicidaris angularis* Ag.; L. Agassiz, p. 8.
1840b. *Hemicidaris angularis* Ag.; L. Agassiz, p. 51, Pl. 19, Figs 4-6.
1856. *Acrosalenia angularis*; E. Desor, p. 140.
1856. *Acrosalenia decorata* Wright; E. Desor, p. 143.
1856. *Acrosalenia decorata*, Haime; T. Wright, p. 249, Pl. 17, Figs 1a-1m.
1872. *Acrosalenia angularis* (Agassiz), Desor; E. Desor & P. de Loriol, p. 253, Pl. 40, Figs 1-4.
1889. *Acrosalenia angularis* (Agassiz), Desor; P. de Loriol, p. 49. Pl. 9, Fig. 4.

1937. *Acrosalenia decorata* HAIME sp.; W. DAMES, p. 130, Pl. 9, Fig. 1.
1957. *Acrosalenia angularis* (AGASSIZ); R. KONGIEL, p. 6, Pl. 1, Figs 1-3.
1975. *Acrosalenia angularis* (AGASSIZ); H. HESS, p. 91. Pl. 35, Fig. 1.

MATERIAL: 29 tests (12 from Karsy, 6 from Korytnica, 6 from Małogoszcz, 3 from Sulejów, 1 from Czarnogłowy, 1 from Sobków).

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
EMa/92	19.8	9.8	6.5	6.4	Pl. 10, Figs 1-1a
EKa/100	16.8	9.8	5.0	6.5	Pl. 10, Figs 3a-3b
EKo/101	17.4	9.9	5.4	6.6	Pl. 10, Fig. 4
EMa/33	17.8	9.0	6.2	—	Pl. 10, Figs 2a-2b
MUZ P.I.G.219.II.1	15.7	8.3	4.9	6.4	Pl. 10, Figs 5a-5c

DESCRIPTION: **The tests** are small, pentagonal in outline, moderately high, and flattened adorally (*see* Pl. 10, Figs 1, 2a-2b, 3a-3b, 4, 5a-5b). **The ambulacra** are straight (*see* Pl. 10, Figs 2b, 5b), uniserial throughout, and composed in a diadematoid manner. Primary tubercles are perforate and crenulate, and decreas in size gradually towards the apical disc. Pore-pairs represented by *P1* and *P2* isopores are relatively large, and obliquely placed. The interporiferous zone is large and covered by numerous small tubercles; below the ambitus these tubercles become less numerous, and decline close the peristome.

The interambulacra are wide with very characteristic ornamentation, divided on the two regions (*see* Pl. 10, Figs 2b, 3b, 5b). The most adapical (three) plates (*see* Pl. 10, Fig. 5a) bear very small perforate and weakly crenulate primary tubercles, which are surrounded by numerous small secondary tubercles. On this region the interradial sutures are depressed. The other interambulacral plates bear a large, perforate and strongly crenulate tubercle (*see* Pl. 10, Fig. 3b). These plates are confluent, and secondary, relatively wide, tuberculation is confined only to the adradial and admedian parts of the plates. The secondary tubercles rease in size at the peristome.

The apical disc is large with three or four (*see* Pl. 10, Figs 1a, 5c) polygonal, suranal plates. The large periproctal opening is displaced toward *U*-shaped genital plate 5. The remaining genital plates are very high, and narrow in acute-angle triangle outline. The large gonopores are situated on the top of the plate. The madreporite is a bit larger than other genital plates. Ocular plates are small and exert. All plates (genital, ocular, suranal) are covered by small tubercles.

The peristome is large, measuring about 42% of the test diameter, with narrow, deep, and well defined buccal slits.

REMARKS: The studied specimens are concordant with those described by L. AGASSIZ (1840b) as "*Hemicidaris angularis*". DESOR (1856) included this species to the AGASSIZ' genus *Acrosalenia*.

The species has formerly been reported from Czarnogłowy by KONGIEL (1957).

Order **Calycina** GREGORY, 1900

Genus *Pseudosalenia* COTTEAU, 1859

Pseudosalenia malogostiana sp.n.
(Pl. 11, Figs1a-1f and Pl. 12, Figs 1a-1f)

HOLOTYPE: The specimen No. EMa/34, presented in Pl. 11, Figs 1a-1f.
TYPE LOCALITY: Małogoszcz Quarry, southwestern margin of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Lower Kimmeridgian, Ataxioceras hypselocyclum Zone; Upper Oolite member.
DERIVATION OF THE NAME: Adjectival name, from neo-Latinized name of the medieval town of Małogoszcz.

MATERIAL: Two tests from Małogoszcz.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
EMa/34 **holotype**	5.0	2.4	3.3	2.9	Pl. 11, Figs1a-1f
EMa/35 **paratype**	6.6	3.3	3.6	3.5	Pl. 12, Figs 1a-1f

DIAGNOSIS: All genital and the suranal plate of the apical disc sculptured by radiate grooves; sutures between plates depressed with small pits at the boundaries of the plates; ambulacral plating unigeminate adapically and ambitally, but in the acrosaleniid style (two plates united by a single tubercle alternating with single primary plate) at the peristome; primary interambulacral tubercles ambitally and adorally perforate.

DESCRIPTION: **The tests** are very small, circular in outline, flattened aborally and adorally (*see* Pl. 11, Figs 1a-1b *and* Pl. 12, Figs 1a-1b).

The ambulacra are narrow, slightly sinuous above the ambitus. Plating is unigeminate adapically and ambitally (*see* Pl. 11, Fig. 1f *and* Pl. 12, Figs 1d, 1f), but at the peristome (*see* Pl. 11, Figs 1c, 1f *and* Pl. 12, Fig. 1e) the acrosaleniid style of ambulacral compounding develops (two plates united by a single tubercle alternating with single primary plate). The primary tubercles are large and have a large, nonperforate mamelon. The vertical columns of primary tubercles are contiguous. The perradial zone is very narrow, and bears a few miliary granules at the ambitus (*see* Pl. 11, Fig. 1f).

The interambulacra are wide, with five or six large plates in a column (*see* Pl. 11, Fig. 1b). Primary tubercles are large, crenulate and have a moderately sized mamelon; they are perforate at the ambitus and adorally (*see* Pl. 11, Fig. 1e *and* Pl. 12, Fig. 1e). Primary tubercles are surrounded by six widely spaced scrobicular tubercles. The interradial zone is very narrow, without miliary granules.

The apical disc is broad, measuring 48-51% of the test diameter, and roundly pentagonal in outline (*see* Pl. 11, Figs 1a, 1d *and* Pl. 12, Fig. 1a). The sutures between plates are depressed, and the small, sutural pits are developed at all triple junctions. The moderately large, pentagonal, suranal plate is centrally placed, and slightly longer than broad. Ocular plates are heart-shaped, and exert. Genital plates are large, elongate, and tapering slightly towards their outer edge. Gonopores are small, and positioned subcentrally on the genital plates (*see* Pl. 11, Fig. 1d). The madreporite is of the same size as other genital plates. Genital plates and suranal plate are sculptured by radiate grooves. The periproct is displaced towards the genital 5, and subpentagonal in outline.

The peristome is large, measuring 53-58% of the test diameter. Buccal slits are shallow, but well defined (*see* Pl. 12, Fig. 1c).

REMARKS: The newly established species *Pseudosalenia malogostiana* sp.n. due to its apical disc with a single, central suranal plate, style of ambulacral plating, and perforate interambulacral tubercles, is herein assigned to the genus *Pseudosalenia* of COTTEAU (1859).

DAMES (1872, p. 134, Pl. 9, Fig. 2 *non* 3!) described from the Upper Oxfordian deposits of Germany a new species under the name of "*Pseudosalenia Ottmmeri* n.sp." from which the newly established species *Pseudosalenia malogostiana* sp.n. differs by the structure of its apical disc, having more elongated genital plates and all ocular plates exsert.

The newly established species *Pseudosalenia malogostiana* sp.n. differs from the type species, *P. aspera* L. AGASSIZ, by its apical disc with distinct ornamentation, and by perforate adoral interambulacral primary tubercles.

Order **Hemicidaroida** BEURLEN, 1937
Family **Hemicidaridae** WRIGHT, 1857

Genus *Hemicidaris* L. AGASSIZ, 1838

Hemicidaris gresslyi ÉTALLON, 1862
(Pl. 49, Figs 5-8)

1869. *Hemicidaris gresslyi*, ÉTALLON; E. DESOR & P. DE LORIOL, p. 120, Pl. 20, Figs 13-14.
1881. *Hemicidaris Gresslyi*, ÉTALLON, 1862; G. COTTEAU, p. 151, Pl. 302, Figs 1-10.
1961. *Hypodiadema hoffmanni* (ROEMER); W. BARCZYK, p. 70, Pl. 4, Fig. 2.

MATERIAL: Some 30 tests from Sulejów.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
ESI/170	33.2	17.6	10.7	15.0	——
ESI/152	29.5	17.4	9.0	13.0	Pl. 49, Fig. 7
ESI/150	28.0	15.7	8.4	13.0	Pl. 49, Figs 5a-5b
ESI/151	26.0	13.2	8.2	13.0	Pl. 49, Fig. 6
ESI/153	24.8	15.8	8.3	11.2	Pl. 49, Fig. 8

DESCRIPTION: **The tests** are circular in outline, low; in majority distinctly flattened aborally and adorally (*see* Pl. 49, Figs 5b, 6, 8).

The ambulacra are slightly sinuous, relatively wide, expanding slightly at the ambitus (*see* Pl. 49, Fig. 8). Ambulacral tuberculation increases in size gradually towards the ambitus. Just below the ambitus, primary tubercles become somewhat larger, strongly perforate and crenulate, surrounded by small secondary tubercles. Pore zones are uniserial from the apex to the ambitus, with pores of type *P1*, characterized by the broad interporal partition, and adorally they become crowded together, and form phyllodes, with pores of type *P3*.

The interambulacra are wide, with 7 plates in each column. Each plate bears one large, perforate and strongly crenulate primary tubercle (*see* Pl. 49, Figs 5b, 6), characterized by a relatively small mamelon, seated on a strongly swollen, high boss, and surrounded by a narrow areole. Close to the apex, areoles are circular in outline, and nonconfluent, but towards the peristome they gradually become confluent, and elliptical in outline.

The apical disc is moderately large (about 28-33% of the test diameter), almost, or evidently, hemicyclic in the largest specimens, with oculars *I* and *V* insert. Genital plates are unequal in size, the posterior ones being smaller than the anterior, with circular gonopores positioned close to the outer margin.

The peristome is moderately large, about 44-50% of the test diameter, with well developed, deep, narrow buccal slits.

REMARKS: The studied specimens, determined herein as *Hemicidaris gresslyi* Étallon, 1862, have earlier been described from this locality by Barczyk (1961) who classified them as "*Hypodiadema hoffmanni* (F.A. Roemer)". They are really similar to *Hemicidaris hoffmanni* (F.A. Roemer, 1836), although they differ by their distinctly lower tests, more flattened, aborally in particular, and by the more pronounced bosses of interambulacral primary tubercles, and by narrower areoles.

Hemicidaris hoffmanni (F.A. Roemer, 1836)
(Pls 13-18)

1836. *Cidarites hoffmanni* Nob.; F.A. Roemer, p. 25, Pl. 1, Fig. 18.
1858. *Hemicidaris hoffmanni* Roemer; E. Desor, p. 53.
1869. *Hemicidaris desoriana*, Cotteau; E. Desor & P. de Loriol, p. 121, Pl. 20, Figs 1a-1e.
1871. *Hemicidaris hoffmanni* (Roemer) Agassiz; E. Desor & P. de Loriol, p. 123, Pl. 20, Figs 2-3.
1872. *Hemicidaris hoffmanni* A. Roem. sp.; W. Dames, p. 109, Pl. 6, Fig. 2.
1881. *Hemicidaris ricetensis* Cotteau, 1856; G. Cotteau, p. 140, Pl. 300, Figs 1-6.
1881. *Hemicidaris desoriana*, Cotteau, 1856; G. Cotteau, p. 142, Pl. 300, Figs 7-13.
1881. *Hemicidaris hoffmanni* (Roemer) Agassiz, 1840; G. Cotteau, p. 146, Pl. 301, Figs 1-11.
1881. *Hemicidaris pisum*, Cotteau, 1856; G. Cotteau, p. 303, Figs 1-8.
1881. *Hemicidaris rathieri*, Cotteau, 1856; G. Cotteau, p. 159, Pl. 303, Figs 9-16.
1881. *Hemipygus virgulinus* (Desor), Étallon, 1859; G. Cotteau, p. 204, Pl. 315, Figs 13-18.
1905. *Hemicidaris hoffmanni* A. Roem. sp.; M. Schmidt, p. 94 and p. 130, Pl. 1, Figs 2-3.
1911. *Hemicidaris hoffmanni* Roemer (*Cidarites*); J. Lambert & P. Thiéry, p. 171.
1937. *Hypodiadema hoffmanni* (Roemer); K. Beurlen, p. 85, Text-figs 21-22.
1957. *Hypodiadema hoffmanni* (Roemer); R. Kongiel, p. 14 and p. 63, Pl. 3, Figs 1-3.
non 1961. *Hypodiadema hoffmanni* (Roemer); W. Barczyk, p. 70, Pl. 4, Fig. 2.
1988. *Hypodiadema hoffmani* (Roemer, 1836); W. Jesionek-Szymańska, p. 378, Pl. 174, Figs 2a-2c.

MATERIAL: Over 560 tests from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
ECz/106	26.3	16.0	8.8	11.4	Pl. 13, Figs 5a-5c
ECz/114	23.8	15.5	8.8	11.0	Pl. 17, Figs 2-2a
ECz/104	23.4	14.0	8.8	11.0	Pl. 13, Figs 3a-3c
ECz/110	17.0	10.0	6.3	8.2	Pl. 15, Figs 1a-1c
ECz/105	13.2	7.2	5.3	7.2	Pl. 13, Figs 4a-4b
ECz/102	10.0	5.0	4.3	6.6	Pl. 13, Figs 1a-1c

DESCRIPTION: **The tests** are circular to subpentagonal in outline, relatively low, hemispherical in profile, with the ambitus lying at about one-third of the test height above the base (*see* Pls 13-14).

The ambulacra (*see* Pl. 13, Figs 2b, 3b, 5c, 6a *and* Pl. 14, Fig. 3b) are slightly sinuous, relatively wide, expanding slightly at the ambitus. Ambulacral tuberculation increases in size gradually towards the ambitus. From the apex to the ambitus, there is an acrosaleniid plate compouding, where one weakly perforate and crenulate primary tubercle occupies two elements followed by one simple plate with a secondary tubercle only (*see* Pl. 16, Figs 2c-2e). In the subapical region, secondary tubercles are well developed, and they densely cover the relatively wide perradial zone. Just below the ambitus, primary tubercles become a bit larger, strongly perforate and crenulate, surrounded by small secondary tubercles. In some specimens, in this region, primary tubercles are developed as distinctly larger than above-ambitally ones (*see* Pl. 14, Fig. 3b). Adorally the primary tubercles gradually decrease in size (*see* Pl. 13, Figs 1b, 4b, 3c, 5b *and* Pl. 14, Fig. 4c). From ambitus to the peristome the plates become trigeminate. Pore zones are uniserial from the apex to the ambitus, with isopores of *P1/P2* type, characterized by the very broad interporal partition (*see* Pl. 16, Fig. 2c); ambitally and subambitally pore-pairs are represented by *P2* isopores, and adorally they become crowded together, and form phyllodes with isopores of *P3* type .

The interambulacra are wide, with 8-9 plates in each column in the largeset specimens.

Each plate bears one large, perforate and strongly crenulate primary tubercle (*see* Pl. 14, Figs 2b, 4b; Pl. 15, Figs 1b, 2b *and* Pl. 16, Fig. 2b), characterized by a relatively small mamelon, seated on a swollen boss, and surrounded by a narrow areole. Close to the apex, areoles are circular in outline, and nonconfluent, but towards the peristome they gradually become confluent and elliptical in outline. Scrobicular rings are composed of relatively numerous tubercles. Adapically scrobicular rings are fully developed (*see* Pl. 14, Figs 3c, 4d), but towards the peristome they are gradually confined to the interradial and adradial sutures (*see* Pl. 16, Fig. 2b). Miliary tubercles are numerous and dispersed among scrobicular tubercles.

The apical disc is moderately large (about 32-35% of the test diameter), almost, or evidently, hemicyclic in the largest specimens, with oculars *I* and *V* insert (*see* Pl. 13, Fig. 5b *and* Pl. 17, Figs 2-2a). Genital plates are unequal in size, the posterior ones being smaller than the anterior, with circular gonopores positioned close to the outer margin. In several specimens (*see* Pl. 17, Fig. 3-3a) there are two gonopores developed in one genital plate. Periproct is large, circular or oval in outline, with its rim smooth (*see* Pl. 14, Figs 3c, 4d), but often strongly faceted by non-preserved periproctal plates (*see* Pl. 17, Figs 1-1a, 2-2a). In one specimen, one periproctal plate is preserved in its normal position (*see* Pl. 18, Fig. 5). Moreover, in some adult specimens, anyone of the periproctal plates may remain in position almost typical of the suranal one (*see* Pl. 15, Figs 1a, 1c, 2a, 3-4). In juvenile forms, the evident suranal plates are often present in position of the genital *3* (*see* Pl. 16, Figs 1, 2a). All plates are covered by small granules.

Besides the above-indicated anomalies in structure or in arrangement of particular plates there also occur more serious abnormalities of the apical disc. They are: (*i*) Presence of two madreporites, the accessory one being in genital *1* (*see* Pl. 18, Fig. 6); (*ii*) Disturbance in the arrangement of genital plates, of which genital *4* is exsert (*see* Pl. 18, Fig. 3); (*iii*) Forking of one of the genital plates (*see* Pl. 18, Fig. 6); (*iv*) Division of one of the genital plates into two sub-plates (*see* Pl. 18, Figs 2, 4); (*v*) Enlargement, and the polygonal shaping, of the periproct, combined with the pushing of one periproctal plate between genitals *1* and *5* (*see* Pl. 18, Fig. 1).

The peristome is moderately large, about 42-45% of the test diameter, with well developed, deep buccal slits (*see* Pl. 13, Figs 3c, 5b *and* Pl. 14, Figs 2c, 4c). The Aristotle's lantern is preserved in one specimen only.

REMARKS: The studied material comes solely from Czarnogłowy, where the most common are not-fully grown specimens, and adults are rare.

The above-listed anomalies in the apical disc are thought to be of a teratologic nature of some specimens that have suffered either a disease or an endoparasitic invasion (*cf.* similar examples reported by SMITH 1988).

The generic assignment of the species has hitherto been variably treated: either, to include into the genus *Hemicidaris* L. AGASSIZ, 1838, as given by DESOR (1858), DESOR & DE LORIOL (1869), DAMES (1872), COTTEAU (1881), or into the genus *Hypodiadema* DESOR, 1858, as given by BEURLEN (1937) and KONGIEL (1957) regarding the specimens from the studied locality Czarnogłowy. A thorough discussion of this matter was offered by BEURLEN (1937, pp. 84-85), who first analyzed in detail the features of the species, and indicated these typical of the genus *Hypodiadema*, although he also remarked (BEURLEN 1937, p. 89) that the species *hoffmanni* of F.A. ROEMER (1836) deviates from the "typical" species of that genus by the presence of a relatively abrupt change in size of primary tubercles just at, and below, the ambitus (and, thus, the presence of an abrupt expansion of ambulacra).

In the present author's opinion, the structure of ambulacra in the studied specimens is really transitional between that of the genus *Hypodiadema* and that of *Hemicidaris*. Thus, when taking into account that the other features (*e.g.* periproct displaced posteriorly) are characteristic of *Hemicidaris*, as already pointed out by BEURLEN (1937, p. 84), it becomes apparent to accommodate the species *hoffmanni* into the genus *Hemicidaris*.

As concerns the synonymy of the species *hoffmanni* of F.A. ROEMER (1836), it was BEURLEN (1937) who included into it the two other species, *Hemicidaris ricetensis* COTTEAU, 1856, and *Hemipygus virgulinus* DESOR, 1857, regardless their generic assignment by former authors.

The present author includes into that synonymy also the species *Hemicidaris desoriana* COTTEAU, 1856, *Hemicidaris pisum* COTTEAU, 1856, and *Hemicidaris rathieri* COTTEAU, 1856, which have earlier been suggested by BEURLEN (1937, p. 89) to represent various ontogenetic stages of *hoffmanni* F.A. ROEMER, 1836. A relatively very rich material from Czarnogłowy (over 560 specimens) confirms BEURLEN's (1937) opinion. Such features as the size of the periproct, the ocular *I* (sometimes jointly with *V*) being insert, and particularly the smaller subambital primary tubercles in ambulacra, are recognizable in all growth stages of the species *Hemicidaris hoffmanni* (F.A. ROEMER, 1836) as herein understood.

Quite an important problem arises, however, because of the presence of the suranal plate in some juvenile and/or youthful specimens, and of a deeply faceted periproctal rim in some of the adults. In other specimens, both juvenile and adult, the periproctal rim is smooth. In other words, the specimens with, or without, a suranal plate occur in all growth classes of *Hemicidaris hoffmanni* (F.A. ROEMER, 1836), precisely in its population from Czarnogłowy.

The presence of any suranal plate firmly integrated with the apical disc has not hitherto been known either in *Hemicidaris*, or in *Hypodiadema*, although the strongly faceted periproctal rim and/or the large periproctal plate lying off ocular *III* almost in position of the suranal plate was observed in some *Hemicidaris* species (*see* MORTENSEN 1935, pp. 389-390, Fig. 205). On the other hand, the presence of one suranal plate, firmly integrated with the apical disc, has commonly been reported (*see* MELVILLE & DURHAM 1966, pp. *U*242-*U*243; FELL & PAWSON 1966, p. *U*368 and p. *U*375; SMITH & WRIGHT 1990, pp. 119-123) as typical of the acrosaleniid genera, such as *Heterosalenia* COTTEAU, 1861, and *Pseudosalenia* COTTEAU, 1859.

The studied specimens bearing an apical disc with a firmly integrated suranal plate, do not differ, by their other features, from all remaining individuals assigned herein to the species. The suranal plate in the apical disc of *Hemicidaris hoffmanni* is relatively smaller than that of the genera *Heterosalenia* and *Pseudosalenia*. It is therefore reasonable to include the specimens with the firmly sutured suranal plate into *Hemicidaris hoffmanni*, and not to a separate species accommodated either in *Heterosalenia*, or *Pseudosalenia*. Moreover, this newly discovered feature may indicate a really close relation of the families Hemicidaridae WRIGHT, 1857, and Acrosaleniidae GREGORY, 1900.

Beyond the scope of the present study is a discussion whether the indicated salenioid genera, or some of their species, may represent not fully-grown (?progenetic) specimens of the hemicidarids.

Hemicidaris intermedia (FLEMING, 1828)
(Pls 19-21; Pl. 22, Figs 2-7 and Pl. 49, Figs 9-9a)

1855. *Hemicidaris intermedia* FORB.; E. DESOR, p. 52, Pl. 11, Figs 4-4a.
1855. *Hemicidaris intermedia*, FLEMING; T. WRIGHT, p. 92, Pl. 5, Figs 1a-1o.
1869. *Hemicidaris intermedia* (FLEMING) FORBES; E. DESOR & P. DE LORIOL, p. 100, Pl. 15, Figs 3-5, and Pl. 16, Figs 1-5.
1872. *Hemicidaris intermedia* FLEMING sp.; W. DAMES, p. Pl. 5, Figs 6a-6f.
1881. *Hemicidaris intermedia* (FLEMING), FORBES, 1851; G. COTTEAU, p. 102, Pl. 289, Figs 1-11 and Pl. 290, Figs 1-15.
1905. *Hemicidaris intermedia* FLEM. sp.; M. SCHMIDT, p. 94 and p. 131, Pl. 1, Figs 4a-4b.
partim 1937. *Hemicidaris* (*Dorytiaris*) *intermedia* (FLEMING); K. BEURLEN, p. 65, Text-figs 11-16.
1957. *Hemicidaris* (*Hemicidaris*) *crenularis* (LAMARCK); R. KONGIEL, p. 10 and p. 61, Pl. 2, Figs 2-4.
1957. *Hemicidaris* (*Hemicidaris*) *crenularis* (LAMARCK) var. *alta* nov.var.; R. KONGIEL, p. 13 and p. 63, Pl. 2, Fig. 5.
1975. *Hemicidaris intermedia* (FLEMING); H. HESS, p. 93, Pl. 34, Fig. 9 and Pl. 36, Figs 8-11, ?Figs 6-7.
1988. *Hemicidaris crenularis* (LAMARCK, 1816); W. JESIONEK-SZYMAŃSKA, p. 377, Pl. 174, Figs 1a-1c.
1996. *Hemicidaris intermedius* (FLEMING, 1828); A. VADET, P. NICOLLEAU & J.P. PINEAU, p. 68, Text-figs 78-79 and Pl. 16, Figs 1-5.

MATERIAL: 90 tests from Czarnogłowy, 80 from Małogoszcz, 24 from Gołuchów, 15 from Wierzbica, 10 from Sobków, 9 from Karsy, 8 from Sulejów, 7 from Karsznice, 6 from Ożarów, 3 from Leśnica; 1 from: Gruszczyn, Annopol, and Niziny.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
EMa/42	33.6	27.8	10.0	15.0	Pl. 22, Fig. 6
EMa/40	33.4	23.0	10.0	16.2	Pl. 19, Figs 5a-5c
EMa/39	30.6	22.8	9.0	14.4	Pl. 19, Figs 4a-4c
ZPAL E.VIII/10	22.3	14.0	7.5	11.7	Pl. 22, Figs 4a-4b

DESCRIPTION: **The tests** are circular to subpentagonal in outline, characterized by very protuberant ambulacra; high (subconical in profile) to relatively low (hemispherical in profile), with the ambitus lying at about one-third of the test height above the base (*see* Pl. 19 *and* Pl. 22, Figs 2-6).

The ambulacra (*see* Pl. 19, Figs 1b, 5b; Pl. 20, Figs 1b-1d; Pl. 21, Figs 1d, 2d *and* Pl. 22, Figs 2b, 3, 5, 6) are sinuous, narrowed adapically, but expanding abruptly at the ambitus, remaining broad subambitally, and tapering slightly adorally. Ambulacral tuberculation expressed typically by four well individualized regions: close to the apex one primary tubercle is confined to every third simple plate (*see* Pl. 20, Figs 1c-1d); in juvenile specimens primary tubercles are arranged in one zigzag row (*see* Pl. 20, Fig. 1c). From subapical region, towards the ambitus, there is an acrosaleniid plate compounding, where one weakly perforate and crenulate primary tubercle occupies two elements followed by one simple plate featured with a secondary tubercle only (*see* Pl. 20, Fig. 1b *and* Pl. 21, Fig. 2d). In the subapical region, secondary tubercles are densely spaced, surrounding each primary tubercle. Just below the ambitus, there is an abrupt change in tuberculation: primary tubercles become large, strongly perforate and crenulate, surrounded by a few small secondary tubercles (*see* Pl. 19, Figs 1b, 5b). In this region the plates are multigeminate with five elements to each. Adorally, the primary tubercles gradually decrease in size, and plates become trigeminate. Pore zones are uniserial from the apex to the ambitus, with isopores of *P1/P2* type, characterized by very broad interporal partition (*see* Pl. 20, Fig. 1c *and* Pl. 21, Fig. 2c); adorally they become crowded togheter and form phyllodes (*see* Pl. 49, Figs 9-9a), composed of *P3* isopores.

The interambulacra are wide, with 8-9 plates in each column in the largeset specimens. Each plate bears one large, perforate and strongly crenulate primary tubercle (*see* Pl. 19, Figs 2b, 3b, 4b; Pl. 20, Fig. 1e; Pl. 21, Fig. 2b *and* Pl. 22, Fig. 4b), characterized by a relatively small mamelon, seated on a swollen boss, surrounded by a narrow areole. Close to the apex, areoles are circular in outline and tangential, but towards the peristome they gradually become confluent and elliptical in outline (*see* Pl. 19, Fig. 4b *and* Pl. 22, Fig. 4b). Scrobicular rings are composed of sparsely spaced, relatively large tubercles, confined to the interradial and adradial sutures (*see* Pl. 20, Fig. 1e *and* Pl. 21, Fig. 2b). Miliary tubercles are not numerous and dispersed among scrobicular tubercles.

The apical disc is moderately large (about 33% of the test diameter), almost, or ideally, hemicyclic in the largest specimens, with oculars *I* and *V* insert (*see* Pl. 19, Figs 4a, 5a). Genital plates are unequal in size, the posterior ones being smaller than the anterior, with oval gonopores positioned close to the outer margin (*see* Pl. 20, Figs 1a, 2). Periproct is large, with its rim often strongly faceted by periproctal plates (*see* Pl. 19, Fig. 4a). Sporadically, in juvenile forms (coming from Czarnogłowy), a suranal plate is present in position either of the genital *2* (*see* Pl. 21, Figs 1a-1b), or ocular *III* (*see* Pl. 21, Fig. 2a). All plates are covered by small granules.

The peristome is large, about 50% of the test diameter, with well developed, deep buccal slits (*see* Pl. 19, Figs 1c, 4c, 5c *and* Pl. 21, Fig. 1c).

The primary spines (*see* Pl. 22, Fig. 7) are long, cylindrical, and sharply pointed. The shaft is smooth and the border between the shaft and the neck is invisible; the collar is short and slightly increases in size towards the milled ring, which is distinctly developed and marked with vertical striae; the base is narrow, and a bit longer than the collar.

REMARKS: The understanding of the studied species has hitherto been variously treated in the literature, as revealed from the fact that their tests are undistinguishable (*see* HESS 1975, p. 93) from those of *Hemicidaris crenularis*, commonly ascribed to LAMARCK (1816), and solely the primary spines being diagnostic; these two species have thus been treated either as identical (MORTENSEN 1935, BEURLEN 1937, KONGIEL 1957), or as separate (WRIGHT 1855, DESOR & DE LORIOL 1869, COTTEAU 1881).

The differently shaped primary spines are thicker and clavate in *Hemicidaris crenularis* of LAMARCK (1816), but thinner and pile-like in *H. intermedia* (FLEMING, 1828). This difference is very well documented by HESS (1975) for the specimens from the Swiss Jura.

Within the collected material, all the recognized spines are typical of *Hemicidaris intermedia* (FLEMING, 1828). Typical of this species are also the two cases of spines attached to the test (*see* Pl. 22, Fig. 7). The present author is therefore of the opinion that all the studied spine-lacking tests should be ascribed to *H. intermedia* (FLEMING, 1828).

Nevertheless, if the shape of spines is accepted as the diagnostic feature, then the holotypes of the both species should be indicated in specimens adorned with the spines. In such a case, *Hemicidaris intermedia* is adequately established by FLEMING (1828) upon a specimen with spines in position, but for *H. crenularis* the first report on a spine-bearing specimen is that by L. AGASSIZ (1840b), who illustrated an individual from the vicinity of Besançon in France, and kept in the *Naturhistorisches Museum* in Vienna. The type of LAMARCK (1816), and coming from the Swiss Jura, established upon older illustrations of BOURGUET (1788), is devoid of spines, and thus has long been a matter of taxonomic controversy (*see* KONGIEL 1957, pp. 12-13 *and* pp. 61-62). In the present author's opinion, it should consequently be declared to recognize L. AGASSIZ (1840b) as the author of the well-diagnozed species *Hemicidaris crenularis*, and all earlier reports of that taxon to be rejected from the synonymy.

In the synonymy of the species *Hemicidaris intermedia* (FLEMING, 1828), the present author includes herein only those from which the spines have been reported. Moreover, into that synonymy included is the specimen referred by KONGIEL (1957) as "*Hemicidaris* (*Hemicidaris*) *crenularis* (LAMARCK) var. *alta* nov. var.", whose test is typified by its relatively larger height; such specimens are dominating a rich assemblage of this species from one locality, namely Gołuchów, and all are herein interpreted as reflecting a phenotypic variability.

Noteworthy for the so-understood species *H. intermedia* (FLEMING, 1828), is the material from Czarnogłowy that contains numerous not-fully grown specimens, similarly as in *H. hoffmanni* (F.A. ROEMER, 1836), and amongst which are specimens with a suranal plate within the apical disc; this phenomenon is also unknown as yet in this species.

Hemicidaris mitra L. AGASSIZ, 1840

(Pl. 49, Fig. 4)

1840a. *Hemicidaris mitra* AG.; L. AGASSIZ, p. 8.

1840b. *Hemicidaris mitra* AG.; L. AGASSIZ, p. 48, Pl. 19, Figs 7-9.

1847. *Hemicidaris mitra* AGASS.; L. AGASSIZ & E. DESOR, p. 33.

1855. *Hemicidaris mitra* AG.; E. DESOR, p. 53.

1855. *Hemicidaris mitra* AGASSIZ; T. WRIGHT, p. 105.

1869. *Hemicidaris mitra* AGASSIZ; E. DESOR & P. DE LORIOL, p. 118, Pl. 19, Figs 11-12.

1881. *Hemicidaris mitra*, AGASSIZ, 1840; G. COTTEAU, p. 137, Pl. 299, Figs 1-10.

1987a. *Hemicidaris mitra* AGASSIZ; A. ZBINDEN, p. 407 and p. 414, Text-figs 33-34.

MATERIAL: One test from Niziny.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	∅*Ad*	∅*Pm*	Figured in:
ENi/149	26.0	16.4	8.5	14.3	Pl. 49, Fig. 4

REMARKS: The studied species, *Hemicidaris mitra* L. AGASSIZ, 1840, is morphologically close (*see* Pl. 22, Figs 2-3) to the three preceding species, *H. gresslyi* ÉTALLON, 1862, *H. hoffmanni* (F.A. ROEMER, 1836), and *H. intermedia* (FLEMING, 1828). Thus, only the differences are hereafter briefly indicated, and these are taken into account for the specimens of similar size.

The species *Hemicidaris mitra* L. AGASSIZ, 1840, differs from the three above listed species of the genus *Hemicidaris* L. AGASSIZ, 1838, by its higher, more conical test (*see* Pl. 49, Fig. 4), by its straight ambulacra, which gradually taper from the ambitus to the apical disc, by the more numerous (11) interambulacral plates per column, and by the more oval and confluent interambulacral areoles.

The species *Hemicidaris mitra* L. AGASSIZ, 1840, has not hitherto been reported from Poland.

Genus *Hemitiaris* POMEL, 1883

Hemitiaris stramonium (L. AGASSIZ, 1840)

(Pl. 22, Figs 1a-1c)

1840a. *Cidaris stramonium* AG.; L. AGASSIZ, p. 8.

1840b. *Cidaris stramonium* AG.; L. AGASSIZ, p. 47, Pl. 19, Figs 13-14.

1847. *Cidaris stramonium* AGASS; L. AGASSIZ & E. DESOR, p. 34.

1855. *Hemicidaris stramonium* AGASSIZ; T. WRIGHT, p. 103.

1857. *Hemidiadema stramonium* AGASS.; E. DESOR, p. 58, Pl. 10, Figs 4-6.

1869. *Hemicidaris stramonium*, AGASSIZ; E. DESOR & P. DE LORIOL, p. 114, Pl. 18, Fig. 6 and Pl. 20, Figs 1-7.

1881. *Hemicidaris stramonium*, AGASSIZ, 1840; G. COTTEAU, p. 131, Pl. 298.

1975. *Hemitiaris stramonium* (AGASSIZ); H. HESS, p. 94, Text-fig. 49, Pl. 35, Figs 4-6 and Pl. 39, Fig. 11.

MATERIAL: One well preserved test from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	∅*Ad*	∅*Pm*	Figured in:
ECz/122	17.0	10.5	5.5	10.7	Pl. 22, Figs 1a-1c

DESCRIPTION: **The test** is circular in outline, moderately high, with the ambitus lying at about one-third of the test height above the base (*see* Pl. 22, Figs 1a-1c).

The ambulacra (*see* Pl. 22, Fig. 1c) are slightly sinuous, narrow adapically, but expanding abruptly at the ambitus, remaining broad subambitally, and tapering slightly adorally. Ambulacral tuberculation is very characteristic, expresed typically by three well- individualized regions: adapically, there is a simple plate compouding, with small, noncrenulate and imperforate primary tubercles. In this region the perradial miliary tubercles are not developed. At the ambitus, there is an abrupt change in tuberculation: tubercles become large, perforate, and crenulate, surrounded by a few small secondary tubercles. Plates are trigeminate above the ambitus, and quadrigeminate at the ambitus. Ambital tuberculation forms characteristic, simple series (*see* Pl. 22, Fig. 1c). Subambitally the primary tubercles decrease in size and become biserial, each plate being trigeminate; this arrangement continues to the peristome.

The interambulacra are wide, the plates numbering seven in a column. Each plate bears a large, crenulate and perforate primary tubercle (*see* Pl. 22, Figs 1a, 1c). The most adapical plate in every column has a markedly smaller primary tubercle. The areoles are almost circular. Two adapical areoles in each column are nonconfluent, and on this region the scrobicular ring is almost fully developed. There are about 17 tubercles in the ring. At the other plates in a column, areoles are confluent and scrobicular tubercles are confined to the adradial and interradial margin of the plates. There are eight scrobicular tubercles on either side of the primary tubercle at the ambitus. Miliaries are weakly developed and dispersed between scrobicular tubercles.

The apical disc (*see* Pl. 22, Fig. 1a) is hemicyclic and relatively large, 32% of the test diameter. Ocular plates I and V are insert, the remaining oculars are separated from the periproct. Genital plates are relatively high, sunken at the centre, and covered by small tubercles. Gonopores are large, and positioned in the outer part of the plates. Periproct is moderately large, and displaced somewhat towards the ocular I.

The peristome is large, about 63 % of the test diameter. Buccal slits are broad and moderately deep (*see* Pl. 22, Fig. 1b).

REMARKS: The studied specimen is consistent with those described and illustrated by AGASSIZ (1840b) as "*Cidaris stramonium*". The species *Hemitiaris stramonium* (AGASSIZ, 1840) has not hitherto been reported from Poland.

Family **Pseudocidaridae** SMITH & WRIGHT, 1993

Genus *Pseudocidaris* ÉTALLON, 1859

Pseudocidaris mammosa (L. AGASSIZ, 1840)
(Pl. 23, Figs 1-8)

1840a. *Hemicidaris mammosa* AG.; L. AGASSIZ, p. 8.
1847. *Hemicidaris mammosa* AG.; L. AGASSIZ & E. DESOR, p. 34.
1856. *Hemicidaris mammosa* AGASS.; E. DESOR, p. 55.
1880. *Pseudocidaris mammosa* (AGASSIZ), DE LORIOL, 1869; G. COTTEAU, p. 21, Pl. 265, Pl. 266 and Pl. 267, Figs 1-4.
1935. *Pseudocidaris mammosa* (AG.); T. MORTENSEN, p. 403, Text-fig. 211.
1957. *Pseudocidaris* (*Pseudocidaris*) *mammosa* (AGASSIZ); R. KONGIEL, p. 8, Pl. 1, Figs 4-6 and Pl. 2, Fig. 1.
1975. *Pseudocidaris thurmanni* (AGASSIZ); H. HESS, p. 95, Text-fig. 50 and Pl. 37, Figs 1-3.
1987a. *Pseudocidaris mammosa* (AGASSIZ); A. ZBINDEN, p. 408 and p. 414, Text-figs 35-37.
1995. *Pseudocidaris mammosa* (AGASSIZ & DESOR, 1847); A. VADET, p. 111, Pl. 8, Figs 1-2.

MATERIAL: Three well preserved tests (2 from Czarnogłowy, 1 from Gruszczyn), and 7 primary spines from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
ECz/125	17.0	11.0	7.0	10.0	Pl. 23, Fig. 6a-6b
EGr/126	11.0	5.0	3.5	5.5	Pl. 23, Fig. 7
MUZ P.I.G.219.II.3	27.0	18.0	8.0	14.0	Pl. 23, Figs 8a-8b

DESCRIPTION: **The tests** are moderately high with the ambitus lying at about half of the test high, circular in outline (*see* Pl. 23, Figs 6a, 8b).

The ambulacra (*see* Pl. 23, Figs 6-8) are narrow, and strongly sinuous above the ambitus. Ambulacral plating and tuberculation is distinguished into three regions. Above the ambitus plating is unigeminate with small, imperforate, noncrenulate primary tubercle on each plate; all, very numerous plates are equally developed; secondary tuberculation between primary tubercles is well developed and represented by densely spaced tubercles smaller than primary ones. At the ambitus plating is unigeminate and bigeminate, tubercles gradually become large, and perforate. Below the ambitus plating is trigeminate, tubercles are large, and perforate. On this region the secondary tuberculation gradually declines; the pore-pairs become more crowded together on the most adoral two or three plates only; above this region up to the apical disc the pore-pairs are uniserial.

The interambulacra (*see* Pl. 23, Fig. 8b) are wide and composed of relatively numerous (6) plates. Above the ambitus the plates are taller than wide. Each plate carries a large, crenulate and perforate tubercle. The mamelons and bosses are large and swollen (*see* Pl. 23, Figs 6b, 7, 8a), the areoles are narrow. Ambitally and adapically the primary tubercles are entirely surrounded by numerous (16), well developed scrobicular tubercles. Below the ambitus the plates become confluent, and the scrobicular tubercles are confined to the adradial and interradial regions. Secondary tuberculation is weakly developed on the interradial zone, and it forms one row of small tubercles only. At the apex, one interrambulacral column ends with a large plate that has a well developed primary tubercle, whereas in the second column, the plate is greatly reduced in size, bearing a rudimentary tubercle (*see* Pl. 23, Fig. 8a).

The apical disc (*see* Pl. 23, Figs 6b, 8a) is hemicyclic (ocular I is insert, others are exsert), and rather small, to measure 30-40% of the test diameter. The ocular plates are small and heart-shaped in outline. The genital plates are unequal in size, the posterior ones are distinctly smaller than the anterior ones. Gonopores are positioned on the outer part of the plates. All plates are covered by radial furrows giving the apical disc a strong ornamentation, but genitals have additionally small tubercles developed close to the outer rim of plates. The disc plates are thick so that the whole apical disc stands out prominently above the coronal plates.

The peristome is large, 50-58% of the test diameter, with shallow and wide buccal slits.

The primary spines (*see* Pl. 23, Figs 1-5) are massive, clavate, more or less elongate. The shaft has an ornament of relatively distinct granules, which are fully developed on the distal part of the spine. The neck, collar and base are very short. The milled ring is well developed.

REMARKS: The studied specimens correspond to those given in the synonymy. In the present author's opinion, the specimens illustrated by HESS (1975) and described as "*Pseudocidaris thurmanni* (AGASSIZ)", due to their large and swollen mamelons on the interambulacral plates, should be classified as *Pseudocidaris mammosa* (AGASSIZ, 1840).

The species *Pseudocidaris mammosa* (AGASSIZ, 1840) has already been reported by KONGIEL (1957) from Czarnogłowy, where it was represented by one specimen only.

Pseudocidaris thurmanni (L. AGASSIZ, 1840)
(Pl. 49, Figs 2-3)

1840a. *Hemicidaris Thurmanni* AG.; L. AGASSIZ, p. 8.
1840a. *Cidaris pyrifera* AG.; L. AGASSIZ, p. 10.
1840b. *Hemicidaris thurmanni* AG.; L. AGASSIZ, p. 50, Pl. 19, Figs 1-3.
1840b. *Cidaris pyrifera* AG.; L. AGASSIZ, p. 71, Pl. 21, Figs 24-26.
1856. *Cidaris pyrifera* AGASS.; E. DESOR, p. 29, Pl. 4, Figs 6, 6a-6b.
1856. *Hemicidaris Thurmanni* AGASS.; E. DESOR, p. 56.
1855. *Hemicidaris Thurmanni* AGASSIZ; T. WRIGHT, p. 104.
1869. *Pseudocidaris Thurmanni* (AGASSIZ), ÉTALLON; E. DESOR & P. DE LORIOL, p. 89, Pl. 13, Figs 10-12 and Pl. 14, Figs 1-14.
1872. *Cidaris pyrifera* AGASSIZ; W. DAMES, p. 102, Pl. 5, Figs 5a-5b.
1880. *Pseudocidaris Thurmanni* (AGASSIZ), ÉTALLON, 1860; G. COTTEAU, p. 32, Pl. 269, Figs 6-15 and Pl. 270, Figs 1-9.
1905. *Pseudocidaris Thurmanni* ET.; M. SCHMIDT, p. 94.
?1937. *Pseudocidaris* (*Pseudocidaris*) *thurmanni* (AGASSIZ); K. BEURLEN, p. 97.
non 1975. *Pseudocidaris thurmanni* (AGASSIZ); H. HESS, p. 95, Text-fig. 50 and Pl. 37, Figs 1-3.

MATERIAL: Seven tests from Niziny.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
ENi/171	22.8	14.7	8.5	—	—
ENi/172	21.3	12.9	—	12.8	—
ENi/147	19.4	12.5	6.7	12.0	Pl. 49, Figs 2a-2b
ENi/148	16.2	9.8	5.2	10.6	Pl. 49, Figs 3a-3b

DESCRIPTION: **The tests** are relatively high, circular in outline, and hemispherical in lateral profile (*see* Pl. 49, Figs 2b, 3b).

The ambulacra are narrow, and strongly sinuous above the ambitus (*see* Pl. 49, Fig. 2b). Ambulacral plating and tuberculation is distinguished into three regions. Above the ambitus, the plating is unigeminate with small, imperforate, noncrenulate primary tubercle on each plate; all the very numerous plates are equally developed; the secondary tuberculation between primary tubercles is well developed and represented by densely spaced tubercles that are smaller than the primary ones. At the ambitus, the plating is unigeminate and bigeminate; the tubercles gradually become large and perforate. Below the ambitus, the plating is trigeminate, tubercles are large, and perforate. In this region the secondary tuberculation gradually declines; the pore-pairs become more crowded together on the most adoral two or three plates only; above this region, up to the apical disc, the pore-pairs are uniserial.

The interambulacra are wide and composed of a few (4) plates only. Each plate carries a relatively small, crenulate and perforate tubercle. The mamelons are small and bosses not very pronounced. Above the ambitus, areoles are large, shallow, circular in outline and surrounded by 14 delicate scrobicular tubercles. Secondary tuberculation is moderately developed. At the apex, one of the interambulacral columns is pointed with a large plate having a well developed primary tubercle, whereas in the other the adapical plate is greatly reduced, bearing a rudimentary tubercle.

The apical disc (*see* Pl. 49, Figs 2a, 3a) is hemicyclic (ocular I is insert, others are exert), and rather small, 30-40% of the test diameter. The ocular plates are small and heart-shaped in outline. The genital plates are unequal in size, the posterior ones are distinctly smaller than the anterior ones. Gonopores are positioned on the outer part of the plates. All plates are covered by radial furrows giving the apical disc a strong ornamentation, but genitals additionally have small tubercles developed close to the outer rim of plates. The disc plates are thick so that the whole apical disc stands out prominently above the coronal plates.

The peristome is very large, 60-64% of the test diameter, with shallow and wide buccal slits.

REMARKS: The studied specimens corespond to those given in the synonymy, and they differ from *Pseudocidaris mammosa* (L. AGASSIZ, 1840) by such characters of interambulacra as the smaller number (4) of interambulacral plates in a column, and distinctly smaller primary tubercles.

A comment on some German species, presented by BEURLEN (1937, pp. 97-98), remains unclear, as his remarks do not clarify the differences with *Ps. mammosa* (L. AGASSIZ, 1840).

The species *Pseudocidaris thurmanni* (L. AGASSIZ, 1840) has been mentioned by SCHMIDT (1905) from Western Pomerania.

Pseudocidaris sanctacrucensis sp.n.
(Pl. 23, Figs 9-16)

HOLOTYPE: The specimen No. EWi/127 presented in Pl. 23, Figs 12a-12c.
TYPE LOCALITY: Wierzbica, northeastern margin of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Lower Kimmeridgian.
DERIVATION OF THE NAME: Adjective *sanctacrucensis* – neo-Latinized, in reference to the Holy Cross region.

DIAGNOSIS: Test low, subconical in profile; interambulacra composed of numerous plates, 6-7 per column; primary interambulacral tubercles with small mamelons and bosses; narrow interradial zone with fine, miliary tuberculation; primary spines almost smooth, covered by fine tubercles only.

MATERIAL: Six well preserved tests (4 from Małogoszcz, 2 from Wierzbica), and about 20 primary spines from Wierzbica.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
EWi/127 **holotype**	29.0	21.0	8.0	14.0	Pl. 23, Figs 12a-12c
EMa/45	18.0	10.0	7.0	10.0	Pl. 23, Figs 11a-11b
ZPAL E.V/13	19.0	11.0	7.0	11.0	Pl. 23, Figs 9-9a
EMa/44	12.5	6.5	5.0	7.5	Pl. 23, Fig. 10

DESCRIPTION: **The tests** are circular in outline, low and subconical in profile, with broad flattish base and ambitus lying close to the base (*see* Pl. 23, Figs 9a, 11a, 12b).

The ambulacra are strongly sinuous above the ambitus (*see* Pl. 23, Figs 9b, 10, 11b, 12a). Above the ambitus, towards the apex, plating is unigeminate; the primary tubercles are equal in size, imperforate and noncrenulate. The perradial zone is narrow, and covered by small and not numerous tubercles. At the ambitus the primary tubercles become gradually large, perforate and weakly crenulate; plating is bigeminate. Below the ambitus the ambulacra expand slightly, tubercles become large, perforate and crenulate; plating is trigeminate. The pore-pairs on the lowest two or three compound plates become biserial.

The interambulacra are wide (*see* Pl. 23, Figs 9a, 12b), composed of relatively numerous (as for the genus *Pseudocidaris*), six or seven plates in a column. There is always one adapical plate in each series, which is greatly reduced and bears a rudimentary, weakly crenulate tubercle (*see* Pl. 23, Figs 11b, 12a). Above the ambitus all plates are higher than wide. Ambital and adapical plates are nonconfluent, and scrobicular rings bear 13-14 widely spaced, small tubercles. Mamelons and bosses are small, but areoles relatively wide (*see* Pl. 23, Figs 9a, 12b). The narrow, zigzag-shaped interradial zone is covered by fine tuberculation and is composed of various-sized small miliary tubercles. Adorally, plates become confluent, and scrobicular tubercles are confined to the adradial and interradial regions.

The apical disc is small, 28-40% of the test diameter (*see* Pl. 23, Fig. 12c). The disc is hemicyclic, the ocular I is exsert, others are insert. The ocular plates are small and heart-shaped in outline. The genital plates are unequal in size, the posterior ones are distinctly smaller than the anterior ones. The gonopores are positioned on the outer part of the plates. The madreporite is larger than others genitals, and covered by small granules.The other genital plates and all oculars are covered by radial furrows giving the apical disc a strong ornamentation, but genitals additionally have small tubercles developed close to the outer rim of plates and few tubercles positioned arround the periproct. The periproct is large oval or circular in outline. The disc plates are thick so that the whole apical disc stands out prominently above the coronal plates.

The peristome is large, 50 % of the test diameter. Buccal slits are shallow and wide (*see* Pl. 23, Fig. 11c).

The primary spines (*see* Pl. 23, Figs 13-16) are massive, clavate, more or less elongate. The shaft is almost smooth or ornamented by very delicate granules. The neck, collar and base are very short. The milled ring is well developed.

REMARKS: The newly established species *Pseudocidaris sanctacrucensis* sp.n. closely resembles *Pseudocidaris thurmanni* (L. AGASSIZ, 1840); it differs by its test, which is low and conical in profile, by a narrower interradial zone, by a smaller peristome, and by an additional interambulacral plate in each column.

The newly established species *Pseudocidaris sanctacrucensis* sp.n. differs from *Ps. mammosa* (L. AGASSIZ, 1840) by its test, which is low and conical in profile and by its distinctly smaller mamelons and bosses on the interambulacral primary tubercles.

Order **Phymosomatoida** MORTENSEN, 1904

Genus *Trochotiara* LAMBERT, 1901

Trochotiara kongieli sp.n.
(Pls 24-25)

partim 1856. *Pseudodiadema mamillanum*; E. DESOR, p. 64, Pl. 12, Figs 1-3.

partim 1872. *Pseudodiadema mamillanum* A. ROEMER sp.; DAMES, p. 115, Pl. 7, Figs 1a-1c.

partim 1882. *Pseudodiadema mamillanum* (ROEMER), DESOR, 1856; G. COTTEAU, p. 363, Pl. 363, Figs 5-14.

partim 1882. *Pseudodiadema neglectum* DESOR, 1856; G. COTTEAU, p. 374, Pl. 365, *non* Pl. 366.

partim 1937. *Polydiadema mamillanum* (ROEMER); K. BEURLEN, p. 110, *non* Text-fig. 25.

1957. *Trochotiara mamillanum* (ROEMER); R. KONGIEL, p. 16, Pl. 3, Figs 4-7.

1961. *Trochotiara mamillanum* (ROEMER); W. BARCZYK, p. 71, Pl. 4, Figs 3 and 5.

HOLOTYPE: The specimen No. ECz/128 presented in Pl. 24, Figs 1a-1c.
TYPE LOCALITY: Czarnogłowy near Szczecin (in German: *Zarnglaff bei Stettin*) in Western Pomerania, northwestern Poland.
TYPE HORIZON: Lower Kimmeridgian.
DERIVATION OF THE NAME: To honor the memory of Roman KONGIEL (1904-1960), a prominent Polish paleontologist (graduated at the University of Wilno, professor of paleontology at the University of Toruń), the author of an earlier monograph of the Czarnogłowy echinoids (*see* KONGIEL 1957).

DIAGNOSIS: Trigeminate compound plates throughout, except at the ambitus with one quadrigeminate plate in adult specimens. Ambulacral and interambulacral plates bearing large primary tubercles with swollen bosses and moderately large mamelons; secondary tubercles scarce.

MATERIAL: 42 well preserved tests from Czarnogłowy, 25 from Karsy, 14 from Małogoszcz, 7 from Sulejów, 4 from Annopol, 3 from Gołuchów, 2 from Ożarów; 1 from: Gruszczyn, Leśnica, and Wierzbica.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
ECz/128 **holotype**	29.2	13.0	10.5	13.0	Pl. 24, Figs 1a-1c
EKa/130	31.5	12.7	13.0	14.4	Pl. 24, Figs 3a-3b
ZPAL E.VIII/11	28.3	11.7	11.2	12.0	Pl. 25, Figs 1a-1b
EMa/46	27.6	11.0	10.0	12.2	Pl. 25, Figs 4a-4c

DESCRIPTION: **The tests** are subpentagonal in outline, low to moderately high, flattened adorally (*see* Pl. 24, Figs 1-3 *and* Pl. 25, Figs 1-4). **The ambulacra** are straight; they taper sharply adapically, expand at the ambitus (*see* Pl. 25, Fig. 6a) and taper gradually towards the peristome (*see* Pl. 25, Fig. 6b). Large pore-pairs are arranged uniserially (*see* Pl. 24, Figs 4, 5a-5b *and* Pl. 25, Figs 5, 6a), except a few ones, which are crowded together close to the peristome (*see* Pl. 25, Fig. 6b) and form narrow phyllodes. Compound plates are all almost trigeminate (*see* Pl. 24, Fig. 5a) in the diadematoid manner (all elements reach the perradius), except at the ambitus, where one plate in each column is quadrigeminate (*see* Pl. 24, Fig. 5b *and* Pl. 25, Fig 6a). On the ambital plates, the pore-pairs are widely spaced, sometimes separated by small granules. Each compound plate bears a single, large, crenulate and perforate primary tubercle. Primary tubercles have a large, swollen boss, and moderately large mamelon (*see* Pl. 24, Fig. 5b); these tubercles gradually decrease in size both adapically and adorally. Areoles are confluent throughout. The perradial zone is very narrow, and secondary and miliary tuberculation is confined only to a zigzag perradial suture (*see* Pl. 25, Fig. 6a).

The interambulacra at the ambitus are about 1.5 times wider than the ambulacra, and are much less tapered both adapically and adradially. Each interambulacral plate bears a large, strongly crenulate and perforate primary tubercle (*see* Pl. 24, Fig. 4). Primary tubercles have a large, swollen boss, and moderately large mamelon. The largest tubercles are present at the ambitus, and they decrease in size gradually both adapically and adorally. Areoles are narrow and tangential adapically, but at the ambitus as well as adorally they become confluent. Secondary tuberculation is sparsely distributed and confined to the adradial and interradial zone. However, on the three or four plates closest to the apical disc, secondary tuberculation disappears, and the interradial zone becomes slightly sunken and naked (*see* Pl. 24, Figs 1a, 3a *and* Pl. 25, Figs 1a, 2a, 3b, 4a).

The apical disc is pentagonal in outline (*see* Pl. 25, Figs 1a, 2a), moderately large, about 40% of the test diameter. The tips of the pentagon lie interradially so that the apical borders of the interambulacra are strongly notched. Apical plates are not preserved in all specimens.

The peristome is large (*see* Pl. 24, Figs 1b, 2b *and* Pl. 25, Figs 1b, 2b, 4b), about 45-50% of the test diameter, and has shallow, but well defined buccal slits.

REMARKS: The newly established species, *Trochotiara kongieli* sp.n., is herein accommodated in the genus *Trochotiara* LAMBERT, 1901, due to the presence of trigeminate compound plates associated with a quadrigeminate one at the ambitus, all of which with the pore-pairs uniserial adapically but crowded together close to the peristome.

Included in the synonymy of the newly established species, *Trochotiara kongieli* sp.n., are some of the specimens presented by former authors under various names. Such specimens were usually assigned to the genus *Polydiadema*, and the to species *mamillanum*, both of which have quite a long and complex history.

The species name *mamillanus* (for *Cidarites*) was introduced by F.A. ROEMER (1836, p. 26) whose description of this species and its illustration (F.A. ROEMER 1836, Pl. 2, Fig. 1) still remain not fully interpretable. Moreover, it became clear soon after that both the nature of the species and its generic assessment gave rise to more doubts than clear facts. A concise review of this history has already been presented both in the Polish literature, by KONGIEL (1957, pp. 18-20 of the Polish text, *and* pp. 63-65 of the French text), and in England, by SMITH & WRIGHT (1993, pp. 219-220 and pp. 248-250). To the present author's recognition, these two reviews fully document the successive steps in the history of the discussed genus and species names, and thus there is no reason to be herein repeated.

Until the nature of F.A. ROEMER's specimen is not recognized, the present author suggests to retain the species name *mamillanum* for the forms with polygeminate compound plates at the ambitus. If so, the species *mamillanum* is to be accommodated in the genus *Polydiadema*, in accordance with the treatment by FELL & PAWSON (1966) and SMITH & WRIGHT (1993, p. 218) who regarded the genera *Trochotiara* and *Polydiadema* as separate. In the *Treatise*, FELL & PAWSON (1966, p. *U*389) indicated the species *mamillanum* as the type of the genus *Polydiadema*.

Other authors, *e.g.* HESS (1975), labelled the species as *Polydiadema mamillanum* and they did not distinguish *Trochotiara* LAMBERT, 1901, from *Polydiadema* LAMBERT, 1888.

In the present author's opinion, to the genus *Trochotiara* should be ascribed the forms with adapically trigeminate compound plates associated, in the adult specimens, with one quadrigeminate plate at the ambitus; such a treatment has earlier been advocated by MORTENSEN (1935, p. 434) and by KONGIEL (1957, p. 18).

Consequently, when *Polydiadema* and *Trochotiara* are accepted as separate genera, part of the specimens (*see* synonymy) described by DESOR (1856), DAMES (1872), COTTEAU (1882), and BEURLEN (1937) belong to the genus *Trochotiara*.

From the type species of the genus *Trochotiara* LAMBERT, 1901, namely *Trochotiara priscum* (L. AGASSIZ, 1840), the newly established species *Trochotiara kongieli* sp.n. differs by its ambulacral columns more distinctly tapered both adapically and adorally, as well as by the more prominent primary tubercles, but less numerous secondary tubercles.

Trochotiara suleiovense sp.n.
(Pl. 26, Figs 1a-1c)

HOLOTYPE: The specimen No. ESl/133 presented in Pl. 26, Figs 1a-1c.
TYPE LOCALITY: Sulejów, southwestern margin of the Holy Cross Mountains, Central Poland.
TYPE HORIZON: Lower Kimmeridgian.
DERIVATION OF THE NAME: Adjective, neo-Latinized in reference to the type locality.

DIAGNOSIS: Small primary tubercles (ambulacral and interambulacral) surrounded by numerous, densely spaced, secondary tubercles equal in size; areoles nonconfluent; apical disc relatively small.

MATERIAL: One well preserved test.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
ESl/133 **holotype**	32.4	11.5	10.6	13.2	Pl. 26, Figs 1a-1c

DESCRIPTION: **The test** is large, low, subpentagonal in outline (*see* Pl. 26, Figs 1a -1c).
The ambulacra are straight and narrow; they sharply taper adapically, expand at the ambitus, and taper gradually towards the peristome. Pore-pairs are arranged uniserially, except those close to the apical disc where they tend to yield an incipient biseriality. A few pore-pairs are crowded together close to the peristome, and form small phyllodes. All plates are trigeminate throughout. Pores are relatively small and densely spaced. Each compound plate bears a relatively small, perforate and crenulate primary tubercle, which is surrounded by small secondaries. Secondary tubercles are well developed at the perradial zone, where they form double zigzag rows. Adapically and adorally tubercles are also present (Pl. 26, Figs 1a-1b). Areoles are nonconfluent. Large primary tubercles are developed at the ambitus, and decrease gradually in size both towards the apical disc and the peristome.
The interambulacra are wide (at the ambitus they are twice as wide as the ambulacra), and much less tapered both adapically and adorally. Each interambulacral plate (11 in a column) bears a small, perforate and crenulate, primary tubercle (Pl. 26, Fig. 10). Primary tubercles are surrounded by numerous equally sized, secondary tubercles, which are not confined only to the adradial and interradial zone, but are also present both adorally and adapically. Areoles are small and nonconfluent, except two or three close to the peristome.
The apical disc is relatively small, 30% of the test diameter. Apical plates are not preserved (*see* Pl. 26, Fig. 1a).
The peristome is moderately large, 40% of the test diameter. Buccal slits are shallow (*see* Pl. 26, Fig. 1b).

REMARKS: The studied specimen, due to its plate compounding (trigeminate throughout) and uniserial arrangement of pore-pairs, as well as the character of the primary tubercles (perforate and crenulate), is assigned to the genus *Trochotiara* LAMBERT, 1901. The newly established species *Trochotiara suleiovense* sp.n. differs from *Trochotiara kongieli* sp.n. by having distinctly smaller primary tubercles, and by the well developed, numerous secondary tubercles, as well as by the small apical disc.

The new species, *Trochotiara suleiovense* sp.n., is also close to the two species known from the Portlandian of France, viz. *Tr. baccarum* (SAUVAGE & RIGAUX, 1872), and *Tr. sauvagei* (RIGAUX, 1882) [both having been suggested to be conspecific by VADET (1989, p. 60)], from which it differs by the lack of a second row of interambulacral granules and by the peristome and apical disc being distinctly smaller.

Family **Diplopodiidae** SMITH & WRIGHT, 1993

Genus *Tetragramma* L. AGASSIZ, 1840

Tetragramma planissimum L. AGASSIZ, 1840
(Pl. 26, Figs 2-3)

1840a. *Tetragramma planissimum* AG.; L. AGASSIZ, p. 9.

1840b. *Tetragramma planissimum* AG.; L. AGASSIZ, p. 26, Pl. 14, Figs 1-3.

1855. *Pseudodiadema planissimum* AGASS.; E. DESOR, p. 69.

1855. *Pseudodiadema planissimum*, AGASSIZ; T. WRIGHT, p. 141.

1871. *Pseudodiadema planissimum*, DESOR (AGASSIZ); E. DESOR & P. DE LORIOL, p. 179 and p. 400, Pl. 32, Fig. 4.

1882. *Pseudodiadema planissimum* (AGASSIZ), DESOR, 1856; G. COTTEAU, p. 369, Pl. 364, Figs 4-8.

1883. *Hexagramma planissimum*; M. POMEL, p. 104.

1890. *Diplopodia planissima*, AGASSIZ; P. DE LORIOL, p. 87, Pl. 15, Figs 11 and 11a-11c.

MATERIAL: One badly preserved test and one fragment from Wierzbica; one badly preserved test from Niziny.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
ZPAL E.V/18	23.8	6.8	13.5	10.0	Pl. 26, Figs 2a-2b

DESCRIPTION: **The test** is wheel-shaped in outline and very low (*see* Pl. 26, Figs 2a-2b).

The ambulacra are straight and narrow; they taper adapically, expand gradually at the ambitus, and slightly taper towards the peristome. Large pore-pairs are arranged biserially close to the apical disc (*see* Pl. 26, Fig. 3a), then become uniserial at the ambitus and just below (*see* Pl. 26, Figs 2d, 3b); close to the peristome they become crowded to form moderately broad phyllodes. All plates are trigeminate (*see* Pl. 26, Figs 2d, 3a-3b). Each compound plate bears a single, large, perforate and crenulate primary tubercle; these tubercles gradually decrease in size both adapically and adorally. The perradial zone is narrow, and secondary and miliary tuberculation is confined to a zigzag perradial suture; few secondaries are positioned near the adradial suture, close to the pore-pairs.

The interambulacra at the ambitus are almost twice as wide as the ambulacra and slightly taper adapically and adorally. Interambulacral plates are very broad, low and *S*-shaped (*see* Pl. 26, Fig. 2c). Each plate bears one primary tubercle positioned centrally and a second one large, positioned adradially. The third large tubercle, developed at the ambital and just above ambital plates, is placed adradially (*see* Pl. 26, Fig. 2c); these third tubercles sharply decrease in size both adapically and adorally. Miliary tuberculation is weakly developed, and dispersed between primary and secondary tubercles.

The apical disc is large, about 56% of the test diameter. Apical plates are not preserved.

The peristome is large, 43% of the test diameter, and has shallow buccal slits.

REMARKS: The studied specimens conform to those described by AGASSIZ (1840b) as *Tetragramma planissimum*. The subsequent authors (*see* synonymy) placed this species into various genera. In the present author's opinion, this species, according to its original assignation, should be retained in the genus *Tetragramma* L. AGASSIZ, 1840. This species has not hitherto been reported from Poland.

Tetragramma pomeraniae KONGIEL, 1957
(Pl. 27, Figs 1a-1f)

1957. *Tetragramma pomeraniae* n.sp.; R. KONGIEL, p. 20 and p. 65, Pl. 4, Figs 1-3.

MATERIAL: Three tests – two from Małogoszcz (one badly preserved), as well as the holotype of KONGIEL (1957), coming from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
MUZ P.I.G.219.II.17 **holotype**	11.0	5.0	5.0	5.0	——
EMa/47	16.0	5.0	—	7.9	Pl. 27, Figs 1a-1f

DESCRIPTION: **The tests** are relatively small, subpentagonal in outline, low, and flattened both adapicall and adorally (*see* Pl. 27, Figs 1a-1c).

The ambulacra are straight; they gradually taper adapically and adorally. Pore-pairs are biserial adapically (*see* Pl. 27, Fig. 1e), but at the ambitus and just below they become uniserial (*see* Pl. 27, Fig. 1f); close to the peristome they crowd together to form phyllodes. Plate compounding is trigeminate throughout (*see* Pl. 27, Figs 1e-1f). Each plate bears a large, perforate and crenulate primary tubercle, which gradually decreases in size adapically and adorally. Secondary and miliary tuberculation is weakly developed, confined only to the perradial suture, and it forms a narrow zigzag row.

The interambulacra at the ambitus are over 1.5 times wider than the ambulacra. Each *S*-shaped and low plate bears two large, equal in size, perforate and crenulate tubercles; these tubercles occupy almost the whole plate (*see* Pl. 27, Fig. 1d), and gradually decrease in size both towards the apical disc and peristome, but adapically they become flattened. Areoles are very narrow, and confluent throughout. Secondary and miliary tuberculation is developed at the moderately wide interradial zone, between two large tubercles, and at the ambitus close to the adradial suture (*see* Pl. 27, Fig. 1d).

The apical disc is large, 55% of the test diameter of the holotype (this region is badly preserved in other specimens).

The peristome is large, 49-55% of the test diameter, and has shallow, but well defined buccal slits (*see* Pl. 27, Fig. 1b).

REMARKS: The species *Tetragramma pomeraniae* KONGIEL, 1957, was established by KONGIEL (1957) on the grounds of one small specimen (holotype). The newly collected material comprises two specimens; they differ from the holotype only in a more developed secondary and miliary tuberculation, but this character results from the larger dimension of the new specimens.

It is noteworthy that the holotype of *Tetragramma pomeraniae* KONGIEL, 1957, has trigeminate plate compounding throughout, and there is no quadrigeminate plate at the ambitus, the presence of which was mentioned by KONGIEL (1957, p. 21).

Family **Phymosomatidae** POMEL, 1883

Genus *Phymosoma* HAIME, 1853

Phymosoma douvillei (COTTEAU, 1875)
(Pl. 27, Figs 2-3)

1883. *Cyphosoma Douvillei*, COTTEAU, 1875; G. COTTEAU, p. 536, Pl. 404.

1987b. *Phymosoma douvillei* (COTTEAU); A. ZBINDEN, p. 522 and 527, Text-figs 39-40.

MATERIAL: Two badly preserved tests, of which one is from Karsy, and another one from Małogoszcz.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	vd	*∅Ad*	*∅Pm*	Figured in:
EMa/48	19.2	6.4	8.9	9.0	Pl. 27, Fig. 2
EKa/135	17.3	6.0	8.2	9.3	Pl. 27, Figs 3a-3e

DESCRIPTION: **The test** is pentagonal in outline, low, flattened adorally and adapically (*see* Pl. 27, Figs 2-3).

The ambulacra are straight, relatively wide, tapering both adapically and adorally. Ambulacral plates number 10-11 in a column. Pore-pairs are arranged biserially adapically (*see* Pl. 27, Fig. 3c); at the ambitus they become sinuous uniserial (*see* Pl. 27, Fig. 3e), but are adorally crowded together and form moderately large phyllodes. At the ambitus, towards the apical disc, there occurs quadrigeminate plate compounding in the phymosomatoid manner (*see* Pl. 27, Figs 3c-3d). Below the ambitus the plate compounding is trigeminate. Each ambulacral plate bears a large, imperforate, crenulate primary tubercle (*see* Pl. 27, Fig. 3d). Each primary tubercles has a well developed, swollen boss, and relatively large mamelon. Areoles are tangential. The perradial zone is narrow, and covered by not numerous, relatively large miliary tubercles, which form a zigzag row (*see* Pl. 27, Fig. 3c).

The interambulacra are 1.3 times wider than the ambulacra; interambulacral plates number 8 in a column. Each plate bears a large primary tubercle, and two relatively large secondary tubercles, which are developed close to the adradial suture (*see* Pl. 27, Fig. 3e). The secondary tubercles are well developed adorally and at the ambitus; adapically they rapidly diminish in size. Primary and secondary tubercles are imperforate and crenulate, and form distinct straight rows (*see* Pl. 27, Fig. 3e). Areoles are narrow, tangential. Miliaries are relatively large, and confined to the adradial and interradial regions of the plate, but adapically they disappear.

The apical disc is subpentagonal in outline, but its plates are not preserved.

The peristome is large, about 53% of the test diameter; buccal slits are shallow.

REMARKS: The studied material comprises only two juvenile and badly preserved specimens which, due to their mode of plate compounding, as well as the presence of imperforate and crenulate tubercles, are assigned to the genus *Phymosoma* HAIME, 1853. The species *Phymosoma douvillei* (COTTEAU, 1875) differs from *Phymosoma supra-*

corallinum (Cotteau, 1865) by its characteristic, well developed secondary tuberculation on interambulacral plates, and by the more pentagonal outline of the test.

Phymosoma supracorallinum (Cotteau, 1865) (Pls 28-29)

1882. *Leiosoma Beaugrandi*, n.sp.; E. Rigaux, p. 626, Pl. 22, Figs 3, 3a-3c.
1883. *Cyphosoma morierei*, Cotteau, 1883; G. Cotteau, p. 539, Pl. 406, Figs 6-11.
1883. *Cyphosoma supracorallinum* Cotteau, 1865; G. Cotteau, p. 541, Pl. 405 and Pl. 406, Figs 1-5.
1910. *Phymosoma morierei* Cotteau; J. Lambert & P. Thiéry, p. 223.
1910. *Phymosoma supracorallinum* Cotteau; J. Lambert & P. Thiéry, p. 223.
1957. *Phymosoma supracorallinum* (Cotteau); R. Kongiel, p. 22, Pl. 4, Figs 4-6.
1987b. *Phymosoma supracorallinum* (Cotteau); A. Zbinden, p. 523 and p. 527, Figs 40-41.

MATERIAL: 28 well preserved tests (26 from Czarnogłowy, 1 from Świętoszewo, 1 from Małogoszcz), 7 fragments from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
MUZ P.I.G.219.II.22	24.0	7.5	11.0	11.0	Pl. 28, Figs 5a-5d
ECz/136	22.0	8.9	10.0	9.4	Pl. 28, Figs 1a-1c
ZPAL E.VIII/14	21.3	8.0	10.0	9.4	Pl. 28, Figs 2a-2b
ECz/137	17.6	6.2	9.0	8.0	Pl. 28, Figs 4a-4b *and* Pl. 29, Figs 1a-1e
ZPAL E.VIII/15	14.2	5.0	6.0	7.0	Pl. 28, Figs 3a-3c

DESCRIPTION: **The tests** are circular to subangular in outline, and strongly flattened adapically and adorally (*see* Pl. 28, Figs 1-4).

The ambulacra are straight; they sharply taper adapically, expand gradually at the ambitus and taper gradually towards the peristome. Porepairs are arranged biserially from the ambitus to the apical disc (*see* Pl. 28, Fig. 5a *and* Pl. 29, Figs 1a, 2a); at the ambitus and just below they become uniserial, but slightly sinuous (*see* Pl. 28, Figs 5c-5d *and* Pl. 29, Figs 1b-1e); close to the peristome they become crowded together, to form moderately broad phyllodes (*see* Pl. 29, Fig. 2b). Plate compounding is variable: from the ambitus to the apical disc it is quadrigeminate (*see* Pl. 28, Fig. 5a *and* Pl. 29, Figs 1b, 1c), at the ambitus quinquegeminate (phymosomatoid; *see* Pl. 28, Figs 5b-5d), but in the juvenile forms it is quadrigeminate ambitally (*see* Pl. 29, Figs 1d-1e); finally, from the ambitus towards the peristome it becomes trigeminate (*see* Pl. 29, Fig. 2b). Each compound plate bears a large, imperforate, crenulate primary tubercle (*see* Pl. 28, Figs 5a-5d). In the juvenile forms, some mamelons, especially close to the peristome, may be perforate (*see* Pl. 29, Figs 1b, 1c, 1e). Primary tubercles gradually decrease in size both adapically and adorally. From the ambitus, towards the peristome, the secondary and miliary tuberculation is confined to the perradial suture, to form a narrow, zigzag row (*see* Pl. 29, Fig. 2b). Above the ambitus, adapically, secondary and miliary tubercles are also present at the adapical sutures.

The interambulacra at the ambitus are about 1.5 times wider than the ambulacra, and are less tapered, both adapically and adorally. Each interambulacral plate bears a large, imperforate and crenulate tubercle (*see* Pl. 29, Fig. 2c). In the juvenile forms, some mamelons are perforate. Secondary tubercles are well developed, and they are positioned close to the adradial sutures, where form the distinct, second row of tubercles; these tubercles towards the apical disc sharply decrease in size. Moderately wide, interradial zone is also covered by small secondary and miliary tubercles, which disappear adapically. Adapically, the interradial zone becomes smooth and sunken (*see* Pl. 28, Figs 2a, 4a).

The apical disc is large, 45-51% of the test diameter, and is pentagonal in outline. Apical plates in all specimens are not preserved.

The peristome is moderately large, 43-45% of the test diameter. Buccal slits are narrow, but well defined (*see* Pl. 28, Figs 1c, 3b).

REMARKS: The studied specimens conform to those known as "*Cyphosoma supracorallinum* Cotteau, 1865", although a relatively rich material from Czarnogłowy comprises numerous juvenile forms, which display some variability in the development of the primary tubercles. Many of them have some of the primary interambulacral and ambulacral tubercles with perforate mamelons. This character of the primary tubercles was noted by Kongiel (1957), who interpreted it as a result of damage.

In the present author's opinion, the perforate tubercles, especially close to the peristome, appear only in juvenile forms; they are not observable in the adults. Consequently, this character results from the juvenile nature of the specimens, and not from their state of preservation.

Family **Stomechinidae** POMEL, 1883

Genus *Stomechinus* DESOR, 1856

Stomechinus gyratus (L. AGASSIZ, 1840)
(Pl. 30, Figs 4-5)

1840a. *Echinus gyratus* AG.; L. AGASSIZ, p. 12.
1840b. *Echinus gyratus* AG.; L. AGASSIZ, p. 87, Pl. 23, Figs 43-46.
1847. *Echinus gyratus* AGASS.; L. AGASSIZ & E. DESOR, p. 62.
1856. *Stomechinus gyratus*, AGASSIZ; T. WRIGHT, p. 215, Pl. 14, Figs 4a-4e.
1871. *Stomechinus gyratus* (AGASSIZ), DESOR; E. DESOR & P. DE LORIOL, p. 226, Pl. 36, Figs 3-5.
1872. *Stomechinus gyratus* AG. sp.; W. DAMES, p. 615, Pl. 22, Fig. 1.
1884. *Stomechinus gyratus* (AGASSIZ), DESOR, 1857; G. COTTEAU, p. 745 and p. 893, Pls 470-471.
non 1905. *Stomechinus gyratus* AG. sp.; M. SCHMIDT, p. 94.
1937. *Stomechinus gyratus* (AGASSIZ); K. BEURLEN, p. 138.
1957. *Stomechinus gyratus* (AGASSIZ); R. KONGIEL, p. 25, and p. 68; Pl. 5, Figs 2-4.
1987b. *Stomechinus gyratus* (AGASSIZ); A. ZBINDEN, p. 526 and p. 528, Text-fig. 46.

MATERIAL: Five tests from Małogoszcz and five fragments (2 from Małogoszcz, 3 from Karsy).

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
EMa/50	52.0	29.3	10.0	—	Pl. 30, Figs 5a-5b
EMa/49	39.5	22.6	7.0	9.0	Pl. 30, Figs 4a-4b

DESCRIPTION: **The tests** are subpentagonal in outline, moderately high, hemispherical in profile, with a broad flattish base and the ambitus lying close to the base (*see* Pl. 30, Figs 4-5).

The ambulacra are straight and taper sharply adapically. Pore zones are broad, slightly depressed with pore-pairs arranged in arcs of three, positioned obliquely to the sutures; close to the peristome they are crowded together and form broad phyllodes. Pore zones are associated with small tubercles dispersed regularly between pore-pairs. Every second ambulacral plate bears an imperforate, noncrenulate, primary tubercle. Each primary tubercle is surrounded by densely spaced secondary and miliary tubercles; at the ambitus and close to the peristome these tubercles become confluent and form narrow rims. Primary tubercles are the largest at the ambitus and just below; they gradually decrease in size both adapically and adorally. At the inner side of the primary tubercles there are two rows of secondary tubercles; these tubercles are equal in size with primary ones at the ambitus and towards the peristome, where they form only one row. From the ambitus, towards the apical disc, secondary tubercles sharply decrease in size. The perradial zone is narrow and smooth.

The interambulacra are more than twice as wide as the ambulacra at the ambitus. Each interambulacral plate bears one small, imperforate, noncrenulate primary tubercle and numerous secondary tubercles almost equal in size. These tubercles form one to three rows outside the primary tubercles (three rows are developed at the plates close to the ambitus); below the ambitus one or two rows of such tubercles are developed. At the inner side of primary tubercles present are two or three rows of secondary tubercles; close to the peristome there is only one row. The interradial zone is broad, smooth, and slightly depressed (*see* Pl. 30, Figs 4a, 5a); the smooth area reaches the ambitus (*see* Pl. 30, Fig. 5b).

The apical disc is dicyclic, with ocular plates well separated from the periproct, small, about 20% of the test diameter. The genital plates are broad and low with large gonopores situated not too close to the outer sutures. The madreporite is distinctly larger than the other genitals. All plates are covered by relatively large tubercles. The periproct is large, subquadrangular in outline (*see* Pl. 30, Figs 4a, 5a).

The peristome is large, about 47% of the test diameter, with relatively deep, and narrow buccal slits.

REMARKS: The studied specimens conform to the holotype and those indicated in the synonymy.

The species has hitherto been reported in Poland from the studied locality Czarnogłowy, by KONGIEL (1957).

Stomechinus semiplacenta
(L. AGASSIZ *in* AGASSIZ & DESOR, 1847)
(Pl. 30, Figs 1-3)

1847. *Echinus semiplacenta* AGASS.; L. AGASSIZ & E. DESOR, p. 62.
1856. *Stomechinus semiplacenta*; E. DESOR, p. 129.
1856. *Stomechinus semiplacenta*, DESOR; T. WRIGHT, p. 225.

1871. *Stomechinus semiplacenta*, DESOR (AGASSIZ); E. DESOR & P. DE LORIOL, p. 228, Pl. 38, Figs 1-3.
1884. *Stomechinus semiplacenta* (AGASSIZ), DESOR, 1847; G. COTTEAU, p. 757, Pl. 475 and Pl. 476, Figs 1-5 and 9-10, ?Figs 6-8.
1905. *Stomechinus gyratus* AG. sp.; M. SCHMIDT, p. 94.
1905. *Stomechinus* cf. *perlatus* DESM. sp.; M. SCHMIDT, p. 94.
1935. *Stomechinus semiplacenta* (AG.); T. MORTENSEN, p. 505.
1937. *Stomechinus semiplacenta* (AGASSIZ); K. BEURLEN, p. 139.
1957. *Stomechinus* cf. *semiplacenta* (AGASSIZ); R. KONGIEL, p. 28 and p. 69; Pl. 4, Fig. 7 and Pl. 5, Fig. 1.
1961. *Stomechinus semiplacenta* (AGASSIZ); W. BARCZYK, p. 71, Pl. 4, Fig. 4.

MATERIAL: 16 tests (14 from Sulejów, 2 from Ożarów).

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
ESl/140	39.0	24.6	7.5	18.3	Pl. 30, Fig. 3
EOz/138	32.5	16.0	7.2	15.7	Pl. 30, Figs 1a-1c
ESl/139	28.0	9.3	5.5	14.4	Pl. 30, Figs 2a-2b

REMARKS: The species *S. semiplacenta* (L. AGASSIZ *in* AGASSIZ & DESOR, 1847) is very similar (*see* Pl. 30, Figs 1-3) to the preceding species, *S. gyratus* (L. AGASSIZ, 1840), from which it differs by the circular outline of the test, and by the smooth interradial areas (in interambulacral columns), which are narrower and shorter, and do not reach the ambitus.

The studied specimens correspond to those indicated in the synonymy. In all former monographs, *S. semiplacenta* has been regarded as a separate species. Nevertheless, in the present author's opinion, it cannot be excluded that the forms classified as *S. semiplacenta* (L. AGASSIZ *in* AGASSIZ & DESOR, 1847) are conspecific with those of *S. gyratus* (L. AGASSIZ, 1840).

The close similarity of these two taxa has already involved some confusion for SCHMIDT (1905) whose forms (*see* SCHMIDT 1905, fossil list in p. 94) reported under the name *S. gyratus*, fall well into *S. semiplacenta*, as recognized by BEURLEN (1937, p. 139) who investigated SCHMIDT's original collection.

The species has hitherto been reported in Poland from the studied section of Sulejów, by BARCZYK (1961), and as *conformis* by KONGIEL (1957), from Czarnogłowy. As remarked above, to this species are also ascribed former reports (SCHMIDT 1905, BEURLEN 1937; *see also* KONGIEL 1957, p. 30 and p. 69) from Trzebieszewo near Czarnogłowy.

Genus *Polycyphus* L. AGASSIZ & DESOR, 1846

Polycyphus distinctus (L. AGASSIZ, 1840)
(Pl. 31, Figs 1-4)

1840a. *Echinus distinctus* AG.; L. AGASSIZ, p. 12.
1847. *Echinus distinctus* AGASS.; L. AGASSIZ & E. DESOR, p. 62.
1856. *Polycyphus distinctus*, AGASSIZ; T. WRIGHT, p. 202.
1857. *Polycyphus distinctus* AGASS.; E. DESOR, p. 118.
1884. *Stomechinus distinctus* (AGASSIZ), COTTEAU, 1884; G. COTTEAU, p. 754, Pl. 474, Figs 1-11.
1890. *Stomechinus distinctus* (AGASSIZ), COTTEAU; P. DE LORIOL, p. 106, Pl. 18, Figs 2, 2a-2e.
1987c. *Polycyphus distinctus* (AGASSIZ); A. ZBINDEN, p. 546 and p. 548, Fig. 47.

MATERIAL: 15 tests (8 from Karsy, 7 from Małogoszcz).

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*ØAd*	*ØPm*	Figured in:
EKa/141	17.5	9.8	4.3	8.0	Pl. 31, Figs 1a-1c
EMa/51	13.4	7.7	3.3	6.5	Pl. 31, Figs 2a-2g
EMa/53	13.3	7.4	3.4	7.0	Pl. 31, Figs 4a-4b
EMa/52	12.6	7.3	—	—	Pl. 31, Fig. 3

DESCRIPTION: **The tests** are small, circular in outline, hemispherical in profile, with a broad flat base and the ambitus lying close to the base (*see* Pl. 31, Figs 1-4).

The ambulacra are straight and taper sharply adapically. The pore zones are broad with biserially arranged pore-pairs; close to the peristome they are crowded together, and form phyllodes. All plates are trigeminate throughout (*see* Pl. 31, Figs 2f-2g). Each ambulacral plate bears a small, imperforate and noncrenulate primary tubercle. Primary tubercles are distinguishable only at the adapical plates; below this region there appears another row of secondary tubercles, which are equal in size with the primary ones; the third row of secondary tubercles may appear at the ambitus (*see* Pl. 31, Figs 2f-2g). Between primary and larger secondary tubercles dispersed are smaller secondary, as well as miliary tubercles (*see* Pl. 31, Fig. 2g). Ambulacral tubercles (primary and secondary ones) sharply increase in size at the adoral plates.

The interambulacra are twice wider than the ambulacra at the ambitus. Each low and broad, interambulacral plate bears one small, imperforate and noncrenulate primary tubercle, which is distinguishable only at the adapical plates, where it is surrounded by a circle of small secondary tubercles (*see* Pl. 31, Fig. 2d). Below this region there gradually appear more numerous secondary tubercles, which are almost equal in size with the primary ones; these tubercles may form two horizontal rows (*see* Pl. 31, Fig. 2e). Interambulacral tubercles (primary and secondary ones) sharply increase in size at the adoral plates. The interradial zone is distinct, depressed, and smooth (*see* Pl. 31, Figs 1a, 1c, 2d).
The apical disc is dicyclic, with all ocular plates exsert, but with ocular *I* displaced close to the periproctal rim. Apical system is small (*see* Pl. 31, Fig. 1a), about 25% of the test diameter. Genital plates are broad and low, with very large gonopores situated subcentrally. The madreporite is distinctly larger than the other genitals. The periproct is large, subquadrangular in outline.
The peristome is large, about 45-50% of the test diameter, with shallow, but well defined buccal slits (*see* Pl. 31, Figs 1b, 2b, 4b).

REMARKS: The studied specimens fully correspond to those given in the synonymy.

The generic assignment of the species, because of the size of primary interambulacral tubercles, has hitherto been variably treated: either, to include it into the genus *Polycyphus* L. AGASSIZ & DESOR, 1846, as given by WRIGHT (1856), DESOR (1857), ZBINDEN (1987c), or into the genus *Stomechinus* DESOR, 1856, as given by COTTEAU (1884) and DE LORIOL (1890).

In the present author's opinion, the primary interambulacral tubercles are only somewhat larger than the secondaries, especially on the aboral side (*see* Pl. 31, Figs 1a, 3), and the whole ornamentation on the interambulacral plates is homogeneous (*see* Pl. 31, Fig. 2e) within all studied specimens which justifies their accommodation in the genus *Polycyphus* L. AGASSIZ & DESOR, 1846. Neither this genus, nor the discussed species, have hitherto been reported from Poland.

Genus *Psephechinus* POMEL, 1883

Psephechinus sp.
(Pl. 32, Figs 1a-1h)

MATERIAL: One juvenile test from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	∅*Ad*	∅*Pm*	Figured in:
ECz/142	9.8	5.0	2.7	5.0	Pl. 32, Figs 1a-1h

DESCRIPTION: **The test** is small, circular in outline, subhemispherical in profile, with a broad flat base and the ambitus lying close to the base (*see* Pl. 32, Figs 1a-1b).
The ambulacra are straight, and sharply taper adapically. All ambulacral plates are trigeminate, with pore-pairs arranged in arcs of three (*see* Pl. 32, Figs 1c-1e). Each plate bears one, large, imperforate and noncrenulate primary tubercle; however, above the ambitus, plates with three small tubercles may appear (*see* Pl. 32, Fig. 1c), but always a primary one is distinguishable amongst the secondary tubercles. Primary tubercles gradually increase in size towards the peristome. Relatively large secondary tubercles are confined to the perradial suture, where they form a zigzag row, and one secondary tubercle appears on every second element of the plate, close to the pore-pair (*see* Pl. 32, Figs 1d-1e).
The interambulacra are over 1.5 times wider than the ambulacra at the ambitus. Each interambulacral plate bears one, large, imperforate and noncrenulate primary tubercle. Primary tubercles are surrounded by broadly spaced scrobicular tubercles (*see* Pl. 32, Fig. 1g) which, from the ambitus towards the peristome, are confined to the adradial and interradial sutures. Close to the adradial suture there appears a row of secondary tubercles (*see* Pl. 32, Fig. 1g); at the ambitus they become equal in size to the primary ones. Above the ambitus the secondary tubercles sharply decrease in size, and disappear adapically.
The apical disc is dicyclic, with all oculars exsert, but with oculars *I* and *II* displaced close to the periproctal rim (*see* Pl. 32, Fig. 1f). The genitals are unequal in size, the posterior ones being smaller than the anterior. The periproct is large, irregularly oval in outline.
The peristome is large, 49% of the test diameter, with shallow buccal slits (*see* Pl. 32, Fig. 1h).

REMARKS: The studied specimen is assigned to the genus *Psephechinus* POMEL, 1883, due to its trigeminate ambulacral plates, with pore-pairs arranged in arcs of three, and the primary imperforate, noncrenulate tubercles, distinguishable amongst the secondary ones. It is similar to *Psephechinus schlumbergeri* COTTEAU, 1864, from the Middle Jurassic (Bathonian) of France, which has primary tubercles well pronounced; it differs, however, by stronger secondary tuberculation.

The relatively small size of the studied specimen, as compared to that of all the species of the genus, is thought to indicate its juvenile character, not yielding features diagnostic of a definite species.

The genus *Psephechinus* POMEL, 1883, has not hitherto been reported from Poland.

Order **Arbacioida** GREGORY, 1900

Genus *Gymnocidaris* L. AGASSIZ, 1840

Gymnocidaris agassizi (F.A. ROEMER, 1839)
(Pls 33-35)

1839. *Cidarites* (*Diadema*) *Agassizii* Nob.; F.A. ROEMER, p. 17, Pl. 17, Fig. 31.

1840a. *Hemicidaris diademata* AG.; L. AGASSIZ, p. 8.

1840b. *Hemicidaris diademata* AGASS.; L. AGASSIZ, p. 49, Pl. 19, Figs 15-17.

1847. *Hemicidaris diademata* AGASS.; L. AGASSIZ & E. DESOR, p. 34.

1855. *Hemicidaris diademata* AGASS.; E. DESOR, p. 54.

1855. *Hemicidaris Cartieri* DESOR; E. DESOR, p. 54, Pl. 10, Figs 11-12.

1855. *Hemicidaris diademata* AGASS; T. WRIGHT, p. 103.

1869. *Hemicidaris diademata* AGASSIZ; E. DESOR & P. DE LORIOL, p. 110, Pl. 17, Figs 8-11 and Pl. 18, Figs 1-3.

1872. *Hemicidaris Agassizi* A. ROEMER sp.; W. DAMES, p. 106, Pl. 6, Figs 1a-1b.

1881. *Hemicidaris Agassizi* (ROEMER), DAMES, 1872; G. COTTEAU, p. 114, Pls 292-294.

1890. *Hemicidaris Agassizi* (ROEMER), DAMES; P. DE LORIOL, p. 70, Pl. 12, Figs 32-33 and ?Pl. 14, Figs 21-22.

non 1975. *Gymnocidaris agassizii* (ROEMER); H. HESS, p. 95, Pl. 36, Fig. 12 (*see* HESS 1985).

MATERIAL: 216 well preserved tests (205 from Małogoszcz, 11 from Karsy); single, badly preserved from: Sulejów, Gołuchów, Leśnica, and Karsznice.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	∅*Ad*	∅*Pm*	Figured in:
EM/55	57.3	38.0	16.2	28.0	Pl. 33, Figs 2a-2b
EKa/59	40.8	22.6	13.6	21.0	Pl. 33, Figs 3a-3c
EMa/61	39.8	24.6	12.4	—	Pl. 34, Fig. 5
EMa/56	32.4	19.7	9.8	16.7	Pl. 34, Figs 1a-1d
EMa/57	24.0	13.7	8.7	8.2	Pl. 34, Figs 2a-2c

DESCRIPTION: **The tests** are moderately large, circular to subpentagonal in outline, and hemispherical to subconical in profile, with the ambitus lying close to the base (*see* Pl. 33 *and* Pl. 34, Figs 1-4).

The ambulacra are straight (*see* Pl. 34, Figs 1b, 2b); aboral and ambital pore-pairs, represented by broad *P1* isopores, are uniserial and well separated (*see* Pl. 35, Fig. 1a-1b, 3b); at the ambitus small tubercles appear between the pore-pairs (*see* Pl. 35, Fig. 1b). Below the ambitus pore-pairs become more oval in outline and are represented by *P2* isopores (*see* Pl. 35, Fig. 3a). Close to the peristome the pores are crowded together (*see* Pl. 35, Figs 2b, 4b) and form broad phyllodes. Above the ambitus, towards the apex, bigeminate plates alternate with simple plates. Each bigeminate plate bears a small imperforate, noncrenulate tubercle, which is surrounded by a circle of small, densely spaced tubercles (*see* Pl. 35, Fig. 1a). Each simple plate carries two or three (on the adambital plates) horizontally placed tubercles. Primary ambulacral tubercles form straight rows. The perradial zone widens towards the ambitus and is covered by densely spaced secondary miliary tubercles. Just below the ambitus, the ambulacra expand abruptly in width and the primary tubercles become large, perforate and strongly crenulate. The plating is quadrigeminate. The perradial zone becomes very narrow and is covered by zigzag-arranged small, secondary and miliary tubercles. Adorally, pore-pairs of *P2* and *P3* isopores are crowded together and form phyllodes (*see* Pl. 35, Figs 2a-2b, 4a-4b).

The interambulacra are wide and composed of 8-9 plates in a column (*see* Pl. 33, Figs 1b, 3b). The upper three adapical plates in each column bear a reduced (imperforate and non crenulate) primary tubercle (*see* Pl. 33, Figs 1a, 2a, 3a *and* Pl. 34, Figs 1a, 2a, 4). The primary tubercles are surrounded by the scrobicular ring of tubercles, which are barely distinguishable from other secondary tubercles. Secondary tubercles are numerous and densely covering the plates. The other interambulacral plates bear a well developed, perforate and crenulate primary tubercle. Primary tubercles have small mamelon set on the large boss (*see* Pl. 33, Figs 1b, 3b). Areoles are shallow, moderately large and confluent. Scrobicular, and well developed secondary, and miliary tubercles are confined to the adradial and interradial zones (*see* Pl. 33, Figs 1b, 2b, 3b).

The apical disc is small, 28-35 % of the test diameter, dicyclic; all small, pentagonal oculars are exsert (*see* Pl. 34, Figs 1d, 5). Each ocular plate bears

three large tubercles. The genital plates are wide and unequal in size; the posterior one (5) is smaller than the others. The madrepores form a dense cluster surrounded by tubercles. The gonopores are positioned on the outer part of the plates, but not very closely to the outer rim. The other genital plates are covered by tubercles, the largest of which form a distinct ring, which surrounds the periproct. The periproct is large, circular or oval in outline. In some specimens the apical disc stands out above the test.
The peristome (*see* Pl. 33, Figs 1c, 3c *and* Pl. 34, Figs 1c, 2c) is large, with distinct, deep buccal slits.

REMARKS: The studied species *Gymnocidaris agassizi* (F.A. ROEMER, 1839) is represented by very numerous specimens (over 200), most of them coming from the Małogoszcz Quarry. This very rich material is relatively homogeneous, and small differences concern only the height, and lateral profile varying from high, subconical to low, hemispherical (*compare* Pl. 33, Figs 2b, 3b). Such a difference is regarded herein as of intraspecific importance.

This species has, surprisingly, not hitherto been reported from Poland.

Suborder **Arbaciina** GREGORY, 1900

Family **Acropeltidae** LAMBERT & THIÉRY, 1911

Genus *Acropeltis* L. AGASSIZ, 1840

Acropeltis aequituberculata L. AGASSIZ, 1840

(Pl. 36, Figs 1a-1e)

1840a. *Acropeltis aequituberculata* AG.; L. AGASSIZ, p. 12.
1847. *Acropeltis aequituberculata* AGASS.; L. AGASSIZ & E. DESOR, p. 36, Pl. 15, Figs 7-8.
1856. *Acropeltis aequituberculata* AGASS.; E. DESOR, p. 86, Pl. 14, Figs 1-2.
1856. *Acropeltis concinna* MERIAN; E. DESOR, p. 86.
1858. *Acropeltis aequituberculata* AGASS.; F. QUENSTEDT, p. 736, Pl. 90, Fig. 3.
1871. *Acropeltis concinna*, MERIAN; E. DESOR & P. DE LORIOL, p. 198, Pl. 33, Fig. 4.
1883. *Acropeltis aequituberculata*, AGASSIZ, 1840; G. COTTEAU, p. 562, Pl. 412, Figs 1-17 and Pl. 413, Figs 1-6.
1891. *Acropeltis aequituberculata*, AGASSIZ; P. DE LORIOL, p. 93, Pl. 16, Fig. 4.
1975. *Acropeltis aequituberculata* AGASSIZ; H. HESS, p. 102, Pl. 39, Fig. 8.

MATERIAL: One broken test from Sobków-Wierzbica.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
ESo/143	12.6	5.6	4.7	7.4	Pl. 36, Figs 1a-1e

DESCRIPTION: **The test** is small, low hemispaerical, flattened below the ambitus (Pl. 36, Figs 1a-1b).
The ambulacra are straight, uniserial, except towards the peristome where a few pore-pairs are crowded together and form small phyllodes. All plates are trigeminate. Each compound plate bears a single, large, imperforate and non crenulate primary tubercle (*see* Pl. 36, Fig. 1e). These tubercles are almost as large as the interambulacral ones. Perradial zone is almost smooth, and bears only few small granules situated close the perradial suture.
The interambulacra are moderately wide. There are 7-8 interambulacral plates in a column. Each plate carries a large, imperforate and non-crenulate primary tubercle with a circular areole (*see* Pl. 36, Fig. 1d). Mamelons are large and areoles are nonconfluent except close to the peristome. Primary tubercles are surrounded by regular scrobicular rings of small, delicate tubercles (*see* Pl. 36, Fig. 1d).
The apical disc is dicyclic with ocular plates well separated from the periproct (*see* Pl. 36, Fig. 1c). The oculars are slightly convex and triangular in outline. The genitals are equal in size, strongly projecting with large gonopores situated at the extreme outer point. Each genital plate bears a large, centrally placed tubercle. The periproct is small, oval in outline.
The peristome is large, with shallow buccal slits.

REMARKS: The studied specimen is compatible with those given in the synonymy. Both the genus, as well as the species, have not hitherto been reported from Poland.

Genus *Glypticus* L. AGASSIZ, 1840

Glypticus sp.

(Pl. 36, Figs 2a-2e)

MATERIAL: One badly preserved test from Sobków-Wierzbica.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
ESo/144	12	6.6	4.9	6.0	Pl. 36, Figs 2a-2e

DESCRIPTION: **The test** is small, low hemisphaerical, flattened below the ambitus (*see* Pl. 36, Figs 2a-2b).

The ambulacra are straight (*see* Pl. 36, Fig. 2d), moderately broad, uniserial, except towards the peristome where, a few pore-pairs are crowded together and form phyllodes. All plates are trigeminate. The large primary tubercles are imperforate and noncrenulate. However, they are well developed at the ambitus and adorally only, but adapically they are small and weakly distinguishable from those of the epistroma. The epistromal tubercles are circular or trabecular in outline (*see* Pl. 36, Figs 2b, 2d) and they are developed in two regular rows adapically, and in three rows just above the ambitus.

The interambulacra are broad, slightly less than twice the width of ambulacra (*see* Pl. 36, Fig. 2e). As in the ambulacra there are large, imperforate and noncrenulate primary tubercles, which are well developed at the ambitus and adorally (*see* Pl. 36, Fig. 2b). Adapically they are small, and weakly distinguishable from epistromal tubercles. Primary tubercles are situated close the adradial sutures. The zone between these tubercles is covered by three rows of small tubercles. The interambulacra are covered by six longitudinal rows of epistromal tubercles just above the ambitus. Adapically, there are only five rows of epistromal tubercles, regularly arranged in successive rows; tubercles, circular or trabecular in outline, equal in size with the ambulacral ones, are well projected, almost stalk-like, and are densely spaced (*see* Pl. 36, Figs 2a, 2e).

The apical disc is dicyclic (*see* Pl. 36, Fig. 2c), relatively large, measuring 41% of the test diameter. The heart-shaped, ocular plates are well separated from the periproct, and projected beyond the genital plates. The genital plates are concave centrally, and pointed distally. The gonopores are large, and positioned at the distal point of each genital plate. The madreporite is somewhat larger than the other genitals. All ocular and genital plates are covered by irregular furrows. The periproct is large, and pentagonal in outline.

The peristome is large, measuring 50% of the test diameter, buccal slits are shallow.

REMARKS: The collected specimen, assigned to the genus *Glypticus* AGASSIZ, 1840, is the closest to the two species, *G. regularis* ÉTALLON, 1858, from the Upper Oxfordian of France, and *G. burgundiacus* MICHELIN, 1853, from the Callovian of France (*see* COTTEAU 1883); these two species have been assigned to the separate genus *Pleiocyphus* POMEL, 1883 (*see* POMEL 1883, FELL & PAWSON 1966) but, as thoroughly argued by MORTENSEN (1941) and SMITH & WRIGHT (1993, p. 209), a distinction of these two genera is not justified.

From these two above-indicated species, the studied specimen differs by the presence of larger and better developed epistromal tubercles, their stalk-like shape, and by their arrangement: the tubercles are more densely spaced (involving the Amb/IAmb sutures to be hardly discernible) and more regularly arranged in longitudinal rows.

From other species of the genus, *Glypticus* sp. differs primarily by the more regular and dense spacing of the epistromal tubercles; but its juvenile character does not yield features diagnostic of a definite species.

Of the genus *Glypticus* L. AGASSIZ, 1840, solely the common European species *G. hieroglyphicus* (GOLDFUSS) has hitherto been known from Poland, having been reported in the Oxfordian strata by F.A. ROEMER (1870, Pl. 25, Figs 22-24) from Bzów in the Polish Jura, and by SAMSONOWICZ (1934) from Przepaść in the Holy Cross Mountains. Moreover, *Glypticus* sp. was noted by ŚWIDZIŃSKI (1931, p. 823) from the Lower Kimmeridgian at Brzegi (near Sobków, *see* Text-fig. 4) in the Holy Cross Mountains.

Superorder UNCERTAIN
(Echinacea or Diadematacea)

Order **Orthopsida** MORTENSEN, 1942
Family **Orthopsidae** DUNCAN, 1889

Genus *Orthopsis* COTTEAU, 1884

Orthopsis pomeraniae KONGIEL, 1957
(Pl. 37, Figs 1a-1i)

1957. *Orthopsis pomeraniae* n. sp.; R. KONGIEL, p. 30 and p. 70, Pl. 5, Figs 5-6.

MATERIAL: Three tests (1 adult and 2 juveniles) from Czarnogłowy.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	*∅Ad*	*∅Pm*	Figured in:
MUZ P.I.G.219.II.25 **holotype**	17.0	9.0	4.5	8.0	—
ECz/145	8.9	4.6	3.5	5.4	Pl. 37, Figs 1a-1i

DESCRIPTION: **The test** is small, circular in outline, subhemispherical in profile, with broad flattish base and the ambitus lying close to the base (*see* Pl. 37, Figs 1a-1c).

The ambulacra are narrow, straight, and gradually taper adapically. All ambulacral plates are imperfectly trigeminate, with distinct sutures between primary plates (*see* Pl. 37, Figs 1d-1f, 1h). The pore zones are straight and uniserial, with large pores separated by narrow granule (*see* Pl. 37, Figs 1e-1f). The interporiferous zone bears two rows of relatively large, perforate, noncrenulate primary tubercles; primary tubercles may be weakly crenulate at the ambitus (*see* Pl. 37, Fig. 1h). Each primary tubercle occupies two or three (at the ambitus) simple plates (*see* Pl. 37, Figs 1f, 1h). Secondary tubercles are three or four times smaller than primary ones, and developed both close to the interradial suture and at every third simple plate (*see* Pl. 37, Fig. 1e).

The interambulacra are composed of relatively narrow and long plates. Each plate bears one perforate, noncrenulate primary tubercle (with a large, swollen boss), positioned close to the adoral suture, and surrounded by broadly spaced scrobicular tubercles (*see* Pl. 37, Fig. 1g). Primary tubercles are almost equal in size throughout, and sporadically may be weakly crenulate (*see* Pl. 37, Fig. 1i). At the ambitus, on the inner side of the primary tubercles are two secondary tubercles, larger than the scrobicular ones. Towards the apical disc these tubercles diminish in size and number; close to the apex they disappear. On the outer side of primary tubercles, in the adult specimen, one row of secondary tubercles is developed. On the juvenile specimens, the secondary tuberculation is weakly developed.

The apical disc is small, hemicyclic, with the ocular *I* insert. The genitals are equal in size, pentagonal in outline, with gonopores positioned subcentrally. The oculars are small, pentagonal in outline. All plates are covered by small tubercles.

The peristome is large, about 47% of the test diameter, with shallow buccal slits (*see* Pl. 37, Fig. 1c).

REMARKS: The studied species *Orthopsis pomeraniae* KONGIEL, 1957, has been established by KONGIEL (1957) on the grounds of only one specimen, indicated as the holotype of the species, from Czarnogłowy. In the collected material from the same quarry, there are also two juvenile specimens, concordant with the holotype (*see* KONGIEL 1957, Pl. 5, Figs 5-6), from which they differ only by their smaller size and weakly developed secondary tuberculation.

Superorder **Eognathostomata** SMITH, 1981
Order **Pygasteroida** DURHAM & MELVILLE, 1957
Family **Pygasteridae** LAMBERT, 1900

Genus *Pygaster* L. AGASSIZ, 1836

Pygaster morrisi WRIGHT, 1851
(Pls 38-39)

1856. *Pygaster morrisii*, WRIGHT; T. WRIGHT, p. 280, Pl. 20, Figs 1a-1f.
1857. *Pygaster Morrisii* WRIGHT; E. DESOR, p. 166.
1872. *Pygaster humilis* nov. spec.; W. DAMES, p. 638, Pl. 24, Figs 2a-2c.
1961. *Pygaster morrisi* WRIGHT; W. BARCZYK, p. 73, Pl. 5, Fig. 2.
1988. *Pygaster gressleyi* DESOR, 1842; W. JESIONEK-SZYMAŃSKA, p. 378, Pl. 175, Figs 1a-1c.

MATERIAL: 45 tests (41 well preserved from Małogoszcz, 2 well preserved from Sobków, 2 badly preserved from Karsy, 1 well preserved from Sulejów).

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	∅*Ad*	∅*Pm*	Figured in:
EMa/70	63.0	28.0	5.0	16.0	Pl. 39, Figs 3a-3b
EMa/66	61.0	26.7	—	16.0	Pl. 38, Figs 1a-1c
EMa/69	46.0	20.0	4.0	13.0	Pl. 39, Figs 2a-2c
EMa/68	43.0	18.5	4.0	12.0	Pl. 39, Figs 1a-1c

DESCRIPTION: **The tests** are flat with the ambitus lying close to the base, distinctly subpentagonal in outline, with a shallow concavity on the posterior margin; the aboral surface is regularly convex, the adoral surface has a shallow central concavity (*see* Pl. 38, Figs 1a-1c *and* Pl. 39, Figs 1-3).

The ambulacra are slightly convex, moderately wide with simple plates compounding throughout (*see* Pl. 38, Fig. 2a *and* Pl. 39, Fig. 4a). The three anterior ones (ambulacra *II*, *III*, *IV*) are straight, but the two posterior ones (ambulacra *I*, *V*) are curved close to the apical disc. Pore-pairs are arranged uniserially in each column, right up to the peristome. Pores of *P2* type are equal in size and separated by a narrow partition (*see* Pl. 38, Figs 2b-2d *and* Pl. 39, Fig. 4b). Aborally, pore-pairs are densely spaced and slightly oblique to the suture, but close to the peristome they become more oblique and scarcely spaced. Pore zones are curved close to the peristome and pore-pairs are developed parallel at the peristomial margin. The interporiferous zone is covered by six rows of relatively large primary tubercles (*see* Pl. 38, Fig. 1c *and* Pl. 39, Figs 1b, 2b): the outermost ones continue throughout the whole ambulacrum, the inner ones disappear close to the apex and the peristome, and the innermost ones are developed at the middle part of the ambulacrum (at the ambitus, and just above, and below). Tubercles are perforate, equal in size, and surrounded by relatively large, deep and circular areoles. The whole surface between primary tubercles is covered by densely spaced miliary tubercles (*see* Pl. 38, Fig. 2a *and* Pl. 39, Fig. 4a). At the adoral surface, the tubercles become gradually large, surrounded by deeper and hexagonal areoles.

The interambulacra are three times wider than ambulacra at the ambitus. The aboral surface of the interambulacrum is covered by numerous, equal-sized, perforate primary tubercles. At the ambitus, the number of tubercles attains 20-22 in one horizontal row. At the interradial zone, the primary tubercles are arranged horizontally, but towards the adradial sutures they become more zigzag. Each tubercle is surrounded by a circular, relatively deep areole. The whole surface between primary tubercles is covered by densely spaced miliary tubercles. At the adoral surface, the primary tubercles become larger, less regularly arranged, and are surrounded by deeper, oval or hexagonal areoles. Close to the peristome the number of primary tubercles is sharply reduced and miliary tubercles are well developed (*see* Pl. 38, Fig. 1b *and* Pl. 39, Fig 3b).

The apical disc is small, with the large, tear-shaped periproct outside the apical system. The genital plates are unequal in size, genital *2* is enlarged, with the madreporite situated centrally. The other genitals (*1*, *3*, *4*, but *5* is missing) are small, strongly projected, with the gonopores situated close to the outer margin of the plates. The ocular plates are small, pentagonal in outline. In contact with the periproct there may remain only the genital *2* and ocular *I*, or genitals *1*, *2*, *4* and ocular *I* (depending on the size of the madreporite).

The peristome is relatively large, 25-28% of the test diameter, with very well developed deep and broad buccal slits (*see* Pl. 38, Fig. 1b *and* Pl. 39, Figs 1c, 2c, 3b).

REMARKS: The collected specimens conform to those indicated in the synonymy. In Poland, the species has hitherto been reported by BARCZYK (1961) from the studied section Sulejów and, referred to as *Pygaster gresslyi* DESOR, 1842, by JESIONEK-SZYMAŃSKA (1988) from Przemianki.

The studied species *Pygaster morrisi* WRIGHT, 1851, differs from *P. gresslyi* DESOR, 1842, by its distinctly lower test, and by the greater number of densely spaced tubercles (at the ambitus: 22 rows of tubercles in interambulacra, and 6 rows in ambulacra).

Pygaster tenuis L. AGASSIZ, 1839
(Pls 40-42)

1839. *Pygaster tenuis*; L. AGASSIZ, p. 83.
1839. *Pygaster umbrella* AG.; L. AGASSIZ, p. 83, Pl. 13, Figs 4-6.
1847. *Pygaster umbrella* AGASS.; L. AGASSIZ & E. DESOR, p. 86.
1847. *Pygaster tenuis* AGASS.; L. AGASSIZ & E. DESOR, p. 86.
1856. *Pygaster umbrella*, AGASSIZ; T. WRIGHT, p. 282, Pl. 20, Figs 2a-2f.
1856. *Pygaster tenuis*, AGASSIZ; T. WRIGHT, p. 290.
1857. *Pygaster tenuis* AGASS.; E. DESOR, p. 166.
1872. *Pygaster umbrella* AG.; W. DAMES, p. 637, Pl. 24, Fig. 1.
1872. *Pygaster tenuis*, AGASSIZ; E. DESOR & P. DE LORIOL, p. 278, Pl. 44, Figs 1-2.
1891. *Pygaster umbrella*, AGASSIZ; P. DE LORIOL, p. 115, Pl. 22, Fig. 1.
1986. *Pygaster tenuis* AGASSIZ; A. ZBINDEN, p. 365 and p. 369, Text-figs 22-23.

MATERIAL: 20 well preserved tests and 16 fragments from Małogoszcz; one badly preserved test from Gołuchów, and one from Wierzbica.

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	∅*Ad*	∅*Pm*	Figured in:
EMa/72	116.0	46.0	—	22.0	Pl. 40, Figs 1a-1b
EMa/74	83.0	40.0	—	17.0	Pl. 41, Figs 2a-2b
EMa/75	83.0	40.0	—	17.0	Pl. 41, Fig. 3

DESCRIPTION: **The tests** are circular to subpentagonal in outline, and hemispherical to high subconical in profile, with the ambitus lying close to the base (*see* Pls 40-41). The oral surface is almost flat, but in the center there is a deep concavity around the peristome (*see* Pl. 41, Fig. 1b).

The ambulacra are narrow with simple plate compounding throughout (*see* Pl. 40, Fig. 1a; Pl. 41, Figs 1c, 2a, 3 *and* Pl. 42, Figs 1a, 2a). The anterior ambulacra are straight, but the posterior ones (ambulacra *I*, *V*) are slightly curved close to the apical disc. Pore-pairs are arranged uniserially in each column, right up to the peristome. Aborally the pores are large and separated by a small granule (*see* Pl. 42, Figs 2b-2c, 3a-3b). Pores of *P2* type are unequal in size, adradial ones are oval and often almost twice larger than the perradial ones (*see* Pl. 42, Figs 3a-3b). At the ambitus and at the adoral surface, the pores become smaller, more equal in size and are separated by a relatively large granule (*see* Pl. 42, Figs 1b, 1c). Close to the peristome, the pore zones are curved and pore-pairs are arranged parallelly to the peristome margin. The interporiferous zone is covered by two rows of perforate tubercles close to the pore zones; these tubercles are developed throughout the whole ambulacral length. At about one-third of the test height there appears the second row of tubercles, situated outside the first one. All these tubercles have circular, shallow areoles surrounded by scarcely spaced miliary tubercles. Miliaries are dispersed on the whole interporiferous zone. Tuberculation is distinctly different between the aboral and adoral surface of the test. Aborally all tubercles are small and delicate, but at the oral surface they become large and the areoles become deeper, oval to subpentagonal in outline.

The interambulacra are four times wider than ambulacra at the ambitus. Aborally, each interambulacral plate bears one centrally placed small primary tubercle, but distinctly larger than the others (*see* Pl. 40, Fig. 1a *and* Pl. 41, Figs 1c, 2a, 3). Besides the primary tubercles, there gradually appear (one to four on every side) smaller secondary tubercles, arranged in zigzag rows. The primary and secondary tubercles have circular, shallow areoles, surrounded by sparcely spaced scrobicular tubercles. Numerous miliary tubercles are dispersed on the remaining surface of the plate. Tuberculation is distinctly different between aboral and oral surface. At the oral surface, the tubercles become large, arranged in regular, horizontal rows (*see* Pl. 41, Fig. 1b) and the areoles become deeper and oval or subpentagonal in outline; miliary tubercles are confined to the aboral and adoral margins of areoles.

The apical disc is relatively small with the large, tear-shaped periproct outside the apical system. The genital plates are unequal in size, genital *2* is enlarged, and the madreporite is situated centrally. The other genital plates (*1*, *3*, and *4*) are small, strongly projected, and sharply pointed with gonopores positioned very close to the outer rim of the plates. Contacted with the periproct is only ocular *V* and, at one point, also genital *4*. All plates are covered by small granules.

The peristome is small, 18-21% of the test diameter, centrally placed in a deep concavity. Buccal slits are deep (*see* Pl. 41, Fig. 1b).

REMARKS: The present author synonymizes the two species established by AGASSIZ (1839), namely *Pygaster tenuis* AGASSIZ, 1839, and *Pygaster umbrella* AGASSIZ, 1839, with the priority name of the former one (*see* AGASSIZ 1839, p. 83), because neither morphological details nor the thickness of test-walls are substantial to distinguish any distinct groups within the studied assemblage (36 specimens and/or fragments) collected at Małogoszcz. In that locality, it is apparent that the thicker-walled specimens occur within the residual lag of *Actinostreon* shellbeds, whereas the thinner-walled ones do solely within the *Exogyra*-bearing marly unit (*see* Text-fig. 6A). To note, it was ZBINDEN (1986) who first recognized a lack of features distinguishing these two species and ascribed the priority name to the species *tenuis* of AGASSIZ (1839).

Order **Holectypoida** DUNCAN, 1889
Suborder **Holectypina** DUNCAN, 1889
Family **Holectypidae** LAMBERT, 1899

Genus *Holectypus* DESOR, 1842

Holectypus corallinus D'ORBIGNY, 1850
(Pls 43-44)

1856. *Holectypus corallinus*, D'ORBIG.; T. WRIGHT, p. 270.
1872. *Holectypus corallinus* D'ORBIGNY; W. DAMES, p. 640, Pl. 24, Fig. 4.
1872. *Holectypus corallinus*, D'ORBIGNY; E. DESOR & P. DE LORIOL, p. 265, Pl. 45, Figs 4-5.
1891. *Holectypus corallinus*, D'ORBIGNY; P. DE LORIOL, p. 112, Pl. 19, Fig. 4.
1957. *Holectypus corallinus* D'ORBIGNY; R. KONGIEL, p. 34 and p. 72, Pl. 6, Figs 3-6.
1961. *Holectypus corallinus* D'ORB.; W. BARCZYK, p. 72, Pl. 4, Fig. 6.
1988. *Holectypus corallinus* D'ORBIGNY, 1850; W. JESIONEK-SZYMAŃSKA, p. 378, Pl. 175, Figs 2a-2c.

MATERIAL: 415 tests (259 from Małogoszcz, 109 from Karsy, 25 from Czarnogłowy, 9 from Gołuchów, 7 from Leśnica, 5 from Celiny, 4 from Gruszczyn; 1 from: Korytnica, and Annopol).

DIMENSIONS (*in* mm):

Coll. No.	*hd*	*vd*	Ø*Ad*	Ø*Pm*	Figured in:
EMa/173	54.0	20.5	2.7	—	—
EMa/81	45.4	20.0	2.5	10.5	Pl. 43, Figs 1a-1c
EMa/87	33.8	16.2	2.3	10.4	Pl. 44, Figs 5a-5b
EMa/85	32.0	16.0	2.2	—	Pl. 44, Figs 3a-3b
EMa/80	31.0	17.0	2.0	—	Pl. 43, Figs 2a-2b

DESCRIPTION: **The tests** are circular to subpentagonal in outline, and hemispherical to subconical in profile, with the ambitus lying close to the base (*see* Pl. 43, Figs 1-3). The oral surface is flattened and concave with peristome placed centrally, and with the regularly oval or amygdaloid periproct situated posteriorly to the peristome (*see* Pl. 43, Fig. 4).

The ambulacra are straight, narrow, with simple plate compounding (*see* Pl. 44, Fig. 1b); pore-pairs represented by *P2* isopores (*see* Pl. 44, Figs 1a, 2b) are arranged uniserially in each column, right up to the peristome. Pores of *P2* type are relatively large, equal in size, and separated by a narrow partition (*see* Pl. 44, Fig. 2b). At the oral surface the pores become larger and more widely spaced (*see* Pl. 44, Figs 2a, 2c, 2d). The interporiferous zone is covered by perforate, almost equally sized tubercles, arranged in rows, which are oblique to the poriferous zones. The number of tubercles increases towards the ambitus and reaches four in one oblique row at the ambitus. Each tubercle has a shallow and relatively large areole surrounded by a circle of miliary tubercles. Tuberculation is distinctly different at the aboral and adoral surface of the test. Above the ambitus, all tubercles all small and delicate; at the ambitus and at the oral surface all tubercles become large.

The interambulacra are three times wider than the ambulacra at the ambitus. Each plate bears a row of horizontally arranged perforate tubercles (*see* Pl. 43, Fig. 5). At the ambitus they number 10-11 on one plate in the largest specimens. Each tubercle has a shallow, circular, and relatively large areole surrounded by a circle of miliary tubercles. At the ambitus and at the oral surface the tubercles become larger. Adorally, the tubercles are less regularly arranged and surrounded by deeper, larger and transversally oval areoles (*see* Pl. 44, Fig. 5b).

The apical disc is small (only 5-7% of the test diameter; *see* Pl. 43, Fig. 4), composed of five genital and five ocular plates. The madreporite, larger than other genital plates, is in contact with the other four genitals. The madreporitic perforations are not only confined to the genital *2*, but can also be found in the adjacent region of the other (*1* and *3*) genital plates. The genital *5* is imperforate, lacking the gonopore. All the gonopores are large and circular in outline. The ocular plates are small and not in contact one with the other.

REMARKS: This is the very common species in the collected material, both as concerns the number of specimens, as well as the localities in which it occurs. The studied specimens conform to those indicated in the synonymy.

The collected material is relatively homogeneous; some specimens higher than others (*see* Pl. 43, Fig. 2a *and* Pl. 44, Fig. 3a) are regarded herein as intraspecific variants.

The species was illustrated in Poland by Kongiel (1957), from Czarnogłowy, by Barczyk (1961), from Sulejów, and by Jesionek-Szymańska (1988), from Leśnica.

Superorder **Microstomata** Smith, 1984
Order **Cassiduloida** Claus, 1880
Family **Clypeidae** Lambert, 1898

Genus *Pygurus* L. Agassiz, 1839

Pygurus blumenbachi Koch & Dunker, 1837
(Text-fig. 7 and Pl. 46, Figs 2-3)

1837. *Clypeaster Blumenbachii*, nobis; F. Koch & W. Dunker, p. 37, Pl. 4, Figs 1a-1c.
1847. *Pygurus Blumenbachi* Agass; L. Agassiz & E. Desor, p. 104.
1860. *Pygurus Blumenbachii*, Koch & Dunker; T. Wright, p. 400, Pl. 38, Figs 1-2.
1869. *Pygurus Blumenbachi*, Koch et Dunker, 1837; G. Cotteau, p. 157, Pl. 38, Fig. 3 and Pls 39-40.
1869. *Pygurus Royerianus* Cotteau, 1854; G. Cotteau, p. 164, Pls 41-42.
1872. *Pygurus Blumenbachi*, Agassiz (Koch et Dunker); E. Desor & P. de Loriol, p. 341, Pl. 53, Figs 4-6.
1872. *Pygurus Blumenbachii* Koch und Dunker sp.; W. Dames, p. 618, Pl. 22, Fig. 4.
1872. *Pygurus royerianus* Cotteau; W. Dames, p. 620, Pl. 22, Fig. 5.
1891. *Pygurus Blumenbachi* (Koch et Dunker), Agassiz; P. de Loriol, p. 120, Pl. 22, Figs 2-3.
1905. *Pygurus* cf. *royeri* Cotteau; M. Schmidt, p. 136.
1933. *Pygurus* (*Pygurus*) *royeri* Cotteau; K. Beurlen, p. 82, Text-fig. 15c.
1988. *Pygurus blumenbachii* Koch & Dunker; A. Zbinden, p. 35 and p. 43, Text-fig. 62.

MATERIAL: Ten tests (4 from Małogoszcz, 2 from Karsy, 2 tests and 2 fragments from Wierzbica).

DIMENSIONS (*in* mm):

Coll. No.	*hd* (*l/w*)	*vd*	*∅Ad*	*∅Pm*	Figured in:
EMa/90	85.0/88.0	23.0	3.5	9.0	Pl. 46, Figs 3a-3c
EMa/91	70.0/76.0	20.5	3.5	——	Pl. 46, Figs 2a-2b

DESCRIPTION: **The tests** are flat, irregularly convex in lateral profile (*see* Pl. 46, Figs 2b, 3b); wider than long (*see* Table of dimensions), subpentagonal in outline; the anterior margin is wide, with a shallow depression; the posterior margin is projected with characteristic depressions aside the projection (*see* Pl. 46, Figs 2a, 3a, 3c); the aboral surface is low convex, with the apex displaced towards the anterior margin; the adoral surface is concave, with the pentagonal peristome situated at the center of the concavity, but displaced somewhat towards the anterior margin, and with a relatively small periproct, amygdaloid in outline, situated close to the posterior margin (*see* Pl. 46, Fig. 3c).

The ambulacra are petaloid; the anterior petal (of ambulacrum *III*) is somewhat narrower than the other. The petals are wide, and developed from the apex to the two-thirds of the aboral surface (*see* Pl. 46, Figs 2a, 3a). Pore-pairs (*see* Text-fig. 7a) in the petals are unequal in size and densely spaced; the perradial pores are small and oval in outline, the adradial ones are fissurate and very narrow. Below the petals, the ambulacra become narrower, and bear the widely spaced, very small, equal-sized pore-pairs (*see* Text-fig. 7b). At the oral surface the ambulacra are in shallow grooves. Close to the peristome, each ambulacrum is widened and forms a sunken phyllode, rhomboidal in outline. In the phyllodes, the pore-pairs are arranged triserially. The interporiferous zone is covered by numerous, irregularly spaced, equal-sized tubercles, surrounded by circular, narrow, and relatively deep areoles.

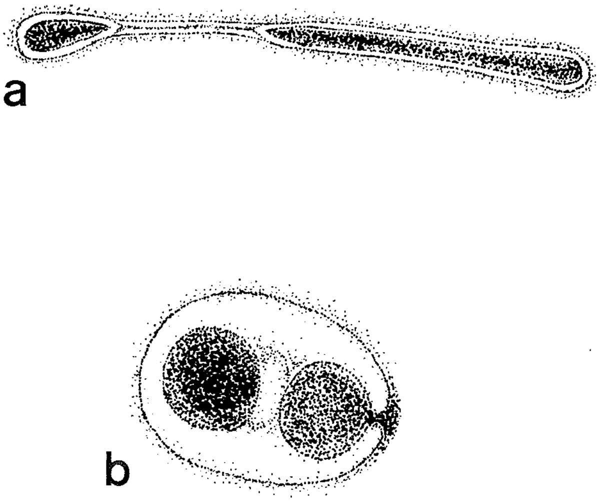


Fig. 7. Ambulacral pore-pairs of *Pygurus blumenbachi* Koch & Dunker, 1837; **a** – petaloid anisopore, **b** – phyllode isopore

The interambulacra are wide, and at the aboral surface they are covered by numerous, densely spaced tubercles, surrounded by circular, narrow, and relatively deep areoles. Tubercles, developed at the narrow zone, surrounding the ambulacrum *III*, are larger and more widely spaced than the others. At the adoral surface, the tuberculation is variably developed: close to the ambitus, tubercles are larger and surrounded by subpentagonal areoles; in the middle part of each interambulacrum, tubercles become smaller and more densely spaced, but close to the peristome they again become large and are surrounded by wide, deep, oval or circular areoles. The interambulacra adjacent to the peristome are swollen (to form bourrelets) and, with the sunken ambulacral phyllodes, they form a rosette-like structure known as the floscelle (*see* Pl. 46, Fig. 3c). The lateral surfaces of bourrelets, touching the peristome, are covered by small, densely spaced tubercles. The whole surface of the test is covered by miliary tubercles between the larger tubercles.

The apical disc is very small, tetrabasal.

REMARKS: The studied specimens conform to those indicated in the synonymy.

The present author considers *Pygurus royerianus* Cotteau, 1854, to be a synonym, because it falls into the intraspecific variability of *Pygurus blumenbachi* Koch & Dunker, 1837, as already indicated by Desor & de Loriol (1872).

This species has hitherto been noted, as *P.* cf. *royerianus*, by Schmidt (1905) from Bardo near Kołobrzeg (in German: *Bartin bei Kolberg*) in Western Pomerania.

Pygurus costatus Wright, 1860
(Pl. 45, Figs 1a-1b)

1860. *Pygurus costatus*, Wright, nov.sp.; T. Wright, p. 397, Pl. 37, Figs 1a-1f.

1961. *Pygurus costatus* Wright; W. Barczyk, p. 74, Pl. 5, Fig. 1.

MATERIAL: One test from Sulejów.

DIMENSIONS (*in* mm):

Coll. No.	*hd* (*l/w*)	*vd*	∅*Ad*	∅*Pm*	Figured in:
ESl/83	56.0/58.0	13.0	3.0	4.5	Pl. 45, Figs 1a-1b

DESCRIPTION: **The test** is very flat, subpentagonal in outline; anterior margin with a shallow depression, posterior margin slightly projected (*see* Pl. 45, Figs 1a-1b); aboral surface low convex, with the apex lying in the center of the test; adoral surface slightly concave, with the small pentagonal peristome situated at the center of the concavity, and with a relatively small periproct, oval in outline, touching the posterior margin (*see* Pl. 45, Fig. 1b).
The ambulacra are petaloid; petals are wide and relatively long (*see* Pl. 45, Fig. 1a). Pore-pairs in petals are unequal in size and densely spaced; inner pores are small and tear-shaped in outline, outer ones are fissurate and very narrow. Below the petals, the ambulacra become narrower, and bear the widely spaced, very small, equally-sized pore-pairs. Close to the peristome, each ambulacrum is widened and forms a sunken phyllode, wide-rhomboidal (foliaceous) in outline. In phyllodes, the pore-pairs are arranged in three or four rows. The interporiferous zone is covered by numerous small, irregularly spaced, equal-sized tubercles.
The interambulacra are wide, and at the aboral surface they are covered by numerous, densely spaced, small tubercles (in the studied specimen the major part of interambulacral surface is worn). At the adoral surface, tubercles become larger and surrounded by oval or subpentagonal areoles. The interambulacra adjacent to the peristome form distinct bourrelets and, with the sunken ambulacral phyllodes, they form a rosette-like floscelle (*see* Pl. 45, Fig. 1b).
The apical disc is very small, tetrabasal.

REMARKS: The studied species has hitherto been reported solely by Barczyk (1961) from the studied section Sulejów.

Pygurus jurensis Marcou, 1847
(Pl. 45, Figs 2-5)

1860. *Pygurus jurensis*, Marcou; T. Wright, p. 412.
1872. *Pygurus jurensis*, Marcou; E. Desor & P. de Loriol, p. 348, Pl. 54, Fig. 2.
1872. *Pygurus jurensis* Marcou; W. Dames, p. 623, Pl. 23, Fig. 2.
1905. *Pygurus jurensis* Marcou; M. Schmidt, p. 135, Pl. 1, Figs 7-8.
1933. *Pygurus* (*Pygurus*) *jurensis* Marcou; K. Beurlen, p. 83, Text-fig. 16.
1957. *Pygurus* (*Pygurus*) *jurensis* (Marcou); R. Kongiel, p. 36, Pl. 7, Figs 1-3.
1988. *Pygurus jurensis* Marcou; A. Zbinden, p. 37.

MATERIAL: Five tests (2 from Małogoszcz, 1 from Sobków, 1 from Czarnogłowy, and 1 from Ożarów).

DIMENSIONS (*in* mm):

Coll. No.	*hd* (*l/w*)	*vd*	∅*Ad*	Figured in:
EMa/88	76.0/70.0	27.0	3.5	Pl. 45, Fig. 4
EOz/93	57.0/57.0	19.0	2.5	Pl. 45, Fig. 5
ESo/85	52.0/48.0	17.0	2.5	Pl. 45, Fig. 2

DESCRIPTION: **The tests** are distinctly pentagonal in outline, much longer than wide (*see* Table of dimensions); anterior margin with a shallow depression, posterior margin projected (*see* Pl. 45, Figs 2-5); aboral surface moderately convex, with the apex lying in the center of the test; adoral surface deeply concave, with the pentagonal peristome situated at the center of the concavity, and with a relatively small periproct, oval in outline, situated in a small depression and touching the posterior margin.
The ambulacra are petaloid; the petals are wide and developed from the apex to the two-thirds of the aboral surface (*see* Pl. 45, Figs 2-5). Pore-pairs in the petals are unequal in size and densely spaced; inner pores are small and tear-shaped in outline, outer ones are fissurate and very narrow. Below the petals, the ambulacra become narrower and bear the widely spaced, very small, equal-sized pore-pairs. At the oral surface the ambulacra are developed in deep, and wide grooves. Close to the peristome, each ambulacrum is widened and forms a sunken phyllode, wide-rhomboidal in outline. In phyllodes, the pore-pairs are arranged triserially. The interporiferous zone is covered by numerous, irregularly spaced, equal-sized tubercles.
The interambulacra are wide, and at the aboral surface they are covered by numerous, densely spaced tubercles (in all studied specimens the major part of interambulacral surface is worn). Tubercles surrounding the ambulacrum *III* are larger and more widely spaced than those around

the other ambulacra. At the adoral surface, tubercles are larger and surrounded by subpentagonal areoles. The interambulacra in the middle part are distinctly swollen; adjacent to the peristome they form bourrelets and, with the sunken ambulacral phyllodes, they form a rosette-like floscelle.
The apical disc is very small, tetrabasal.

REMARKS: The studied material comprises a few rather badly preserved specimens, but all are characterized by a distinctly pentagonal outline of the test with well developed posterior prolongation, by wide and relatively short petals, and by deeply concave inner surface. These characters allow to assign the studied specimens to the species *Pygurus jurensis* MARCOU, 1847.

The species has hitherto been reported by DAMES (1872) and SCHMIDT (1905) from Bardo near Kołobrzeg (in German: *Bartin bei Kolberg*) and by KONGIEL (1957) from Czarnogłowy.

Family **Nucleolitidae** L. AGASSIZ & DESOR, 1847

Genus *Nucleolites* LAMARCK, 1801

Nucleolites brodiei (WRIGHT, 1859)
(Text-figs 8-9 and Pl. 48, Figs 4-9)

1859. *Echinobrissus Brodiei*, WRIGHT, nov.sp.; T. WRIGHT, p. 353, Pl. 35, Figs 1a-1e and Pl. 43, Fig. 3.
1872. *Echinobrissus Brodiei* WRIGHT; G. COTTEAU, p. 304, Pl. 81, Figs 1-13.
1933. *Echinobrissus brodiei* WRIGHT; K. BEURLEN, p. 49, Text-fig. 7.

MATERIAL: 20 tests from Niziny.

DIMENSIONS (*in* mm):

Coll. No.	*l*	*w*	*h*	*w/l*	*h/l*	Figured in:
ENi/168	35.0	34.2	17.2	0.977	0.491	Pl. 48, Fig. 9
ENi/167	34.4	33.5	14.8	0.974	0.430	Pl. 48, Figs 8a-8b
ENi/165	33.0	30.8	15.0	0.933	0.455	Pl. 48, Figs 6a-6b
ENi/167	30.2	27.0	13.0	0.894	0.430	Pl. 48, Figs 7a-7b
ENi/163	21.0	18.8	10.0	0.976	0.476	Pl. 48, Fig. 4

DESCRIPTION: **The tests** are relatively large (*see* Pl. 48, Figs 6a, 7a, 8a, 9), slightly elongate, oval to subrectangular in outline, always a bit longer than wide. The anterior margin is regularly rounded, posterior one is angular. Tests are greatly flattened (*see* Table of dimenssions); in lateral view (*see* Pl. 48, Figs 6b, 7b, 8b) they are regularly convex. The periproct (*see* Pl. 48, Figs 4, 5, 6a, 7a, 8a, 9) is oval and passes into a short, broad anal furrow which takes less than a half of the posterior interambulacral length. The adoral surface is concave, with the pentagonal peristome displaced towards the anterior margin.

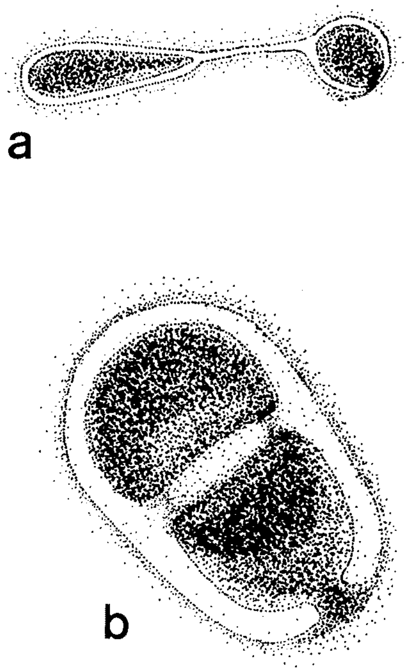


Fig. 8. Ambulacral pore-pairs of *Nucleolites brodiei* (WRIGHT, 1859); **a** – petaloid anisopore, **b** – phyllode isopore

The ambulacra are subpetaloid, and composed of anisopores (*see* Text-fig. 8a), characterized by small perradial pores, circular or slightly oval in outline, and by amygdaloid adradial pores. Close to the ambitus the pores become equal in size, and at the adoral surface they are small (*see* Text-fig. 8b), and pore-pairs are obliquely and widely spaced. The interporiferous zone is covered by four rows of primary tubercles. Small tubercles (6 in number), arranged in regular, transverse rows are developed between every pore-pair.

The interambulacra are wide and composed of low, broadly *V*-shaped plates. The surface of the plates is covered by numerous, densely spaced primary tubercles, surrounded by shallow areoles, circular in outline.

The apical disc (*see* Text-fig. 9) is tetrabasal, situated at the center of the test. The madreporite is much larger than the other genital plates, and is in contact with all of them and with all the ocular plates. Genital plates *1*, *3*, *4* are

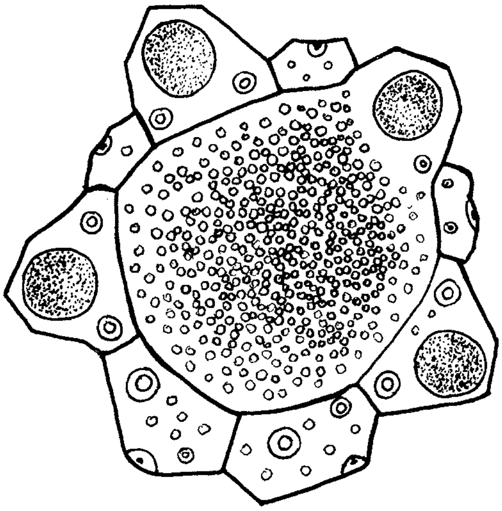


Fig. 9. Apical disc of *Nucleolites brodiei* (Wright, 1859)

small, pentagonal in outline, and almost their whole surface is occupied by large, circular genital pores. Ocular plates *II*, *III*, *IV* are small and low-hexagonal in outline; large, pentagonal oculars *I* and *V* are in contact.

REMARKS: The collected specimens differ from these of the other studied species of the genus *Nucleolites* Lamarck, 1801, by their distinctly larger size, by their flattened aboral surface, by their subquadrangular outline, and by the wide but shorter anal furrow, as well as by the structure of the apical disc possessing a large madreporite.

The species *Nucleolites brodiei* Wright, 1859, has not hitherto been reported from Poland.

Nucleolites letteroni (Cotteau, 1870)
(Pl. 47, Figs 1-8)

1870. *Echinobrissus Letteroni*, Cotteau, 1870; G. Cotteau, p. 290, Pl. 77, Figs 10-14 and Pl. 78, Figs 1-6.

1905. *Echinobrissus Letteroni*, Cotteau; M. Schmidt, p. 96 and p. 135.

1933. *Echinobrissus letteroni* Cotteau; K. Beurlen, p. 59, Text-figs 8g-8h and Text-figs 9c-9d.

MATERIAL: Some three hundred tests from Czarnogłowy, 7 from Ożarów, 1 from Wierzbica.

DIMENSIONS (*in* mm):

Coll. No.	*l*	*w*	*h*	*w/l*	*h/l*	Figured in:
ECZ/158	19.6	18.2	10.6	0.930	0.582	Pl. 47, Figs 7a-7c
ZPAL E.VIII/18	18.0	16.7	8.1	0.927	0.450	Pl. 47, Figs 6a-6c
EOz/157	17.5	16.5	8.8	0.942	0.502	Pl. 47, Fig. 5
ECz/156	16.5	14.2	8.3	0.860	0.503	Pl. 47, Fig. 3
ZPAL E.VIII/17	13.7	12.7	6.3	0.927	0.460	Pl. 47, Figs 4a-4b
ECz/154	12.3	11.7	6.6	0.902	0.540	Pl. 47, Figs 1a-1c

DESCRIPTION: **The tests** are small, elongate oval to regularly rounded, but always longer than wide (*see* Table of dimensions). The maximum width lies close to the mid-length of the test, or just below, towards the posterior margin. The anterior margin is regularly rounded; the posterior one is almost straight, with a variably developed median notch (*see* Pl. 47, Figs 1a-1b; 2; 3; 4, 5, 6a-6b, 7a-7b). Tests are from relatively high (*see* Table of dimensions and Pl. 47, Figs 1c, 7c) to low (*see* Pl. 47, Fig. 6c), with the apex situated on the apical disc positioned anteriorly. In lateral profile the anterior part of the test slants more steeply than the posterior one (*see* Pl. 47, Figs 1c, 6c, 7c). The periproct is oval and passes into a short, relatively broad anal furrow, which occupies about half of the posterior interambulacral length. The adoral surface is slightly concave, with the pentagonal peristome situated at the center of the concavity, but displaced towards the anterior margin (*see* Pl. 47, Figs 1b, 6b, 7b).
The ambulacra are subpetaloid, with small perradial pores, circular in outline, and with amygdaloid adradial pores; close to the ambitus the pores in the pore-pairs become equal in size. Adorally, the pores are developed in double series and form narrow phyllodes.
The apical disc is tetrabasal, situated at the center of the test, composed of four, relatively large, short genital plates with large, circular gonopores. The madreporite is moderately large, placed subcentrally. Ocular plates *I* and *V* are in contact (*see* Pl. 47, Fig. 8a).

REMARKS: The collected specimens conform to those indicated in the synonymy. To note, the whole material from the locality Czarnogłowy is characterized by the dominancy of not-fully grown individuals (1cm or less in length), whereas the larger forms (up to 2cm) are quite subordinate, numbering only a few specimens.

Within the studied assemblage the greatly variable feature is the height/length ratio, ranging 0.450-0.582, and regarded herein as of intraspecific significance.

The species has hitherto been reported by Schmidt (1905) from Kłęby near Golczewo (German: *Klemmen bei Gülzow*) in Western Pomerania.

Nucleolites truncatus (Desor, 1857)
(Text-fig. 10 and Pl. 48, Figs 1-3)

1857. *Echinobrissus truncatus*, Desor; E. Desor, p. 268.
1859. *Echinobrissus truncatus*, Desor; T. Wright, p. 359.
1872. *Echinobrissus truncatus*, Desor; E. Desor & P. de Loriol, p. 325, Pl. 50, Figs 9-10.
1933. *Echinobrissus truncatus* Desor; K. Beurlen, p. 62.

MATERIAL: 15 tests from Celiny.

DIMENSIONS (*in* mm):

Coll. No.	*l*	*w*	*h*	*w/l*	*h/l*	Figured in:
ECe/174	29.0	26.0	12.0	0.897	0.414	——
ECe/160	28.2	23.7	14.6	0.840	0.517	Pl. 48, Figs 1a-1b.
ECe/161	27.1	23.7	13.6	0.875	0.502	Pl. 48, Figs 2a-2b
ECe/175	23.0	19.5	12.0	0.848	0.522	——
ECe/162	22.4	18.8	8.7	0.839	0.366	Pl. 48, Figs 3a-3c

DESCRIPTION: **The tests** are moderately large, elongate-oval in outline, but always much longer than wide (*see* Table of dimensions), often distinctly widened close to the posterior margin. The anterior margin is relatively narrow, and regularly rounded; the posterior one is slightly convex, with a variously developed median notch (*see* Pl. 48, Figs 1a, 2a, 3a). Tests are of different height, from relatively very elevated to rather low (*see* Table of dimensions *and* Pl. 48, Figs 1b, 2b, 3c). The aboral surface is regularly convex, with the apex situated on the apical disc positioned somewhat towards the anterior margin. The periproct is oval and passes into a narrow and relatively shallow anal furrow occupying two-thirds of the interambulacral length. The adoral surface (*see* Pl. 48, Fig. 3b) is concave, with the pentagonal peristome situated at the center of the concavity, but displaced towards the anterior margin.

The ambulacra are subpetaloid, with small inner pores, circular in outline, and with long-oval to fissurate outer pores; close to the ambitus the pores in pore-pairs become equal in size. Adorally, pores are developed in double series and form narrow phyllodes.

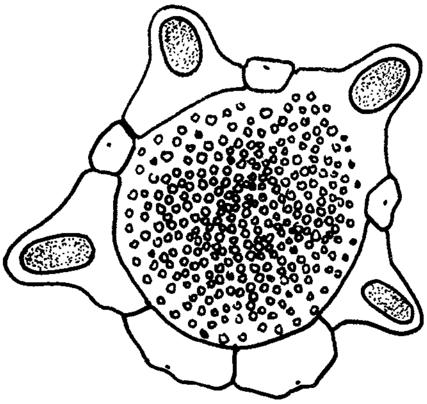


Fig. 10. Apical disc of *Nucleolites truncatus* (Desor, 1847)

The apical disc (*see* Text-fig. 10) is tetrabasal, situated in the center of the test. The madreporite is moderately large and placed centrally. The other genital plates are relatively narrow and high, pentagonal in outline, with large, oval gonopores. Genitals *1* and *4* are separated by oculars *I* and *V*. The oculars are small, and subrectangular in outline.

REMARKS: The collected specimens, all from Celiny, conform to those indicated in the synonymy. They represent fully-grown individuals, varying in their height/length ratio that ranges 0.366-0.522, and regarded herein as indicative of intraspecific variability.

The species has not hitherto been reported from Poland.

Order **Holasteroida** Durham & Melville, 1957
Family **Collyritidae** d'Orbigny, 1853

Genus *Collyrites* Desmoulins, 1835

Collyrites sp.
(Pl. 46, Figs 1a-1b)

MATERIAL: One badly preserved test from Karsy.

DIMENSIONS (*in* mm):

Coll. No.	*l*	*w*	*h*	*∅Pm*	*∅Pe*	Figured in:
EKa/146	52.5	52.5	23.4	6.2	8.3	Pl. 46, Figs 1a-1b

DESCRIPTION: **The test** is broad, almost circular in outline, with a small shallow frontal groove, flat and ovoid in lateral profile, with flattened posterior and rounded anterior part of the test (*see* Pl. 46, Fig. 1a). The oval periproct is situated on the steep posterior surface. The widest point of the test lies a little posteriorly to the anterior paired ambulacra. The ambitus lies close to the base. The frontal groove is shallow and 5.5 mm broad at the ambitus. The groove continues right to the anteroapical system, and also adorally up to the peristome.

The ambulacra are separated into three anterior and two posterior ones (*see* Pl. 46, Fig. 1b). The posterior pair is juxtaposed above the periproct. The ambulacra are not petaloid; pore-pairs are small and obliquely placed; close to the peristome they increase in abundance and become shorter, separated by the more distinct partition.

The interambulacra are poorly preserved, as the specimen is worn, and the sutures between the plates are not visible; almost the whole adoral part of the test being destroyed.

The apical disc is disjunct, with the anteroapical segment composed of ocular plates *II*, *III*, and *IV*, and genital plates *1*, *2*, *3*, and *4*. In this segment oculars *II* and *IV* are large, and juxtaposed. The genitals *2* and *3* are strongly projected and bear the madreporitic perforation. The genitals *1* and *4* are smaller than *2* and *3*. All genitals have circular gonopores close to the outer margin. The posteroapical segments consist of oculars *I* and *V*, not in contact with the periproct.

The peristome is small, transverse-oval in outline, and is close to the anterior margin in a shallow depression.

REMARKS: The studied specimen, due to the character of ambulacra and apical disc, is herein assigned to the genus *Collyrites* DESMOULINS, 1835. Its bad preservation does not allow for specific determination. Such a form has not hitherto been reported from the Upper Jurassic sequence of Poland.

Noticeable is a relatively large size of this specimen, comparable to that of some Oxfordian forms from the Swiss Jura (*see* HESS 1975, p. 107 and Pl. 43, Fig. 5), but much exceeding that one of the *Collyrites* species from the Middle Jurassic sequence of Poland (*see* JESIONEK-SZYMAŃSKA 1963, pp. 375-378).

ECOLOGY OF THE STUDIED ECHINOIDS

The fossil echinoids constitute a group in which the analysis of the test may deliver information very substantial for the recognition of their mode of life and their paleobiology. This results primarily from a high morphological potential of their variably sculptured tests, as well as from a similarly high preservational potential due to the calcitic composition of the tests.

Tests buried sometimes with their spines and the jaw apparatus, that is the Aristotle's lantern, may also supply valuable taphonomic information. The extant echinoids, in which morphology of the test is closely related to the life functions display, moreover, a wide spectrum of features important for interpretation of the ancient individuals and their extinct stocks.

Within the studied material, many of the collected tests are in an excellent state of preservation, what allows for an attempt to interpret the functional morphology of the monographed species.

Morphological analysis is based on the general shape of the test and the structure of tubercles, combined with the structure of ambulacral pores. Particularly, the structure and arrangement of ambulacral pores can often be used (*see* SMITH 1978a, 1978b, 1980, 1984) to identify the morphology and function of the associated tube feet, and the latter can be related to the echinoid's mode of life, the energy of the environment, nature of the substrate, temperature, and depth.

Tube feet of echinoids exhibit a great variety of structure and function, and they may be involved in locomotion, gaseous exchange, adhesion, absorption, burial, feeding, and chemosensory reception. A functional interpretation of pore structure provides considerable information about the tube foot associated and allows a reconstruction of tube feet from fossil echinoid tests. Analysis of the functional structure must take into account the number of pores, overall shape and size of the pore, size of the attachment area, shape and size of the interporal partition, presence of conjugate furrow, development and position of the neural canal (*see* SMITH 1978b, 1980). Among Recent regular echinoids, six morphologically distinct types of ambulacral pores have been described (*see* SMITH 1978b), but many more types are recognized in Recent irregular echinoids (*see* SMITH 1980).

All ambulacral pore-pairs of regular echinoids possess two more or less equal-sized pores per tube foot, and these are termed the *isopores*. They are separated, on the ground of presence or absence of a conjugate groove, in the two categories: *partitioned isopores* and *conjugate isopores*. SMITH (1978b), on the basis of attachment-area breadth, pore size, and interporal partition shape, has distinguished four types of partitioned isopores, designated by the general symbol *P*.

The *P1* isopores are characterized by poor development of an attachment area around the pores, and an interporal partition narrow and commonly ridged. The tube feet associated with *P1* isopores lack suckers and are thin-walled with a well developed septum. In such tube feet the primary function is gaseous exchange.

The *P2* isopores are characterized by a narrow but continuous attachment area (except for the neural canal), by moderately large pores, and usually arched interporal partition. The tube feet associated with *P2* isopores possess a small terminal sucker, moderately well developed wall and a septum that extends between one-third and two-thirds of the length of the tube-foot lumen. In those tube feet the gaseous exchange continues to be the primary function, but not so effectively as in *P1* isopores; they can attach by suction to the substrate, but their adhesion power is not very strong.

The *P3* isopores are characterized by a broad attachment area, continuous except for the neural canal, by relatively small pores, and by a narrow and convex interporal partition, often reduced to a small knob. The tube feet associated with *P3* isopores possess a terminating sucking disc, a thick wall with a thick retractor muscle-fiber layer, and a short septum. In these feet the primary function is adhesion and locomotion.

The *P4* isopores are characterized by a very broad attachment area and small pores, separated by a large interporal partition. The tube feet associated with *P4* isopores bear a large and well developed sucking disc and are thick-walled with a completely lacking septum. In this type of tube feet the gaseous exchange function is maximally reduced and the primary functions are adhesion and locomotion.

Conjugate isopores possess two equal-sized pores separated by a broad interporal area. In most cases the two pores are linked by a depression, narrower centrally and broadening towards each pore.

Conjugate isopores are designated by the general symbol *C* and are separated into two categories on the presence or absence of an attachment area (*see* SMITH 1978b).

The *C1* isopores are characterized by large, circular pores, by the absence or by the presence of a very narrow attachment area, and by broad interporal area, with developed or not a narrow, interporal furrow. The tube feet associated with *C1* isopores are thin-walled, terminated by a poorly developed sensory pad. In these tube feet the primary function is the gaseous exchange, and among all the tube feet associated both with *P*- and *C*-types of isopores, these tube feet play an extremely effective part in gaseous exchange.

The *C2* isopores are less elongate than *C1* isopores and are characterized by smaller pores, the perradial ones bearing a well-defined neural canal, and by a broad interporal region with a broad and poorly defined interporal furrow, as well as by a recognizable attachment area of moderate breadth. The tube feet associated with *C2* isopores have a small sucker disc and are relatively thick. In the tube feet the primary function is gaseous exchange, but not so effective as in tube feet associated with *C1* isopores.

Among irregular echinoids variation in the tube foot morphology and structure of the ambulacral pores is much greater than in regular ones (*see* SMITH 1980). Three type of pores are recognized; *isopores* – more or less equal-sized pores per tube foot, *anisopores* – markedly unequal in size, and *unipores* – a single pore penetrating the test. These pores are further subdivided on the basis of pore size and shape, size and position of the neural canal, and the development of an attachment area and of the periporial area. The tube feet associated with these pores are highly modified, and have sensory, respiratory, suckering, feeding, and funnel-building function.

All these types of ambulacral pores, both in regular and irregular echinoids, are substantial for paleoecological interpretations.

For a comparative study and ecological interpretation are chosen these species which are represented by the most numerous specimens from the whole studied assemblage, or by the most numerous from one of the studied locations.

Consequently, nine species of regular echinoids were examined: *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840), *Acrosalenia angularis* (L. AGASSIZ, 1840), *Hemicidaris hoffmanni* (F.A. ROEMER, 1836), *Hemicidaris intermedia* (FLEMING, 1828), *Trochotiara kongieli* sp.n., *Phymosoma supracorallinum* (COTTEAU, 1865), *Stomechinus gyratus* (L. AGASSIZ, 1840), *Stomechinus semiplacenta* (L. AGASSIZ *in* AGASSIZ & DESOR, 1847), and *Gymnocidaris agassizi*

(F.A. Roemer, 1839). Of the irregular echinoids five species were chosen, namely: *Pygaster morrisi* Wright, 1851, *Pygaster tenuis* L. Agassiz, 1840, *Holectypus corallinus* d'Orbigny, 1850, *Pygurus blumenbachi* Koch & Dunker, 1837, and *Nucleolites brodiei* (Wright, 1850).

Functional analysis and ecological interpretation of selected species of regular echinoids

Rhabdocidaris orbignyana (L. Agassiz, 1840)

TEST

The test is large, high and sphaerical in outline, flattened adorally and adapically (*see* Pl. 1, Fig. 4b *and* Pl. 3, Figs 1b, 2b). The wall of the test is relatively thin in comparison to the test diameter. The peristome is large and subpentagonal in outline (*see* Pl. 3, Fig. 1c).

TUBERCLE ARRANGEMENT AND SPINES

Tubercles of the interambulacral primary spines are perforated and strongly crenulated (*see* Pl. 3, Fig. 2b). Areoles are large and, above the ambitus, circular in outline (*see* Pl. 1, Figs 2c, 4b), but below the ambitus, towards the peristome, they become oval in outline (*see* Pl. 3, Fig. 1c). The bosses and associated mamelons on the ambital and adoral plates are slightly adapical in position, and consequently the area of muscle attachment is slightly broader at the adoral suture. This feature indicates that the inserting muscles pulled more strongly in the adoral direction.

Only one specimen is preserved (*see* Pl. 2, Figs 10a-10c) with attached primary, scrobicular and ambulacral spines. Primary spines (*see* Pl. 2, Figs 1-8, *and* Figs 10a-10c) are large, massive and bladed (rhomboidal in cross-section). One completely preserved oral primary spine attached to the test is 10.6 mm long, and it is short relatively to the diameter (35 mm) of the test. Scrobicular spines are relatively short, flattened (oval in cross-section), covered by longitudinal striae, whereas ambulacral spines are spicular, thin and slightly flattened too.

PORE-PAIRS

The ambulacral pore-pairs are generally identical throughout the whole ambulacrum, however, the most adoral pore-pairs are less elongate than the others, but the pores still remain relatively large and are linked by a narrow furrow; the attachment area is poorly developed. In such a case, they are interpreted as *C1* type of isopores. The other isopores (*see* Pl. 4) are strongly elongate; the pore adjacent to the perradial suture is circular in outline, with a poorly defined neural canal (*see* Pl. 4, Figs 3b, 1d, 1e), and the next pore is more elongated. The attachment area is poorly developed, the interporal area broad, with a narrow interporal furrow, positioned centrally (*see* Pl. 4, Fig. 1c).

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

The analysis of the preserved spines indicates that the length of the primary spines in *Rhabdocidaris orbignyana*, like in many Recent cidaroid species (*see* Mortensen 1928), is distinctly differentiated. The oral spines are short, and were used for locomotion, but the aboral ones are distinctly longer and massive; they could not easily be broken and had a defensive function.

The shape of subambital and adoral areoles (with more developed adoral area) of the primary tubercles indicates that the associated spines were attached obliquely to the test and the tips of the spines were directed downwards, to the substrate. This feature confirms the locomotory function of the adoral primary spines. The tips of the spines are flattened but relatively broad, which suggests that the spines enabled the animal to stalk on moderately firm, coarse-grained substrate. The absence of any isopores associated with tube feet involved in locomotion or adhesion means that *Rhabdocidaris orbignyana* used for locomotion its spines only. A lack of suckered tube feet and thus exclusive use of spines for locomotion is preferred in low energy environments, where the currents and/or waves cannot overturn the echinoid. A low energy environment is indicated by the relatively fragile test, which in high energy environments might be easily crushed.

The presence, throughout the whole ambulacrum, of *C1* isopores associated with the most effective respiratory tube feet indicates that the metabolic rate of oxygen consumption was high (*see* Smith 1978b). The high rate of respiration in this species may have been related to a relatively great size of the specimens, but at first to the environmental conditions. Generally, a high oxygen consumption (*see* Smith 1978b, p. 778) is typical of echinoids inhabiting shallow, warm waters.

In addition, the obvious lack of specialized tube feet and of spines that were able to remove sediment from the test indicates that *Rhabdocidaris orbignyana* inhabited only environments with very low to zero sedimentation rates (*comp.* Baumeister & Leinfelder 1998, p. 210).

The relatively large peristome suggests a more mobile lantern; the large peristomial membrane allows the lantern freedom of movement.

Summarizing, *Rhabdocidaris orbignyana* was adapted for life in low energy environments with very low sedimentation rate, favoring coarse (shell gravel) bottoms in shallow, warm waters sheltered from currents and/or stronger waves. Specimens fed using their lanterns to rasp encrusting organisms from the bottom material.

Acrosalenia angularis (L. AGASSIZ, 1840)
(examined with optical microscope only)

TEST

The test is small, low, flattened adorally. The wall of the test is relatively thick in comparison to the test diameter. The peristome is large, positioned centrally, and deeply sunken on the ventral surface. The margin of the peristome is notched by prominent buccal slits. The periproct (*see* Pl. 10, Figs 1a, 5c) is large, *U*-shaped, placed among the apical disc, but moved posteriorly.

TUBERCLE ARRANGEMENT AND SPINES

Generally, tubercles of the primary interambulacral spines are perforate and strongly crenulate. Those at the aboral side have small mamelons, swollen bosses, and deeply sunken, relatively large, oval areoles. Areoles are distinctly deeper and broader at the adapical suture than at the adoral one. This feature indicates, that the inserted muscles pulled more strongly in the adapical direction. The adoral tubercles have distinctly flattened and asymmetric bosses (very elongated at the adoral direction), but very narrow and shallow areoles. Such deformation of the shape of the adoral-most tubercles is an effect of the strong curvature of the test towards the peristome. Morphology of these tubercles indicates that the spines attached in the adoral region have relatively weak muscles and a strong collagenous catch apparatus.

At the adapical region, which comprises three plates per column (*see* Pl. 10, Figs 1a, 5c), the primary tubercles rapidly diminish in size and become rudimentary.

The primary and secondary spines are badly preserved and on one specimen only. These spines were probably long and needle-pointed, with a very distinct milled ring and an asymmetric base, that corresponded with asymmetric tubercles on the test.

PORE-PAIRS

The ambulacral pore-pairs are represented by two types of isopores, *P1* aborally and *P2* adorally.

The isopores *P1* are characterized by very narrow but distinct attachment area, large, rounded equal-sized pores and by a narrow and distinctly arched interporal partition. The isopores *P2* have the attachment area (especially developed at the adoral and adapical direction) more distinct than the *P1* ones.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

Analysis of the primary tubercles and associated spines indicates that they were distinctly distinguished in their length and function. The most adapical spines on the rudimentary tubercles were much reduced; the other adapical ones, connected with strongly crenulated mamelons, were long, and attached obliquely to the test, with their tips inclined adapically. These spines were probably used for defence and protection of the relatively naked adapical region. The adoral spines just below the ambitus were attached to relatively small tubercles, and their muscles have still pulled more strongly in adapical direction. These spines were shorter than the adapical ones and could be used for locomotion. The most adoral spines on tubercles with small mamelons, broad, flattened bosses, and narrow areoles were probably short and rigid, inclined strongly to the peristome.

The presence aborally of *P1* isopores associated with respiratory tube feet, and *P2* adorally associated with suckered tube feet may indicate either cold or deep water habitats where oxygen consumption rate was reduced, or warm, low to moderate energy, shallow-water environments (*comp.* SMITH 1978b, p. 776 *and* pp. 783-789). The latter explanation seems the most probable, since *Acrosalenia angularis* lived epifaunally (as indicated by the general character of spines), where the supply of oxygen-rich water was no problem. The adoral suckered tube feet were arranged uniserially; they might, however, have been used for climbing on rocks, to hide (as a protection against predators and/or strong waves) during daylight. The flattened oral side involved a greater number of the tube feet in contact with the substrate, and this enhanced their functionality. This feature indicates that *Acrosalenia angularis* might have inhabited moderately high-energy environments.

The low test and relatively naked adapical part of the test made it easier to squeeze into crevices. At night, *Acrosalenia* may have returned to the bottom surface to forage. A nocturnal mode of life would have guaranted better protection against predators and smaller consumption of oxygen.

The representatives of *Acrosalenia angularis* had an active lantern (indicated by the large peristome and deep buccal slits) that was very effective for food gathering, however, unlikely to other regular echinoids that rasp the bottom material, they were scooping up bottom sediment. This kind of feeding, suggested by SMITH (1984, p. 58), is indicated by the large, *U*-shaped periproct, moved posteriorly. The large periproct served to discharge a great bulk of feces. The relatively large naked region around the apical disc and the periproct allowed to more effectively clean this area from fecal material.

The most adoral spines, evidently directed to the mouth, might have helped in gathering sediment, or to protect the mouth from larger sediment particles.

Summarizing, *Acrosalenia angularis* inhabited warm, shallow-water, moderately high-energy environments. It was adapted for epifaunal life and during daylight hours occupied crevices in hard bottom, whereas by night it returned to the muddy bottom areas to forage.

Hemicidaris hoffmanni (F.A. ROEMER, 1836)

TEST

The test is regularly hemisperical, flattened adorally. The wall of the test is thick in comparison to the test diameter. The peristome is large, with deep buccal slits (*see* Pl. 13, Fig. 5b).

TUBERCLE ARRANGEMENT AND SPINES

Tubercles of the primary interambulacral spines are perforated and strongly crenulated (*see* Pl. 16, Fig. 2b). Areoles are narrow, but adorally they become slightly broader at the adoral suture. Of primary spines only one broken fragment is preserved, pushed into the test. This fragment and the spine illustrated by F.A. ROEMER (1836, Pl. 1, Fig. 18d) allow to suppose that the primary spines were long and needle-pointed.

PORE-PAIRS

The ambulacrum is combined of three types of isopores, *P1/P2* aborally (*see* Pl. 16, Fig. 2c), *P2* ambitally and subambitally (*see* Pl. 16, Figs 2d-2e), and *P3* adorally (*see* isopores of *H. intermedia* in Pl. 49, Figs 9-9a).

The *P1/P2* isopores are characterized by equal-sized pores, by a relatively broad and conspicuous attachment area, by a very large and ridged interporal partition, and by a relatively conspicuous neural canal (*see* Pl. 16, Fig. 2c). The *P3* isopores are arranged in phyllodes, and they have a broad attachment area, relatively small pores, and an interporal partition narrow and convex, or reduced to a small knob. These isopores are closely related to those observable (*see* Pl. 49, Fig. 9) in *Hemicidaris intermedia*, but in the studied specimens the attachment area is somewhat narrower.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

Analysis of primary tubercles and associated spines indicates that the adoral spines, which were directed to the peristomal margin, were used for locomotion, but the long, needle-shaped aboral ones were used for defence. The presence of *P3* isopores arranged in phyllodes suggests the presence of suckered tube feet, with relatively large suckers, whose power of adhesion was strong. The power of adhesion was enhanced upon that the large number of tube feet were in contact with the hard substrate. Suckered oral tube feet allow the echinoid to climb as well as to clamp the lantern firmly against the substrate for more efficient rasping. The large peristome with deep buccal slits indicates that *Hemicidaris hoffmanni* had a well developed, very mobile lantern, which was used for rasping.

Needle-shaped spines and oral suckered tube feet indicate that *Hemicidaris hoffmanni* has both stalked and adhered to stable bottom material. Strong tube feet and the thick-walled test are a necessity for echinoids living in turbulent shallow-water habitats, where they must resist wave action (*see* SMITH 1978b, p. 777).

The aboral isopores *P1/P2* and ambital *P2* were associated with respiratory tube feet. The large interporal partition (*see* Pl. 16, Figs 2c, 2e) indicates that these respiratory tube feet had a large, long septum (*see* SMITH 1978b, p. 774), which optimized the efficiency of gaseous exchange. This type of tube feet assured an efficient gaseous exchange in warm, shallow water, high-energy environments, where strong waves assured water exchange and oxygen supply.

Summarizing, *Hemicidaris hoffmanni* inhabited warm, shallow-water, high-energy environments. It stalked on hard bottom using its cylindrical, needle-shaped spines and climbed using strong, suckered tube feet. The representatives of this species foraged by rasping the bottom material.

Hemicidaris intermedia (FLEMING, 1828)

This species is closely related to *Hemicidaris hoffmanni*; therefore, the important differences will be indicated only.

The test is much higher and thick-walled than in *H. hoffmanni*, with stronger sinuous ambulacra, and with a larger peristome. The higher test and more sinuous ambulacra show that the number of aboral isopores was more numerous than in *H. hoffmanni* specimens with comparable dimensions.

The arrangement of ambulacral pore-pairs is generally very close in both studied species (*comp.* Pl. 16 *and* Pls 20-21). The isopores are represented by three types: *P1/P2* aborally and ambitally, *P2* subambitally (*see* Pl. 20, Figs 1c-1d *and* Pl. 21, Figs 2a, 2c-2d), and *P3* adorally (*see* Pl. 49, Figs 9, 9a); however, *P3* isopores have an attachment area somewhat larger than in *H. hoffmanni*. This feature indicates that the aboral tube feet were stronger, adorned with a large suckered disc.

Specimens of *Hemicidaris intermedia* inhabited the same environment as *H. hoffmanni*; these two species were found in the same layers at Czarnogłowy quarry. Consequently, concluded is that they lived in a warm, shallow-water, high energy environment. Probably, *H. intermedia* was better adapted for life in areas of higher energy, strongly exposed to waves, as indicated by the thicker test, and the more strongly developed suckered aboral tube feet. The species *Hemicidaris intermedia* had a very mobile lantern that was presumably used for rasping.

Trochotiara kongieli sp.n.

TEST

The moderately thin-walled test is strongly flattened adapically and adorally. On the adoral side the interradial zones are slightly sunken and naked. The peristome is large with deep buccal slits (*see* Pl. 24, Fig. 16 *and* Pl. 25, Fig. 16).

TUBERCLE ARRANGEMENT AND SPINES

The tubercles are relatively densely spaced, and their size is equal on interambulacral and ambulacral columns (*see* Pls 24-25). The largest tubercles are at the ambitus (*see* Pl. 24, Figs 1c, 2c, 3b). All tubercles are perforated and strongly crenulate; aboral areoles are circular, shallow and relatively symmetric (*see* Pl. 24, Fig. 4 *and* Pl. 25, Fig. 6a), but the adoral ones become slightly oval and broader adorally.

Spines are not preserved, but tubercle size shows that the longest spines were attached at the ambitus; towards the apical disc and peristome they gradually diminished in size.

PORE-PAIRS

The ambulacra are composed of three types of isopores *P1/P2*, *P2*, and *P3*, as follows: *P2* aborally, *P1/P2* ambitally, and *P2* and *P3* adorally. All those types pass gradually into each other. The *P2* isopores (*see* Pl. 24, Figs 4, 5a *and* Pl. 25, Fig. 5) are characterized by the relatively broad attachment area, circular equal-sized pores, and by a small, weakly defined neural canal. The *P1/P2* isopores (*see* Pl. 25, Fig. 6a) are characterized by a narrow but well defined attachment area, by large, circular pores, and by the relatively narrow ridged interporal partition. The *P3* isopores (*see* Pl. 25, Fig. 6b) are arranged in narrow phyllodes. The attachment area of these isopores is broad, pores are relatively small, and the interporal partition is narrow and convex.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

Analysis of the primary tubercles indicates that the adoral spines were slightly inclined adorally and were used for stalking. Phyllodes with *P3* isopores indicate the presence of strong, suckered tube feet, which allowed the echinoids to climb onto obstacles and adhere to the bottom during strong waves. The slightly sunken and naked areas on the aboral side could help to channel the water and to wash the test. Strong flattening of the adoral side of the test greatly increased the proportion of the tube feet in contact with the bottom. These features indicate that *Trochotiara kongieli* could inhabit high-energy environments.

The aboral *P2* and *P1/P2* isopores indicate the presence of the respiratory tube feet. However, the well defined attachment area of *P2* and *P1/P2* isopores indicates that moderately strong, suckered tube feet would have arisen from these pores, of which the second function was picking up small particles to camouflage the test. Particularly, the arrangement of isopores and associated tube feet shows that the tube feet increased their length in accordance with the spine length towards the ambitus; this made them protrude out of the spine coat for transportation of bottom particles.

Equal-sized primary tubercles, both on interambulacra and ambulacra, indicate that the adjacent spines in the aboral part of the test were similar in size and gave rise to a uniform coat. The small mamelons and swollen bosses indicate that the spines were relatively short and rigidly settled. Recent, short-spined echinoids with aboral suckered tube feet cover themselves with coarse bottom material (*see* SMITH 1978a, p. 64). The same seems to have been true for *Trochotiara kongieli* which certainly was able to thatch itself.

The large peristome with deep buccal slits indicates a very mobile lantern which was supposedly used for rasping; the power of rasping was reinforced by the presence of phyllodes.

Summarizing, *Trochotiara kongieli* sp.n. inhabited shallow-water, high-energy environment, with the ability of a relatively active style of life, having been able to climb onto bottom obstacles and rasp them to forage. When attacked by predators, *Trochotiara kongieli* may have been able to cover itself with coarse bottom material, using its tube feet and spines.

Phymosoma supracorallinum (COTTEAU, 1865)

TEST

The moderately thin-walled test is strongly flattened both adapically and adorally. The peristome is large with well developed buccal slits.

TUBERCLE ARRANGEMENT AND SPINES

The moderately large tubercles are crenulate and generally imperforate. In some specimens the ambital and adapical tubercles are perforated (*see* Pl. 29, Figs 1b, 1c, 1e). The primary tubercles, on both the interambulacra and ambulacra, are equal in size, but gradually diminish towards the apical disc and peristome. The areoles are shallow, circular and symmetric, indicating that attachment muscles pulled in all directions with the same power.

The rows of secondary tubercles are relatively well developed. These features indicate that generally the test was densely covered with primary and secondary spines. However, the adapically interradial zones are slightly sunken and naked.

Only one fragment of a primary spine was found, and it indicates that the spines were cylindrical, relatively long, needle-shaped, and slightly curved.

PORE-PAIRS

The ambulacra are composed of two types of isopores: *P2* aborally and partly adorally (*see* Pl. 28, Figs 5a-5d *and* Pl. 29, Figs 1a-1e, 2c), and *P3* adorally (*see* Pl. 29, Fig. 2b). The aboral isopores are arranged in two rows (*see* Pl. 28, Figs 5a-5b *and* Pl. 29, Figs 1a, 2a), only at the ambitus they become uniserial (*see* Pl. 29, Figs 1b-1e). The adoral *P3* isopores are arranged in moderately large phyllodes *(see* Pl. 29, Fig. 2b*)*.

The *P2* isopores are characterized by a relatively large attachment area, by the broad interporal partition and by moderately large, circular pores.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

Analysis of primary tubercles, spines and adoral isopores of *P3* type, arranged in phyllodes, indicates that *Phymosoma* used for moving on stable bottom both its adoral spines that were mobile in all directions, as well as the strong, suckered tube feet associated with *P3* and *P2* isopores. Flattening of the adoral side of the test and phyllodes, like in *Trochotiara kongieli*, increased the number of the tube feet in contact with the bottom. This suggests that *Phymosoma supracorallinum* could climb as well as adhere to the bottom during wave action. The slightly sunken and naked areas on the aboral side could help to channel the water and wash the test. These features indicate that *Phymosoma supracorallinum* inhabited a high-energy environment.

Analysis of *P2* isopores indicates, that all tube feet associated with these isopores were relatively strong, and suckered. The main function of these tube feet was for gaseous exchange; the biserial arrangement of aboral tube feet (increasing their number) may have balanced their lower effeciency. The relatively broad attachment area in *P2* isopores, shows that the associated tube feet were probably strong, and possessed a terminal sucker. The presence aborally of strong, suckered tube feet indicates, like in many Recent species (*see* SMITH 1978b), that *Phymosoma supracorallinum* was able to thatch itself, using its tube feet and spines for the transport of coarser bottom material.

In some specimens, part of ambital and adoral tubercles are perforate, indicating that the spines on such tubercles had an additional central ligament. This ligament strongly fixed the spine to its tubercle and, together with a crenulated boss, helped to hold the spine firmly in position. These firmly attached spines probably served to keep themselves stable against the load of thatched particles.

Summarizing, *Phymosoma supracorallinum* inhabited warm, shallow-water, high-energy environments, and performed an active life, climbing over bottom obstacles to forage, and being able to thatch when endangered. It was feeding by the use of a movable lantern to rasp small organisms from the substrate.

Stomechinus gyratus (L. AGASSIZ, 1840) and ***Stomechinus semiplacenta*** (L. AGASSIZ *in* AGASSIZ & DESOR, 1847) (examined with optical microscope only)

The two closely related species will be analyzed together, because small differences in arrangement of tubercles and in general shape of the test resulted neither from the mode of life nor from environmental preference.

TEST

The test is moderately thin-walled, low- to high-hemispherical in profile, and flattened adorally. The relatively deeply sunken peristome is large with deep buccal slits.

TUBERCLE ARRANGEMENT AND SPINES

The aboral part of the test is covered with densely spaced, small, relatively uniform, imperforate and noncrenulate primary and secondary tubercles (*see* Pl. 30, Figs 1a, 2b, 3, 4, 5a). Aborally, the tubercles become distinctly larger, but remain still densely spaced (*see* Pl. 30, Fig. 1b). Naked areas on interambulacra and ambulacra are developed in both species, but in *Stomechinus gyratus* these areas are broad and reach the ambitus.

The aboral areoles are narrow and circular, but the adoral ones become polygonal in outline, deeply incised, and often bordered by a narrow, ridged rim.

PORE-PAIRS

The aboral pore-pairs are arranged triserially, but adorally they form large phyllodes. The pore-pairs are represented by two types of isopores: *P2* aborally and *P3* adorally. The *P2* isopores are characterized by moderately large attachment area, equal-sized pores, and by the broad interporal partition. The partition bears an additional narrow ridge positioned parallelly to the adapical and adoral plate sutures. The *P3* isopores are characterized by a broad attachment area, relatively small pores, and by a narrow interporal partition reduced to a small knob.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

The test of individuals of both species were densely covered with primary and secondary spines. The analysis of the aboral tubercles indicates that all the spines were probably relatively short, and needle-shaped. The naked areas on the test functioned most likely as shallow grooves amongst the spines to provide easier washing of the test, and down-flow current of water during stronger turbulence. The adoral spines were more massive, but still densely spaced. The polygonal outline of the areoles enabled a high spine density. The deeply sunken areoles and the rims which surround them, indicate that the muscles have strongly adhered to the test and they strongly fixed the spines. These spines were used for stalking over the hard bottom.

The aboral *P2* isopores indicate the presence of relatively short, suckered respiratory tube-feet. The lower efficiency of these tube feet was balanced by their triserial arrangement, which greatly increased their number. The smaller length of the respiratory tube feet was probably related to the smaller length of the surrounding spines. These tube feet probably did not protrude above the spines and, in such a case, were well protected against any damage. Simultaneously, their number was sufficient to assure an effective gaseous exchange in a high-energy environment.

The presence of phyllodes combined with *P3* isopores, associated with strong, suckered tube feet, also indicate a high-energy environment. The large phyllodes allowed the animals to climb onto bottom obstacles and adhere with sufficient power to the substrate during strong turbulence.

The presence of a large peristome with deep buccal slits and of the relatively small periproct positioned centrally in the apical disc indicates that *Stomechinus gyratus* and *St. semiplacenta*, like many regular echinoids, used a very mobile lantern for rasping.

Summarizing, the both species were very well adapted to active life in a warm, shallow-water, high-energy environment.

Gymnocidaris agassizi (F.A. ROEMER, 1839)

TEST

The thick-walled test is hemispherical in lateral profile. The large periproct is positioned slightly eccentrically in the apical disc (*see* Pl. 33, Figs 2a, 3a *and* Pl. 34, Figs 1d, 5). The peristome is very large with deep buccal slits (*see* Pl. 33, Figs 1c, 3c *and* Pl. 34, Figs 1c, 2c). One specimen was found with preserved lantern (*see* Pl. 34, Fig. 3).

TUBERCLE ARRANGEMENT AND SPINES

The aboral primary interambulacral and ambulacral tubercles are very characteristic. The most adapical 2-3 interambulacral plates bear rudimentary imperforate and noncrenulate tubercles surrounded by secondary tubercles (*see* Pl. 33, Figs 2a, 3a *and* Pl. 34, Figs 1a, 1d, 4, 5). Towards the ambitus, the other aboral interambulacral tubercles become rapidly larger in size, perforate and strongly crenulate (*see* Pl. 33, Figs 2b, 3b). The ambulacral primary tubercles are also divided into two types; those developed above the ambitus towards the apical disc are small, noncrenulate and imperforate, but at the ambitus they become rapidly large, perforate and crenulate (*see* Pl. 34, Figs 1b, 2b). Adorally, both ambulacral and interambulacral tubercles diminish gradually in size (*see* Pl. 34, Figs 1c, 2c).

The areoles of the aboral tubercles are circular, relatively narrow and shallow; adorally, they become still narrower, oval and more deeply incised. All areoles are relatively symmetric.

PORE-PAIRS

The pore-pairs are represented by three types of isopores: *P1* aborally and ambitally (*see* Pl. 35, Figs 1a, 1b, 3b), *P2* subambitally (*see* Pl. 35, Figs 2a, 3a), and *P3* adorally (*see* Pl. 35, Figs 2b, 4a, 4b).

The *P1* isopores are of two types. The aboral ones (*see* Pl. 35, Figs 1a, 3b) are relatively long, characterized by a narrow but conspicuous attachment area, circular equal-sized pores, and by the very broad and arched interporal partition. The ambital isopores (*see* Pl. 35, Fig. 1b) become shorter, but still have a narrow attachment area and a very broad, arched interporal partition. These isopores gradually pass into *P2* isopores (*see* Pl. 35, Fig. 1b); these are characterized (*see* Pl. 35, Figs 2a, 3a) by a broader attachment area and relatively smaller pores. The *P3* isopores are arranged in phyllodes (*see* Pl. 35, Fig. 2b); they have (*see* Pl. 35, Figs 4a-4b) a broad attachment area, small pores, and the narrow, interporal partition reduced to a small knob.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

The analysis of the tubercle arrangement indicate that the individuals were covered by two types of primary spines. The most adapical, relatively large region was covered by small, probably short, primary spines on rudimentary tubercles. This region remained relatively naked. The other aboral spines were probably long and massive (*comp.* COTTEAU 1881, Pl. 294). From the ambitus towards the peristome the spines became shorter, and both ambulacral and interambulacral ones were used for stalking, although they could move in all directions with equal power.

The presence of phyllodes composed of *P3* isopores, associated with strong, suckered tube feet, like in the other above-mentioned regular echinoids, indicates that *Gymnocidaris agassizi* inhabited a warm, shallow-water, high-energy environments and was able to climb onto bottom obstacles and adhere to hard substrate during strong turbulence.

The relatively numerous *P1* isopores were associated with respiratory tube feet that were sufficiently effective in gaseous exchange for all the specimens displaying an active mode of life in warm, shallow-water habitats.

The very large peristome allowed the lantern to move freely, both laterally and vertically. The lantern was used for rasping, and the large periproct indicates that the volume of eaten material and thus the volume of fecal materials was great. The presence of a large, relatively naked area around the periproct was probably a result of adaptation to prevent fouling the aboral surface with copious fecal discharge, and/or to facilitate hiding under ledges or in crevices. The same kind of adaptations is recognizable in *Acrosalenia angularis*, as described above.

Nevertheless, the great volume of fecal material may also indicate that *Gymnocidaris agassizi* has simply ingested large amounts of larger particles, that were not crushed by the lantern. If so, this species may have fed on small-sized, but shelled organisms adhered to the bottom, such as the polychaetes, bryozoans, bivalve and/or other mollusk spat, but not on algae or other marine plants.

Summarizing, *Gymnocidaris agassizi* inhabited a warm, shallow-water, high-energy environments. Its individuals stalked on the hard bottom using their oral spines or climbed onto obstacles and adhered to the bottom during strong turbulence, using strong, suckered oral tube feet. The movable lantern was used for rasping bottom-attached, small-sized shelled organisms.

Functional analysis and ecological interpretation of selected species of irregular echinoids

Pygaster morrisi WRIGHT, 1851, and *Pygaster tenuis* L. AGASSIZ, 1839

These two closely related species will be analyzed together in comparison with *Plesiechinus ornatus* (BUCKMAN), which has been studied in detail by SMITH (1978a). Since these three species are morphologically very close, important differences, related with the style of life and environment, will be discussed only.

TEST

The individuals of *Pygaster morrisi* have the relatively stronger, thicker-walled test, and larger tear-shaped periproct. Those of *Pygaster tenuis* are of larger size, more arched, and have a relatively thin-walled test in comparison to the test diameter.

TUBERCLE ARRANGEMENT AND SPINES

The general arrangement of tubercles, and the structure of many details (like shape of the areole, development of bosses of adoral tubercles), are very close in the three species mentioned. However, the individuals of *Pygaster morrisi* have much more densely spaced tubercles, both on the aboral and the adoral side, whereas those of *Pygaster tenuis* have very sparsely spaced, delicate aboral tubercles and more densely spaced the adoral ones; these are surrounded by very deeply incised, bilaterally elongated areoles.

The shape of the adoral areoles in both species is very similar (*comp.* Pl. 38, Fig. 1b; Pl. 41, Fig. 1b *and* SMITH 1978a, Fig. 2) to that of *Plesiechinus ornatus*, although those of *P. tenuis* are more enlarged adambitally.

The spines of the two species have not been found.

PORE-PAIRS

The arrangement of pore-pairs in these three species is identical, uniserial throughout. The pore-pairs are represented by *P2* isopores (smilarly as in regular echinoids). In *Pygaster morrisi* the isopores are almost identical (*comp.* Pl. 38, Figs 2a-2d; Pl. 39, Figs 4a-4b *and* SMITH 1978a, Figs 5b, 5d) with those of *Plesiechinus*, whereas in *P. tenuis* the isopores are relatively long and have pores unequal in size (*see* Pl. 42). All these isopores are characterized by a relatively broad attachment area (broader in isopores developed at adoral side), by the moderately broad but distinctly arched interporal partition, by the relatively large pores, and by a well defined neural canal. The most adoral isopores in the both species are arranged parallelly to the peristome margin.

FUNCTIONAL INTERPRETATION END PALEOECOLOGY

SMITH (1978a), on the ground of the tubercle arrangement and ambulacral pore-pairs, has presented an ecological interpretation of *Plesiechinus ornatus*. He postulated (*see* SMITH 1978a, p. 64) that *Plesiechinus* covered itself with coarse bottom material, using its suckered tube feet associated with *P2* isopores, and relatively short aboral spines, and that the oral spines pushed the coarse substrate out from beneath the animal, which is indicated by radially arranged bilaterally symmetric adoral tubercles. The individuals of *Plesiechinus* inhabited warm, shallow-water, low-energy environment, simply nuzzled into the sediment and held coarse material (relatively large particles) around and above, and used the lantern and peristomial tube feet for feeding.

The large periproct displaced from the apex may suggest that a great volume of fecal material was being excreted, and that *Plesiechinus* ingested bottom particles in preference to browsing (*see* SMITH 1978a).

This interpretation of the lifestyle and environment may be successfully adopted for the two *Pygaster* species studied. However, the differences in arrangement of tubercles, general shape and thickness of the test wall may suggest different preferences.

Consequently, the strongly flattened thick-walled test indicates that *Pygaster morrisi* might have inhabited a moderately high-energy environment, because the low profile of the test could provide greater stability in currents. The densely spaced primary and secondary spines probably better protected the animal from contamination of the test by small-sized bottom particles. Thus, it is thought that *Pygater morrisi* might have covered itself with relatively smaller particles as compared with *Plesiechinus*. The large tear-shaped periproct is slightly depressed and passes into a shallow, but very short groove. Although it is not the typical anal sulcus, this development of the periproctal region suggests that the fecal material was channelled more efficiently, by using natural water currents, than that of *Plesiechinus*.

The very large size of the periproct indicates that the volume of feces was great, and the size of its particles might have been quite large. Therefore, *Pygaster morrisi* may have been an unselective (opportunistic) deposit-feeder, swallowing or rasping large quantities of bottom material.

The individuals of *Pygaster tenuis* are large and relatively high-arched with a thin-walled test. The density of aboral tubercles (spines) is comparable (*see* Pl. 40, Fig. 1a; Pl. 41, Figs 1c, 2a, 3 *and* SMITH 1978a, Fig. 1B), but the adoral ones are more numerous and surrounded by deeply incised and more adambitally enlarged areoles (*see* Pl. 41, Fig. 1b *and* SMITH 1978a, Fig. 2). The large number of adoral spines allowed to distribute more uniformly the weight of the echinoid adorned with attached particles. The more adambitally enlarged areoles indicate that the attached muscles pulled more strongly in this direction, and the animal had to use great power to push out the coarse-grained substrate by its oral spines, a consequence of the reasonably great weight of the animal and the relatively high profile of the test. The individuals of *Pygaster tenuis* probably had to dig deeply to hide themselves, but even so, they were positioned semi-infaunally.

The more elongate isopores indicate that the associated tube feet were also elongate, and their efficiency in gaseous exchange was probably more effective than those of *Pygaster morrisi*. The greater efficiency of tube feet resulted from a higher ratio of the body volume to the surface of the test.

The thin-walled and high-profiled test indicates that *Pygaster tenuis* inhabited the more protected areas in a low-energy environment.

Holectypus corallinus D'ORBIGNY, 1850

This species is very close to *Holectypus depressus* (LESKE, 1778), which has been studied in detail by SMITH (1984). The small differences in arrangement of secondary tubercles can be regarded as unimportant. Consequently, it is believed that paleoecological interpretation of *Holectypus corallinus* is fully compatible with that of *H. depressus* given by SMITH (1984). The studied individuals of *Holectypus corallinus* are therefore thought to have been adapted to life on loose bottom sediments and they burrowed vertically into coarse-grained bottom, mostly shell gravels, using their oral spines. They buried themselves for protection from predators during daytime and returned to the surface at night to forage; they fed using only their lantern to scoop up bottom sediment unselectively. The large periproct indicates that the volume of fecal material was great and that the ingested particles were relatively large. The individuals of *Holectypus corallinus* inhabited a warm, shallow-water, low-energy environment.

Pygurus blumenbachi KOCH & DUNKER, 1837
(examined with optical microscope only)

TEST

The thick-walled test is very low in lateral profile and strongly flattened adorally (*see* Pl. 46, Figs 2b, 3b). The petaloid ambulacra are relatively broad and long, but the *III* ambulacrum is shorter and narrower than the others. The oral side of the test is strongly folded, and the ambulacra are relatively deeply sunken (*see* Pl. 46, Fig. 3c). The pentagonal peristome is moved slightly to the anterior margin. The relatively large, tear-shaped periproct is close to the posterior margin.

TUBERCLE ARRANGEMENT AND SPINES

The aboral tubercles are small, densely spaced and relatively equal-sized. Close to the *III* ambulacrum they become larger, scarcely spaced, and deeply incised adapically. Areoles of these tubercles are circular in outline, and enlarged adapically.

The adoral side of the test is generally sunken and folded. The arrangement of tubercles is relatively variable. The most densely spaced tubercles are present close to the ambitus; these are small, and bear polygonal, deeply incised areoles. The smallest tubercles are developed in the central culmination of the interambulacra. From that culmination, towards both the sunken ambulacra and the peristome, the tubercles become larger and scattered. Areoles of these tubercles are generally enlarged towards the posterior margin. The tubercles developed close to ambulacra have adambulacrally enlarged areoles.

Close to the peristome, among the primary tubercles appear small granules, which cover steep slopes of bourrelets adjacent to the peristome.

PORE-PAIRS

Ambulacra of *Pygaster blumenbachi* are very characteristic: their aboral part is petaloid, whereas the adoral one is moderately deeply sunken, and towards the peristome it is enlarged and shaped into rhomboidal phyllodes.

The petaloid pore-pairs (*see* Text-fig. 7a), are represented by conjugate anisopores, which are extremely elongate, and parallel to the adoral plate suture. The perradial pore is small, and tear-shaped. The adradial pore is very elongate, and separated from the perradial pore by the moderately broad interporal partition. The two pores are linked by a narrow furrow. The attachment area is not developed.

Towards the ambitus, the petalodia become narrower, and the anisopores pass gradually into very small partitioned isopores. These isopores are positioned obliquely to the adoral plate suture. At the adoral side of the test, the isopores are very widely spaced, but close to the peristome they become crowded together to form broad phyllodes, composed of three pore-pairs in one row. The isopores (*see* Text-fig. 7b) are characterized by equal-sized oval pores, a relatively broad attachment area, a very narrow interporal partition, and by the axially positioned neural canal.

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

The arrangement and character of aboral tubercles indicates the presence of the relatively uniform spine cover. The spines developed close to the *III* ambulacrum were inclined at an acute angle to the test, having their tips directed towards the posterior margin. It was probably an effect of pushing the sediment away during ploughing through the bottom.

The adoral tubercles (showing no rapid increase in size) were associated with spines used for locomotion and manipulation of sediment. The locomotory spines were generally developed on the interambulacral culmination, and the uniform direction of enlargement of areoles indicates a preference for unidirectional (anterior) locomotion. A low profile and the anteriorly narrowed test were an adaptation for ploughing in the sediment.

The spines associated with the widely spaced tubercles, developed close to the ambulacra, were inclined to these and were used for sediment manipulation.

The development of bourrelets indicates the presence of spines that formed a dense grille across the peristome. These spines were modified to help push sediment into the mouth (*see* SMITH 1984).

The petalodia developed aborally are relatively long and are composed of conjugate anisopores, which were associated with respiratory tube feet. These tube feet were elongate and narrow, and extended only a short distance above the test. This type of tube feet is an adaptation to the infaunal mode of life (*see* SMITH 1980, p. 78). The long petalodia of *Pygurus blumenbachi* indicate that the depth of ploughing was not great, so that the major part of the aboral side of the echinoid was exposed above the sediment/water interface.

The ambital and adoral pore-pairs are represented by partitioned isopores associated with suckered tube feet. These tube feet were involved in picking up and transporting bottom particles, which were equal to, or larger in size than, the suckered disc. This seems to be related to the grain size of the material ingested. It is thought that the individuals of *Pygurus blumenbachi* ingested smaller particles than those of *Pygaster morrisi*, *P. tenuis*, or *Holectypus corallinus*. However, *Pygurus blumenbachi* still ingested with a limited selectivity, because it had suckered tube feet, and never exploited fine-grained substrates.

It is worthy of mentioning that the adoral suckered tube feet, developed between the ambitus and the phyllodes, are very widely spaced. The resultant contribution of these few tube feet to sediment transport was smaller than that of the spines adjacent to the ambulacra, the more so as the ambulacra on the oral side are moderately deeply incised and form grooves. These grooves were involved to help transport sediment particles directly to the mouth, benefiting also from the currents induced by spines close to the ambulacra.

The numerous ambulacral pore-pairs in the phyllodes of *Pygurus blumenbachi* were associated with relatively small tube feet. The smaller size of the tube feet allowed them to pick up smaller particles, whereas the great number of tube feet around the peristome increased their efficiency (*see* SMITH 1984, p. 73). These features indicate that *Pygurus blumenbachi* was able to ingest relatively small particles, but the volume of sediment, probably of low organic content, must have been great. The great volume of ingested sediment increased the discharge of fecal material, so that the periproct moved from the apex onto the oral side. In the same manner, the problem of removal of the fecal material was solved by *Holectypus corallinus*.

Summarizing, *Pygurus blumenbachi* inhabited a shallow-water, coarse-grained bottom environment, ploughing shallowly through the sediment. Therefore, it retained a semi-infaunal mode of life. It selectively ingested sediment of relatively low organic content, using both its adambulacral and adoral spines, as well as the suckered tube feet.

Nucleolites brodiei (WRIGHT, 1850)
(examined with optical microscope only)

TEST

The oval, slightly elongate test is low in lateral profile and flattened adorally (*see* Pl. 48, Figs 7a, 8a). The petals are typical of all *Nucleolites* species; they are relatively weakly defined and become narrower close to the ambitus. On the oral side, narrow phyllodia are developed. The broad, oval, relatively short periproct is displaced to close the posterior margin and is connected with a broad, shallow anal groove. The relatively small, subpentagonal peristome is moved close to the anterior rim.

TUBERCLE ARRANGEMENT AND SPINES

The aboral equal-sized tubercles are very small, densely spaced. The areoles of these tubercles are symmetrically circular in outline or slightly enlarged adapically. Between two petaloid anisopores developed is one row of 6-7 small, equal-sized tubercles. The oral side is covered with relatively larger tubercles that become densely spaced towards the ambitus. The areoles of these tubercles are slightly oval and generally enlarged towards the posterior margin. Around the peristome, small densely spaced tubercles are developed.

The region around the periproct and anal groove in all specimens studied is worn.

PORE-PAIRS

The petalodia are composed of non-conjugate anisopores (*see* Text-fig. 8a) that are characterized by the oval perradial pore, by the elongated, slit-shaped adradial pore, and by the narrow but well defined attachment area. These two pores are linked by a conspicuous, narrow and long rim. The petaloid anisopores pass gradually into small partitioned isopores (*see* Text-fig. 8b), which are characterized by equal-sized oval pores, a narrow interporal partition, a narrow attachment area, and by the axially positioned neural canal. At the oral side these pores are relatively densely spaced and positioned obliquely to the adoral plate suture. Close to the peristome they are crowded together and form narrow phyllodes, typical of all *Nucleolites* species (*see* SMITH 1984, Fig. 3. 33).

FUNCTIONAL INTERPRETATION AND PALEOECOLOGY

The uniform, small aboral tubercles indicate that the covering spines were small, delicate, equal-sized, and oriented vertically or slightly adapically.

The areoles of oral tubercles show a uniform, posterior elongation, which indicates that all spines on those tubercles were used for forward locomotion. Only small spines developed around the peristome were used for sediment manipulation.

The petals are composed of non-conjugate anisopores which were associated with specialized respiratory tube feet. However, the elongation of *Nucleolites* anisopores is relatively much smaller than that of petaloid anisopores in *Pygurus*. The relatively small elongation of anisopores indicates that associated tube feet were less elongate, and therefore less specialized for gaseous exchange. There appears to be a correlation between the development of specialized respiratory tube feet and the size of the echinoid test (*see* SMITH 1980, p. 71); the small-sized species, like *Nucleolites brodiei*, had less specialized tube feet, which resulted from the ratio of the surface area to the volume of the echinoid.

The rows of small tubercles running between anisopores indicate the presence of small, equal-sized spines, which probably were involved in promoting currents, to clean areas between tube feet and to provide oxygen-rich water.

The ambital and adoral pore-pairs represented by partitioned isopores were associated with small, suckered tube feet, and these, like in *Pygurus*, were involved in picking up and transporting bottom particles, which were equal to, or larger, in size than the disc. This feature indicates that *Nucleolites brodiei* was relatively limited in selection of the sediment particles. The rather great density of the adoral isopores indicates that these pores may have taken the major part in transport of sediment towards the mouth, while the contribution of spines was reasonably smaller.

The most adoral pore-pairs form narrow phyllodes towards the peristome. These pores are represented by ovoid-shaped partitioned isopores, which are comparable with those of *Galeropygus agariciformis* (FORBES) illustrated by SMITH (1978a, Figs 4b *and* 5a). Most probably the studied isopores were associated with moderately muscular, suckered tube feet, richly endowed with sensory epithelial tissue. These tube feet were involved in taste and tactile sense organs, and were also used for transport of bottom particles towards the mouth. Because the number of these tube feet was relatively small, the volume of ingested sediment was probably limited.

The posteriorly displaced periproct, extended into the anal groove, was an adaptation for channelling the fecal discharge.

The phyllodes reach about two thirds of the aboral ambulacral length, and their extent shows the limit of depth to which the specimens may have ploughed through the sediment. In such cases, *Nucleolites brodiei* was a relatively shallow-ploughing species, so that the major part of the aboral side of the echinoid was exposed above the sediment/water interface. The low profile and strongly flattened oral side of the test helped in ploughing, and provided stablility against strong currents and/or wave action. All the *Nucleolites* species are reported from sediments deposited in warm, shallow-water habitats (*see* SMITH 1984). Consequently, it is inferred that *Nucleolites brodiei* inhabited a warm, shallow-water, probably high-energy environment. Individuals of this species had to constantly plough through the sediment to forage, using its suckered tube feet and spines, keeping primarily a semi-infaunal attitude.

CONCLUSIONS ON ECHINOID HABITAT AND BURIAL

The above-given functional analysis of the echinoid tests allows to draw some general conclusions. A warm, shallow-water habitat, required by all the analyzed echinoid species (*see* Table 2), agrees well with the recognized environmental

Table 2

A summary of ecologic requirements of the selected species of echinoids and their burial lithology

SPECIES	**Mode of life**	**Mode of forage**	**Habitat**	**Common burial lithology**
Rhabdocidaris orbignyana (L. AGASSIZ, 1840)	– epifaunal, in protected areas	– using only lantern, to rasp encrusting organisms	– warm, shallow-water, low-energy – coarse, shell- gravel bottom	pea-grits, marly oyster-hash beds
Acrosalenia angularis (L. AGASSIZ, 1840)	– epifaunal, probably nocturnal, searching for hiding place to be protected against predators or strong waving	– using lantern and probably oral spines, to scoop up bottom material	– warm, shallow-water, moderately high-energy – coarse-grained bottom	marly biocalcarenites
Hemicidaris hoffmanni (F.A. ROEMER, 1836) & ***Hemicidaris intermedia*** (FLEMING, 1828)	– epifaunal, able to climb obstacles	– using only lantern, to rasp encrusting organisms	– warm, shallow-water, high-energy – stable bottom	marly pea-grits, rarely marly limestones and marly oolites
Trochotiara kongieli sp.n.	– epifaunal and occasionally semi-infaunal, – covers itself	– using only lantern, to rasp encrusting organisms	– warm, shallow-water, high-energy, – coarse-grained bottom	pea-grits & oyster shellbeds
Phymosoma supracorallinum (COTTEAU, 1865)	– epifaunal, and occasionally semi-infaunal, – covers itself	– using only lantern, to rasp encrusting organisms	– warm, shallow-water, high-energy, – coarse-grained bottom	pea-grits & oyster shellbeds
Stomechinus gyratus (L. AGASSIZ, 1840) & ***Stomechinus semiplacenta*** (L. AGASSIZ *in* AGASSIZ & DESOR, 1847)	– epifaunal, able to climb obstacles	– using only lantern, to rasp encrusting organisms	– warm, shallow-water, high-energy, – stable bottom	pea-grits & oyster shellbeds
Gymnocidaris agassizi (F.A. ROEMER, 1839)	– epifaunal, able to climb obstacles	– using only lantern, to rasp encrusting and/or shelled organisms	– warm, shallow-water, high-energy, – stable bottom	pea-grits & oyster shellbeds
Pygaster morrisi WRIGHT, 1851	– semi-infaunal, – burrows vertically, and covers itself	– using lantern and oral suckered tube feet, probably also spines	– warm, shallow-water, low- to moderately high-energy, – coarse, shell-gravel bottom	pea-grits, oyster-hash beds and marly/oolitic biocalcarenites
Pygaster tenuis L. AGASSIZ, 1839	– semi-infaunal, – burrows vertically, and covers itself	– using lantern and oral suckered tube feet, probably also spines	– warm, shallow-water, low-energy, – coarse, shell-gravel bottom	pea-grits, oyster-hash beds and marly/oolitic biocalcarenites
Holectypus corallinus D'ORBIGNY, 1850	– semi-infaunal, – burrows vertically, and covers itself during daily hours	– using only lantern, to scoop up bottom sediment	– warm, shallow-water, low-energy, – coarse, shell-gravel bottom	marly pea-grits, marly oyster-hash beds
Pygurus blumenbachi KOCH & DUNKER, 1837	– semi-infaunal, – ploughs through sediment	– ingests selectively sediment, using oral tube feet and spines	– warm, shallow-water, moderately high-energy, – loose, fine-grained bottom	marly biocalcarenites, marlstones
Nucleolites brodiei (WRIGHT, 1859)	– semi-infaunal, – ploughs through sediment	– ingests selectively sediment, using oral tube feet and spines	– warm, shallow-water, high-energy, – loose, fine-grained bottom	marly biocalcarenites, marly oolites, marlstones

conditions of the Early Kimmeridgian sequences, typified by the bahamite facies yielding diverse oolite, onkolite, and shellbed members.

The requirement of either high- or low-energy habitat indicates that diverse biotopes, distributed among the patchy realm of particular facies, were successfully colonized by the specialized species. Unfortunately, a further attempt to characterize their settlement in more detail is not possible because all echinoids studied, except of a few, were transported after their death.

A column of the "Common burial lithology"(*see* Table 2) is thus presented mainly to indicate the lithology in which the given species typically occurs. This may, but does not have to, inform about the habitats, that is the biotopes, the studied echinoids lived in. When the lithology yielding the most common occurrences coincides with the habitat features, a more or less *autochthonous burial* is inferred. In other cases, either a remote habitat, in which some specimens could temporarily live, or a more or less *allochthonous burial* must be invoked. Under the hydrodynamic conditions of the studied Early Kimmeridgian carbonate platforms some extent of auto- and/or allochthony must be assumed for almost all echinoids having been deposited in regular horizontal layers indicative of a rather longer transport and/or wave action.

For the ecological requirements of the studied species, when compared with their burial conditions, two cases should be discussed.

Firstly, it is to indicate that the two species, *Pygurus blumenbachi* KOCH & DUNKER, 1837, and *Nucleolites brodiei* (WRIGHT, 1859) display an almost identical mode of life and habitat requirement, differing from those of all other species studied. Consequently, these two species and/or their congeners (*Pygurus costatus*, *P. jurensis*, and *Nucleolites letteroni*, *N. truncatus*, respectively) occur typically in layers/sequences other than the rest of the studied species. To note, of these two genera, *Nucleolites* tends to occur in more oolitic deposits, pure oolites including.

Secondly, a more intriguing conclusion arises from the anatomy (*i.a.* of pore-pairs, tube feet and their functions) of *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840), namely, that it was adapted to a low-energy habitat. Its occurrence together with *Holectypus corallinus* (D'ORBIGNY, 1850) and *Pygaster* of similar requirements, but also with other species of high-energy habitats, indicates not only that it was transported after death, but also, that it lived in protected areas of the seafloor topography where material for pea-grits and oyster hash layers was formed. Presumably, these were the depressions among heaps or mounds either of onkolites or oyster shells, and/or of both, accumulated by action of littoral currents (?subtidal) and/or wave action. To note, a low-energy habitat of *Rhabdocidaris* has recently been inferred also in other facies of the Upper Jurassic carbonates in Germany (BAUMEISTER & LEINFELDER 1998).

As concerns the burial lithologies, worthy to comment are the three localities – Karsy, Sulejów, and Celiny, where in one highly fossiliferous layer there occur echinoids of diverse mode of life and habitat requirements. On the other hand, in locality Gołuchów, the echinoids appear in a part of one layer. These peculiar occurrences are briefly discussed as follows.

Karsy: Oyster-hash marly biocalcarenite, about 1m thick, replete with diverse shell material in which the most common echinoid *Holectypus corallinus* is associated with 12 other species (*see* Table 1: total list of the locality comes from this very layer, *arrowed* in Text-fig. 6*D*). Diverse fossils are represented by mollusks (mostly bivalves with various life requirements, few gastropods, nautiloids, ammonites), brachiopods (*Sellithyris subsella*, *Septaliphoria pinguis*), elasmobranch teeth, and large-sized calcareous sponges

Fig. 11. Grazing traces of regular echinoids

1 – *Apiocrinites* holdfast scratched by the grazing traces, partly covered by successive growth bands of the crinoid; arrowed is a part magnified in *1a*; nat. size

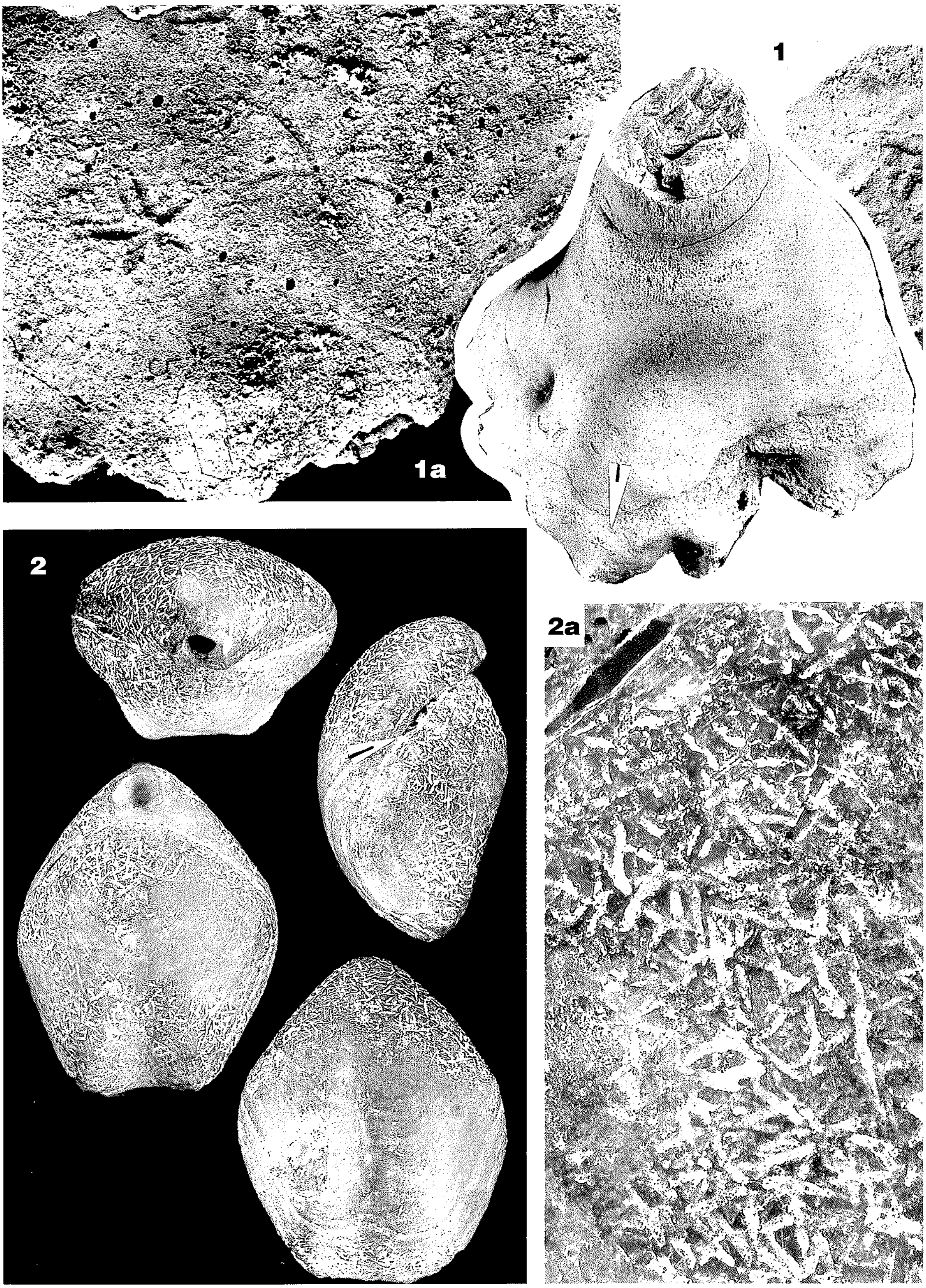
1a – Close-up, to show two solitary, five-rayed grazing traces of different size, shape, and depth; × 5

[The specimen from the Małogoszcz Quarry, the Upper Oolite member]

2 – Shell of the terebratulid brachiopod, *Sellithyris subsella* (LEYMERIE), taken in four views, to show the extent of grazing traces almost allover the shell; arrowed is a part magnified in *2a*; taken × 1.5

2a – Close-up, to show the maze of grazing traces in the umbonal part of the brachiopod's dorsal valve; × 5

[The specimen from the Małogoszcz Quarry, the *Exogyra* pea-grit]



Grazing traces of regular echinoids (explanation *see* the opposite page)

Elasmostoma. This marly layer is quite structureless, but contains pieces of variably cemented lime deposits and variably preserved fossils (either fresh or abraded, or encrusted by epizoans and/or coated by onkolitic envelopes). It has supposedly been formed as a submarine mudflow, fed by deposit fragments and shells derived from various biotopes the substrate of which underwent liquefaction and mass-movement.

Sulejów: Marly biocalcarenite, merely 1m thick, structureless, with all collected specimens (25) of *Hemicidaris gresslyi*, associated with *Hemicidaris intermedia* and *Stomechinus semiplacenta*. This layer, the thickest carbonate layer in a marl/marlstone sequence exposed at the Sulejów lime-kiln, contained also numerous bivalves, and brachiopods (*Sellithyris subsella*, *Septaliphoria pinguis*). It has supposedly been formed due to a storm-induced agitation and deposition of the stirred-up material over a muddy bottom.

Celiny: Marly fossiliferous oolite, about 1 feet thick (*arrowed* in Text-fig. 6*C*), in which the most common echinoid *Nucleolites truncatus* is associated with many fragments of *Rhabdocidaris orbignyana* (1 complete specimen) and one specimen of a rare species, *Pedina sublaevis*. All the collected material (*see* Table 1) comes from this layer, which may have formed as a result of storm agitation that stirred up and transported bioclasts from diverse biotopes and settled them as a tempestite. Indistinct horizontal lamination suggests a distal part of that tempestite.

Gołuchów: Compact peastone, in a marly lenticular inlier of which, about 2m long (*arrowed* in Text-fig. 6*B*), all collected specimens (24) of large, showy individuals of *Hemicidaris intermedia* were contained. This sediment has supposedly been also formed by a storm agitation and tempestite deposition.

In conclusion, high-energy agents were responsible not only for shaping the echinoid habitats and biotopes, but also for echinoid taphonomy. These agents involved processes that led to the fragmentation of echinoid tests, their transport (and/or reworking), and their final burial in various sequences, tempestite or mudflow layers including.

Consequently, as concerns environmental conditions, it is apparent that the functional analysis of echinoid tests delivers a bulk of information not lesser than that supplied by taphonomic and sedimentological data. Moreover, an additional information is also revealed by an analysis of traces of life activity of the echinoids, which are briefly characterized in the following chapter.

GRAZING TRACES OF THE STUDIED ECHINOIDS

The only traces of life activity of the studied echinoids are grazing traces left on various shelly substrates (*see* Text-figs 11-12). These traces are composed of a series of scratches, of variable depth and length, that tend to keep a five-rayed pattern corresponding to five teeth of Aristotle's lantern. In an ideal case, a star-shaped rosette is thus formed of five grooves, of which some may be paired, as seen on an *Apiocrinites* holdfast (Text-fig. 11/1-1a). Such ideal cases of an isolated, single trace are very rare. Usually the shelly substrate is covered by a maze of grooves superposing each other, and overlying the ones earlier formed (Text-figs 11/2-2a *and* 12/1-3).

Grazing traces of the maze type are met in the *Exogyra* marls with pea-grits of the Małogoszcz section (*see* Text-fig. 6*A*), where they occur primarily on shells of terebratulid brachiopods (Text-fig. 11/2-2a) and on echinoid tests (Text-fig. 12/1-3). In the latter case, damage of the test is often so serious that the original sculpture of the test becomes quite diffuse. In tests of *Rhabdocidaris orbignyana* only interambulacral columns and a ghost of interambulacral plates remains detectable (Text-fig. 12/1-1a), whereas in those of *Gymnocidaris agassizi* the adapical part (devoid of larger tubercles) is usually less damaged (Text-fig. 12/2-2a), but specimens totally and deeply grazed are also present (Text-fig. 12/3-3a).

Fig. 12. Grazing traces (taken × 5) of regular echinoids upon tests of their confrères

1 – Maze of traces on the test of *Rhabdocidaris orbignyana*, damaged more heavily at its ambital part; the test inserted as *1a* taken × 1.5

2 – Maze of traces on the test of *Gymnocidaris agassizi*, damaged outside its apical part; the test inserted as *2a* taken × 1.5

3 – Maze of traces on the test of another specimen of *Gymnocidaris agassizi*, heavily scratched allover the test, to destruct completely its original sculpture and to produce a kind of 'echinoid wreck'; the test inserted as *3a* taken × 1.5

[All specimens from the Małogoszcz Quarry; the pea-grit layers of *Exogyra* shellbeds]

In the illustrated specimens of echinoid tests, the maze of grazing traces (Text-fig. 12/1-3) do not inform about the number of grazing attacks, and/or the number of grazing echinoids in action. One case more instructive in this matter is that of the shell of the terebratulid *Sellithyris subsella* (LEYMERIE) upon which the grazing pattern is composed of grooves of a similar size and shape, and thus is thought to have been produced by the action of one echinoid only. This echinoid, when grazing, was able to manoeuvre with the shell, to turn it round (like a squirrel does with a hazelnut), to rasp off the edible tidbits. If taken into account that the terebratulid shells are naked, the grazing pattern indicates that not the shell itself but its epibionts (? algal film, ? kelp, ? hydrozoans, ? bryozoans) were the objects upon which the echinoid foraged. The same conclusion must be drawn for the echinoderm substrata (*Apiocrinites* holdfasts, all echinoid tests), where not an epithelium, but epibionts were scratched away for food. The latter interpretation, on the other way, suggests that epibiontic coats could protect echinoid tests for some time against their fast destruction on the sea bottom.

Since all the illustrated specimens come from one section, of Małogoszcz, although from different members, it is clear that the studied grazing traces cannot be, even tentatively, ascribed to the activity of any of the echinoid taxa contained in these members. Nevertheless, when a grazing activity is thought to have been performed upon epibiontic coats of the shelly substrates, a question arises of either live or dead nature of the shell owners. It seems that these two alternatives were realized: the crinoids *Apiocrinites* were evidently alive and able, by their holdfast bands, to overgrow the former scratches (*see* Text-fig. 11/1), but the heavily damaged brachiopod shells and echinoid tests had to be covered by a thick epibiontic coat that certainly propagated upon emptied shells/tests of their original inhabitants.

In other Early Kimmeridgian sequences of the Holy Cross Platform identical grazing traces have recently been recorded by MACHALSKI (1998, pp. 622-623 *and* Fig. 9*F-H*), as common on shells of *Exogyra* (*Nanogyra*) *virgula* in the Wierzbica section.

The studied grazing traces are fully compatible with those described comprehensively by BROMLEY (1975), and adorned with an ichnologic designation of *Gnathichnus pentax* BROMLEY, 1975, to cover the whole variety of such traces produced by regular echinoids, both present-day and ancient, ranging since the Lower Jurassic. Of the subsequent authors, MICHALIK (1977) extended that range down to the Upper Triassic (Rhaetian), whereas the others (MARTINELL 1981, 1982; SMITH 1984; BRETON & *al.* 1992) supplemented the data, both from modern habitats and from the geologic past (*see also* ZIEGLER 1998, pp. 578-579).

To note, none of the ichnotaxa introduced by MICHALIK (1977) and BRETON & *al.* (1992) bear features which could be diagnostic at an ichnospecies or ichnogenus level separate from *Gnathichnus pentax* of BROMLEY (1975).

DISCUSSION and FINAL REMARKS

In general, the composition of the studied echinoid fauna from the Lower Kimmeridgian strata of Poland is featured, at the species level, by the dominancy of regular forms (31 species, that is 76% of total). This figure, coinciding with that once presented by KIER (1977, Table 1: 81%) for Kimmeridgian time, may indicate that the studied fauna is representative for this time interval allover the world. Its comparison to other coeval echinoid faunas is, hovewer, not easy.

As judged from the literature, the studied echinoid fauna is comparable the best to that of the *Badener Schichten* and/or Oxfordian *Liesberg Schichten* of the Swiss Jura (*see* HESS 1975; ZBINDEN 1986, 1987a,b,c, 1988). To some extent, it is also comparable to that of Boulonnais in France (*see* RIGAUX 1882; VADET 1988, 1989). The species morphologically similar are, moreover, typical of the Middle Jurassic of England developed as a carbonate platform with facies diversity (*e.g.* Pea Grit Series of the Lower Inferior Oolite) almost identical (*see* MUDGE 1978; SMITH 1984, pp. 19-21) to that of the studied Holy Cross Platform.

The functional analysis of the most common species from the Lower Kimmeridgian of Poland allowed to recognize the habitat conditions under which these species had lived, and to compare this with their burial conditions. The latter were concluded for several localities (Karsy, Celiny, Sulejów, Gołuchów) in which the echinoids are frequent in one layer. The richest assemblages, yielded by localities with larger sections exposed, should also be briefly summarized, regardless their coming either from thicker sets of strata, or from particular layers. Such localities are two, *viz.* Małogoszcz in the Holy Cross Mountains and Czarnogłowy in Western Pomerania, where the echinoids were collected in huge exposures through a longer span of time.

At **Małogoszcz**, within the collection of the greatest variability at the species level (17 regular and 5 irregular; *see* Table 1), four species dominate. Of these, *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840) and *Gymnocidaris agassizi* (F.A. ROEMER, 1839) are very rare in other localities, taking a more significant part only at Karsy (*see* Table 1). At the Małogoszcz Quarry, they both occur mostly within the topmost parts of *Actinostreon* shellbeds and the lowest parts of *Exogyra* marls (*arrowed* in Text-fig. 6*A*).

The functional analysis of its relatively fragile test shows that *Rhabdocidaris orbignyana* preferred low-energy environments with a low sedimentation rate, having been thus adapted to habitats sheltered from an action of rough waters. Contrary to that, thick-walled *Gymnocidaris agassizi* was adapted to high-energy habitats, having been able to climb onto bottom obstacles and to adhere more or less firmly to the substrate during strong turbulence. Under such circumstances, an alternative interpretation of the "naked" aboral part of the test may be offered: namely, it could help the specimens of *Gymnocidaris agassizi* in distribution of the surge impact.

In this context, *Gymnocidaris agassizi* (F.A. ROEMER, 1839) is thought to have been confined to extremely shallowest depths, at which its "naked" aboral part could temporarily been even exposed above the surf waters. Supposedly, it occupied settings similar to these reported for the present-day *Colobocentrotus atratus* (LINNAEUS, 1758) and those inferred for the low-Upper Jurassic (Oxfordian) *Acrocidaris nobilis* L. AGASSIZ, 1840 (*see* MORTENSEN 1935, BLAKE 1984, ZBINDEN 1985, BAUMEISTER & LEINFELDER 1998).

Life requirements similar to those of *Rhabdocidaris orbignyana* and *Gymnocidaris agassizi* are also concluded for *Hemicidaris intermedia* (FLEMING, 1828), taking an important share in the Małogoszcz assemblage (*see* Table 1).

On the other hand, such a share in the Małogoszcz assemblage is also displayed by the two species of *Pygaster*, viz. *P. morrisi* WRIGHT, 1851, and *P. tenuis* L. AGASSIZ, 1839, the both very rare in other occurrences (*see* Table 1), and associated with *Holectypus corallinus* D'ORBIGNY, 1850. These three species are typified by an ability to cover (thatch) their tests (*see* Table 2), what is also suggestive of extremely shallow-marine conditions. The majority of functional bases of the "covering reaction" (waving, desiccation, light operation; *see* LAWRENCE 1976), that is of the thatching behavior of echinoids, are active in very shallow waters, within the limits of the photic zone in which the thatched specimens may, among others, become invisible for potential predators.

The functional analysis of echinoid tests thus supports the earlier statements, resulted from the ecology of other fossils, that environmental conditions of the echinoid-bearing parts of the *Actinostreon* shellbeds and/or *Exogyra* marls were characterized by the decreasing mud sedimentation, combined with winnowing (SEILACHER, MATYJA & WIERZBOWSKI 1985), and by a more or less condensed, residual-lag nature of the deposit (KUTEK, MATYJA, RADWAŃSKI & WIERZBOWSKI 1992, p. 33) that formed at extreme shallow depths.

Under such very life conditions, one more remarkable feature is an interhabitat variability of the species *Pygaster tenuis* (L. AGASSIZ, 1839) which displays diverse shell-thicknesses dependant on the habitat conditions (*see* Systematic Account), a feature noted only in this species, pronounced by its largest size of all the echinoids studied. Such an interhabitat variability controlled by the substrate characters is comparable to that recognized formerly by NÉRAUDEAU (1991) for some echinoids of Upper Cretaceous age.

Supplemented to this is a recognition that the habitat diversity (open *versus* protected/sheltered) had to exist prior to winnowing and/or reworking of the bottom material containing live and/or dead echinoids. In other words, this clearly indicates a rather conspicuous irregular topography of the seafloor at time when the echinoids lived. A total damage of their biotopes/habitats was caused by temporary harsh water conditions leading to transportation, segregation (trimming of spines), and allochthonous burial of the tests.

The temporary fatal conditions are thought to have very likely been involved not only by the increasing energy of waters situated at stable depths, but also by such factors as, for instance, an extreme shallowing of water column (growth of sediment stock, sea-level fluctuations of any nature, the extreme tides including) and, consequently, even its overwarming beyond the temperature the echinoids could survive (*cf.* SMITH 1984, p. 15 *and* references therein).

The deposition, featured by horizontal layers, took evidently place over a uniformly shaped seafloor, under quiet-water conditions similar (or close) to those under which *Rhabdocidaris orbignyana* lived. For specimens of this species it was therefore a weakly allochthonous burial that explains a good preservation state of their relatively fragile, thin-walled tests and a common occurrence of their isolated spines. For *Gymnocidaris agassizi* it was a fully allochthonous burial, before which all the spines had completely been removed from the tests and damaged.

Finally, a conclusion on the origin and subsequent damage of irregular topography of a very shallow seafloor formed either by the *Actinostreon* hash or pea-grit materials of the *Exogyra* marls in which *Gymnocidaris agassizi* domiciled, and situated amidst quiet-water (sheltered) slacks inhabited by *Rhabdocidaris orbignyana*, may also explain their very irregular patchy distribution in the discussed sequence exposed at Małogoszcz.

At **Czarnogłowy**, characteristic of the collection abundant numerally but rather poor in species diversity (*see* Table 1), is a prevalence of one species, *Hemicidaris hoffmanni* (F.A. ROEMER, 1836), known in Poland from this locality only, and whose frequency has once been estimated as "about 90% of the assemblage" (JESIONEK-SZYMAŃSKA 1988, p. 377), but which is really of about 50% (*see* Table 1). Its representatives display an almost normal GAUSS' size-frequency distribution (*see* Text-fig. 13), indicative of the content of all ontogenic classes, with an advanced share of the smallest one (sized over 5mm; smaller not present in the collections) regarded as the juveniles. This size-frequency distribution is thus suggestive of a more autochthonous burial (*cf.* NÉRAUDEAU 1991), supposedly catastrophic (thanatocenotic) in its nature, of members of successive populations, rather than of a higher mortality of the juveniles. To note, this is the only section in which the common occurrence of juveniles is stated, and *Hemicidaris hoffmanni* is the only species in which the juveniles are easily recognizable (formerly treated even as separate taxa - *see* Systematic Account).

Moreover, typical at Czarnogłowy is the presence of peculiar features (anomalies) of the apical disc, both in *Hemicidaris hoffmanni* (F.A. ROEMER, 1836) and *Hemicidaris intermedia* (FLEMING, 1828), unknown in any *Hemicidaris* species from other localities (*see* Systematic Account). These structural features are treated herein as of specific variability, possibly of phyletic nature, although some of them are, partly at least, malformations of teratologic origin.

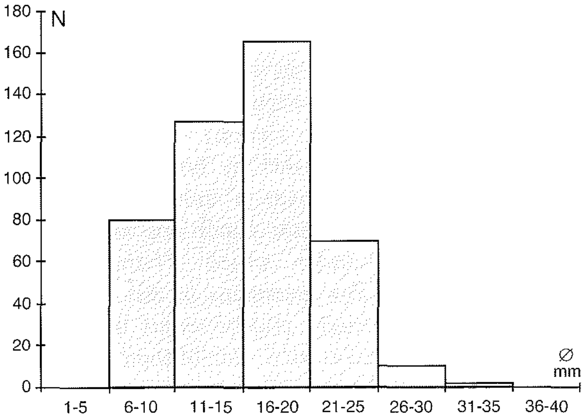


Fig. 13. Bar diagram showing the size-frequency distribution of *Hemicidaris hoffmanni* (F.A. ROEMER, 1836) from Czarnogłowy in Western Pomerania

Notable at Czarnogłowy is also the occurrence of small-sized species *Nucleolites letteroni* (COTTEAU, 1870). If its frequency is taken into account (300 specimens, *see* Table 1), an impression arises about the presence of dwarfish (? pedomorphic) specimens common in this locality.

The above-indicated peculiarities may inform about an environmental stress involved locally within the area of Czarnogłowy, or throughout the whole Pomeranian Platform situated along the offshores of the Fennoscandian Shield. A greater supply of clay material and/or other terrestrial wastes from the hinterland, a salinity fluctuation/crisis (? greater influx of freshwater, or higher evaporation over the shoals), or even a temperature drop at the higher latitude (*see* Text-fig. 1) might have introduced the factors absent in the Holy Cross Platform situated nearer to the oceanic realm of the Tethys.

When the echinoid assemblages of the two discussed localities, **Małogoszcz** and **Czarnogłowy**, are compared, a more permanent high-energy environment is supposed for the former, and the more quiet waters are inferred for the latter.

With regard to the species diversity of echinoid assemblages of the so-differing conditions from these localities, an inverse frequency of the two *Hemicidaris* species, viz. *H. intermedia* (FLEMING, 1828) and *H. hoffmanni* (F.A. ROEMER, 1836), is apparent (*see* Table 1). Beyond the scope of this summary review is a judgement whether these two "*paleontological species*" could be interpreted as phenotypic variants of one "*biological species*".

A general characteristics of the regional extent is that within the **Holy Cross Platform** that embranced an area of the large part of present-day Poland at Early Kimmeridgian time (*see* Text-fig. 1*B*) the environmental conditions for echinoids' life were extremely favorable. A great species diversity and abundance of echinoids in some strata clearly induce such a statement. Contrary to a high facies diversity, the intraspecific variability of particular species is very low, and it may evidently be demonstrated, as given above, only by the species characterized by the largest size of the test, that is *Pygaster tenuis* AGASSIZ, 1839, from Małogoszcz. Such very low intraspecific variability gives a rise to the twofold conclusion that: either (*i*) the facies of different lithology have propagated under conditions not sufficiently diversified the phenotypic variability of particular echinoid species could be manifested in their test morphology, or (*ii*) except of *Pygaster tenuis*, the other echinoid species did not exhibit any interhabitat variability at all, having been strictly confined to a definite type of habitat in which the intraspecific variability could not be realized. The spatial pattern of all these habitats has completely been blurred by subsequent hydrodynamic processes. As the resultant echinoid occurrences are patchy, both in relation to space and sedimentary facies, none of them can be classified as "echinoid biofacies" *sensu* BOGGILD & ROSE (1984). Nevertheless, an almost mass-occurrence of some species, especially of *Hemicidaris* abundant in a few layers of the studied sections (Gołuchów, *and* one layer at Sulejów), and of *Nucleolites*, may suggest their herd mode of life.

On the other hand, a high frequency, in some layers, of echinoids of diverse habitat requirements and behavior, indicates their post-mortem transportation and/or segregation (also isolation of spines) due to harsh dynamic conditions (stormy agitation, triggering of mudflows). Anyway, a rapid burial responsible for preservation of skeletal elements other than the test (*see* NÉRAUDEAU 1991, RADWAŃSKA 1996) has occurred very locally and temporarily.

Summarizing, an analysis of test morphologies leading to their interpretation in functional terms has revealed some new data (*cf.* SMITH 1984, BAUMEISTER & LEINFELDER 1998) on the habitat conditions under which the studied Lower Kimmeridgian echinoids lived and to which they had to adapt. Generally, these conditions were established within platform areas of warm, shallow marine waters, with variable types of bottom material and morphology. An easy access of harsh hydrodynamic agents (storms, currents, or even tides) has commonly led to total destruction of echinoid habitats, transportation (? and/or even reworking) of their tests, but rarely to rapid burial of live specimens. As the majority of specimens underwent a more or less allochthonous burial, the population structure/dynamics and intrahabitat variability of particular species (*cf.* NÉRAUDEAU 1991), as well as full data on the echinoid biodiversity (*cf.* NEBELSICK 1996), may be deciphered to a very limited extent.

As concerns the whole area under study, and the Holy Cross Platform particularly, the relevant information on the echinoid life and burial history is supplied by sedimentological data from the echinoid-bearing strata (*see* review in Introduction). An additional focus in further research should also be recommended on the ecology and taphonomy of other fossils, locally ubiquitous, associated with the studied echinoids. To a final statement it is to say that such an integrated eco/taphonomic *versus* sedimentological analysis, compatible with actualistic ("*actuopaleontological*") approaches (*cf.* NEBELSICK 1992, 1995), of all echinoid-bearing strata or members of Lower Kimmeridgian age in Poland remains actually beyond the subject of the present paper.

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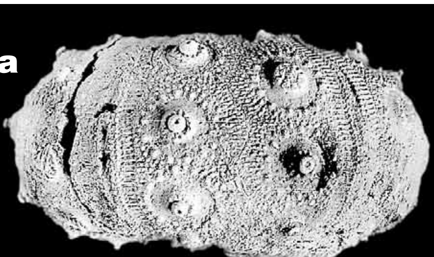
PLATES 1 – 49

PLATE 1

Fig. **1** — *Rhabdocidaris nobilis* (MÜNSTER, 1826); **1a** – lateral view, to show interambulacrum, **1b** – aboral view; nat. size; Specimen No. EMa/1

Figs **2-4** — *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840); **2a** – lateral view, to show interambulacrum, **2b** – aboral view, **2c** – lateral view, to show ambulacrum; × 1.5; Specimen No. EMa/2; **3a** – lateral view, to show ambulacrum, **3b** – aboral view; × 1.5; Specimen No. EMa/3; **4a** – aboral view, **4b** – lateral view, to show ambulacrum; × 1.5; Specimen No. EMa/4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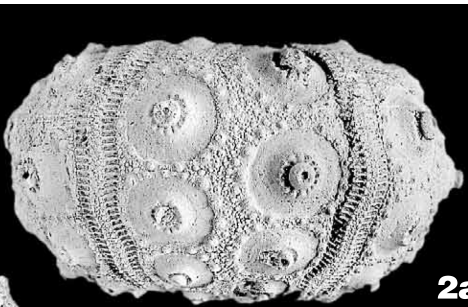
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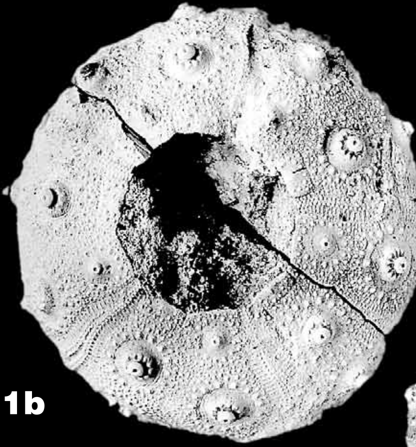
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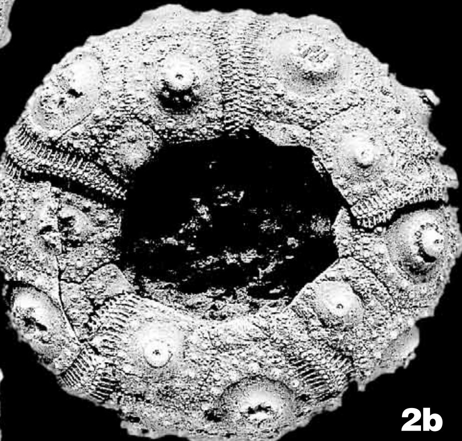
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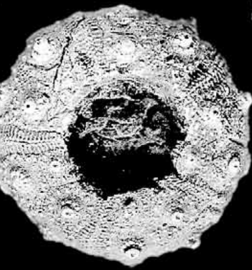
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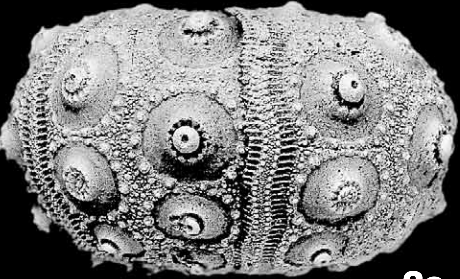
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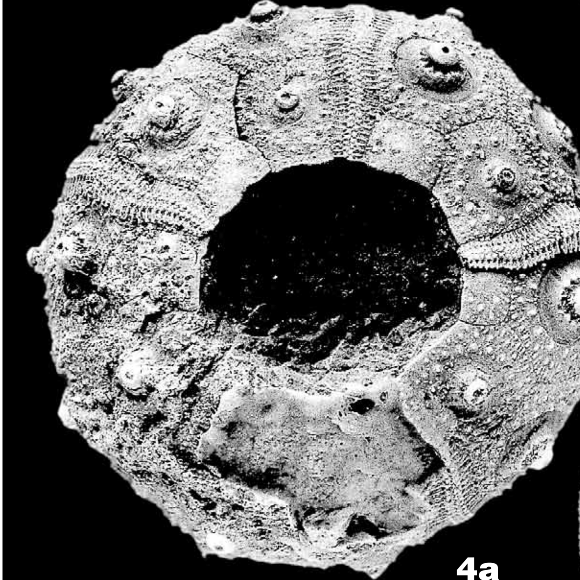
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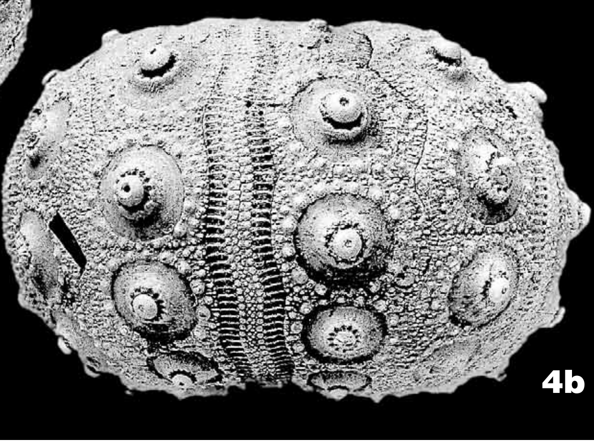
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PLATE 2

Figs **1-11** — *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840); **1-8** – primary interambulacral spines; all taken × 1.5; Specimens No. EMa/5-EMa/12; **9** – aboral view; nat. size; Specimen No. EMa/13; **10** – test with primary and secondary spines partly preserved, **10a** – aboral view, **10b** – lateral interambulacral view, **10c** – oral view; × 1.5; Specimen No. EMa/14; **11** – aboral view; nat. size; Specimen No. EMa/15


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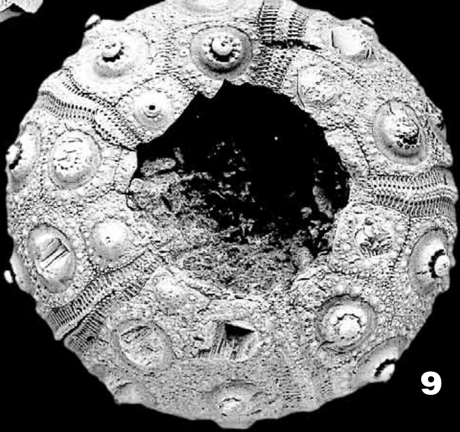
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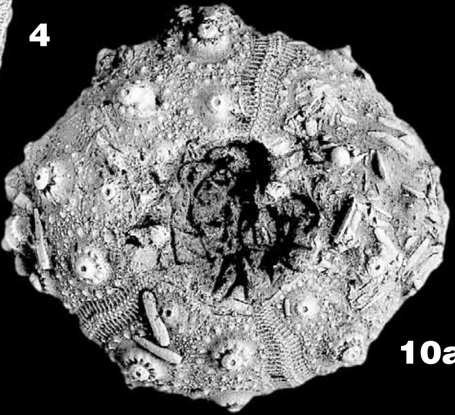
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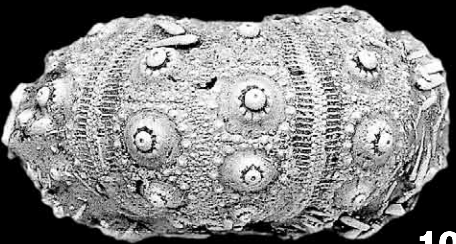
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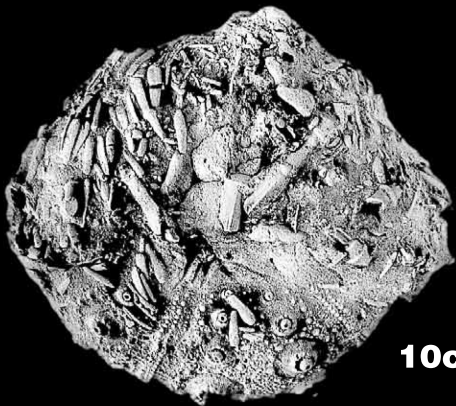
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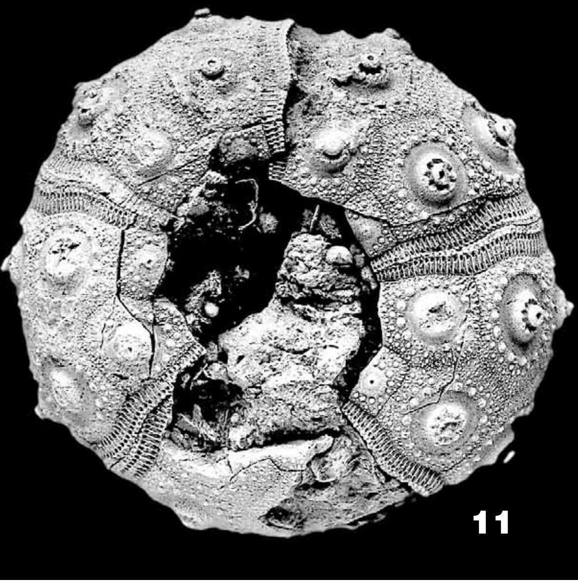
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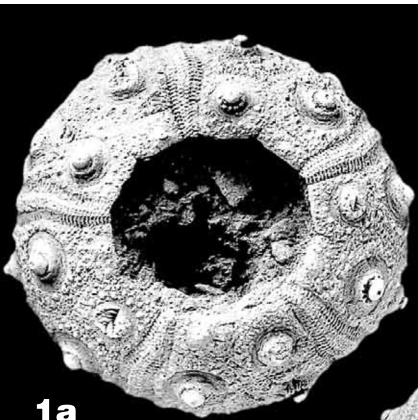
PLATE 3

Figs **1-3** — *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840); **1a** – aboral view, **1b** – lateral view, to show ambulacrum, **1c** – oral view; nat. size; Specimen No. EMa/16; **2a** – aboral view, **2b** – lateral view, to show ambulacrum; × 1.5; Specimen No. EMa/17; **3** – aboral view of the test, to show the apical disc preserved; × 1.5; **3a** – close-up view of the apical disc; × 3; Specimen No. EMa/18, fouled by the ostreid (*Exogyra*) spat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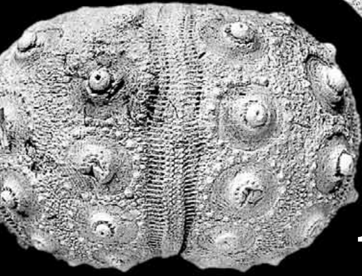
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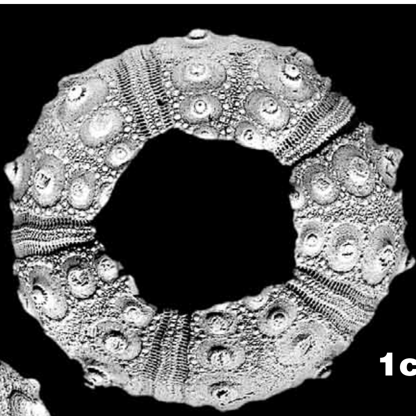
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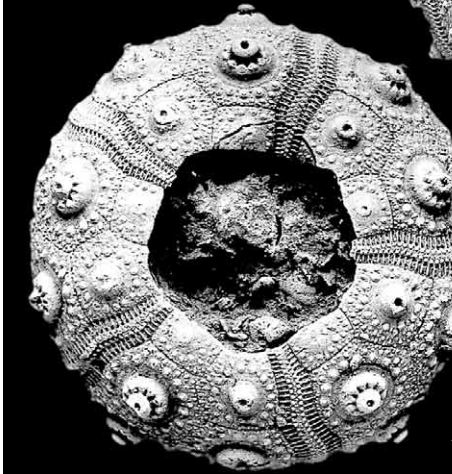
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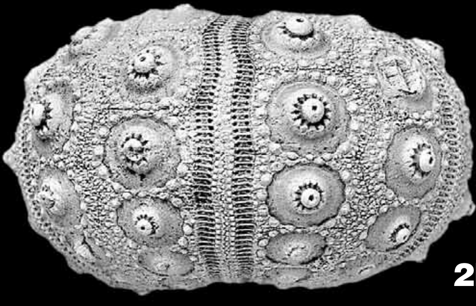
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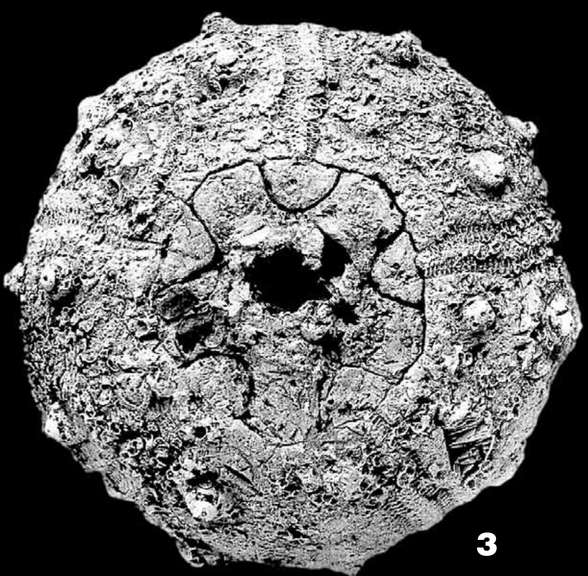
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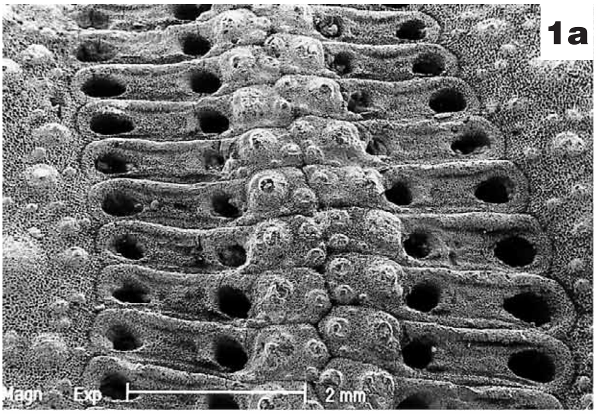
PLATE 4

Figs **1-3** — *Rhabdocidaris orbignyana* (L. AGASSIZ, 1840); **1a** – adapical part of ambulacrum, **1b**, **1d**, **1e** – close-up view of adapical *C1* isopores, **1c** – close-up view of adapical *C1* isopores, to show interporal ornamentation; **2** – subambital part of ambulacrum; **3a-3b** – ambital part of ambulacrum, **3b** – close-up view of ambital *C1* isopores; all specimens taken by SEM; Figs 1a-1e – Specimen No. EMa/19; Fig. 2 – Specimen No. EMa/22; Figs 3a-3b – Specimen No. EMa/21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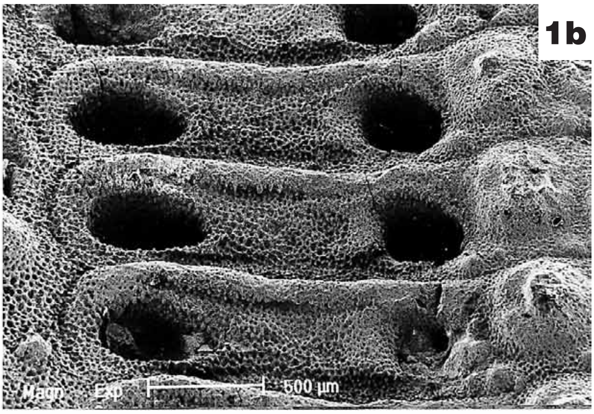
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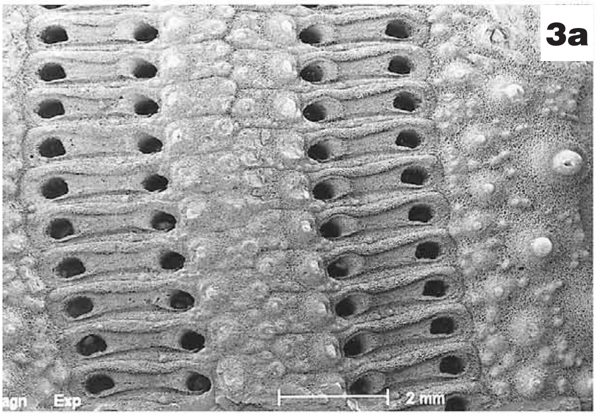
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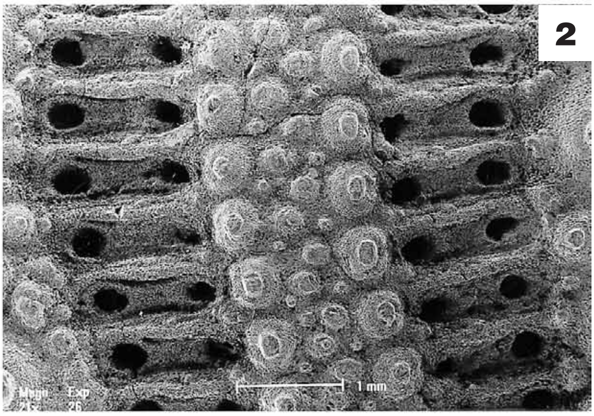
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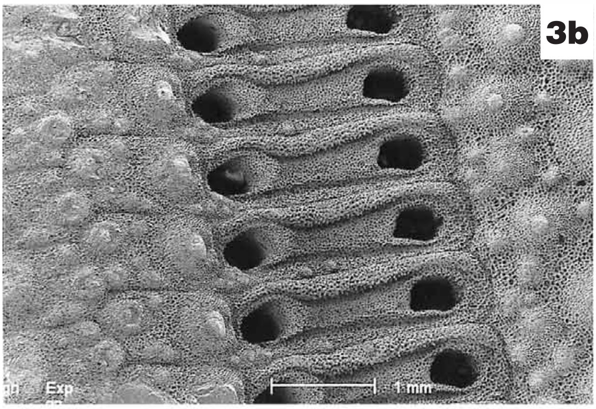
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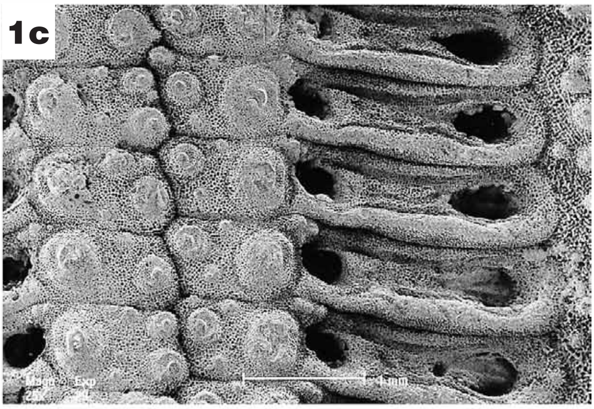
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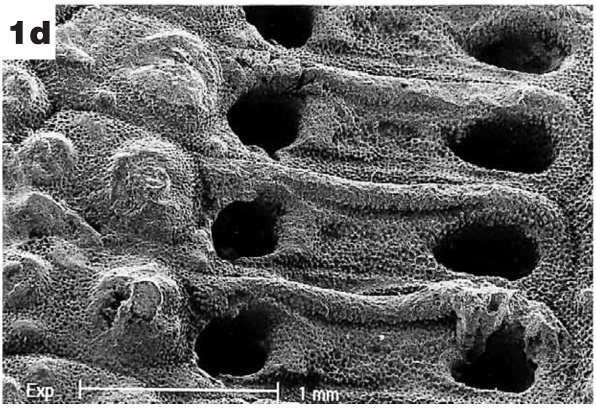
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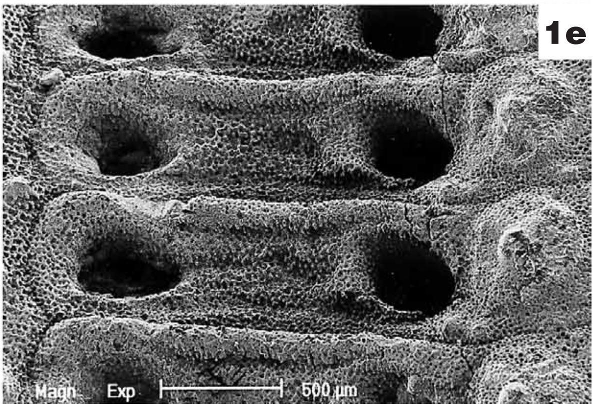
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PLATE 5

Figs **1-5** — *Paracidaris smithi* (WRIGHT, 1855); **1** – oral view; nat. size; Specimen No. ZPAL E.V/5; **2** – fragment of the test with preserved ambulacral and interambulacral columns; nat. size; Specimen No. EMa/23; **3** – fragment of the test, interambulacral column; nat. size; Specimen No. EMa/24; **4** – close-up of the interambulacral plate, to show primary and secondary tuberculation; SEM; Specimen No. EWi/95; **5** – close-up of a fragment of the interambulacral plate with associated ambulacral ones; SEM; **5a** – close-up of a part of the ambulacrum, to show ambulacral pore-pairs and interporal ornamentation; SEM; Specimen No. EWi/96

Figs **6-11** — Histocidarinae, gen. et sp. indet., primary spines; all taken × 2; Figs 6-11 – Specimens No. EWi/97


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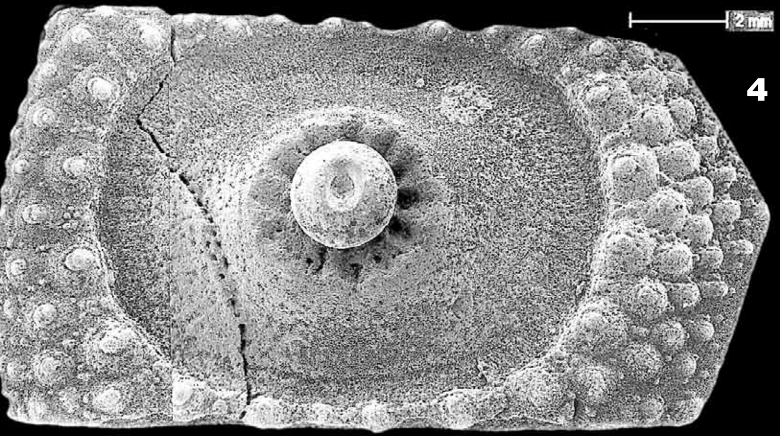
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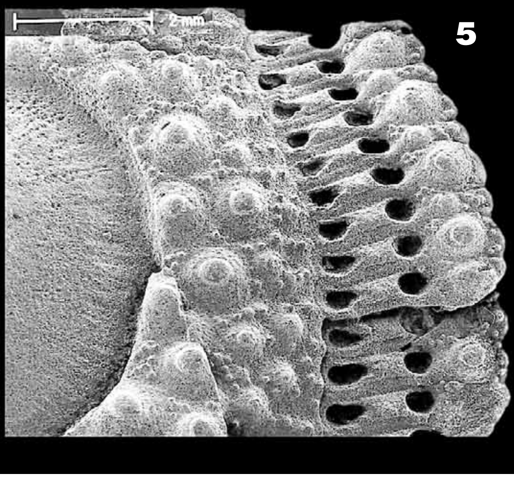
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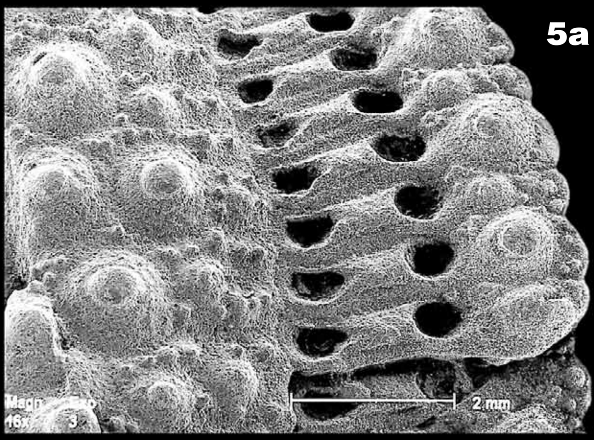
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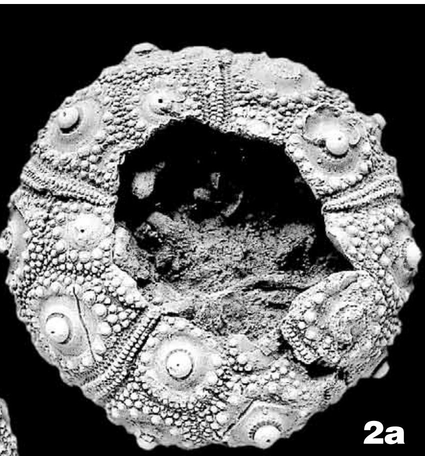
PLATE 6

Figs **1-4** — *Plegiocidaris crucifera* (L. AGASSIZ, 1840); **1a** – lateral view, to show ambulacrum, **1b** – aboral view, **1c** – oral view; × 1.5; Specimen No. EMa/25; **2a** – aboral view, **2b** – lateral view, to show interambulacrum; × 1.5; Specimen No. EMa/26; **3a** – aboral view, **3b** – lateral view, to show ambulacrum, **3c** – oral view; × 1.5; Specimen No. EMa/27; **4** – fragment of the interambulacral plate with associated ambulacral ones; SEM; **4a** – close-up view of a part of the ambulacrum, to show ambulacral pore-pairs; SEM; Specimen No. EMa/28

1a

1b



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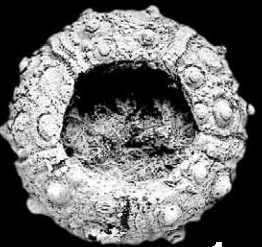

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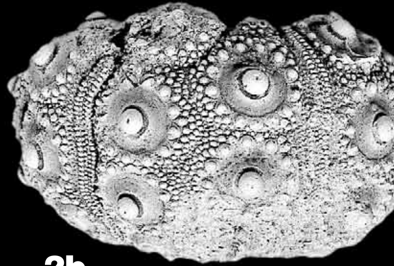

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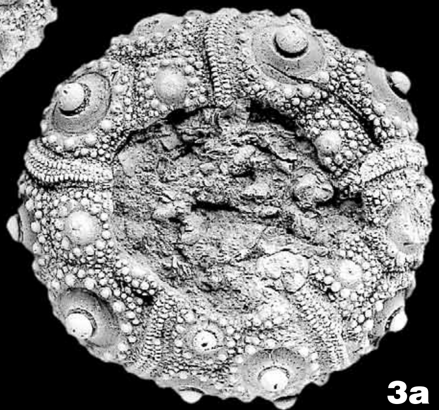

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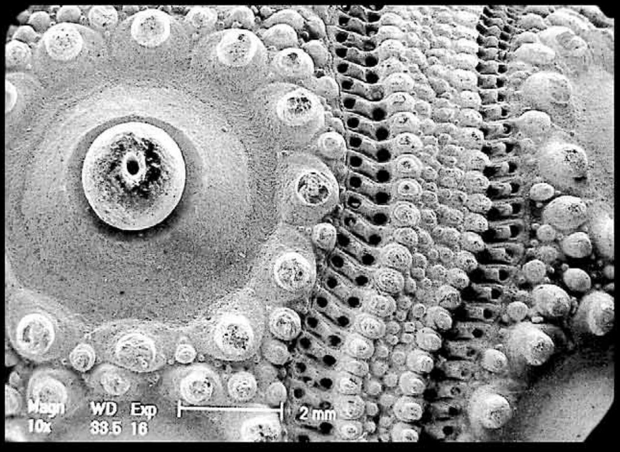

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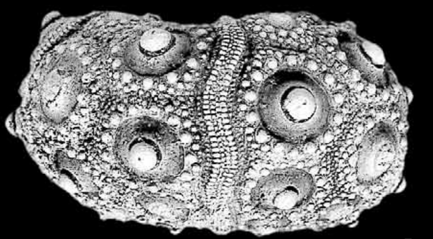

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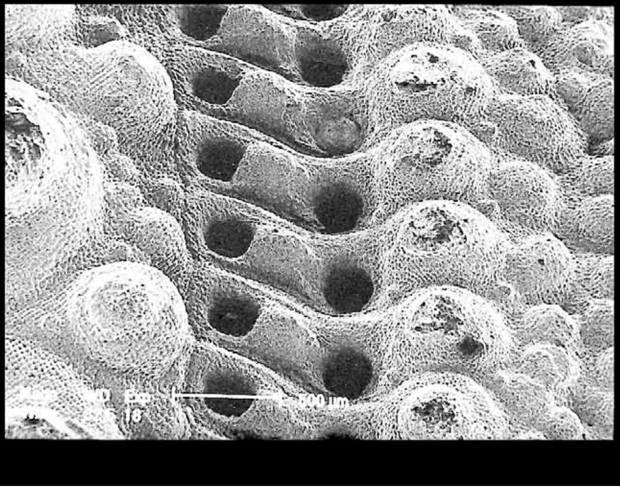
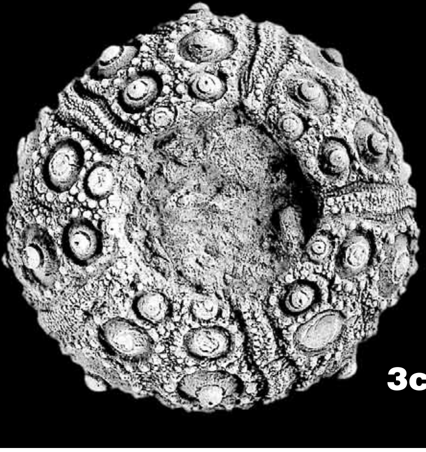


4a

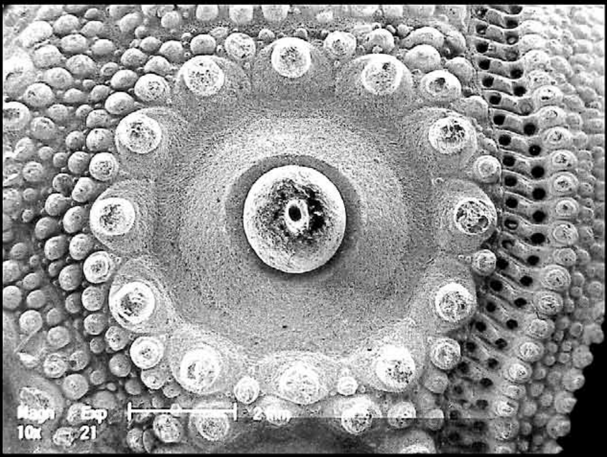


3c

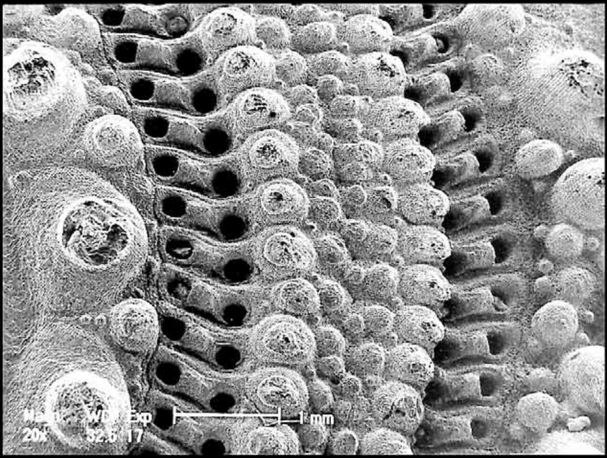
PLATE 7

Figs **1-3** — *Plegiocidaris crucifera* (L. AGASSIZ, 1840); **1** – fragment of the interambulacral plate, to show primary and scrobicular tubercles; SEM; Specimen No. EMa/28; **2** – fragment of ambulacrum, to show interporal ornamentation; SEM; **2a** – close-up view of ambulacral pore-pairs; SEM; Specimen No. EMa/28; **3a-3b** – primary spine; × 2; Specimen No. EMa/29

Fig. **4** — *Pedina sublaevis* L. AGASSIZ, 1840; **4a** – aboral view, **4b** – lateral view, **4c** – oral view, nat. size; Specimen No. EMa/30



1



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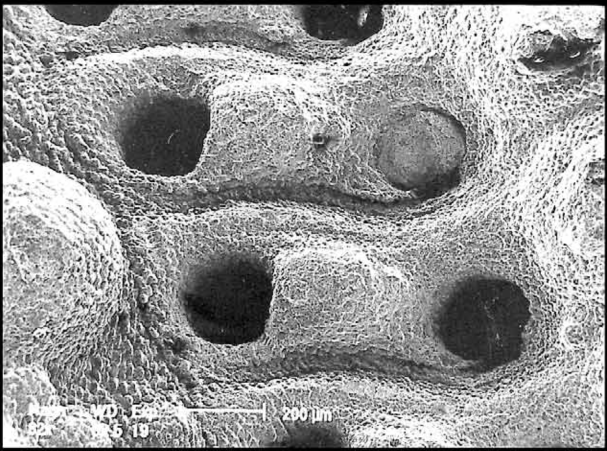
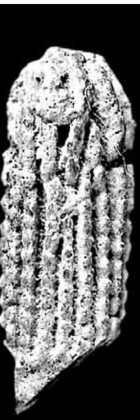
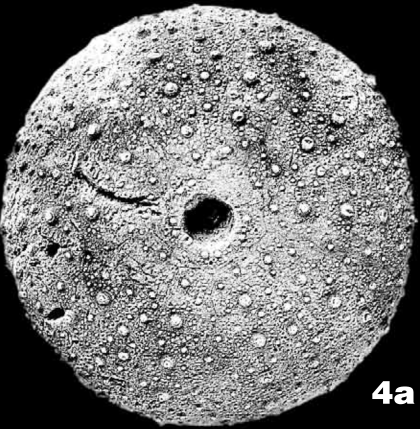


2a



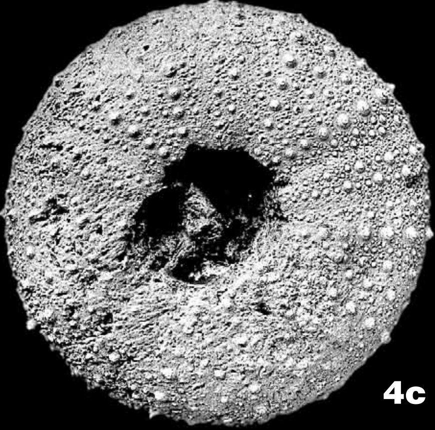
3a

3b



4a

4b



4c

PLATE 8

Figs **1-2** — *Pedina sublaevis* L. AGASSIZ, 1840; **1a** – aboral view, **1b** – lateral ambulacral view, **1c** – oral view; × 1.5; Specimen No. EMa/31; **2a** – aboral view, **2b** – oral view, **2c** – lateral view; nat. size; Specimen No. EMa/32

Figs **3-4** — *Pseudodiadema tetragramma* (L. AGASSIZ, 1840); **3** – aboral view; × 5; **3a** – close-up view of the aboral part of ambulacrum; SEM; Specimen No. EAn/98; **4** – aboral view; × 5; Specimen No. EAn/99

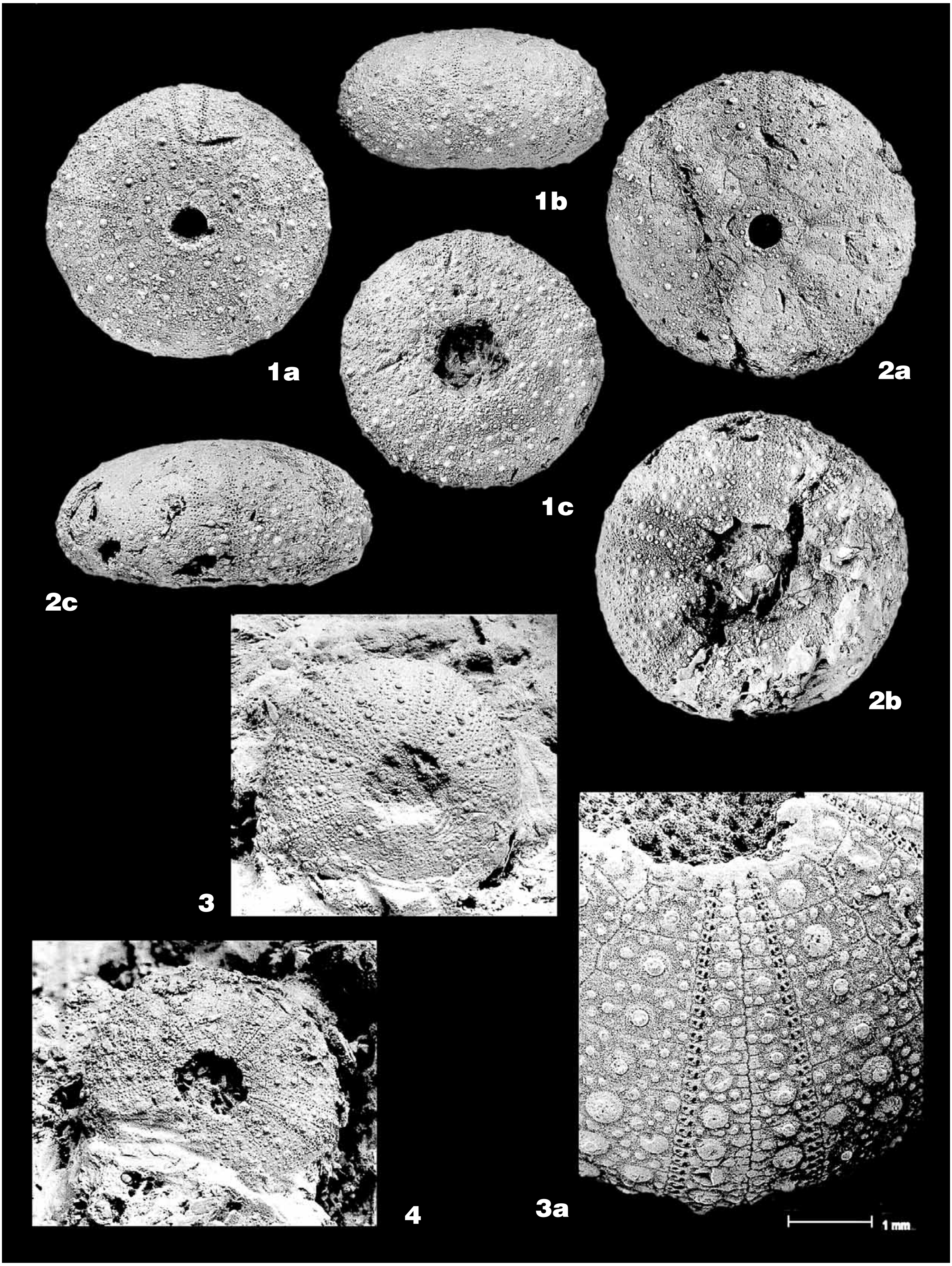
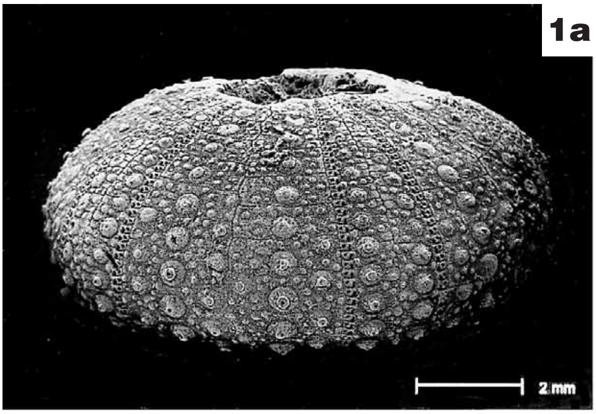

1a
1b
1c
2a
2b
2c
3
3a
4
1 mm

PLATE 9

Figs **1a-1h** — *Pseudodiadema tetragramma* (L. AGASSIZ, 1840); **1a** – lateral view, **1b** – aboral view, **1c** – close-up view of the diadematoid ambulacral plate, **1d** – close-up view of the aboral part of ambulacrum, **1e** – close-up view of the ambital part of ambulacrum, **1f** – close-up view of the adoral part of ambulacrum, **1g** – ambital view of interambulacrum, **1h** – oral view; SEM; Specimen No. EAn/98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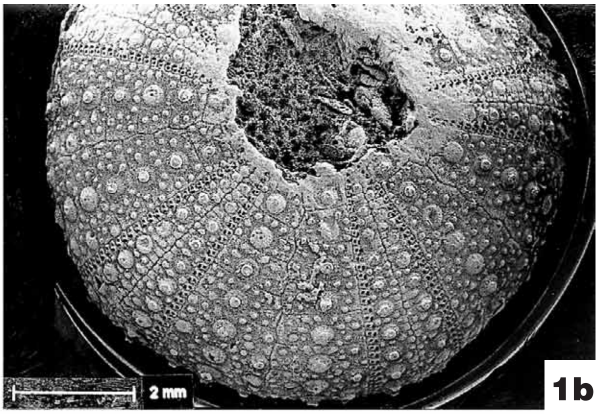
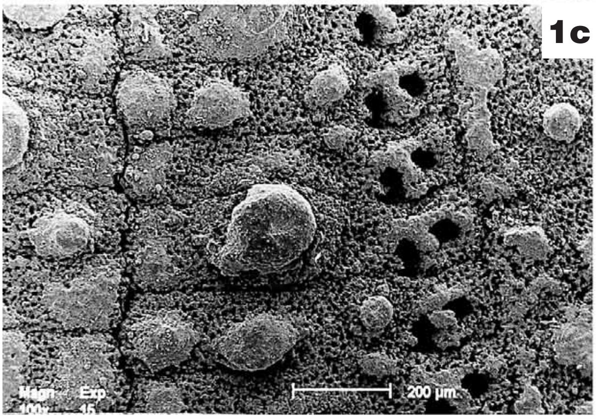

1b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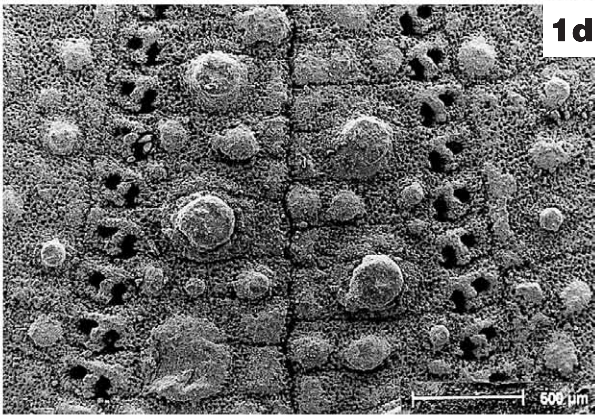
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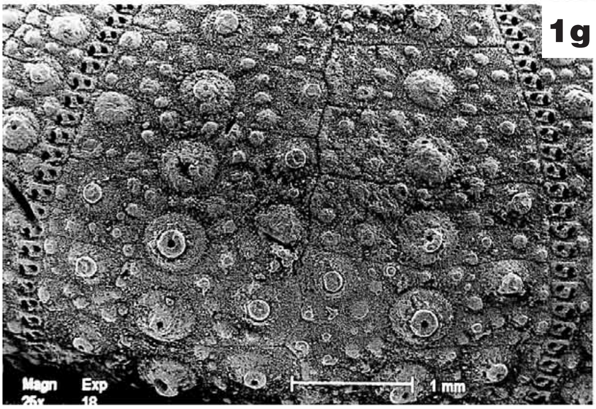
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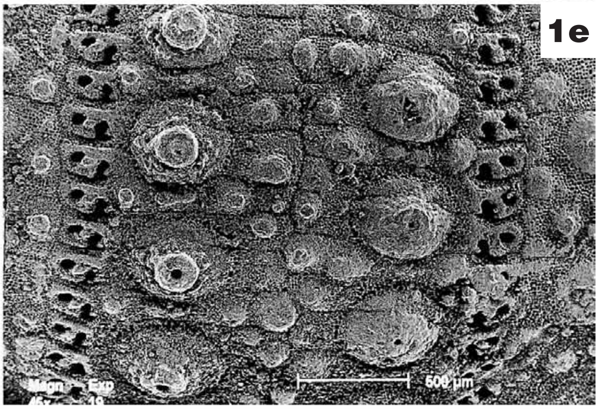
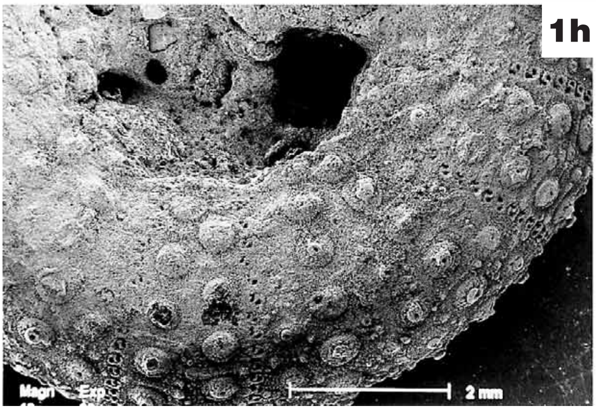

1e


1h

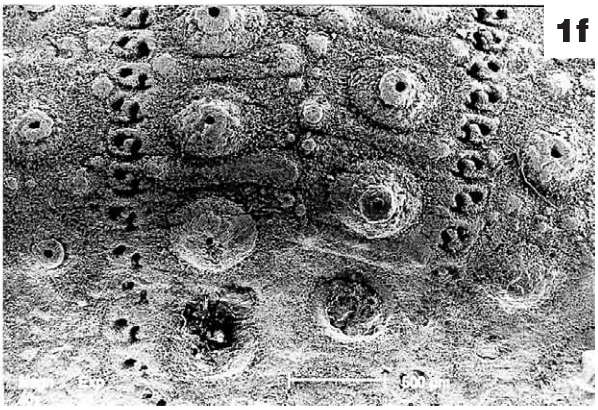
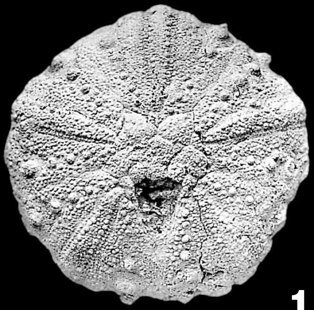

1f

PLATE 10

Figs **1-5** — *Acrosalenia angularis* (L. AGASSIZ, 1840); **1** – aboral view; × 2; **1a** – close-up view of the apical disc; × 5; Specimen No. EMa/92; **2a** – aboral view, **2b** – lateral view, to show ambulacrum; × 2; Specimen No. EMa/33; **3a** – aboral view, **3b** – lateral view, to show interambulacrum; × 2; Specimen No. EKa/100; **4** – aboral view; × 2; Specimen No. EKo/101; **5a** – aboral view, **5b** – lateral view, to show ambulacrum, **5c** – close-up view of the apical disc; Figs 5a-5b × 2, Fig. 5c × 5; Specimen No. MUZ P.I.G. 219. II. 1, the same as figured by KONGIEL (1957, Pl. 1, Figs 1-3)



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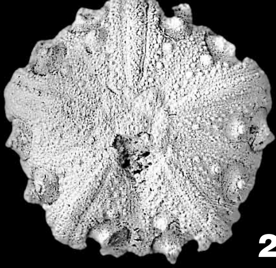
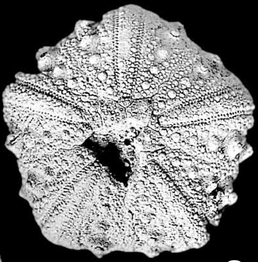


2a

2b



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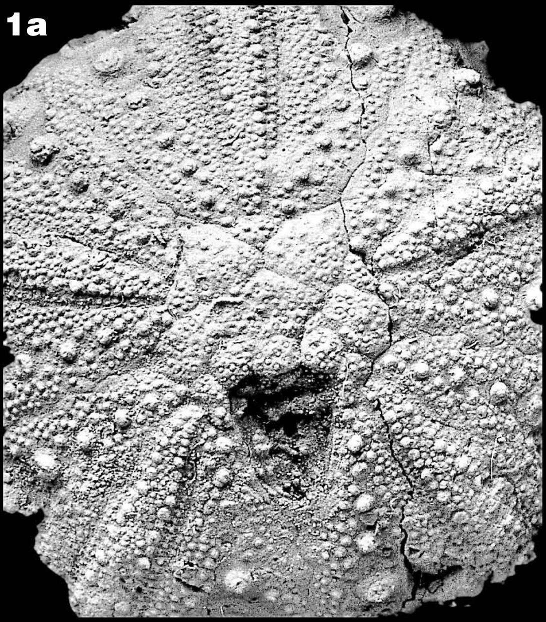
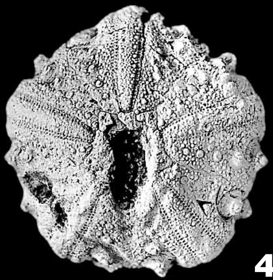


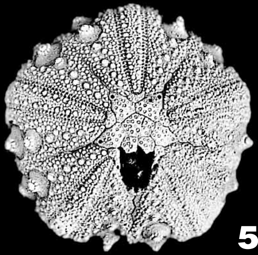
1a

3b

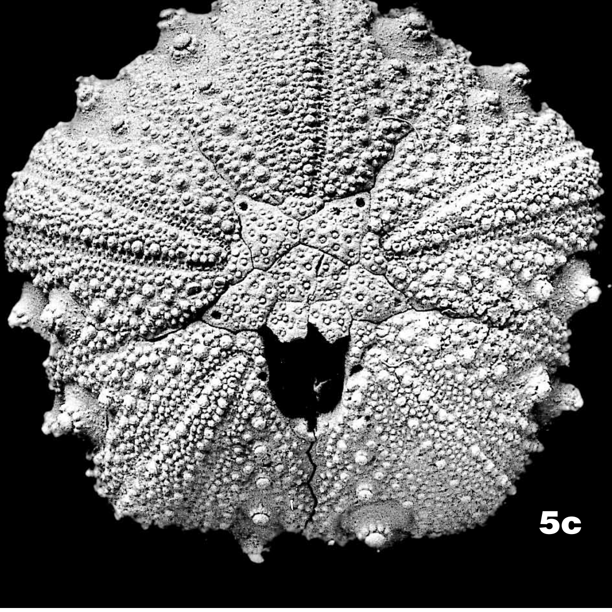


4

5b



5a



5c

PLATE 11

Figs **1a-1f** — *Pseudosalenia malogostiana* sp.n., **holotype**; **1a** – aboral view, **1b** – lateral view, to show interambulacrum, **1c** – close-up view of the adoral part of ambulacrum, **1d** – close-up view of the apical disc, **1e** – adoral view of interambulacrum, **1f** – ambital view of ambulacrum; SEM; Specimen No. EMa/34

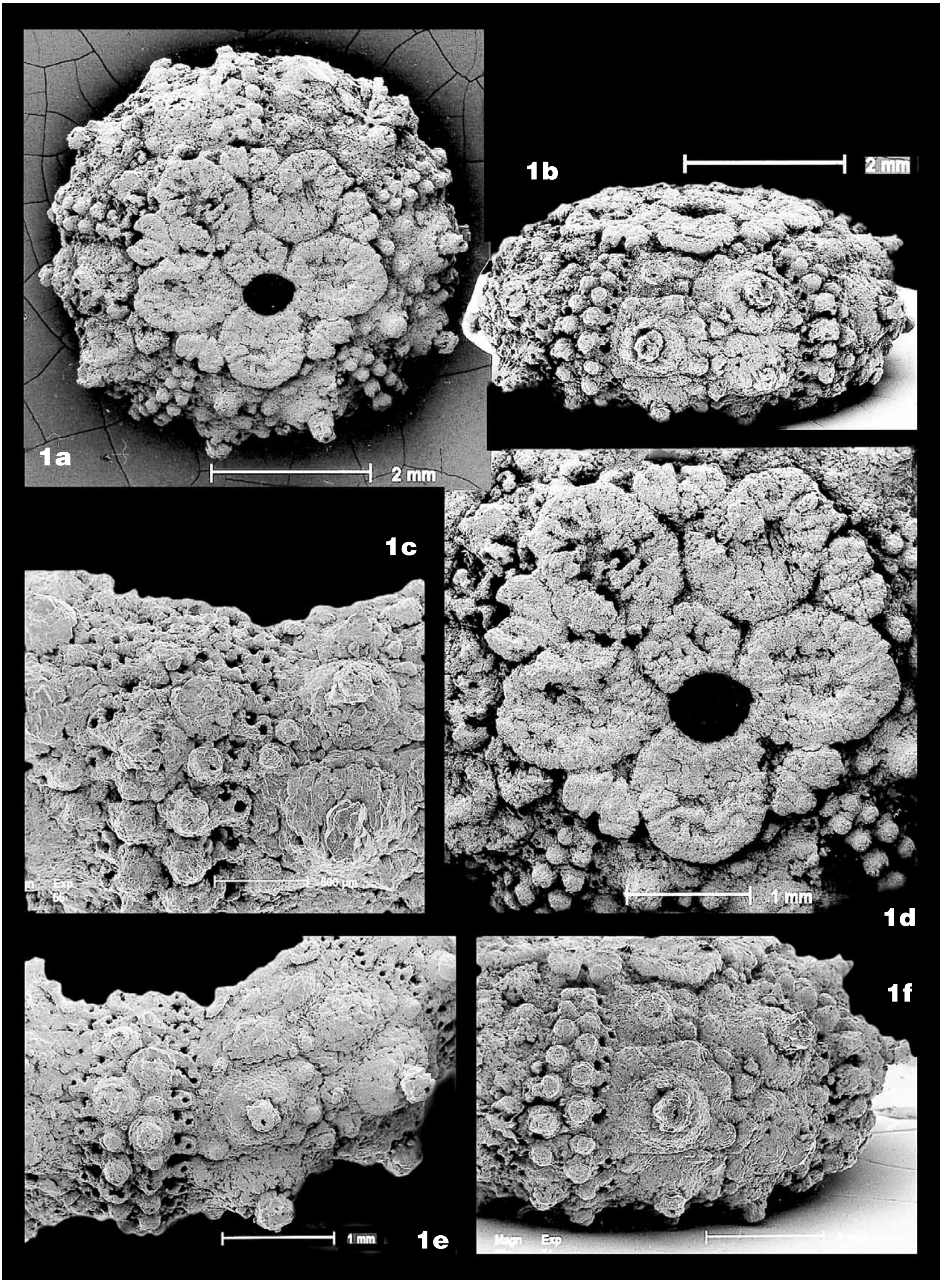
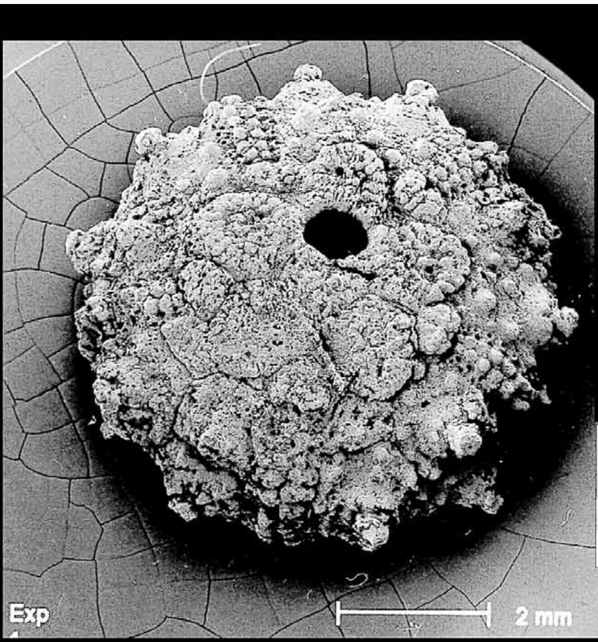

1a
2 mm
1b
2 mm
1c
500 µm
1d
1 mm
1e
1 mm
1f
Magn Exp

PLATE 12

Figs **1a-1f** — *Pseudosalenia malogostiana* sp.n., **paratype**; **1a** – aboral view, **1b** – lateral view, **1c** – oral view, **1d** – lateral view, to show ambulacrum; **1e** – adoral view of ambulacrum, to show bigeminate plates; **1f** – close-up of the aboral part of ambulacrum, to show simple plates; SEM; Specimen No. EMa/35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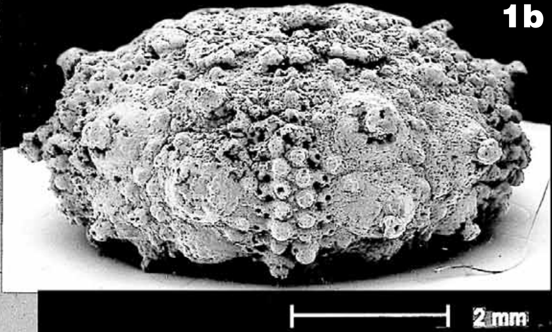
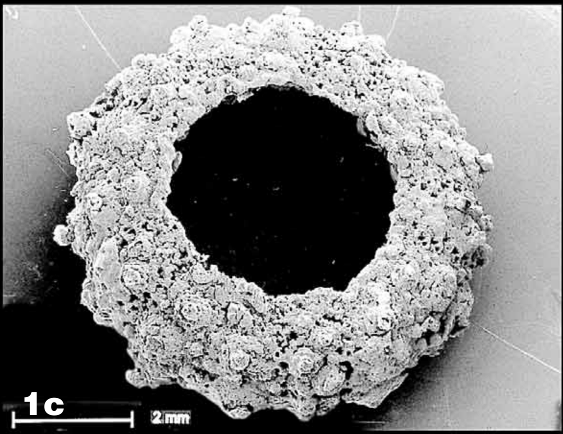
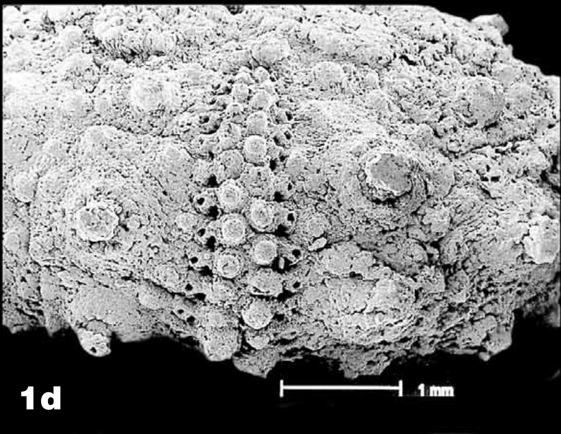
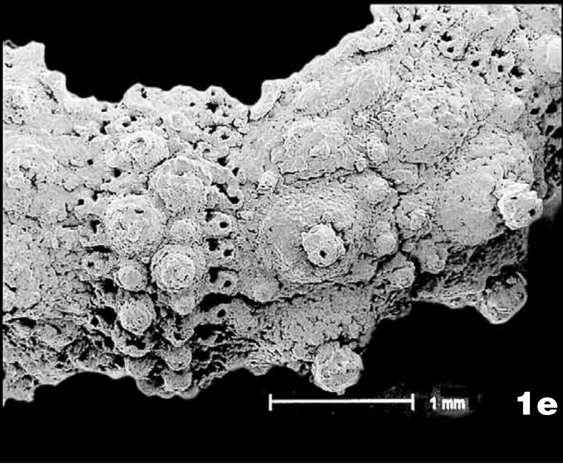

1b


1c


1d


1e

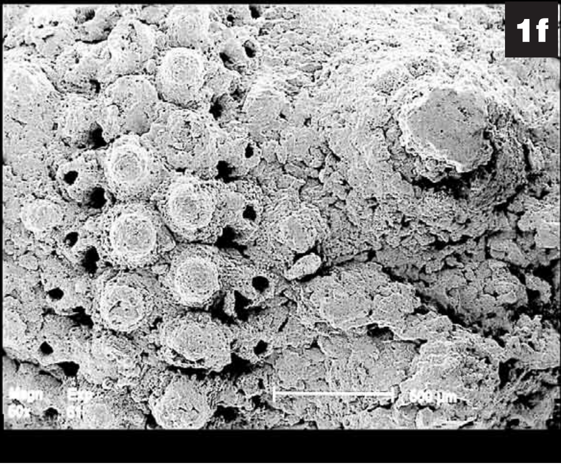

1f

PLATE 13

Figs **1-6** — *Hemicidaris hoffmanni* (F.A. ROEMER, 1836); **1a** – aboral view, **1b** – oral view, **1c** – lateral view, to show ambulacrum; Specimen No. ECz/102; **2a** – aboral view, **2b** – lateral view, to show interambulacrum; Specimen No. ECz/103; **3a** – aboral view, **3b** – lateral view, to show ambulacrum, **3c** – oral view; Specimen No. ECz/104; **4a** – aboral view, **4b** – oral view; Specimen No. ECz/105; **5a** – aboral view, **5b** – oral view, **5c** – lateral view, to show ambulacrum; Specimen No. ECz/106; **6a** – lateral view, **6b** – aboral view; Specimen No. ECz/107; all figures taken × 2

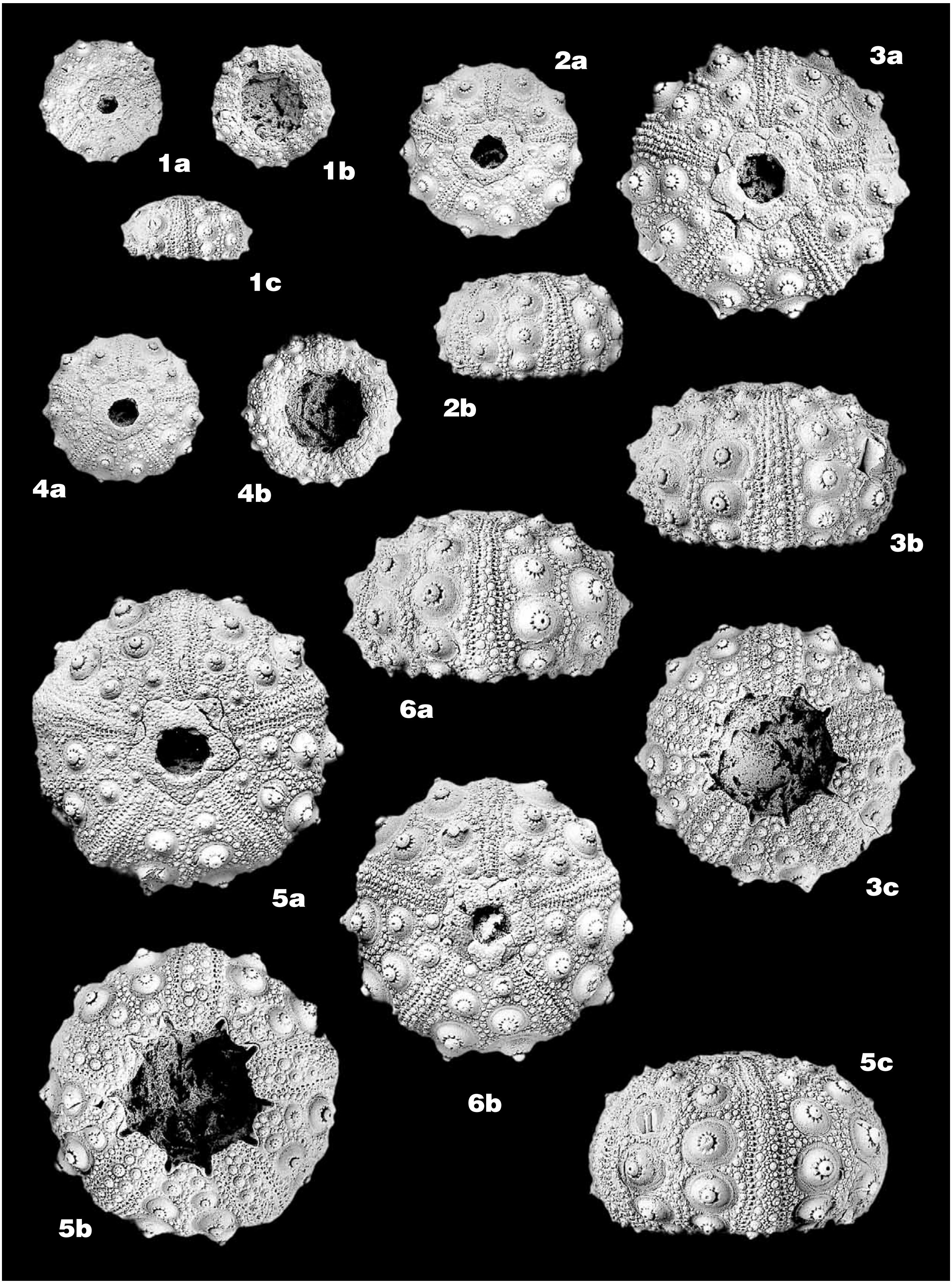

1a
1b
2a
3a
1c
2b
4a
4b
3b
6a
5a
3c
6b
5c
5b

PLATE 14

Figs **1-4** — *Hemicidaris hoffmanni* (F.A. ROEMER, 1836); **1a** – aboral view, **1b** – lateral view, to show interambulacrum, **1c** – oral view; × 2; Specimen No. ZPAL E.VIII/1; **2a** – aboral view, **2b** – lateral view, to show interambulacrum, **2c** – oral view; × 2; Specimen No. ECz/108; **3a** – aboral view, **3b** – lateral view, to show ambulacrum; **3c** – close-up view of the apical disc; Figs 3a-3b × 2, Fig. 3c × 5; Specimen No. ZPAL E.VIII/2; **4a** – aboral view, **4b** – lateral view to show interambulacrum, **4c** – oral view, **4d** – close-up view of the apical disc; Figs 4a-4c × 2, Fig. 4d × 5; Specimen No. ECz/109

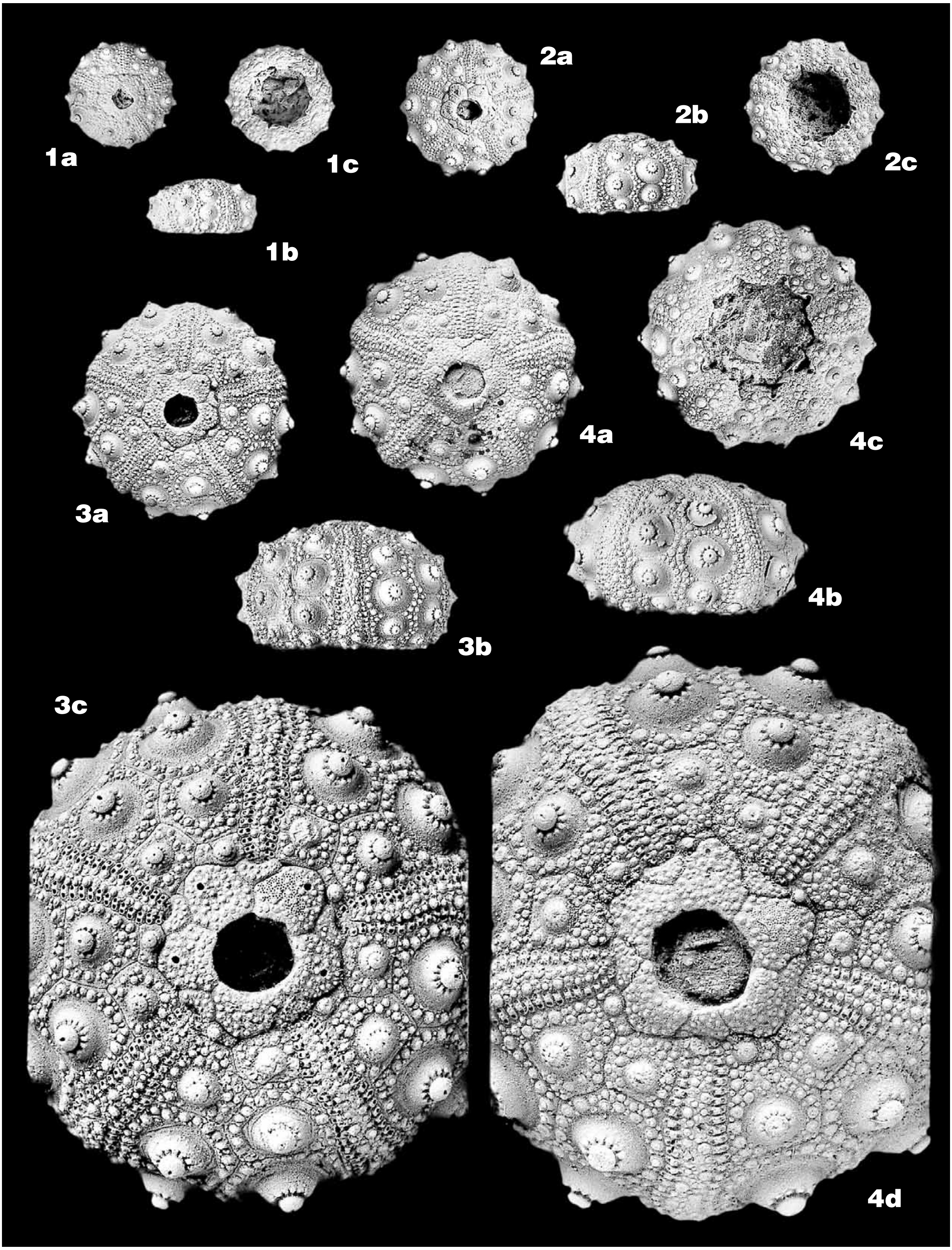
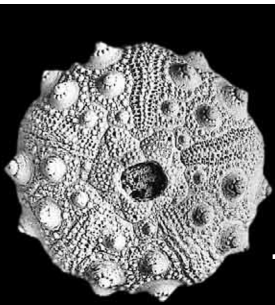
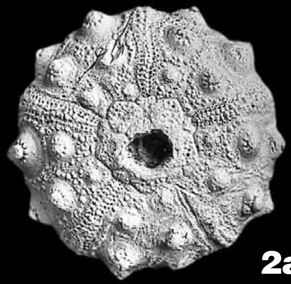

1a
1b
1c
2a
2b
2c
3a
3b
3c
4a
4b
4c
4d

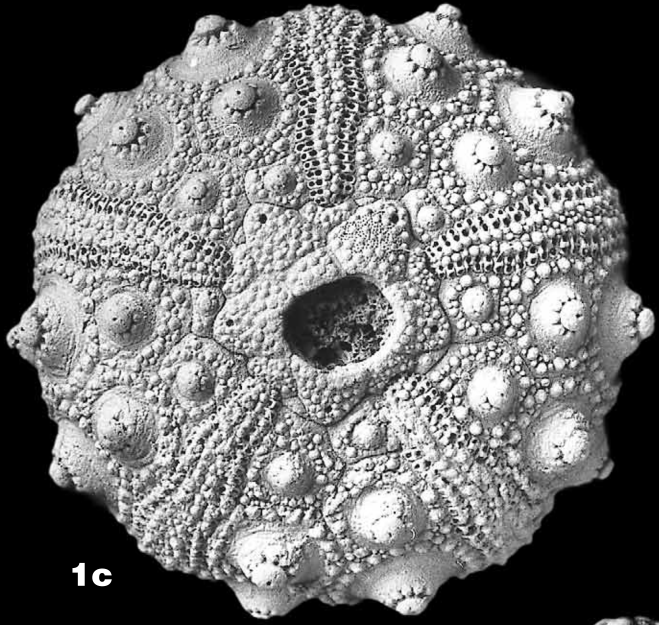
PLATE 15

Figs **1-4** — *Hemicidaris hoffmanni* (F.A. Roemer, 1836); all specimens with the apical disc bearing the suranal plate in position of genital *3*; **1a** – aboral view, **1b** – lateral view, to show interambulacrum, **1c** – close-up view, to show the apical disc with the suranal plate; Figs 1a-1b × 2; Fig. 1c × 5; Specimen No. ECz/110; **2a** – aboral view, **2b** – lateral view, to show interambulacrum; × 2; Specimen No. ECz/111; **3** – aboral view; × 2; Specimen No. ZPAL E.VIII/3; **4** – close-up view, to show the apical disc with an empty place of the non-preserved suranal plate (compare specimen figured in Fig. 1c), and with the doubled gonopore in genital *2*; × 5; Specimen No. ZPAL E.VIII/4

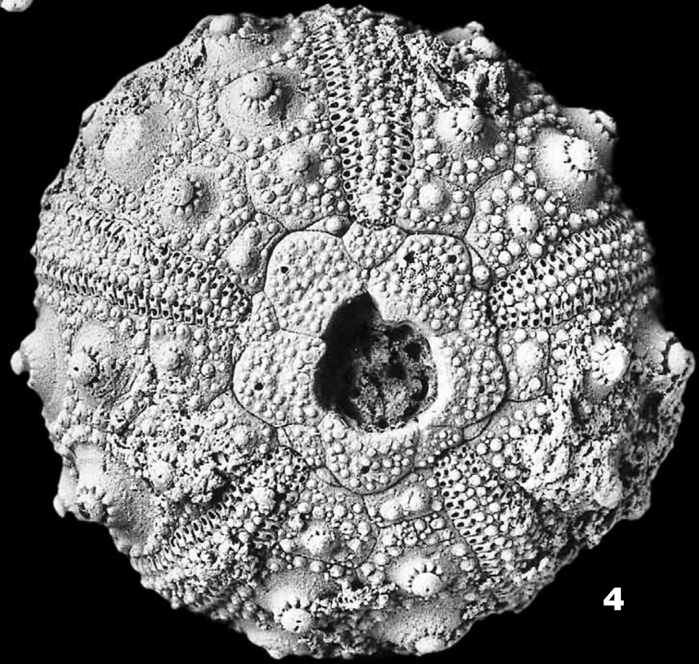

1a


1b


2a


1c


2b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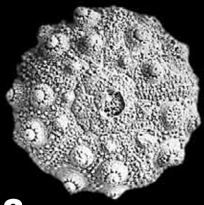

3

PLATE 16

Figs **1-2** — *Hemicidaris hoffmanni* (F.A. ROEMER, 1836); juvenile specimens with the suranal plate in position of genital *3*; **1** – close-up view of the apical disc without open gonopores; SEM; Specimen No. ECz/113; **2a** – close-up view of the apical disc of a not fully-grown specimen, **2b** – close-up view of the ambital part of interambulacrum; **2c** – close-up view of the adapical part of ambulacrum; **2d** – lateral view of ambulacrum, **2e** – close-up view of the ambital part of ambulacrum; SEM; Specimen No. ECz/112

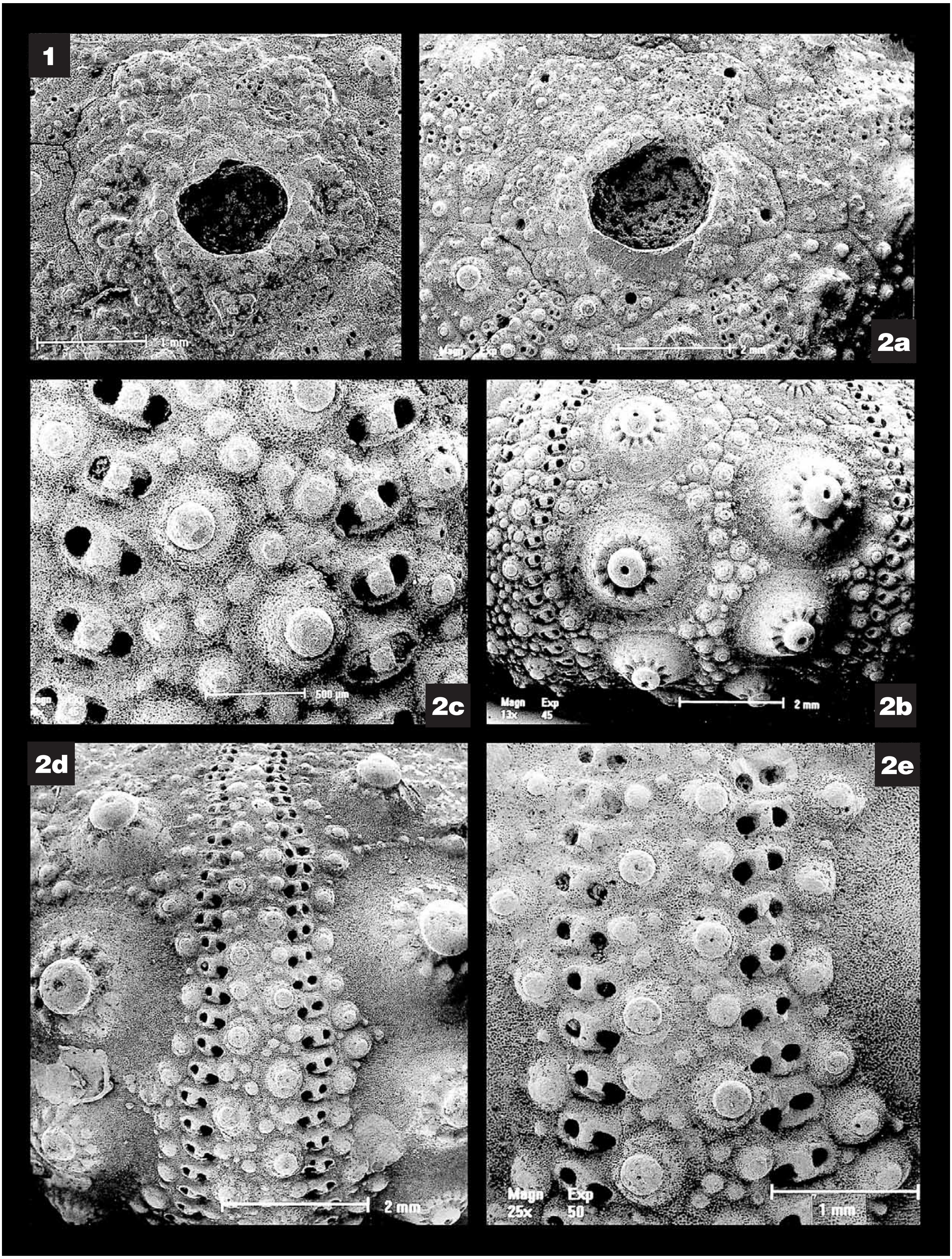
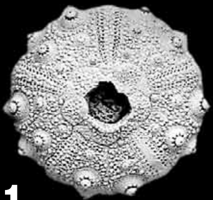

1
1 mm
Magn Exp
2 mm
2a
500 µm
2c
Magn Exp
13x 45
2 mm
2b
2d
2 mm
2e
Magn Exp
25x 50
1 mm

PLATE 17

Figs **1-3** — *Hemicidaris hoffmanni* (F.A. ROEMER, 1836); specimens with the periproctal rim strongly faceted by periproctal plates, or with gonopore anomalies; **1** – aboral view, **1a** – close-up view, to show the apical disc; Fig. 1 × 2; Fig. 1a × 5; Specimen No. ZPAL E.VIII/5; **2** – aboral view, **2a** – close-up view of the apical disc; Fig. 2 × 2, Fig. 2a × 5; Specimen No. ECz/114; **3** – aboral view, **3a** – close-up view, to show genital *4* with two gonopores; Fig. 3 × 2, Fig. 3a × 5; Specimen No. ECz/115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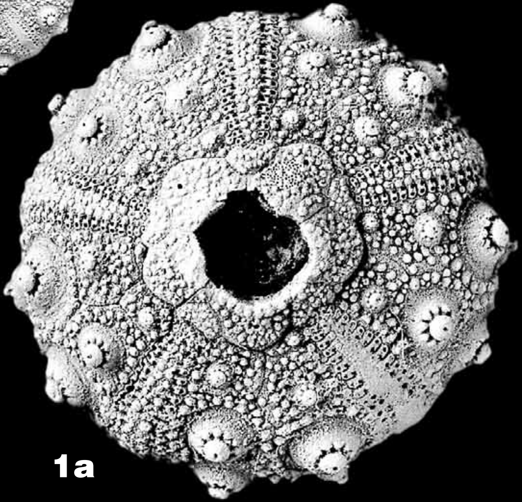
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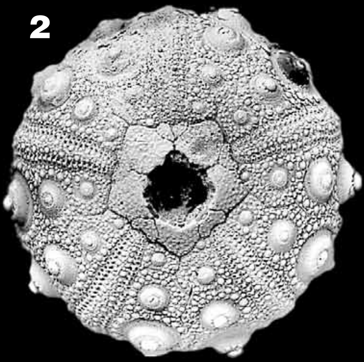
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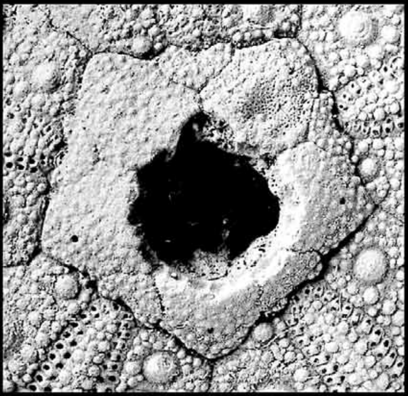
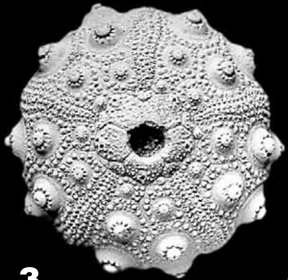

2a


3

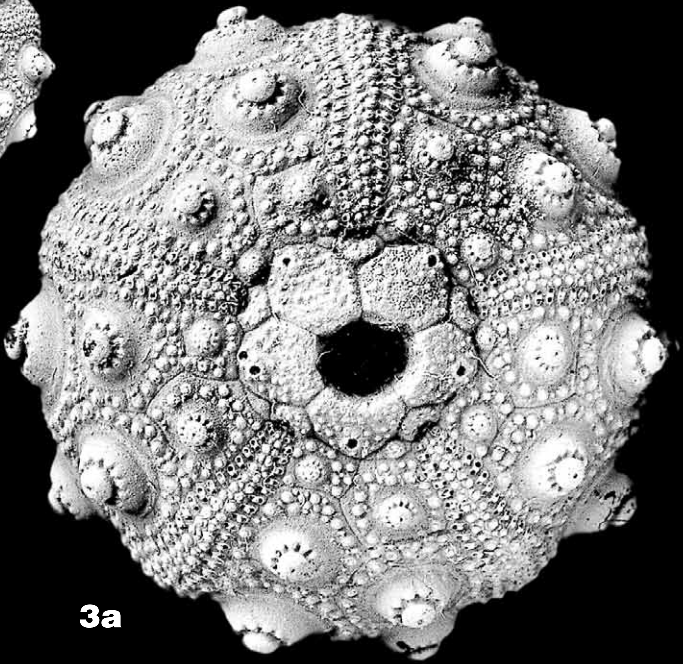
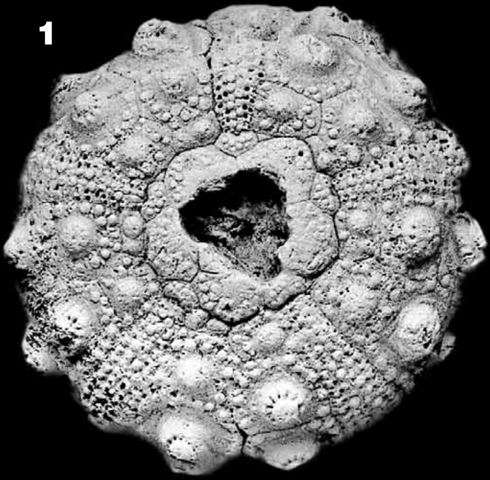

3a

PLATE 18

Figs **1-6** — *Hemicidaris hoffmanni* (F.A. Roemer, 1836); specimens with anomalies of the periproctal rim; **1** – apical disc with the enlarged and polygonally shaped periproct; Specimen No. ZPAL E. VIII/6; **2** – apical disc with two genital plates (*2* and *3*) divided into two subplates each; Specimen No. ZPAL E. VIII/7; **3** – apical disc with genital *4* exsert; Specimen No. ECz/116; **4** – apical disc with genital *3* divided into two subplates; Specimen No. ECz/117; **5** – apical disc with one periproctal plate preserved; Specimen No. ECz/118; **6** – apical disc with the forked genital *3* and the accessory madreporite in genital *1*; Specimen No. ECz/119; all figures taken × 5



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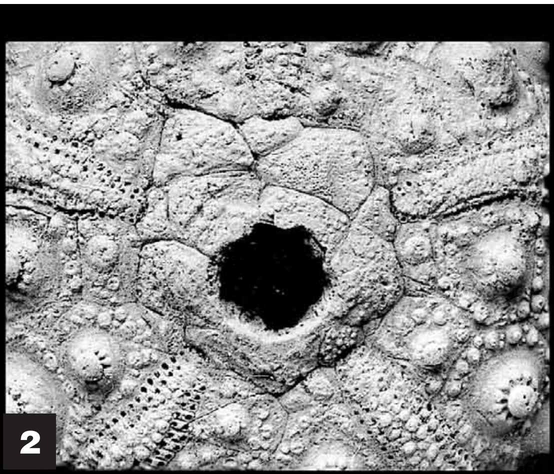

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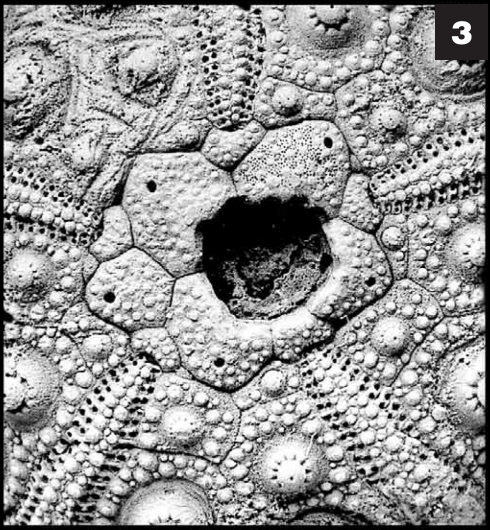

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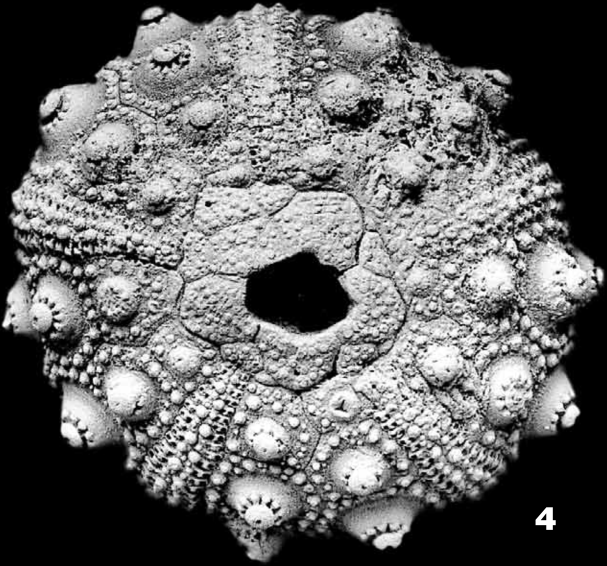

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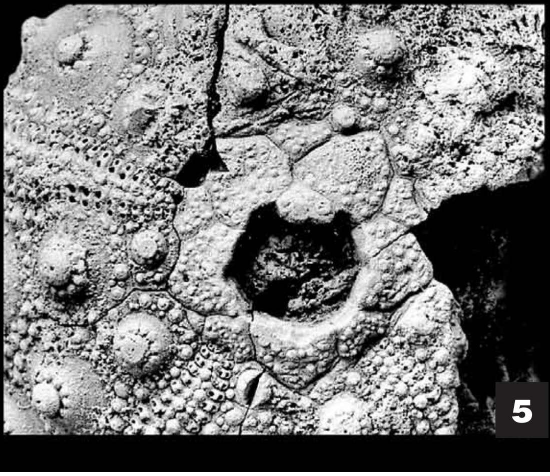

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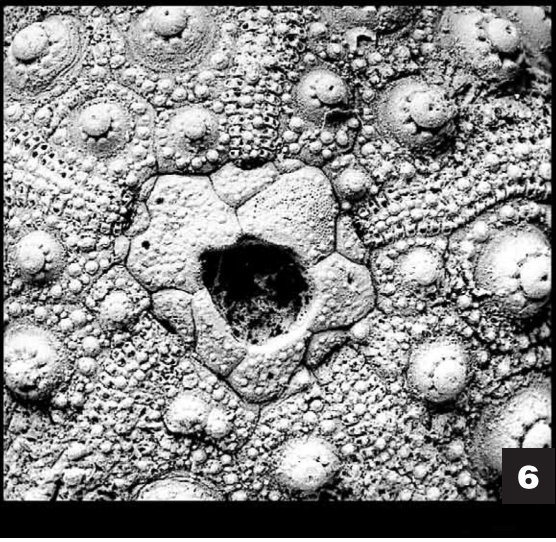
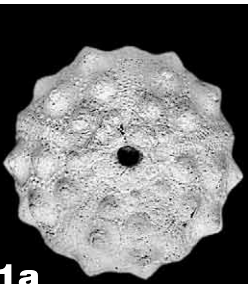


6

PLATE 19

Figs **1-5** — *Hemicidaris intermedia* (FLEMING, 1828); **1a** – aboral view, **1b** – lateral view, to show ambulacrum, **1c** – oral view; × 1.5; Specimen No. EMa/36; **2a** – aboral view, **2b** – lateral view, to show interambulacrum; × 1.5; Specimen No. EMa/37; **3a** – aboral view, **3b** – lateral view, to show interambulacrum; × 1.5; Specimen No. EMa/38; **4a** – aboral view, **4b** – lateral view, to show interambulacrum, **4c** – oral view, to show the peristome; × 1.5; Specimen No. EMa/39; **5a** – aboral view, **5b** – lateral view, to show ambulacrum; **5c** – oral view, to show the peristome; × 1.5; Specimen No. EMa/40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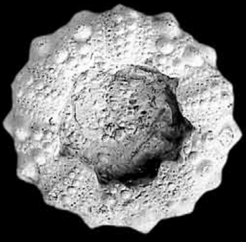
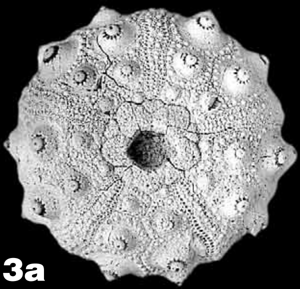
1b


1c


2a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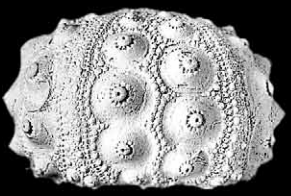
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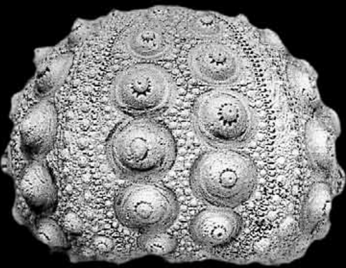
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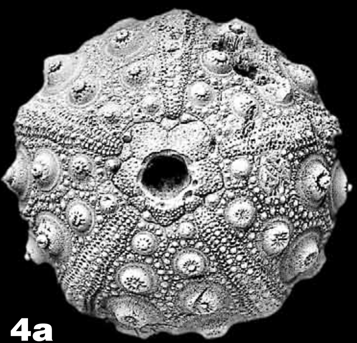
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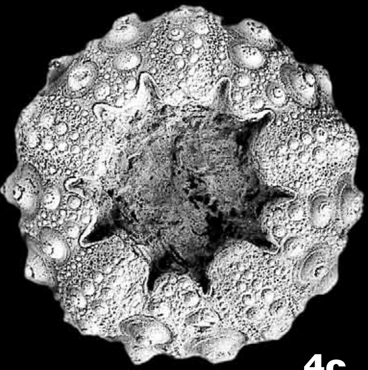
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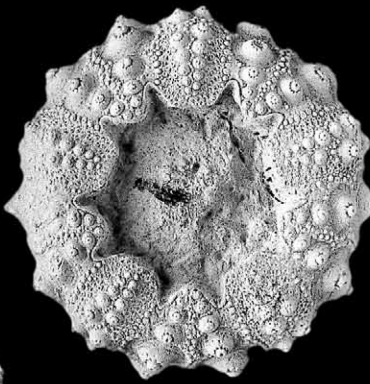
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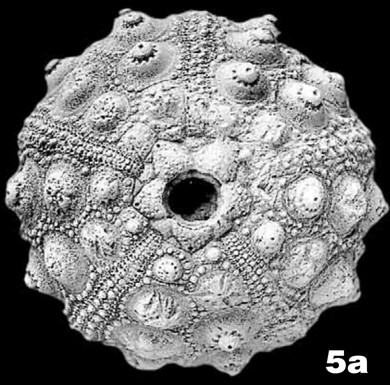
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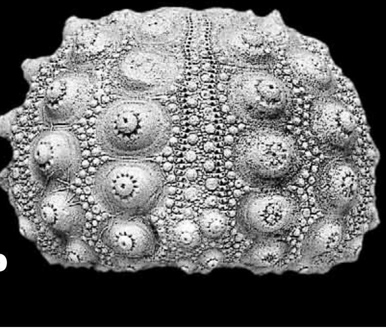
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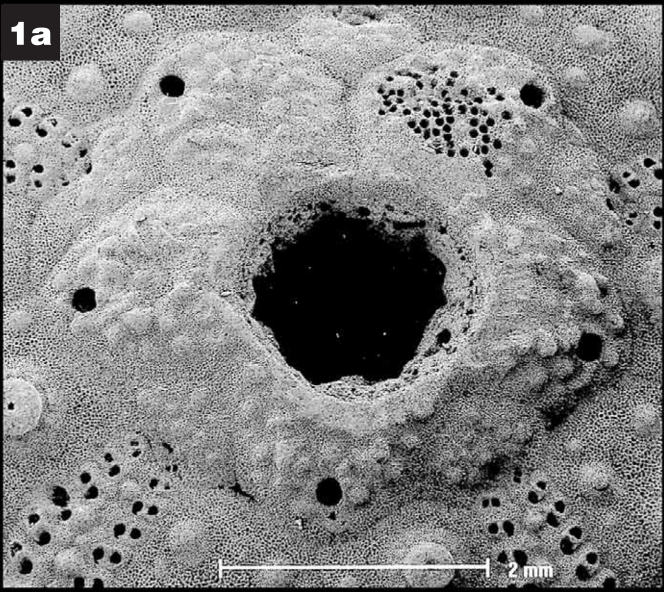
PLATE 20

Figs **1-2** — *Hemicidaris intermedia* (FLEMING, 1828); juvenile specimens; **1a** – close-up view of the apical disc, **1b** – lateral view, to show ambulacrum, **1c** – close-up view of the ambital part of ambulacrum, **1d** – close-up view of the adapical part of ambulacrum, **1e** – close-up view of the ambital part of interambulacrum; SEM; Specimen No. ECz/120; **2** – close-up view of the apical disc; SEM; Specimen No. ZPAL E.VIII/8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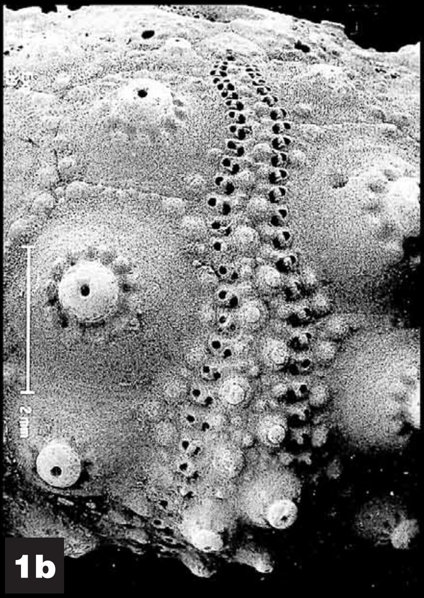
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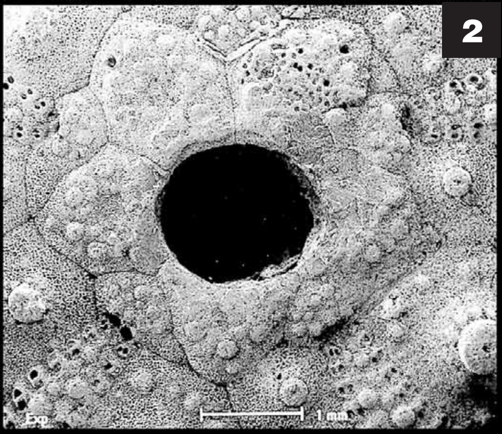
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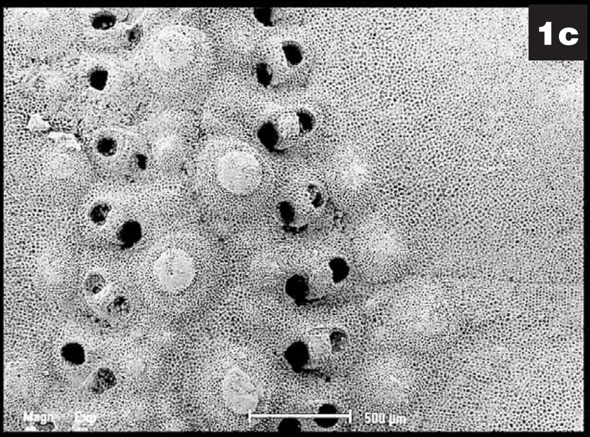
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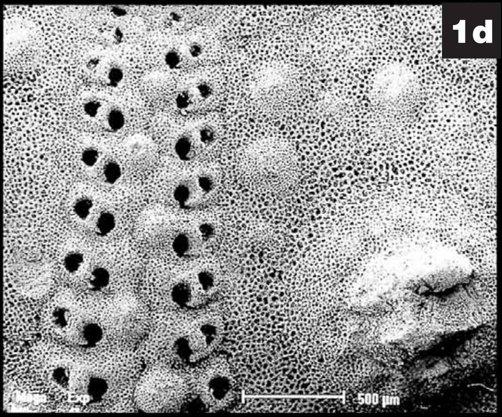
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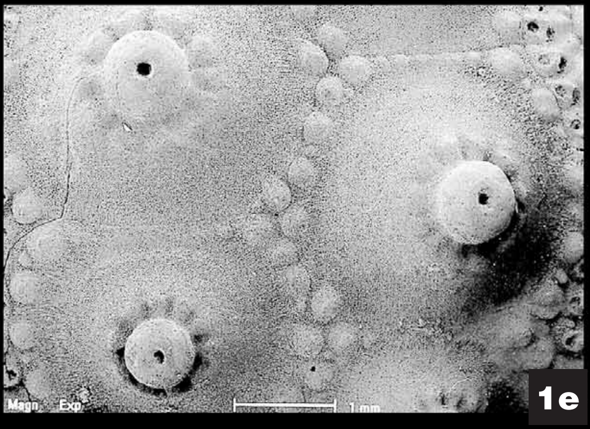
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PLATE 21

Figs **1-2** — *Hemicidaris intermedia* (FLEMING, 1828); specimens with suranal plates in the apical disc; **1a** – aboral view, **1b** – close-up view, to show the suranal plate in position of genital *2*; **1c** – oral view, **1d** – lateral view, to show ambulacrum; Figs 1a, 1c-1d × 1.5; Fig. 1b × 5; Specimen No. ECz/121; **2a** – close-up view of the apical disc, to show the suranal plate in position of ocular *III*, **2b** – lateral view, to show interambulacrum, **2c** – close-up view of the adapical part of ambulacrum, **2d** – lateral view, to show ambulacrum; SEM; Specimen No. ZPAL E.VIII/9

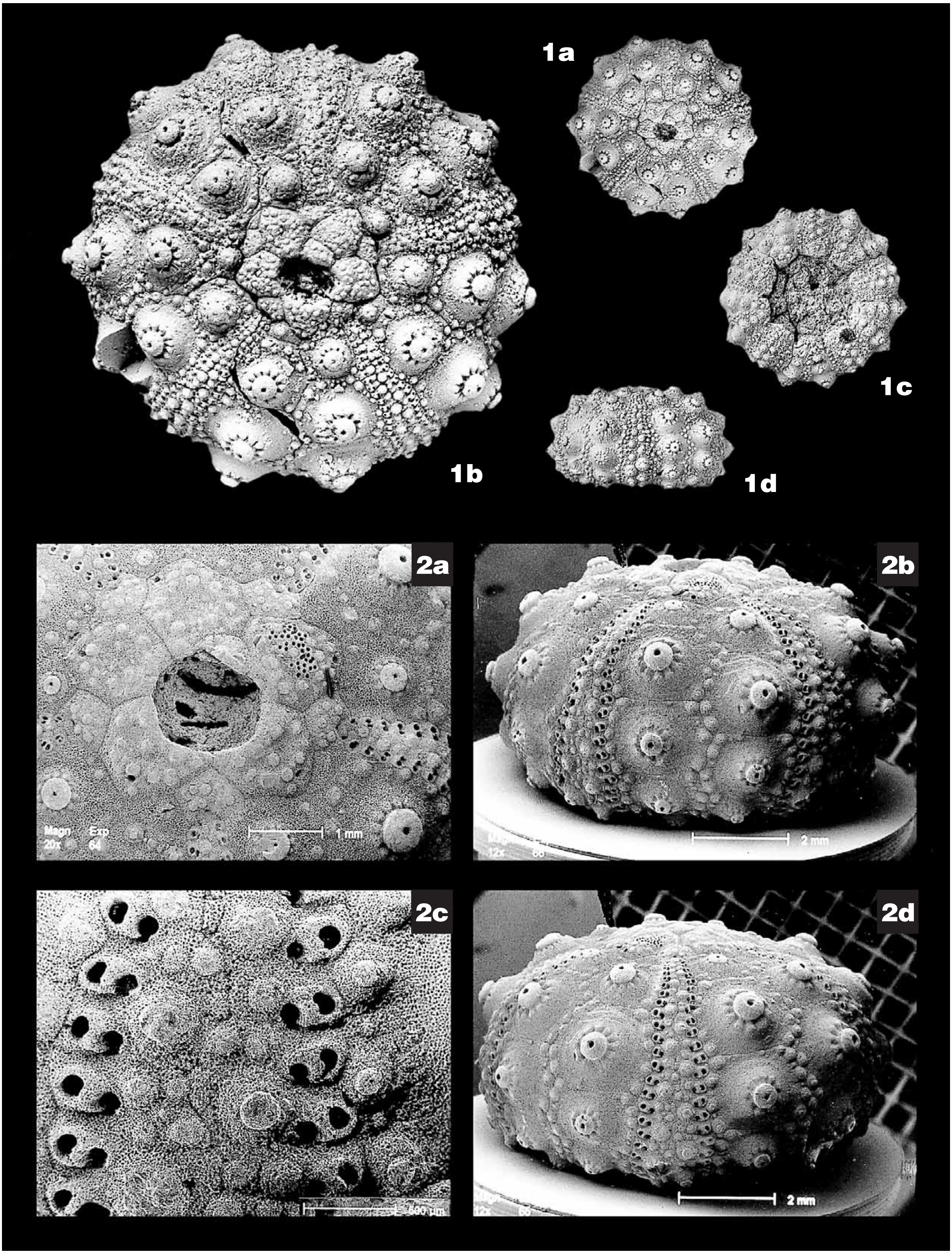
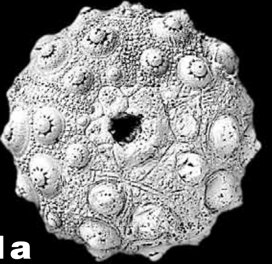

1a
1b
1c
1d
2a
Magn 20x
Exp 64
1 mm
2b
12x
2 mm
2c
500 µm
2d
12x
2 mm

PLATE 22

Fig. **1** — *Hemitiaris stramonium* (L. AGASSIZ, 1840); **1a** – aboral view, **1b** – oral view, **1c** – lateral view, to show ambulacrum; × 2; Specimen No. ECz/122;

Figs **2-7** — *Hemicidaris intermedia* (FLEMING, 1828); **2a** – aboral view, **2b** – lateral view, to show ambulacrum, **2c** – oral view; × 1.5; Specimen No. EOz/123; **3** – lateral view, to show ambulacrum; × 1.5; Specimen No. EOz/124; **4a** – aboral view, **4b** – lateral view, to show interambulacrum; × 2; Specimen No. ZPAL E.VIII/10; **5** – lateral view, to show ambulacrum; × 1.5; Specimen No. EMa/41; **6** – lateral view, to show ambulacrum; × 1.5; Specimen No. EMa/42; **7** – fragment of the test with primary spines preserved; nat. size; Specimen No. EMa/43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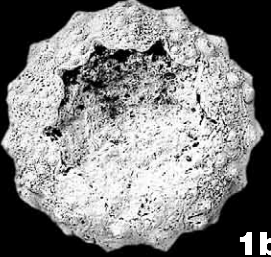
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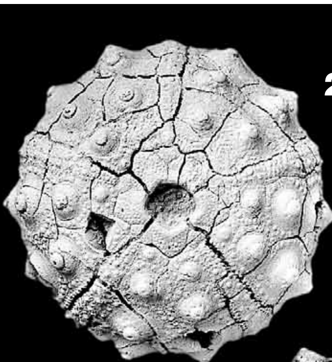
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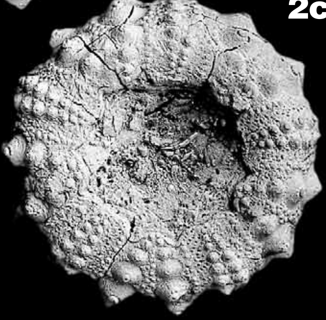
1c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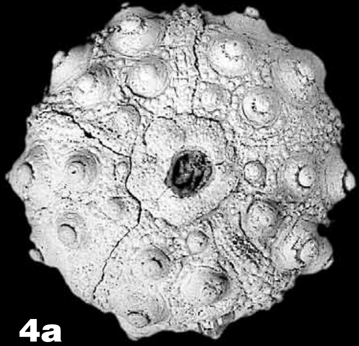
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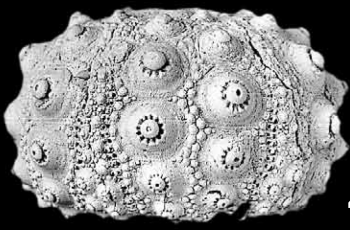
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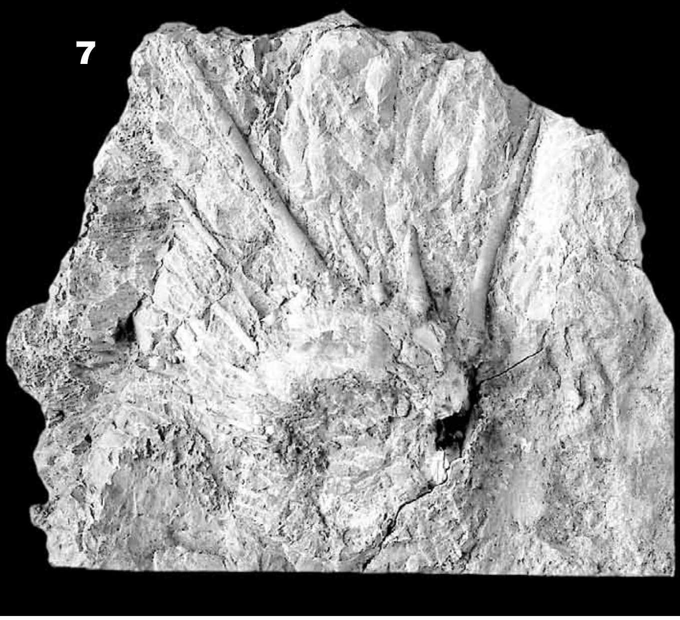
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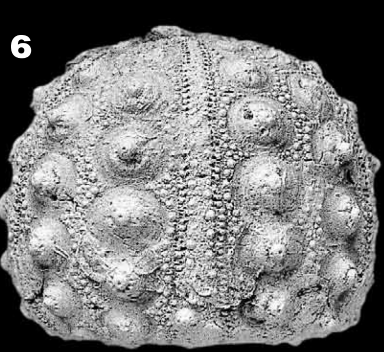
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PLATE 23

Figs **1-8** — *Pseudocidaris mammosa* (L. AGASSIZ, 1840); **1-5** – primary spines, Fig. 1 – Specimen No. MUZ P.I.G. 219. II. 3, the same as figured by KONGIEL (1957, Pl. 2, Fig. 1), Fig. 2 – Specimen No. MUZ P.I.G. 219. II. 10, Fig. 3 – Specimen No. MUZ P.I.G. 219. II. 3a, Fig. 4 – Specimen No. MUZ P.I.G. 219. II. 3b, Fig. 5 – Specimen No. MUZ P.I.G. 219. II. 3c; **6a** – lateral view, to show ambulacrum, **6b** – aboral view; × 1.5; Specimen No. ECz/125; **7** – aboral view; × 2; Specimen No. EGr/126; **8a** – aboral view, **8b** – lateral view, to show ambulacrum; × 1.5; Specimen No. MUZ P.I.G. 219. II. 2, the same as figured by KONGIEL (1957, Pl. 1, Figs 4-6)

Figs **9-16** — *Pseudocidaris sanctacrucensis* sp.n.; **9-11** – **paratypes**, **9a** – lateral view, to show interambulacrum, **9b** – aboral view; × 1.5; Specimen No. ZPAL E.V/13; **10** – aboral view; × 1.5; Specimen No. EMa/44; **11a** – lateral view, to show ambulacrum, **11b** – aboral view, **11c** – oral view; × 1.5; Specimen No. EMa/45; **12** – **holotype**, **12a** – aboral view, **12b** – lateral view, to show interambulacrum, **12c** – close-up view of the apical disc; Figs 12a-12b × 1.5, Fig. 12c × 5; Specimen No. EWi/127; **13-16** – **paratypes**, primary spines; all taken × 1.5; Fig. 13 – Specimen No. ZPAL E.V/21b, Fig. 14 Specimen No. ZPAL E.V/21a, Fig. 15 – Specimen No. ZPAL E.V/42, Fig. 16 – Specimen No. ZPAL E.V/26


1


2


3

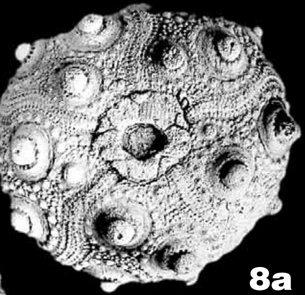

4


5


6a


6b


7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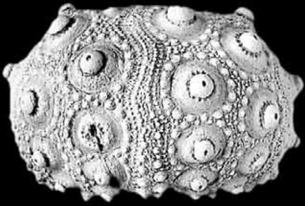
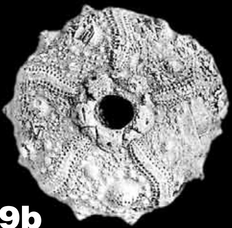
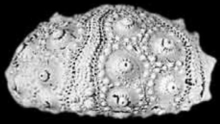

8b


9a


9b


10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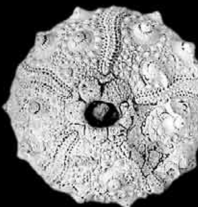
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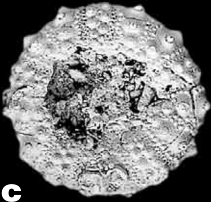
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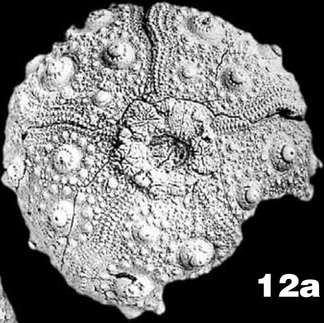
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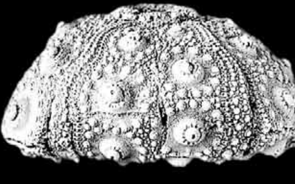
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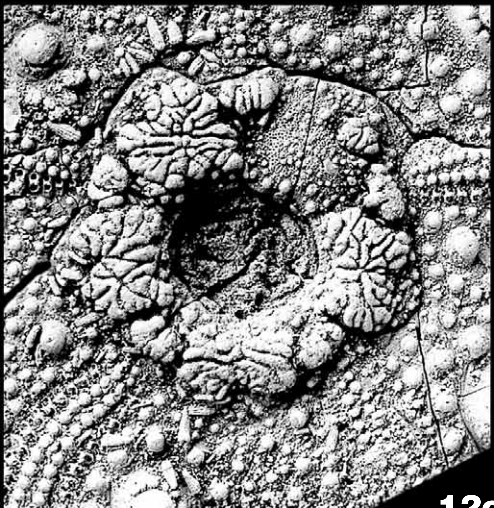

12c


13

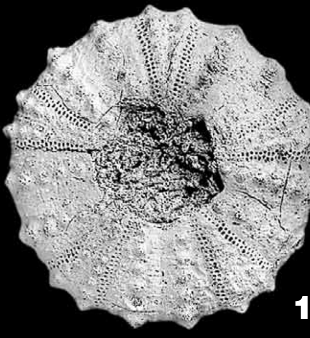

14


15


16

PLATE 24

Figs **1-5** — *Trochotiara kongieli* sp.n.; **1** – **holotype**, **1a** – aboral view, **1b** – oral view, **1c** – lateral view; × 1.5; Specimen No. ECz/128; **2-5** – **paratypes**, **2a** – aboral view, **2b** – oral view, **2c** – lateral view; × 1.5; Specimen No. ECz/129; **3a** – aboral view, **3b** – lateral view; × 1.5; Specimen No. EKa/130; **4** – close-up view of the ambital part of interambulacrum; SEM; Specimen No. ECz/131; **5a** – close-up view of the adapical and ambital parts of ambulacrum, **5b** – close-up view of the ambital part of ambulacrum, to show quadrigeminate plates; SEM; Specimen No. ECz/132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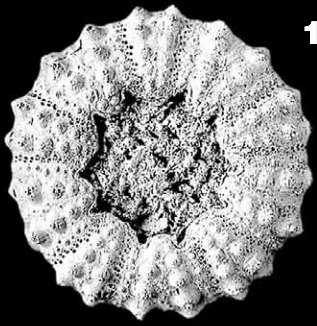
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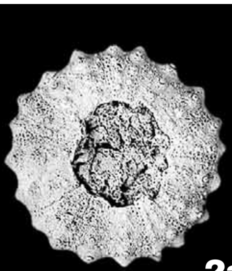
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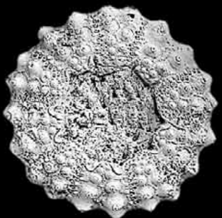
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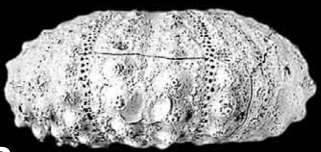
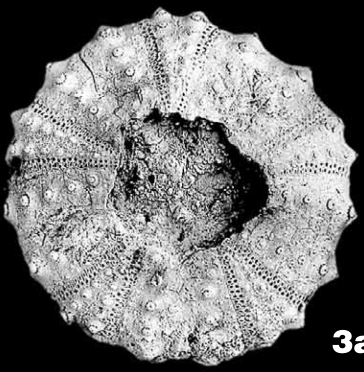

1c


2c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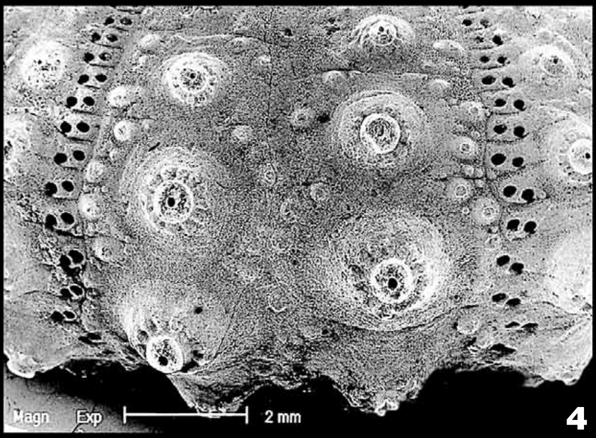

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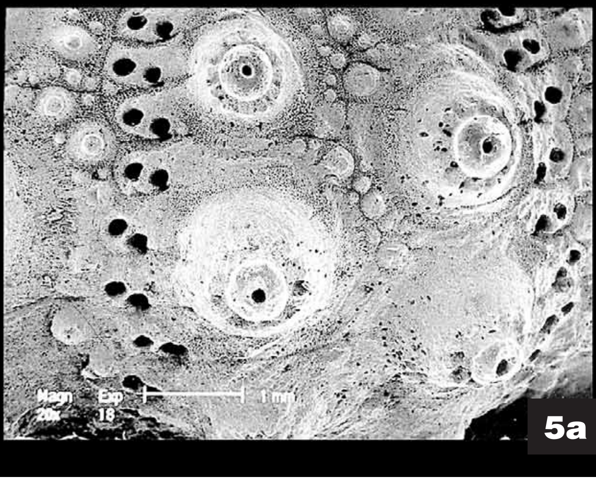
3b



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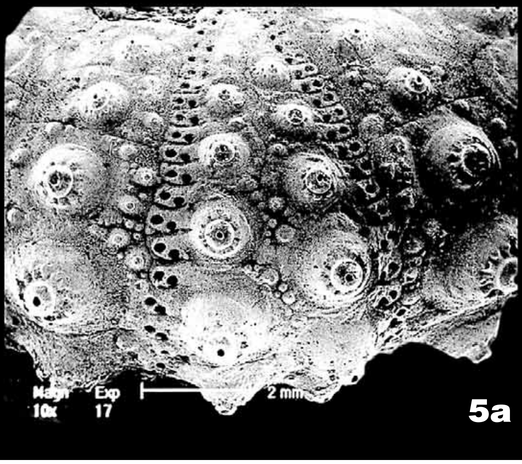
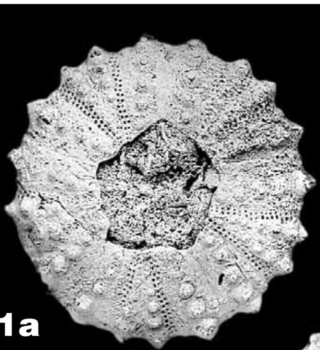


5a

PLATE 25

Figs **1-6** — *Trochotiara kongieli* sp.n., **paratypes**; **1a** – aboral view, **1b** – oral view; × 1.5; Specimen No. ZPAL E.VIII/11; **2a** – aboral view, **2b** – oral view, **2c** – lateral view; × 1.5; Specimen No. ZPAL E.VIII/12; **3a** – lateral view, **3b** – aboral view; × 1.5; Specimen No. ZPAL E.VIII/13; **4a** – aboral view, **4b** – oral view, **4c** – lateral view; × 1.5; Specimen EMa/46; **5** – close-up view of the right column of ambulacrum; SEM; Specimen No. ECz/132; **6a** – close-up view of the ambital part of ambulacrum, to show quadrigeminate plates, **6b** – close-up view of the adoral part of ambulacrum; SEM; Specimen No. ECz/131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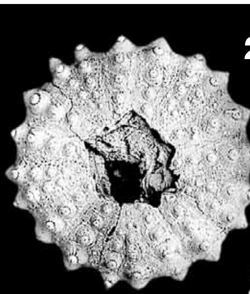
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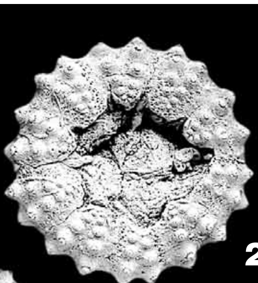
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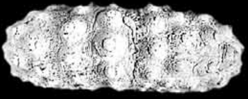
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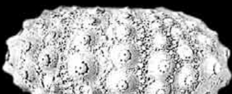
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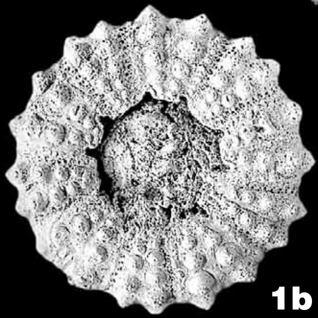
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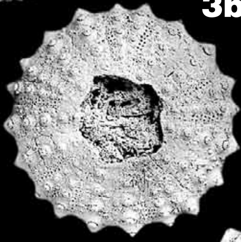
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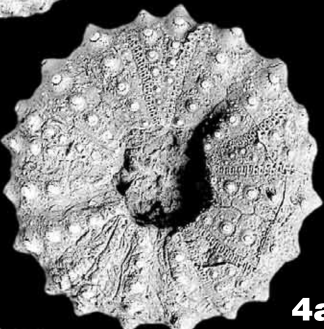
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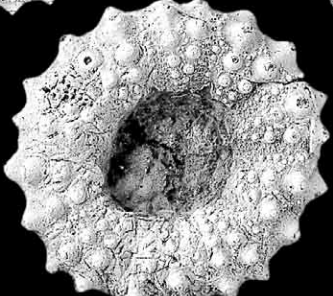
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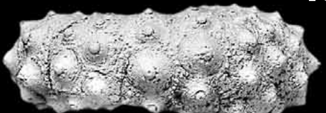
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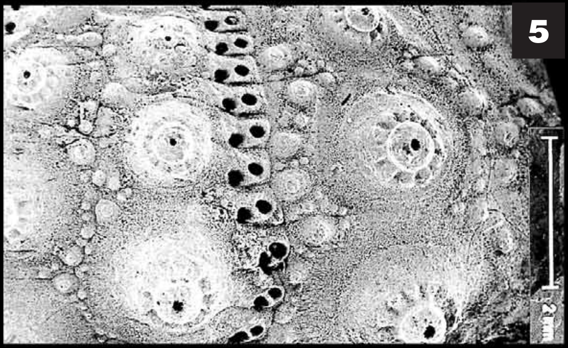
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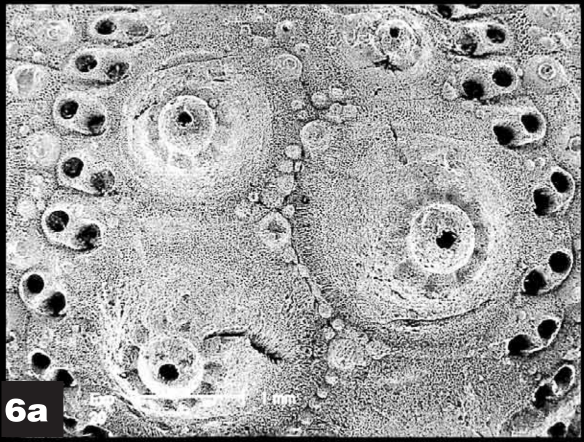
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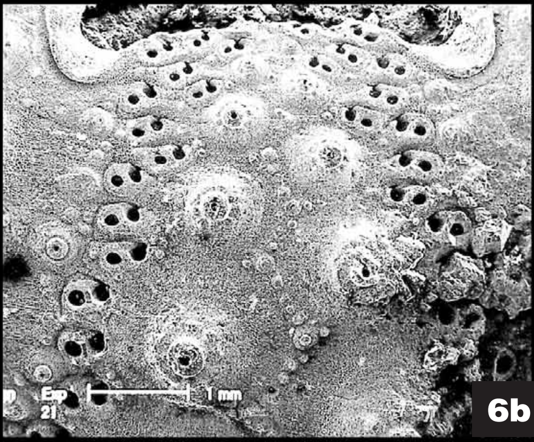

6b

PLATE 26

Fig. **1** — *Trochotiara suleiovense* sp.n., **holotype**; **1a** – aboral view, **1b** – oral view, **1c** – lateral view; × 1.5; Specimen No. ESl/133

Figs **2-3** — *Tetragramma planissimum* L. AGASSIZ, 1840; **2a** – aboral view, **2b** – lateral view, **2c** – close-up view of ambital interambulacral plates, **2d** – close-up view of the ambital part of ambulacrum, to show trigeminate plates; Figs 2a-2b × 1.5, Figs 2c-2d SEM; Specimen No. ZPAL E.V/18; **3a** – close-up view of the adapical part of ambulacrum, to show biserially arranged trigeminate plates, **3b** – close-up view of the ambital part of ambulacrum, to show uniserially arranged trigeminate plates; SEM; Specimen No. EWi/134

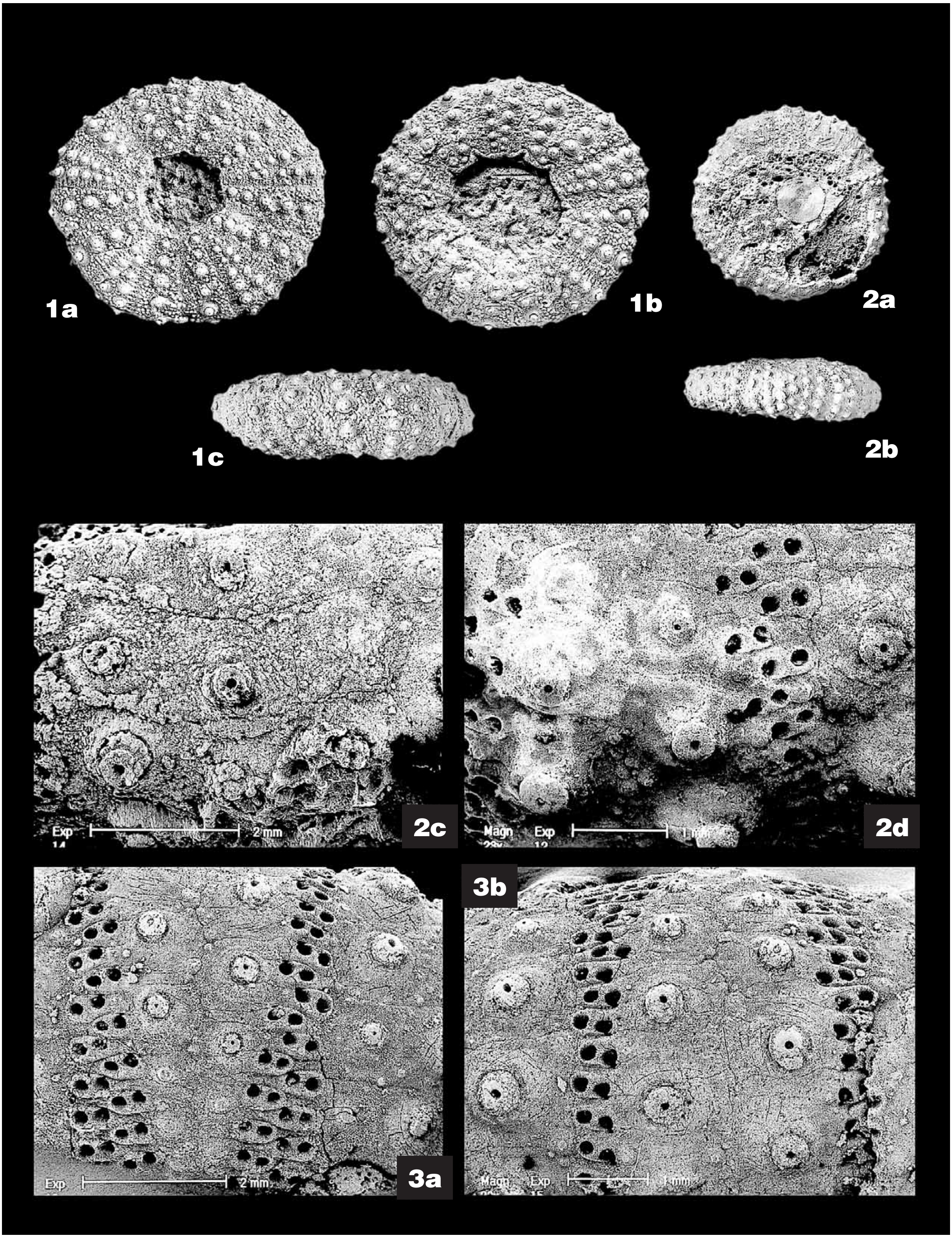
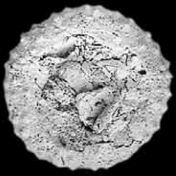

1a
1b
2a
1c
2b
Exp
2 mm
2c
Magn
Exp
1 mm
2d
3b
Exp
2 mm
3a
Magn
Exp
1 mm

PLATE 27

Fig. **1** — *Tetragramma pomeraniae* KONGIEL, 1957; **1a** – aboral view, **1b** – oral view, **1c** – lateral view, **1d** – close-up view of the ambital part of interambulacrum, **1e** – close-up view of the adapical part of ambulacrum, to show biserially arranged trigeminate plates, **1f** – close-up view of the ambital part of ambulacrum, to show uniserially arranged trigeminate plates; Figs 1a-1c × 1.5, Figs 1d-1f SEM; Specimen No. EMa/47

Figs **2-3** — *Phymosoma douvillei* (COTTEAU, 1875); **2** – aboral view; × 1.5; Specimen No. EMa/48; **3a** – aboral view, **3b** – lateral view, **3c** – close-up view of the ambital part of ambulacrum, **3d** – close-up view of the ambital quinquegeminate ambulacral plate, **3e** – close-up view of the ambital part of interambulacrum; Figs 3a-3b × 1.5, Figs 3c-3e SEM; Specimen No. EKa/135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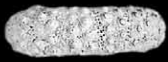
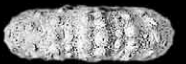
1b


1c


2


3a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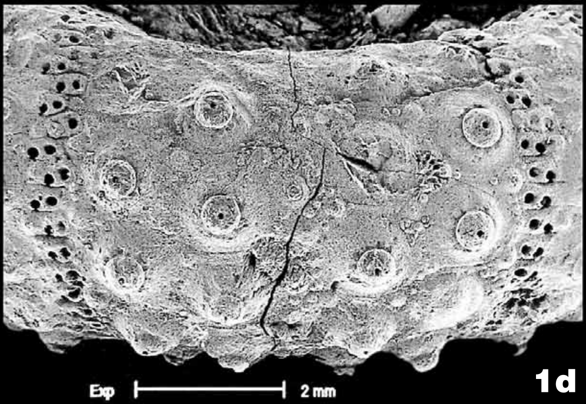

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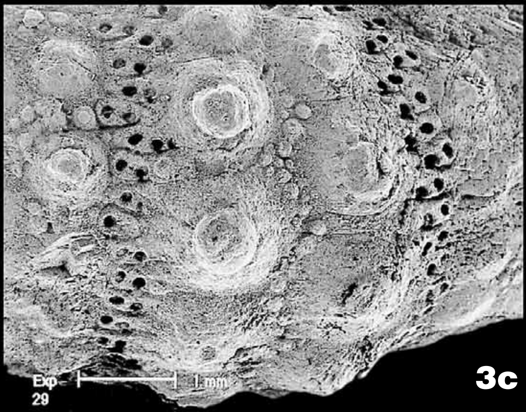

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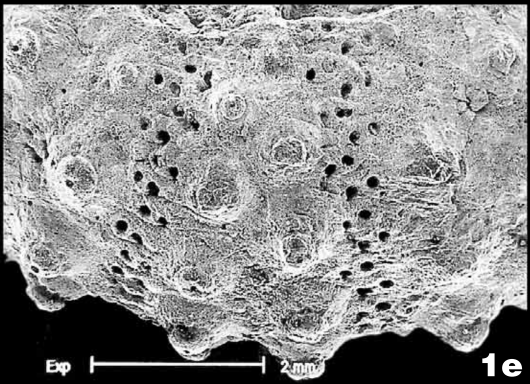

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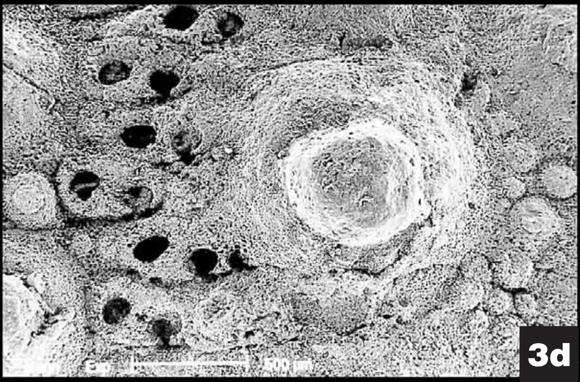

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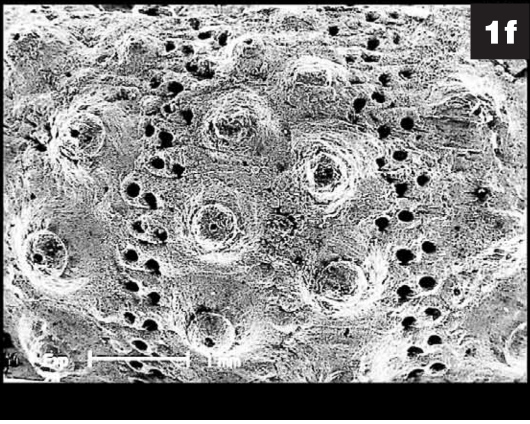

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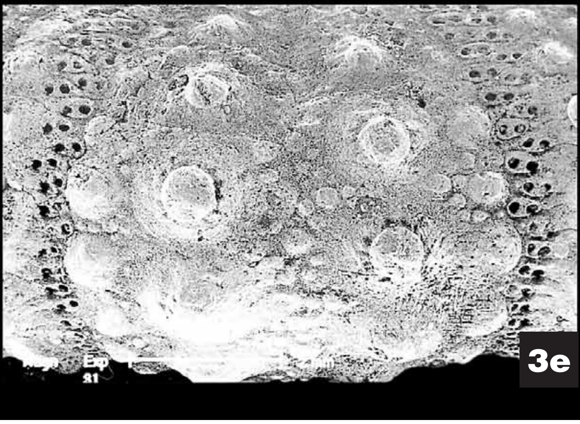
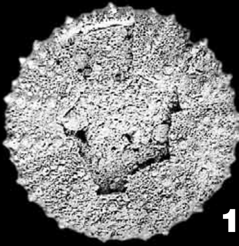


3e

PLATE 28

Figs **1-5** — *Phymosoma supracorallinum* (Cotteau, 1865); **1a** – aboral view, **1b** – lateral view, **1c** – oral view; × 1.5; Specimen No. ECz/13; **2a** – aboral view, **2b** – lateral view; × 1.5; Specimen No. ZPAL E.VIII/14; **3a** – aboral view, **3b** – oral view, **3c** – lateral view; × 1.5; Specimen No. ZPAL E.VIII/15; **4a** – aboral view, **4b** – lateral view; × 1.5; Specimen No. ECz/137; **5a** – close-up view of the adapical part of ambulacrum, to show biserially arranged trigeminate plates; **5b-5c** – close-up views of ambital quinquegeminate ambulacral plates; **5d** – close-up view of the quinquegeminate ambulacral plate, to show the non-perforate primary tubercle; SEM; Specimen No. MUZ P.I.G. 219.II.22, the same as figured by Kongiel (1957, Pl. 4, Figs 4-6)

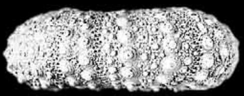

1a


2a

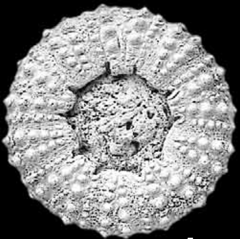

3a


3b


3c


2b


4a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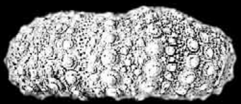
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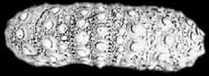
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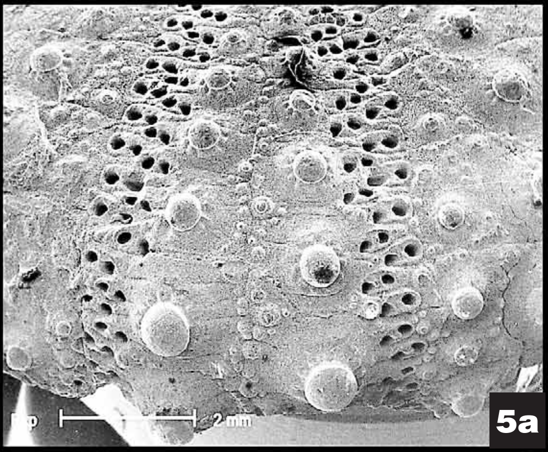

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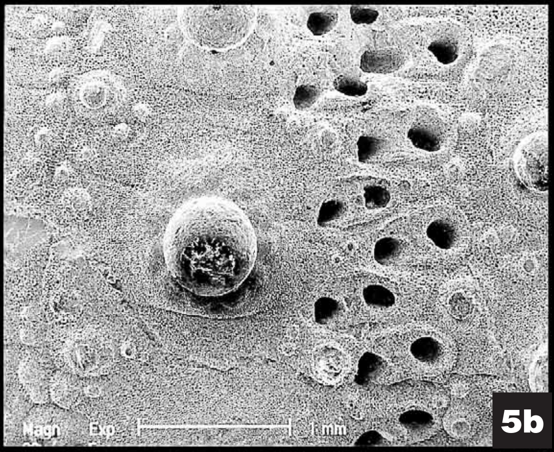

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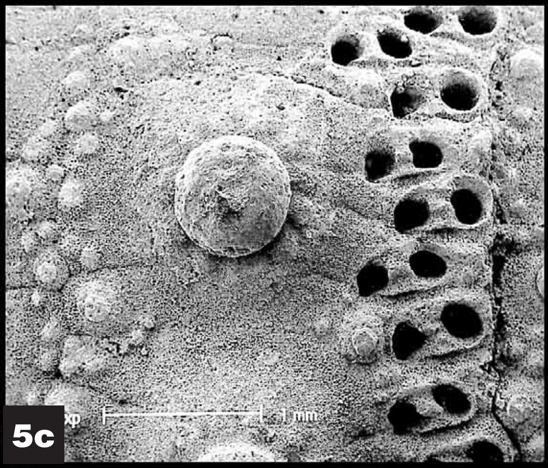

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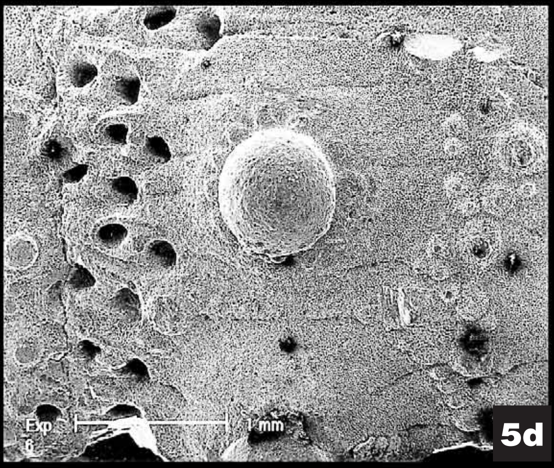
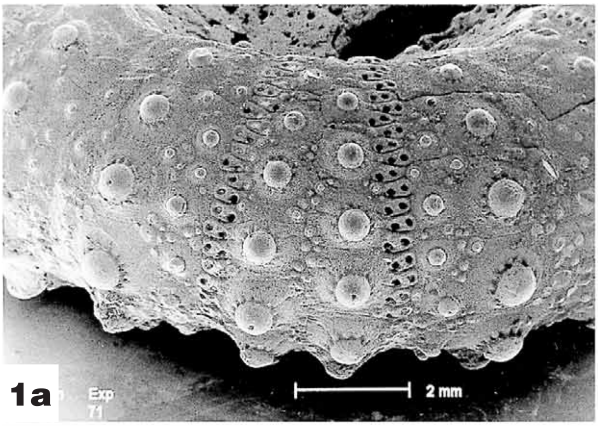


5d

PLATE 29

Figs **1-2** — *Phymosoma supracorallinum* (COTTEAU, 1865); **1a** – aboral part of ambulacrum, **1b-1c** – close-up view of the ambital part of ambulacrum, **1d** – close-up view of the quadrigeminate ambulacral plate, to show the non-perforate primary tubercle, **1e** – close-up view of the quadrigeminate ambulacral plate, to show the perforate primary tubercle; SEM; Specimen No. ECz/137; **2a** – close-up view of the adapical part of ambulacrum, to show biserially arranged pores, **2b** – adoral view of interambulacrum, **2c** – ambital view of interambulacrum; SEM; Specimen No. ZPAL E.VIII/16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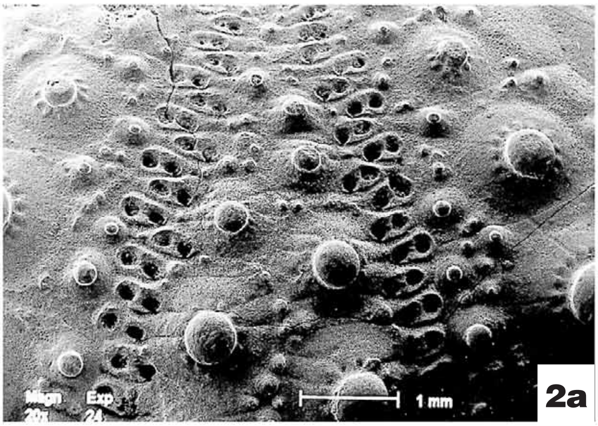
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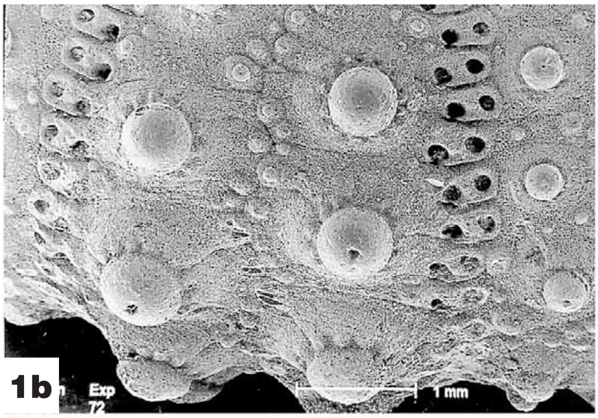
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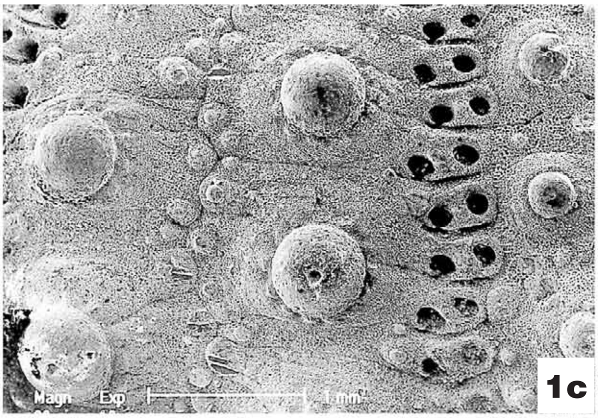
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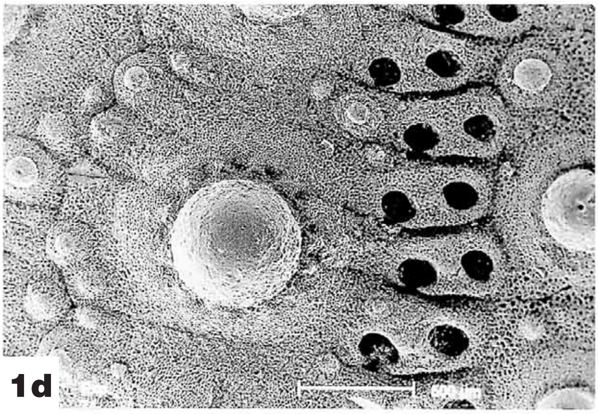
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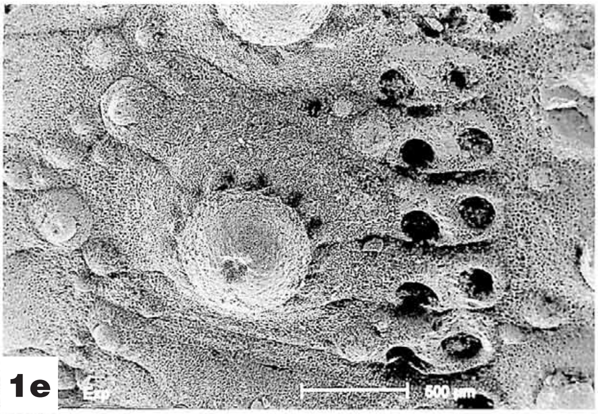
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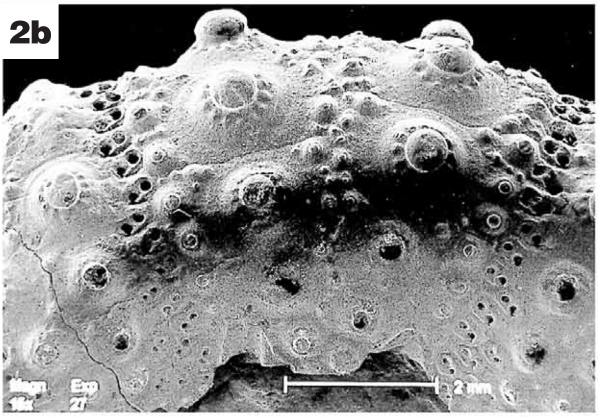
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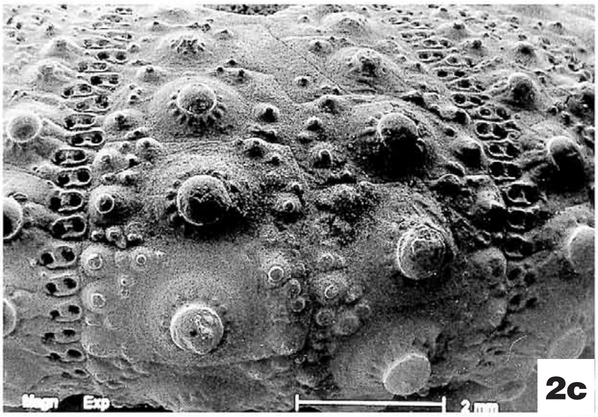
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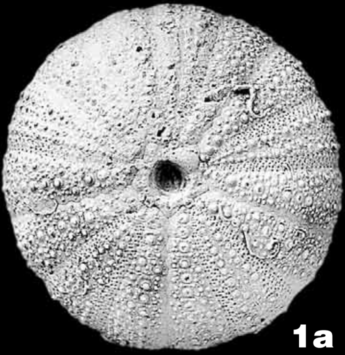
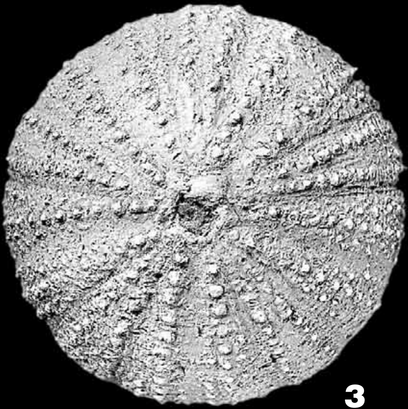
PLATE 30

Figs **1-3** — *Stomechinus semiplacenta* (L. AGASSIZ *in* AGASSIZ & DESOR, 1847); **1a** – aboral view, **1b** – oral view, **1c** – lateral view; × 1.5; Specimen No. EOz/138; **2a** – lateral view, **2b** – aboral view; × 1.5; Specimen No. ESl/139; **3** – aboral view; × 1.5; Specimen No. ESl/140

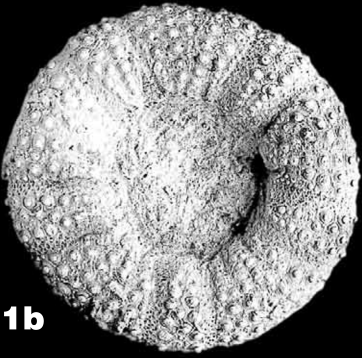
Figs **4-5** — *Stomechinus gyratus* (L. AGASSIZ, 1840); **4a** – aboral view, **4b** – lateral view; × 1.5; Specimen No. EMa/49; **5a** – aboral view, **5b** – lateral view; × 1.5; Specimen No. EMa/50


1a

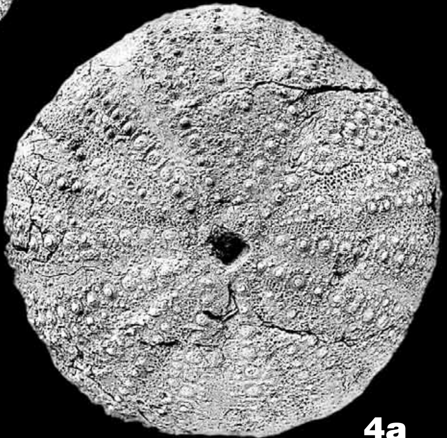

2a


3

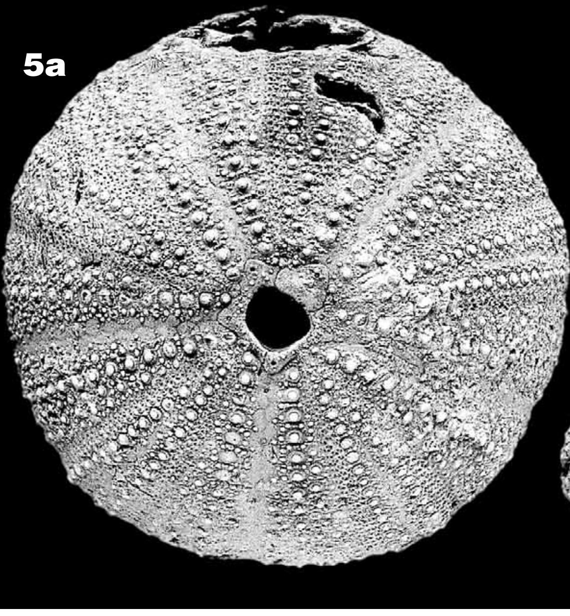

2b


1b


1c


4a


4b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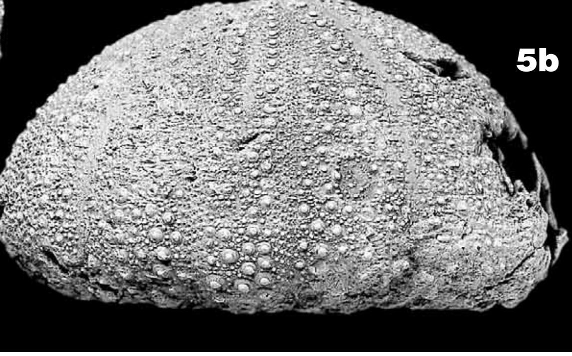

5b

PLATE 31

Figs **1-4** — *Polycyphus distinctus* (L. AGASSIZ, 1840); **1a** – aboral view, **1b** – oral view, **1c** – lateral view; × 2; Specimen No. EKa/141; **2a** – aboral view, **2b** – oral view, **2c** – lateral view, **2d** – ambital view of interambulacrum, **2e** – close-up view of interambulacral plates, to show ornamentation, **2f** – ambital view of ambulacrum, **2g** – close-up view of the ambital part of ambulacrum, to show trigeminate plates with biserially arranged pores; Figs 2a-2c × 2, Figs 2d-2g SEM; Specimen No. EMa/51; **3** – aboral view; × 2; Specimen No. EMa/52; **4a** – aboral view, **4b** – oral view; × 2; Specimen No. EMa/53

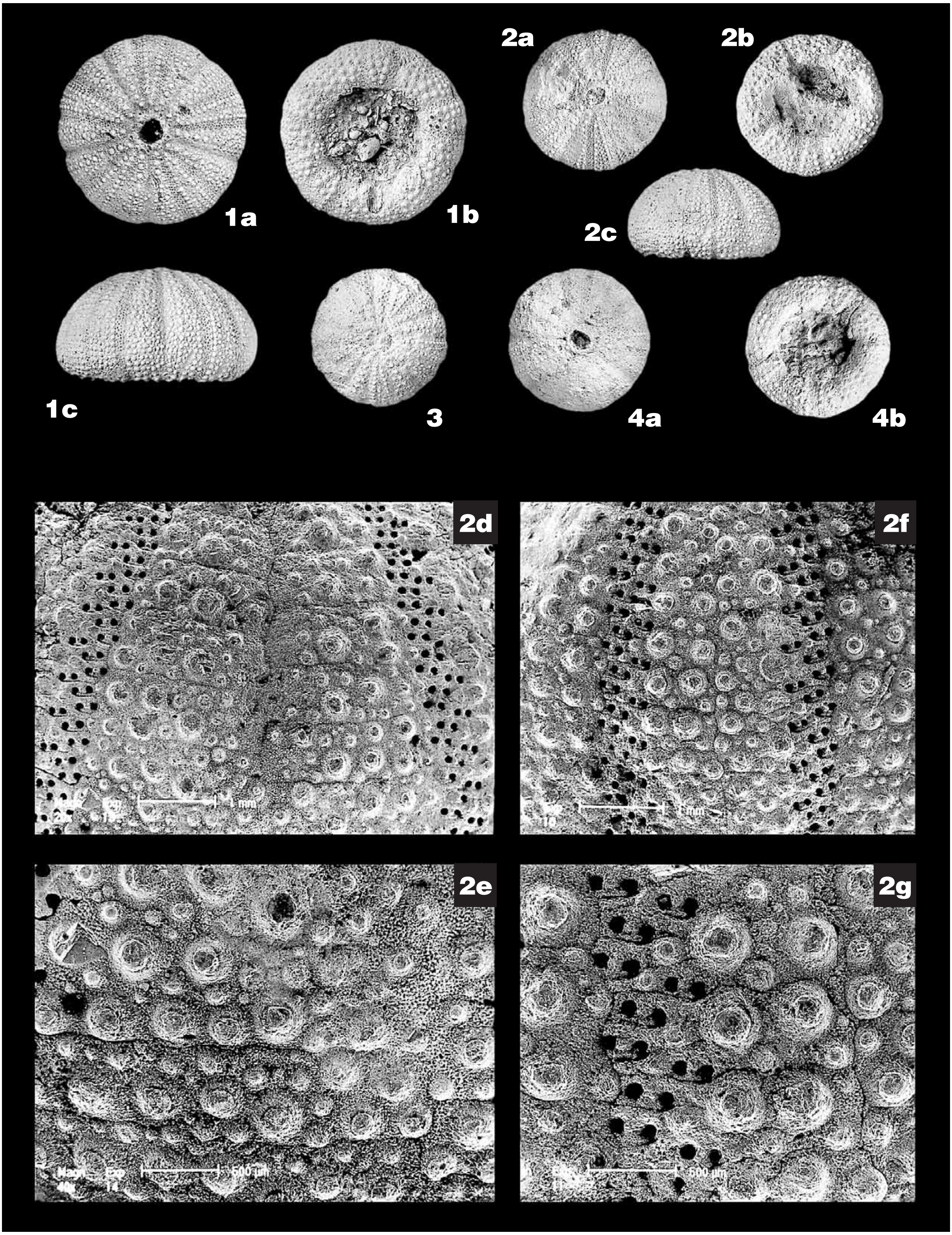
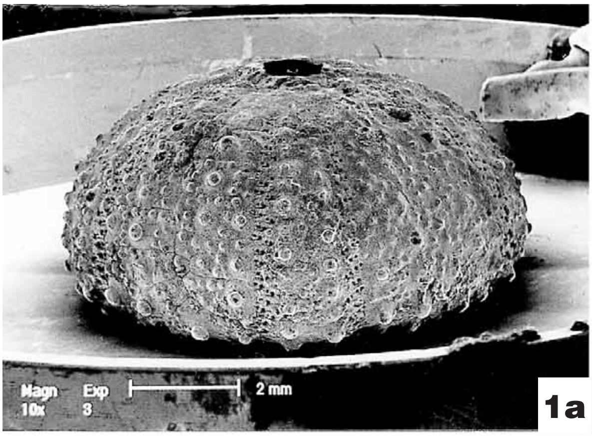

2a
2b
1a
1b
2c
1c
3
4a
4b
2d
2f
1 mm
1 mm
2e
2g
500 µm
500 µm

PLATE 32

Figs **1a-1h** — *Psephechinus* sp.; **1a** – lateral view, **1b** – aboral view, **1c** – lateral view, **1d** – close-up view of the ambital part of ambulacrum; **1e** – close-up view of ambital ambulacral trigeminate plates, **1f** – close-up view of the apical disc, **1g** – ambital view of interambulacrum, **1h** – oral view of the test; SEM; Specimen No. ECz/142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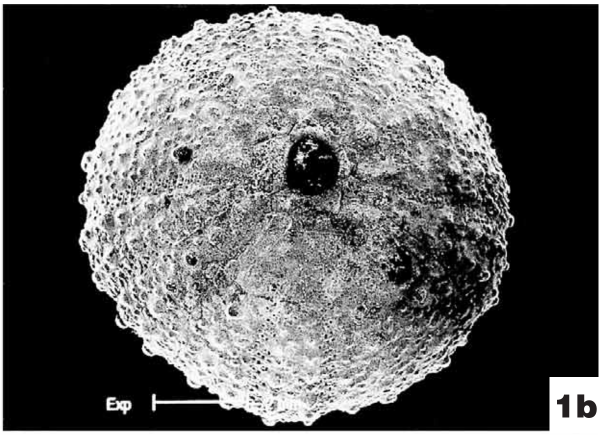
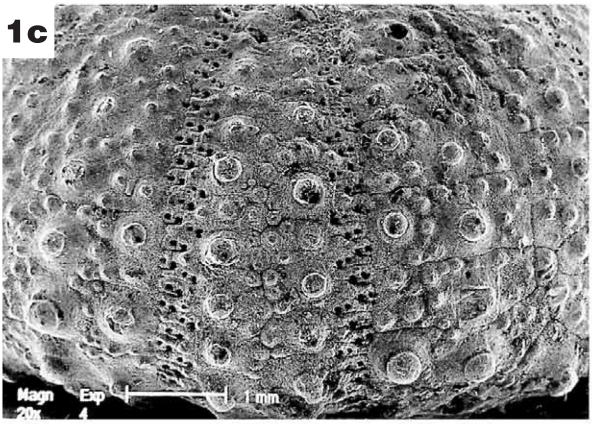
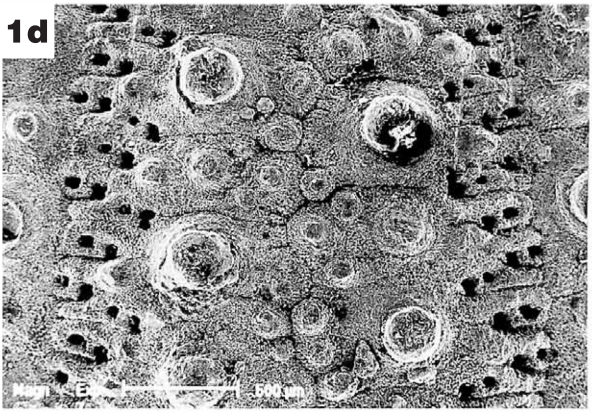
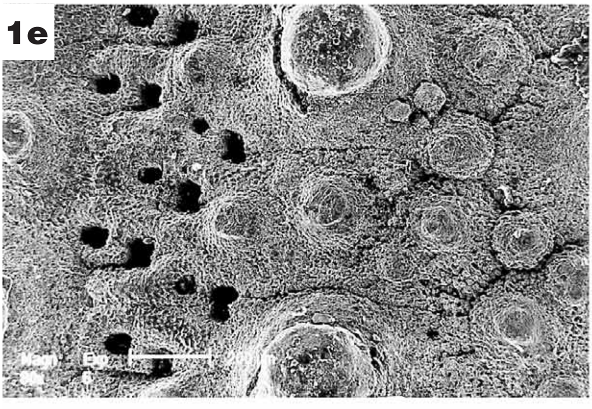
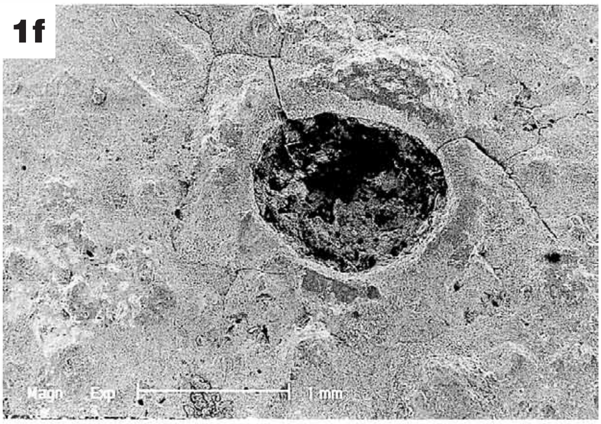
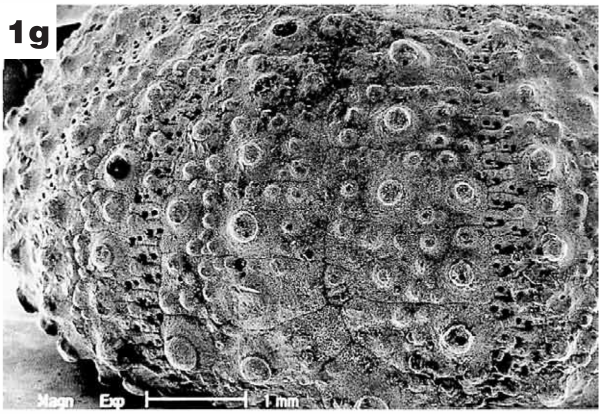

Exp
1b


1c
Magn Exp
20x 4
1 mm


1d
Magn Exp
500 µm


1e
Magn Exp
6


1f
Magn Exp
1 mm


1g
Magn Exp
1 mm


1h
Exp

PLATE 33

Figs **1-3** — *Gymnocidaris agassizi* (F.A. ROEMER, 1839); **1a** – aboral view, **1b** – lateral view, to show interambulacrum, **1c** – oral view; × 1.5; Specimen No. EMa/54; **2a** – aboral view, **2b** – lateral view, to show interambulacrum; nat. size; Specimen No. EMa/55; **3a** – aboral view, **3b** – lateral view, to show interambulacrum, **3c** – oral view; × 1.5; Specimen No. EKa/59

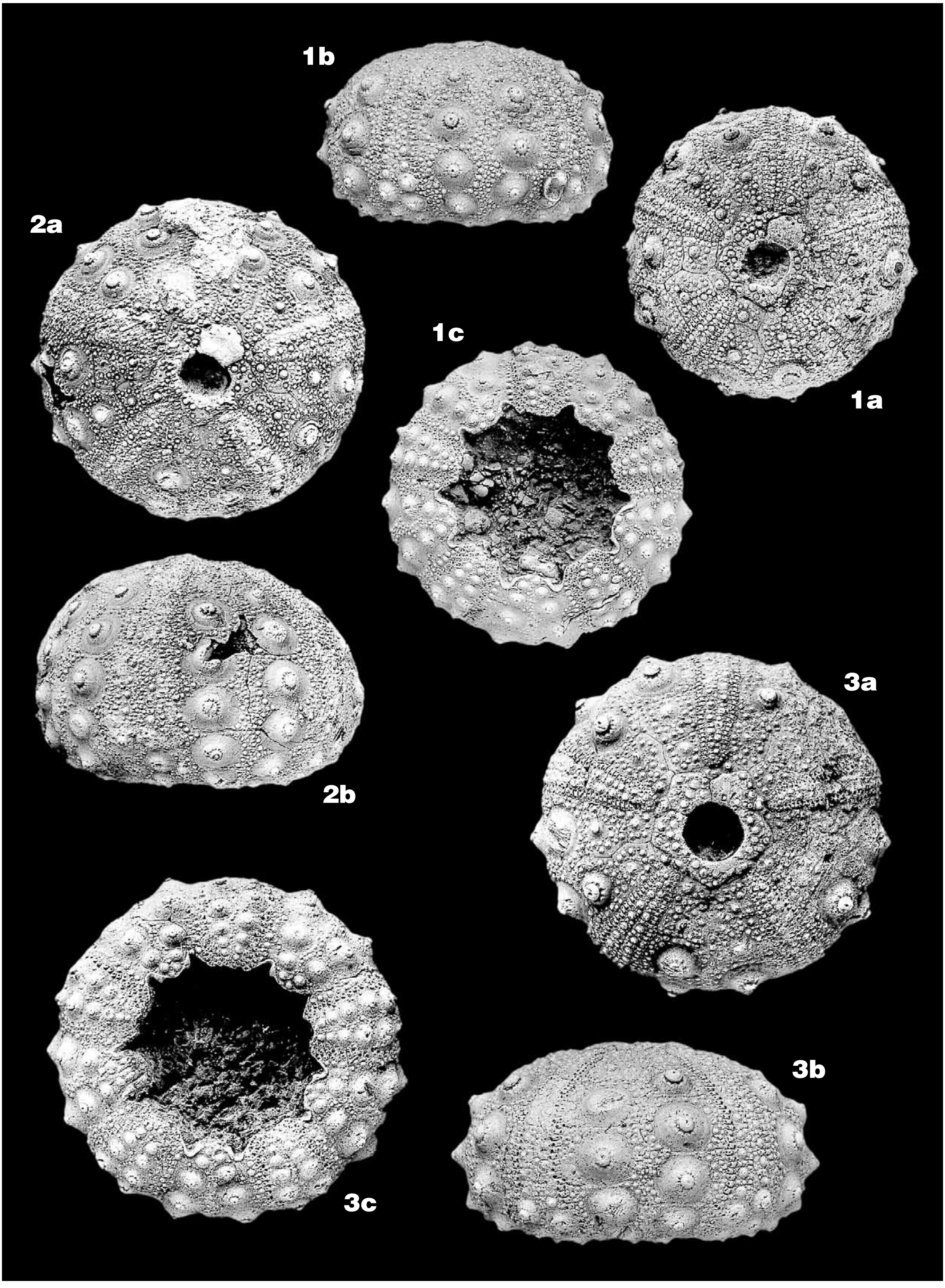
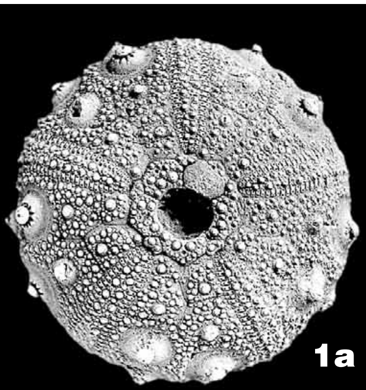

1b
2a
1a
1c
2b
3a
3b
3c

PLATE 34

Figs **1-5** — *Gymnocidaris agassizi* (F.A. ROEMER, 1839); **1a** – aboral view, **1b** – lateral view, to show ambulacrum, **1c** – oral view, **1d** – close-up view of the apical disc; Figs 1a-1c × 1.5, Fig. 1d × 5; Specimen No. EMa/56; **2a** – aboral view, **2b** – lateral view, to show ambulacrum, **2c** – oral view; × 1.5; Specimen No. EMa/57; **3** – oral view, to show the preserved fragment of Aristotle's lantern; nat. size; Specimen No. EMa/58; **4** – aboral view; nat. size; Specimen No. EMa/60; **5** – close-up view of the apical disc; × 5; Specimen No. EMa/61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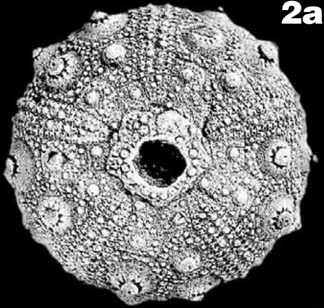
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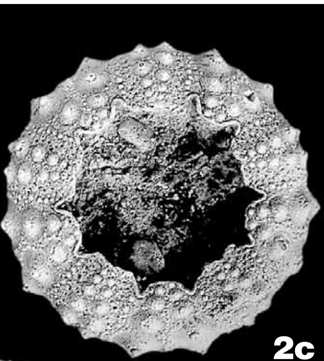
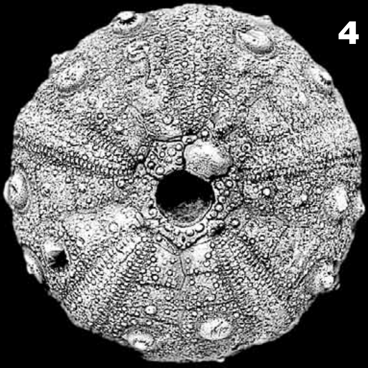

2c


1b


2b


3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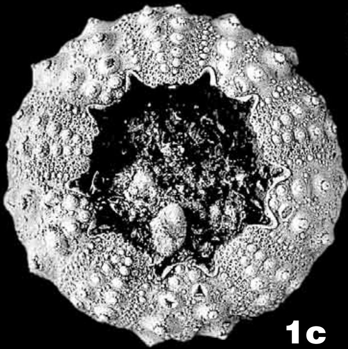
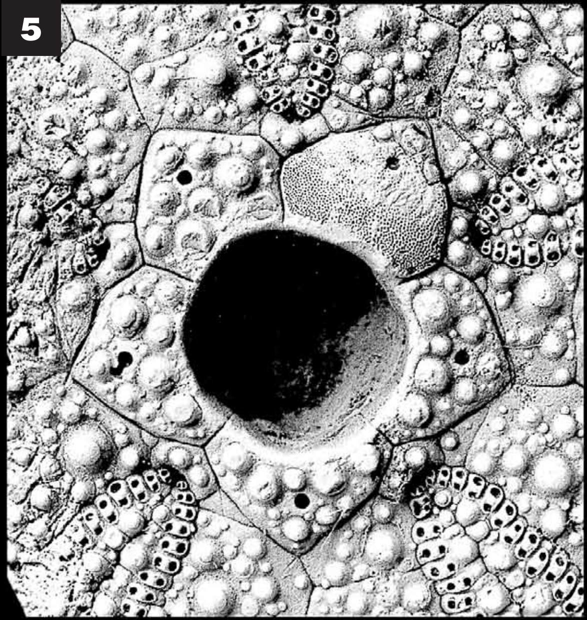

1c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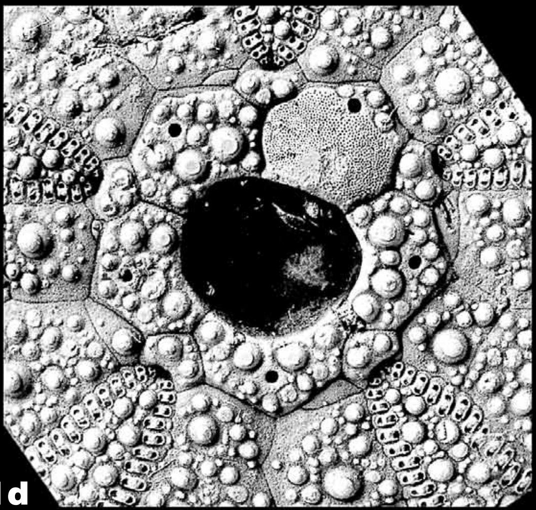
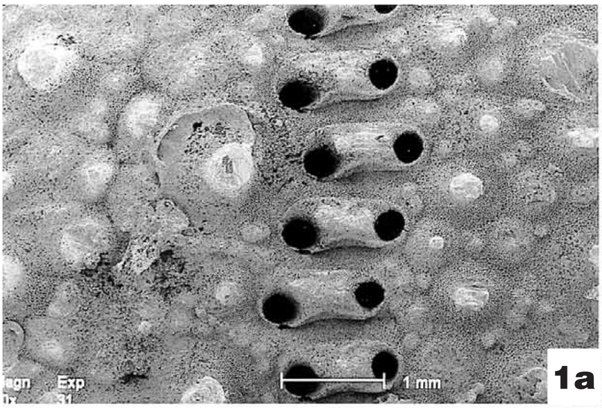
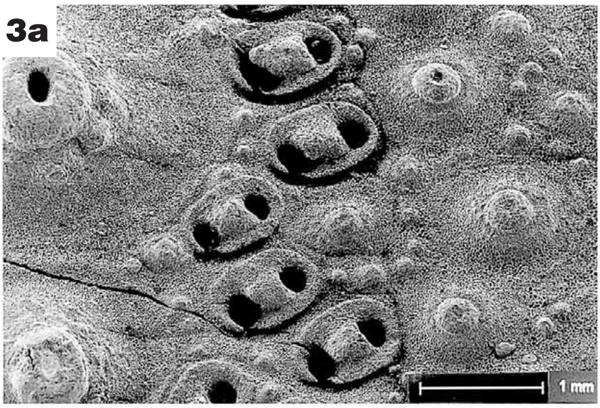
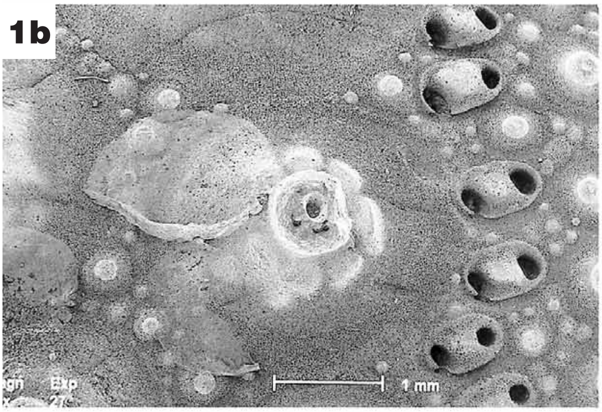

1d

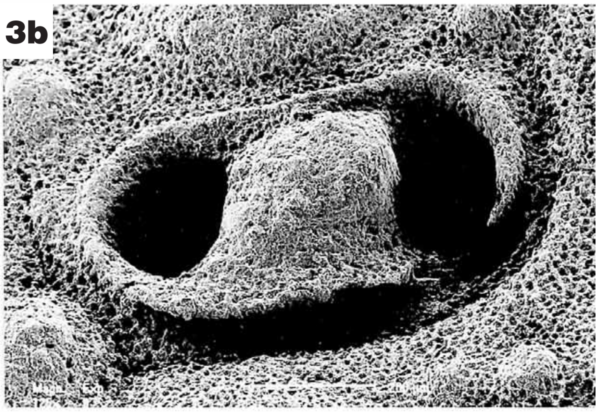
PLATE 35

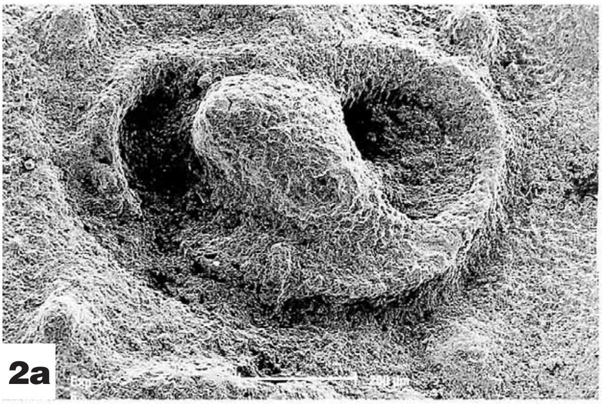
Figs **1-4** — *Gymnocidaris agassizi* (F.A. ROEMER, 1839); **1a** – close-up of the adapical part of ambulacrum, to show *P1* isopores; **1b** – close-up view of the ambital ambulacral plate, to show *P1* isopores; SEM; Specimen No. EMa/62; **2a** – close-up view of the subambital pore-pair, to show *P2* isopores; **2b** – close-up view of the adoral part of ambulacrum, to show phyllodes; SEM; Specimen No. EMa/63; **3a** – close-up view of the subambital part of ambulacrum, to show *P2* isopores; **3b** – close-up view of the adapical pore-pair; SEM Specimen No. EMa/64; **4a** – close-up view of the phyllode pore-pair, to show *P3* isopore; **4b** – close-up view of a part of the phyllode; SEM; Specimen No. EMa/65

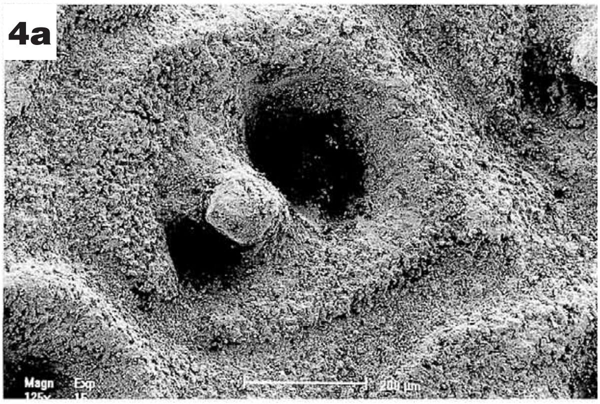

1a

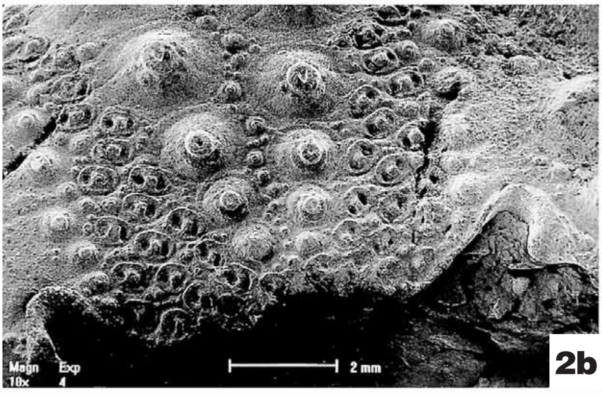

3a


1b


3b


2a


4a


2b

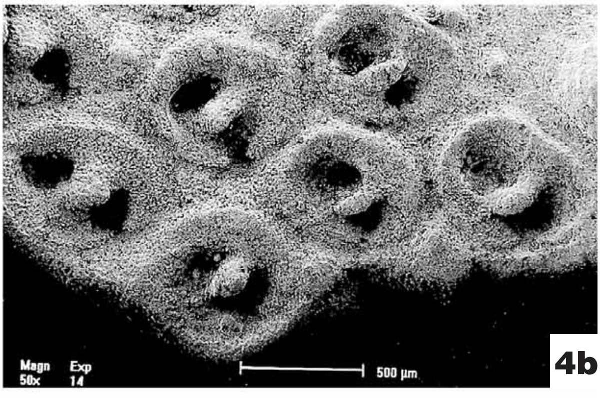

4b

PLATE 36

Figs **1a-1e** — *Acropeltis aequituberculata* L. AGASSIZ, 1840; **1a** – aboral view, **1b** – lateral view, **1c** – close-up view of the preserved part of apical disc, **1d** – ambital view of interambulacrum, **1e** – ambital view of ambulacrum; Figs 1a-1b × 2, Figs 1c-1e SEM; Specimen No. ESo/143

Figs **2a-2e** — *Glypticus* sp.; **2a** – aboral view, **2b** – lateral view, **2c** – close-up view of the apical disc, **2d** – close-up view of the adapical part of ambulacrum, **2e** – lateral close-up view; Figs 2a-2b × 3, Figs 2c-2e SEM; Specimen No. ESo/144

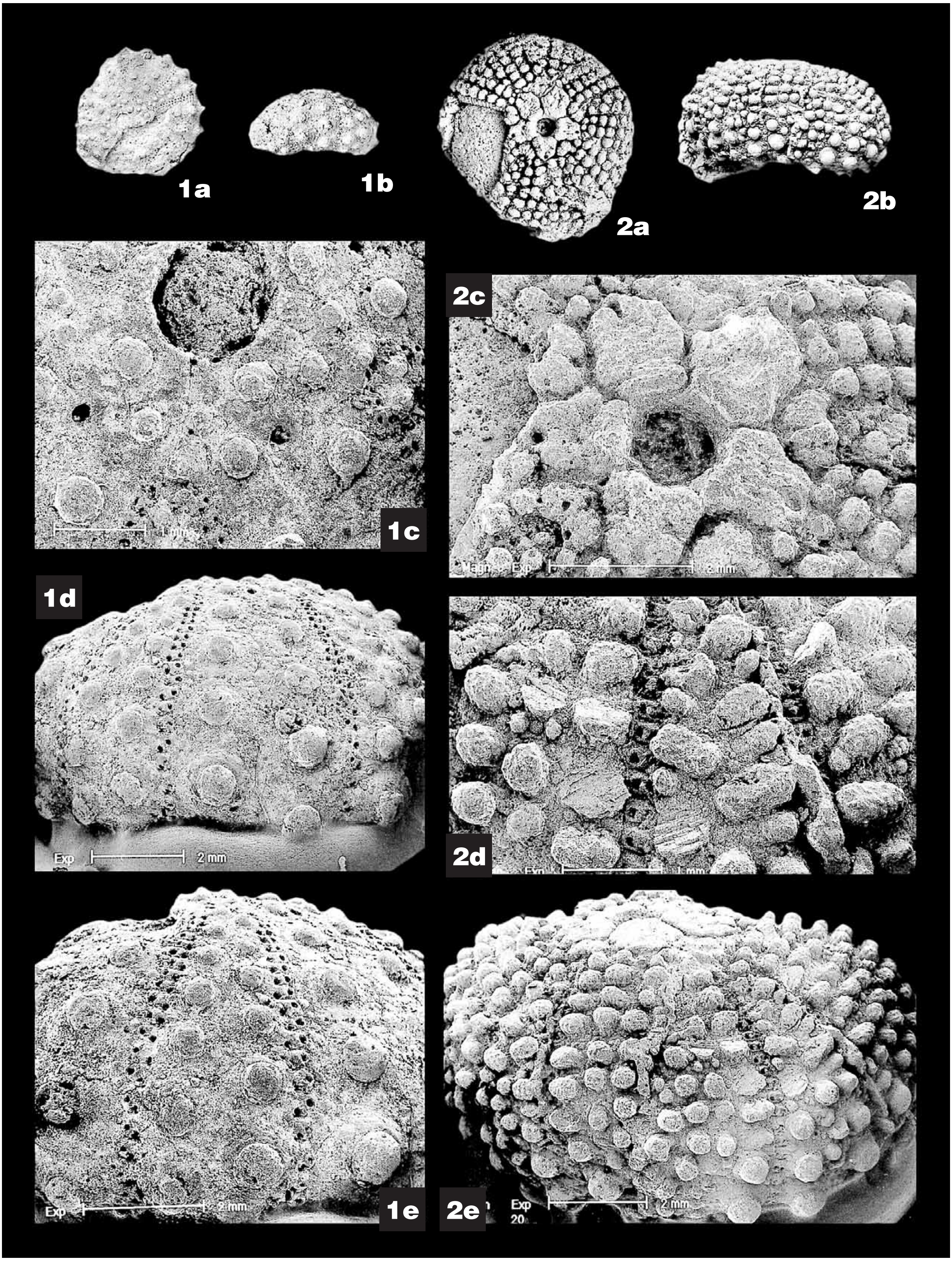

1a
1b
2a
2b
1c
1 mm
2c
Magn
Exp
2 mm
1d
Exp
2 mm
2d
Exp
1 mm
1e
Exp
2 mm
2e
Exp
20
2 mm

PLATE 37

Figs **1a-1i** — *Orthopsis pomeraniae* KONGIEL, 1957; **1a** – aboral view, **1b** – lateral view, **1c** – oral view, **1d** – close-up view of the adapical part of ambulacrum, **1e** – close-up view of adapical ambulacral plates, **1f** – close-up view of the ambital trigeminate plate, to show distinct sutures between simple plates, **1g** – close-up view of the interambulacral plate, to show primary and scrobicular tubercles, **1h** – close-up view of the ambital part of ambulacrum, **1i** – close-up view of the ambital part of interambulacrum; Figs 1a-1c × 4, Figs 1d-1i SEM; Specimen No. ECz/145

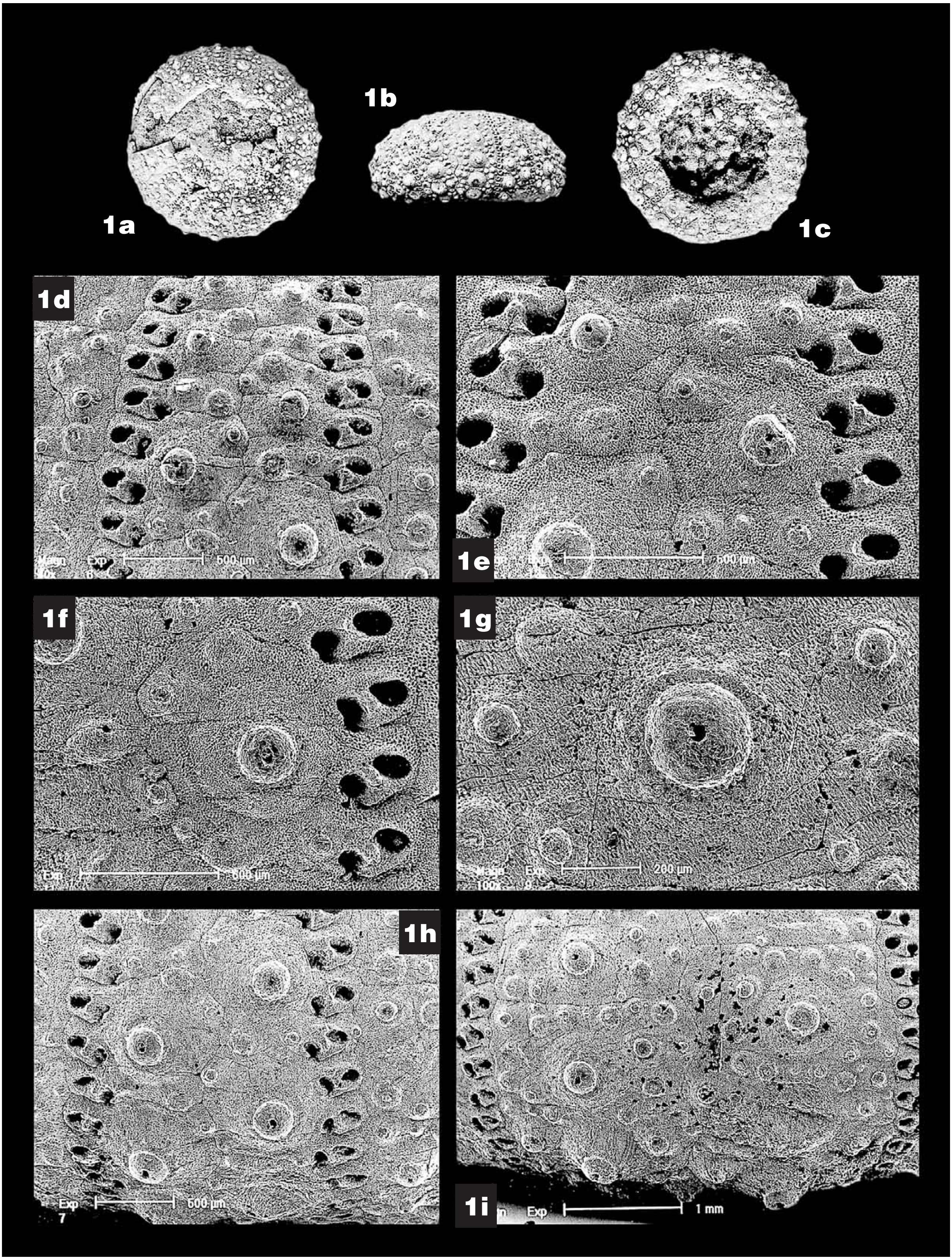
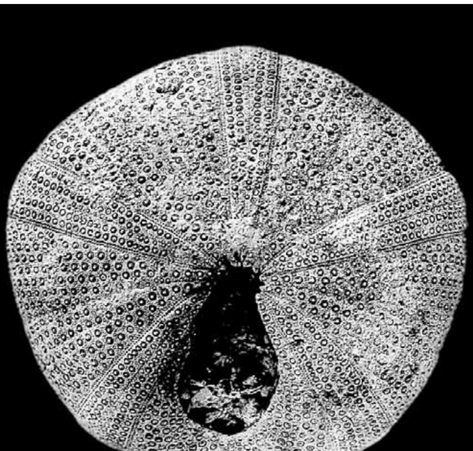
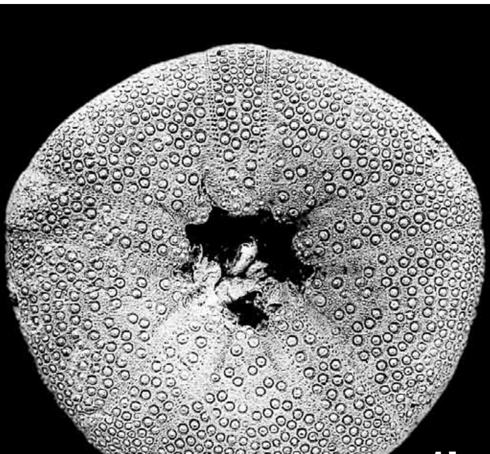

1a
1b
1c
1d
Magn
70x
Exp
8
500 µm
1e
Exp
500 µm
1f
Exp
500 µm
1g
Magn
100x
Exp
9
200 µm
1h
Exp
7
500 µm
1i
Exp
1 mm

PLATE 38

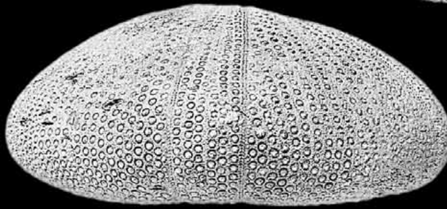
Figs **1-2** — *Pygaster morrisi* WRIGHT, 1851; **1a** – aboral view, **1b** – oral view, **1c** – left lateral view; nat. size; Specimen No. EMa/66; **2a** – close-up view of the adoral part of ambulacrum, **2b-2c** – close-up view of the left column of ambulacrum, to show simple plates and ornamentation, **2d** – close-up view of ambulacral *P2* isopores; SEM; Specimen No. EMa/67



1a

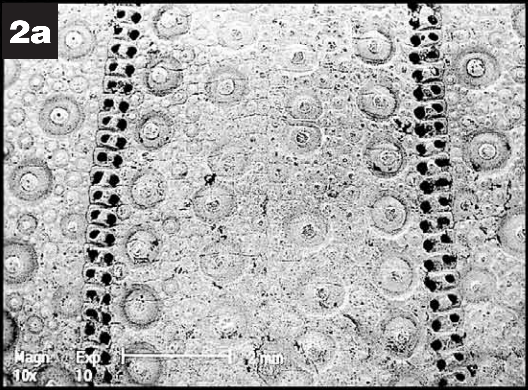


1b

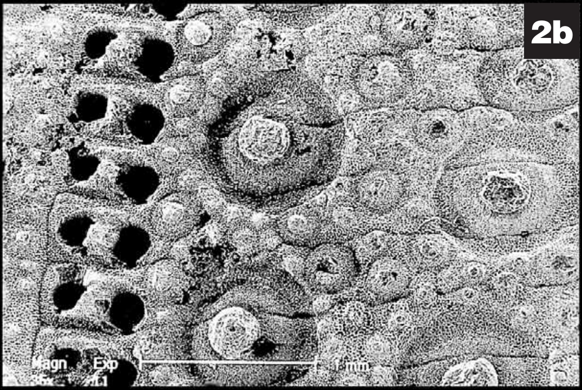


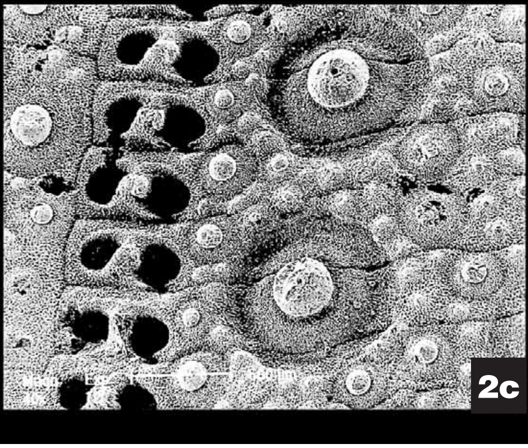
1c

2a

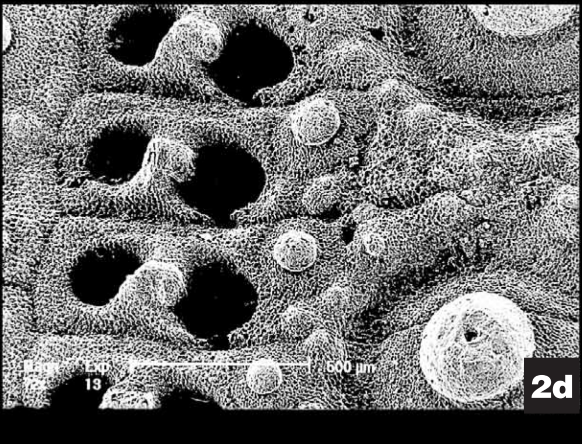


2b





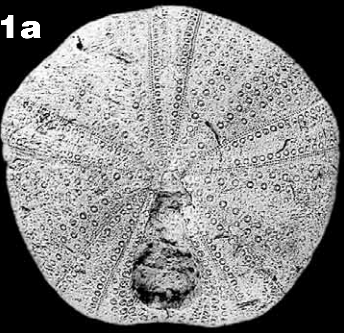
2c

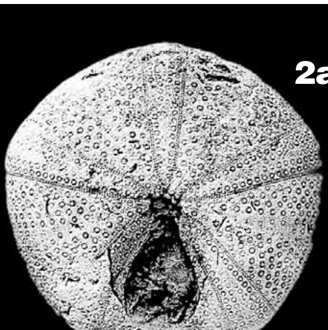


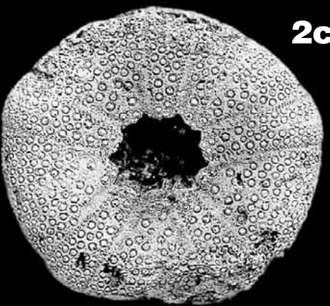
2d

PLATE 39

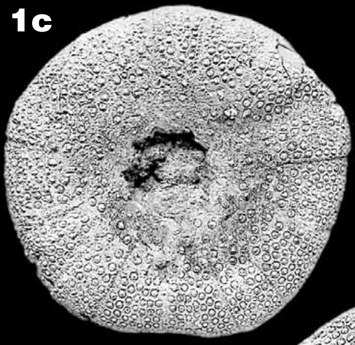
Figs **1-4** — *Pygaster morrisi* WRIGHT, 1851; **1a** – aboral view, **1b** – left lateral view, **1c** – oral view; nat. size; Specimen No. EMa/68; **2a** – aboral view, **2b** – left lateral view, **2c** – oral view; nat. size; Specimen No. EMa/69; **3a** – aboral view, **3b** – oral view; nat. size; Specimen No. EMa/70; **4a** – close-up view of the adapical part of ambulacrum, **4b** – close-up view of the right column of ambulacrum, to show *P2* isopores; SEM; Specimen No. EMa/71


1a

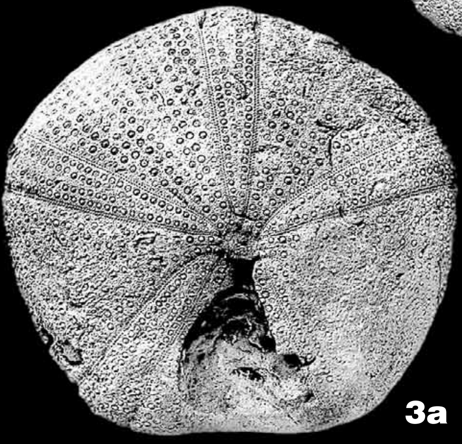

2a

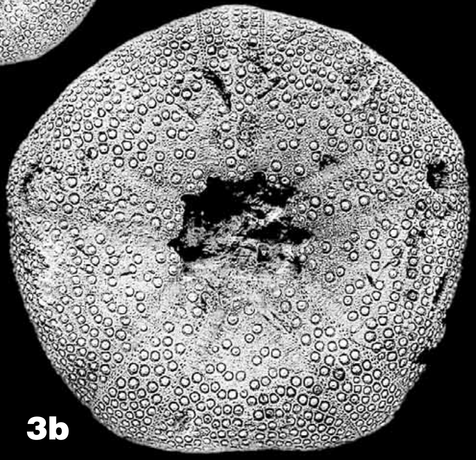

2c

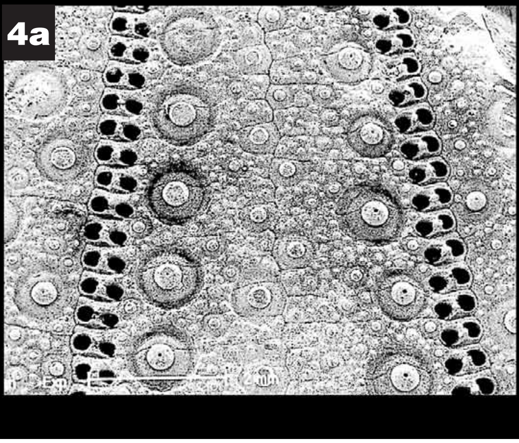

1b


1c


2b


3a


3b


4a

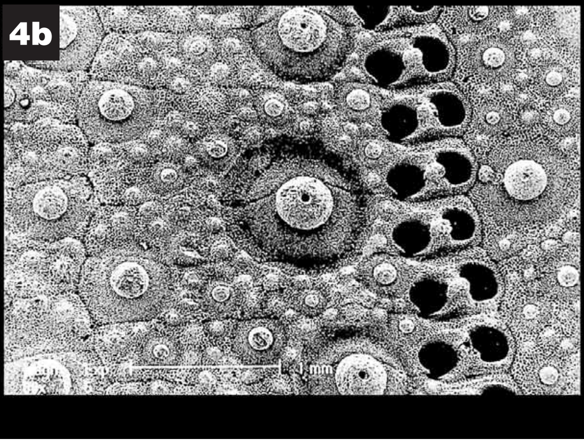
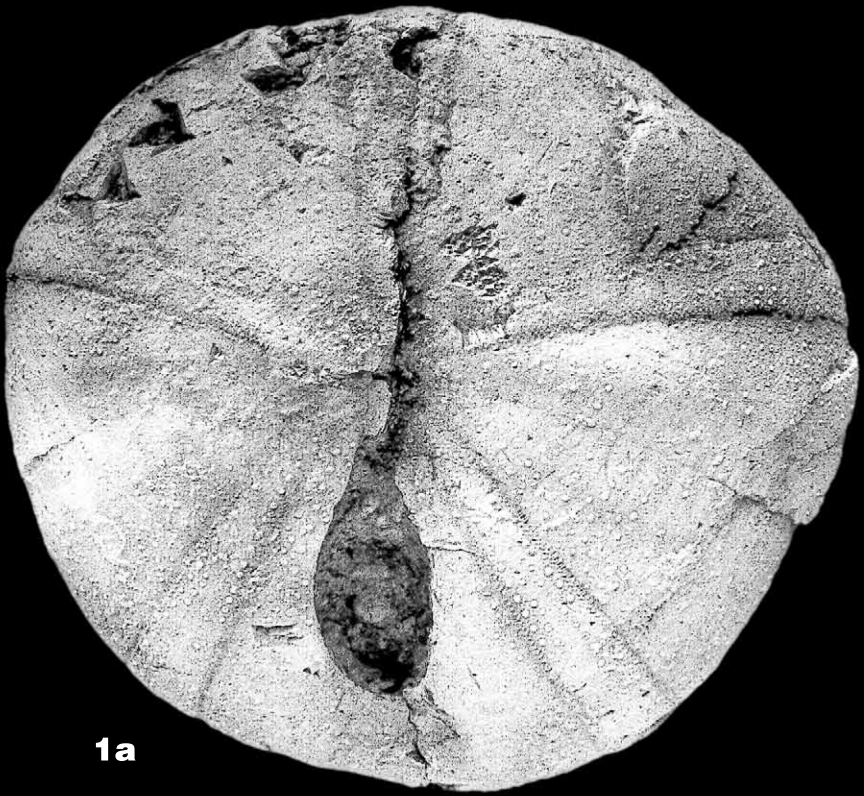

4b

PLATE 40

Fig. **1** — *Pygaster tenuis* L. AGASSIZ, 1839; **1a** – aboral view, **1b** – left lateral view; nat. size; Specimen No. EMa/72



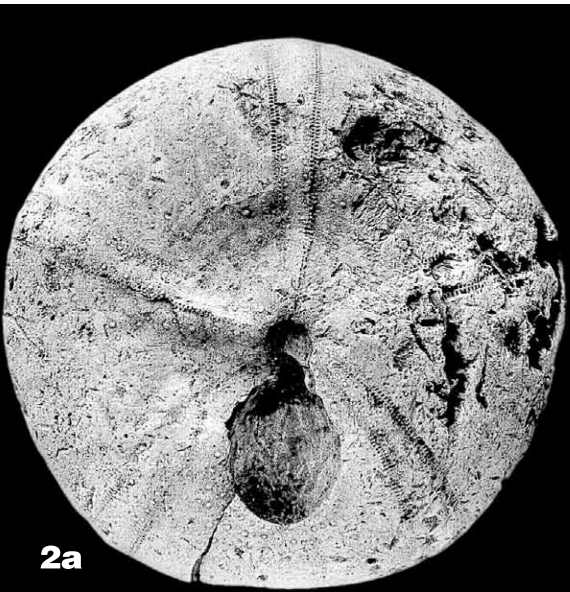
1a

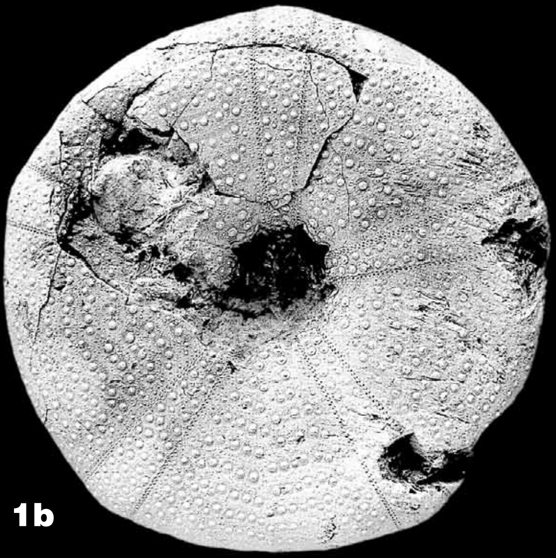
1b

PLATE 41

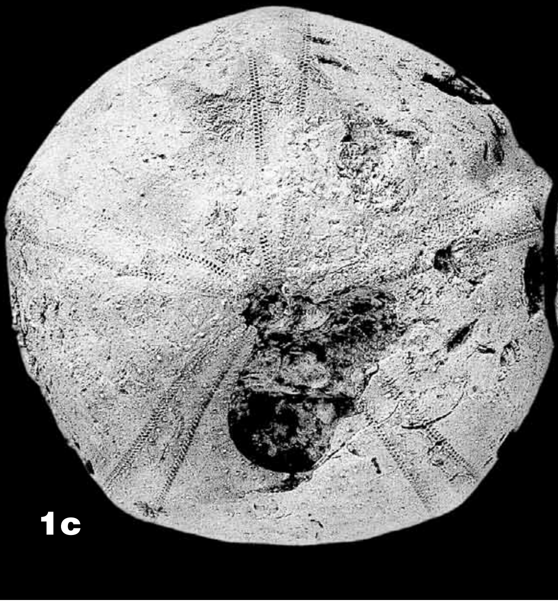
Figs **1-3** — *Pygaster tenuis* L. AGASSIZ, 1839; **1a** – left lateral view, **1b** – oral view, **1c** – aboral view; × 0.9; Specimen No. EMa/73; **2a** – aboral view, **2b** – left lateral view; × 0.9; Specimen No. EMa/74; **3** – aboral view; × 0.9; Specimen No. EMa/75


1a


2a


1b


2b


1c

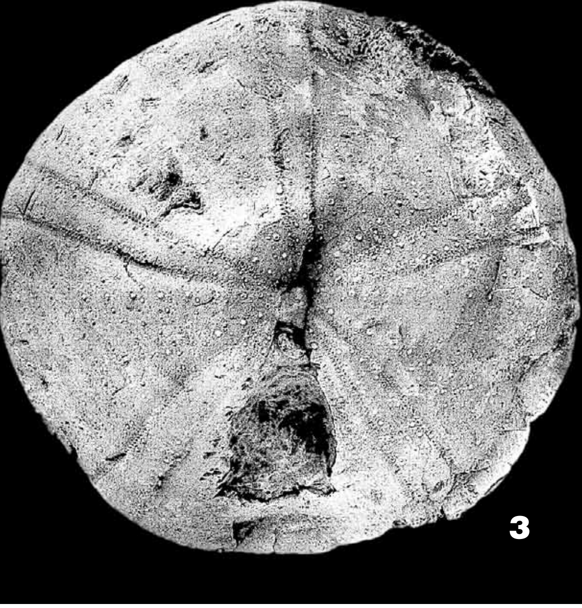
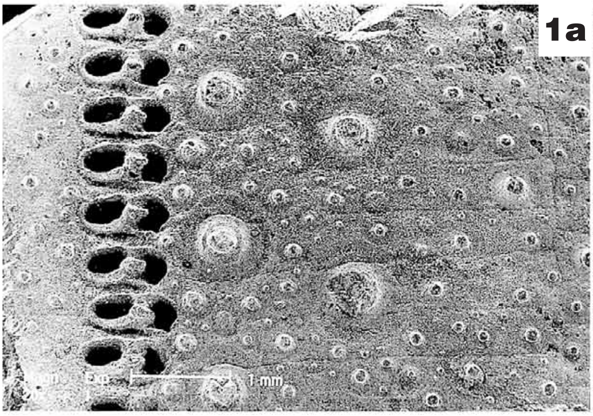

3

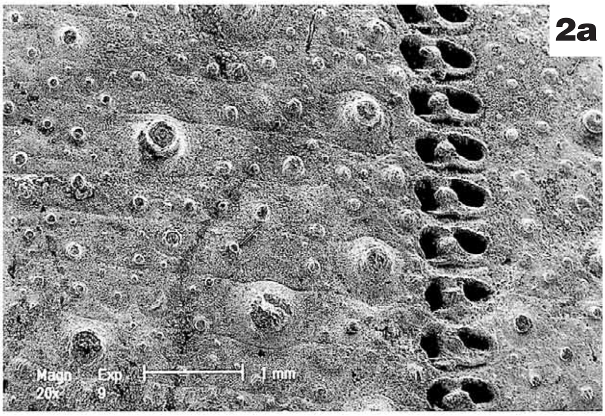
PLATE 42

Figs **1-3** — *Pygaster tenuis* L. AGASSIZ, 1839; **1a** – fragment of the left ambulacral column, to show ornamentation, **1b-1c** – close-up views of more adoral parts of ambulacrum, to show *P2* isopores with relatively equal pores separated by a broad interporal partition; SEM; Specimen No. EMa/76; **2a** – fragment of the right ambulacral column, to show ornamentation, **2b-2c** – close-up views of aboral ambulacral pore-pairs; SEM; Specimen No. EMa/77; **3a-3b** – close-up views of the adapical part of ambulacrum, to show *P2* isopores with relatively unequal pores separated by a narrow interporal partition; SEM; Specimen No. EMa/78

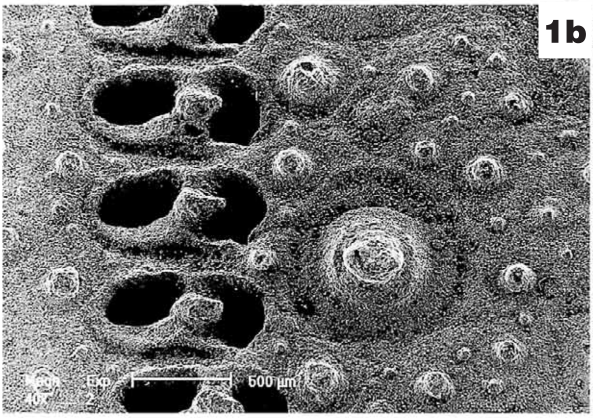
1a



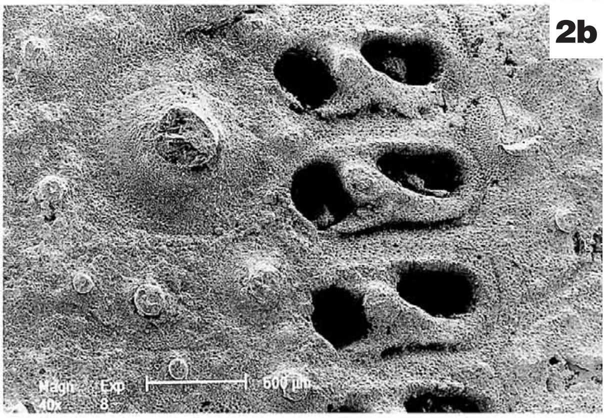
2a



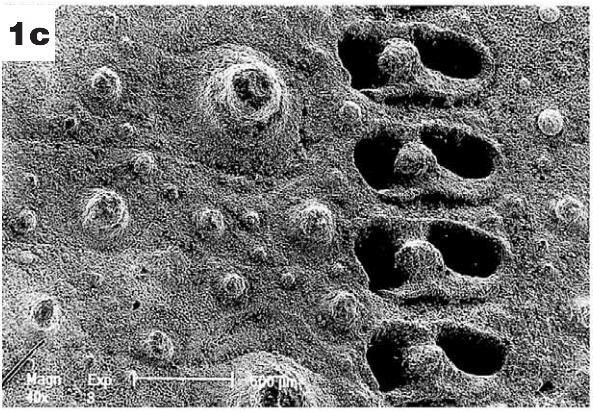
1b



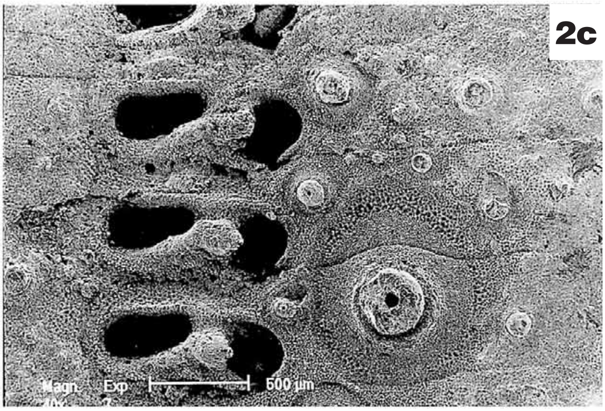
2b



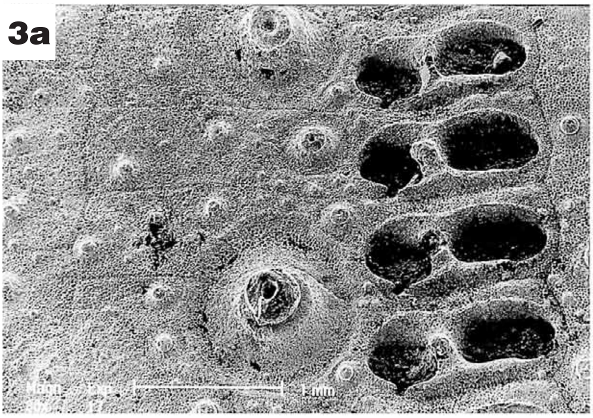
1c



2c



3a



3b

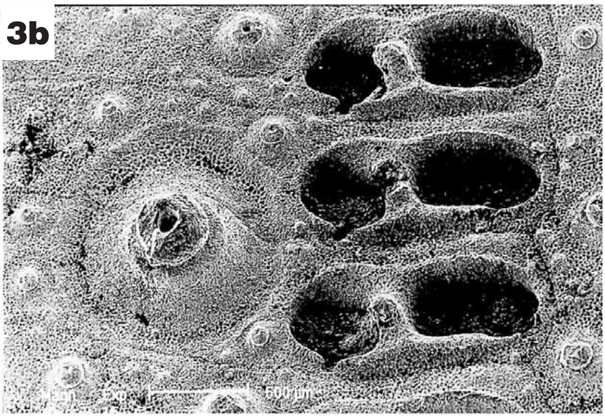
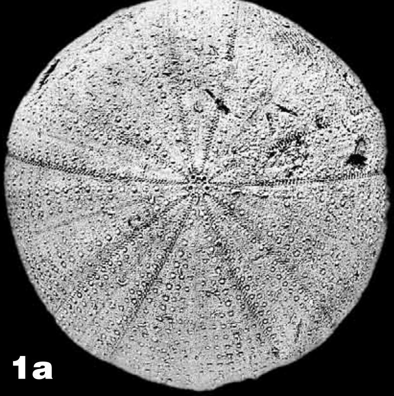


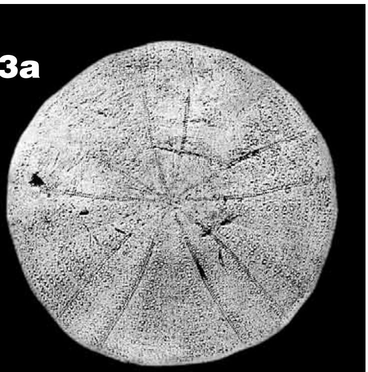
PLATE 43

Figs **1-6** — *Holectypus corallinus* D'ORBIGNY, 1850; **1a** – aboral view, **1b** – oral view, **1c** – lateral view; × 1.5; Specimen No. EMa/79; **2** – lateral view; × 1.5; Specimen No. EMa/80; **3a** – aboral view, **3b** – lateral view, **3c** – oral view; nat. size; Specimen No. EMa/81; **4** – oral view; × 1.5; Specimen No. EMa/86; **5** – close-up view of interambulacral plates, to show ornamentation; SEM; Specimen No. ECz/84; **6** – close-up view of the apical disc; SEM; Specimen No. EMa/82

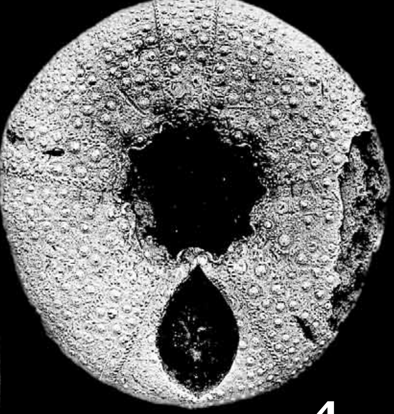


1a

2

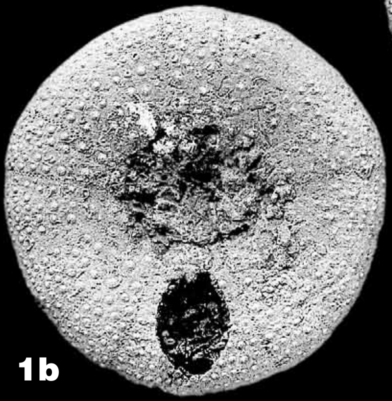


3a

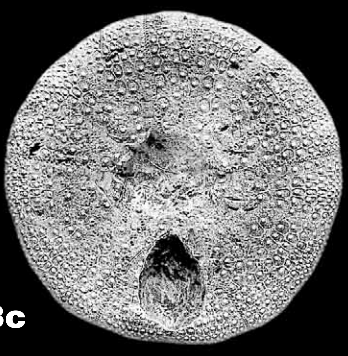


4

3b

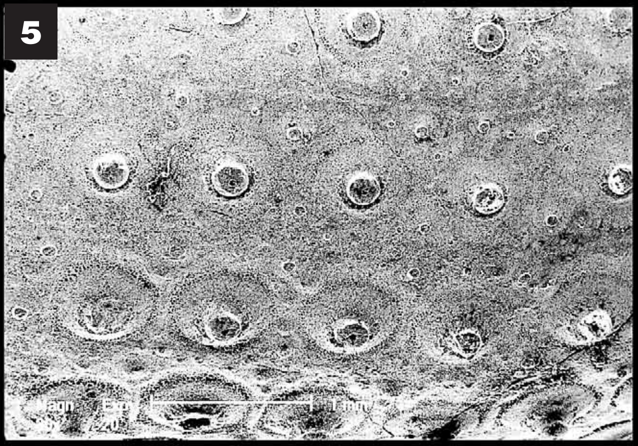


1b



3c

1c

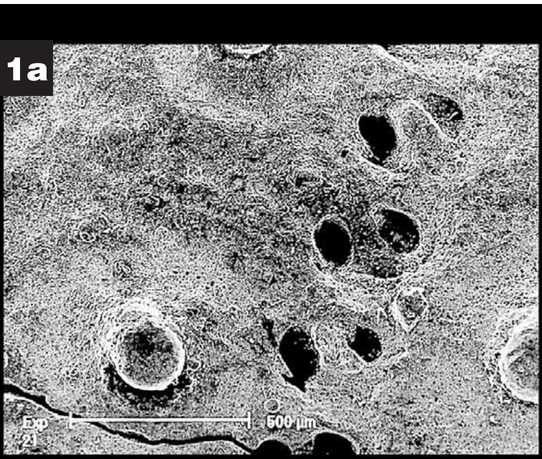


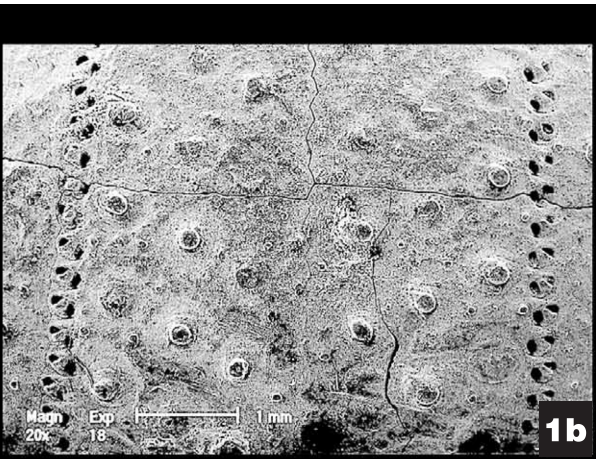
5

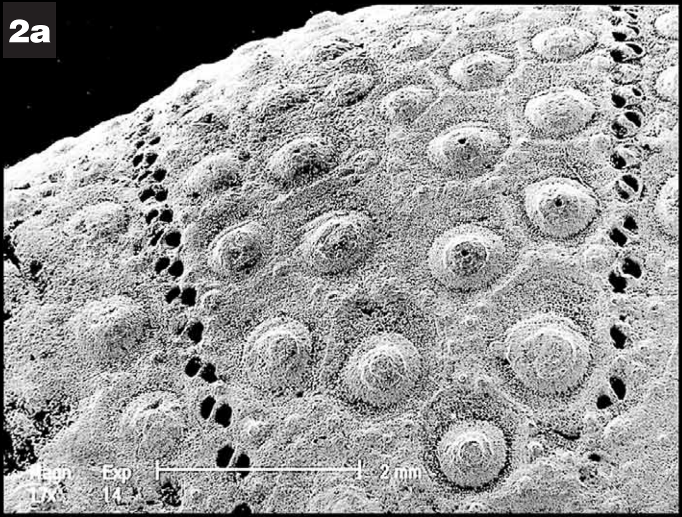
6

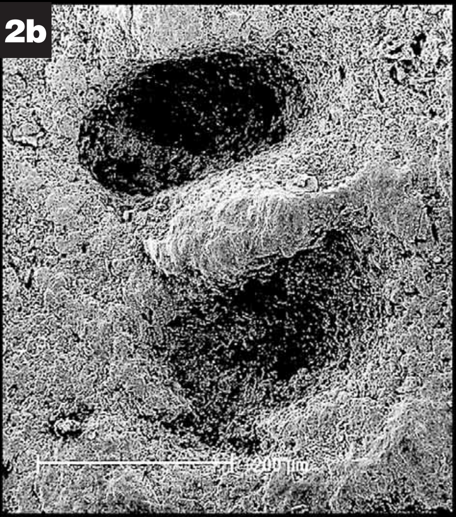
PLATE 44

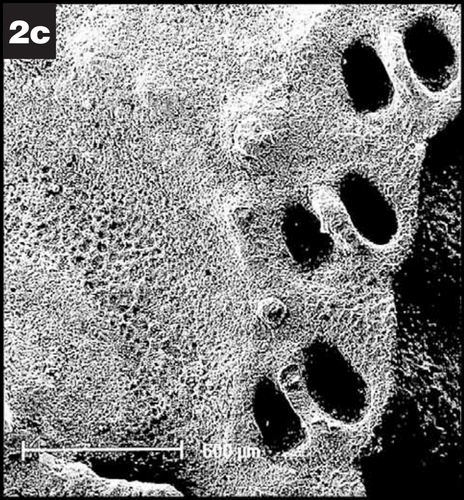
Figs **1-2** — *Holectypus corallinus* D'ORBIGNY, 1850; **1a** – close-up view of ambital *P2* isopores; **1b** – close-up view of the ambital part of ambulacrum, to show interporal ornamentation; Figs 1a-1b, Specimen No. ECz/84; **2a** – adoral view of ambulacrum, to show adambitally enlarged areoles; **2b** – close-up view of the *P2* isopore; **2c** – close-up view of the most adoral *P2* isopores; **2d** – close-up view of the most adoral *P2* isopores, to show strongly deformed adoral tubercles; Figs 2a-2d, Specimen No. EKo/87; all specimens taken by SEM


1a
Exp
21
500 µm


Magn
20x
Exp
18
1 mm
1b


2a
Magn
17x
Exp
14
2 mm


2b
200 µm


2c
500 µm

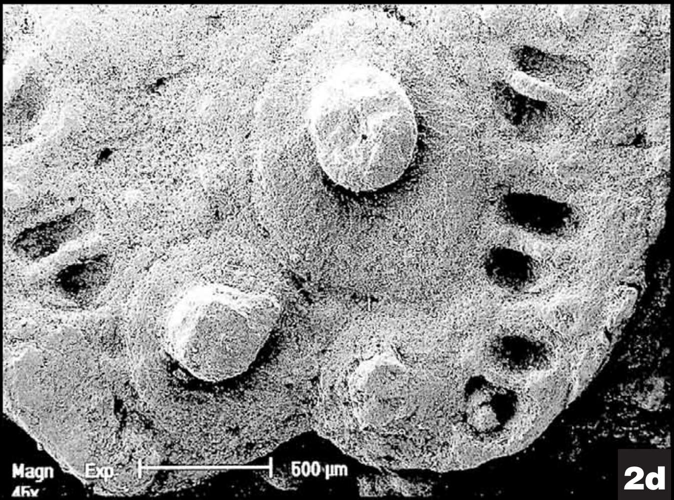
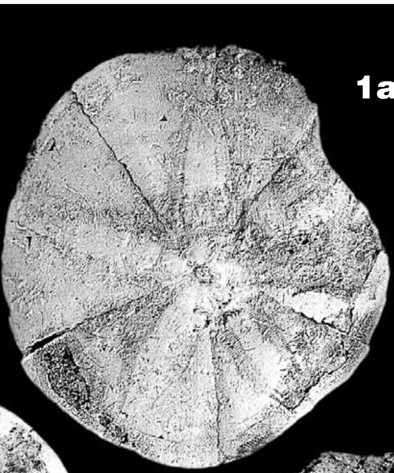

Magn
45x
Exp
500 µm
2d

PLATE 45

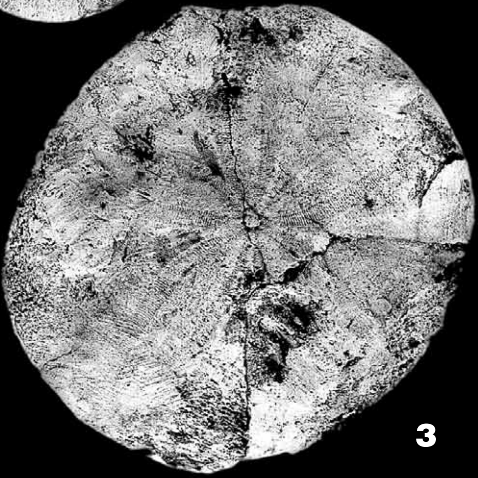
Fig. **1** — *Pygurus costatus* WRIGHT, 1860; **1a** – aboral view, **1b** – oral view; nat size; Specimen No. ESl/83, the same as figured by BARCZYK (1961, Pl. 5, Figs 1-1b)

Figs **2-5** — *Pygurus jurensis* MARCOU, 1847; **2** – aboral view; nat size; Specimen No. ESo/85; **3** – aboral view; nat. size; Specimen No. EMa/88; **4** – aboral view; nat size; Specimen No. EMa/89; **5** – aboral view; × 1.5; Specimen No. EOz/93


2


1a


1b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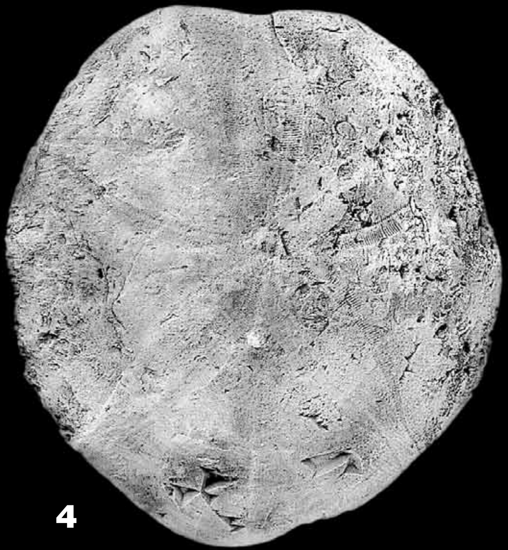
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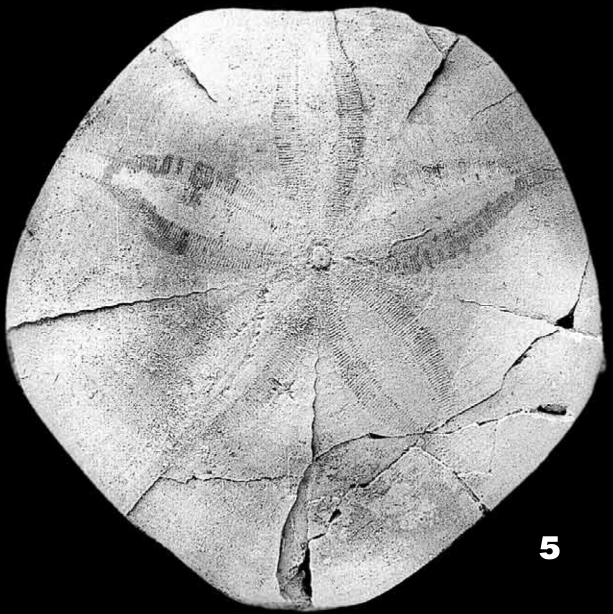
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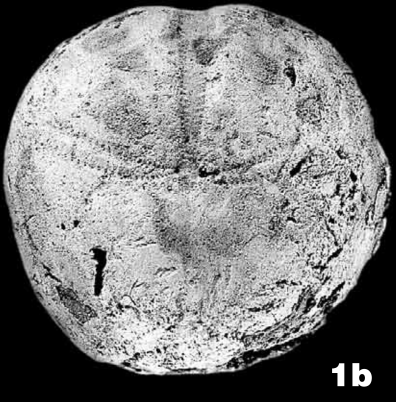
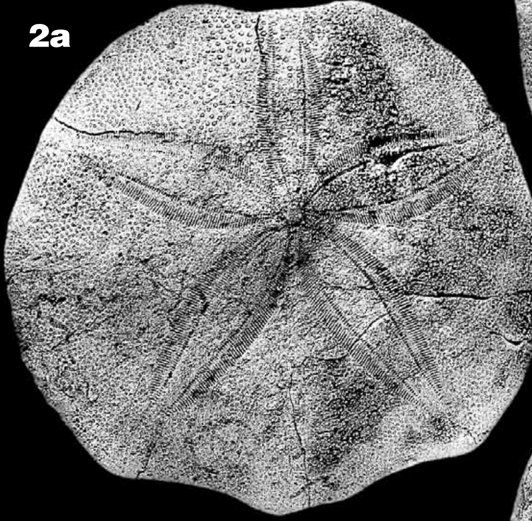
PLATE 46

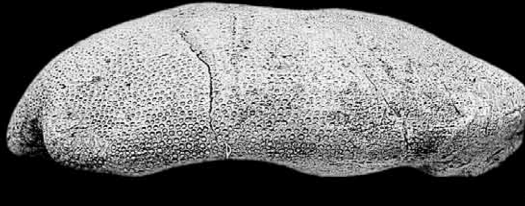
Fig. **1** — *Collyrites* sp.; **1a** – left lateral view, **1b** – aboral view; nat. size; Specimen No. EKa/146

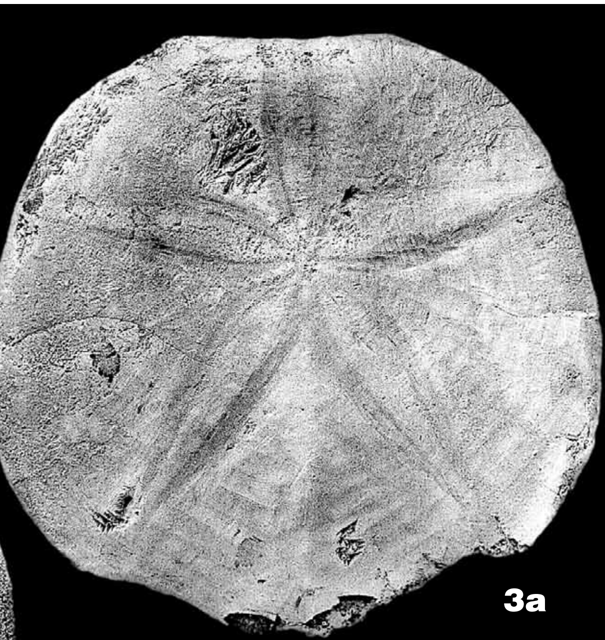
Figs **2-3** — *Pygurus blumenbachi* KOCH & DUNKER, 1837; **2a** – aboral view, **2b** – left lateral view; nat. size; Specimen No. EMa/90; **3a** – aboral view, **3b** – left lateral view, **3c** – oral view; nat. size; Specimen No. EMa/91


1a


1b


2a


2b


3a


3b

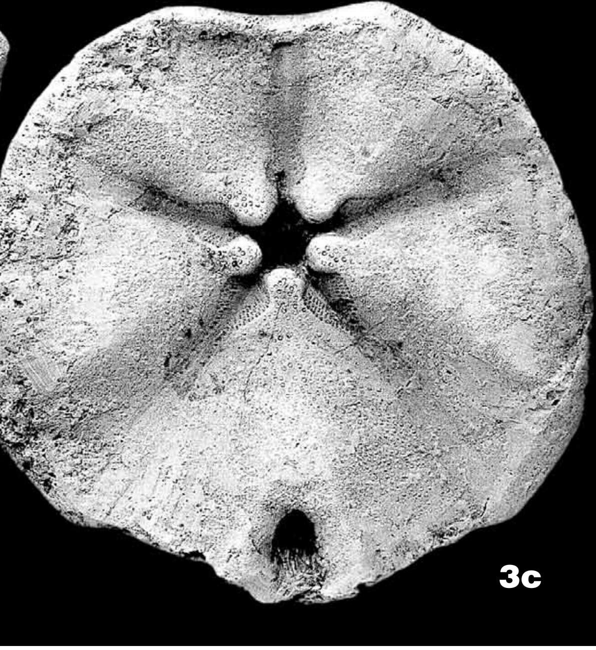

3c

PLATE 47

Figs **1-8** — *Nucleolites letteroni* (COTTEAU, 1870); **1a** – aboral view, **1b** – oral view, **1c** – lateral view; × 2; Specimen No. ECz/154; **2** – aboral view; × 2; Specimen No. ECz/155; **3** – aboral view; × 2; Specimen No. ECz/156; **4a** – aboral view, **4b** – oral view; × 2; Specimen No. ZPAL E.VIII/17; **5** – aboral view; × 2; Specimen No. EOz/157; **6a** – aboral view, **6b** – oral view, **6c** – right lateral view; × 2; Specimen No. ZPAL E.VIII/18; **7a** – aboral view, **7b** – oral view, **7c** – right lateral view; × 2; Specimen No. ECz/158; **8a** – aboral view, to show the apical disc; **8b-8c** – close-up views of the aboral fragment of ambulacrum, to show anisopores; SEM; Specimen No. ECz/159

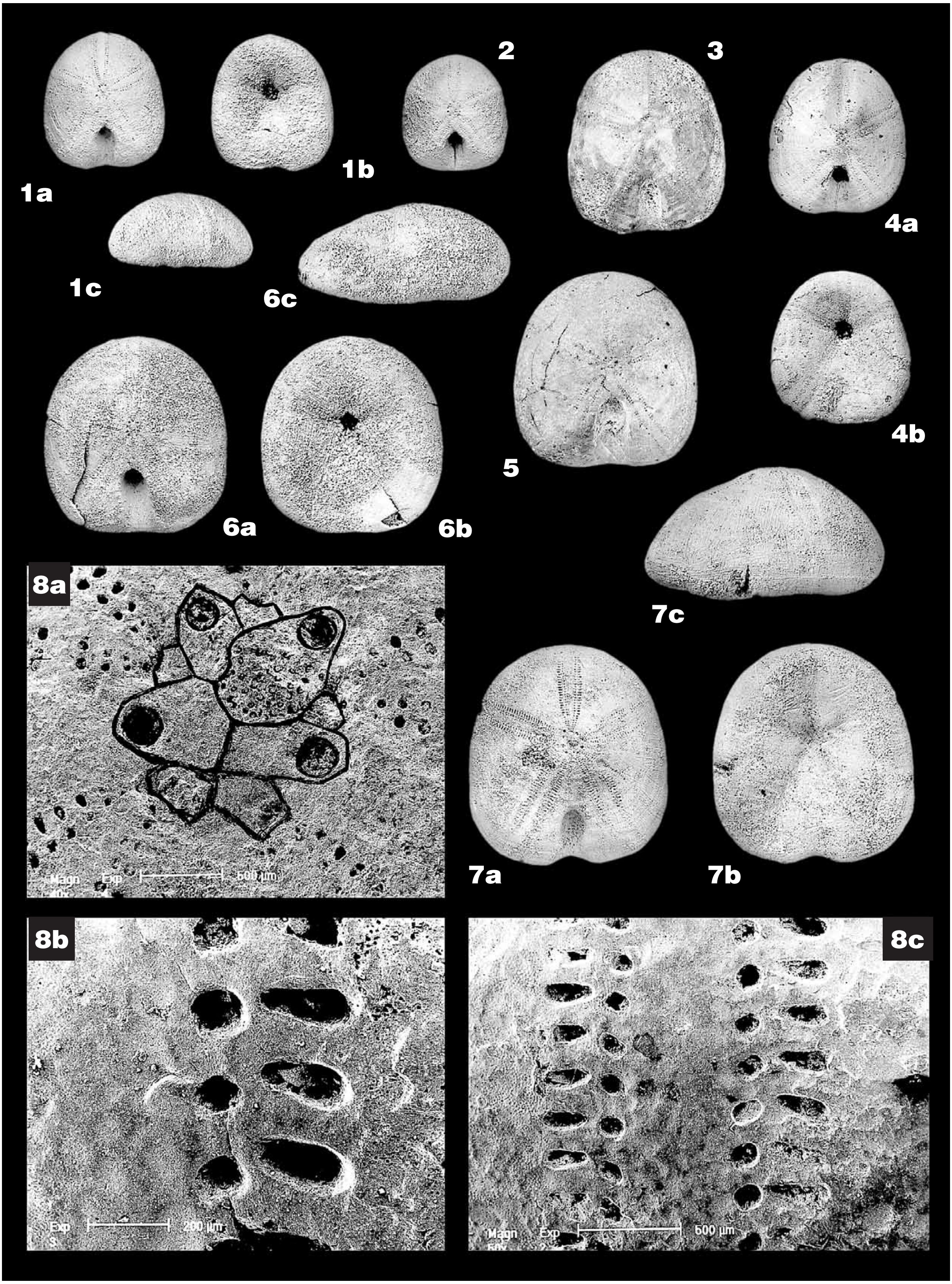
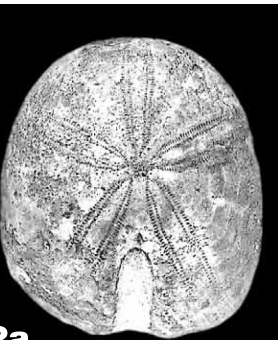

1a
1b
2
3
4a
1c
6c
5
4b
6a
6b
7c
8a
500 µm
7a
7b
8b
200 µm
8c
500 µm

PLATE 48

Figs **1-3** — *Nucleolites truncatus* (DESOR, 1847); **1a** – aboral view, **1b** – posterior view, to show the anal groove; × 1.5; Specimen ECe/160; **2a** – aboral view, **2b** – right lateral view; × 1.5; Specimen ECe/161; **3a** – aboral view, **3b** – oral view, **3c** – right lateral view; × 1.5; Specimen No. ECe/162

Figs **4-9** — *Nucleolites brodiei* (WRIGHT, 1859); **4** – aboral view; × 1.5; Specimen No. ENi/163; **5** – aboral view; × 1.5; Specimen No. ENi/164; **6a** – aboral view, **6b** – posterior view, to show the anal groove; × 1.5; Specimen No. ENi/165; **7a** – right lateral view, **7b** – aboral view; × 1.5; Specimen No. ENi/166; **8a** – right lateral view, **8b** – aboral view; × 1.5; Specimen No. ENi/167; **9** – aboral view; × 1.5; Specimen No. ENi/168

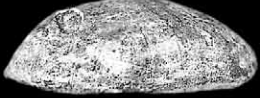
1a



2a

3a

3b

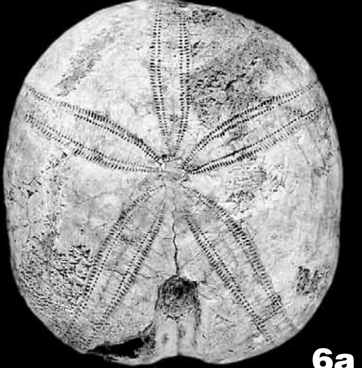


3c

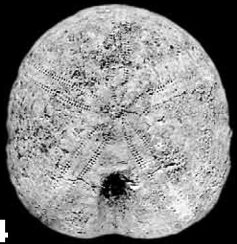
1b

2b

5



6a

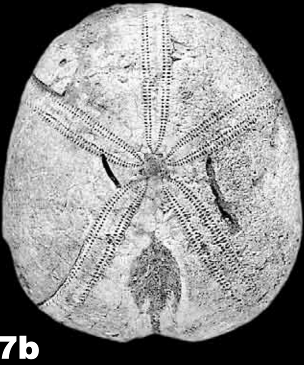


4

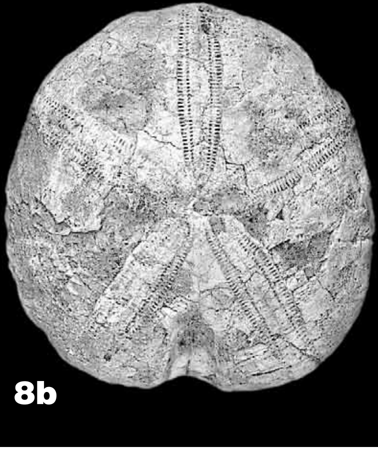
8a

6b

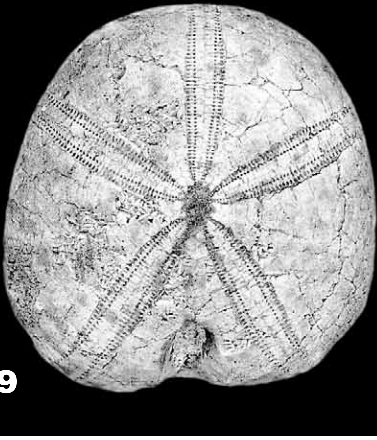
7a



7b



8b



9

PLATE 49

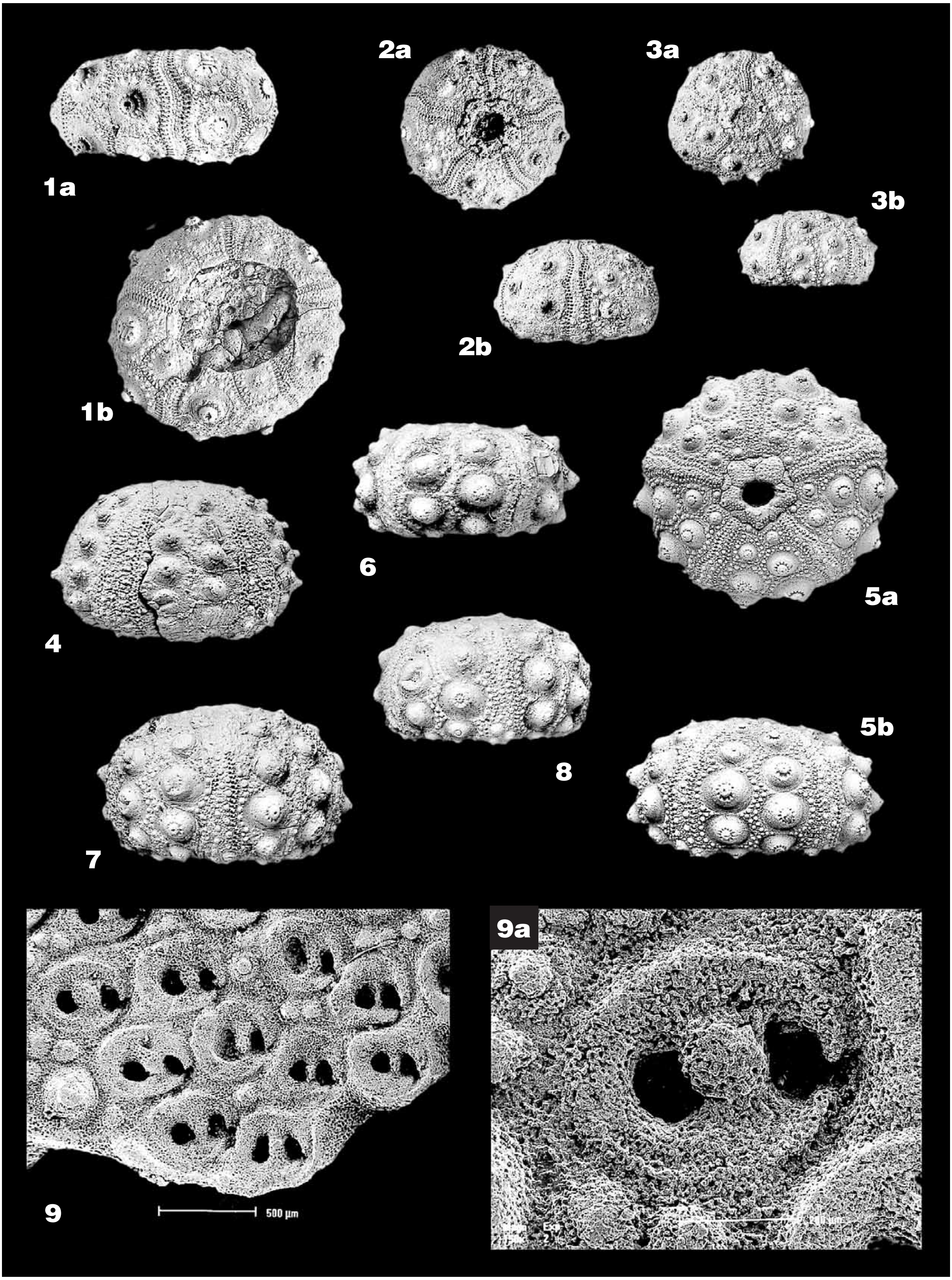
Fig. **1** — *Rhabdocidaris* sp.; **1a** – lateral view, to show ambulacrum, **1b** – aboral view; × 1.5; Specimen No. EMa/94

Figs **2-3** — *Pseudocidaris thurmanni* (L. AGASSIZ, 1840); **2a** – aboral view, **2b** – lateral view, to show ambulacrum; × 1.5; Specimen No. ENi/147; **3a** – aboral view, **3b** – lateral view, to show interambulacrum; × 1.5; Specimen No. ENi/148

Fig. **4** — *Hemicidaris mitra* L. AGASSIZ, 1840; lateral view, to show interambulacrum; × 1.5; Specimen No. ENi/149

Figs **5-8** — *Hemicidaris gresslyi* ÉTALLON, 1862; **5a** – aboral view, **5b** – lateral view, to show interambulacrum; × 1.5; Specimen No. ESl/150; **6** – lateral view; × 1.5; Specimen No. ESl/151; **7** – lateral view, to show ambulacrum; × 1.5; Specimen No. ESl/152; **8** – lateral view; × 1.5; Specimen No. ESl/153

Fig. **9** — *Hemicidaris intermedia* (FLEMING, 1828); **9** – close-up view of the phyllode, to show *P3* isopores; **9a** – close-up view of the *P3* isopore; SEM; Specimen No. EMa/169


1a
2a
3a
3b
1b
2b
6
5a
4
8
5b
7
9
500 µm
9a