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Creusoid cirripedes from the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland)

ABSTRACT: The creusoid cirripedes recognized within rich organic communities in the topmost part of the Korytnica Clays (Middle Miocene; Holy Cross Mountains, Central Poland) are represented by the two species domiciled in the specifically selected coral species: common *Creusia sanctacrucensis* BAŁUK & RADWAŃSKI, 1967, in *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME), and relatively rare *Creusia moravica* PROCHÁZKA, 1893, in *Porites* sp. The latter creusoid species, synonymized formerly with the other (*C. costata* SEGUENZA), is recognized as valid. The commensal relationship of these creusoid species to the host corals is reminded, and the problem of the host selectivity in the ancient creusoid cirripedes is discussed.

INTRODUCTION

The aim of the present paper is to supplement the previous data (BAŁUK & RADWAŃSKI 1967c) on the occurrence of creusoid cirripedes within the extremely rich organic communities of the Korytnica Clays deposited in the Middle Miocene (Badenian) Korytnica Basin which developed on the southern slopes of the Holy Cross Mountains, Central Poland. This occurrence has hitherto been demonstrated by the species *Creusia sanctacrucensis* BAŁUK & RADWAŃSKI, 1967, domiciled exclusively in the coralla of *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME). Further researches, especially of the sifted samples from the locality Korytnica-Plebania have resulted in a supply of the specimens of another species, *Creusia moravica* PROCHÁZKA, 1893, domiciled in another colonial-coral species, *Porites* sp. In the present paper, the occurrence of these two species of the coral-inhabiting cirripedes will be reviewed, and some new data on their relationships to the corals will be discussed.

PROBLEMS OF THE ANCIENT CREUSIOID CIRRIPEDES

At the time of the former publication on the ancient creusioid cirripedes of Europe and their relation to the present-day forms (BAŁUK & RADWAŃSKI 1967c) the main problems were in the recognition of: (1) Generic and higher rank taxonomy of the ancient coral-inhabiting cirripedes, (2) Mutual relation between the ancient and extant genera and phylogeny, (3) Functional morphology of the shell, (4) Biological relationship between the creusioid cirripedes and the corals. A revision of all the ancient taxa and a comparative study of the present-day creusioid cirripedes have led the authors (BAŁUK & RADWAŃSKI 1967a, b, c) to the following statements.

Ad (1): All the ancient creusioid cirripedes belong to the genera *Creusia* LEACH, 1817, with four compartments in the crown (carina + two laterals + rostrum), and *Pyrgomina* BAŁUK & RADWAŃSKI, 1967, with two compartments (carina + „rostrum” composed of the rostrum fused with two laterals). These two genera, together with the present-day genus *Pyrgoma* LEACH, 1817, make up within the family Balanidae LEACH, 1817, a separate subfamily, Creusiinae BAŁUK & RADWAŃSKI, 1967, as given in the systematic account of the present paper.

Ad (2): The generic stock *Creusia* → *Pyrgomina* → *Pyrgoma* is interpreted as a phyletic lineage which evolved from the main stock of the Balanidae, somewhen in the Early Tertiary, due to a neotenic development of ordinary acorn barnacles, the present-day forms of which display in their ontogeny a four-compartmental stage (carina + two laterals + rostrum) of the creusioid type (RUNNSTRÖM 1925, Fig. 11; COSTLOW 1956) and thus they recapitulate the features of their ancestors, common with the creusioids.

Ad (3): The peculiar shell morphology results from its adaptation to life inside the living colonies of the corals, and it is emphasized by a more or less remarkable elongation of the base which has thus acquired a possibility to contain almost the whole animal's body.

Ad (4): The biological relationship which had previously been regarded as either parasitic, as emphatically expressed by ABEL (1927, 1928, 1935), or epibionthic, has been interpreted as commensal: the creusioid cirripede gaining its life space, and the coral not suffering from the guest and tolerating it by adaptation of its morphology, precisely the pattern of corallites (see Pl. 3, Figs 1—3) to the growing creusioids.

The reports presented by other students of the subject and published since the time present-authors' publications appeared (BAŁUK & RADWAŃSKI 1967a,b,c) have generally confirmed the above statements for other ancient creusioid cirripedes from Europe (MORONI 1967, PAJAUD 1976a,b), North Africa (MOISSETTE & SAINT MARTIN 1982), and the United States (WEISBORD 1972). Objections have been raised by ROSS

& NEWMAN (1973) and NEWMAN & ROSS (1976), who revising the present-day and ancient balanomorph barnacles offered another taxonomy.

The problem which has not been definitely recognized is the commensal relationship to a definite coral species. The data on the present-day creusioid species indicate rather their preference and not a selective choice of the coral (cf. HIRO [= UTINOMI] 1931, 1935, 1938, 1962, 1967; NILLSON-CANTELL 1938; ROSS & NEWMAN 1973), with one exception, of *Pyrgoma monticulariae* GRAY, 1831, which selects its host (see below). In ancient examples the problem is less studiable, because many creusioid species are known solely from occurrences of the shells (composed of calcite) isolated from aragonitic coralla due to post-depositional solution (cf. BAŁUK & RADWAŃSKI 1976a,b; MORONI 1967; NEWMAN & LADD 1974; PAJAUD 1976a,b; RADWAŃSKI 1977. Pl. 5g-f; ZAMMIT-MAEMPEL 1977, Pl. 27a-c). The Korytnica Clays make up an exceptional case as the creusioids are contained (cf. BAŁUK & RADWAŃSKI 1967c) in completely preserved coralla of *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME), what allowed to recognize the mutual biological relationship between these animals. A comparable preservational case has recently been reported (MOISSETTE & SAINT MARTIN 1982) from the Upper Miocene (Messinian) reefal deposits of Oran (Alger), where *Creusia oraniensis* MOISSETTE & SAINT MARTIN, 1982, occurs preferentially in *Porites lobatosepta* CHEVALIER, but less frequently it also does in *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME) and *Porites* aff. *collegniana* MICHELIN. Of the American reports, one from the Miocene deposits of Florida (WEISBORD 1972) concerns *Creusia neogenica* WEISBORD, 1972, in *Siderastraea pliocenica* VAUGHAN, and another one from the Pleistocene of that state (BROOKS & ROSS 1960) concerns *Creusia prefloridana* (BROOKS & ROSS, 1960) in *Manicina mayori* (WELLS). All other occurrences of the ancient creusioids have been surveyed with very poor or none data on the coral host.

OCCURRENCE SITES IN THE KORYTZNICA BASIN

In the Korytnica Basin, the species *Creusia sanctacrucensis* BAŁUK & RADWAŃSKI domiciled in *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME) appears in the topmost part of the Korytnica Clays, deposited under extreme shallow marine conditions (cf. RADWAŃSKI 1969; BAŁUK & RADWAŃSKI 1977, 1979, 1984). The new occurrences of *Creusia moravica* PROCHÁZKA domiciled in specifically undeterminable *Porites* (the genus previously unknown from the Korytnica Basin; cf. DEMBIŃSKA-RÓŻKOWSKA 1932, BAŁUK & RADWAŃSKI 1977) are also confined to the same part of the clay sequence, but they have been recognized in limited areas of only two localities: more commonly at Korytnica-Plebania, and rarely north of Mt. Lysa (see Text-fig. 1).

ENVIRONMENTAL NOTE

Shallow marine conditions, characterized by tropical and/or subtropical climate were established through the whole deposition spantime of the Korytnica Clays. The former record of the creusoid cirripedes (BAŁUK & RADWAŃSKI 1967c) was one of the first approaches to recognize here such very conditions. Gradual shallowing of the Korytnica Basin, due to progressive clay sedimentation, has finely effected in its filling with sediments almost to sea level (cf. RADWAŃSKI 1969, BAŁUK & RADWAŃSKI 1977), what suited the environmental conditions favorable for settlement of the creusoid cirripedes. Further studies upon diverse organic communities of the Korytnica Clays have richly supplemented the above conclusions, especially when recognizing the bivalved gastropods *Berthelinia* (by BAŁUK & JAKUBOWSKI 1968), the inarticulate brachiopods *Discinisca* (by RADWAŃSKA & RADWAŃ-

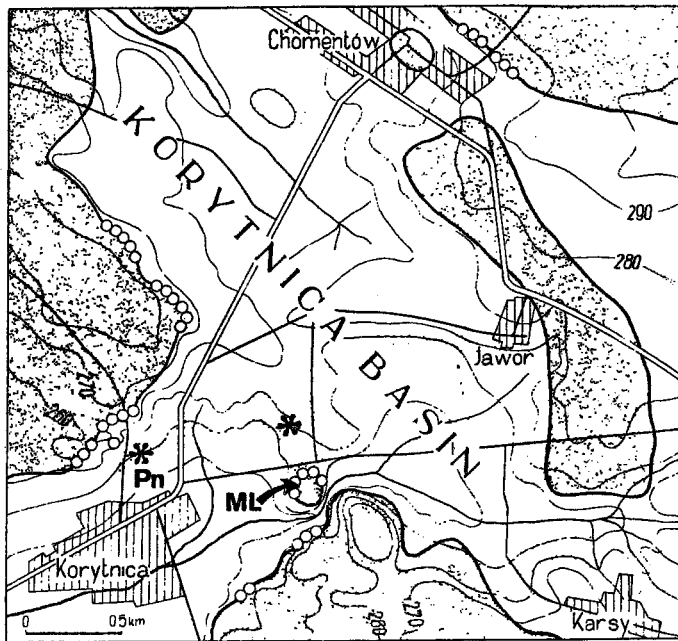


Fig. 1. Paleoenvironmental sketch of the Korytnica Basin (adopted from: BAŁUK & RADWAŃSKI 1977, Text-fig. 2)

Indicated are: marine area of the Korytnica Basin during the Middle Miocene (Badenian) transgression (blank) and present-day outcrops of the Korytnica Clays (stippled), preserved fragments of littoral structures (circled), and land or island areas along the seashore (hachured)

The occurrence sites of the creusoid cirripedes are indicated by asterisks: Korytnica-Plebania (Pn), and north of Mt. Lysa (ML), arrowed is the island of the present-day Mt. Lysa)

SKI 1984), and other invertebrates, some of which are also indicative of the Indo-Pacific bioprovince affinities (cf. BAŁUK & RADWAŃSKI 1977, 1979, 1984).

SYSTEMATIC ACCOUNT

Class Cirripedia BURMEISTER, 1834

Ordo Thoracica DARWIN, 1854

Subordo Balanomorpha PILSBRY, 1916

Family Balanidae LEACH, 1817

Subfamily Creusiinae BAŁUK & RADWAŃSKI, 1967

Genus *Creusia* LEACH, 1817

***Creusia moravica* PROCHÁZKA, 1893**

(Pl. 1, Figs 1-5)

1893. *Creusia moravica* nov. spec.; V. J. PROCHÁZKA, p. 30 and Pl. 2, Figs 2a-2e.

MATERIAL: Numerous, more or less damaged specimens, all embedded in very fragile fragments of *Porites* sp.

REMARKS: The investigated specimens, represented primarily by more or less damaged shells (see Pl. 1, Figs 3a-3c), or isolated crowns (see Pl. 1, Fig. 2), and rarely by almost complete shells devoid, however, of opercular plates (Pl. 1, Fig. 1), are attributable to the species *Creusia moravica* PROCHÁZKA, 1893, known exclusively from the original description, and reported by PROCHÁZKA (1893) from the Middle Miocene (Badenian) deposits of Moravia in Czechoslovakia (Lomnice, Mikulov = Nikolsburg, Drnovice) and Wöllersdorf in the Vienna Basin, Austria.

The species has formerly been put into synonymy of *Creusia costata* (SEGUENZA 1876), both by the present authors (BAŁUK & RADWAŃSKI 1967c; p. 477) and by the others (ROSS & NEWMAN 1973, p. 166; NEWMAN & ROSS 1976, p. 58). A redescription of the species, and a revision of successive determinations given by SEGUENZA in his four papers in the period of 1872-1876, has allowed MORONI (1967) to designate the neotype of the species (MORONI 1967, Pl. 10, Figs 1a-1d and Pl. 13, Figs 1a-1h) as the originals of SEGUENZA had been lost during the earthquake of Messina in 1908. This neotype however differs so much from some specimens illustrated under this name by SEGUENZA (1876), and from those either included formerly into the synonymy of the species (cf. BAŁUK & RADWAŃSKI 1967, ROSS & NEWMAN 1973, NEWMAN & ROSS 1976) or reported under this name (e.g., ZAMMIT-MAJEMPEL 1977, Pl. 27c), that the present authors feel justified in regarding the species established by PROCHÁZKA (1893) as a valid one, and distinctly separate from the neotype designated by MORONI (1967).

The investigated specimens display the basis elongated less than the crown length (see Pl. 1, Figs 3a-3c), although less so than in specimens investigated by PROCHÁZKA (1893, p. 30). They are also smaller (maximum carino-rostral length 4 mm, against 7.9-8.0 mm recorded by PROCHÁZKA), and their bear a lesser number of ribs (20-22, against 28-32 recorded by PROCHÁZKA). Consequently, it is thought that the investigated specimens from the Korytnica

Basin are either dwarfish or juvenile forms of the species. To this species assigned are also the external casts of the bases, recognizable in many fragments of *Porites* sp., which are of the same size and indicate the presence of about 20 ribs in a basis (see Pl. 1, Figs 4–5). All the collected specimens are brownish in color and bear no signs of primary coloration of the shell.

Creusia sanctacrucensis BAŁUK & RADWAŃSKI, 1967

(Pl. 2; Pl. 3, Figs 1–3; and Pl. 4, Figs 1–3)

1967(c). *Creusia sanctacrucensis* n. sp.; BAŁUK & RADWAŃSKI, pp. 468–475, Text-figs 1–5 and Pls 1–6.

REMARKS: This species, typical component of organic communities in the topmost part of the Korytnica Clays (cf. BAŁUK & RADWAŃSKI 1977, Fig. 5), remains still unknown outside the Korytnica Basin. The previous material (cf. BAŁUK & RADWAŃSKI 1967c) has been supplemented by many specimens, all embedded in *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME). In some coralla, the species occurs gregariously, as exemplified by a fragmented corallum, which at one temporary growth-surface about 15 sq cm large (see Pl. 2), contains 48 specimens, and 12 others just beneath. All these specimens are slightly smaller than those growing singly or in small groups (cf. BAŁUK & RADWAŃSKI 1967c, Pl. 1, Fig. 1). The adaptation of the corallite pattern in colonies of *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME) is always the same, and indicates a mutual growth of the creusoid and this coral species (see Pl. 3, Figs 1–3; taken from BAŁUK & RADWAŃSKI 1967c, Pls 2–3). The morphology of the crown and opercular plates agrees with that presented in the original description (see Pl. 4, Figs 1–3; taken from BAŁUK & RADWAŃSKI 1967c, Pl. 4). Noteworthy is the coloration of the shell, preserved in the form of grayish-violet, bluish-cherry or slightly pinkish bands, usually 2 to 5 in number (rarely one, as in Pl. 4, Fig. 1), and much variable in their width and position in particular specimens (compare Pl. 2 and Pl. 4, Figs 1–3).

ECOLOGICAL CONCLUSIONS

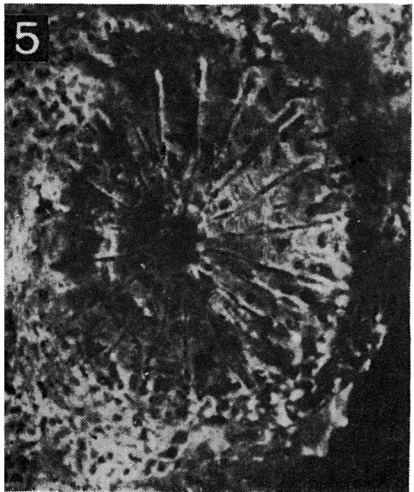
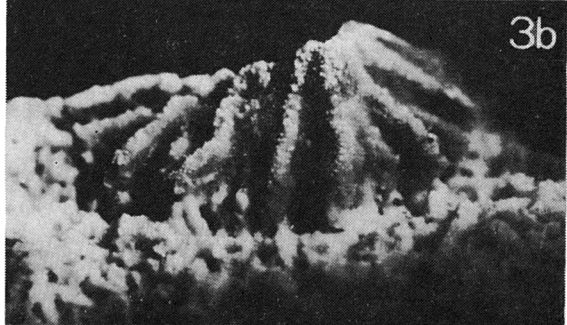
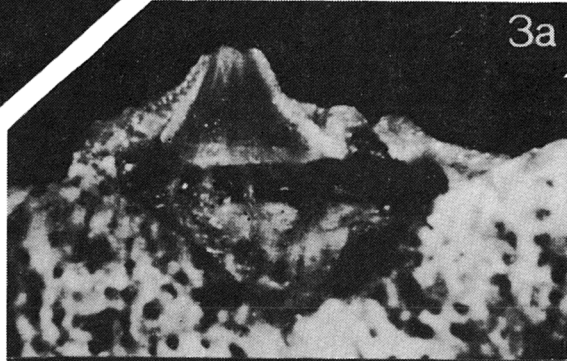
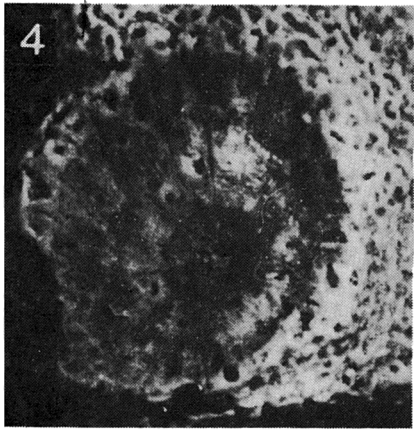
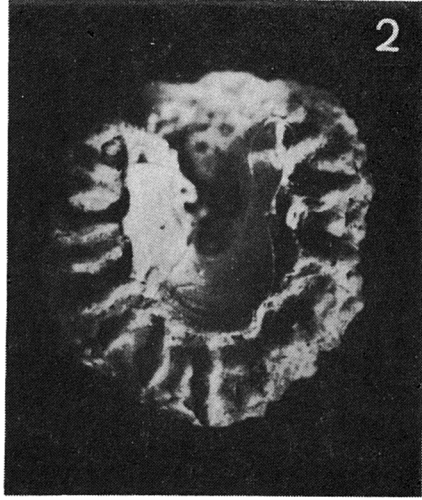
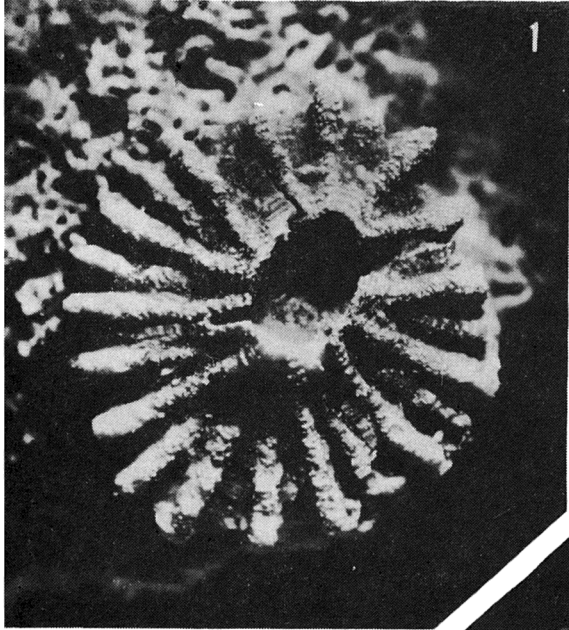
The new data on the occurrence of creusoid cirripedes in the Korytnica Basin, and the reports on both present-day and ancient forms published in the last two decades, allow to make some conclusive remarks on the host specificity of these cirripedes.

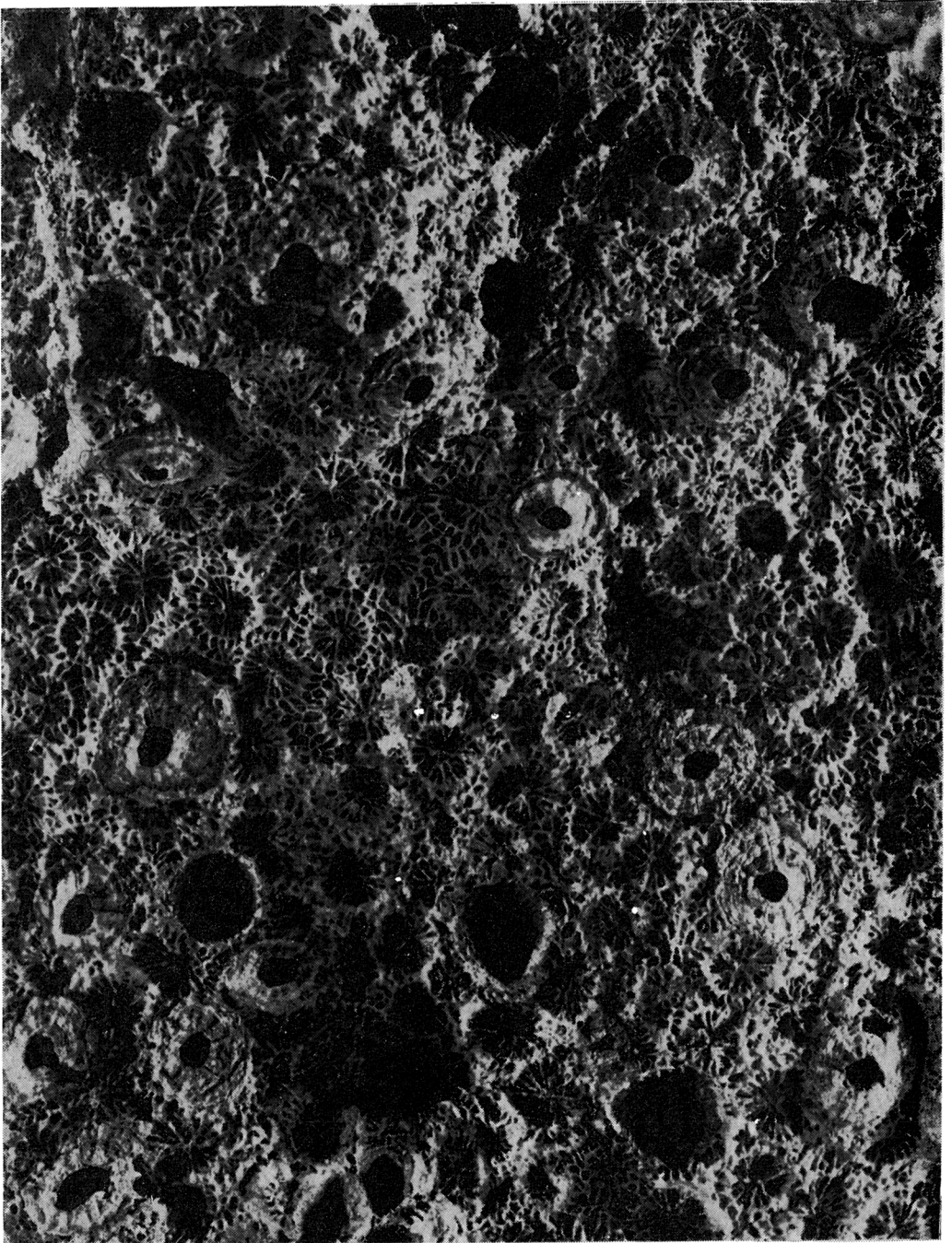
PLATE 1

Creusia moravica PROCHÁZKA in *Porites* sp. from the Korytnica Clays

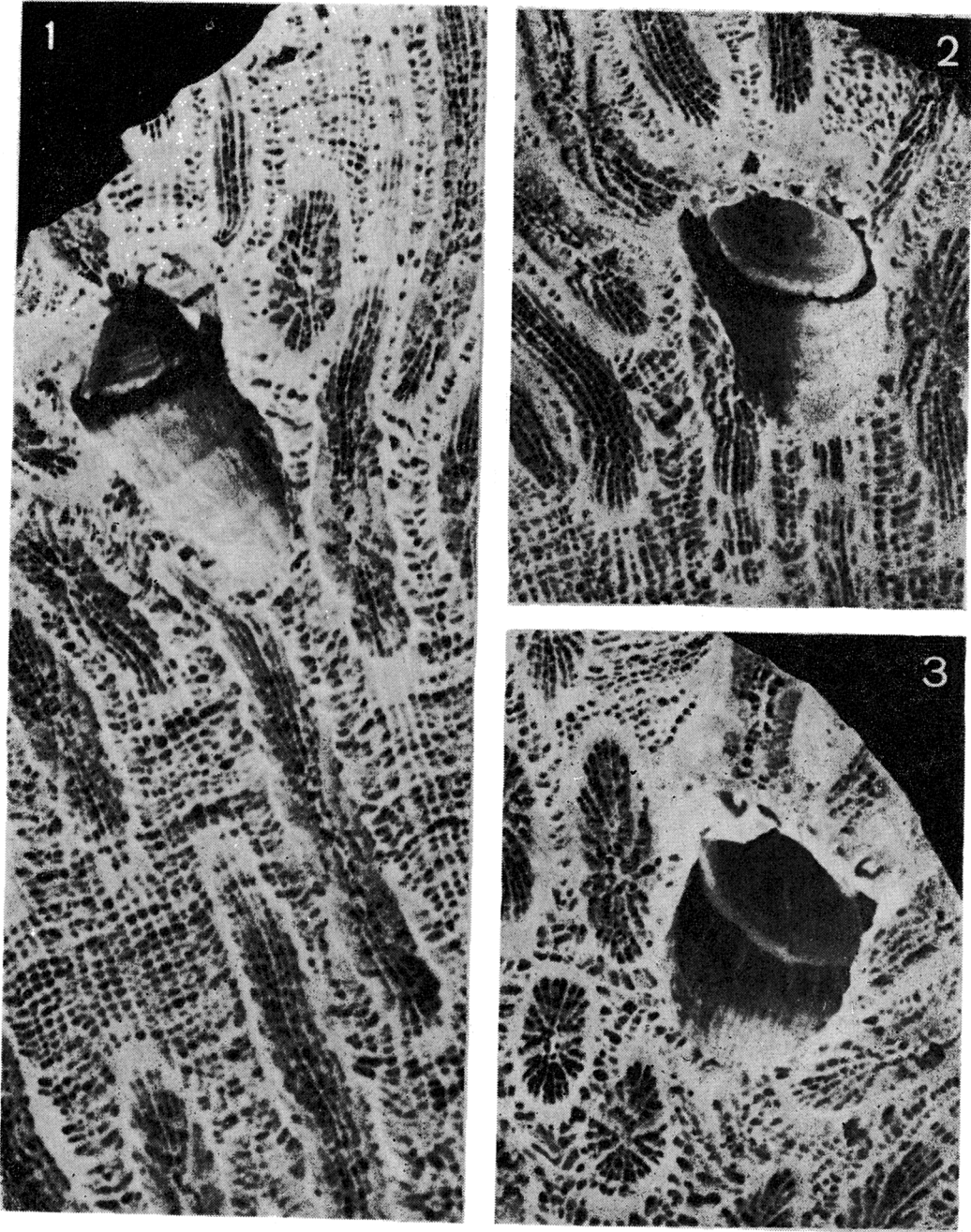
- 1 — Upper view of the best preserved specimen (carina oriented upwardly; four sutures well visible in the crown); taken x 15
- 2 — Inner side of another crown, with its carina broken off; taken x 15
- 3 — Partly damaged shell in inner side (3a), outer side (3b), and upper (3c) views
- 4-5 — External casts of the bases embedded in fragmented coralla; taken x 10

Photos taken by L. ŁUSZCZEWSKA, M. Sc. and by K. ZIELIŃSKA



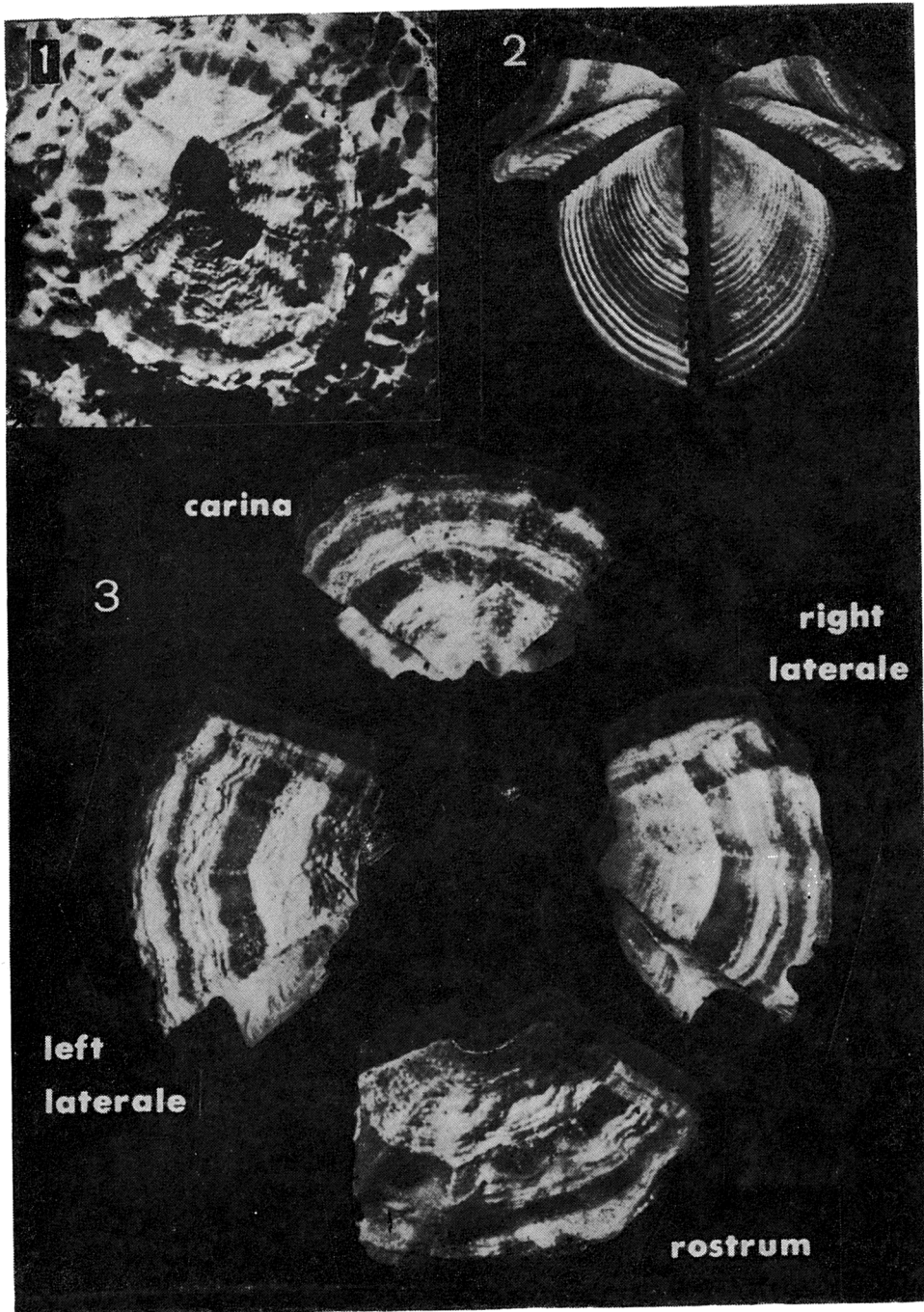


Mass-occurrence of *Creusia sanctacrucensis* BAŁUK & RADWAŃSKI at the temporary growth-surface of *Tarbellastraea reussiana* (MILNE-EDWARDS & HAI-ME) from the Korytnica Clays; the outermost layer of the colony has been removed; taken x 5



Disturbances of the corallite pattern in *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME) from the Korytnica Clays, caused by the commensal growth of *Creusia sanctacrucensis*: taken x 4

Photos taken by B. DROZD, M. Sc.



Creusia sanctacrucensis BAŁUK & RADWAŃSKI
from the Korytnica Clays

- 1 — Complete crown (rostrum partly broken at the orifice), with the color band near the crown edge, embedded in *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME); taken x 10
- 2 — Opercular plates of the holotype, with two color bands; taken x 15
- 3 — Separated compartments of another specimen (rostrum partly damaged), with five color bands; taken x 15

Photos taken by L. ŁUSZCZEWSKA, M. Sc.

The Korytnica example demonstrates that within an environment where two species of the colonial corals are present, a definite creusioid species is selectively confined to one coral species (cf. Pls 1—4): *Creusia sanctacrucensis* BAŁUK & RADWAŃSKI to *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME), and *Creusia moravica* PROCHÁZKA to *Porites* sp. A similar selectivity is also noted in the afore-given examples from the Mio-Pliocene and Pleistocene of Florida (BROOKS & ROSS 1960, WEISBORD 1972). In the Late Miocene of Oran, an endemic creusioid species (MOISSETTE & SAINT MARTIN 1982) inhabits however the three species of corals, *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME) including. The latter coral species is therefore not specifically selected by a definite creusioid species. This coral species, common in the Miocene deposits of Europe and North Africa, has also been reported as inhabited by diverse creusioids (some of them specifically indeterminate; see BAŁUK & RADWAŃSKI 1967c) from Lapugy in the Transylvanian Basin, Rumania (ABEL 1928, 1935), Forchtenau in the Vienna Basin, Austria (ABEL 1928, 1935), and a few localities in northern Bulgaria (KOŁOSVÁRY 1962). The hitherto available reports on the ancient creusioids have not offered any example of a coral domiciled by more than one creusioid species, and comparable to the case which has once been observed by HIRO (1931, p. 154). Consequently, it is thought that the ancient occurrences of creusioid cirripedes concern primarily the environments sparsely populated by the corals, and then the species selectivity could realize; in the reefal environment of Oran, densely populated by the corals (cf. MOISSETTE & SAINT MARTIN 1982), one creusioid could however domicile diverse hosts.

In all the ancient cases, the mutual relationship of the creusioid cirripede and the coral is evidently commensal (BAŁUK & RADWAŃSKI 1967c; NEWMAN, JUMARS & ROSS 1976). The only exception has been recognized in the present-day, much peculiar species *Pyrgoma monticulariae* GRAY, 1831, an endemite to the Indian Ocean, Singapore, and Japan (cf. HIRO 1935; ROSS & NEWMAN 1969, 1973; NEWMAN & ROSS 1976), which occurs exclusively in the species *Hydnophora exesa* (PALLAS) and becomes its parasite (ROSS & NEWMAN 1969).

A mass occurrence of *Creusia sanctacrucensis* BAŁUK & RADWAŃSKI in some colonies of *Tarbellastraea reussiana* (MILNE-EDWARDS & HAIME) in the Korytnica Basin, as exemplified by a specimen with some fifty specimens at a temporary growth-surface of the coral colony (cf. Pl. 2), indicates that even dense population has not been dangerous for the colony life. This colony has evidently survived a temporary settlement and growth of the creusioids, without any disturbance of its development. Similar cases of gregarious occurrence of the ancient creusioids in one colony (ABEL 1928, Pl. 1, Fig. 6; BROOKS & ROSS

1960, Pl. 6, Fig. 1) have formely been discussed in the terms of either parasite-influenced mortality (ABEL 1928), or ecological competition (BAŁUK & RADWAŃSKI 1967c, p. 493). These few ancient examples of the gregarious creusoid cirripedes evidence a high tolerancy of the colonial corals against their commensals since the Miocene time.

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