

CYPRIAN KULICKI

NEW OBSERVATIONS ON *RHABDOPLEURA KOZLOWSKII*
 (PTEROBRANCHIA) FROM THE BATHONIAN OF POLAND

Abstract. — Specimens of *Rh. kozlowskii* Kulicki, 1969 have here been described from the Bathonian of southern Poland. A secondary layer, never observed before, has been found inside zooidal tubes.

INTRODUCTION

At present, the genus *Rhabdopleura* is represented by at least two species clearly different from each other, i.e. *Rh. normani* Allman, 1869 and *Rh. striata* Schepotieff, 1909. All other Recent species display a considerable similarity to *Rh. normani* and the necessity to distinguish them is called in question by many investigators (Schepotieff, 1906; Dawydoff 1948; Thomas & Davis, 1949; Burdon-Jones, 1954 and others). The species *Rh. compacta* Hincks, 1880 has recently been restored by Stebbing (1970), who concludes that *Rh. compacta* differs from *Rh. normani* mostly in the form of colonies and lack of ring-shaped part of the stolon.

The following three fossil species have hitherto been described: *Rh. vistulae* Kozłowski, 1956 from the Danian of Poland, *Rh. eocenica* Thomas & Davis, 1949 from the Eocene of England, and *Rh. kozlowskii* Kulicki, 1969 from the Callovian of Poland.

The specimens of *Rh. kozlowskii*, described in the present paper, were etched with hydrochloric acid from calcareous-marly concretions which occur in black and dark-gray Bathonian clays, *Morrisiceras morrisi* Zone (Różycki, 1953) of Blanowice near Zawiercie. The concretions, varying in shape, are mostly spherical or ellipsoidal and fluctuate in size between a few and some scores of centimetres. Many of the concretions collected contain a macrofauna of molluscs or pieces of wood. The remains of hydroids, scolecodonts, organic linings of foraminifers, plant remains and other, unidentified remains, including many similar to the Callovian ones

from Łuków (Kulicki, 1969), were etched out along with the remains of *Rhabdopleura*. The specimens of *Rh. kozłowskii* from the Bathonian of Blanowice are preserved much the same as those from the Callovian of Łuków and are represented by these same elements of tubarium.

Specimens of *Rh. normani* from Bergen, Norway, have been used by the present writer as a comparative material. The terminology of the elements of tubarium has been adopted according to Kozłowski (1956) and the writer's previous work (Kulicki, 1969). Schepotieff's definition "steril Knospe" (sterile bud) was replaced by the writer (after Stebbing) with the term "dormant bud". Schepotieff (1907) believed that the buds contained in cysts, could not be turned into zooids. Stebbing studies (1970) have, however, shown that such buds may develop into normal individuals and, therefore, the term a dormant bud is more appropriate for them. A diagram of fundamental measurements of various elements of tubarium is shown in Fig. 1.

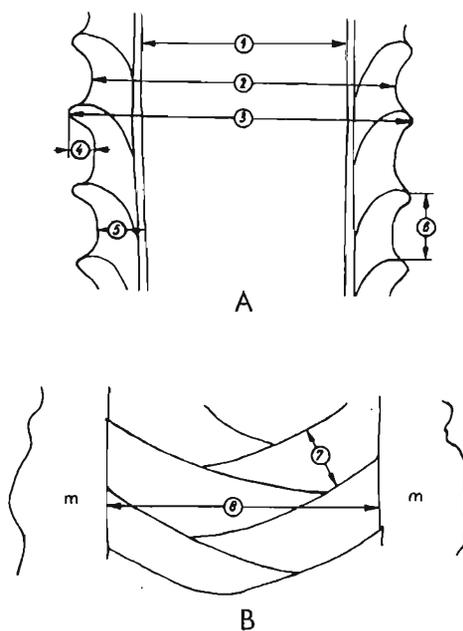


Fig. 1. — Diagram of fundamental measurements of zooidal (A) and stolonal (B) tubes of the genus *Rhabdopleura*: 1 inner diameter, 2 outer diameter without fusellar collars, 3 outer diameter with fusellar collar, 4 width of fusellar collar 5 thickness of wall of zooidal tube, 6, 7 width of fusellus, 8 outer diameter of stolonal tube, *m* marginal membrane.

The specimens of *Rh. kozłowskii* and *Rh. normani* described in the present paper are housed at the Palaeozoological Institute, Polish Academy of Sciences, for which the abbreviation Z. Pal. is used.

DESCRIPTION

Family **Rhabdopleuridae** Harmer, 1905

Genus *Rhabdopleura* Allman, 1869

Rhabdopleura kozłowskii Kulicki, 1969

(Text-figs. 2—7)

1969. *Rhabdopleura kozłowskii* Kulicki, 1969; C. Kulicki, The discovery..., pp. 540, 542, 544, 545; Figs. 1E, 3B, 4A, 5J.

Material. — Thirty-one fragmentary zooidal tubes, seven fragmentary stolonal tubes, 23 variously-sized fragments of stolons and 69 cysts of dormant buds, some of them with stolons.

Description. — *Zooidal tubes.* A diameter of the erect parts of zooidal tubes, the width of fusellar collars not taken into account, varies within limits of 124 and 189 μ , averaging 154 μ , whereas a diameter of tubes including fusellar collars amounts to 143—235 μ , averaging 178 μ ; a mean width of a fusellar collar amounts to 12 μ . The width of fuselli varies from 20 to 53 μ , averaging 42 μ . Within the range of particular zooidal tubes, the width of fuselli is considerably variable although the differences do not exceed extreme values.

In many specimens from Blanowice and Łuków, one or two layers of skeletal substance, similar to that which forms the fusellar part of tube and which is termed by the writer a secondary layer (Figs. 3, 7) occur inside zooidal tubes under the fusellar layer. The secondary layer does not display any traces of fusellar structure. All injuries and cracks of the secondary layer (cf. Fig. 3) run along the longitudinal axis of tube. A peculiar texture of secondary layer with parallel and closely spaced, dark striae running along the longitudinal axis of tube are visible in strong magnification. No such texture can, on the other hand, be observed in the fusellar layer. The secondary layer is frequently thicker inside tubes with small than normal and large diameters. In one case, the secondary layer is double (Fig. 3) and in many specimens it is not observed at all.

Stolonal tubes. The width of stolonal tubes, minus the marginal membrane, amounts to 130 to 158 μ , averaging 154 μ , and the width of their fuselli fluctuates within limits of 30 and 58, averaging 39 μ . The lower, flat wall of stolonal tubes is frequently lacking. It is much thinner than the convex wall.

Stolons. In transverse section, stolons are semicircular, with an upper wall convex and lower flat and several times thinner than the convex one. The width of stolons varies from 25 to 51 μ , averaging 38 μ . Such a variability is even observed within a specimen of a bifurcated stolon. In places of bifurcation, a lateral stolon may be separated from the main

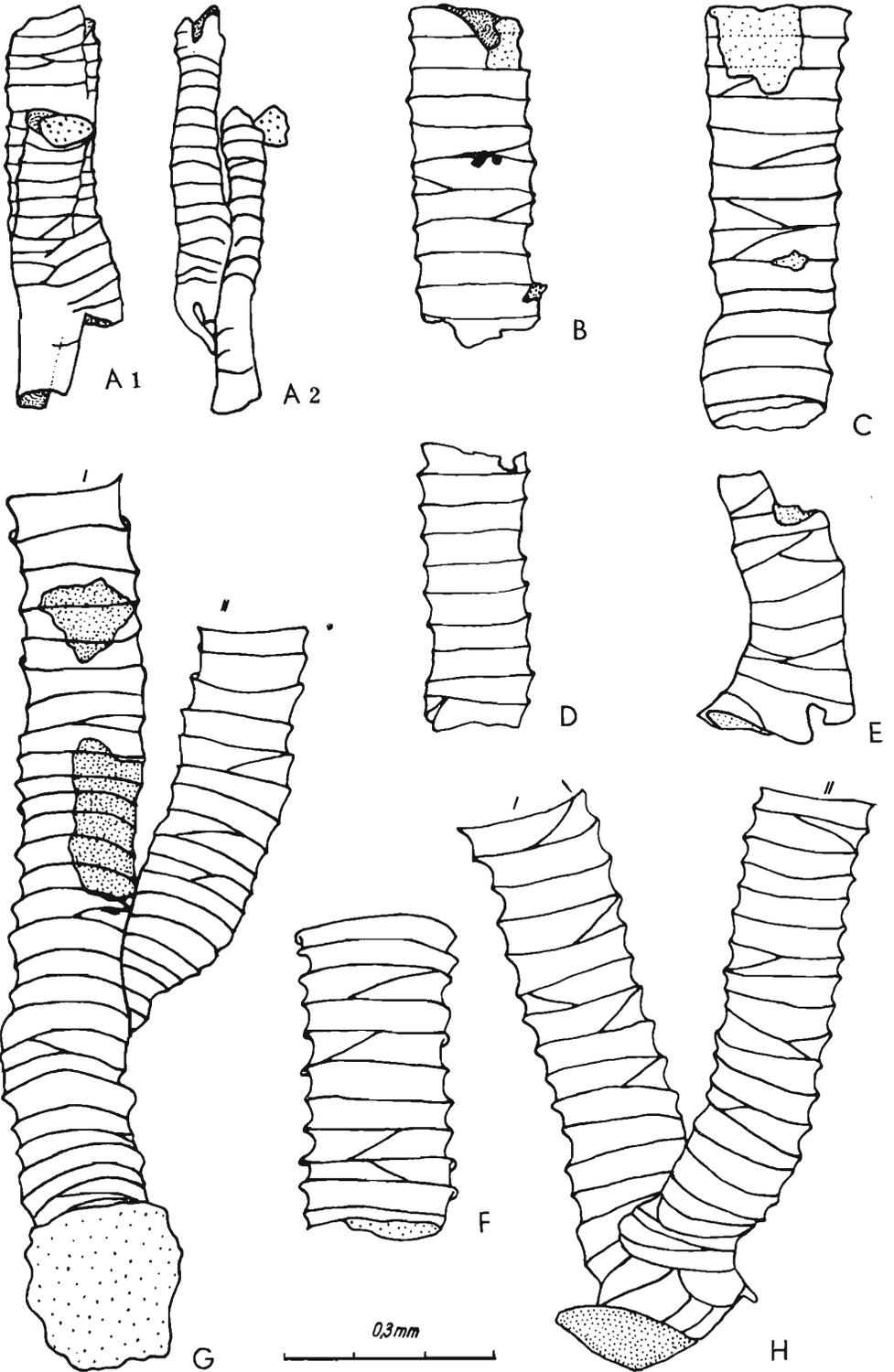


Fig. 2

one by a few diaphragms having 7—9 μ wide pores. The diaphragms are mostly situated in contractions of the vesicular extensions of the proximal part of the lateral stolon. Peduncular and lateral stolons detach themselves alternately from the main one at intervals of about 310 to 630 μ . Peduncular stolons are short and vesicular, mostly provided with two or three diaphragms having 4—9 μ wide (averaging 7 μ) pores. Peduncular stolons with a higher number of diaphragms were also observed (Fig. 5 B, C₃).

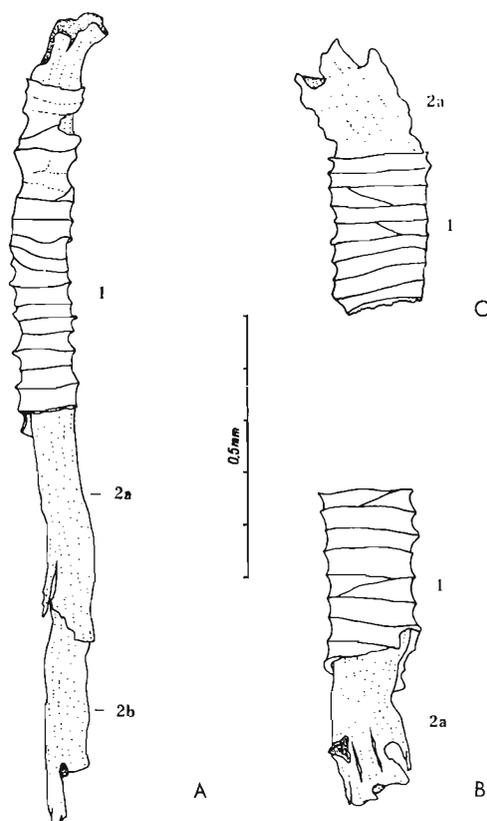


Fig. 3. — *Rhabdopleura kozlowskii* Kulicki (Z. Pal. Pb. II/8—10): A a zooidal tube, Bathonian, Blanowice; B—C zooidal tubes, Callovian, Łuków: 1 a fusellar layer of a zooidal tube, 2a, 2b particular laminae of a secondary layer.

Cysts of dormant buds. The cysts of dormant buds resemble in shape the proximal part of a contractile stalk of a zooids (Schepotieff, 1907) and they are formed on its basis (Stebbing, 1970). The width of the cysts of dormant buds, which closely adhere to the walls of stolonial tubes, varies

Fig. 2. — A *Rhabdopleura* sp., Bathonian, Blanowice: zooidal tubes connected by common fuselli (Z. Pal. Pb. II/1); B—F *Rh. kozlowskii* Kulicki, Bathonian, Blanowice: erect part of zooidal tubes (Z. Pal. Pb. II/2—7); G—H *Rh. normani* Allman, Recent, Bergen, Norway: bifurcated zooidal tubes (Z. Pal. Pb. I/101).

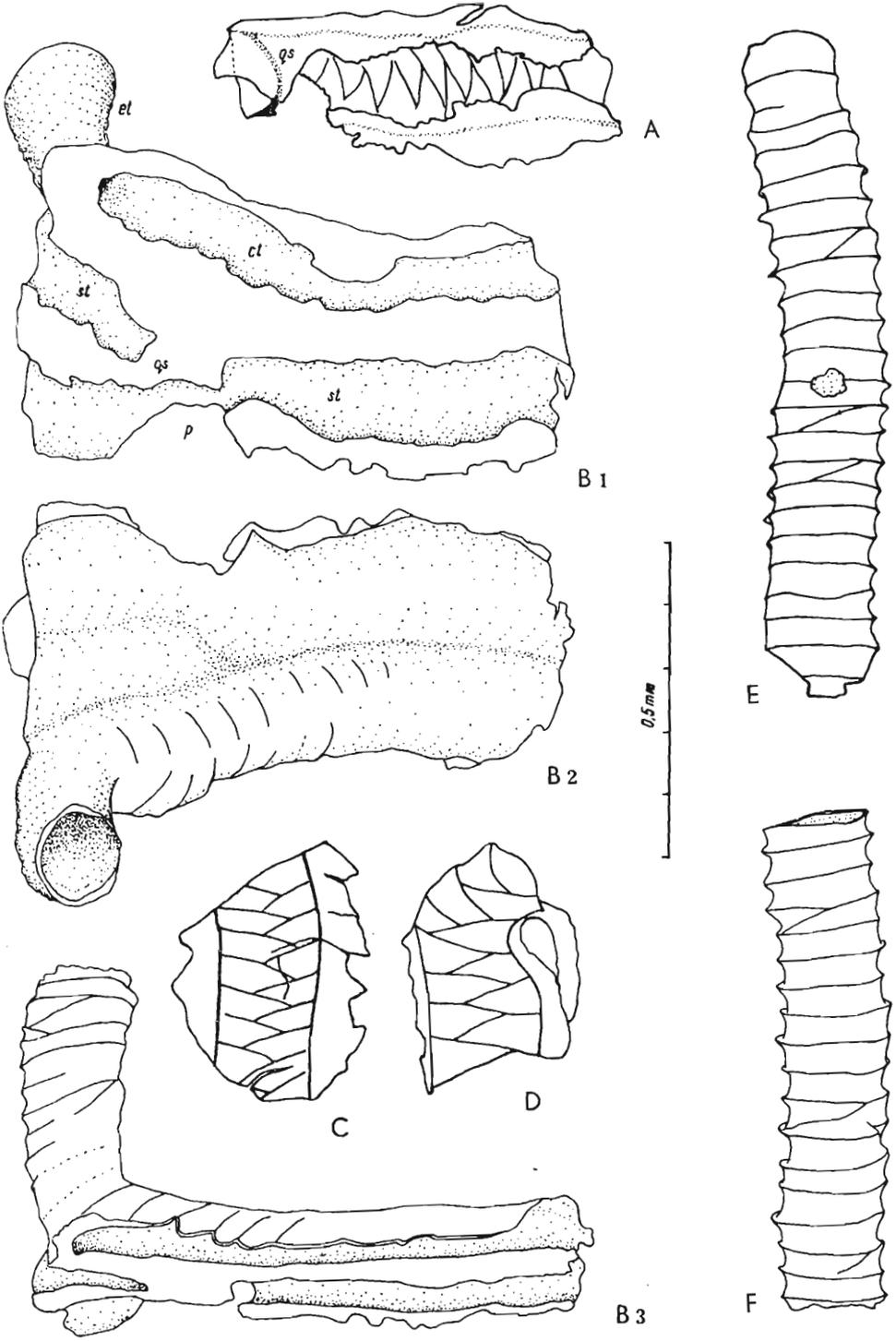


Fig. 4

within limits of 85 and 166 μ , averaging 129 μ , and their length 260 and 460 μ , averaging 344 μ .

Remarks. — The dimensions of the specimens of *Rh. kozłowskii* from the Bathonian of Blanowice are contained within the range of individual variability of the specimens of this same species from the Callovian of Łuków. Mean dimensions of the elements of tubarium are approaching each other in the two forms. In other respects, the stolon tubes and cysts of dormant buds in the Bathonian form do not differ radically from the Callovian one or from the remaining species, except for *Rh. striata*. A certain number of peduncular stolons, divided by a larger number of diaphragms and being longer than those of the Callovian, specimens from Łuków (Fig. 5, B, C₃), which occur among the Bathonian specimens make up a small differences between them. This difference is, however, too small to constitute a basis for the distinction of the Bathonian form as a separate species. As follows from Kozłowski's (1956) and Kulicki's (1969) studies, the structure of peduncular stolons and the shape of the transverse section of the main stolon are of a decisive importance to distinguishing species.

The secondary layer, internally lining the ascending parts of zooidal tubes, is a quite new skeletal element observed in *Rh. kozłowskii* only. The occurrence of a thicker or bilaminar secondary layer inside the tubes with small or normal diameters or its frequent lack in the tubes with large diameters, induce the present writer to conclude that the secondary layer played a reinforcing role. Its presence and degree of thickening depend on the length and diameter of the tubes and on environmental conditions.

What is known as longitudinal ribs, occurring inside zooidal tubes between the creeping and ascending part of a tube was described by Schepotieff (1907) in *Rh. normani* as reinforcing elements. This author found that, in the case of short zooidal tubes, the longitudinal ribs do not occur at all or are poorly developed. No reinforcing elements have been found in *Rh. vistulae* Kozłowski.

Figs. 2 A₁ and A₂ show zooidal tubes, which closely adhere to each other and whose fusellar systems are connected with each other by common fuselli. This close connection might be formed in the case of a simultaneous growth of both tubes, which probably were parts of one and the same colony. Due to their small diameters (without fusellar collars amounting to 90 and 133 μ and with fusellar collars — to 101

Fig. 4. — *Rhabdopleura kozłowskii* Kulicki, Bathonian, Blanowice (Z. Pal. Pb. II/11—16): A a stolon tube with a transverse septum, dorsal view; B₁₋₃ a fragment of a colony, B₁ dorsal view, B₂ ventral view, B₃ lateral view; C—D stolon tubes, ventral view; E—F zooidal tubes, qs transverse septum, ct creeping part of a zooidal tube, et erect part of a zooidal tube, st stolon tube, p attachment place of a zooidal tube.

and $143\ \mu$) and width of fuselli, smaller than in the remaining specimens from Łuków and Blanowice (24 and $25\ \mu$), their assignment to *Rh. kozłowskii* and other known species remains uncertain.

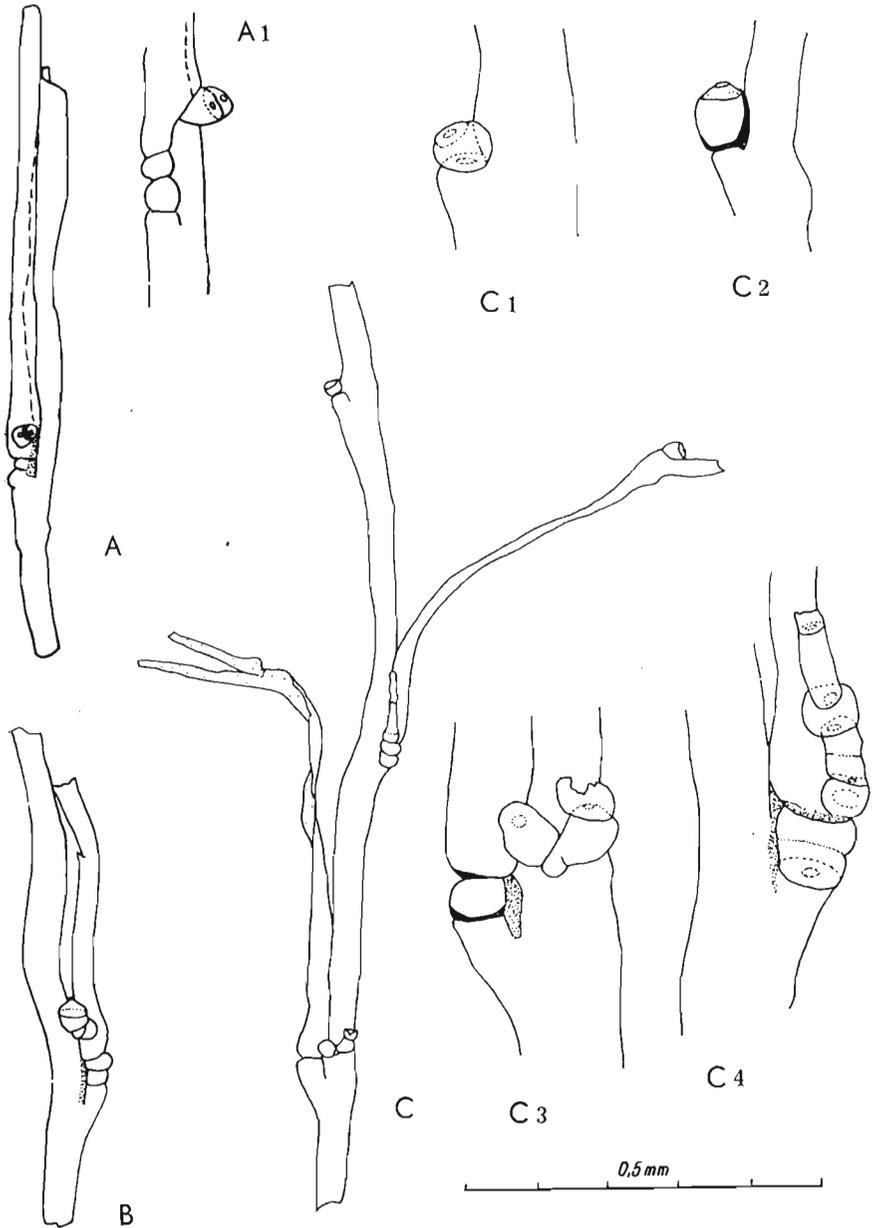


Fig. 5. — *Rhabdopleura kozłowskii* Kulicki, Bathonian, Blanowice (Z. Pal. Pb. II/17—19): A—B bifurcated stolons with peduncular stolons; C a bifurcated stolon with five, clearly visible peduncular stolons, C₁—C₂ peduncular stolons with two diaphragms, C₃ a peduncular stolon with at least four complete and one incomplete diaphragm C₄ a peduncular, abnormally developed stolon.

In *Rh. kozlowskii*, the proximal parts of ascending zooidal tubes have smaller diameters than the distal parts. Besides, they have poorly developed fusellar collars and, frequently, narrower fuselli (Figs. 2E, 4B). A similar growth of zooidal tubes, which may be explained by a zooid growth in the process of forming the tube may sometimes be observed

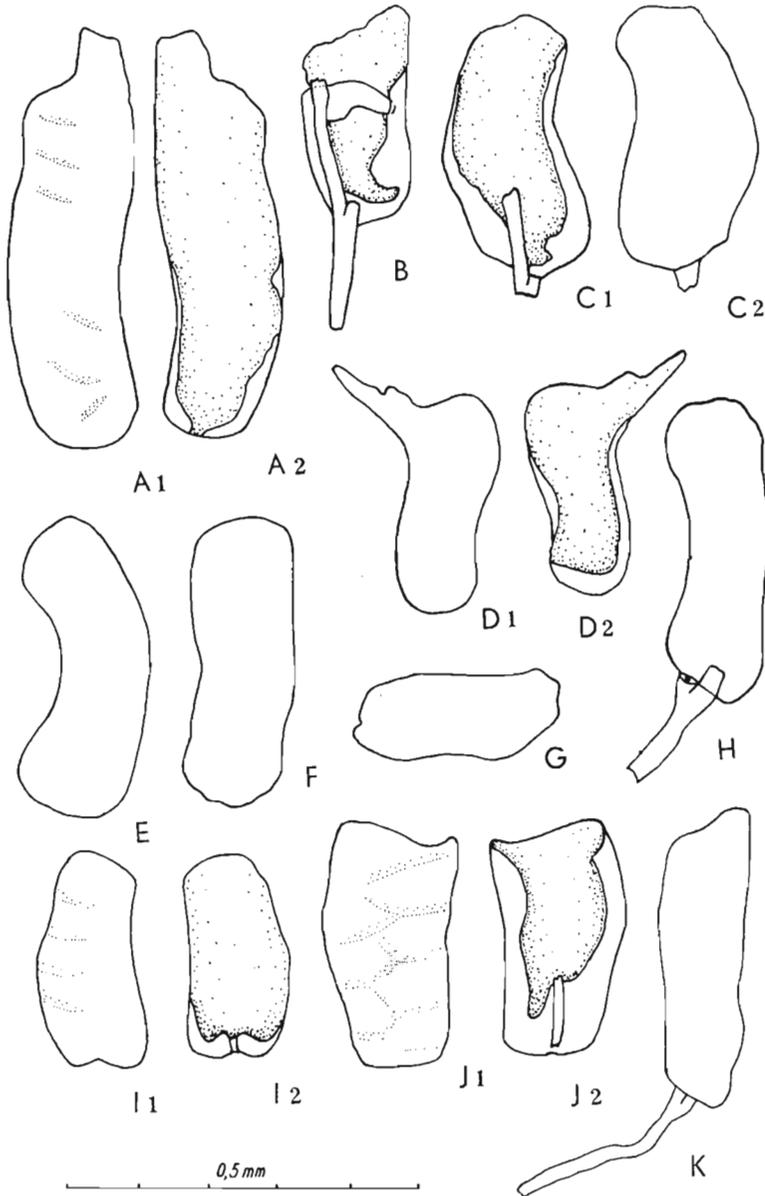


Fig. 6. — A—B *Rhabdopleura normani* Allman, Recent, Bergen, Norway; cysts of dormant buds (Z. Pal. Pb. I/101): A₁ ventral view, A₂, B dorsal view; C—K *Rh. kozlowskii* Kulicki, Bathonian, Blanowice; cysts of dormant buds (Z. Pal. Pb. II/20—28): C₂, D₁, E—H, I₁, J₁ ventral view, C₁, D₂, I₂, J₂ dorsal view.

in *Rh. normani* (Schepotieff, 1907). Bifurcated zooidal tubes were observed by Kozłowski (1948, Fig. 14) and the present writer (Figs. 2 G, H) in the Recent material. In such cases, one of the branches is always older than the other. Impurities of various types occur in the distal parts of older tubes. Most likely, these impurities got inside the tubes in the process of and after the degeneration of an zooid when it was incapable of removing them. In the case of the regeneration of this same zooid, it used the same zooidal tube, if it was not excessively filled with impurities or, if it was, only its proximal part, with a simultaneous construction of a new zooidal tube, which was built after perforating an opening in the old tube. Such an explanation results from the facts that the new tube beings with a smaller diameter and narrower fuselli and has less prominent fusellar collars than its distal part, which allow one to suppose that a repeated growth of the zooid took place as a new tube was formed. The processes of degeneration and regeneration of the zooids were described by Schepotieff (1907) and Stebbing (1970).

Ecological remarks. — Recent representatives of *Rhabdopleura* are widely distributed over the Earth. In the southern hemisphere, they were recorded near Celebes, New Zealand, Tasmania, South Australian coasts and Antarctica (Johnston, 1937). In the northern hemisphere, they occur near Ceylon (Schepotieff, 1909) in the Bay of Marseilles, in the Atlantic Ocean, in the Bay of Biscay, in the North Sea, Norwegian Sea, Barents Sea, in Davis Straits near Greenland, as well as in the Arctic Sea near Spitsbergen (cf. Burdon-Jones, 1954 and Stebbing, 1970). The depths at which the genus occurs range from 2 m in the case of *Rh. striata* (Schepotieff, 1909) and 5 m of *Rh. normani* (Burdon-Jones, 1957) to 896 m (Stebbing, 1970). The salinity of waters in which *Rh. normani* is found fluctuates within limits of 33 and 35‰ (Burdon-Jones, 1954) and their temperature -1°C (Stebbing, 1970) and $+12^{\circ}\text{C}$ (Burdon-Jones, 1954). Recent colonies of *Rhabdopleura* occur attached on other organisms such as corals, bryozoans, serpulids or on the shells of molluscs, on stones and even directly on a rocky, stony, gravelly, sandy, clayey and loamy bottom. They are accompanied by molluscs, tunicates, brachiopods, bryozoans, serpulids and other polychaetes, corals, hydroids, sponges and foraminifers (Burdon-Jones, *l.c.*, Stebbing, *l.c.*).

Rh. kozłowskii Kulicki, 1969 found at Łuków occurs in calcareous concretions embedded in clays. These same concretions contain the remains of echinoderms, shells of molluscs, brachiopods, bryozoans, polychaetes, hydroids, spicules of sponges, foraminifers and remains of land plants (Makowski, 1952; Kulicki, 1969). Likewise, specimens of *Rh. kozłowskii* from the Bathonian of Blanowice were found in calcareous-marly concretions occurring in black and gray clays, together with molluscs, hydroids, polychaetes, foraminifers and remains of land plants. The genera



Fig. 7. — A—C *Rhabdopleura kozłowskii* Kulicki, Callovian, Łuków: longitudinal section through the wall of zooidal tube in its erect part; a secondary layer variable in thickness clearly visible under a fusellar layer (Z. Pal. Pb. II/29—31); D *Rh. normani* Allman, Recent, Bergen, Norway: a longitudinal section through the wall of a zooidal tube in its erect part (Z. Pal. Pb. I/101).

of gastropods from the Callovian of Łuków: *Turbo*, *Trochus*, *Natica*, *Turritella* and *Ceritium*, as well as pelecypods: *Lima*, *Pinna* and *Leda* occur at present from the water level down to a depth of 400 m (Davitashvili & Merklin, 1966, 1968). A mean depth of their occurrence amounts to about 135 m.

The Recent *Rh. normani* most frequently occurs at a depth between 100 and 300 m (Schepotieff, 1906). Since the concentration of fauna in

the Łuków concretions was probably accompanied by waving (Makowski, 1952, p. IX), we may assume that the depth of a sea basin, in which the Callovian fauna lived, was approaching 100 to 150 m and, therefore, it was contained within the range of the optimum occurrence of *Rh. normani*. Likewise, the temperature requirements of *Rh. kozłowskii* are within limits characteristic of a Recent species. On the basis of ammonites from Łuków and using the isotopic methods, Stahl & Jordan (1969), have evaluated a palaeotemperature at 12.5—13.5°C, which may be placed near the upper limit of *Rh. normani*'s temperature requirements. The type of deposits and faunal associations in which *Rh. eocenica* and *Rh. vistulae* occur are similar to those of *Rh. normani* and *Rh. kozłowskii*. It is also the Ordovician *Eorhabdopleura urbaneki* Kozłowski, 1970, displaying a great morphological similarity to the genus *Rhabdopleura* Allman (Kozłowski, 1970)¹, that probably lived at moderate depths (found in an organodetrital limestone). Considering that all fossil species of the genus *Rhabdopleura* were found in either neritic, or littoral deposits together with shallow water fauna, we may state that the Rhabdopleuridae did not change their ecological requirements, at least from the Jurassic and even Ordovician. This is in conformity with Kozłowski's (1970) statement that the genus *Rhabdopleura* makes up a tribe strongly conservative both morphologically and ecologically.

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Warszawa, Żwirki i Wigury, 93
September, 1970

REFERENCES

- BURDON-JONES, C. 1954. The habitat and distribution of *Rhabdopleura normani* Allman. — *Naturvitensk. Rekke*, **11**, 3—17, Bergen.
- DAVITAŠVILI, L. & MERKLIN, R. 1966. Spravočnik po ekologiji morskich dvustvorok. 5—349, Moskva.
- & 1968. Spravočnik po ekologiji morskich briuchonogich. 5—169, Moskva.
- DAVYDOFF, C. 1948. Class des Ptérobranches. In: P. Grassé, *Traité de Zoologie*, **2**, 454—489, Paris.
- JOHNSTON, T. H. 1937. Australian Antarctic Expedition 1911—1914. — *Sci. Reports*, **C**, Zool. Botany, **3**, 4, 2—8, Sydney.
- KOZŁOWSKI, R. 1948. Les Graptolithes et quelques nouveaux groupes d'animaux du Tremadoc de la Pologne (Graptolity i parę nowych grup zwierząt z tremadoku Polski). — *Palaeont. Pol.*, **3**, I—XII+1—235, Warszawa.

¹ A tentative assignment of this species to a new genus results from the structure of its stolons being unknown, although the known elements of tubarium display a great similarity to these same elements in other representatives of the genus *Rhabdopleura* Allman (Kozłowski, 1970).

- 1956. Sur Rhabdopleura du Danien de Pologne (Rhabdopleura z danu Polski). — *Acta Palaeont. Pol.*, 1, 1, 12—21, Warszawa.
- 1970. Nouvelles observations sur les Rhabdopleuridés (Ptérobranches) Ordoviciens (Nowe obserwacje nad ordowickimi Rhabdopleurida (Pterobranchia) — *Ibidem*, 15, 1, 3—17.
- KULICKI, C. 1969. The discovery of Rhabdopleura (Pterobranchia) in the Jurassic of Poland (Odkrycie Rhabdopleura (Pterobranchia) w jurze Polski). — *Ibidem*, 14, 4, 537—551.
- MAKOWSKI, H. 1952. La Faune Callovienne de Łuków en Pologne (Fauna kelowejska z Łukowa). — *Palaeont. Pol.*, 4, I—X+1—64, Warszawa.
- RÓŻYCKI, S. Z. 1953. Górny dogger i dolny malm Jury Krakowsko-Częstochowskiej. — *Prace Inst. Geol.*, 17, 110—115, Warszawa.
- SCHEPOTIEFF, A. 1906—1907. Die Pterobranchier. — *Zool. Jb. Anat. etc.* (2), 23/24, 463—534, 193—238, Jena.
- 1909. Die Pterobranchier des Indischen Ozeans. — *Zool. Jb. Syst. etc.* (1), 28, 429—448, Jena.
- STAHL, W. & JORDAN, R. 1969. General considerations on isotopic palaeotemperature determinations and analyses on Jurassic ammonites. — *Earth Planet. Sci. Lett.*, 6, 173—178, Amsterdam.
- STEBBING, A. R. D. 1970. The Status and ecology of Rhabdopleura compacta (Hemichordata) from Plymouth. — *J. Mar. Biol. Assoc. Un. Kingdom*, 50, 1, 209—221, Cambridge.
- 1970. Aspects and life cycle of Rhabdopleura compacta (Hemichordata). — *Int. J. Life Oc. Coast. Waters*, 5, 3, 205—212, Heidelberg, New York.
- THOMAS, H. D. & DAVIS A. G. 1949. The pterobranch Rhabdopleura in English Eocene. — *Bull. Brit. Mus. (Nat. Hist.), Geol.*, 1, 1, 1—19, London.

CYPRIAN KULICKI

NOWE OBSERWACJE NAD RHABDOPLEURA KOZŁOWSKII (PTEROBRANCHIA)
Z BATONU POLSKI

Streszczenie

W pracy tej opisano okazy *Rh. kozłowskii* Kulicki, 1969 znalezione w batońskich konkrekcjach w gliniance w Blanowicach koło Zawiercia. Gatunek ten znany był dotychczas z keloweju Łukowa. Nowe znalezisko obniżyło do batonu dolną granicę geologiczną występowania rodzaju. W porównaniach formy batońskiej z kelowejską nie stwierdzono większych różnic ilościowych i jakościowych. Opisano nowy element wzmacniająca, rozwinięty we wznoszącej się części rurek zoidalnych w postaci warstwy wtórnej, nie wykazującej budowy fuzelarnej, wyścielającej wewnętrzną powierzchnię rurek. Znane u współczesnego gatunku *Rh. normani* Allman wewnętrzne żeberka podłużne pełniły zapewne podobną rolę, lecz mniej wszechstronnie niż

warstwa wtórna. Autor uważa, że obecność warstwy wtórnej uzależniona jest od średnicy i długości rurek zoidalnych, a także od wpływów środowiska zewnętrznego. W wyniku porównań morfologicznych i ekologicznych, autor potwierdza wniosek Kozłowskiego (1970), że rodzaj *Rhabdopleura* jest szczepem bardzo starym i konserwatywnym pod względem morfologicznym i ekologicznym.

ЦЫПРІЯН КУЛІЦКІ

НОВЫЕ ДАННЫЕ О *RHABDOPLEURA KOZLOWSKII* (ПТЕРОБРАНХІА)
ИЗ БАТСКОГО ЯРУСА ПОЛЬШИ

Резюме

В работе описаны экземпляры *Rh. kozlowskii* Kulicki, 1969, найденные в батских конкрециях в глиняном карьере местности Бляновице близ г. Заверце. Этот вид до сих пор был известен в келловее района г. Лукув. Новое местонахождение передвинуло в батский ярус нижнюю границу распространения рода. При сравнении батской и келловейской форм существенные различия количественного и качественного характера не были выявлены. Описан новый укрепляющий элемент в восходящей части зооидных трубок в виде вторичного слоя, не проявляющего фюзеллярной структуры, выстилающего внутреннюю поверхность трубок. Известные у современного вида *Rh. normani* Allman внутренние продольные ребра играют, вероятно, подобную роль, однако не настолько всестороннюю как вторичный слой. Автор предполагает, что наличие вторичного слоя зависит от диаметра и длины зооидных трубок, а также от условий внешней среды. На основании морфологических и экологических сопоставлений автор поддерживает взгляд Козловского (1970), который гласит, что род *Rhabdopleura* является древним и консервативным типом в морфологическом и экологическом отношениях.
