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THE DISCOVERY OF *RHABDOPLEURA* (PTEROBRANCHIA) IN THE JURASSIC OF POLAND

Abstract. — Fragments of tubarium of *Rhabdopleura kozlowskii* n.sp., etched from calcareous concretions occurring in Callovian clays in Łapiguz clay pit in Łuków are described. Comparisons with the species *Rh. vistulae* Kozłowski from Danian of Poland and the Recent *Rh. normani* Allman from Norway have shown that *Rh. kozlowskii* n. sp. more strongly resembles the Recent species.

INTRODUCTION

The genus *Rhabdopleura* Allman, 1869 is represented in Recent seas by the following three species: 1) *Rh. normani* Allman, 1869, occurring in the northern hemisphere from the Lofoten to the Azores and from the western coasts of Greenland to the Bay of Biscay, where it lives at a depth of 5—600 m, temperature of 5—12°C and salinity of 33—35‰ (Burdon Jones, 1954); 2) *Rh. striata* Schepotieff, 1909, found on coral reefs near Ceylon at a depth of 2—15 m (Schepotieff, 1909); 3) *Rh. annulata* Norman, 1912, living near Celebes, New Zealand, Tasmania and the coasts of South Australia, at a depth of 75—549 m (Johnston, 1937; Hyman, 1959). We cannot be sure, however, if the species *Rh. annulata* is not conspecific with *Rh. normani*. If such would be the case, the genus *Rhabdopleura* would be represented in the Recent fauna by two species only.

In the fossil state, only two species, i.e. *Rh. eocenica* Thomas & Davis, 1949 from Eocene of England and *Rh. vistulae* Kozłowski, 1956 from Danian of Poland have been known so far.

Rh. kozlowskii n.sp., described in the present paper, is the third and the oldest representative of this genus found in the fossil state. Its remains were separated by etching from a calcareous concretion, about 30 kg in general weight, found in black Callovian clays in a clay pit Łapiguz in Łuków about 100 km south-east of Warsaw.

The Callovian clays outcropped in Łuków make up an erratic mass of northern origin 1 sq km in area, in Quaternary formation. The clays themselves are almost completely devoid of fauna, but the concretions, occurring in them, contain a rich and well-preserved fauna (ammonites, pelecypods, gastropods, belemnites) and, sometimes, even debris of wood. The concretions are also met with which apparently are unfossiliferous but, after dissolving them in hydrochloric acid, many spicules of sponges may be found in the residue.

The concretions have varying diameters, on the average of 30 cm. Clayey minerals and bituminous substances they contain give them a black or gray colouration.

Views concerning the stratigraphic position, origin of concretions and concentration of organisms they contain were presented by Makowski (1952). Ammonites from concretions, *Kosmoceras jason* (Reinecke), *K. spinosum* (Sowerby) and *Peltoceras athleta* (Philips) determine the age of the clays as the Middle and the lowermost part of the Upper Callovian. The effect of waving (Makowski, 1952, p. IX) was probably one of the conditions of forming concretions which would be an evidence of a not very great depth of the basin. Debris of wood and spores of land plants indicate a small distance from the shore. Approximate conditions of life of *Rh. kozlowskii* n. sp. may be reproduced on the basis of these facts.

The remains of *Rhabdopleura* occur both in the concretions containing shells of molluscs and fragments of wood and in those lacking such remains. Fragments of periderm of hydroids, scolecodonts, organic linings of tests of forminifers and abundant plant remains such as wood, macrospores, dinoflagellates, hystricospheres, cuticles and many other unidentified remains were etched together with the remains of *Rhabdopleura* from these some concretions. The colonies of *Rh. kozlowskii* n. sp. probably settled on shells of molluscs, pieces of wood and sponges which were resting on the bottom of a not very deep sea. *Rh. kozlowskii* n. sp. is likely to have identical ecological requirements with those of the Recent *Rh. normani.*

The specimens of *Rh. kozlowskii* n. sp., described in the present paper, are housed at the Palaeozoological Institute of the Polish Academy of Sciences in Warsaw for which the abbreviation Z. Pal. is used.

I would like to express my heartfelt thanks to Prof. R. Kozłowski (Palaeozoological Institute, Polish Academy of Sciences, Warsaw) and Docent A. Urbanek (Palaeozoological Laboratory of the Warsaw University) for their valuable remarks and advice which were very helpful in my work.

DESCRIPTION

Family **Rhabdopleuridae** Harmer, 1905
Genus *Rhabdopleura* Allman, 1869
Rhabdopleura kozlowskii n. sp.

(Text-figs. 1-6)

Cotypi: A stolon in Fig. 4*A*; a zooidal tube in Fig. 1*E*; a stolonal tube in Fig. 3*B*; cysts of sterile buds in Fig. 5*J*. Collection numbers: Z. Pal. Pb. I/38, 45, 29, 24.

Locus typicus: Łapiguz clay pit, Łuków, Poland.

Stratum typicum: Callovian, *Kosmoceras jason, K. spinosum* and *Peltoceras athleta* zones.

Derivatio nominis: Named in honour of Prof. Roman Kozłowski, an investigator of fossil hemichordates.

Diagnosis. — Zooidal and stolonal tubes similar in size to those in *Rh. normani*. Fuselli of stolonal tubes much more frequently arcuate than those in *Rh. vistulae*, *Rh. eocenica* and *Rh. normani*. In transverse section, stolons semicircular as in *Rh. normani*. Peduncular stolons short and provided with 1-3 diaphragms.

Material. — Fragmentary zooidal tubes — 340 specimens; cysts of sterile buds — 180; stolonal tubes — 35; zooidal tubes with a creeping part — 11; stolons — 20.

Description. — *Zooidal tubes* (Fig. 1). Broken and rarely occurring in fragments longer than 0.5 mm, not flattened. In regard to the state of preservation, they resemble zooidal tubes of Recent specimens from which they differ, however, in a much stronger pigmentation of the walls.

In more than 60 measurements, the diameter of these tubes, the width of fusellar collars not taken into account, varied within limits of 115 and 207 μ (on the average, 155 μ). Together with fusellar collars, these dimensions amounted to 139—241 μ (on the average, 182 μ). The differences between these values give a certain notion of the width of fusellar collars. Their width varies within limits of 12 and 21 μ, the most often met with being 15 μ wide. There is a certain interdependence between the diameter of tubes and width of collars: tubes with a small diameter have somewhat narrower fusellar collars than those in tubes with large diameters. The width of fuselli of zooidal tubes also displays a considerable variability: between 18 and 62 μ (averaging 37 μ). On the other hand, no correlation is observed between the diameter of tubes and the width of fuselli. Although the largest mean width of fuselli is recorded in tubes with a large diameter, the tubes with small diameters frequently have wider fuselli than those in tubes with larger diameters (Table 1).

The thickness of walls of zooidal tubes, measured in optical sections, fluctuated within limits of 7 and 14 μ (averaging 10 μ). The thickness

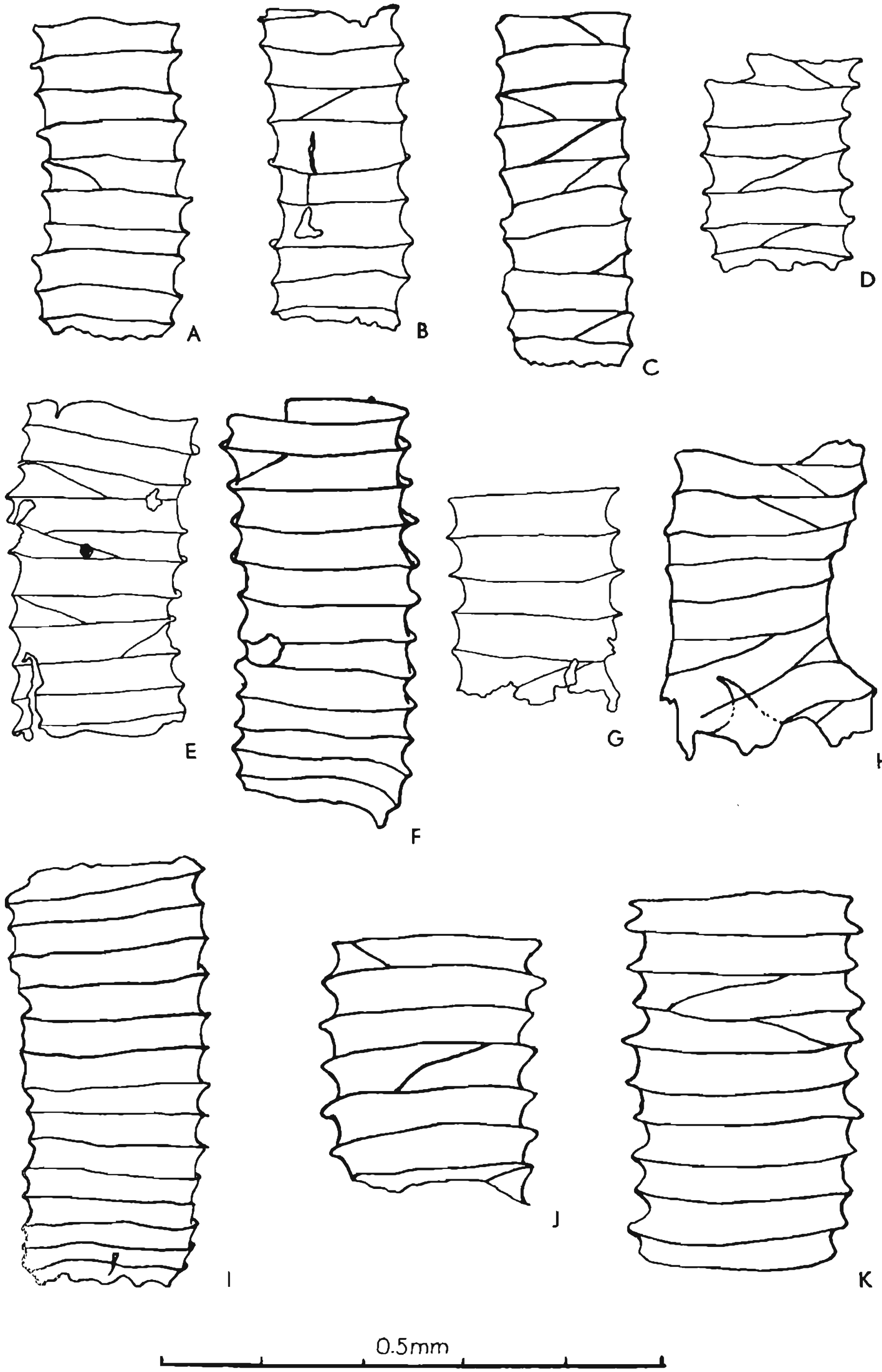

Fig. 1. — *Rhabdopleura kozlowskii* n.sp. *A-C* zooidal tubes with small diameters (Z. Pal. Pb. I/45-47), *D-K* zooidal tubes with most frequent diameters (Pb. I/33, 44, 48—52, 102), *E* a cotype.

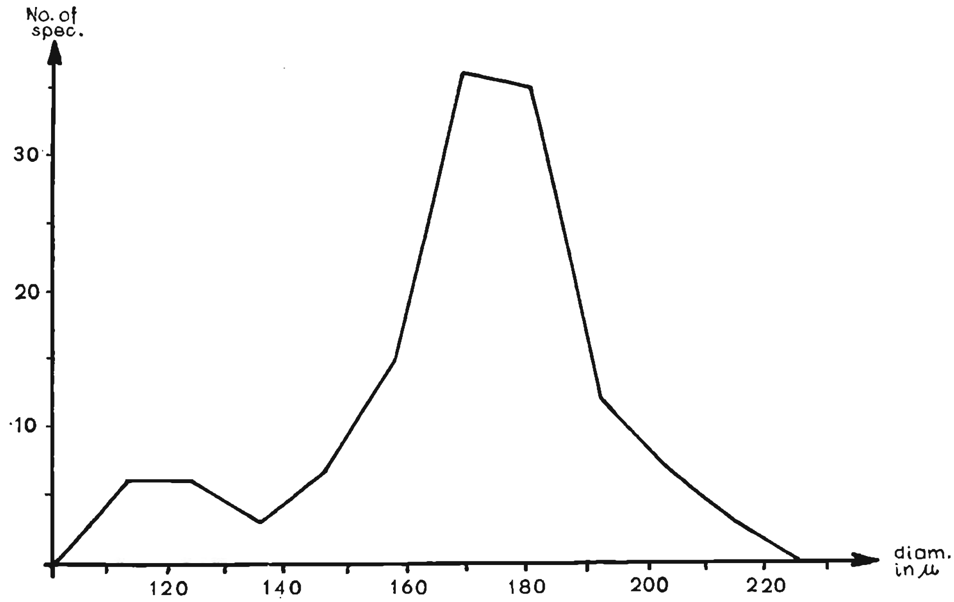

Fig. 2. — Frequency distribution curve of zooidal tubes diameter, drawn on the basis of specimens etched from two concretions.

of a wall, measured on microtomic sections amounts to 0.5—1.0 μ. This difference probably results from a decrease in the volume of the substance of which tubes are formed as an effect of dehydration of specimens in alcohol and xylene. The walls of zooidal tubes in the proximal part are always thicker than in the distal part. Zooidal tubes with smallest diameters (115—122 μ) considerably differ in appearance from the remaining ones, their fuselli (Fig. 1 *A-C*) being wide in proportion to the diameter. The observation may be also made that the curve is bimodal: one with a diameter of 118 μ, and the other with a diameter of 168 μ (Fig. 2).

Stolonal tubes (Fig. 3). The basal wall of stolonal tubes, which during the animal's life time directly adheres to the substratum, is as a rule destroyed so that most specimens examined are devoid of it. Some of a few specimens with the basal wall preserved have also stolons. The wall itself is considerably thinner than the wall with a zigzag suture. One of the specimens is preserved together with a fragmentary cyst of a sterile bud and three with septa. Almost all stolonal tubes are bordered by a narrow marginal membrane. The width of these tubes measured on ten specimens, without taking into account the marginal membrane, fluctuates within limits of 126 and 163 μ (on the average, 145 μ). A still clearer idea concerning the width of stolonal tubes is imparted by the width of cysts of sterile buds which were enclosed in stolonal tubes and strongly adhered to their walls. These measurements,

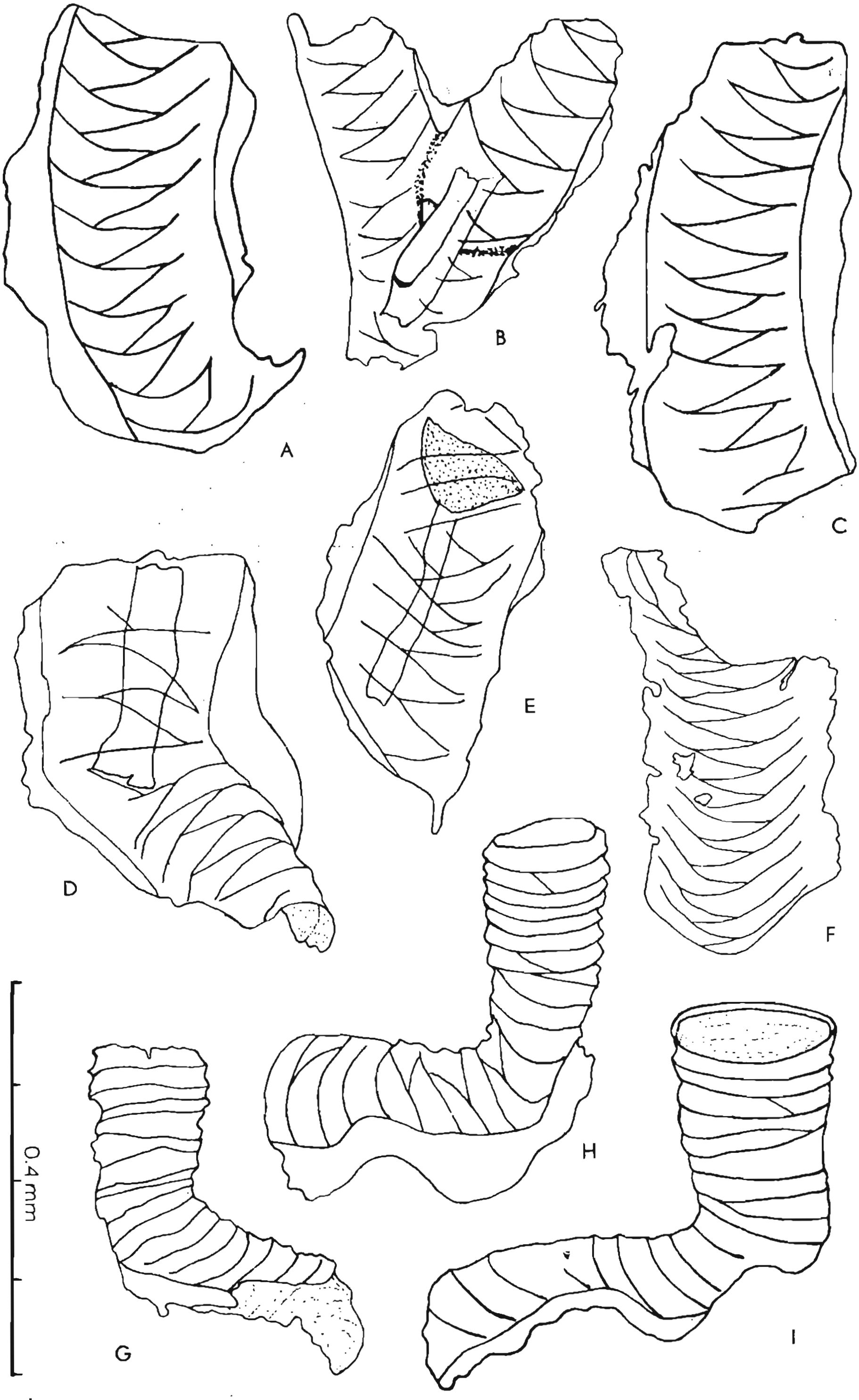

Fig. 3

taken on a considerable number of specimens, display a fluctuation within limits of 97 and 255 μ (averaging 162 μ).

The width of fuselli of stolonal tubes also displays a considerable variability (22—58 μ, averaging 42 μ). No smaller variability is recorded in the tubes which belong to one and the same colony (bifurcated tubes) and in which fuselli 49, 51, 51 μ wide occur succeeding each other. In the lateral branch there are fuselli 33, 35, 32 μ wide. Fuselli occurring on both sides of a stolonal tube join each other at a certain angle. The apex of this angle points usually to the proximal end of tube, but in some cases of *Rh. normani* Allman, illustrated by Schepotieff (1907), Pl. 17, Figs. 2, 4) an opposite orientation was observed. In *Rh. striata* Schepotieff, 1909, apexes of angles formed by fuselli are directed distally (Schepotieff, 1909, Pl. 7, Fig. 7). In the specimens of *Rh. kozlowskii* n. sp. examined, in the points in which the bifurcation of the tube or stolon or the position of the zooidal tube unequivocally determine the proximal and the distal part of a specimen, fuselli form an obtuse angle whose apex in all cases points proximally. In *Rh. kozlowskii* n. sp. these fuselli are, as a rule, arcuate and only infrequently straight.

Stolons (Fig. 4). In transverse section, stolons are semicircular, with a flat lower and convex-semicircular upper wall. The flat wall is very rarely preserved. In specimens in which this wall is preserved fragmentary, one can ascertain that it is many times thinner than the convex wall.

The width of stolons fluctuates within limits of 17 and 53 μ (averaging 31 μ) and the width also considerably varies within one and the same stolon (28—53 μ). The largest width is reached by stolons before bifurcations or before the points in which peduncular stolons detach themselves.

Peduncular stolons, which are attachment places of a contractile peduncle of zooid or which are connected with the lumen of cysts of sterile buds, are situated alternately on the left and on the right side of the main stolon at intervals of, on the average, about 480 μ. The smallest distance observed amounted to 271 μ, the largest 989 μ. Peduncular stolons are vesicular and mostly have two diaphragms, a basal and a distal one, with pores 3—12 μ in diameter (averaging 6 μ). Pores in both diaphragms may be equal or varying in diameter. The walls of diaphragm may be distally bent around a pore. In the case when a stolon bifurcates in the place in which a lateral stolon is formed, it usually starts with a vesicle having two diaphragms and resembling a peduncular

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Fig. 3. — *Rhabdopleura kozlowskii* n.sp. *A,C,F* stolonal tubes (Z. Pal. Pb. I/34-36); *B* a bifurcated stolonal tube with a bifurcated stolon and with a transverse septum (Pb. I/29), a cotype; *D* a stolonal tube with stolon (Pb. I/31); *E* a stolonal tube with stolon and septum (Pb. I/30); *G-I* zooidal tubes with a creeping part (Pb. I/28, 32, 37).

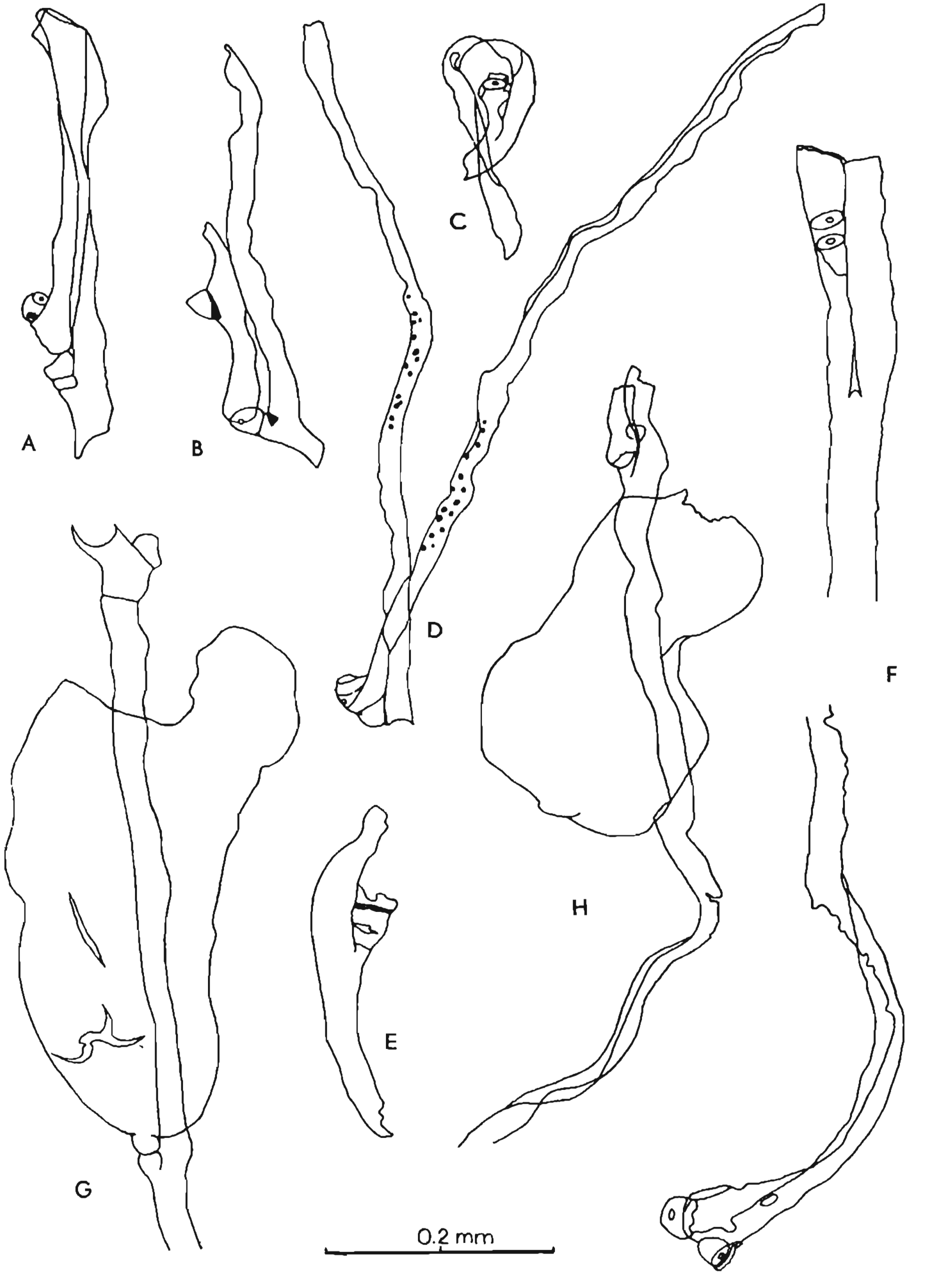

Fig. 4. — *Rhabdopleura kozlowskii* n.sp. *A,B,D,F* bifurcated stolons with peduncular stolons (Z. Pal. Pb. I/38, 40, 41, 43); *A* a cotype; *C,E* fragmentary stolons (Pb. I/42, 43); *G,H* stolons with cysts of sterile buds (Pb. I 25, 26).

stolon. In one case, two successive vesicles were observed with three diaphragms (Fig. 4*A*) behind which a lateral stolon runs. On one of the specimens, having a stolonal vesicle, a subsequent bifurcation was visible

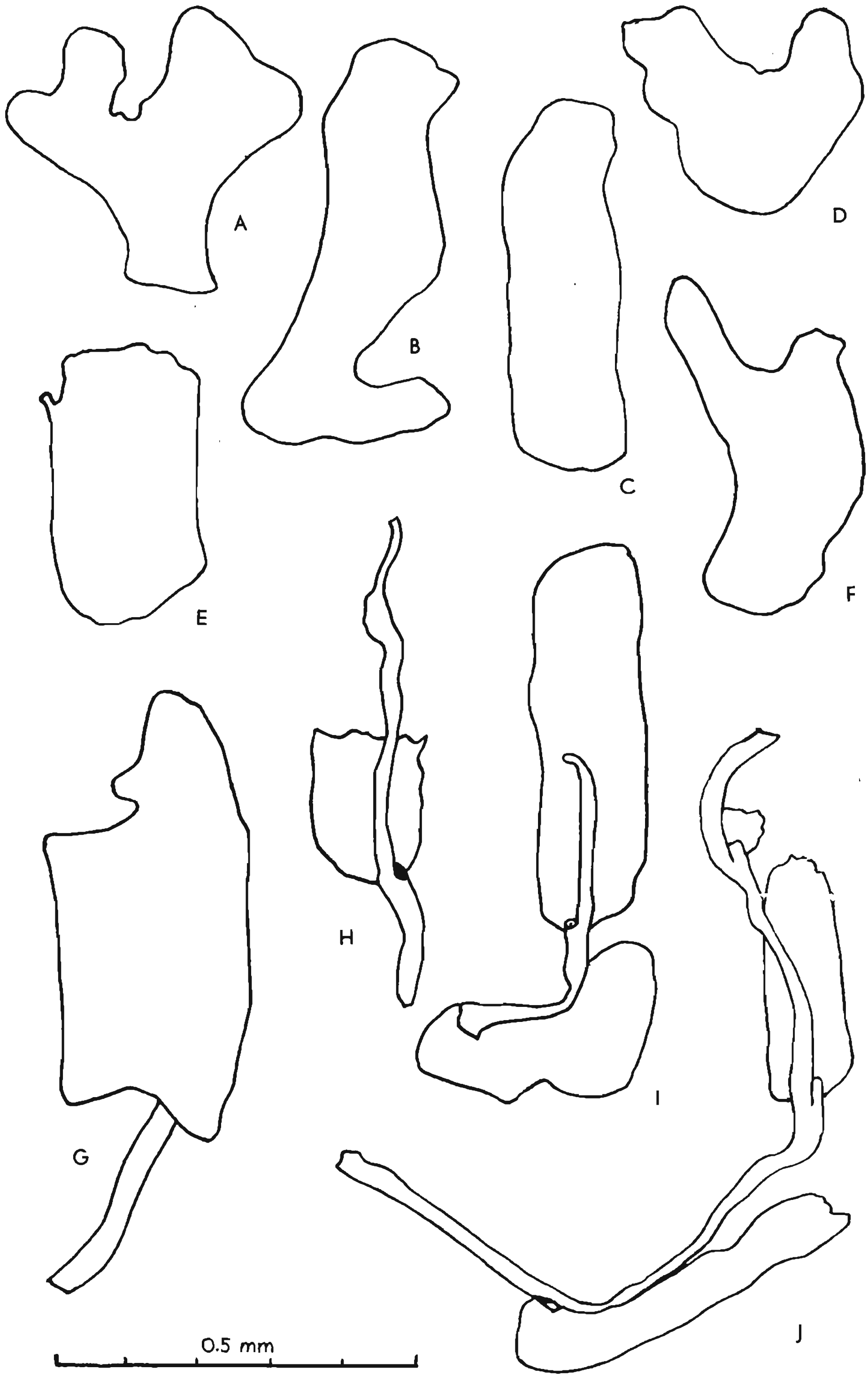

Fig. 5. — *Rhabdopleura kozlowskii* n.sp. *A-J* cysts of sterile buds (Z. Pal. Pb. I/1-10, *J* a cotype.

in which vesicles were not formed, but two successive diaphragms (Fig. 4*F*) were situated in the lateral stolon at some distance behind the place of bifurcation. The size of pores in these diaphragms is variable but equalling that in diaphragms of peduncular stolons. Bifurcated stolons, in which a peduncular stolon detaches itself from the lateral stolon just behind the point of bifurcation, are frequently observed.

Cysts of sterile buds (Fig. 5). The cysts are found either as isolated elements, or together with stolons. Short peduncular stolons which connect the main stolon with the proximal part of cysts are very often devoid of the basal diaphragm (Fig. 4 *G-H*), so that in most cases, the inside of a cyst is separated from the inside of a stolon by only one diaphragm having a small pore.

The cysts of sterile buds adhered closely to the walls of stolonal tubes. The following facts make up the evidence for this statement: 1) in most of the cysts, impressions of fuselli are preserved on the outer surface of the wall; 2) in specimens with the lower wall preserved, stolon is always embedded in and fused with it; 3) a very close adherence of both elements is observed in a specimen of stolonal tube with a fragmentary cyst of sterile bud. Upper walls of cysts are convex, semicircular or slightly flattened and considerably thicker than the lower ones.

The width of cysts varies from 97 to 255 μ (averaging 162 μ) and the length from 300 to 681 μ. An average length of a cyst is more than twice as large as width, although wide and short, or narrow and long or even irregularly shaped cysts are also found (Fig. 6).

The frequent occurrence of cysts of sterile buds is most likely the result of a considerable degree of their resistance. In some samples,

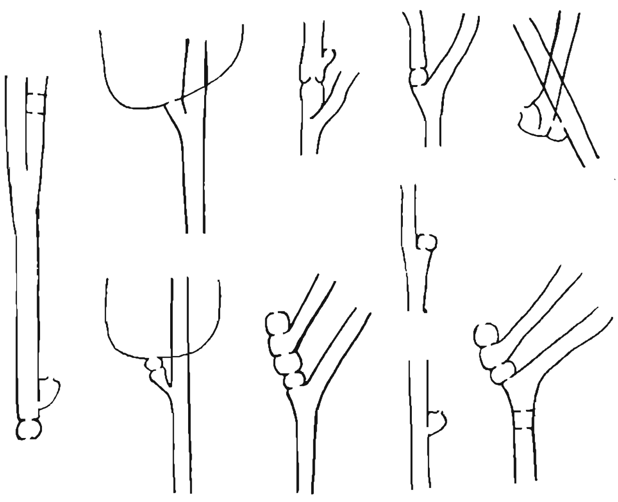

Fig. 6. — *Rhabdopleura kozlowskii* n.sp. Diagrams of the different stolons and diaphragms observed.

no other remains of *Rh. kozlowskii* n. sp. were found, but the cysts of sterile buds only.

Comparisons. — *Rhabdopleura kozlowskii* n. sp. may be fully compared with *Rh. vistulae* Kozłowski and *Rh. normani* Allman. The comparison with *Rh. eocenica* Thomas & Davis is impossible because of a different degree of preservation of specimens of this species (pyritization) and the lack of some anatomical elements.

In regard to their dimensions, the zooidal tubes of *Rh. vistulae*, *Rh. eocenica* and *Rh. kozlowskii* n. sp. do not differ from each other to any significant extent. The range of variability of the diameter of tubes and width of fuselli is given in Table 2. The number of these same elements, known in *Rh. eocenica* and *Rh. vistulae* was more limited and, besides, they were not so well preserved. This might be the reason why the greatest variability of these elements was observed in *Rh. kozlowskii* n. sp. The tubes with smaller and larger diameters which occurred together in *Rh. kozlowskii* n. sp. might be also a manifestation of sexual dimorphism.

Stolonal tubes of the species compared also do not differ in size from each other to a significant extent. All other species compared may be also placed within this range of variability. The width of fuselli of stolonal tubes in *Rh. kozlowskii* n. sp. is, on the average, smaller than that in *Rh. normani* and both fossil species and the fuselli of *Rh. kozlowskii* n. sp. are more strongly arcuate than those of *Rh. normani*, *Rh. vistulae* and *Rh. eocenica*.

The width of stolons in *Rh. kozlowskii* n. sp. is, on the average, slightly larger than that in the remaining species. The transverse section through a stolon of the new species is, in all cases, semicircular, with characteristic triangular margins and a very thin lower wall, i.e. identical as that in *Rh. normani* (Schepotieff, 1906; Pl. 33, Figs. 5, 9) and different than that in *Rh. vistulae*, in which it is rounded (Kozłowski, 1956. Fig. 1). On the other hand, peduncular stolons of *Rh. kozlowskii* n. sp. are similar in structure to these elements in *Rh. vistulae*. They are short, vesicular and provided with 1—3 diaphragms having pores. Peduncular stolons, adhering to cysts of sterile buds, frequently have only one distal diaphragm. Such a structure of peduncular stolons clearly differs *Rh. kozlowskii* n. sp. from *Rh. normani*. In *Rh. kozlowskii* n. sp. branching lateral stolons are most frequently separated from the main stolon by a short, vesicular stolon having two diaphragms. This vesicular stolon strongly resembles peduncular stolons. Such a structure is never met with in *Rh. vistulae*. In *Rh. normani*, only diaphragms situated in lateral stolon occur instead of short, vesicular stolons. Such diaphragms may be also met with in *Rh. kozlowskii* n. sp. behind or before the place in which stolons bifurcates (Fig. 5). In a general outline, *Rh. kozlowskii*

Table 1

Comparative table of measurements of some elements of tubarium (in μ)

	No. of specimens Z. Pal. Pb.	*Rhabdopleura kozlowskii* n. sp. diameter without collars	with collars	width of fuselli	average	*Rh. vistulae** diameter	width of fuselli	*Rh. normani** diameter	width of fuselli
Zooidal tubes	I/105	207	241	48 62 46 58	54	160	39	172	34
	I/104	183	215	44 46 53 44 46 37	45	172	39	180	24
	I/103	170	200	35 44 39 39 39 37 40 38 38 37 37	38	176	46	184	37
	I/48	164	190	35 32 35 24 35 30 28 28 30 25 30 28 18	29	186	40	205	25
	I/44	162	187	26 35 29 32 29 36 32 36 36 30	32	195	39	206	30
	I/107	155	175	22 25 28 28 30 32 30 32 39	30				
	I/106	148	175	28 35 37 32 30 39 35 30	33				
	I/47	122	152	35 35 55 36 36 31 31 32 32	34				
	I/46	122	148	43 39 40 41 35 43 39	40				
	I/45	115	139	33 38 36 38 36 40 41 36 28	36				
Stolonal tubes		width				width		width	
	I/34	163		44 41 38 41 51 43 37 41 46	42	148	49	168	52
	I/36	162		41 45 33 36 48 47	41	207	72	172	57
	I/108	156		54 53 40 41 43 49 38 39 46	45	216	62	176	53
	I/109	147		36 38 40 43	39	252	57	182	52
	I/35	143		23 22 30 31 33 35 30 35 29	30				
	I/31	154		53 55	54				
	I/37	129		30 31 35 35 33 25 24 25 41	31				
	I/29	127		33 35 32 32 37 33 35	34				
	lateral branch			49 48 46 49 51 51	49				
	I/30	126		48 49 47 32 38 27 58 51	44				

Table 2

Comparative table of measurements of tubarium (in μ)

Elements measured	*Rh. normani* Allman	*Rh. eocenica* Thomas & Davis	*Rh. vistulae* Kozłowski	*Rh. kozlowskii* n. sp.
Diameter of zooidal tube with collars	152—184	174—228*	132—200*	139—241
Diameter of zooidal tube without collars	—	—	—	115—207
Width of fusellus in zooidal tube	17—40	40—45	34—50	18—62
Width of stolonal tube	168—182	150—195	148—252	126—163
Width of fusellus in stolonal tube	17—62	60—72	39—105	22—58
Width of stolon	10—42	22	14—35	17—53
Width of cysts of sterile buds	147—156	—	—	97—255
Width of zooidal tubes wall	4—14	—	—	7—14
Distance between peduncular stolons	—	220—640**	300—900	271—989

* Zooidal tubes more or less flattened.
** Distance between zooidal tubes corresponding approximately to the distance between peduncular stolons.

n. sp. is more similar in the structure of stolons as in the structure of cysts of sterile buds — to *Rh. normani* than to *Rh. vistulae*. A peduncular stolon is always connected with the cyst in the latter's proximal part as is the case in *Rh. normani*, whereas in *Rh. vistulae* Kozłowski the attachment place is always slightly shifted distally (Kozłowski, 1956). In *Rh. kozlowskii* n.sp. main stolon is depressed and fused with the lower wall of cyst as is the case in *Rh. normani* Allman and in contrast to that *Rh. vistulae* Kozłowski (Kozłowski, 1956). It is clear from this comparison that the elements of tubarium in *Rhabdopleura* are only slightly variable evolutionally and the largest differences are observed in the structure of stolons.

Rh. kozlowskii n. sp. in many respects resembles the Recent *Rh. normani* rather than the Danian *Rh. vistulae* and the Recent species may be more easily derived from the new Jurassic species here described than from the Danian one.

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ODKRYCIE *RHABDOPLEURA* (PTEROBRANCHIA) W JURZE POLSKI

Streszczenie

W pracy tej podany jest opis części szkieletowych kolonii *Rhabdopleura* Allman, 1869 (Pterobranchia), odkrytych przez autora w konkrecjach z iłów kelowejskich w gliniance Łapiguz w Łukowie i zaliczonych do nowego gatunku — *Rhabdopleura kozlowskii* n.sp. Zbadane zostały rurki zoidalne, rurki stolonalne, stolony oraz cysty pączków sterylnych. Dane liczbowe odnośnie wymiarów tych elementów podane są w tabelach tekstu angielskiego, w zestawieniu z danymi dotyczącymi gatunku kopalnego z danu Polski *Rh. vistulae* Kozł. i gatunku współczesnego *Rh. normani* Allman. Porównanie nowego gatunku z *Rh. vistulae* doprowadza autora do wniosku, że gatunek kelowejski jest morfologicznie bardziej podobny do współczesnego *Rh. normani,* niż do *Rh. vistulae.* Świadczy to o bardzo małych zmianach ewolucyjnych rodzaju *Rhabdopleura* Allman od jury do dziś. Dokładne porównanie *Rh. kozlowskii* n.sp. z gatunkiem *Rh. eocenica* Thomas & Davis, opisanym z eocenu Anglii, nie jest możliwe, gdyż materiał angielski był kompletnie spirytyzowany, co zatarło drobne szczegóły jego budowy.

ЦЫПРИЯН КУЛИЦКИ

ОТКРЫТИЕ *RHABDOPLEURA* (КРЫЛОЖАБЕРНЫЕ) В ЮРЕ ПОЛЬШИ

Резюме

Автор описывает скелетные части колонии *Rhabdopleura* Allman, 1869 (Pterobranchia), найденные им в глиняном карьере Лапигуз около Лукова в известковых конкрециях келловейского яруса. Для этих остатков автор установил вид *Rhabdopleura kozlowskii* n. sp. Вид этот представлен зооидными и столональными трубками и стерильными почками. Числовые данные, касающиеся размеров этих элементов, представлены на таблицах вместе с данными, относящимися к ископаемому виду *Rhabdopleura vistulae* Kozłowski из датского яруса Польши и современного вида *Rh. normani* Allman. Сравнение этих видов приводит автора к выводу, что келловейский вид морфологически ближе к современному *Rh. normani*, чем к датскому *Rh. vistulae*. Это свидетельствует о том, что род *Rhabdopleura* претерпел небольшие изменения с юры до нашего времени. Подробное сравнение нового вида с *Rh. eocenica* Thomas & Davis из эоцена Англии невозможно, так как английские образцы были сильно пиритизованы.