

Biometrical analysis of three species of the genus *Lapeirouseia* from the Campanian-Maastrichtian of Stranice (North-East Slovenia)

Biometrične analize treh vrst rodu *Lapeirouseia* iz campanijsko-maastrichtijskih plasti pri Stranicah (severovzhodna Slovenija)

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Abstract

The rudist rich deposits of the region of Styria in the north-eastern Slovenia are known since the beginning of the 20th century. Three *Lapeirouseia* species distributed from Campanian to Maastrichtian are found in this outcrop of the Upper Cretaceous. The biometrical analysis of the species *Lapeirouseia zitteli* Douvillé, *Lapeirouseia laskarevi* Milovanović and *Lapeirouseia plana* Milovanović showed that these three species constitute a single phylogenetic line.

Kratka vsebina

Pri Stranicah v severovzhodni Sloveniji je bogato nahajališče rudistov, znano že od začetka 20. stoletja. S tega zgornjekrednega območja izhajajo tudi tri vrste rodu *Lapeirouseia* iz campanijskih do maastrichtijskih plasti in sicer *Lapeirouseia zitteli* Douvillé, *L. laskarevi* Milovanović in *L. plana* Milovanović. Te tri vrste je avtor raziskal z biometričnimi analizami in dokazal, da predstavljajo isti filogenetski niz.

Introduction

A rich fauna of rudists that consists of hippuritids and radiolitids coming from the locality of Stranice in the north-east of Slovenia (Fig. 1) was recently described by Pleničar and Šribar (1992) and Pleničar (1993 and 1994). On the basis of the assemblage of benthonic foraminifers the authors assigned the limestones and breccia with rudists to a period ranging from Campanian to Maastrichtian. Moreover, the authors analysed the stratigraphic position of

the levels of limestones and breccia with rudists belonging to the Cretaceous limestones of Styria that form part of the Gosau beds.

The most common radiolitids found in the rudist deposit of Stranice belong to the genera *Lapeirouseia* and *Prae-lapeirouseia*. In second place, *Radiolites*, *Biradiolites* and *Sauvagesia* are also found. It is worth noting that among *Sauvagesia*, the species *Lapeirouseia zitteli* Douvillé, *Lapeirouseia laskarevi* Milovanović and *Lapeirouseia plana* Milovanović have an outer shell morphology apparently very similar among

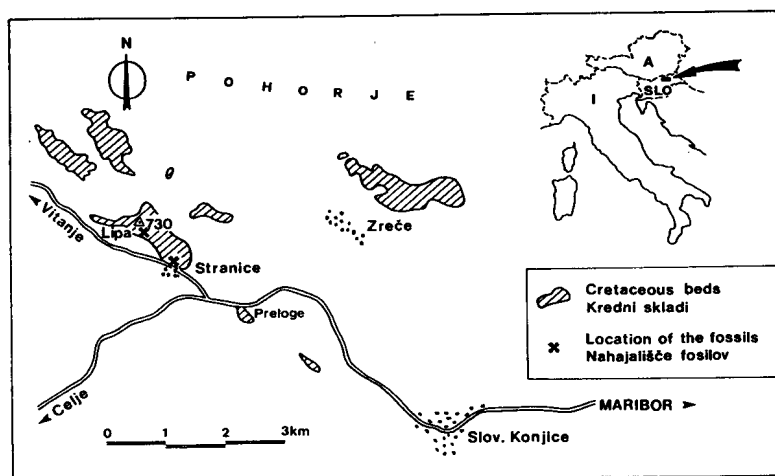


Fig. 1. Location map of the rudist fauna of Stranice

them and according to Milovanović (1938 and 1951), *L. plana* represents the evolution of the more ancient species *L. zitteli* and *L. laskarevi*.

The availability of well-preserved specimens of *L. zitteli*, *L. laskarevi* and *L. plana* allowed to study the outer morphological characters of the shells. Subsequently, measures of some biometrical parameters were obtained from the inner morphology.

The aims of the present paper are to describe the different morphostructural characteristics of the shell of the three studied species and to define by means of biometrical analysis whether there is a phylogenetic line that links these species.

Systematic palaeontology

The main morphostructural characters used for the taxonomy of the genus *Lapeirouseia* are the cellular structure of the shell and the morphology of the pseudopillars. The outer ornamentations of the shell exhibit a great variability of shape among specimens (intraspecific variations) but the outer ornamentations at the ventral area can be considered as a valid character for the taxonomy of this genus as proposed by Milovanović (1951).

The systematic study of the three mentioned species of *Lapeirouseia* coming from Stranice was previously done (Pleničar 1993). In that systematic study, the author

described the structure of the shell and pseudopillars of the examined valves. Therefore, for the description of the general taxonomic characters of *L. laskarevi*, *L. plana* and *L. zitteli* see Pleničar (1993). However, some remarks on particular morphological characters of each species that are important for the aim of this research are mentioned below.

All specimens found at Stranice that were used for this study are deposited at the University of Ljubljana.

Genus: *Lapeirouseia* Bayle 1878
Lapeirouseia laskarevi Milovanović 1938
 Pl.4, figs.3,5; Pl.6, fig.1.

1938 *Lapeirouseia laskarevi* n. sp.; Milovanović, 291-292, fig.5 in text.

1951 *Lapeirouseia laskarevi* Milovanović; Milovanović, 167-171 and 216-218.

1988 *Lapeirouseia laskarevi* Milovanović; Pejović, Pl.5, fig. 1.

1993 *Lapeirouseia laskarevi* Milovanović; Pleničar, 58-59, Pl. 13, figs.1-2.

The structure of the shell and pseudopillars are the most particular characters of this species. The structure of the pseudopillars is more evolved and specialised than that of *L. zitteli* Milovanović (1951). About *L. laskarevi* and *L. zitteli* Milovanović (1951) says: "par son aspect extérieur, par le limbe radialement plissé, par la structure de la partie principale de la couche prismatique, *L. laskarevi* ressemble

beaucoup a *L. zitteli*. Toutefois, la partie intérieure de la couche externe et la structure des pseudo-piliers sont beaucoup plus spécialisés, a cause de l'extreme développement de la zone lamelleuse".

The distribution of this species is in the Upper Santonian of eastern Serbia and in the Lower Santonian of the Brač island.

Lapeirouseia plana Milovanović 1935

Pl.4, figs.1,2; Pl.5, figs.1,2.

1935 *Lapeirouseia plana* n.sp.; Milovanović, 134

1939 *Lapeirouseia plana* Milovanović; Milovanović 4, Pl. 3, figs. 1-2, textfigs. 8-9.

1951 *Lapeirouseia plana* Milovanović; Milovanović, 186-190, textfigs. 9-10.

1972 *Lapeirouseia plana* Milovanović; Sladić-Trifunović, 136-137, Pl. 13, fig.5.

1993 *Lapeirouseia plana* Milovanović; Pleničar, 59-60, Pl. 12, figs. 1-2; Pl. 13. fig. 3.

The structure of the pseudopillars, consisting of small polygonal cells and tiny lamellae, is the most specialised comparing with the same structure of *L. laskarevi* and *L. zitteli*. For the description of the specimens of this species from the outcrop of Stranice see Pleničar (1993).

The stratigraphic distribution is Maastrichtian in Serbia and Bulgaria.

Lapeirouseia zitteli Douvillé 1913

Pl.4, figs.4,6; Pl.6, fig.2.

1913 *Lapeirouseia zitteli* n.sp.; Douvillé, 92.

1938 *Lapeirouseia zitteli* Douvillé; Milovanović, 287-291, figs.3-4 in text.

1951 *Lapeirouseia zitteli* Douvillé; Milovanović, 159-165 and 211-216, figs.1-3.

1992 *Lapeirouseia zitteli* Douvillé; Pleničar & Šribar 305, Pl.3, figs.1-2.

1993 *Lapeirouseia zitteli* Douvillé; Pleničar, 61, Pl 14, figs. 1-2; Pl. 17, figs. 1-2; Pl. 18, figs. 1-3.

The primitive structure of the pseudopillars that characterises this species is well described by Milovanović (1938). This structure consists of big polygonal cells and lamellae and the pseudopillars occupy smaller areas than those of the species *L. laskarevi* and *L. plana*.

The distribution of this species is in the Santonian of Untersberg near Salzburg, in the Santonian and Lower Campanian of eastern Serbia and in the Lower Santonian of Monts Apuseni in Romania.

Biometrical parameters

The parameters are obtained from the transversal sections of right valves in the

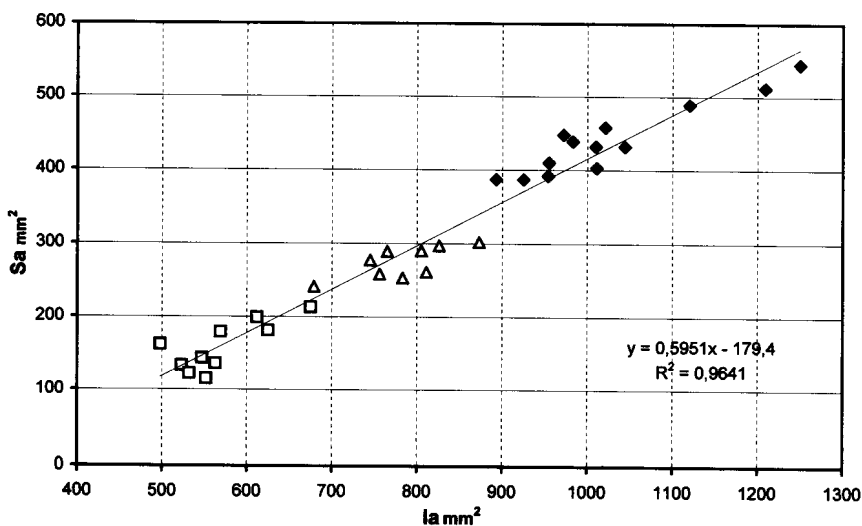


Fig. 2. Shell area (Sa) vs inner area (Ia). Regression values and dispersion coefficient are shown.

	Sa mm ²	Ia mm ²	(P1-P2)a mm ²	Sa/Ia	P1^P2	samples
L. plana	1250	544	16	2,30	62	1
	1044	432	13	2,42	55	2
	954	392	11	2,43	51	3
	1011	403	12,5	2,51	56	4
	983	439	13,2	2,24	54	5
	893	387	11,5	2,31	50	6
	1021	458	13,5	2,23	59	7
	972	448	12	2,17	55	8
	1209	512	14	2,36	61	9
	955	410	12,9	2,33	54	10
	1010	432	13,2	2,34	59	11
	1120	489	15,2	2,29	57	12
	925	387	11,5	2,39	53	13
L. laskarevi	745	277	8	2,69	64	24
	765	289	9,5	2,65	52	25
	873	302	9	2,89	63	26
	826	297	10,5	2,78	51	27
	679	241	7	2,82	55	28
	805	290	8	2,78	58	29
	783	253	7,5	3,09	51	30
	756	258	7,5	2,93	56	31
	811	261	8	3,11	60	32
L. zitteli	675	213	8,5	3,17	49	14
	563	136	6,5	4,14	43	15
	625	181	7	3,45	56	16
	523	133	6	3,93	44	17
	547	143	6,5	3,83	53	18
	612	199	7,5	3,08	47	19
	532	122	5,5	4,36	56	20
	569	179	7,5	3,18	42	21
	498	162	7	3,07	54	22
	552	115	5	4,80	51	23

Table 1. Measures of the parameters Sa, Ia and (P1-P2)a in mm² and P1^P2 in degrees.

region close to the commissure. These biometrical parameters were previously used in other studies of radiolitids (Cestari 1992, Caffau and Pleničar 1996, Caffau and Protopsalti 1999) and

represent biological characters that are peculiar to the species under study (Pl.1, fig.1a).

- Sa (mm²): shell area or surface of the mantle that is responsible for the incoming

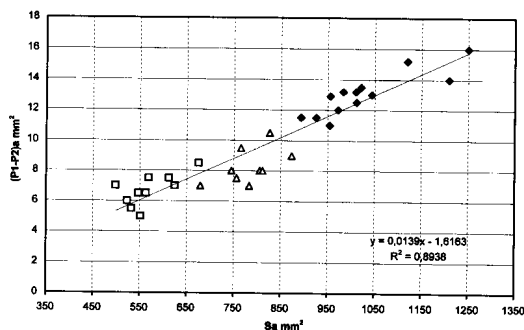


Fig. 3. Pseudopillars area (**P1-P2**)a vs shell area (**Sa**). Regression values and dispersion coefficient are shown.

water flux and the entrance of nutrients in the inner cavity

- **Ia** (mm²): area of the inner cavity that contains the organic tissues.

- (**P1-P2**) a (mm²): area of the pseudopillars P1 and P2

- **P1^P2**: measure of the angle P1^P2

The values of these parameters obtained from all the analysed transverse sections (Tab.1) are plotted in dispersion diagrams.

The plot **Sa** versus **Ia** (Fig.2) show a very good correlation between the parameters **Sa** and **Ia** with a coefficient of determination $R^2=0.9641$ very close to the unit. There is also a good correlation between the parameters (**P1-P2**) a and **Sa** (Fig.3) with $R^2=0.8938$.

The plot **Sa/Ia** versus **P1^P2** (Fig.4) puts in evidence three fields of values. Each one of these fields consists of values belonging to individuals of the same species.

In all the plots, the values form three distinct groups, limited in not overlapping fields that characterise each species.

Discussion

The presence of the three species with different chronological distribution in the same level of breccia should be seen as a result of the process of reworking.

Due to the great intraspecific variability of the outer morphological characters the systematic attribution of the specimens of *L. zitteli*, *L. laskarevi* and *L. plana* may often be difficult. The analysis of the biometrical data showed the formation of distinct groups of values that characterise each

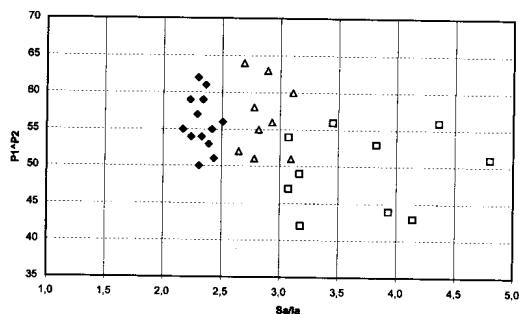


Fig. 4. Ratio **Sa/Ia** vs **P1^P2** in degrees.

species. Moreover, the parameter values increase from the most ancient species to the most recent one. It is noteworthy that this kind of analysis is an important tool to give a reliable systematic attribution to specimens of these species.

Finally, the good correlation between the biometrical parameters **Sa** and **Ia**, (**P1-P2**)a and **P1^P2** of *L. zitteli*, *L. laskarevi* and *L. plana* confirms that they are involved in the same phylogenetic line.

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Biometrične analize treh vrst rodu *Lapeirouseia* iz campanijsko-maastrichtijskih plasti pri Stranicah (severovzhodna Slovenija)

Bogata favna hipuritidov in radiolitidov pri Stranicah v severovzhodni Sloveniji dokazuje campanijsko do maastrichtijsko starost plastem, podobnim gosauskim. Najpogostnejše vrste radiolitidov pripadajo tu rodovoma *Lapeirouseia* in *Praelapeirouseia*. Pozornost vzbujajo vrste *Lapeirouseia zitteli* Douvillé, *L. laskarevi* Milovanović in *L. plana* Milovanović, ki so po zunanji plasti spodnjih lupin morfološko med seboj zelo podobne in ki po Milo-

vanoviću (1938, 1951) predstavljajo razvojni niz od *L. zitteli* in *L. laskarevi* v *L. plana*. Avtor je izvršil primerjavo morfoloških značilnosti zunanjih lupin teh vrst. Morfološke parametre je dobil s prečnih presekov desnih lupin, narejenih najverjetneje blizu njihovih komisur. Ti parametri, ki predstavljajo značilne biološke značilnosti teh vrst na prečnih presekih lupin in so jih uporabljali že prej drugi avtorji pri preučevanju rudistov, so naslednji:

Sa (mm²) = površina preseka lupine

Ia (mm²) = površina notranje votline, ki vsebuje organsko tkivo

P1 - P2 (mm²) = površina psevdostebričkov P1 in P2

Velikost kota **P1^P2** med psevdostebričkoma P1 in P2

Diagrami, ki kažejo razmerja med Sa in Ia, P1-P2 in Sa ter Sa/Ia in P1^P2 dokazujejo, da omenjene tri vrste rodu *Lapeirouseia* pripadajo istemu filogenetskemu nizu. Skupno nastopanje teh treh vrst v breči v istem nahajališču nam tudi kaže na način poteka njihovega transporta.

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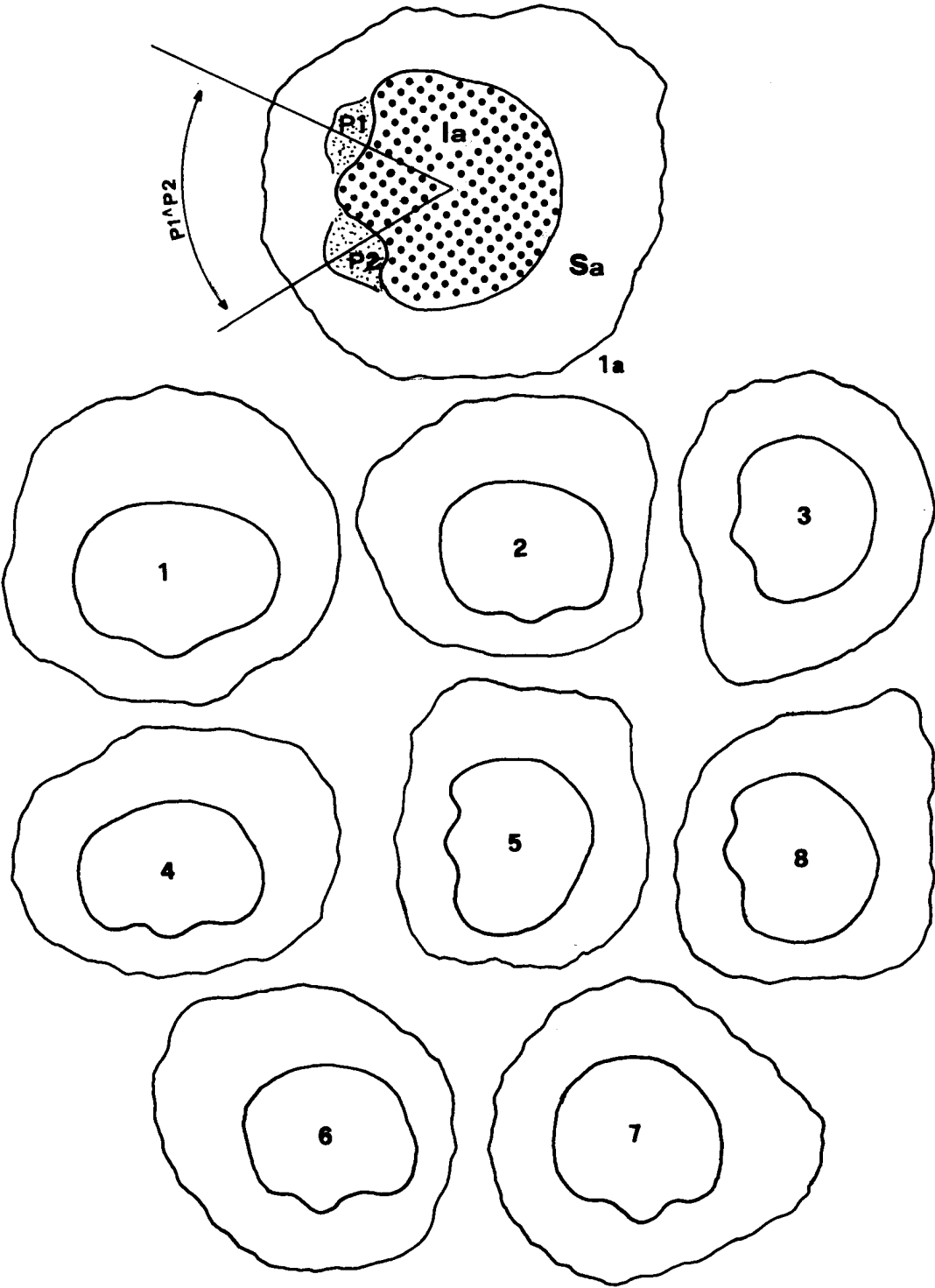
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Plate 1

Fig. 1a. Transverse section of a right valve of *Lapeirouseia* where the measured parameters are indicated.

Figs. 1-8. *Lapeirouseia plana*. Transverse sections of right valves used for biometrical analysis. Natural size.



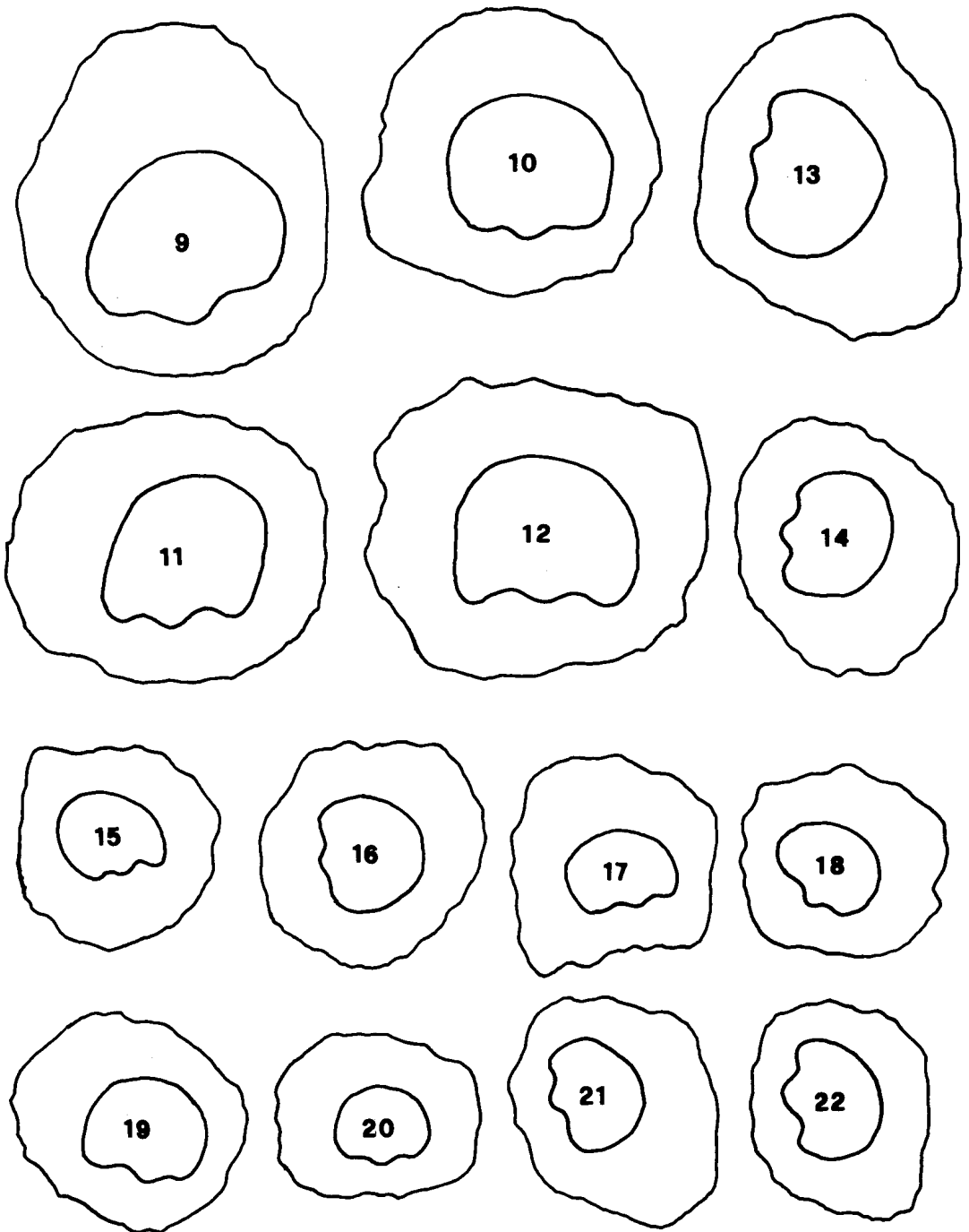


Plate 2

Figs. 9-13. *Lapeirouseia plana*. Transverse sections of right valves used for biometrical analysis. Natural size.

Figs. 14-22. *Lapeirouseia zitteli*. Transverse sections of right valves used for biometrical analysis. Natural size.

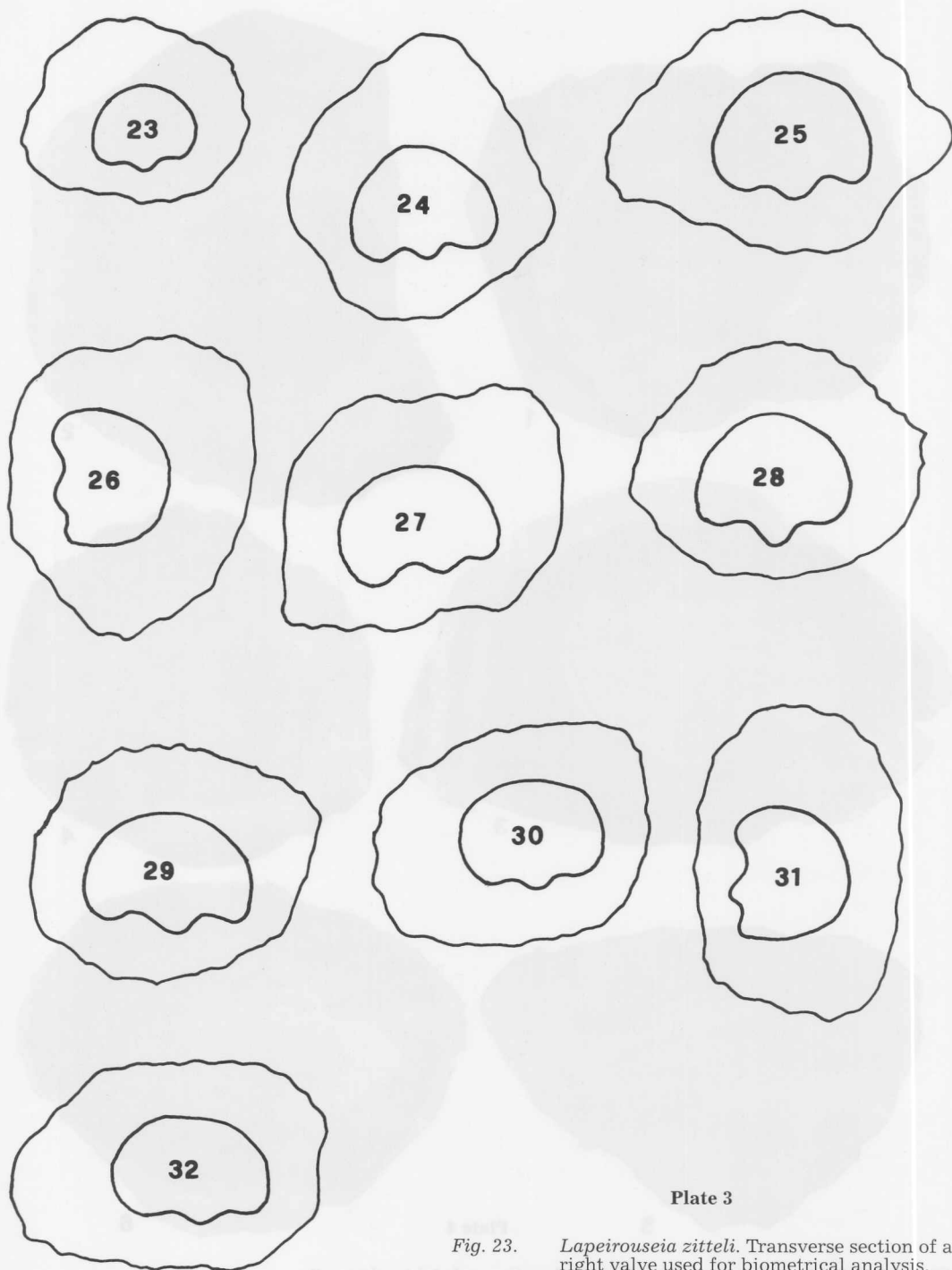


Plate 3

Fig. 23. *Lapeirouseia zitteli*. Transverse section of a right valve used for biometrical analysis. Natural size.

Figs. 24-32. *Lapeirouseia laskarevi*. Transverse sections of right valves used for biometrical analysis. Natural size.

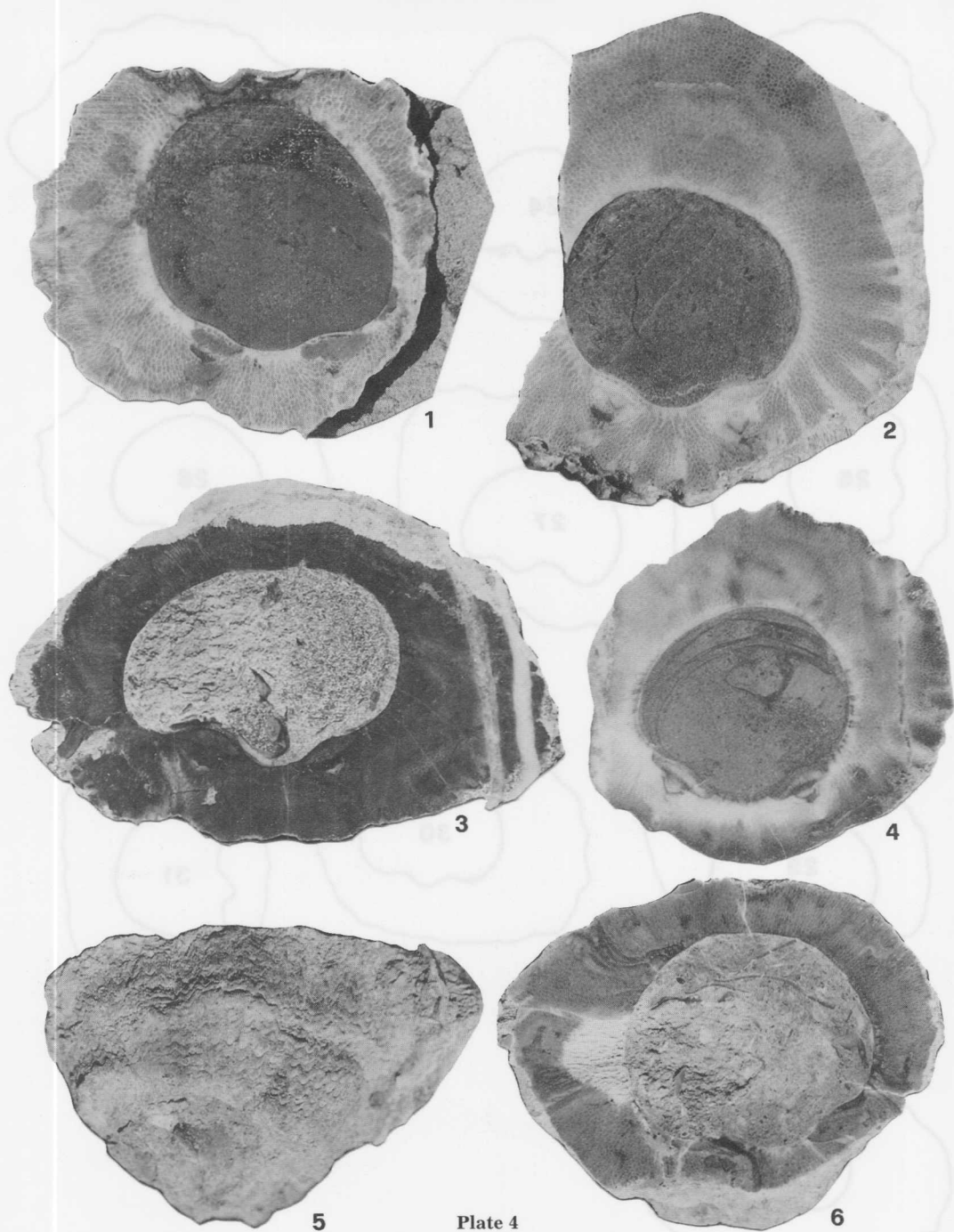


Plate 4

Figs. 1 and 2. *Lapeirouseia plana*. Polished sections of right valves. $\times 2$.

Figs. 3 and 5. *Lapeirouseia laskarevi*. Polished section of the right valve ($\times 2$) and ventral view ($\times 1.8$) of the same individual.

Figs. 4 and 6. *Lapeirouseia zitteli*. Polished sections of right valves. $\times 2$.

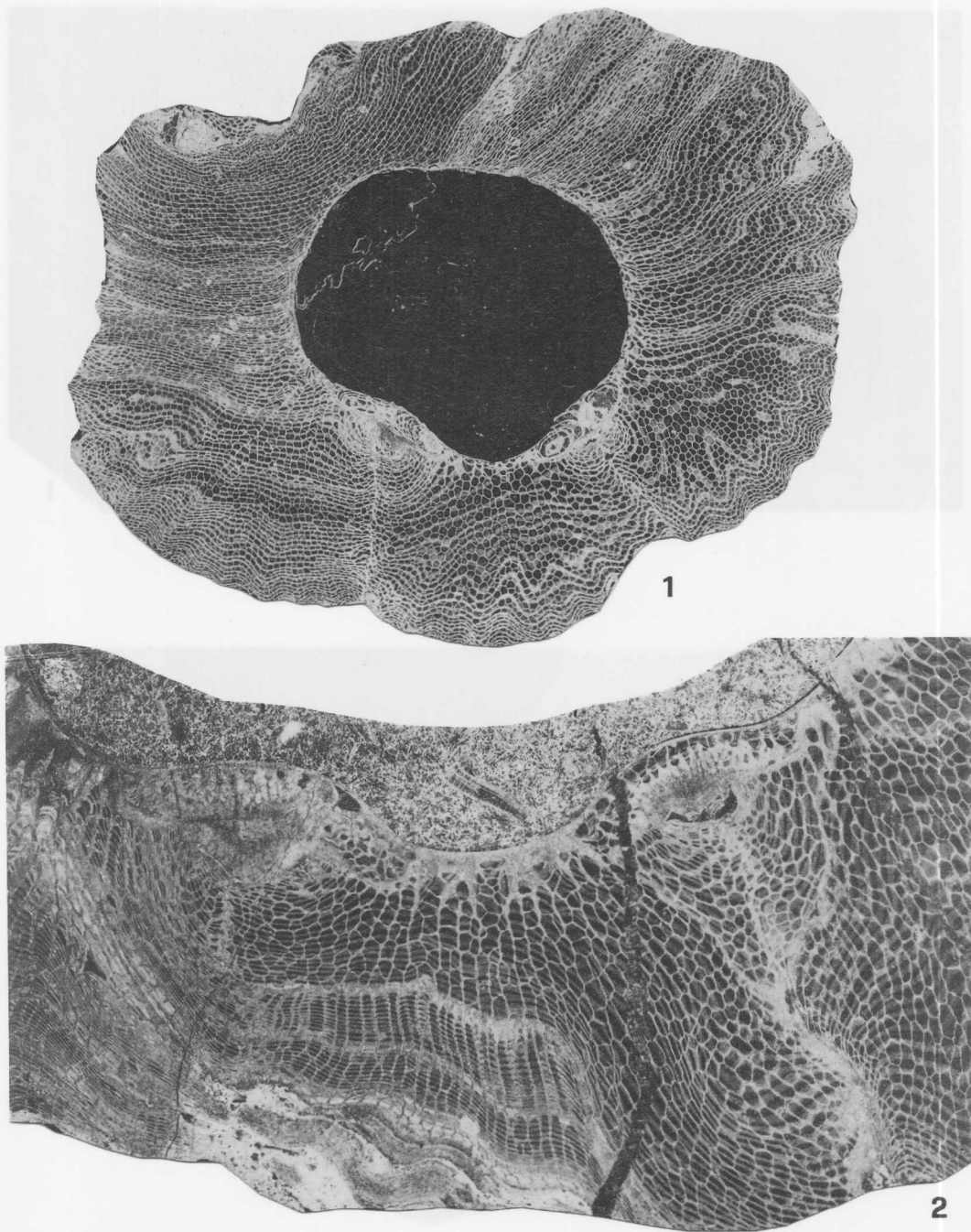


Plate 5

- Fig. 1. *Lapeirouseia plana*. Thin transverse section of right valve. $\times 3.5$.
Fig. 2. *Lapeirouseia plana*. Detail of the pseudopillars structure. $\times 7.5$.

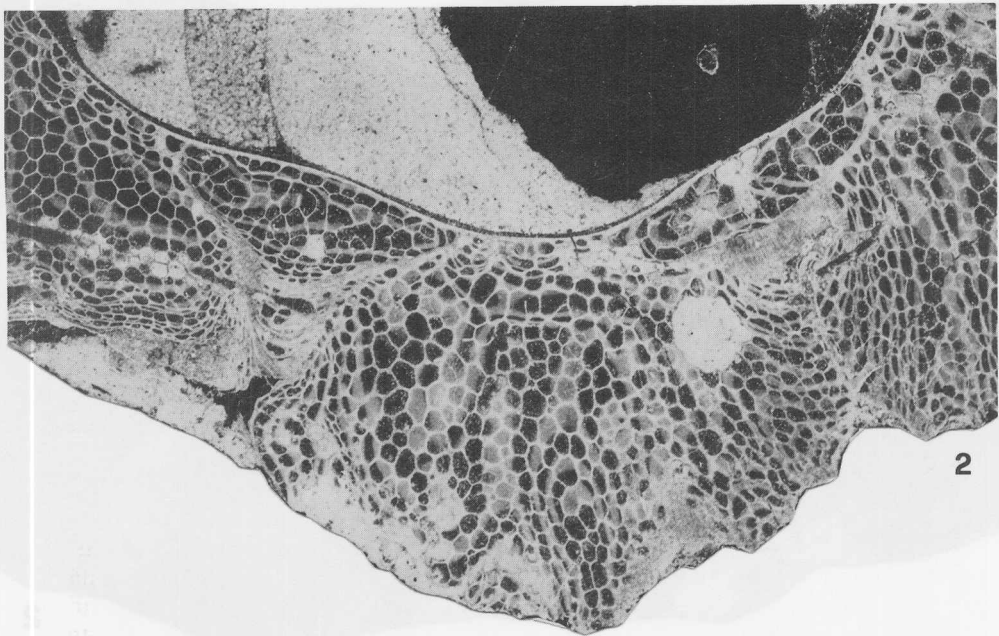
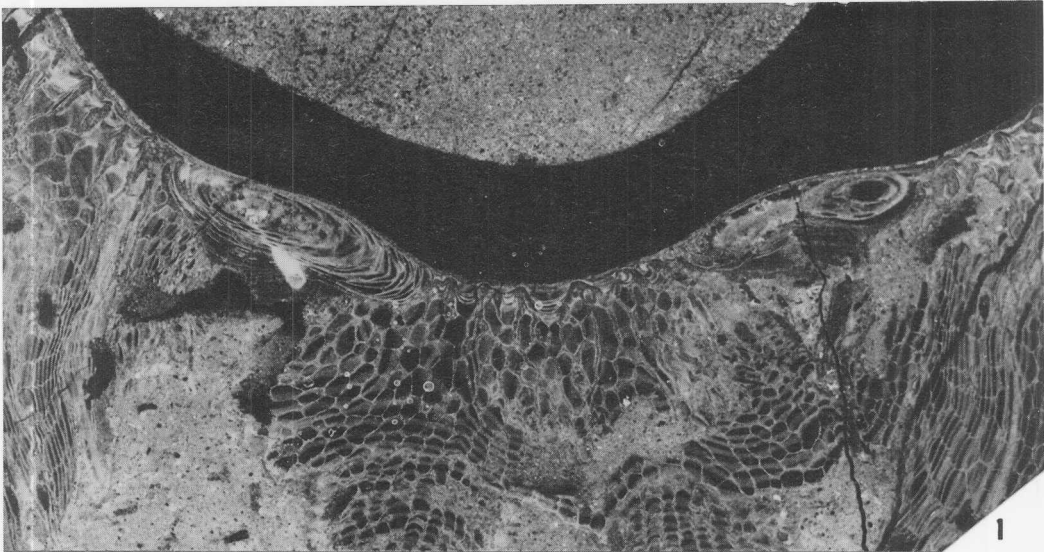


Plate 6

Fig. 1. *Lapeirouseia laskarevi*. Detail of the pseudopillars structure. $\times 10$.
Fig. 2. *Lapeirouseia zitteli*. Detail of the pseudopillars structure. $\times 10$.