

## Preliminary biometrical analysis on three similar hippuritid species

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### Abstract

The hippuritids species *Hippuritella lapeirousei* (Goldfuss, 1840), *Hippuritella nabresinensis* (Futterer, 1893) and *Hippuritella heritschi* (Kühn, 1947) were studied through biometrical analysis. For this purpose, the areas of three morphological characters which are related by their biological functions (as described by Realy, 1992) were measured on transversal sections of lower valves. These morphometrical values are: a) shell area ( $Sa$ ), b) inner area ( $Ia$ ) and c) pillars area ( $Pl-P2a$ ). This analysis highlighted a morphological similarity between *Hl. nabresinensis* and *Hl. heritschi*, meanwhile the morphometric values for *Hl. lapeirousei* showed to be different.

### Introduction

The hippuritid species *Hippuritella lapeirousei* (Goldfuss, 1840), *Hippuritella nabresinensis* (Futterer, 1893) and *Hippuritella heritschi* (Kühn, 1947) are very similar from the morphological point of view. In fact, this topic was discussed in literature by different authors.

Douvillé (1891-97) observed a clear similarity between *Hl. lapeirousei* and *Hl. nabresinensis* and, later, Parona (1900) and Toucas (1903-1904) considered *Hl. nabresinensis* as a synonym of *Hl. lapeirousei*. However several authors observed a wide variability in the ornamentation of these species. Toucas (1903-1904) noted it analysing the lower valve of *Hl. lapeirousei*. Successively, Pleničar (1975, 1994) and Vicens (1992) observed this variability between *Hl. nabresinensis* and *Hl. lapeirousei*. Afterwards, Sladić-Trifunović (1972, 1978) and Laviano (1985) discussed the problem about the great similarity among the three species.

Thus, their similarity focuses on a still unsolved taxonomical problem. The aim of this paper is to discuss about this taxonomical problem through morphometric analysis carried out on specimens belonging to the three species.

### Material

Part of the morphometrical measures was obtained analysing the specimens of *Hl. Lapeirousei*, *Hl. Nabresinensis* and *Hl. heritschi* described in literature, including the holotypes of the three species (tables 1, 2, 3). Moreover, 300 lower valves of *Hl. nabresinensis* coming from the area of the holotype (Aurisina/Nabrežina – Karst of Trieste) have been analyzed (table 4). Forty-eight of them were selected in that they revealed an excellent state of conservation. Fifteen valves of *Hl. heritschi* coming from Stranice and Senožeče (Slovenia) have been analysed and measured. These samples show similar morphological characters with respect to those of the holotype described by Kühn (1947).

Unfortunately it was not possible to carry out similar analysis with specimens of *Hl. lapeirousei*, because in the area of the Karst of Trieste (Italy) and Triest-Komen plain (Slovenia) this species is represented by scarce and bad-preserved specimens.

The studied valves of *Hl. nabresinensis* and *Hl. heritschi* are deposited in the collection of the "Istituto di Geologia e Paleontologia dell'Università di Trieste", and in the collection of the "Katedra za geologijo in paleontologijo univerze v Ljubljani", respectively, meanwhile those coming from Senožeče (Slovenia) have been kindly lent by doctor Bogdan Jurkovšek from his private collection.

The systematics and taxonomic aspects of the three species are shortly discussed below.

### Palaeontological description

Familia Hippuritidae Gray, 1848

Genus *Hippuritella* Douvillé, 1908

*Hippuritella lapeirousei* (Goldfuss, 1840)

1891–97 *Hippurites lapeirousei* var. *crassa* Goldfuss – Douvillé, 222, pl. 24, fig. 10.

1900 *Hippurites lapeirousei* Goldfuss – Parona, 11, pl. 1, figs. 1–3.

1912 *Orbignya lapeirousei* var. *crassa* Goldfuss – Schubert, 62.

1975 *Hippurites (Orbignya) lapeirousei* Goldfuss – Pleničar, 87, pl. 1, fig. 10.

1981 *Hippuritella lapeirousei* (Goldfuss) – Sánchez 10, cum syn.

1992 *Hippuritella lapeirousei* (Goldfuss) – Vicens, 123.

1994 *Hippuritella lapeirousei* (Goldfuss) – Pleničar, 50, pl. 2, figs 9–10.

**Taxonomical remarks:** According to Douvillé (1891–97), *Hl. lapeirousei* is characterized by a cylindrical or cylindrical-conical lower valve ornamented by longitudinal costae of variable wideness, which are separated by concave rounded canals. The distance between the costae varies among specimens coming from different geographical areas. The upper valve is covered by polygonal pores, which are arranged into regular and radial rows on the border of the valve.

The inner characters are the ligamental ridge, absent or hardly marked by a small inflexion in the outer layer of the shell, and the rounded pillars, which are slightly different between them. The cardinal apparatus is situated near the dorsal margin of the lower valve. The tooth *N* is X-shaped. The narrow and elongated alveolus of

the anterior tooth is situated along the dorsal margin, while that of the posterior one is small and rounded. The miophore cavities are well developed.

Douvillé (1895) observed that "les caractères de l'ornamentation extérieure, quoique d'une importance beaucoup moindre, peuvent être aussi d'une certaine utilité pour distinguer ces espèces."

Douvillé (1895) defined the group of *Hippuritella variabilis* Munier-Chalmas, 1867 in which he included the following species: *Hippuritella maestrei* Vidal, 1878, *Hippuritella variabilis* and *Hippuritella lapeirousei*.

Sladić-Trifunović (1978) observed that the holotype of *Hl. lapeirousei* is characterized by a conical valve, while the holotype of *Hl. nabresinensis* is cylindrical.

Distribution: This species has been found in the Upper Campanian-Lower Maastriichtian in Spain in the areas of Montsec and Valencia, in Italy in the zones of Matese Mt. and Maiella Mt. (Pons & Sirna, 1992) and at Stranice in the Maastriichtian (Slovenia) (Pleničar, 1994).

The transversal sections of the lower valves of the individuals of the species *Hippuritella lapeirousei* are presented on the plate 1, the morphometrical measures of the same individuals on the table 1.

#### *Hippuritella nabresinensis* (Futterer, 1893)

1926 *Hippurites (Orbignya) lapeirousei* Goldfuss - Parona, 349.

1969 *Hippurites nabresinensis acuticostatus* Lupu - Lupu, 210, pl. 1.

1975 *H. (Orbignya) nabresinensis* Futterer - Pleničar, 107, pl. 1, fig. 2., textfig. 3.

1981 *H. nabresinensis* Futterer - Sánchez, 20, cum syn.

1982 *H. nabresinensis* Futterer - Czabalay, 80, pl. 10, fig. 5.

1982 *H. nabresinensis* Futterer - Accordi et al., 770, pl. 7, figs. 8, 10.

1985 *H. nabresinensis* Futterer - Laviano, 325, pl. 7, figs. 2, 4.

1992 *H. nabresinensis* Futterer - Peza, 294, pl. 1, fig. 3.

Table 1. Morphometrical measures of samples of *Hl. lapeirousei* described in literature

N	SPECIMENS	Sa	Ia	PI-P2a
1	Douvillé, 1893, tab. 24, fig. 10	340	419	16
2	Toucas, 1903, p.53, fig. 83	140	207	8
3	Toucas, 1903, p.53, fig. 84	122	137	8
4	Pleničar, 1975, p.7, fig. 2	194	182	11
5	Parona, 1900, tab. 1, fig. 2	426	510	30
6	Goldfuss, 1840, tab. 165, fig. 5c	52	95	4
7	Czabalay, 1982, tab. 24, fig. 1	287	349	21
8	Pons, 1977, tab. 25, fig. 1	21	38	2
9	Pons, 1977, tab. 25, fig. 2	97	145	7
10	Pons, 1977, tab. 17, fig. 1	390	754	36
11	Pleničar, 1994, tab. 2, fig. 6	351	574	22
12	Vicens, 1992, tab. 1, fig. 17	239	336	13
13	Vicens, 1992, tab. 1, fig. 19	87	133	7
14	Vicens, 1992, tab. 1, fig. 20	226	371	17

Sa Shell area; Ia Inner area; PI-P2a Pillars area. The area's values are expressed in mm<sup>2</sup>

**Taxonomical remarks:** Futterer (1893) in the description of the *Hl. nabresinensis* focused his attention specially on the external characters of this species. He described the cylindrical lower valve with a length of 270mm and a diameter of 30 to 40mm. The shell is crossed by about 21 longitudinal and rounded costae, which are from 2 to 5mm wide. The pillar *P1* is rounded and its base is wider than that of the pillars *P2*. Accordi et al. (1982) observed that the shell is crossed by rounded costae which include narrow canals. These canals are also crossed by thin ribs. The external shell presents weak concavities in correspondence to the pillars. The presence of a ligamental ridge is not mentioned by Futterer (1893) in his description of the holotype. This character is confirmed by personal observations on 300 lower valves of this species coming from the type locality Aurisina/Nabrežina.

The Futterer's description (1893) receives two years later the first objection from Douvillé (1895), who placed *Hl. nabresinensis* as a synonym of *Hippurites lapeirousei* var. *crassa* because these characters were not enough to create a new species. Parona (1900) also observed the great similarity between *Hl. nabresinensis* and *Hl. lapeirousei* and the same author placed *Hl. nabresinensis* as a synonym of *Hl. lapeirousei* in 1926 confirming the previous observations of Douvillé (1895). Also Schubert (1912) placed *Hl. nabresinensis* as synonym of *Hl. lapeirousei* var. *crassa*.

Kühn (1947) described a new species *Hl. heritschi*. Later, other authors discussed about the similarity between these species: Sladić-Trifunović (1972, 1978) analysed the taxonomical problem and Laviano (1985) summarized the observations about the differences between the three species, according to the previous authors (Lupu, 1976; Sladić-Trifunović, 1972, 1978; Accordi et al., 1982).

**Distribution:** the holotype described by Futterer (1893) has been found in the type locality Aurisina/Nabrežina (Karst of Trieste) in the limestones of the Santonian-Campanian (Cucchi et al., 1987).

The transversal sections of the lower valves of the individuals of the species *Hippuritella nabresinensis* are presented on the plates 2, 3a and 3b, the morphometrical measures of the same individuals on the tables 2 and 3.

Table 2. Morphometrical measures of samples of *Hl. nabresinensis* described in literature

N	SPECIMENS	<i>Sa</i>	<i>Ia</i>	<i>P1-P2a</i>
1	Accordi et al., 1982, tab. 4, fig. 10	135	113	11
2	Accordi et al., 1982, tab. 4, fig. 10	180	177	14
3	Futterer, 1893, tab. 22, fig. 3a	235	608	37
4	Polšak, 1979, tab. 10, fig. 7	775	766	43
5	Polšak, 1979, tab. 10, fig. 7	779	947	56
6	Laviano, 1985, tab. 7, fig. 4	203	209	20
7	Czabalay, 1982, tab. 10, fig. 5	134	144	12
8	Sladić-Trifunović, 1972, tab. 12, fig. 1b	284	361	21
9	Sladić-Trifunović, 1972, tab. 12, fig. 2b	174	168	13
10	Accordi et al., 1990, tab. 1, fig. 5	884	877	90

*Sa* Shell area; *Ia* Inner area; *P1-P2a* Pillars area. The area's values are expressed in mm<sup>2</sup>

Table 3. Morphometrical measures of samples of *Hl. nabresinensis* coming from to Aurisina/Nabrežina (Karst of Trieste)

N	Sa	Ia	P1-P2a	N	Sa	Ia	P1-P2a
1	63	57	4	25	1029	1524	63
2	485	365	29	26	275	296	17
3	25	34	2.5	27	2405	1729	137
4	26	38	2.5	28	589	531	34
5	545	468	36	29	502	584	51
6	491	381	31	30	285	330	22
7	184	190	7	31	283	231	16
8	229	244	20	32	515	533	39
9	320	292	15	33	485	628	38
10	65	86	5	34	98	70	4
11	51	76	2	35	159	191	13
12	895	905	72	36	454	561	36
13	414	340	24	37	47	52	3
14	89	104	3	38	259	244	16
15	574	591	54	39	456	536	29.5
16	526	770	33	40	239	394	25
17	81	267	19	41	152	114	5.5
18	510	448	40	42	64	84	4
19	957	926	72	43	50	37	3.5
20	268	174	15	44	85	77	4
21	121	240	6	45	103	62	6
22	175	283	14	46	178	210	20
23	357	401	36	47	71	93	7
24	124	81	11	48	108	121	9

Sa Shell area; Ia Inner area; P1-P2a Pillars area. The area's values are expressed in mm<sup>2</sup>

### *Hippuritella heritschi* (Kühn, 1947)

1908 *Hippurites colliciatatus* Woodward - Schmidt, 238.

1934 *Hippurites (Orbignya) lapeirousei* Goldfuss - Milovanović, 223, fig. 18.

1951 *H. (Orb.) nabresinensis* Futterer - Pejović, 94, pl. 1, fig. 2; pl. 2, fig. 2; pl. 3, fig. 2.

1960 *H. heritschi* Kühn - Kühn, 48.

1962 *H. heritschi* Kühn - Kaumanns, 305, pl. 2, fig. 4; text. fig. 6.

1970 *H. heritschi* Kühn - Pamouktchiev, 48.

1978 *H. heritschi* Kühn - Sladić-Trifunović, 422, pl. 1-8, text. fig. 1, 2.

1979 *Hippuritella heritschi* (Kühn) - Pamouktchiev, 220, pl. 7, figs. 1-3.

1982 *Hippurites heritschi* Kühn - Czabalay, 79, pl. 13, fig. 14; pl. 18, fig. 1.

1992 *Hippurites heritschi* Kühn - Caffau et al., Pl. 1, fig. 1.

1994 *Hippuritella heritschi* (Kühn) - Pleničar, 51, pl. 2, fig. 7; pl. 3, fig. 1, 2.

Taxonomical remarks: the conical lower valve is crossed by longitudinal costae, separated by rounded canals. In some specimens the shell is very thick and can be as large as 27mm, as described by Sladić-Trifunović (1978). The pillars are

triangular with approximately the same dimensions. The upper valve, which was described for the first time by Sladić-Trifunović (1978), is covered by polygonal pores and radially crossed by canals. The ligamental ridge is absent. Sladić-Trifunović (1978) analysed the taxonomical problem concerning the similarity of this species with the *Hl. lapeirousei* and *Hl. nabresinensis*. He also observed that in all stages of the ontogenetical development, the shell of *Hl. heritschi* is always thick. In our opinion, such character is also present in *Hl. nabresinensis*. According to Pejović and Kühn (1960), Laviano (1985) considered the shape and dimension of the shell and pillars as distinctive characters between *Hl. nabresinensis* and *Hl. heritschi*.

Table 4. Morphometrical measures of samples of *Hl. heritschi* described in literature

N	SPECIMENS	Sa	Ia	PI-P2a
1	Laviano, 1985, tab. 9, fig. 1	1873	1550	101
2	Caffau et al., 1992, tab. 1, fig. 1	966	657	56
3	Accordi et al., 1987, tab. 2, fig. 6	1595	1689	127
4	Pejović, 1951, tab. 3, fig. 2	2706	2099	168
5	Pejović, 1951, tab. 1, fig. 2	1863	1039	97
6	Sladić-Trifunović, 1978, tab. 1, fig. 2	1790	1880	62
7	Sladić-Trifunović, 1978, tab. 4, fig. 3	1299	1124	63
8	Sladić-Trifunović, 1978, tab. 6, fig. 3	557	380	31
9	Sladić-Trifunović, 1978, tab. 6, fig. 2	978	820	64
10	Sladić-Trifunović, 1978, fig. 1	1061	631	54
11	Pleničar, 1994, tab. 3, fig. 1	2214	2115	143

Sa Shell area; Ia Inner area; PI-P2a Pillars area. The area's values are expressed in mm<sup>2</sup>

Table 5. Morphometrical measures of samples of *Hl. heritschi* from Stranice (samples 1-2) and from Senožeče (samples 3-15), Slovenia

N	Sa	Ia	PI-P2a
1	747	687	37
2	572	483	43
3	575	549	46
4	121	88	12
5	419	375	30
6	462	378	38
7	213	149	14
8	559	482	42
9	415	397	20
10	427	384	25
11	251	201	16
12	110	114	8
13	945	1088	74
14	568	463	51
15	755	381	45

Sa Shell area; Ia Inner area; PI-P2a Pillars area. The area's values are expressed in mm<sup>2</sup>

**Distribution:** *Hl. heritschi* was found in Maastrichtian in Katschberg, near the St. Bartholomä in Austria (Sladić-Trifunović, 1978). Furthermore, in the Upper Campanian–Lower Maastrichtian in the zone of Valencia in Spain, in Italy in the Apennines in the zone of Maiella Mt. and Matese Mt. and in Sicilia (Pachino) (Pons & Sirna, 1992).

The transversal sections of the lower valves of the individuals of the species *Hippuritella heritschi* are presented on the plates 4 and 5, the morphometrical measures of the same individuals on the tables 4 and 5.

### Biometrical analysis

We recall that the examined material for this study included: a) specimens which are already described in literature and b) specimens coming from different outcrops (tab. 3a, 3b, 5; pl. 3, 5).

In the first case, the morphometrical values were obtained from published illustrations (tab. 1, 2, 4; pl. 1, 2, 4). In the latter case, the lower valves were cut and their transversal sections were subjected to morphometric measurements. Some characters, which are related by their biological functions (Reali, 1992) were selected for this biometrical study and their areas were measured as shown in Fig 1a. These morphometrical values are: a) the surface mantle or shell area ( $Sa$ ) responsible for the incoming water flux and the entrance of nutrients in the internal cavity; b) the area of the internal cavity ( $Ia$ ) which contains the organic tissues where assimilation of nutrients takes place; c) the surface of pillars ( $P1-P2a$ ), related to the expulsion of metabolic residues. Taking into account that pillars and mantle thickness are in close biological relationship with the internal cavity (Skelton, 1976),  $P1-P2a$  and  $Sa$  values were plotted against  $Ia$ .

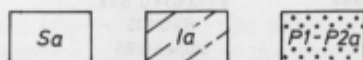
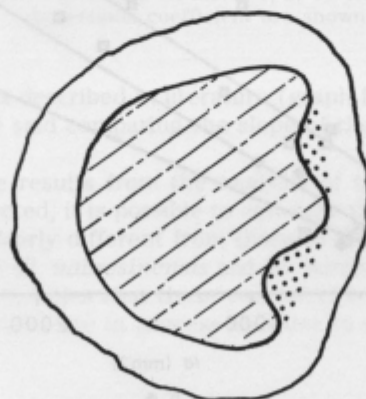


Fig. 1a. Transversal section of a lower valve where the measured areas are indicated

In all the graphs, the regression lines corresponding to *Hl. lapeirousei*, *Hl. nabresinensis* and *Hl. heritschi* were indicated as a, b, and c, respectively.

### Results and final consideration

In all the cases, the regression lines of *Sa* versus *Ia* and *P1-P2a* versus *Ia* (figs. 1-4) have a dispersion coefficient ( $r$  squared =  $R$ ) close to the unit.

This value indicates a very good correlation between these morphological characters, also including specimens coming from different geographical areas. In detail, in graph fig. 1 the slope of the regression lines for the species *Hl. nabresinensis* and *Hl. heritschi* are 0.85 and 0.91 respectively while for *Hl. lapeirousei* is 0.59. In graph fig. 2, the regression lines for *Hl. nabresinensis* and *Hl. heritschi* have a slope of 0.059 and 0.057 respectively while for *Hl. lapeirousei* is 0.046. Comparing these values (graphs figs. 1 and 2) it can be seen that the slope of the regression line for the species *Hl. lapeirousei* differs from the other two, which are very similar between them.

The same values for the collected samples of the species *Hl. nabresinensis* and *Hl. heritschi* (graph fig. 3: slope values of 1.03 and 0.87 respectively) are very similar

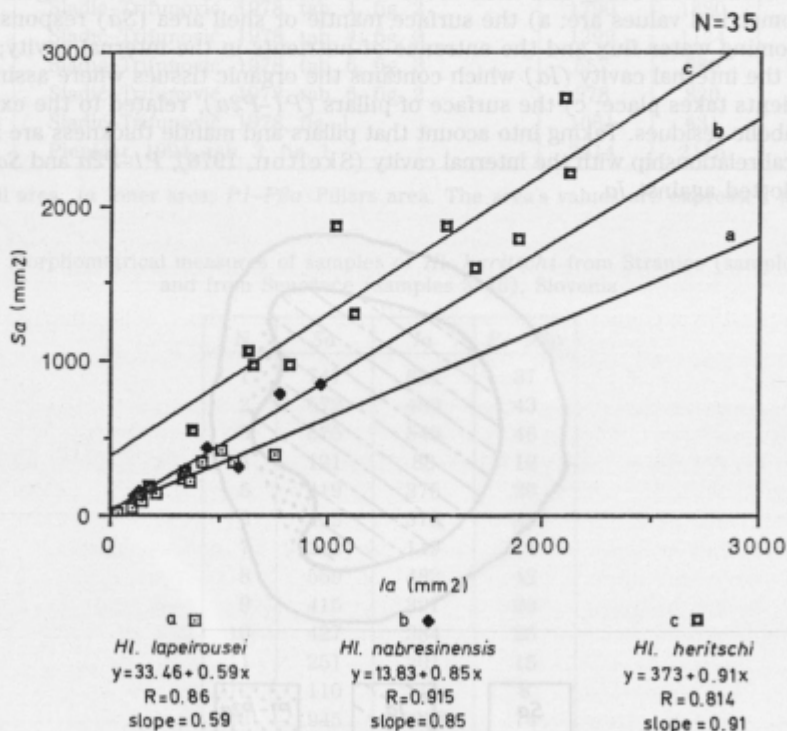


Fig. 1. Shell area (*Sa*) versus inner area (*Ia*) of samples of the three described in literature (see data on tables 1, 2, 4). Regression values and dispersion coefficient are shown



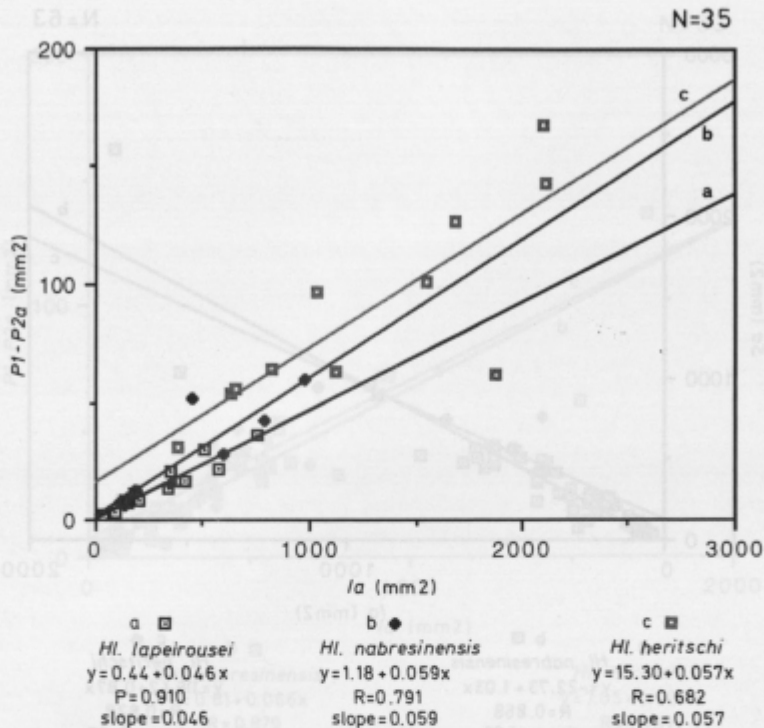


Fig. 2. Pillars area ( $PI-P2a$ ) versus inner area ( $Ia$ ) of samples of the three described in literature (see data on tables 1, 2, 4). Regression values and dispersion coefficient are shown

to those of the specimens described in literature (graph fig. 1: 0.85 and 0.91 respectively). The same can be said comparing the slope of the regression lines in graphs figs. 4 and 2.

Thus, combining the results from the analysis of the specimens described in literature and those collected, it is possible to conclude that the biological characters of *Hl. lapetrousei* are clearly different from those of the other two species. On the contrary, the characters of *Hl. nabresinensis* and *Hl. heritschi* are very similar between them. This fact leads to the idea that these two species could be the same. In fact, new morphometrical analysis are in process in order to confirm this hypothesis.

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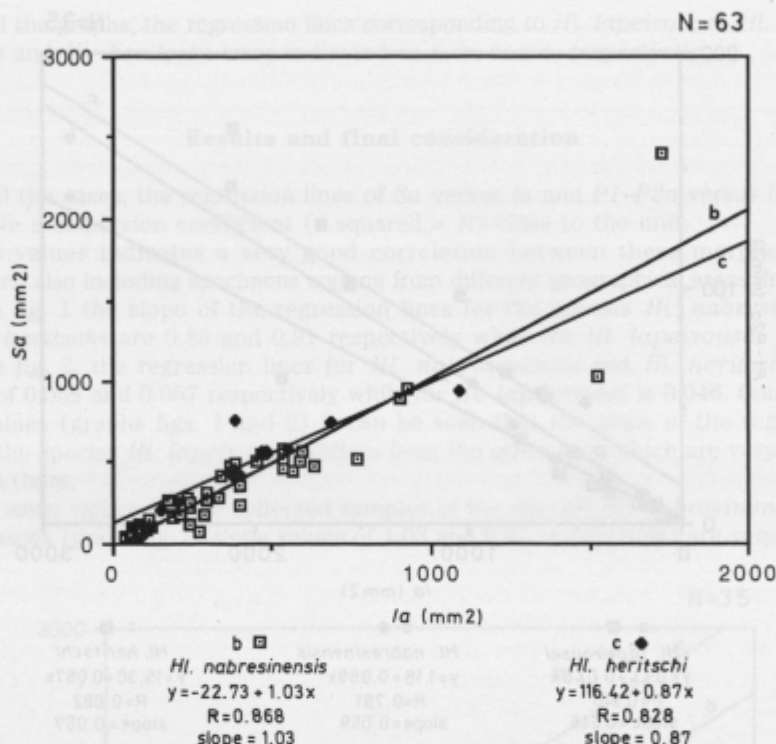


Fig. 3. Shell area ( $S_a$ ) versus inner area ( $I_a$ ) of samples of *Hl. nabresinensis* and *Hl. heritschi* recently found in outcrops (see data on tables 3, 5). Regression values and dispersion coefficient are shown

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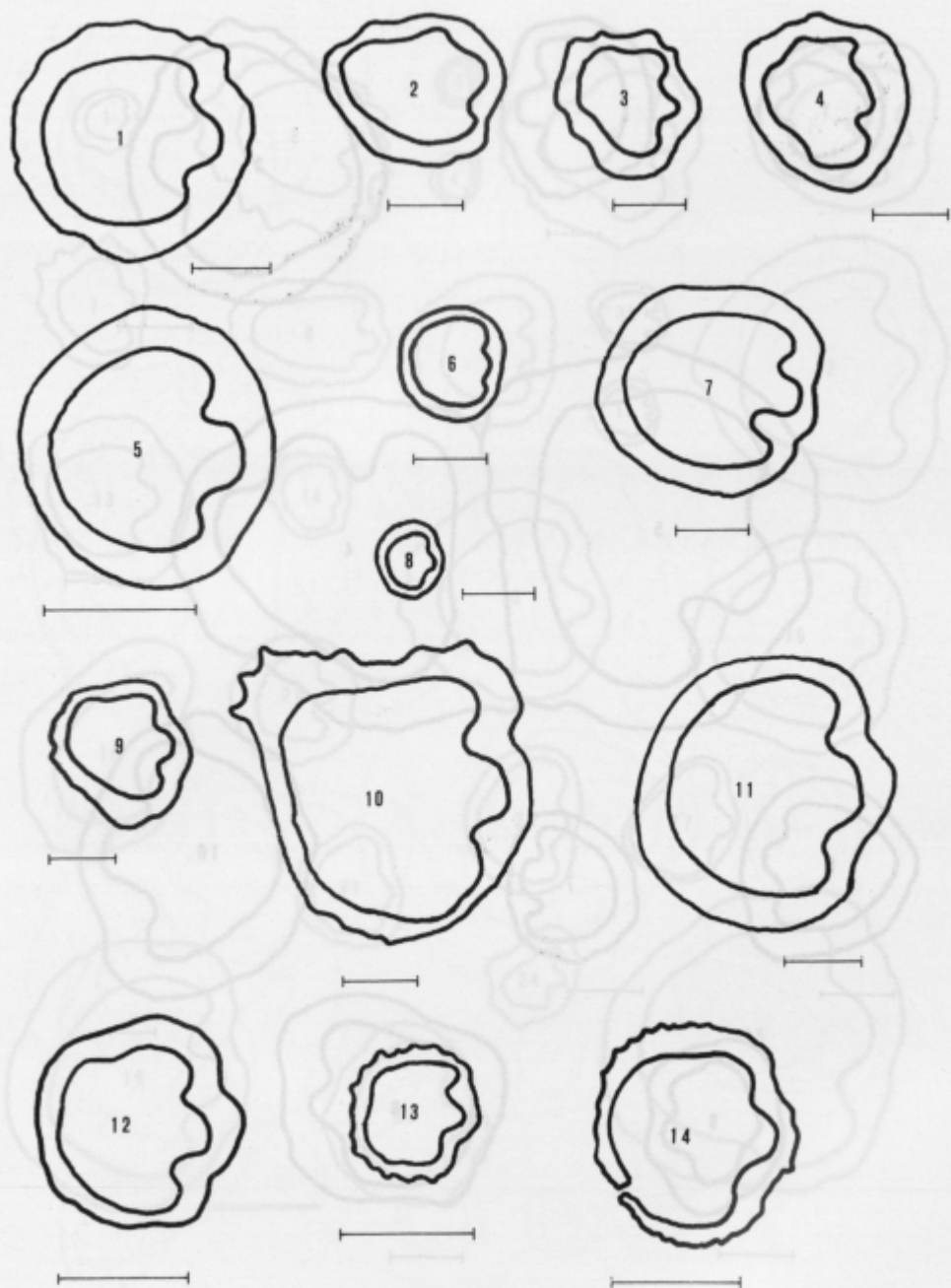
Warmest thanks are extended to all.

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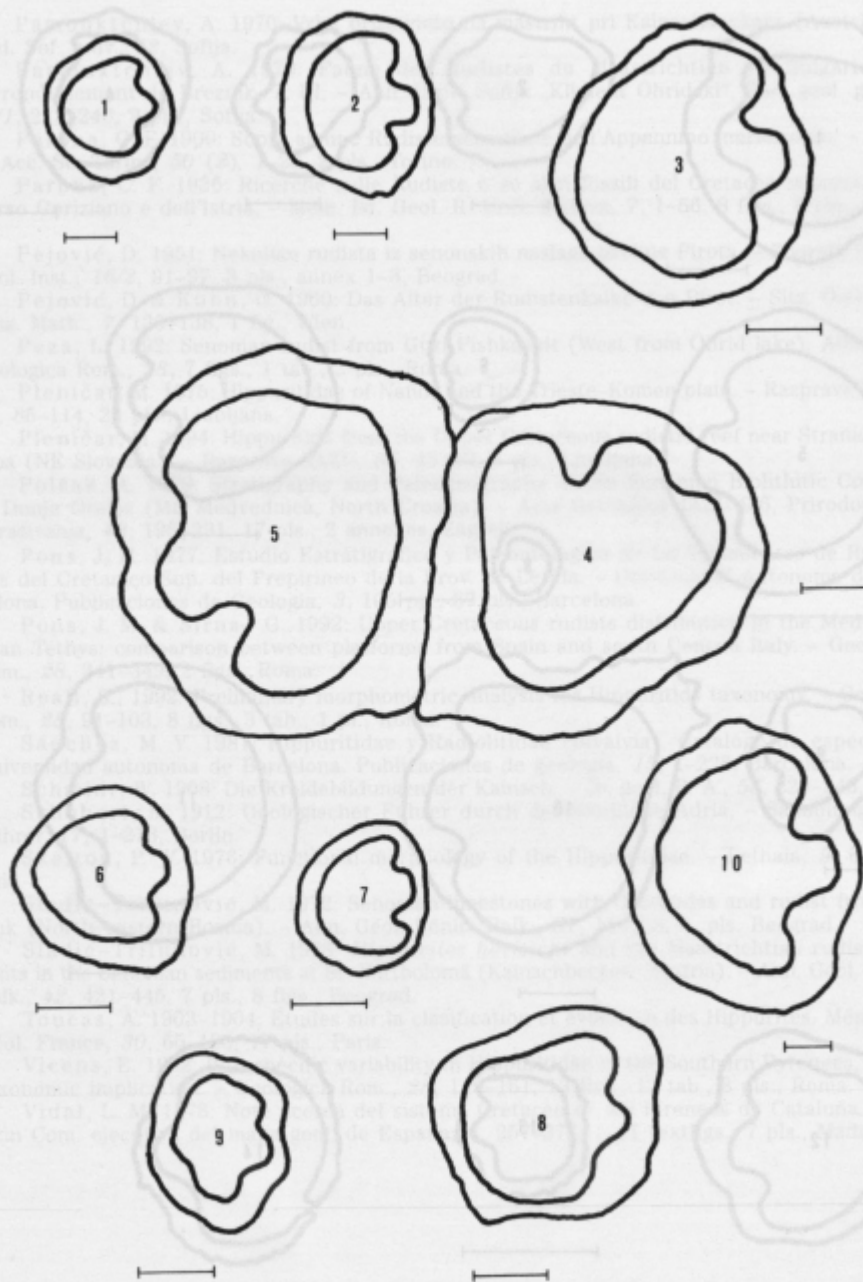
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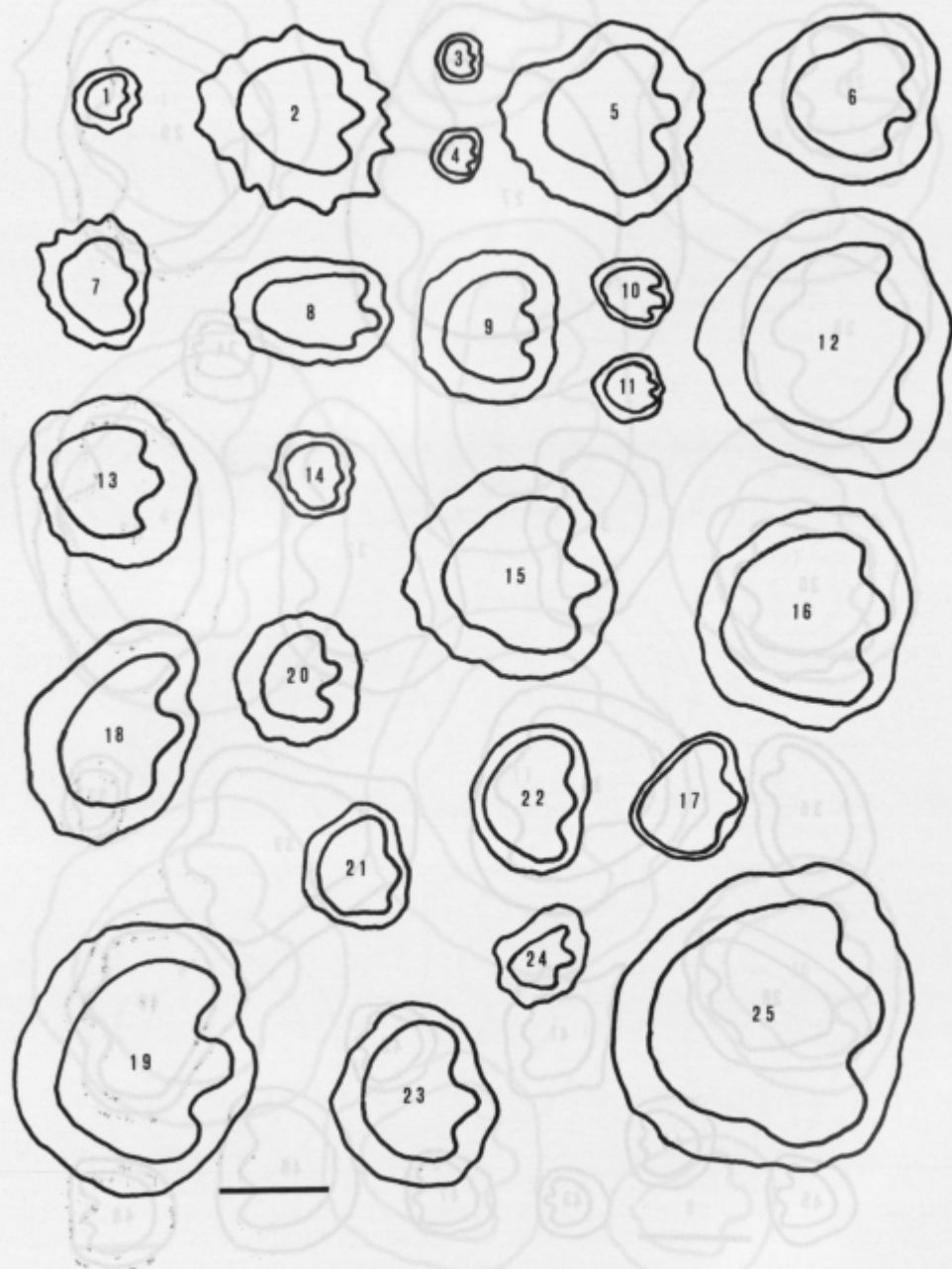
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**Plate 1**

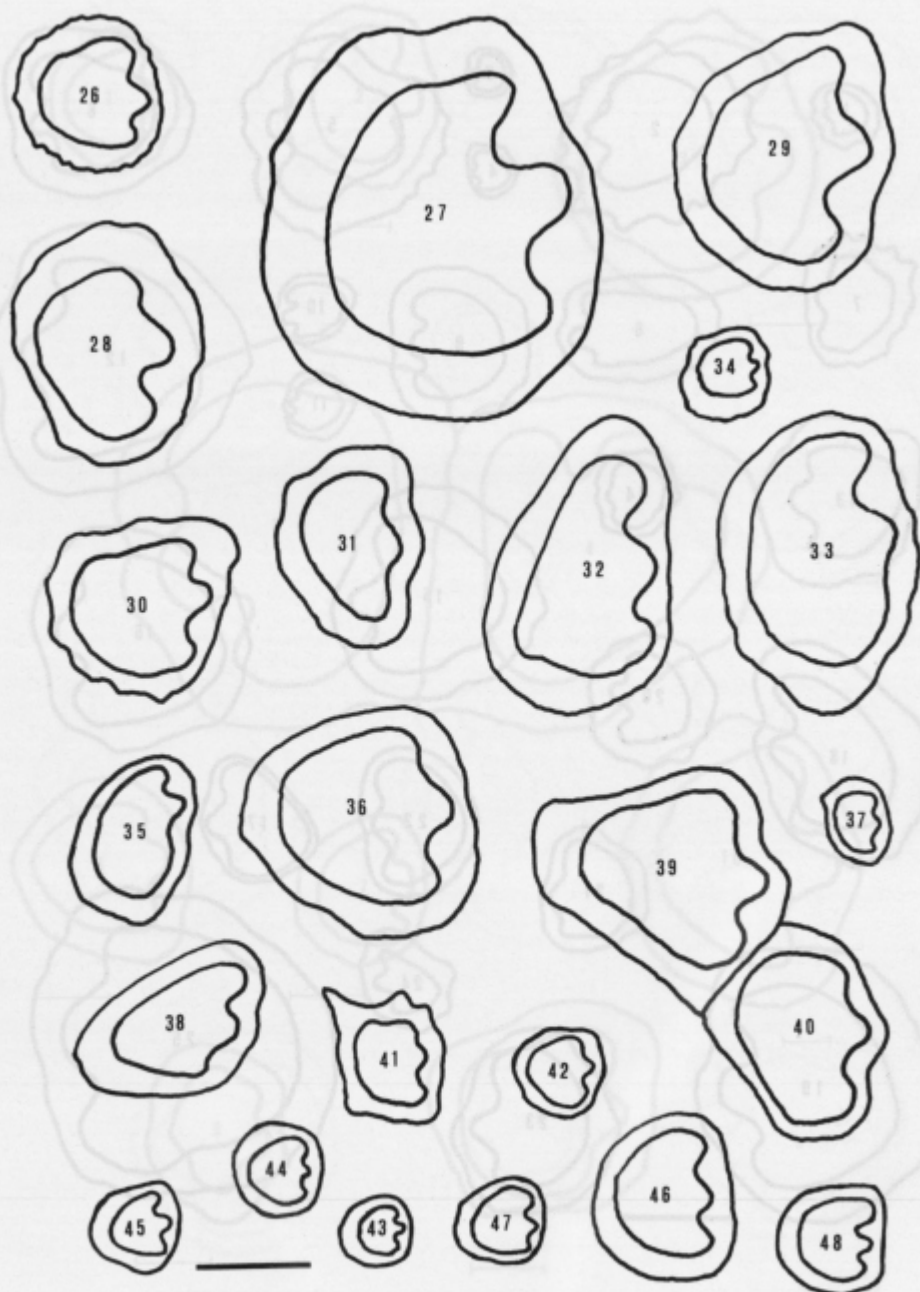
*Hl. lapeirousei*, transversal sections of lower valves of individuals described in literature, measured and numbered. Bar scale: 10mm

**Plate 2**

*Hl. nabresinensis*, transversal sections of lower valves of individuals described in literature, measured and numbered. Bar scale: 10mm

**Plate 3a**

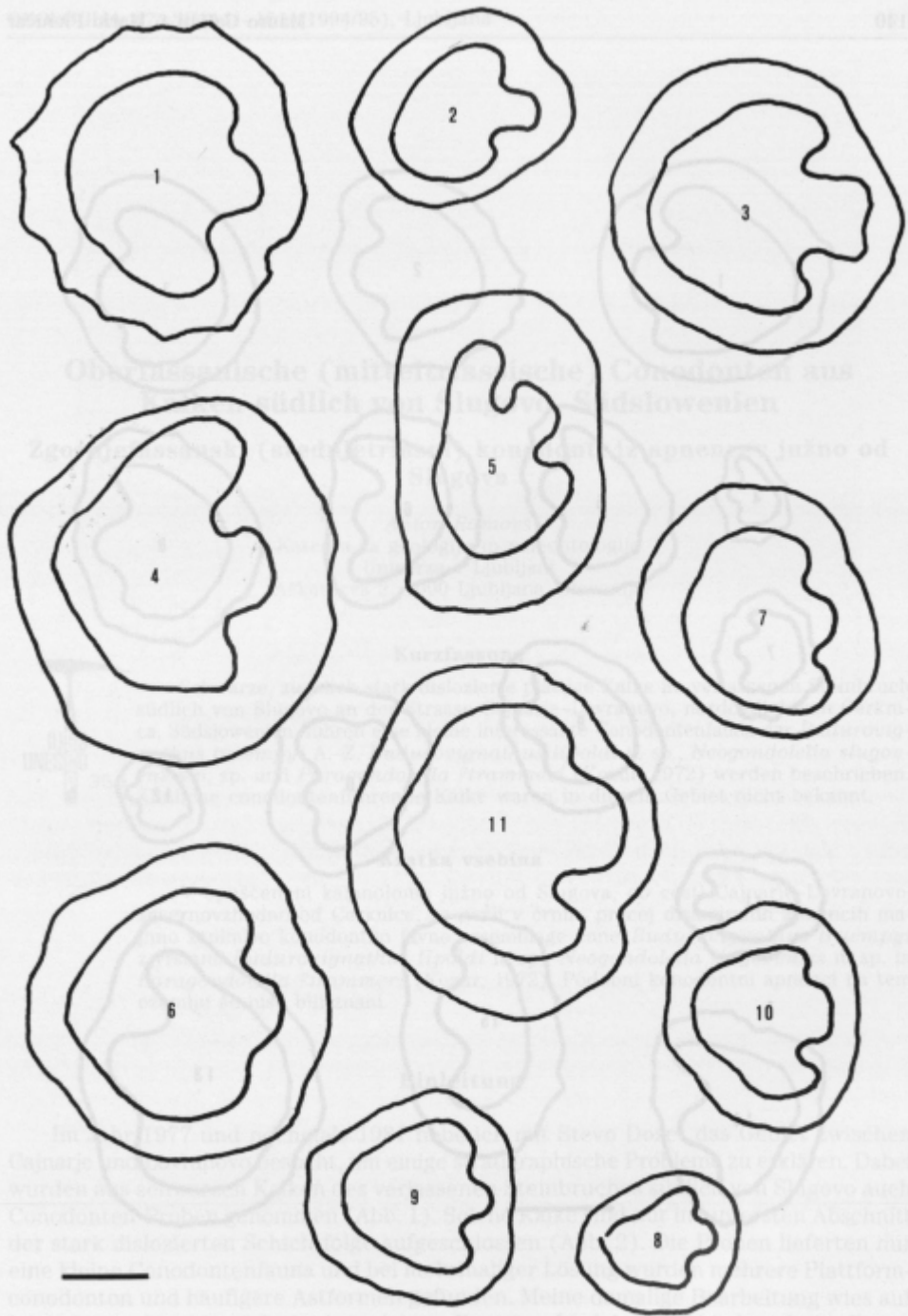
*Hl. nabresinensis*, transversal sections of the lower valves of individuals that belong to Aurisina/Nabrežina (Karst of Trieste), measured and numbered. Bar scale: 20mm



**Plate 3b**

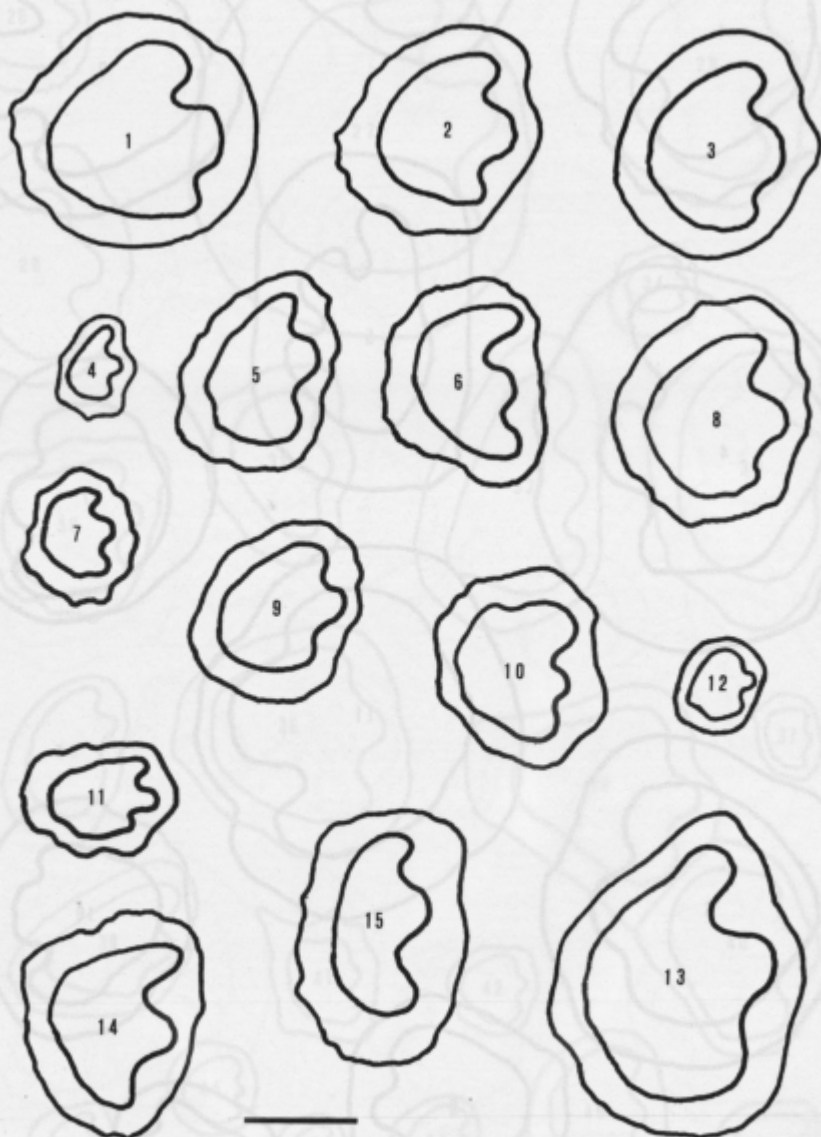
*Hl. nabresinensis*, transversal sections of the lower valves of individuals that belong to Aurisina/Nabrežina (Karst of Trieste), measured and numbered. Bar scale: 20mm





**Plate 4**

*HL. heritschi*, transversal sections of lower valves of individuals described in literature, measured and numbered. Bar scale: 20mm

**Plate 5**

*Hl. heritschi*, transversal sections of lower valves of individuals from Stranice (samples 1-2) and from Senožeče (samples 3-15) measured and numbered. Bar scale: 20mm