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The Taxonomy of the Descendants of the Genus *Jigulites* Rosovskaya, 1948 (Foraminifera, Schwagerinida)

A. P. Vilesov

Perm State University, ul. Bukireva 15, Perm, 614600 Russia

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Abstract—In addition to the genus *Anderssonites* Syomina, Solovieva, et Bensh, 1987, the direct descendants of the genus *Jigulites* Rosovskaya, 1948, include the groups *"Pseudofusulina" kossovoii* Alexeeva et Polozova and *"Pseudofusulina" gregaria* (Lee). The morphologies of these schwagerinid groups suggest their generic status. The name *Retijigulites* gen. nov. is proposed for the *"P." kossovoii* group. *"P." gregaria* group is separated into the genus *Lapigerella* gen. nov. with the type species *Lapigerella taberna* sp. nov.

INTRODUCTION

The genus *Anderssonites* Syomina, Solovieva, et Bensh, 1987, embracing late Gzhelian and early Asselian schwagerinids with thick strongly folded, well-ordered septae and massive internal deposits is usually thought to be the only descendant of the genus *Jigulites* Rosovskaya, 1948 (Kireeva, 1972; Syomina *et al.*, 1987; Vilesov, 1998). However, the real diversity of *Jigulites* descendants is considerably higher than is reflected by the present system of the order Schwagerinida. The examination of Gzhelian and Asselian schwagerinids from the Central Urals and data available in the literature allow two new genera of the family Pseudofusulinidae to be erected as descendants of *Jigulites*.

MATERIAL

The phylogenetic considerations presented in this paper are based primarily on the materials from the thoroughly studied Kholodnyi Log section (Kosva River, the Central Urals). These are the large collection of Yu.A. Ekhlakov and author's collection. The sampling points of thin sections used in the paper are given according to the description of the section in (*Mezhdunarodnyi...*, 1991).

MORPHOGENESIS IN THE GENUS *JIGULITES*

Jigulites and *Daixina* dominated in the schwagerinid communities of the late Gzhelian basins of the Russian Plate, Urals, and adjacent regions. The genus *Jigulites* evolved toward stronger septal folding and test enlargement (Rosovskaya, 1950; Davydov, 1988). The morphology of *Jigulites* is characterized by plasticity. Rosovskaya (1950) noted that the evolution paths of this genus were quite diverse. By the late Noginian time of Gzhelian age, different phyletic lines of *Jigulites* gave new schwagerinid groups, which must be considered in the generic status.

In particular, evolution of the group *Jigulites magnus* Rosovskaya with short fusiform younger whorls, strong regular septal folding, and thick septae has resulted in the appearance of first anderssonits [*Anderssonites anderssoni* (Schellwien) and *A. eliseevi* (Michailova); text-figs. 1c, 1h, 1i]. In the Kholodnyi Log section, anderssonits appear in Bed 6 of Outcrop 26.

Jigulits with elongated tests, slender septae, strong weakly ordered septal folding, and obscure apertures (*J. formosus* Rosovskaya) evolved toward test enlargement and further intensification of septal folding. During the Noginian, this group gave specific schwagerinids belonging to the genus *Pseudofusulina* (e.g., *"P." kossovoii* Alexeeva et Polozova, *"P." excessa* Alksne *et al.*; text-figs. 1b, 1g). Earlier, Alexeeva (1977) described these jigulit descendants from the Mesen Syneclise. Here, the schwagerinids of *"P." kossovoii* group are separated into a short-living, dead-end genus, *Retijigulites*.

In the Kholodnyi Log section, the earliest retijigulits occur in Bed 7 of Outcrop 26; thus, stratigraphically, they follow the earliest anderssonits.

The group *Jigulites altus* (Rosovskaya) with elongated commonly subcylindrical test, pronounced aperture, and relatively ordered septal folding gave rise to *"Pseudofusulina" gregaria* (Lee) with thick massive axial deposits and thick septae (Figs. 1a, 1d–1f). This group evolved toward more ordered septal folding and larger tests. This phyletic group was outlined by Davydov (1988), who did not distinguish between the group *"Pseudofusulina" gregaria* and the genus *Anderssonites*. He considered both of them to be the genus *Gregariella*, which was proposed by Alexeeva *et al.* (1983). However, the latter genus does not satisfy Articles 13.1 and 13.3 of the International Zoological Code (2000), since no type species were designated for its subgenera

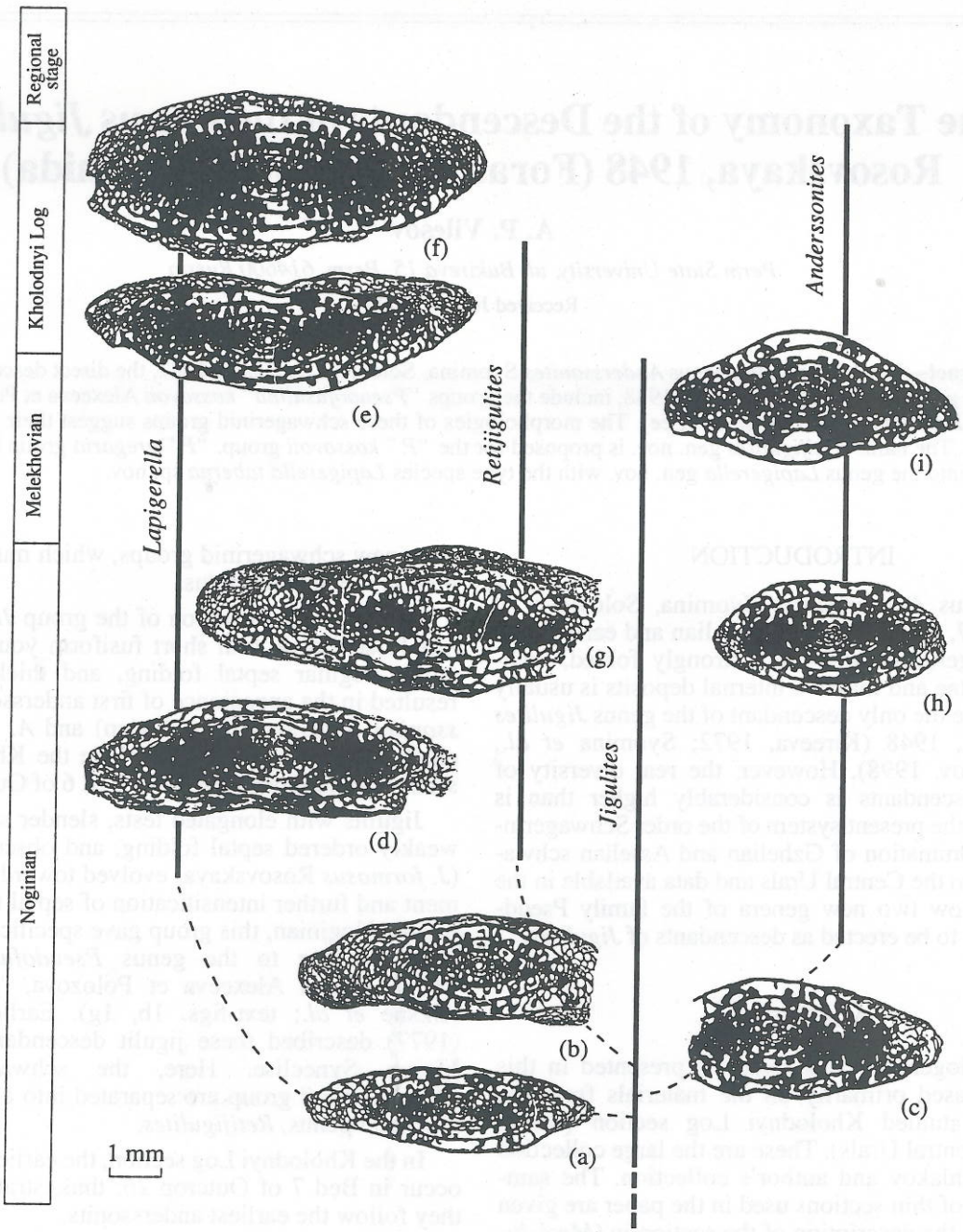

Fig. 1. Schematic phylogeny of the genus *Jigulites* and its descendants, (a) *Jigulites altus* (Rosovskaya, 1952), specimen 3984, Kholodnyi Log Section (KhL), Outcrop 26, Bed 6; (b) *Jigulites formosus* (Rosovskaya, 1950), specimen 3976, KhL, outcrop 26, bed 7, (c) *Jigulites magnus* (Rosovskaya, 1950), specimen 32-2/5, KhL, Outcrop 26, Bed 7; (d) *Lapigerella* aff. *L. praegregaria* (Scherbakova, 1977), specimen 3974, KhL, Outcrop 26, Bed 7; (e) *Lapigerella furnishi* (Ross, 1965), specimen 24-5-9/5, KhL, Outcrop 24, Bed 5; (f) *Lapigerella taberna* sp. nov., specimen 3315, KhL, Outcrop 22, Bed 7; (g) *Retijigulites kossovoii* (Alexeeva et Polozova, 1972), specimen 3960, KhL, Outcrop 26, Bed 7; (h) *Anderssonites* aff. *A. anderssoni* (Schellwien, 1908), specimen 3977, KhL, Outcrop 26, Bed 7; and (i) *Anderssonites ognevae* Vilesov, 1998, holotype 3-4/1, Ostanets Section, Bed 3; thick vertical lines indicate stratigraphic ranges of schwagerinid genera; thin dashed lines indicate supposed phyletic relations; schwagerinids shown in Figs. 1a, 1b, 1d, 1f, 1g, and 1h are originated from the collection of Yu.A. Ekhlakov; all images are shown in one magnification.

Gregariella and *Paragregariella*, as well as for the genus itself, and the generic diagnosis was not published. The genus *Gregariella*, therefore, should be considered invalid.

Here, a new generic name, *Lapigerella*, is proposed for the *"Pseudofusulina" gregaria* species group. In the Kholodnyi Log section, *Lapigerella* cooccur with *Retijigulites* in Bed 7 of Outcrop 26.

SYSTEMATIC PALEONTOLOGY

Family Pseudofusulinidae Dutkevich, 1934

Subfamily Pseudofusulininae Dutkevich, 1934

Genus *Retijigulites* Vilesov, gen. nov.

Pseudofusulina: Grozdilova, 1966, p. 264 (part.); Kalmykova *et al.*, 1972, p. 20 (part.); Zolotova *et al.*, 1977, p. 109 (part.).

Etymology. Latin *rete* (grid) and the generic name *Jigulites*.

Type species. *Pseudofusulina kossovoii* Alexeeva et Polozova, 1972; Kalmykova *et al.*, 1972, p. 24, pl. 8, figs. 5 (holotype) and 6; Lower Permian, Asselian, Sokol'ja Gora regional stage, boreholes in the villages of Verkhnii Smolenets and Koinas, Mezen River, Arkhangelsk Region.

Diagnosis. Test large and medium-sized, elongated fusiform to subcylindrical. Winding denser in internal whorls than in external. Test extends along axis in first whorls, while whorl height increases gradually. Test wall in internal whorls thin, in adult whorls of moderate thickness (up to 90 μm). Septae thin, strongly folded. Folding high, pronouncedly irregular to relatively ordered. Arches rounded, often arranged in two tiers, thus forming characteristic laces. Sometimes septal folding occurs in aperture region. Axial deposits variously expressed: absent or rudimentary in some species, in others relatively thick, occupying several internal whorls. Aperture slitlike, narrow, somewhat wider in external whorls. Sometimes it is hardly discernible because of strong septal folding. Chomata small, rounded, present on proloculus. Pseudochomata weak, slender, hook-shaped.

Comparison. *Retijigulites* gen. nov. is distinguished from *Pseudofusulina* Dunbar et Skinner, 1931 (sensu stricto) by having thinner septae, irregular lacy septal folding, looser test winding, and less distinct aperture. The latter is due to the lack of well-developed massive pseudochomata and strong septal folding in the medial region of the test.

Retijigulites is distinguished from the ancestral genus *Jigulites* by having a larger subcylindrical and elongated fusiform test, chomata only on the proloculus, and weak pseudochomata.

Retijigulites is distinguished from its relative *Anderssonites* by having thin irregularly folded septae, weak pseudochomata, and an elongated sometimes subcylindrical test shape.

Species composition. *Retijigulites kossovoii* (Alexeeva et Polozova, 1972), *Daixina sokensis* and *Daixina bosbytauensis–Globifusulina robusta* zones, Gzhelian, Upper Carboniferous of Arkhangelsk Region and the Central Urals; *R. onerosus* (Alexeeva et Polozova, 1972), *Daixina bosbytauensis–Globifusulina robusta* Zone, Gzhelian, Upper Carboniferous and *Schwagerina vulgaris–Schwagerina fusiformis* Zone, Asselian, Lower Permian, Arkhangelsk Region; *R. grozdilovae* (Alexeeva et Polozova, 1972), same age and region; *R. mezenensis* (Alexeeva et Polozova, 1972), same age and region; *R. excessus* (Alksne, 1977), *Daixina sokensis* Zone, Gzhelian, Upper Carboniferous of the Central Urals and Fore-Urals; *R. fusinus* (Scherbakova, 1977), same age and region; *R. volozhaninae* (Konovalova, 1977), *Schwagerina vulgaris–Schwagerina fusiformis* Zone, Asselian, Lower Permian, the Timan-Pechora and the Central Urals; *R. limatus* (Grozdilova, 1966), *Daixina sokensis* Zone, Gzhelian, Upper Carboniferous of the Northern Timan.

Occurrence. *Daixina sokensis* Zone of the Gzhelian (Upper Carboniferous) through *Schwagerina vulgaris–Schwagerina fusiformis* Zone of the Asselian (Lower Permian) of northeastern European Russia: Mezen River basin, the Timan, the Pechora Fore-Urals, and the Central Urals.

Genus *Lapigerella* Vilesov, gen. nov.

Schellwienia: Lee, 1931, p. 288.

Pseudofusulina: Rauser-Tchernoussowa, 1938, p. 132 (part.); 1940, p. 77 (part.); Rauser-Tchernoussowa and Scherbovich, 1958, p. 30 (part.); Kanmera, 1958, p. 194 (part.); Michailova, 1974, p. 67 (part.); Rosovskaya, 1975, p. 99 (part.); Zolotova *et al.*, 1977, p. 109 (part.); Davydov, 1986, p. 93 (part.) et auct. al.

Schwagerina: Nogami, 1961, p. 187 (part.) et auct. al.

Parafusulina: Ross, 1965, p. 77.

Gregariella: Alexeeva *et al.*, 1983, p. 4 (part.).

Dunbarinella: Bensh, 1987, p. 40 (part.).

Etymology. Latin *lapis* (stone) and *gero* (carry).

Type species. *Lapigerella taberna* Vilesov, sp. nov., Kholodnyi Log regional stage, Asselian, Lower Permian; Kosva River, Perm Region.

Diagnosis. Test small and medium-sized, ovoid, fusiform, elongated fusiform and subcylindrical, with rounded extremities. Young shell extends rapidly, from subspherical in first whorl through fusiform in second to elongated fusiform in third. Internal whorls winded denser than external ones, especially in microspherical tests. Test wall in internal whorls thin, in adult whorls of moderate thickness (up to 90 μm). Septae thick, moderately and strongly folded. Septal folding varying from irregular to relatively ordered. Septae bear additional massive deposits. Arches of different height, in section trapezoidal, rectangular, arcuate. Axial deposits usually massive, wide, occupying several whorls. Aperture distinct, uniformly widens from narrow in juvenile whorls to relatively wide slitlike in external whorls. Chomata small, rounded, present on proloculus and first whorl. Pseudochomata often massive, hook-shaped or fungiform.

Comparison. *Lapigerella* is distinguished from the ancestral genus *Jigulites* by having thicker massive axial deposits and reduced chomata.

Lapigerella is distinguished from *Pseudofusulina* Dunbar et Skinner, 1931 (sensu stricto) by having an irregular septal folding, thicker septae, thinner-walled juvenile whorls, more densely winded juvenarium, and wider massive axial deposits.

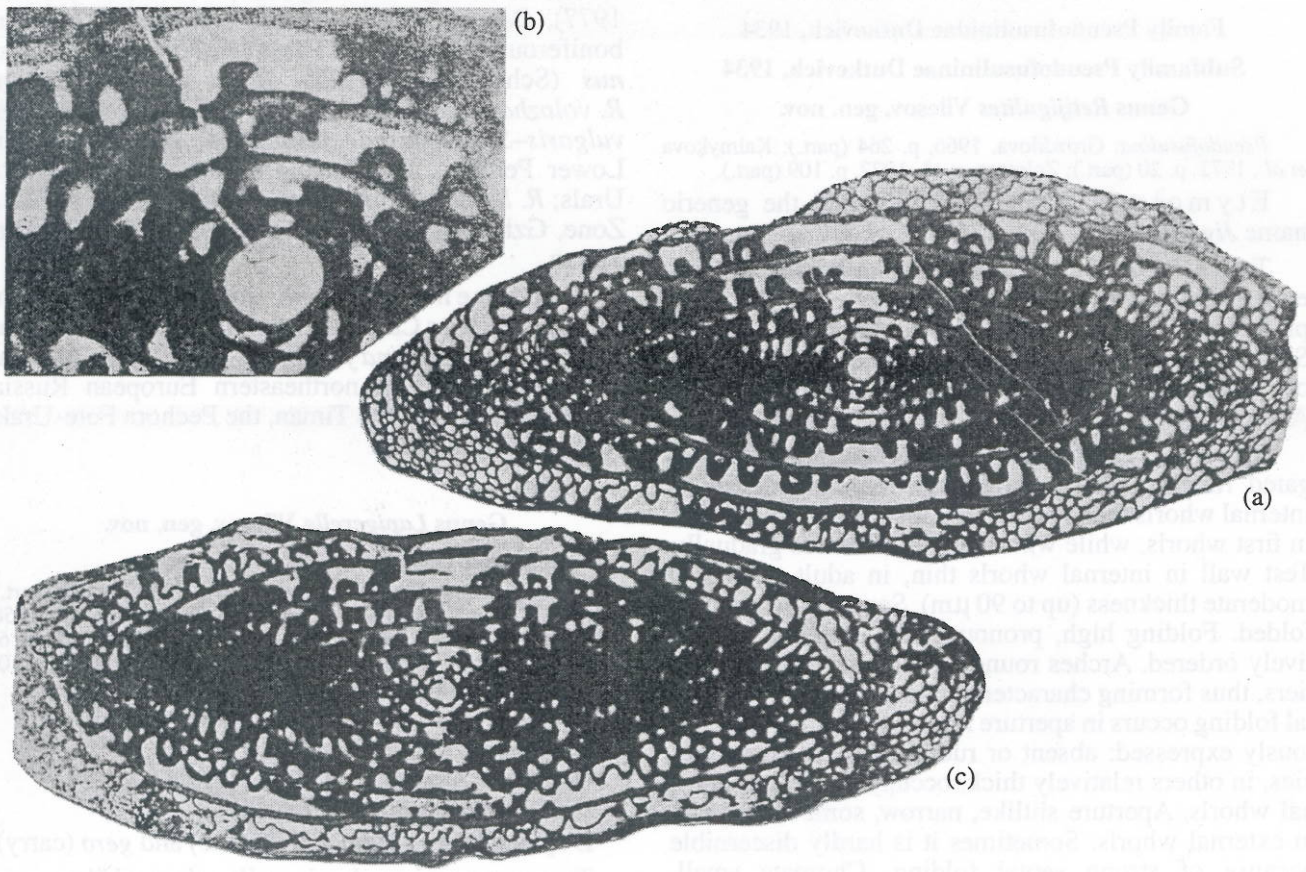

Fig. 2. *Lapigerella taberna* sp. nov., (a) holotype 3215, axial section, ×15, KhL, Outcrop 22, Bed 7; (b) internal whorls of the same test, ×50; and (c) paratype 3216, axial section, ×15; same bed and locality.

Lapigerella is distinguished from *Anderssonites* by having an elongated test that extends axially even in its younger whorls, unlike anderssonits, which retain their short fusiform tests throughout all ontogenic stages.

Lapigerella is readily distinguished from *Retijigulites* gen. nov. by its septae, which can be thicker than the test wall, while in retijigulits they are appreciably thinner than the test wall. Also, retijigulits possess considerably stronger septal folding that tends to form two tiers of arches and sometimes occurs in the aperture region. In lapigerells, the septal folding does not extend to the aperture except for the last gerontic whorl.

Species composition. *Lapigerella taberna* Vilesov, sp. nov. (occurrence see in the species description); *L. furnishi* (Ross, 1965) (part.; p. 77, pl. 10, figs. 2, 4, and 7, non fig. 5 = *Anderssonites eliseevi* (Z. Michailova)), *Daixina sokensis* Zone, Gzhelian, Upper Carboniferous through *Schwagerina vulgaris–Schwagerina fusiformis* Zone, Asselian, Lower Permian, Spitzbergen, and the Central Urals; *L. gregaria* (Lee, 1931), early Asselian of China, Japan, Central Asia, the Urals, and the Russian Plate; *L. inconstans* (Scherbovich, 1958), *Schwagerina moelleri–Globifusulina fecunda* Zone, Asselian, Lower Permian, the Russian Plate and the Urals; *L. narjanmarica* (Konovalova, 1977), *Schwagerina vulgaris–Schwagerina fusiformis* Zone, Asselian, Lower Permian, Timan-Pechora and the Urals; *L. praegregaria* (Scherbakova, 1977), *Daixina sokensis* Zone, Gzhelian, Upper Carboniferous, the Urals; *L. kumasoana* (Kamnera, 1958), *Pseudoschwagerina minatoi* Zone, Gzhelian, Upper Carboniferous, Japan.

Occurrence. *Daixina sokensis* Zone, Gzhelian, Upper Carboniferous–*Schwagerina moelleri–Globifusulina fecunda* Zone, Asselian, Lower Permian; Spitzbergen, northern European Russia, the Urals, Volga Region, Central Asia, China, Japan.

***Lapigerella taberna* Vilesov, sp. nov.**

Etymology. Latin *taberna* (beam).

Holotype. Thin section PGU 3215 from the Kholodnyi Log Section (base of Bed 7, Outcrop 22); collection of Yu.A. Ekhlakov, Polenov Museum of Paleontology and Historical Geology, Perm State University; Kholodnyi Log Regional Stage, *Schwagerina vulgaris–Schwagerina fusiformis* Zone, Asselian, Lower Permian.

Description (Fig. 2). The test is elongated fusiform, with widely rounded extremities. The proloculus

Table 1. Index of coiling (P) in holotype

7	6	5	4	3	2	First whorl	2	3	4	5	6	7
1.0	1.2	1.3	1.7	1.1	1.5		1.7	1.3	1.5	1.3	1.0	1.0

is medium-sized, spherical, 0.264–0.288 mm in diameter. The first whorl is subspherical or short fusiform. In the second whorl, the test axially extends to become fusiform. In the third or fourth whorls, the test becomes elongated fusiform.

Within two or three internal whorls, the test is wounded denser than in the external whorls. Broadening of whorls proceeds gradually, without any thresholds. In fifth and sixth whorls, the whorl height becomes constant. The seventh gerontic whorl is somewhat narrower, its wall thins. The index of test compactness (CI) is 0.20–0.23. The index of coiling (P) of the holotype axial section on either side of the proloculus is shown in Table 1.

The wall in the first two whorls is thin; in the subsequent whorls, it gradually thickens to become constant (less than 0.075 mm) in the fourth to sixth whorls.

The septae are thick; in the adult whorls, they are of nearly the same thickness as the test wall. The septal folding is high, strong, relatively regular. In the first two whorls, the septae are folded only in the polar regions; in the later whorls, folds appear along the entire septum length. The arches are trapezoidal, rectangular, and arcuate. In the last whorl, the septae are thin and become strongly and chaotically folded. The axial interlacements are narrow, finely alveolar. The aperture is low; in the internal whorls, of moderate width; in the adult whorls, appreciably broader; in the last whorl, obscure. The chomata are tiny, rounded, present on the proloculus and the first whorl. The pseudochomata are faint, fungiform or columnar. The axial deposits are massive, strongest in the fourth to sixth whorls.

Table 2. Measurements of *Lapigerella taberna* sp. nov. (in mm)

Specimen no.	Whorl length (L)						
	1	2	3	4	5	6	7
1 3215	0.60	1.20	1.97	3.29	5.76	7.30	8.40
2 3216	0.62	1.15	2.28	3.60	5.04	6.89	8.64
	Whorl diameter (D)						
1	0.40	0.64	0.92	1.37	1.94	2.52	3.19
2	0.38	0.58	0.89	1.32	1.85	2.40	2.83
	L/D						
1	1.5	1.9	2.1	2.4	3.0	2.9	2.6
2	1.6	2.0	2.6	2.7	2.7	2.9	3.0
	Aperture width						
1	0.068	0.096	0.216	0.288	0.480	0.720	no.
2	0.070	0.112	0.168	0.224	0.434	0.714	no.
	Wall thickness						
1	0.022	0.036	0.044	0.074	0.072	0.072	0.046
2	0.025	0.030	0.049	0.056	0.070	0.076	0.070

Measurements (Table 2). The length of the last whorl (L) is 8.30–8.64 mm; the diameter of the last whorl (D) is 2.83–3.20 mm; L/D in the external whorls is 0.26–0.3; the number of whorls is 6.5–7; CI is equal to 0.20–0.23.

Remarks. The species is described only on megaspherical tests, since the studied material contains no microspherical specimens.

Comparison. The new species is distinguished from *Lapigerella inconstans* (Scherbovich, 1958) by having considerably larger tests and less extended first whorls; from *L. kumasoana* (Kanmera, 1958), it differs in having stronger septal folding, thicker septae, thinner wall of adult whorls, and shorter test (its test index is 2.6–3.0 against 2.8–3.6 in *L. kumasoana*.)

Material. Holotype, paratype, and two oblique sections.

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