

# Ordovician and Lower Silurian thelodonts from Severnaya Zemlya Archipelago (Russia)

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Märss T. & Karatajūtė-Talimaa V. 2002. — Ordovician and Lower Silurian thelodonts from Severnaya Zemlya Archipelago (Russia). *Geodiversitas* 24 (2) : 381-404.

## ABSTRACT

Six new and one earlier known thelodont from the Ordovician and Lower Silurian of Severnaya Zemlya Archipelago are described. Scales of the earliest dated thelodont *Stroinolepis maenniki* n. gen., n. sp. were obtained from the Strojnyaya River section, October Revolution Island, upper Ozernaya and Strojnyaya formations, Middle-Upper and Upper Ordovician, correspondingly. *Loganellia matura* n. sp. was found from the Srednii Island, Golomyannyj Formation, middle Llandovery. *Paralogania klubovi* n. sp. and Loganelliidae gen. et sp. indet. come from the middle(?) Llandovery of Pioneer Island. *L. grossi* Fredholm, 1990 in the Matusevich River section, *Paralogania consimilis* n. sp. and *Thelodus calvus* n. sp. in the Ushakov River section, and *Shielia multispinata* n. sp., in the Spokojnaya River section, are distributed in the Samojlovich Formation, Wenlock, Lower Silurian of October Revolution Island.

## KEY WORDS

Agnatha,  
Thelodonti,  
Middle-Upper Ordovician,  
Upper Ordovician,  
Lower Silurian,  
Severnaya Zemlya Archipelago,  
Russia,  
scale morphology,  
histology.

## RÉSUMÉ

*Thélodontes de l'Ordovicien et du Silurien inférieur de l'Archipel de Severnaya Zemlya (Russie).*

Six thélodontes nouveaux et une forme déjà connue de l'Ordovicien et du Silurien de l'Archipel de Severnaya Zemlya sont décrits. Les écailles du thélodonte le plus ancien connu *Stroinolepis maenniki* n. gen., n. sp. ont été récoltées dans la coupe de la rivière Strojnaya, Île de la Révolution d'Octobre, dans la partie supérieure de la Formation Ozernaya et de la Formation Strojnaya, respectivement de l'Ordovicien moyen-supérieur et de l'Ordovicien supérieur. *Loganellia matura* n. sp. a été découverte dans la Formation Golomyannyj (Llandoverly moyen de l'Île Srednii). *Paralogania klubovi* n. sp. et Loganelliidae gen. et sp. indet. proviennent du Llandoverly moyen (?) de l'Île Pionnier. *L. grossi* Fredholm, 1990 de la coupe de la rivière Matusевич, *Paralogania consimilis* n. sp. et *Thelodus calvus* n. sp. de la coupe de la rivière Ushakov, et *Shielia multispinata* n. sp. de la coupe de la rivière Spokojnaya sont répartis dans la Formation Samojlovich (Wenlock, Silurien inférieur) de l'Île de la Révolution d'Octobre.

## MOTS CLÉS

Agnatha,  
Thélodonti,  
Ordovicien moyen-terminal,  
Ordovicien supérieur,  
Silurien inférieur,  
Archipel de Severnaya Zemlya,  
Russie,  
morphologie des écailles,  
histologie.

## THE AGE OF EARLY VERTEBRATES ON SEVERNAYA ZEMLYA

Finds of Ordovician thelodonts around the world are rare. Sansom *et al.* (1996) recorded the preliminary descriptions of putative shark and thelodont scales from the Harding Sandstone Formation, Caradoc, Upper Ordovician of Colorado, USA. Their detailed descriptions are in progress.

The first definite Ordovician thelodonts, *Sandivia melnikovi* Karatajütë-Talimaa, 1997 and *S. angusta* Karatajütë-Talimaa, 1997, have been described from the Bagan Formation, Middle-Upper Ordovician, and Muker and Khoreiver formations, Upper Ordovician, from 14 bore core sections of Timan-Pechora Region by Karatajütë-Talimaa (1997).

On the October Revolution Island, Severnaya Zemlya Archipelago, the earliest thelodonts come from the uppermost beds (sample MF 49-7) of the Ozernaya Formation, Middle-Upper Ordovician, and from the Strojnaya Formation (samples MF 49-9, 11; MF 50-3), Upper Ordovician, of the Strojnaya River section (Fig. 1). The section was studied during field work in the archipelago organized in 1979 by Dr. A. F. Hapilin, SEVMORGEO, Norilsk.

Samples for obtaining conodonts and vertebrates were dissolved by Dr. P. Männik, Tallinn. Conodonts give some results for the age determination (data by Männik 1999). In the Ozernaya Formation (samples from MF 48-3 up to 49-5) *Aphelognathus* sp. occurs. This taxon is known to date from the Middle-Upper Ordovician. In the lowest beds of the Vodopad Formation (MF 51-1), only *Panderodus* sp. has been found. The next sample (MF 51-3) with conodonts yielded *Ozarkodina* ex gr. *oldhamensis* (Rexroad, 1967) and *Conodonta* gen. et sp. 1 which can be correlated with the lowest Raikküla Stage (upper part of Rhuddanian) of Estonia. In sample MF 51-9, *Panderodus* aff. *serratus* Rexroad, 1967, *Panderodus greenlandensis* Armstrong, 1990, *Ozarkodina* aff. *oldhamensis* and some other species confirm that the lowest Vodopad Formation is of uppermost Juuru or lowest Raikküla age. Thelodont finds occur between the two described conodont levels and their age is determined as Middle-Upper (sample MF 49-7) to Upper Ordovician (samples MF 49-9 up to MF 50-3).

The Lower Silurian loganiid thelodont *Loganellia matura* n. sp. is distributed in the Golomyannyj Formation, from the middle part of the

Ord.		Silurian						Devonian			System
		Llandoverey		W.	Ludl.	Přid.	Lochk.	Pr.	Series		
Ozernaya	Strojnaya	Vodopad	Golomyannyj	Srednii	Samojlovich	Ust'-Spokojnaya	Krasnaya Bukhta	Severnaya Zemlya	Pod'ernaya	Spokojnaya	Formation
+	+										<i>Stroinolepis maenniki</i> n. gen., n. sp.
			+								<i>Loganellia matura</i> n. sp.
					+						<i>Loganellia grossi</i> Fredholm, 1990
						+	+				<i>Loganellia cuneata</i> (Gross, 1947)
		+			+	+	+				Loganelliidae indet.
					+						<i>Shielia multispinata</i> n. sp.
			+								<i>Paralogania klubovi</i> n. sp.
					+	+					<i>Paralogania consimilis</i> n. sp.
						++					<i>Paralogania ex gr. martinsoni</i> (Gross, 1967)
						++					<i>Paralogania</i> sp. 1 (see Karatajūtė-Talimaa & Märss 2002)
							+	+			<i>Paralogania cf. borealis</i> (Karatajūtė-Talimaa, 1978)
							+				<i>Paralogania</i> sp. 2 ( see Karatajūtė-Talimaa & Märss 2002)
							+	*			<i>Paralogania</i> sp. 3 (Karatajūtė-Talimaa & Märss 2002)
						+					<i>Valiukia</i> sp. 1 (see Karatajūtė-Talimaa & Märss 2002)
			+								Loganelliidae gen. et sp. indet.
						+					<i>Phlebolepis elegans</i> Pander, 1856
							+	+			<i>Goniporus alatus</i> (Gross, 1947)
					+	+					<i>Thelodus calvus</i> n. sp.
						++					<i>Thelodus</i> sp. 1 (see Karatajūtė-Talimaa & Märss 2002)
		+		+	+	+					<i>Thelodus</i> sp.
						++					<i>Thelodus ex gr. schmidti</i> (Pander, 1856)
								++	+		<i>Turinia pagei</i> (Powrie, 1970)
								+			<i>Turinia polita</i> Karatajūtė-Talimaa, 1978
								+			<i>Turinia</i> sp. 1 (see Karatajūtė-Talimaa in press)
								+			<i>Boreania minima</i> Karatajūtė-Talimaa, 1985
								+			<i>Nikolivia aligera</i> Karatajūtė-Talimaa
								++	+		<i>Nikolivia elongata</i> Karatajūtė-Talimaa, 1978
								++			<i>Canonina</i> sp.

FIG. 1. — Distribution of thelodonts in the Ordovician to Devonian sections of October Revolution and coeval strata of Srednii (marked with triangles) and Pioneer (marked with stars) islands.

Llandovery of Srednii Island, and is followed by *L. grossi*, *Shielia multispinata* n. sp., *Paralogania consimilis* n. sp., and *Thelodus calvus* n. sp. in the Samojlovich Formation, Wenlock. *P. consimilis* n. sp. and *T. calvus* n. sp. come from the Ushakov River; *S. multispinata* n. sp. from the Spokojnaya River section of October Revolution Island. *P. consimilis* n. sp. and *T. calvus* n. sp. probably also occur in the higher, Ust'-Spokojnaya Formation, Ludlow. *Paralogania klubovi* n. sp. and Loganelliidae gen. et sp. indet. are distributed in the upper Llandovery of Pioneer Island (collections of B. Klubov and E. Kachanov from 1976; see Klubov *et al.* 1980; Karatajūtė-Talimaa & Märss 2002).

## SYSTEMATICS

In the present study, the taxonomy of thelodonts elaborated by Gross (1967) and Karatajūtė-Talimaa (1978, 1997) has been used. The scales with collection numbers having a combination of letters Pi and numbers, are deposited in the palaeontological collection of the Institute of Geology, Tallinn Technical University; those with LIG 35 and specimen number are in the Institute of Geology, Vilnius.

Subclass THELODONTI Kiaer, 1932  
Order KATOPORIDA Gross, 1967

Family LOGANELLIIDAE Karatajūtė-Talimaa, 1997  
(= LOGANIIDAE Karatajūtė-Talimaa, 1978)

TYPE GENUS. — *Loganellia* Turner, 1991.

Genus *Stroinolepis* n. gen.

TYPE SPECIES. — *Stroinolepis maenniki* n. gen., n. sp., by monotypy.

ETYMOLOGY. — After the Strojnyaya River where the samples with the scales were collected, and the Greek word *lepis* meaning the scale.

OCCURRENCE. — Middle-Upper Ordovician, Ozernaya Formation; Upper Ordovician, Strojnyaya

Formation, Strojnyaya River, October Revolution Island, Severnaya Zemlya Archipelago.

DIAGNOSIS. — Simple small scales, length 0.2–0.4 mm, in rare cases up to 1.0 mm. Crowns of diagnostic trunk scales are divided into three parts: the medial part is smooth or with a furrow and two sharp ridges, and lateral parts have a sharp ridge or slanting short ridgelets. Specific rhomboidal pulp depression is surrounded by the wall-like base. Extremely fine branching dentine canals form a network.

## COMPARISON

*Stroinolepis* n. gen. differs from *Paralogania* Karatajūtė-Talimaa, 1997 and *Shielia* Märss, 1998 (in Märss & Ritchie 1998) in lacking spines postero-laterally of the crown, and in lacking the medial crown plate as seen in *Paralogania*. The new genus has an anterior triangular area of the crown, weakly developed base and, in young scales, a shallow pulp depression like *Sandivia* Karatajūtė-Talimaa, 1997 from Upper Ordovician of Timan-Pechora Region, and *Valyalepis* Turner, 1995 (in Turner & Nowlan 1995) from the Lower Silurian of eastern Canada, but differs from *Sandivia* in the lack of an arrow- or anchor-shaped posterior section of the crown. *Angaralepis* Karatajūtė-Talimaa, 1997 (Lower Silurian of Siberia) has comparatively wide and short scales with crowns that are covered anteriorly by longitudinal ribs and posteriorly having arrow- or anchor-shape, while *Stroinolepis* n. gen. has elongated scales covered with a few longitudinal ridges over the crown. *Stroinolepis* n. gen. and *Loganellia* Turner, 1991 are similar in having longitudinal ridges on the crown but differ in the presence of an anterior triangular area in *Stroinolepis* n. gen.

*Stroinolepis maenniki* n. sp.  
(Figs 2A–M; 3; 4)

HOLOTYPE. — Trunk scale Pi 7481 (Fig. 2H, I).

ETYMOLOGY. — Named after Dr. P. Männik, Institute of Geology at Tallinn Technical University, who found and kindly gave the scales for the study.

TYPE LOCALITY AND HORIZON. — Sample MF 49-9, Strojnyaya River section, Strojnyaya Formation, Upper Ordovician.

MATERIAL EXAMINED. — 49 scales, mainly broken.

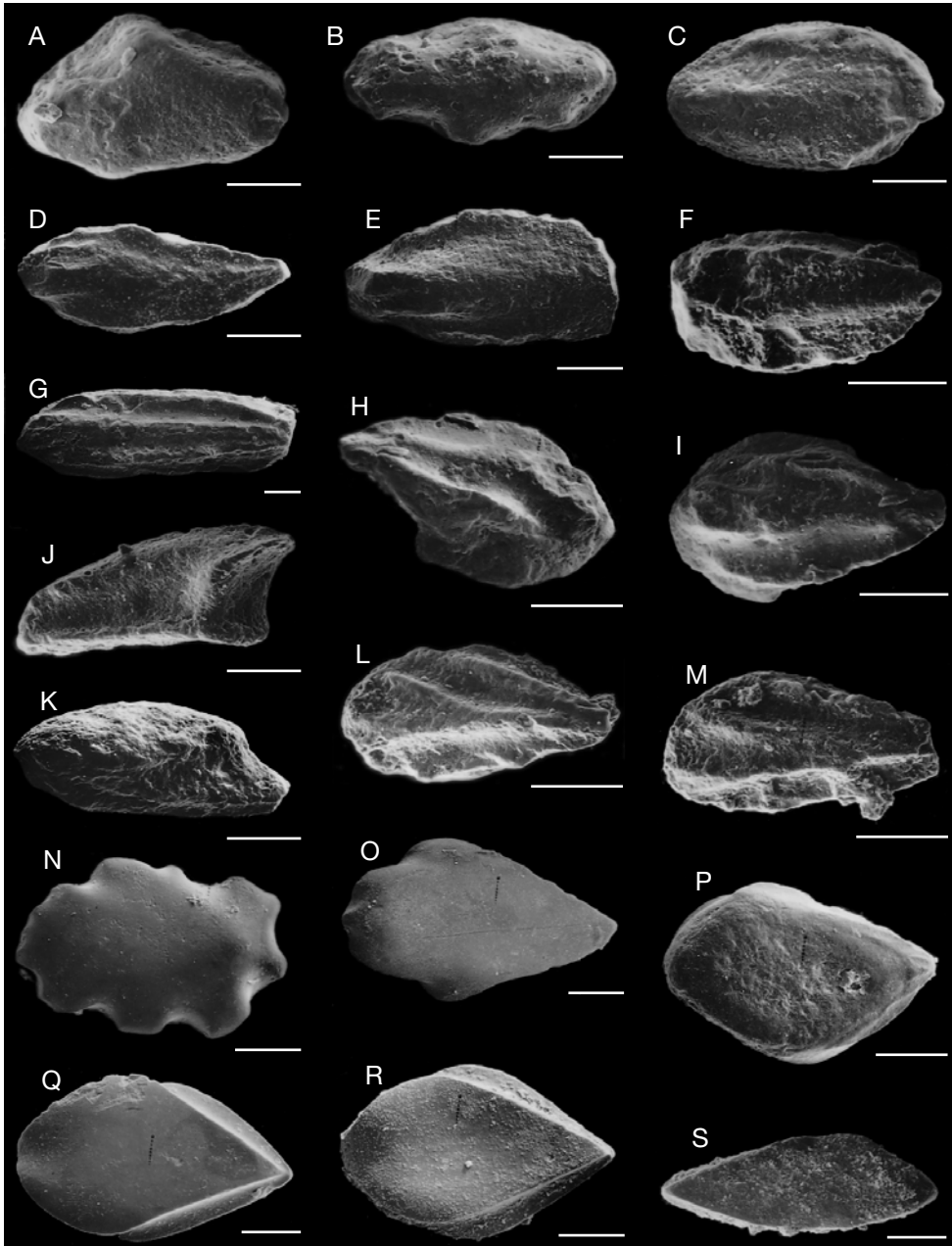


FIG. 2. — **A-M**, *Stroinolepis maenniki* n. gen., n. sp.; **A**, head scale; **B-E**, transitional scales; **F-M**, undivided trunk and fin scales; **A-G**, **I**, **L**, **M**, scales in crown view; **H**, lateral oblique view; **J**, **K**, lateral view; **A**, Pi 7476; **B**, Pi 7479; **C**, Pi 7477; **D**, Pi 7484; **E**, Pi 7480; **F**, Pi 7472; **G**, Pi 7478; **H**, **I**, Pi 7481; **J**, Pi 7474, scale is lost; **K**, Pi 7470; **L**, Pi 7469; **M**, Pi 7473; **A**, **C**, **F**, **G**, **J-M**, sample MF 49-7, Strojnyaya River, Ozernaya Formation, Middle-Upper Ordovician; **B**, **E**, **H**, **I**, sample MF 49-9; **D**, sample MF 49-11, Strojnyaya River, October Revolution Island, Strojnyaya Formation, Upper Ordovician; **N-S**, *Loganellia grossi* Fredholm, 1990; **N**, head scale; **O**, transitional scale; **P-S**, trunk scales; **N**, **O**, **Q-S**, scales in crown view; **P**, a scale in base view; **N**, Pi 7530; **O**, Pi 6839; **P**, Pi 7533; **Q**, Pi 7532; **R**, Pi 6837; **S**, Pi 7535; sample 2-68, Matusevich River, October Revolution Island, upper part of Samoijlovich Formation, Wenlock, Lower Silurian. Scale bars: 0.1 mm.

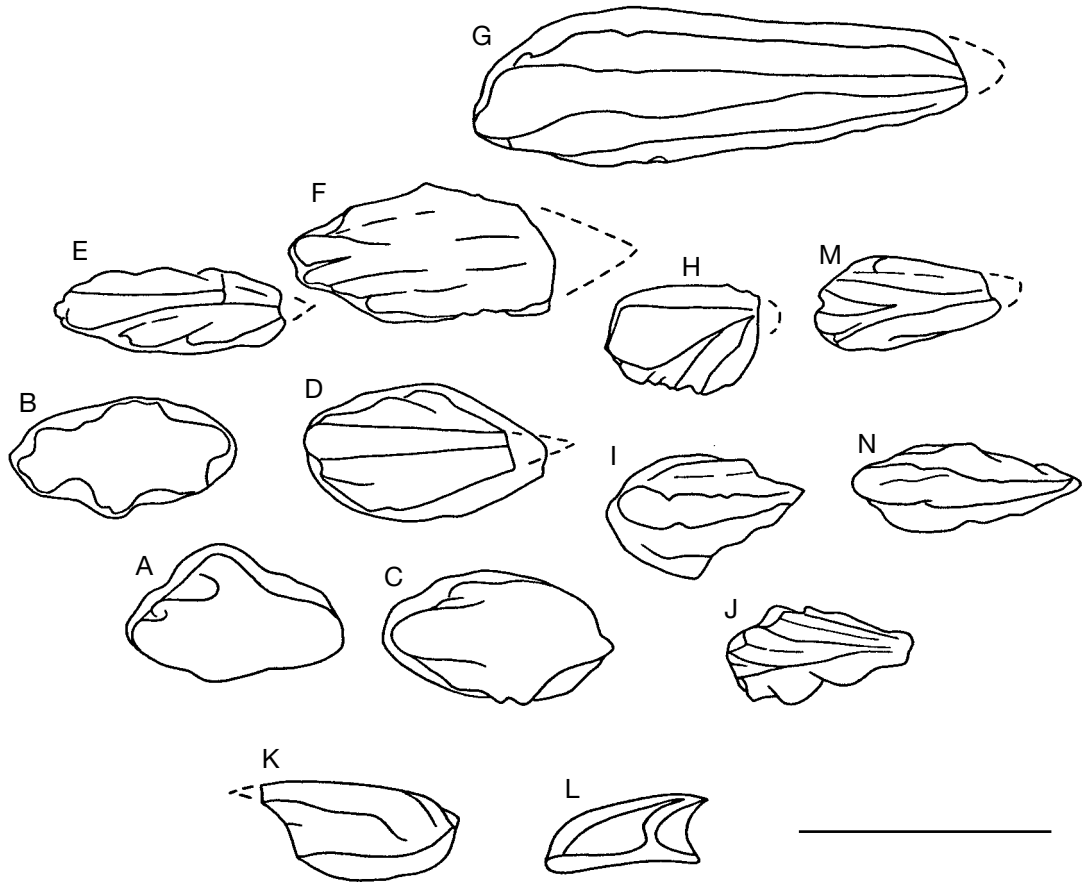


FIG. 3. — Set of scales of *Stroinolepis maenniki* n. gen., n. sp., the same scales are presented in Fig. 2; **A-M**, *Stroinolepis maenniki* n. gen., n. sp.; **A**, head scale; **B-E**, transitional scales; **F-M**, undivided trunk and fin scales; **A-G**, **I**, **L**, **M**, scales in crown view; **H**, lateral oblique view; **J**, **K**, lateral view; **A**, Pi 7476; **B**, Pi 7479; **C**, Pi 7477; **D**, Pi 7484; **E**, Pi 7480; **F**, Pi 7472; **G**, Pi 7478; **H**, **I**, Pi 7481; **J**, Pi 7474, scale is lost; **K**, Pi 7470; **L**, Pi 7469; **M**, Pi 7473; **A**, **C**, **F**, **G**, **J**, **M**, sample MF 49-7, Strojnyaya River, Ozernaya Formation, Middle-Upper Ordovician; **B**, **E**, **H**, **I**, sample MF 49-9; **D**, sample MF 49-11, Strojnyaya River, October Revolution Island, Strojnyaya Formation, Upper Ordovician. Scale bar: 0.5 mm.

**OCCURRENCE.** — Sample MF 49-7, Ozernaya Formation, Middle-Upper Ordovician; samples MF 49-9,11, MF 50-3, Strojnyaya Formation, Upper Ordovician, Strojnyaya River, October Revolution Island, Severnaya Zemlya Archipelago.

**DIAGNOSIS.** — As for genus, by monotypy.

#### DESCRIPTION

##### *Morphology*

Head scales are rounded or oval (Fig. 2A). The crown surface is smooth, slightly concave; the crown margins are gently crenulated. The neck

is low and rather distinct. The base is in the shape of a vertical wall around a shallow diamond-shape or oval pulp depression. Transitional scales (Fig. 2B-E) are slightly longer than the head scales. They have an oval or elongated diamond-shape configuration of the crown. The latter has the anterior part divided into three with two notches and three ridges, of which the central one is pronounced; the lateral parts are narrow. The central and posterior parts of the crown are rather smooth. The neck is indistinct anteriorly and well developed posteriorly.

orly of the scale. The base is low. The pulp depression is diamond-shaped and shallow. Scales in Fig. 2F-M are treated here as trunk and fin scales. The set of scales is too small to tell for certain where in the squamation they come from. The scale in Fig. 2G characterizes this type; it is twice as large as other scales, strongly elongated, and its crown has three ridges (the lateral ones being sharper). The crown surface rises backwards, and the posterior crown apex is united with the base by a slanting rib. The neck is not distinct. The base is in a shape of a weak wall. The pulp depression is rhomboidal, and the opening of a pulp canal is not observed. All other scales are small, their crowns having three ridges, medial and lateral ones. The medial part can be flat or divided by a longitudinal furrow. The latter can occur only on the anterior part of the crown or reach the posterior end of it. Elongated ridges or short ridgelets are placed laterally. It is rather characteristic that all elongated ridges have sharp crests. The ridges start in the smoothly rounded antero-lateral corners of the base or in the posterior part of it. The neck is not clear in all scales. The base is concave or convex depending on the growth stage of the scale. The pulp depression in younger scales is rhomboidal. The set of scales shown in Fig. 3 exhibits the different size of the scales, and their crown sculpture.

#### *Histology (Fig. 4)*

It was mainly studied in anise oil. Dentine canals arising from the pulp depression are extremely fine. In the material available for study of the microstructure, the pulp canal is not present. Instead of the latter, some long dentine canals occur. Dentine canals in the crown branch at some levels and in vertical cross section they form a complicated network.

#### Genus *Loganellia* Turner, 1991

TYPE SPECIES. — *Loganellia scotica* (Traquair, 1898).

#### *Loganellia matura* n. sp. (Figs 5A-O; 6A, B)

HOLOTYPE. — Trunk scale Pi 7492 (Fig. 5G).

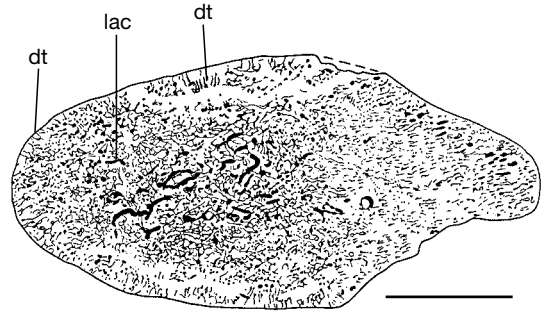


FIG. 4. — *Strojnolepis maenniki* n. gen., n. sp., microstructure of the scales, Pi 7648, sample MF 49-7, Strojnyaya River, October Revolution Island, Ozernaya Formation, Middle-Upper Ordovician. Abbreviations: **dt**, dentine tubules; **lac**, lacunae of dentine canals. Scale bar: 0.1 mm.

ETYMOLOGY. — From *matura*, Latin word *maturus*, meaning mature, referring to the fact that the genus *Loganellia* had already attained all characteristic features for the scales in the Llandovery.

TYPE LOCALITY AND HORIZON. — Sample MF 3-8, Srednii Island, Golomyannyj Formation, middle part of Llandovery, Lower Silurian.

MATERIAL EXAMINED. — 47 well preserved scales.

OCCURRENCE. — A sample MF 3-8, Golomyannyj Formation, middle part of Llandovery, Srednii Island.

DIAGNOSIS. — Head scales with strong ridges directed to the centre of the crown. Transitional scales with two to three elongated grooves anteriorly of the convex crown, shallow neck and strong, often high vertical base. Trunk scales tripartite: medial part with central longitudinal furrow, and wide lateral down-stepped portions of the crown extending far posteriorly. Scales having two lateral ribs, each successively situated on a lower level, are also present. Crown margins are gently serrated. Pulp canal and dentine canals open into the pulp depression. Pulp canal continues with several fine dentine tubules backwards. Dentine canals wide in the lower part of the scale, forming complicated lacunae-like widenings in the middle part of it. Dentine canals and dentine tubules relatively straight in the upper part of the scale.

#### DESCRIPTION

##### *Morphology*

Scales in the collection are of small to medium size (length 0.4-0.6, mainly 0.5 mm). Anterior head scales (Fig. 5A, B) are with strong ridges directed to the centre of the crown, the base is

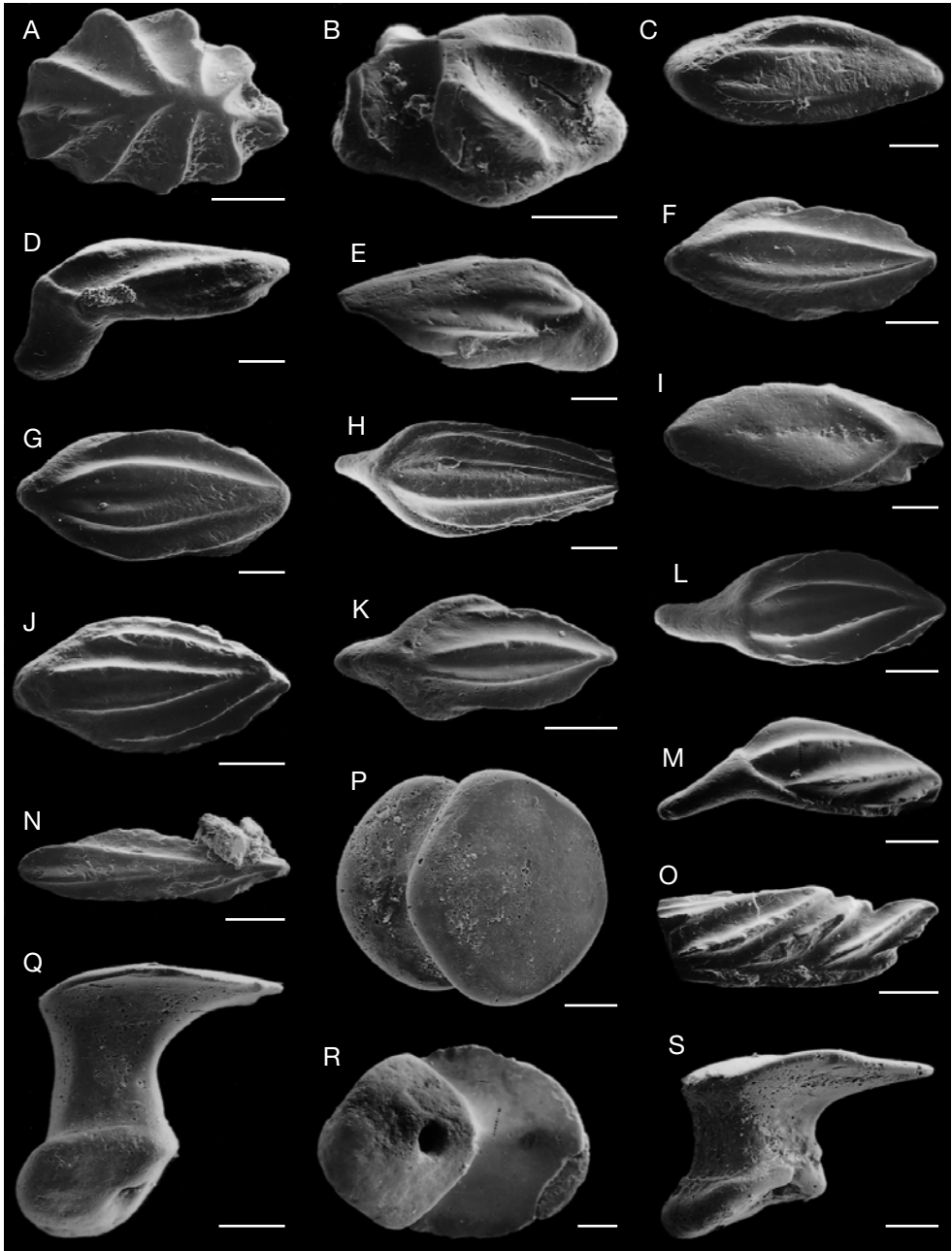


FIG. 5. — **A-O**, *Loganelia matura* n. sp.; **A, B**, head scales; **C-E**, transitional scales; **F-M, O**, trunk scales; **N**, fin? scale; **A, C, F-H, J-L, N**, scales in crown view; **B, D, E, M**, scales in lateral view; **I**, a scale in base view; **N**, posterior half of a trunk? scale in lateral view; **A**, Pi 7486; **B**, Pi 7487; **C**, Pi 7499; **D**, Pi 7496; **E**, Pi 7489; **F**, Pi 7494; **G**, holotype Pi 7492; **H**, Pi 7490; **I**, Pi 7497; **J**, Pi 7493; **K**, Pi 7501; **L, M**, Pi 7495; **N**, Pi 7485; **O**, Pi 7500; sample MF 3-8, Srednii Island, Sedov Archipelago, Golomyannyi Formation, middle Llandoverly, Lower Silurian; **P-S**, *Thelodus calvus* n. sp.; **P**, LIG 35-907; **Q**, holotype Pi 7503; **R**, Pi 7505; **S**, Pi 7504; **P**, a scale in crown view; **Q, S**, in lateral view; **R**, in base view; **P**, sample 32a-208; **Q-S**, sample MF 46-23; Ushakov River, October Revolution Island, Samojlovich Formation, Wenlock, Lower Silurian. Scale bars: 0.1 mm.



square with a central pulp cavity. Transitional scales and/or scales of the leading edges of the fins (Fig. 5C-E) are elongate with two deep and one shallow notches anteriorly of the crown. The base can have a vertical spur (Fig. 5D). Trunk scales (Fig. 5F-M, O) are rhomboidal, their crown is with up to three lateral ribs which converge in the posterior crown apex, the medial one not reaching the posterior end of the crown. In Fig. 5O the posterior half of a scale in lateral view exposes a series of ridges arising from the neck upwards and backwards. The base is swollen anteriorly, often with a spur-like process, which can constitute one third of the whole length of the scale. Scales with a smooth and flat central part are missing in our collection, hence the reason for establishing a new species. The scales most similar to *L. scotica* are bigger, mainly 0.6 mm and up to 0.8 mm in length. In Fig. 5N there is a very narrow and rather long scale with a slightly higher medial part and one or two down-stepped lateral ones, that could be a fin scale.

#### *Histology (Fig. 6A, B)*

In the anteriorly placed scales of the squamation only one pulp canal occurs. Posterior scales have up to three canals. Pulp canals, a medial and a pair of lateral ones, spring from the pulp depression up and backwards. The size of medial and lateral pulp canals is the same and all canals are independent. Dentine canals are relatively wide, and they possess lacunae-like expansions in the middle part of the scale. Pulp canals continue as a bunch of dentine tubules posteriorly. Dentine tubules are relatively straight. Distinct tubules of Sharpey's fibres occur in the base, which are parallel to each other and perpendicular to the base surface. Aspidine "pegs" in the anterior part of the base are arranged in a criss-cross network.

#### COMPARISON

*Loganellia matura* n. sp. differs from other *Loganellia* species in having rather wide lateral portions of the crown extending far posteriorly. It differs from *L. scotica* (Traquair, 1898) in having ridged sculpture instead of the plate of the crowns. *L. matura* n. sp. has up to three pulp

canals while *L. scotica* has one, comparatively short pulp canal.

#### *Loganellia grossi* Fredholm, 1990 (Fig. 2N-S)

SYNONYMY. — See Fredholm (1990) and Märss (1996).

MATERIAL EXAMINED. — About 200 scales of varying preservation.

OCCURRENCE. — Samples 2-62, 2-67, 2-68, Matusевич River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian.

#### REMARKS

Scales are small. Head scales have round or oval configuration (Fig. 2N), crenulated margin and slightly convex crown surface. The neck is very low, pulp depression has a central position in young scales. Transitional scales (Fig. 2O) anteriorly with notches, postero-lateral margins of the crown smooth. Outline of the scales is more rhomboidal. Trunk scales (Fig. 2Q-S) are relatively small (length 0.2-0.5 mm), medial rhomboidal plate is smooth and flat, anterior to it a short and shallow notch can occur. Short lateral down-stepped rims unite beneath and behind the apex of medial plate. Neck is not very distinct. Base is, depending on the stage of development of the scale, concave or convex.

#### Genus *Shielia* Märss, 1998

TYPE SPECIES. — *Shielia taiti* (Stetson, 1931).

#### *Shielia multispinata* n. sp. (Figs 6C-F; 7A-S)

HOLOTYPE. — Pi 6803 (Fig. 7K), sample MF 157-7, Spokojnaya River, upper part of Samojlovich Formation, Wenlock, Lower Silurian.

ETYMOLOGY. — From the Latin word *multispinata*, to indicate that trunk scales of this species have several spines posteriorly of the crown.

MATERIAL EXAMINED. — About 100 scales of good and fairly good preservation.

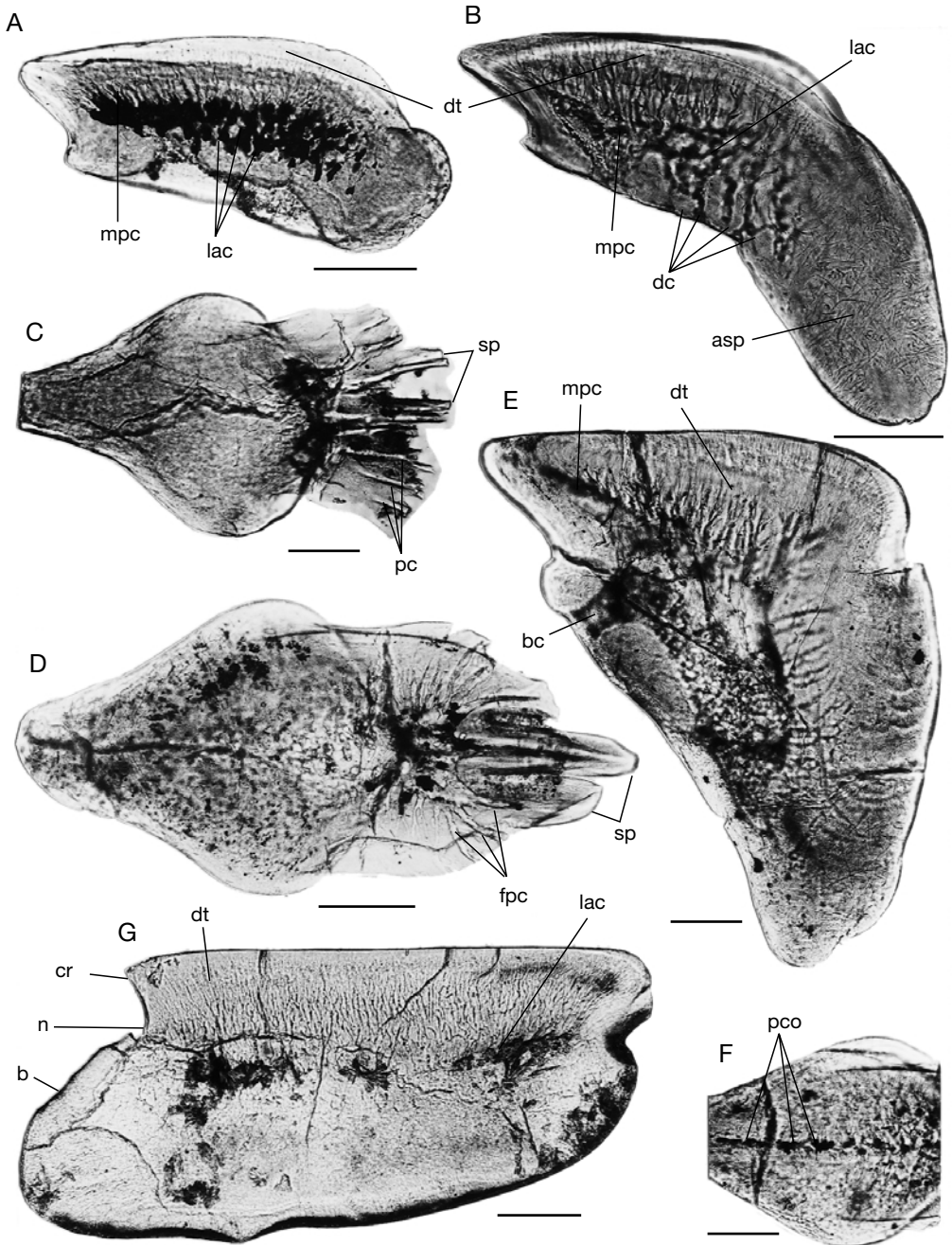


FIG. 6. — Microstructure of the scales; **A, B**, *Loganelia matura* n. sp.; **C-F**, *Shielia multispinata* n. sp.; **G**, *Paralogania consimilis* n. sp.; **A**, Pi 7624; **B**, Pi 7625; **C**, Pi 7626; **D**, Pi 7627; **E**, Pi 7628; **F**, Pi 7629; **G**, Pi 7630; **A, B**, sample MF 3-8, Srednii Island, Golomyannyj Formation, middle part of Llandovery, Lower Silurian; **C-F**, sample MF 157-7, Spokojnaya River, upper part of Samojlovich Formation, Wenlock, Lower Silurian; **G**, sample MF 46-23, Ushakov River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian. Abbreviations: **asp**, aspidine "pegs" in the base; **b**, base; **bc**, canal in the base; **cr**, crown; **dc**, dentine canal; **dt**, dentine tubules; **fpc**, fan-shaped pulp canals; **lac**, lacunae of dentine canals; **mpc**, main pulp canal; **n**, neck; **pc**, pulp canal; **pco**, pulp canal opening; **sp**, spine. Scale bars: 0.1 mm.

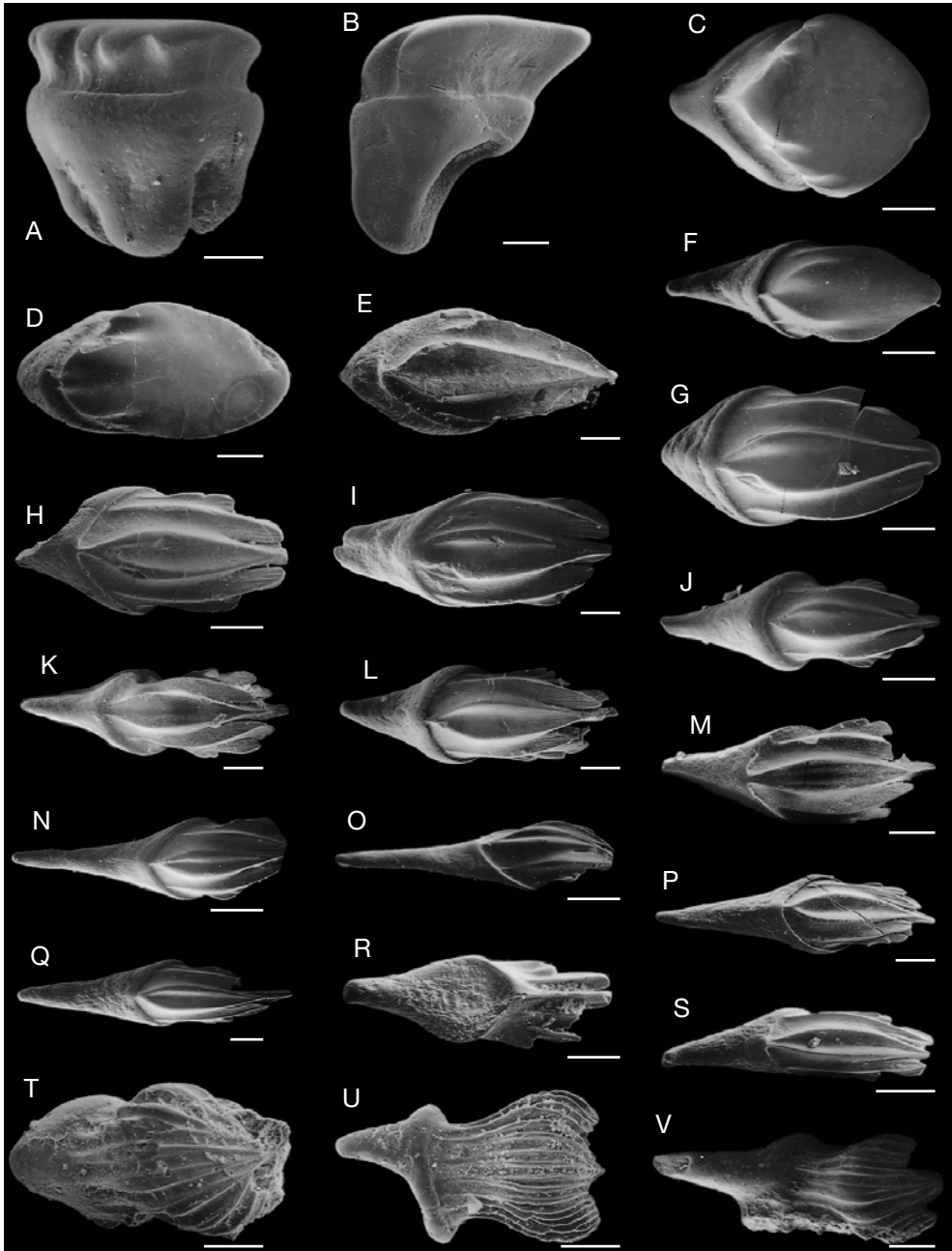


FIG. 7. — **A-S**, *Shiella multispinata* n. sp.; **A**, head scale; **B-D, F**, transitional scales; **E, G-P**, trunk scales; **Q-S**, fin scales; **A, B**, scales in lateral view; **C-N, P, Q, S**, scales in crown view; **O**, a scale in oblique view; **R**, a scale in base view; **A**, Pi 7517; **B**, Pi 7519; **C**, Pi 7518; **D**, Pi 7520; **E**, Pi 7521; **F**, Pi 6804; **G**, Pi 7523; **H**, Pi 7522; **I**, Pi 7524; **J**, Pi 7525; **K**, holotype Pi 6803; **L**, Pi 6805; **M**, Pi 6801; **N, O**, Pi 7526; **P**, Pi 6802; **Q**, Pi 7527; **R**, Pi 7529; **S**, Pi 7528; sample MF 157-7, Spokojnaya River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian; **T-V**, *Thelodus?* sp., scales in crown view; **T**, Pi 7516; **U**, LIG 35 908; **V**, Pi 6814; **T, V**, sample MF 46-23; **U**, sample 32a-208, Ushakov River, October Revolution Island, Samojlovich Formation, Wenlock, Lower Silurian. Scale bars: **A-I, K-M, P-V**, 0.1 mm; **J, N, O**, 0.2 mm.

**OCCURRENCE.** — Sample MF 157-7, Spokojnaya River, upper part of Samojlovich Formation, Wenlock, Lower Silurian.

**DIAGNOSIS.** — Scales of medium size. Head scales rounded to oval with crenulated margins. Neck is rather distinct; base deep with vertical rootlets. Transitional scales are oval to rhomboidal with crenulation in the antero-lateral margins and one posterior crown apex. Diagnostic trunk scales bear a central part with a shallow groove, a pair of lateral ribs directed towards the posterior central crown apex, and two-three spines beneath the lateral ribs, one single spine situated below the central crown apex. Each more laterally positioned crown portion (ribs and spines) are downstepped. Anterior horizontal process of the base, sometimes very long, is present in all trunk scales. Neck is low but distinct. Pulp depression large. Opening of the main, medial, pulp canal is situated in the posterior portion of the base. Two to four pairs of lateral pulp canals may be present. Dentine canals start from the pulp depression or pulp canals; they are similar to the orthodentine canals. Fine dentine tubules occur in the crown but can also be found in the base. The crown surface is from a layer of enameloid.

## DESCRIPTION

### *Morphology*

Only one sample (MF 157-7) yields the scales of this new species. In the set, comparatively large head and transitional scales are present in contrast to the small trunk and fin scales. The length of scale crowns range from 0.2 up to 0.5 mm. Elongated spiny trunk scales have an anterior horizontal basal spur up to 0.5 mm long and another 0.5 mm makes the crown. The smallest scale is only 0.1 mm wide. Large head scales have a vertical base that is 0.5 mm high at maximum. The holotype (Fig. 7K) has a 0.25 mm long horizontal spur and 0.5 mm long crown with width of 0.25 mm. Head scales (Fig. 7A) have a round or oval crown and base configuration. The crown surface is flat and smooth with crenulated margins, with the neck in the shape of a shallow groove. The pulp cavity is placed in the middle of the scale and surrounded by vertical rootlets of the base. Transitional scales (Fig. 7B-D, F) are oval or rhomboidal with crenulation or two notches antero-laterally of the crown. The base is becoming more horizontal. Trunk scales (Fig. 7E, G-P) are rather flat-

tened. A longitudinal shallow groove is placed on the medial elongated portion of the crown surface. On both sides of it a slightly downstepped rib starts from the base and is directed towards the posterior medial crown apex; lateral ribs do not join with the latter and a split occurs between them. The second pair of downstepped ribs can be relatively long or consist of up to three spines. The lower side of the posterior crown portion exhibits five ridges. The base has an anterior spur-like process. The pulp depression is large, and openings of pulp canals have a posterior position. Fin scales (Fig. 7Q-S) have the same shape as trunk scales but are much smaller.

### *Histology (Fig. 6C-F)*

The pulp cavity of the young head and transitional scales can be rather deep and wide, but is narrower in adult scales. The pulp depression of trunk scales is large; from the posterior part of it three to nine forked or fan-shaped pulp canals (a medial and four pairs of lateral) enter into three to nine posterior spines and go far posteriorly (Fig. 6C, D). The openings of pulp canals can form a longitudinal row in the base (Fig. 6F). Fine, nearly parallel dentine canals go out from the pulp canals or from the base (Fig. 6E). Dentine canals are relatively straight and numerous. They resemble more the canals in the orthodentine than in the mesodentine. Dentine tubules straight. In the base, fine tubules of Sharpey's fibres, perpendicular to the base surface, and aspidine "pegs" are distributed.

### COMPARISON

Head and transitional scales of *Shielia multi-spinata* n. sp. differ from those in *S. taiti* (Stetson, 1931) in being larger and more crenulated while in *S. taiti* they are smaller (*S. taiti* has scales up to 0.5 mm long), simpler anteriorly and with two wing-like structures laterally. The new species has trunk scales with lateral ribs directed towards the posterior central crown apex; in *S. taiti* they start from the neck, tend to run more parallel to the central portion and end with free spines posteriorly. *S. taiti* has deeper

grooves between the ribs. In *S. multispinata* n. sp. the spines start beneath the lateral ribs.

Genus *Paralogania* Karatajūtė-Talimaa, 1997

TYPE SPECIES. — *Paralogania kummerowi* (Gross, 1967).

*Paralogania klubovi* n. sp.  
(Figs 8-10)

HOLOTYPE. — LIG 35-834, trunk scale (Fig. 8G).

ETYMOLOGY. — In honour of Dr. B. A. Klubov (Magadan, Russia), researcher of Silurian and Devonian deposits of the Pioneer Island in 1976.

MATERIAL EXAMINED. — 32 scales from one sample.

TYPE LOCALITY AND HORIZON. — Pioneer Island, Member 2, bed 1, sample 2zh, Lower Silurian, middle(?) Llandovery.

OCCURRENCE. — A single sample 2zh from the Pioneer Island (Member 2, bed 1, see Klubov *et al.* 1980). Based on revised biostratigraphy of conodonts from this member by P. Männik, this level is dated as middle(?) Llandovery, Early Silurian.

DIAGNOSIS. — Scales very small (0.30-0.45 mm). Head scales low, flat, with deeply crenulated margins around the crown. Transitional scales elongated with low base occurring as a narrow weak wall around the large, shallow pulp depression. Short medial crown area developed only anteriorly. Trunk scales with narrow and deeply furrowed, or with wide and shallow medial area. Wider lateral crown areas not developed in all trunk scales. Lateral spinelets (two to three) situated anteriorly, and may occur as flat widened to flat short areas. Base low, anteriorwardly more convex. Numerous openings of dentine canals situated on the surface of pulp depression of the head and transitional scales. Short pulp canal developed only in trunk scales. Dentine canals comparatively long, branching at several levels with widened proximal parts.

DESCRIPTION

*Morphology*

Very restricted, insufficient material does not allow a complete morphological description of a set of scales. Nevertheless, the basic morphological types, head, transitional and trunk scales are represented in the collection.

Head scales (Figs 8A, B; 9A, B) have a low and flat shape which is characteristic for early loganiids. The crown surface is smooth. The

crown margins are rounded and deeply crenulated, the cuts being wide. The distal crown area is distinct in more elongated scales (Fig. 8B). The base is low and smaller than the crown (Fig. 9A, B), with its central part of the base containing openings of dentine canals.

A single scale, figured in Fig. 8C, is ascribed to the transitional scale type. Its crown surface is flat and smooth. The short medial area is distinct anteriorly, and laterally the cuts are not as deep as in head scales. The distal part is monolithic with a tapered posterior point. The base is low and in the form of a narrow wall seen along all the perimeter. The pulp depression is shallow and very large; dentine canal openings are placed evenly. Several morphological varieties are observed among trunk scales.

**Type A.** The crown is composed of a narrow central (medial) area, and of one pair of lateral ones (Fig. 8D-E). The central area is higher than the remaining crown surface and separated from lateral areas by deep longitudinal grooves. A comparatively deep groove (or furrow) is situated at the proximal part of the central area only (Fig. 8D) or is extended over its length (Fig. 8E). Wing-like lateral ribs, two to three on each crown side, correspond to the lateral thornlets of trunk scales of *Paralogania*. The base is low and flat, with openings of dentine canals (Fig. 9C); it can also be anteriorly slightly convex.

**Type B.** Elongated scales with a rather narrow, elevated central area that tapers posteriorly. A shallow furrow is situated along the central area (Figs 8F; 9 D). Lateral crown areas repeat the outline of the central one. They form lateral rib, one on both sides.

**Type C.** Mostly typical for trunk scales of *Paralogania* (Fig. 8G, selected for the holotype). It illustrates the early stage of formation of rows of thornlets, characteristic for this genus. The crown is composed of an elongated rhomboidal central area and one pair of lateral ribs. The proximal part of the lateral ribs is divided into two thornlets, i.e. the disintegration of a complete lateral rib into a row of separate thornlets has taken place.

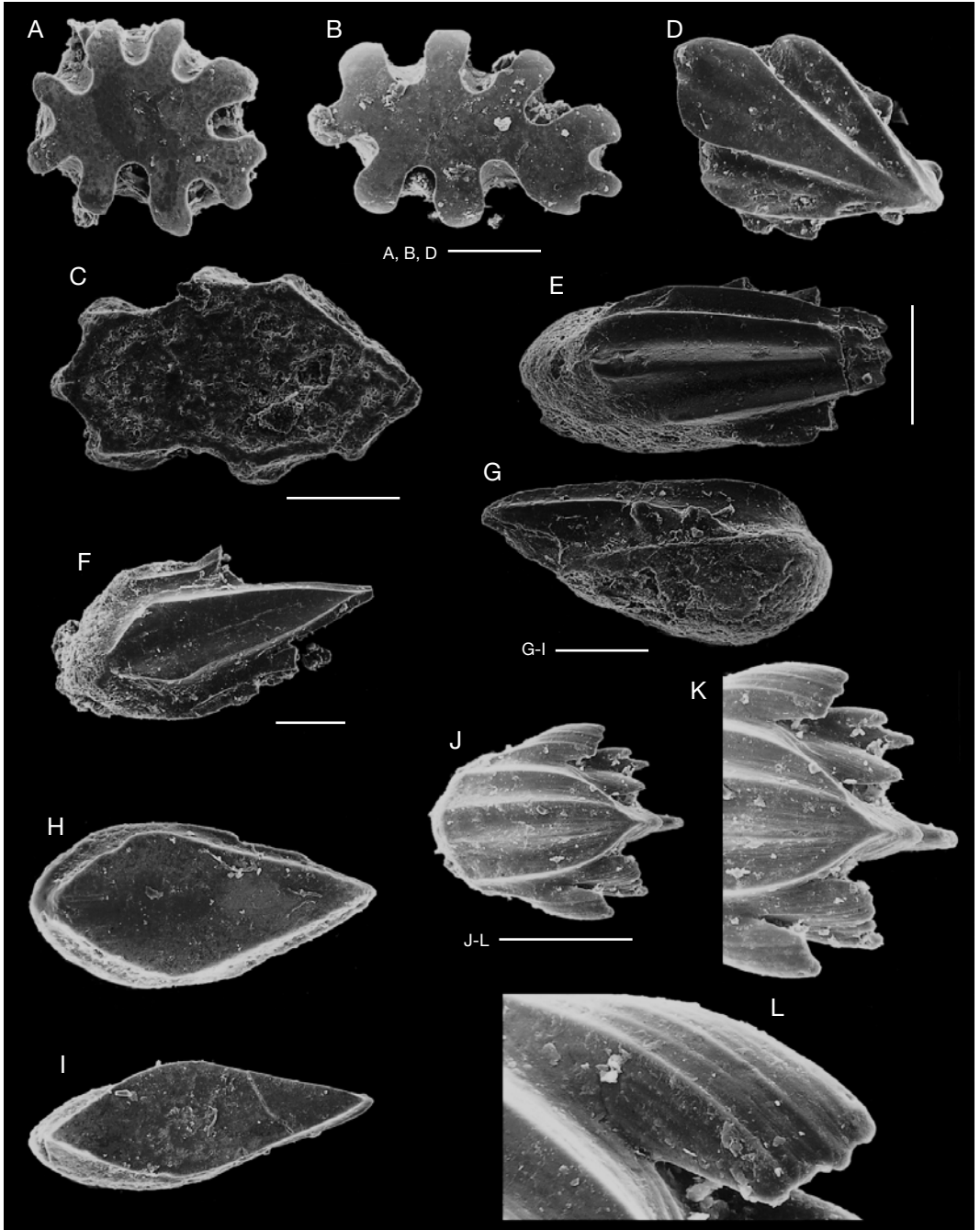


FIG. 8. — **A-I**, *Paralogania klubovi* n. sp.; **A, B**, head scales; **C**, transitional scale; **D-I**, trunk scales; **A, B, D-F, H, I**, scales in crown view; **C**, a scale in base view; **G**, a scale (holotype) in lateral view; **A**, LIG 35-085; **B**, LIG 35-086; **C**, LIG 35-832; **D**, LIG 35-087; **E**, LIG 35-833; **F**, LIG 35-088; **G**, LIG 35-834; **H**, LIG 35-835; **I**, LIG 35-836; **J-L**, Loganelliidae gen. et sp. indet.; **J**, scale in crown view; **K**, posterior part of the same scale; **L**, enlarged part of left posterior section, LIG 35-089; sample 2zh, Pioneer Island, middle(?) Llandovery, Lower Silurian. Scale bars: 0.1 mm

**Type D.** It represents a morphological variety of scales which is almost entirely composed of rhomboidal and elongated central areas. The lateral areas are very narrow (Fig. 8H) or are not developed at all (Fig. 8I). The lateral crown walls are smooth.

Scales of C and D types have bases that are comparatively high and more convex anteriorly. The pulp canal starts from the depression in the distal corner of the base (Fig. 9D).

### Histology

The microstructure of the scales was successfully observed in anise oil. No thin section was made because of insufficient material. Fig. 10 shows the arrangement and shape of dentine canals in the head scales (Fig. 10A) and trunk scales (Fig. 10B). The proximal part of the dentine canals is rather wide; that is why their openings on the surface of the pulp depression are easily seen even at low magnification. The dentine canals are comparatively long (at least in lateral crown parts), and branch at several levels. The trunk scales of the type A (Figs 8D; 9B) have short pulp canal in its initial stage of development only. Trunk scales with more elongated distal part of the central crown area (types B, C and D) have more distinctly developed pulp canal.

### COMPARISON

By the presence of a single pair of lateral ribs (wing-like lateral ledges or thornlets), *Paralogania klubovi* n. sp. may be attributed to the *P. kummerowi* (Gross, 1967)-*P. martinsoni* (Gross, 1967) group (see Karatajūtė-Talimaa 1997: fig. 7g). The head and transitional scales of *P. klubovi* n. sp. differ from the representatives of the group in their characteristic crown shape and presence of comparatively large openings of

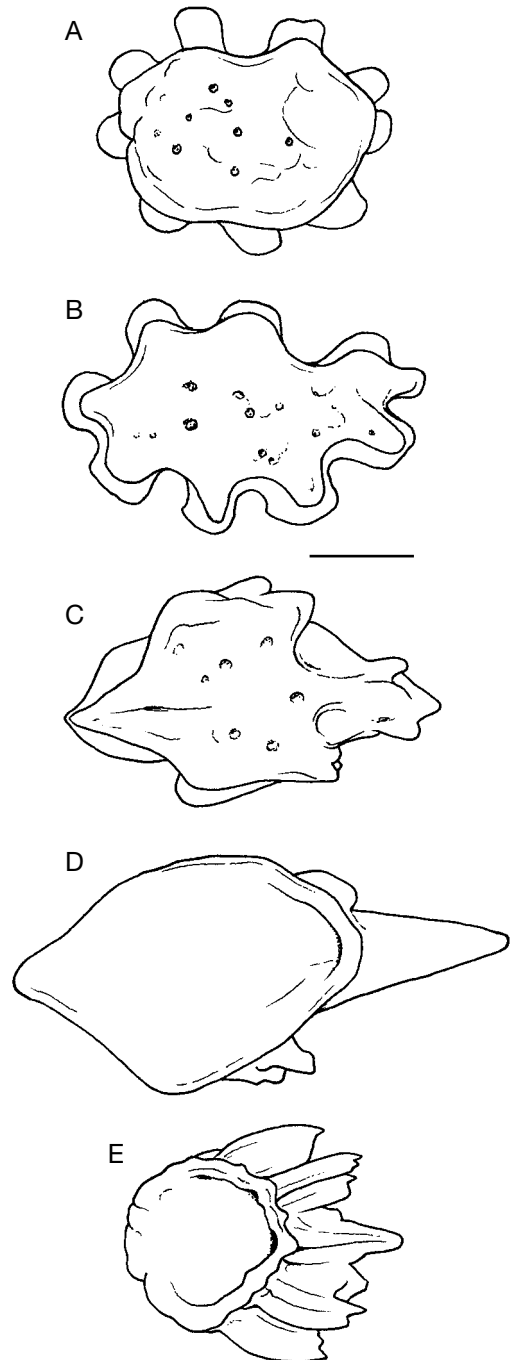


FIG. 9. — **A-D**, *Paralogania klubovi* n. sp.: **A**, **B**, head scales in base view (see Fig. 8A, B); **C**, trunk scale of type A in base view (see Fig. 8D); **D**, trunk scale of type B in base view (see Fig. 8F); **A**, LIG 35-085; **B**, LIG 35-086; **C**, LIG 35-087; **D**, LIG 35-088; **E**, Loganelliidae gen. et sp. indet.; scale in base view (see Fig. 8J, K), LIG 35-089; sample 2zh, Pioneer Island, middle(?) Llandovery, Lower Silurian. Scale bar: 0.1 mm.

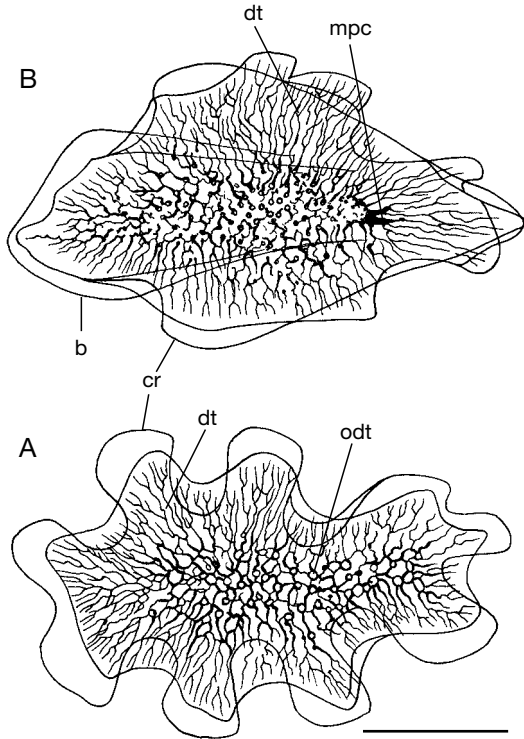


FIG. 10. — *Paralogania klubovi* n. sp., microstructure of the scales; **A**, head scale, LIG 35-086; **B**, trunk scale, LIG 35-087; the scales were drawn in anise oil; sample 2zh, Pioneer Island, middle(?) Llandovery, Lower Silurian. Abbreviations: **b**, base; **cr**, crown; **dt**, dentine tubules; **odt**, openings of dentine tubules; **mpc**, main pulp canal. Scale bar: 0.1 mm.

dentine canals. Partial disintegration of complete lateral rib into separate thornlets is observed in trunk scales of *P. klubovi* n. sp. only. In scale size, *P. klubovi* n. sp. resembles other early species of loganiid thelodonts.

*Paralogania consimilis* n. sp.  
(Figs 6G; 11-13)

HOLOTYPE. — Trunk scale Pi 7515 (Fig. 11O, P).

ETYMOLOGY. — From the Latin word *consimilis* meaning “similar to” to indicate that the new species has some features similar to *P. martinsoni* and some to *P. ludlowiensis*.

MATERIAL EXAMINED. — About 250 scales.

TYPE LOCALITY AND HORIZON. — Sample MF 46-23, 32a-208, Ushakov River, October Revolution Island,

upper part of Samojlovich Formation, Wenlock, Lower Silurian.

OCCURRENCE. — Samples MF 46-23 and 32a-204, 32a-208, Ushakov River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian; (?)sample MF 11-1, Matusевич River, Ust'-Spokojnaya Formation, Ludlow, Upper Silurian.

DIAGNOSIS. — Length of scales up to 1.1 mm and width up to 0.4 mm. Anterior head scales with crenulated margins around the crown, transitional scales with two to four notches antero-laterally, trunk scales of two type: with flat crown plate, spines (= thornlets) on the lateral vertical crown portion and high base; or flattened scales with medial crown portion having a longitudinal groove, lateral rib and up to four spines beneath the rib and one below the posterior crown apex. Scales of the latter type usually have long anterior spur-like projection of base. From the pulp depression spring medial and up to three pairs of lateral pulp canals. Widening of lateral pulp canals form lacunae arranged in a line in the neck and crown just above the base. Dentine canals and dentine tubules are fine and straight. Branching dentine tubules are distributed in the anterior sprong of the base, irregular aspidine “pegs” are present in base.

DESCRIPTION

*Morphology*

The anterior head scales (Figs 11A-C; 12A-E) are deeply crenulated, with a distinct neck and vertical base that has a thickened anterior part. The posterior margin of a head scale (Fig. 11C) is sharply cut with a peg-like projection. Transitional scales (Figs 11D, G; 12F, G) are with two rather deep and some shallow notches antero-laterally. Transitional (or from the leading edges of fins) scales can have a spur-like anterior projection (Fig. 11G). They are not numerous in our samples. Trunk scales (Figs 11E, F, H-T; 12H-P, S, T, X) are up to 1.1 mm long and 0.4 mm wide, the length of the crown being 0.8 mm. Measurements for the holotype (Fig. 11O, P): length 0.8 mm, width 0.6 mm. There are two main types of trunk scales. First, they can be with a flat smooth crown plate and with just a few (up to four) spines on the lateral vertical crown portions (Figs 11H, J; 12S, T) with an anteriorly placed base. Their length is 0.6 mm and width 0.3 mm. The crowns of some scales show two to three spines and a short rib anterior to them (Fig. 11E, K, M, N); anteriorly



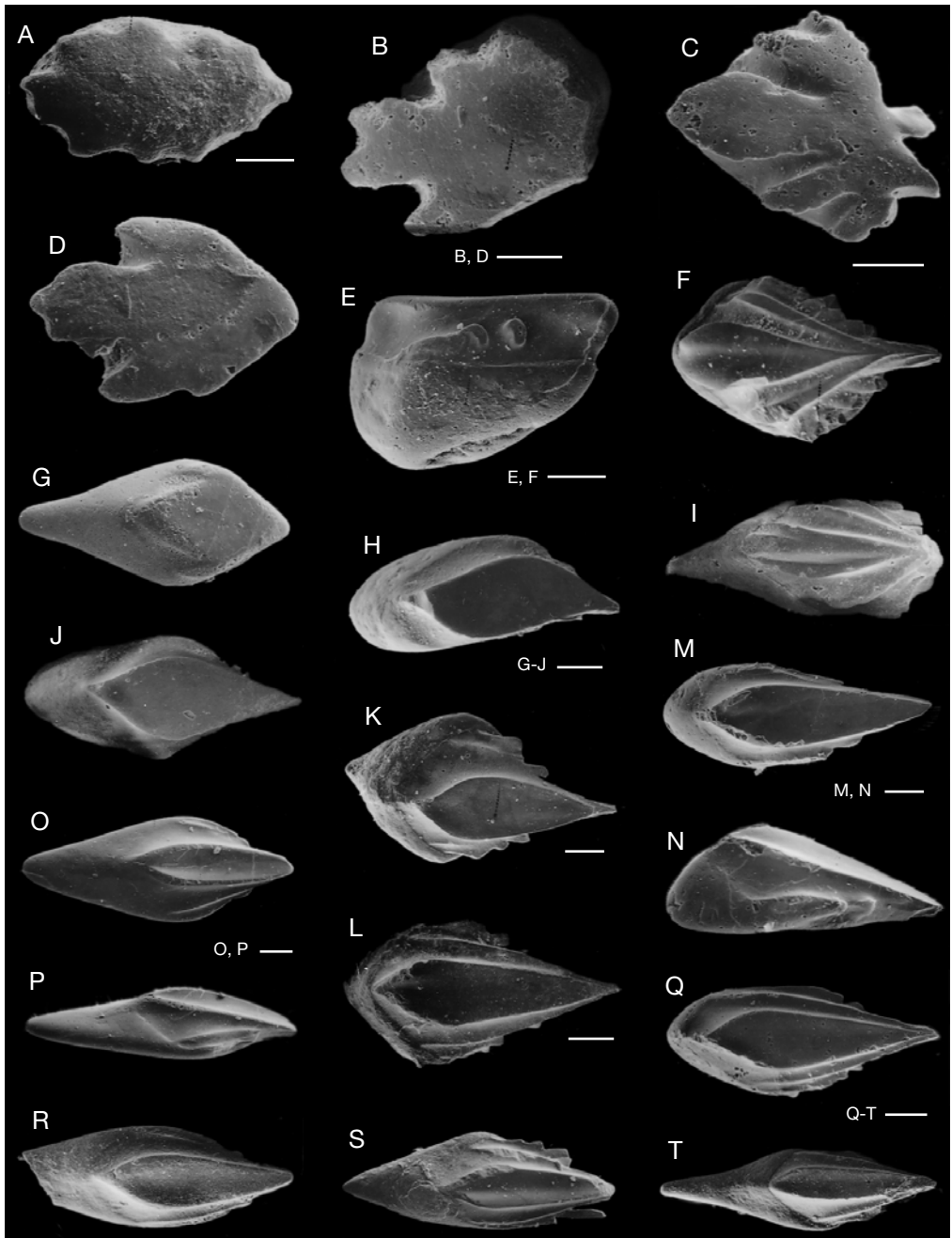


FIG. 11. — *Paralogania consimilis* n. sp.: **A-C**, head scales; **D, G**, transitional scales; **E, F, H-T**, trunk scales; **A-D, F-M, O, Q, R**, scales in crown view; **E, N, P**, scales in lateral view; **A**, Pi 7510; **B**, Pi 6808; **C**, Pi 7508; **D**, Pi 7509; **E**, Pi 7507; **F**, Pi 6806; **G**, Pi 7514; **H**, Pi 7506; **I**, Pi 6816; **J**, Pi 6809; **K**, Pi 7511; **L**, Pi 6810; **M, N**, Pi 7512; **O, P**, holotype Pi 7515; **Q**, Pi 6813; **R**, Pi 6817; **S**, Pi 7513; **T**, Pi 6811; sample MF 46-23, Ushakov River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian. Scale bars: 0.1 mm.

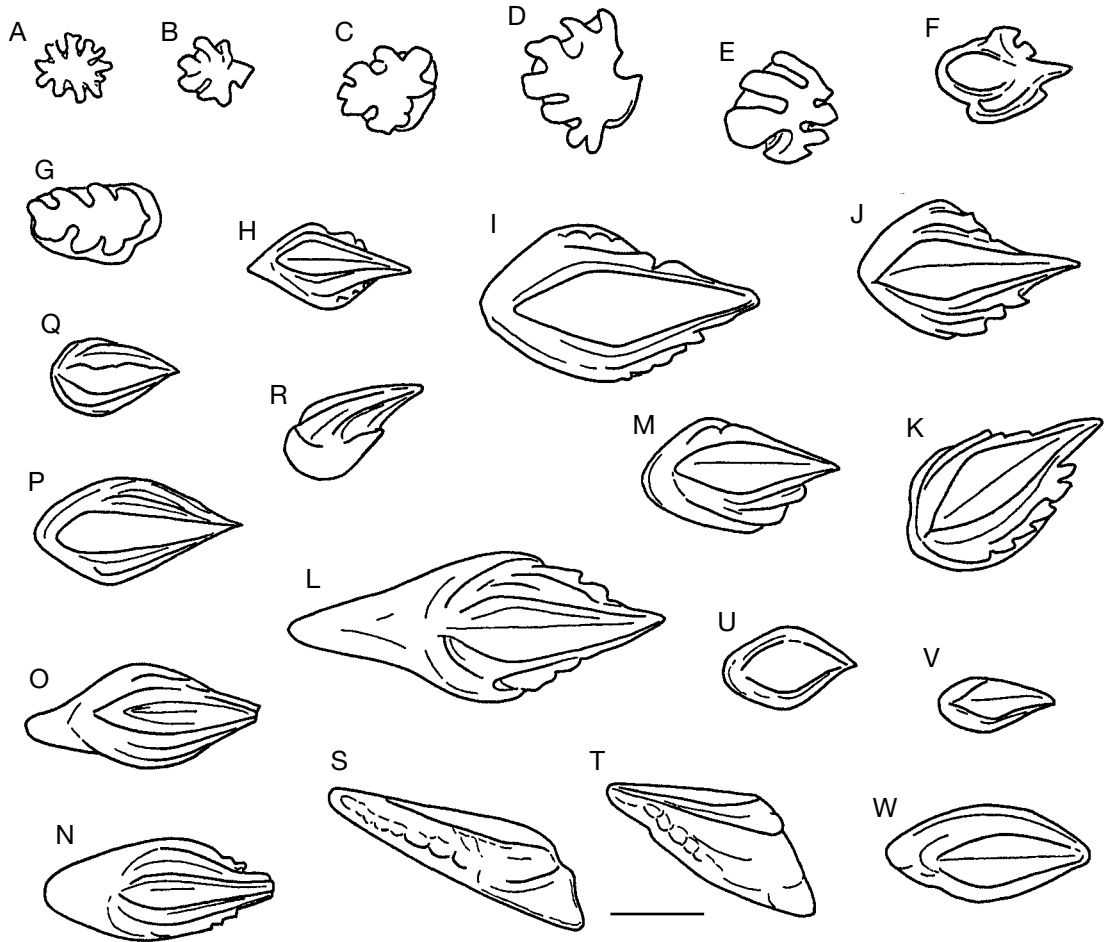


FIG. 12. — Set of scales of *Paralogania consimilis* n. sp.: **A-E**, head scales; **F, G**, transitional scales; **H-P, S, T, W**, trunk scales; **Q, R, U, V**, fin scales; **A**, LIG 35-149; **B**, LIG 35-150; **C**, LIG 35-151; **D**, LIG 35-152; **E**, LIG 35-153; **F**, LIG 35-154; **G**, LIG 35-155; **H**, LIG 35-156; **I**, LIG 35-163; **J, K**, LIG 35-168; **L**, LIG 35-169; **M**, LIG 35-170; **N**, LIG 35-171; **O**, LIG 35-172; **P**, LIG 35-173; **Q, R**, LIG 35-174; **S**, LIG 35-175; **T**, LIG 35-176; **U**, LIG 35-177; **V**, LIG 35-178; **W**, LIG 35-179; sample 31-208, Ushakov River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian. Scale bar: 0.3 mm.

on the crown plate there is just a very shallow furrow. Secondly, fully formed trunk scales characteristic for the species are flattened, have the crown plate with a medial furrow, carry lateral ribs converging posteriorly a little farther than the crown apex is, and have four to five spines beneath the lateral ribs and one below the posterior apex. The neck is indistinct, and the base is with a peg-like projection anteriorly. Fin scales (Fig. 12Q, R, U, V) are short and narrow, some have a tripartite posterior crown portion

but most crowns are pointed posteriorly. The smallest spiny scales are 0.5 mm long and 0.2 mm wide; overall, the smallest scales in our collection are 0.3 mm long and 0.15 mm wide. Special scale varieties should be noted. A very few scales (e.g., Fig. 11F) in the samples are built from a short and narrow medial portion of the crown. It is separated from the lateral ridges by a steep and comparatively deep groove. The ridges converge on the posterior medial apex, and lateral spines (four to five in number) lie

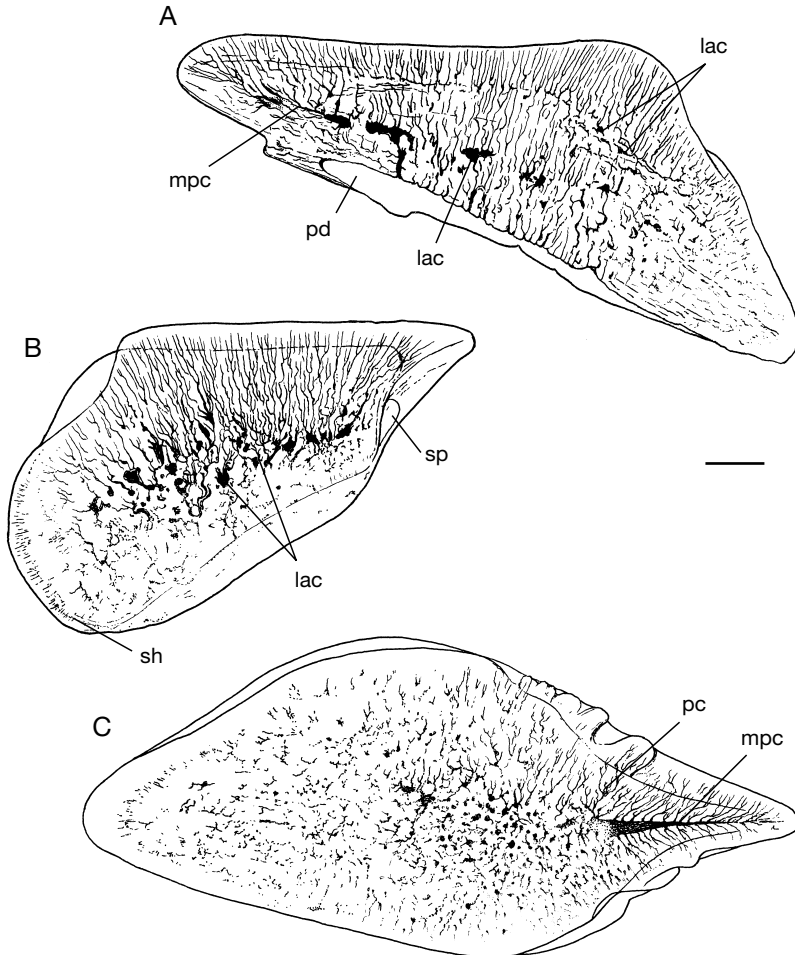


FIG. 13. — *Paralogania consimilis* n. sp., microstructure of the scales; **A, B**, vertical longitudinal section; **A**, Pi 7621; **B**, Pi 7620; **C**, horizontal section, Pi 7622; sample 46-23, Ushakov River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian. Abbreviations: **lac**, lacunae; **mpc**, main pulp canal; **pc**, pulp canal; **pd**, pulp depression; **sh**, canals of Sharpey's fibres; **sp**, spine. Scale bar: 0.1 mm.

with their proximal part on the crown margins. A second variety present in the samples is ridged scales with spines (Fig. 11I). A sample (MF 11-1) from Matusевич River, Ust'-Spokojnaya Formation, contains some scales that because of the lateral rib above the spines can be identified as *P. consimilis* n. sp. (see Karatajūtė-Talimaa & Märss 2002: fig. 3G-I).

#### Histology

See Diagnosis, and Figs 6G and 13.

#### COMPARISON

*Paralogania consimilis* n. sp. is intermediate between *P. martinsoni* (Gross, 1967) and *P. ludlowiensis* (Gross, 1967). Head and transitional scales are rather similar in the new species and *P. martinsoni*. Trunk scales differ in these species, *P. consimilis* n. sp. having a lateral rib and spines beneath it. Such a structure characterizes *P. ludlowiensis* but the latter has two spines below the posterior crown apex while *P. consimilis* n. sp. has one like *P. martinsoni*.

Head scales of *P. consimilis* n. sp. and *P. ludlowiensis* differ strongly because *P. ludlowiensis* has a high *traquairi*-type of head scales but those of *P. martinsoni* have crenulated crown margins and a smooth central part. An anterior spur-like projection is present in *P. consimilis* n. sp. while in *P. ludlowiensis* it is absent. *P. kummerowi* (Gross, 1967) scales are much bigger than *P. consimilis* n. sp., and without lateral ribs; the number of spines is greater in *P. kummerowi*.

Loganelliidae gen. et sp. indet.  
(Figs 8J-L; 9E)

Together with *Paralogania klubovi* n. sp., the sample 2zh from the middle(?) Llandovery of Pioneer Island contained a single well preserved scale that cannot be attributed to either *Paralogania* or other thelodont genera because of its specific morphological features. It is doubtfully determined as Loganelliidae gen. et sp. indet. (new genus of family Loganelliidae; see Karatajūtė-Talimaa & Märss 2002). Based on the very large pulp depression and low, wall-like base, it is thought to be a young trunk scale. Its crown is small, wide and short (length of the crown is 0.3 mm); it is composed of an enlarged central area, which is wide at the proximal part and tapered, keel-like, at the distal part of the crown. The central area is furrowed. The distal part of the crown is wider, and composed of wing-like areas that are positioned at different levels (higher or lower) (Fig. 8I, K). Each higher area overlaps the lower one, and a notch is situated between them. Each area ends with an independent posterior apex. The posterior end of the central one has two medial, tapered apices beneath it, the lowest being the longest. The crown surface of all areas is covered by fine longitudinal striations (Fig. 8J-L). The lower side of the crown (Fig. 9E) shows wing-like structures from below; its elongated ribs end with spines. The base is at the anterior of the scale. Openings of pulp canals are observed in the comparatively deep pulp depression, in the bases of the longitudinal ribs.

Order THELODONTIDA Kiaer, 1932

Family COELOLEPIDAE Pander, 1856

TYPE GENUS. — *Thelodus* Agassiz, 1839.

Genus *Thelodus* Agassiz, 1839

TYPE SPECIES. — *Thelodus parvidens* Agassiz, 1839.

*Thelodus calvus* n. sp.  
(Figs 5P-S; 14; 15)

HOLOTYPE. — Pi 7503 (Fig. 5Q).

ETYMOLOGY. — From the Latin word *calvus*, “bald”, referring to the smooth unsculptured surface of the scales.

TYPE LOCALITY AND HORIZON. — Sample MF 46-23, 32a-208, Ushakov River, October Revolution Island, Severnaya Zemlya Archipelago; upper part of Samojlovich Formation, Wenlock, Lower Silurian.

MATERIAL EXAMINED. — More than 300 scales of good preservation.

OCCURRENCE. — Samples MF 46-23, 32a-204, 32a-208, Ushakov River, and MF 157-7, Spokojnaya River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian; (?)MF 34-1, Cape October, and MF 46-26, Ushakov River, October Revolution Island, Severnaya Zemlya Archipelago, Ust'-Spokojnaya Formation, Ludlow, Upper Silurian.

DIAGNOSIS. — Scales small; average length 0.4 mm, width 0.4 mm and height 0.4 mm. Scale crowns squarish to oval, smooth and flat or slightly convex. Neck very distinct, rather high, base placed at anterior of scale. Pulp opening in centre or slightly posteriorly in base. Pulp cavity complicated, having openings of dentine canals. Dentine canals occur in base, neck and lower part of crown. Bunches of dentine tubules arise from dentine canals. Both aspidine “pegs” and tubules of Sharpey’s fibres present.

DESCRIPTION

*Morphology*

The morphology of the scales is very simple. The length of the scale ranges from 0.3 to 0.9 mm, width 0.2-0.7 mm and height 0.2-0.6 mm; in the holotype the length/height measurements are 0.4/0.4 mm. The crown is mainly rhombic with slightly rounded anterior corner but they also

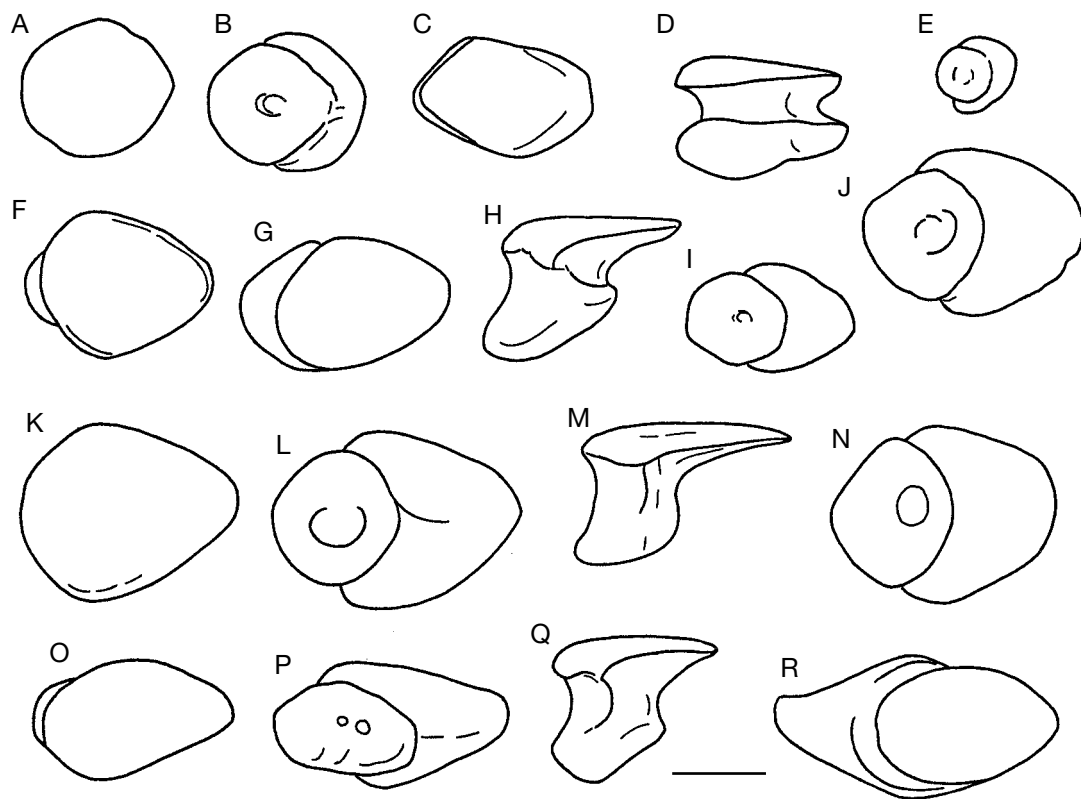


FIG. 14. — Set of scales of *Thelodus calvus* n. sp.: **A, B**, LIG 35-180; **C, D**, LIG 35-181; **E**, LIG 35-182; **F**, LIG 35-183; **G**, LIG 35-184; **H**, LIG 35-185; **I**, LIG 35-186; **J**, LIG 35-187; **K, L**, LIG 35-188; **M**, LIG 35-191; **N**, LIG 35-192; **O, P**, LIG 35-189; **Q**, LIG 35-190; **R**, LIG 35-193; sample 32a-208, Ushakov River, October Revolution Island, upper part of Samojlovich Formation, Wenlock, Lower Silurian. Scale bar: 0.3 mm.

can be oval. The scales reveal no sculpture. The neck is very distinct, smooth and high. The lateral margins of the crown are slightly elevated (Fig. 5Q, S). The base is anteriorly longer than the crown and protrudes forward. The rounded pulp opening is situated in the centre or in the posterior part of the base. Fig. 14 exhibits the set of scales of *T. calvus* n. sp.

*Histology (Fig. 15)*

The pulp cavity continues posteriorly as a pulp canal at a right angle from pulp cavity (Fig. 15F). The walls of the pulp cavity are uneven because of openings of dentine canals (Fig. 15A, B). Dentine canals that start in the cavity enter into the base, anterior portion of the crown (Fig. 15A) and the neck (Fig. 15B). The poste-

rior region of the neck has very few canals if any. Numerous dentine tubules are distributed as bunches going out from the dentine canals. Dentine tubules in the posterior crown portion are directed upwards and backwards, then they turn anteriorly and again posteriorly, before running straight up towards the crown surface (Fig. 15B). Horizontal thin sections (Fig. 15E, G) of the uppermost part of the crown, show rather straight dentine tubules. In a little deeper section (Fig. 15C, D) dentine canals are also visible. In the base, aspidine “pegs” and tubules of Sharpey’s fibres occur.

COMPARISON

Scales of *T. calvus* n. sp. are to some extent similar to smooth flat small scales of *Thelodus parvi-*

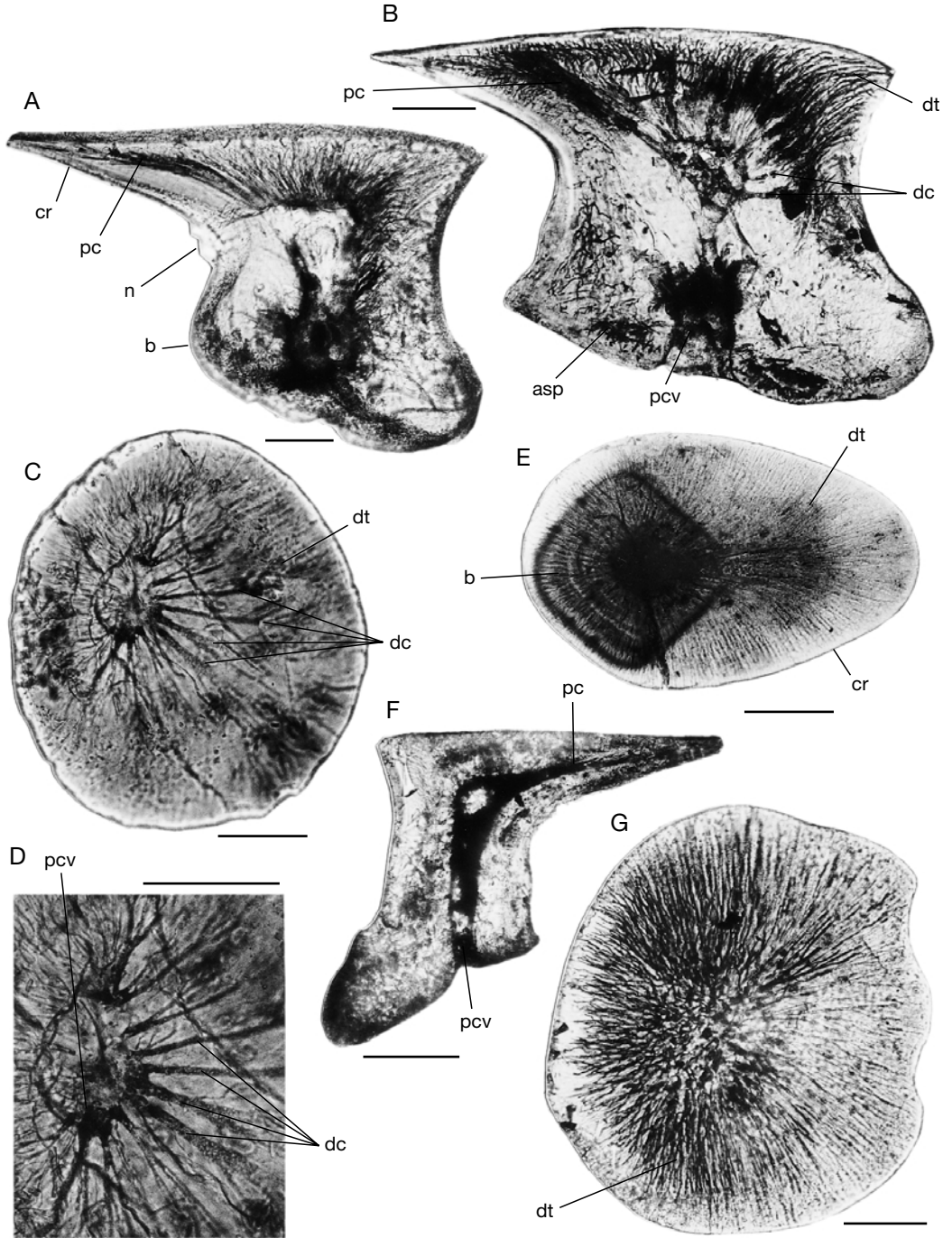


FIG. 15. — *Thelodus calvus* n. sp., microstructure of the scales; **A**, Pi 7631; **B**, Pi 7632; **C**, **D**, Pi 7633; **E**, Pi 7634; **F**, Pi 7635; **G**, Pi 7636; sample MF 46-23, Ushakov River, October Revolution Island, Samojlovich Formation, Wenlock, Lower Silurian. Abbreviations: **asp**, aspidine "pegs" in the base; **b**, base; **cr**, crown; **dc**, dentine canal; **dt**, dentine tubules; **n**, neck, **pc**, pulp canal; **pcv**, pulp cavity. Scale bars: 0.1 mm.

*dens* Agassiz, 1839. They differ from other *Thelodus* species in lacking any sculpture. Among *Thelodus* species, dentine canals occur only in *T. calvus* n. sp. Similar scales with a smooth crown and high smooth neck have been found in the Wenlock of East Baltic (see e.g., Märss 1986; Karatajütē-Talimaa & Brazauskas 1995).

*Thelodus?* sp.  
(Fig. 7T-V)

Ridged scales without spines (Figs 7T-V) have been found in the Samojlovich Formation, Wenlock, Lower Silurian, Ushakov River section on October Revolution Island, and have been identified as *Thelodus?* sp. in this work. The possibility cannot be excluded that such scales might also belong to *Paralogania*. Both *Thelodus* and *Paralogania* scales are present in the same sample.

## CONCLUSIONS

Thelodonts from Severnaya Zemlya Archipelago have been known for three decades. Data about their biostratigraphical distribution have been published in a few papers (Karatajütē-Talimaa 1978; Klubov *et al.* 1980; Märss 1982, 1989, 1990; Matukhin *et al.* 1982; Karatajütē-Talimaa & Märss 1999). A new genus and species, *Boreania minima*, was described by Karatajütē-Talimaa (1985). The scale morphology and histology of some taxa (*Logania* [= *Paralogania*] *martinssoni*, *Thelodus calvus* n. sp.) were compared with those from Baltic by Märss (1986). The taxonomy of all thelodonts known up to now is described in Karatajütē-Talimaa (in press), and this article (see also Karatajütē-Talimaa & Märss 2002).

In this paper, six new thelodonts and an earlier known thelodont are described from the Middle-Upper and Upper Ordovician to Lower Silurian of Severnaya Zemlya Archipelago. *Stroinolepis maenniki* n. gen., n. sp. comes from the upper part of Ozernaya and Strojnyaya for-

mations, Middle-Upper and Upper Ordovician, of the Strojnyaya River section of October Revolution Island. *Loganellia matura* n. sp. was found in the Golomyannyj Formation, middle Llandovery of Srednii Island. *Paralogania klubovi* n. sp. and Loganelliidae gen. et sp. indet. were discovered from the middle(?) Llandovery of Pioneer Island. Four thelodonts were identified from the Samojlovich Formation, Wenlock, Lower Silurian: *Loganellia grossi* from the Matusевич River section, *Paralogania consimilis* n. sp. and *Thelodus calvus* n. sp. from the Ushakov River section and *Shielia multispinata* n. sp. from the Spokojnyaya River section of October Revolution Island.

## Acknowledgements

T. M. acknowledges Estonian Science Foundation grant 2854 and 4160. Thelodont scales were obtained and made available to the authors by P. Männik, Tallinn. He also gave his unpublished data on conodont distribution in the part of Strojnyaya River section. The SEM photos were taken by U. Moldov and V. Mikli, prints were made by G. Baranov, and figures of scales re-drawn by K. Ronk, Tallinn. English language was improved by A. Noor, Tallinn, Dr. G. Budd, Uppsala, and abstract translated into French by D. Goujet. Our sincere thanks go to all of them as well as to the referees of our manuscript, M. M. Smith (London), and S. Turner (Brisbane), who also made linguistic corrections.

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Submitted on 29 September 1998;  
accepted on 2 July 1999.