

On the Revision of the Permian Ray-Finned Fishes of European Russia. Part 1

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Abstract— Some originals of Permian ray-finned fishes from European Russia from the collection of D.N. Esin, which was transferred to PIN RAS, are revised. The diagnoses and images of taxa that preserved the original (assigned at the first description) systematic status are given: *Acropholis kamensis*, *A. silantievi*, *Kazanichthys golyushermensis*, *K. viatkensis*, and *Boreolepis tataricus*. An image of the holotype of *Kazanichthys viatkensis* is published for the first time.

Keywords: Actinopterygii, scales, Permian, East Europe, stratigraphy

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INTRODUCTION

Dmitry N. Esin played a crucial role in the study of Permian ray-finned fishes from European Russia (Bakaev, in press). He was employed by Moscow State University (MSU), but after his death in 2003, this collection was transferred to Borissiak Paleontological Institute (PIN) RAS. It has been stored under old MGU numbers and has not been revised.

In total, Esin's collection includes type and illustrated material of 12 fish species he described: *Wardichthys inobilis* Esin, 1993 (Esin, 1993), *Acropholis kamensis* Esin, 1995, *Kazanichthys golyushermensis* Esin, 1995, *Koinichthys ivachnenkoi* Esin, 1995, *Elonichthys contortus* Esin, 1995 (Esin, 1995b), *Acropholis silantievi* Esin, 1996, *Kazanichthys viatkensis* Esin, 1996, *Boreolepis tataricus* Esin, 1996, *Reticulolepis insolita* Mashin et Esin, 1996, *Acroctenolepis nikolaevae* Esin, 1996, *Amblypterina grandicostata* Esin, 1996, and *A. pectinata* Esin, 1996 (Esin and Mashin, 1996). When examining the transferred collection, the original specimens of *Koinichthys ivachnenkoi* and *Elonichthys contortus* were not found. Some taxa preserved their systematic status (*Acropholis kamensis*, *A. silantievi*, *Kazanichthys golyushermensis*, *K. viatkensis*, *Boreolepis tataricus*), and some others changed it (*Wardichthys inobilis*, *Reticulolepis insolita*, *Acroctenolepis nikolaevae*, *Amblypterina grandicostata*, *A. pectinata*). The present paper considers those taxa that have not changed their systematic status.

MATERIAL AND METHODS

The studied material is represented by isolated scales of good and satisfactory preservation from four

localities, as well as an incomplete skeleton of *Kazanichthys viatkensis* (Fig. 1). Original specimens of *Acropholis silantievi* come from the Pechora (Dozmer) locality. Scales *Acropholis kamensis* and *Kazanichthys golyushermensis* are from the Golyusherma-2 locality. The holotype of *Kazanichthys viatkensis* was found in the Shikhovo-Chirki locality. Original specimens of *Boreolepis tataricus* were collected in the Pronkino locality.

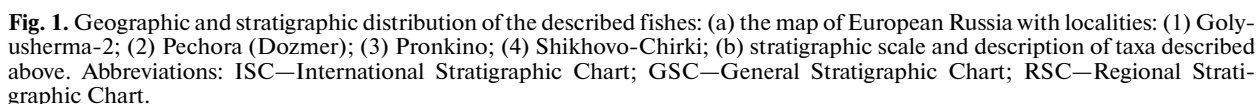
To describe the general morphology, Esin's method (1995a) has been applied. Märss's terminology (2006) has been applied to describe the ultrasculpture of the free field of a scale. Images of individual scales were taken in the analytic center of PIN RAS using TESCAN VEGA-II XMU, and TESCAN VEGA-III XMU (without coating) microscopes. The general image of the holotype of *Kazanichthys viatkensis* was taken with a Canon EOS 650D.

DESCRIPTION OF LOCATIONS

Pechora (Dozmer). Komi Republic, Troitsko-Pechorsky District; right bank of the Pechora River, 0.5 km below the Dozmera River mouth (Efremov and Viyushkov, 1955; Ivakhnenko et al., 1997), 7 km north of the settlement of Znamenka.

Bone Bed 6. Limestone, black, thinly plated, bituminous with meroleims. Thickness 0.6 m (Efremov and Viyushkov, 1955).

Paleontological material: fishes: *Acropholis silantievi*, *Grygorichthys murchisoni* (Fischer), *Acropholis* sp., *Kazanichthys* sp., *Platysomus* sp., *Palaeostrugia* cf. *rhombifera* (Eichwald), *Acrolepis* cf. *sedgwicki* Agassiz, cf. *Plegmolepis* sp., *Elonichthys* sp., *Kargalichthys* sp.,



Shikhovo-Chirki. Kirov region, Slobodskoy District; right bank of the Vyatka River, upstream from the Cheptsa River, downstream from the village of Chirki, 22 km from the town of Kirov. Bone zone is

located in the northeastern part of the quarry, near the boundary between fields of Shikhovo-Chirki and the territory of a lime plant. See detailed description in (Gomankov et al., 1993).

Bone Bed 4. Limestone light or gray, massive or soft, alternating with gray marls, sometimes bedded. Thickness up to 9 m (Efremov and Viyushkov, 1955).

Paleontological material: fishes: *Kazanichthys viatensis*, *Samarichthys nikolaevae*, *Palaeoniscum kasanense*, *Platysomus biarmicus*, *Elonichthys* cf. *contortus*, *Palaeoniscum freiselebeni*, *Kargalichthys pritonensis* (Esin, 1995a); bivalves: *Palaeomutela vjatensis*, *Prilukiella* sp., *P. lata*; tetrapods: *Leptorophya talonophora*, *Melosaurus platyrhinus*, *Nyctiboetus kassini*, *Platyoposaurus watsoni*; plants: *Phyllothea* sp., *Catamites* sp. (Golubev, 1995).

Stratigraphic level: Middle Permian (Biarmian), Kazanian Stage, Upper Kazanian Substage, Verkhny Uslon Beds (*Stratotipicheskii...*, 2001).

SYSTEMATIC PALEONTOLOGY

SUPERCLASS OSTEICHTHYES

CLASS ACTINOPTERYGII

Order Elonichthyiformes

Family Acrolepididae Aldinger, 1937

Genus *Acropholis* Aldinger, 1937

Acropholis kamensis Esin, 1995

Plate 8, figs. 9–13

Acropholis kamensis: Esin, 1995b, p. 124, pl. 11, figs. 21, 22, 25, 26, 29; 1995c, p. 80, Figs. 2a, 2b; Minikh and Minikh, 2009, p. 65, pl. 2, figs. 1–5.

Holotype. PIN, no. 5798/1 (previously, MGU, no. 263-401/1-1), scale of the area “B”; Udmurt Republic, Alnashsky District, Golyusherma-2 locality (Bed 14); Middle Permian (Biarmian), Kazanian Stage, Lower Kazanian Substage, Baitugan Beds.

Description (modified after Esin, 1995b). Scales are large, thick, and almost rectangular. Anterodorsal corner is high and directed straight upwards. The anteroventral angle is oblique. The peg is short, weakly developed. The keel looks like a

rounded ridge. The free field is wide; it occupies about 1/2 length of the scales of the area “B”. The depressed field may have small grooves and pores, enclosing vesicles; it is slightly convex, due to this the anterior margin of the flat free field is noticeable. The ends of the lobate projections are rounded or slightly pointed. Sculpture of the free field is represented by narrow, high ridges, tending to merge at the posteroventral corner, subtriangular in section. Borrows separating ridges are wide, especially at the anterior margin of the free field; they contain small pores.

The ridges may merge at the posterior margin to form a single denticle but may also terminate in several distinct denticles. Some ridges begin to merge at the very beginning of the free field. The ridges are almost parallel to the main diagonal of the scale and begin to merge together only at the posteroventral corner.

Measurements. The reconstructed length of the holotype (isolated scales) is approximately 0.5 cm, and the height is 0.45 cm. The size of the whole fish is difficult to reconstruct. However, by comparison with the similar species *A. stensioei*, the complete skeletons of which have been found, a total body length of *A. kamensis* reach 1 m.

Comparison. *Acropholis kamensis* differs from *A. stensioei* in the narrower and higher, less numerous ridges in the sculpture and much wider grooves between them.

Remarks. There are significant contradictions between the numbers of scales, indicated in (Esin, 1995b) and in the thesis research (Esin, 1995a). Thus, in the thesis research, three different scales (Esin, 1995a, pl. 2, figs. 4–6) have the same numbers (MGU, no. 263-401/1-5), but in (Esin, 1995b) all three scales have their own numbers. Therefore, in the present paper, the author uses the numbering presented in (Esin, 1995b).

Occurrence. Kazanian Stage, Upper Permian of the Middle Kama region.

Material. Apart from the holotype, specimens MGU, nos. 263-401/1-2, 263-401/1-3, 263-401/1-5, and 263-401/1-6 from the type locality in the PIN collection were assigned the PIN numbers 5798/2,

Explanation of Plate 8

Figs. 1–8. *Acropholis silantievi* Esin, 1996, isolated scales from different parts of the fish body, exterior view: (1) holotype PIN, no. 5839/24, scales of the area “A” from the lateral line; (2) specimen PIN, no. 5839/28, scales of the area “F”, near the area “A”; (3) specimen PIN, no. 5839/26, scales of the area “C”; (4) specimen PIN, no. 5839/25, scales of the area “C”; (5) specimen PIN, no. 5839/29, scales of the area “C”, near the area “B”, from the lateral line; (6) specimen PIN, no. 5839/30, scales of the area “C”, near the area “D”; (7) specimen PIN, no. 5839/31, scales of the area “F”, near the area “C”; (8) specimen PIN, no. 5839/27, scales of the area “A”; Komi Republic, Troitsko-Pechorsk District, Dozmer locality; Lower Permian (Cisuralian), Ufimian Stage.

Figs. 9–13. *Acropholis kamensis* Esin, 1995, isolates scales from different areas of the fish body, exterior view: (9) holotype PIN, no. 5798/1, scales of the area “B”; (10) specimen PIN, no. 5798/3, scales of the area “C”; (11) specimen PIN, no. 5798/4, scales of the area “C”, near the area “F”; (12) specimen PIN, no. 5798/5, scales of the area “C”; (13) specimen PIN, no. 5798/2, scales of the area “B”, near the area “F”; Udmurt Republic, Alnashsky District, Golyusherma-2 locality; Middle Permian (Biarmian), Kazanian Stage, Lower Kazanian Substage, Baitugan Beds.

Scale bar 0.5 mm.

Plate 8



5798/3, 5798/4, 5798/5, respectively. Besides, there are five scales, received the following numbers: nos. 5798/6–10.

Acropholis silantievi Esin, 1996

Plate 8, figs. 1–8

Acropholis silantievi: Esin and Mashin, 1996, p. 280, text-fig. 5.5–7, pl. 5.5–I, figs. 1–3; Minikh and Minikh, 2009, p. 65, pl. 2, figs. 14–16.

Holotype. PIN, no. 5839/24 (previously, MGU, no. 201/1-1), scale of the area “A” from the lateral line; the Komi Republic, Troitsko-Pechorsky District, Pechora (Dozmer) locality; Lower Permian (Cisuralian), Ufimian Stage.

Description (after Esin and Mashin, 1996). Scales are square or rectangular, large- to medium-sized. The anterodorsal corner is well developed and directed vertically upwards. The keel wide and flat or looks like a rounded swollen tubercle. The socket and peg are small. The peg is close to the anterior upper corner. The depressed field is wide and occupies 1/3 the length of the scale. On the surface of the free field are distinct ridges, rounded or subtriangular in cross-section. The anterior ends of lobate projections, situated along the anterior margin of the free field, are usually pointed. The ridges are parallel to the main diagonal of the scale. Pairwise merging of ridges is often observed, usually in the middle part of the free field. Bridges connecting two or three parallel ridges are observed. Apart from long ridges, extending from the anterior margin to posterior margin of the free field, there are also short denticle-like small ridges. They are located mainly near the posterior margin and in the posterior upper corner of the free field. Posterior ends of the small ridges are narrow, elongated, sharply pointed; often expand behind the posterior margin of scales, forming denticles. Grooves separating the ridges are not wide, but deep.

Measurements. The holotype (an isolated scale) is approximately 0.5 cm long and 0.6 cm high. The size of the whole fish is difficult to reconstruct. However, by comparison with the similar species *A. stensioei*, complete skeletons of which have been

found, the total body length of *A. silantievi* can be estimated at 1 m.

Comparison. The species differs from the most similar species *A. kamensis* in the narrower and more numerous ridges of the sculpture, narrower grooves separating them, the presence of bridges between the ridges, narrower anterior ends of the ridges, and the presence of short, small ridges near the posterior margin of the scales.

Remarks. In the original description, no image of the holotype scale is given, but a schematic drawing (Esin and Mashin, 1996, text-fig. 5.5–7) allowed the identification of the type specimen.

Occurrence. Ufimian Stage, Lower Permian (Cisuralian), Permian System; north and east of European Russia.

Material. Apart from the holotype, the MGU specimens, nos. 201/1-4, 201/1-6, 201/1-12, 201/1-13 were transferred to the PIN collection, and they were assigned the following PIN numbers: 5839/25, 5839/26, 5839/27, 5839/28, respectively; unnumbered samples were assigned PIN numbers 5839/29, 5839/30, 5839/31; all specimens are from the type locality. Specimen MGU, no. 201/1-1 (Esin and Mashin, 1996; pl. 5.5–I, fig. 1) was badly damaged being transported; for this reason, it does not have its own number in the PIN collection.

Genus Kazanichthys Esin, 1995

Kazanichthys golyushermensis Esin, 1995

Plate 9, figs. 1–6

Kazanichthys golyushermensis: Esin, 1995b, p. 125, pl. 10, figs. 1–11; Minikh and Minikh, 2009, p. 67, pl. 3, figs. 1–9.

Holotype. PIN, no. 5798/11 (previously, MGU, no. 263-401/2-2), scale of the area “B”; Udmurt Republic, Alnashsky District, Golyusherma-2 locality (Bed 14); Middle Permian (Bairmian), Kazanian Stage, Lower Kazanian Substage, Baitugan Beds.

Description (modified after Esin, 1995b). Scales are relatively small, thin. The anterodorsal corner is very high, strongly protrude upwards. The anteroventral corner is strongly oblique, posteroventral corner is pointed, slightly protrude backwards and

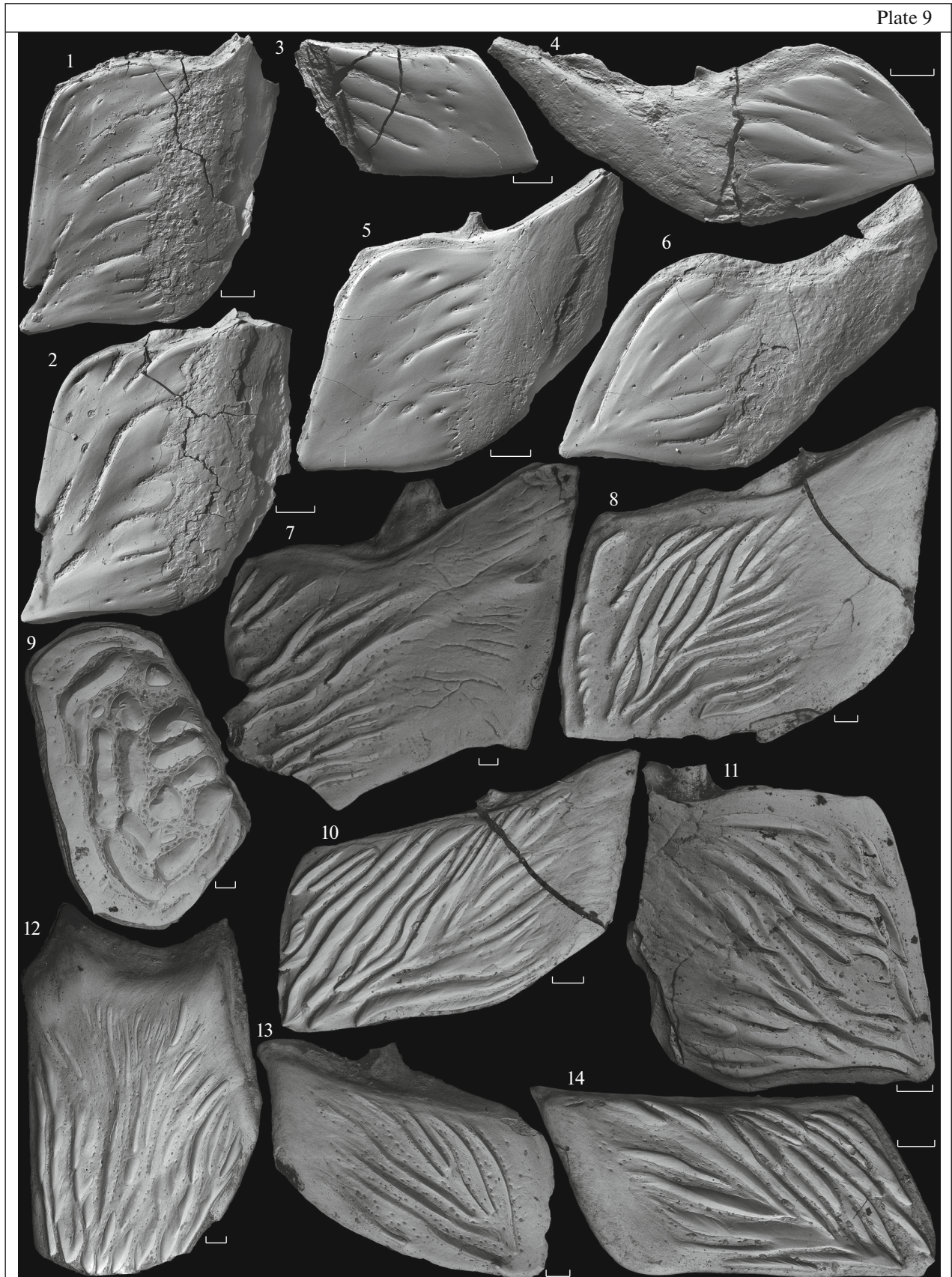
Explanation of Plate 9

Figs. 1–6. *Kazanichthys golyushermensis* Esin, 1995, isolated scales from different parts of the fish body, exterior view: (1) holotype PIN, no. 5798/11, scales of the area “B”; (2) specimen PIN, no. 5798/12, scales of the area “B”; (3) specimen PIN, no. 5798/13, scales of the area “C”; (4) specimen PIN, no. 5798/16, scales of the area “F”; (5) specimen PIN, no. 5798/1, scales of the area “B”, near the area “C” from the lateral line; (6) specimen PIN, no. 5798/14, scales of the area “F”, near the area “B”; Udmurt Republic, Alnashsky District, Golyusherma-2 locality; Middle Permian (Bairmian), Kazanian Stage, Lower Kazanian Substage, Baitugan Beds.

Figs. 7–14. *Boreolepis tataricus* Esin, 1996, isolated scales from different parts of the fish body, exterior view: (7) specimen PIN, no. 5784/11, scales of the area “A”; (8) holotype PIN, no. 5784/12, scales of the area “B”; (9) specimen PIN, no. 5784/28, dermal bone; (10) specimen PIN, no. 5784/14, scales of the area “B”, near the area “C”; (11) specimen PIN, no. 5784/13, scales of the area “B”; (12) specimen PIN, no. 5798/17, ridge scale; (13) specimen PIN, no. 5798/23, scales of the area “C,” (14) specimen PIN, no. 5784/15, scales of the area “C”; Orenburg region, Sorochinsky District, Pronkino locality; Upper Permian (Tatarian), Vyatkian Stage, Kutulak Formation.

Scale bar 0.5 mm.

Plate 9



downwards, posterodorsal corner is obtuse. The peg and socket are small, located in the middle of the length. The peg has a wide base, considerably lower than anterodorsal corner. The keel is flat, shifted anteriorly. The depressed free field is wide; it is developed both at the anterior margin and at the upper margin and occupies 1/2 the length the scale. There scarce lobate projections, with pointed ends. Ridges of sculpture low, rounded-triangular or flat-triangular in cross-section; they reach the mid-free field and, then, either merge or reach the posterior margin forming short denticle, not extending beyond posterior margin of scale. The ridges and separating grooves in the central part of the free field have a diagonal direction, while in the periphery they are concentric, almost parallel to the margins. The posteroventral corner has a single denticle. Ganoine layer does not reach margins of scales. Therefore, the posterior and lower margins of the scales have a protruding bone rim.

Measurements. The length of the holotype (isolated scale) is approximately 0.3 cm, and the height is 0.4 cm. It is difficult to reconstruct the size of the whole fish. However, by comparison with the similar species *K. viatkensis*, the complete skeletons of which have been found, a total body length of *K. golyushermensis* can be estimated at up to 0.5 m.

Comparison. *K. golyushermensis* differs from *K. viatkensis* and *K. uralensis* A. Minikh in significantly higher and sharper ridges of the sculpture, a more divided free field, and wide and long grooves between the ridges.

Occurrence. The entire Lower Kazanian and the lower Upper Kazanian (up to Prikazanian Beds of the Pechishchi stratotype section, inclusive) substages of the Middle Permian (Biarmanian), Permian System; East European Platform and Cis-Uralian region.

Material. Except the holotype, specimens MGU, nos. 263-401/2-3, 263-401/2-5, 263-401/2-6, 263-401/2-9, 263-401/2-12 were transferred to the PIN collection and received the following PIN numbers 5798/12, 5798/13, 5798/14, 5798/15, 5798/16, respectively, as well as some more 14 scales, which received the PIN specimens, nos. 5798/16–30; all of them are from type locality. Specimens MGU, nos. 263-503/1-1, 263-501/1-4, 263-501/1-2, 263-501/1-8, 263-501/1-8 (Esin, 1995b, pl. 10, figs. 1, 5, 8, 10, 11) were not found.

Kazanichthys viatkensis Esin, 1996

Kazanichthys viatkensis: Esin and Mashin, 1996, p. 281, pl. 5.5-1, figs. 4–6, text-fig. 5.5-8; Minikh and Minikh, 2009, p. 67, pl. 3, figs. 10–12; pl. 4, fig. 1; pl. 11, figs. 5–8.

Holotype. PIN, no. 5802/15 (previously, MGU, no. ShCh-4/2), incomplete skeleton of the fish, without the head, with poorly preserved pectoral, dorsal, and anal fins; Kirov Region, Slobodskoy District, Shikhovo-Chirki locality; Middle Permian

(Biarmanian), Kazanian Stage, Upper Kazanian Substage, Verkhnyi Usloñ Beds.

Description (modified after Esin and Mashin, 1996) (Fig. 2). Scales are medium-sized, rectangular and rhomboidal. The anterodorsal corner is strongly developed and extended upwards. The anteroventral corner is oblique. The keel is wide and flat. The socket and peg are normally developed, medium-sized. The peg is wide at the base, with pointed apex. The depressed field is wide, usually 1/2 or more the length of the scale in the anterior part of the body. The posterior lower corner is pointed and bent downward. There are scarce lobate projections with rounded ends. The ridges of the sculpture are mainly flat-rounded. Individual ridges of scales in the anterior part of body are triangular in cross-section. The ridges reach the end of the first third of the free field, where they merge, and only single ones reach the posterior margin forming short denticles.

The ridges and separating grooves originate from the anterodorsal part of the free field. They have diagonally oriented, and are concentric on the periphery, almost parallel to the margins. At the posterior margin, the ganoine forms a pair of denticles not extending beyond the edge of the scales; the posterior and ventral margins of the scales have a protruding bone rim.

Measurements. The body length of the holotype is unknown because of considerable deformation. However, the reconstructed length is approximately 25 cm. More complete specimens of this species are known; for example, the complete, almost undeformed skeleton (no. 6014) in the collection of Perm State University (PSU) has a body length of 24 cm (BakaeV et al., 2021, Text-fig. 4, fig. 1).

Comparison. *K. viatkensis* differs from *K. golyushermensis* in the less pronounced ridges of sculpture, a weakly dissected free field, and very short interridge grooves. It differs from *K. uralensis* in the smaller size of the bone protruding below the ganoine layer along the lower and posterior margins of the scale and in a smaller number of pores on the free field.

Remarks. At the first description (Esin and Mashin, 1996), the holotype was described but a drawing or image was not given. However, the holotype was illustrated in Esin's thesis (1995a, pl. 8, fig. 6), which allowed it to be found in the collection and to recognize with certainty. Although an image of the holotype is desirable in the original description, it is not mandatory under the "International Code of Zoological Nomenclature" (1999). *Kazanichthys viatkensis* is a valid taxon from its original description (Esin and Mashin, 1996).

Occurrence. Permian, Middle Permian (Biarmanian), Kazanian Stage, Upper Kazanian Substage of European Russia.

Material. None of the published scales, other than those on the holotype, have been found in the collection. However, the published images and scales

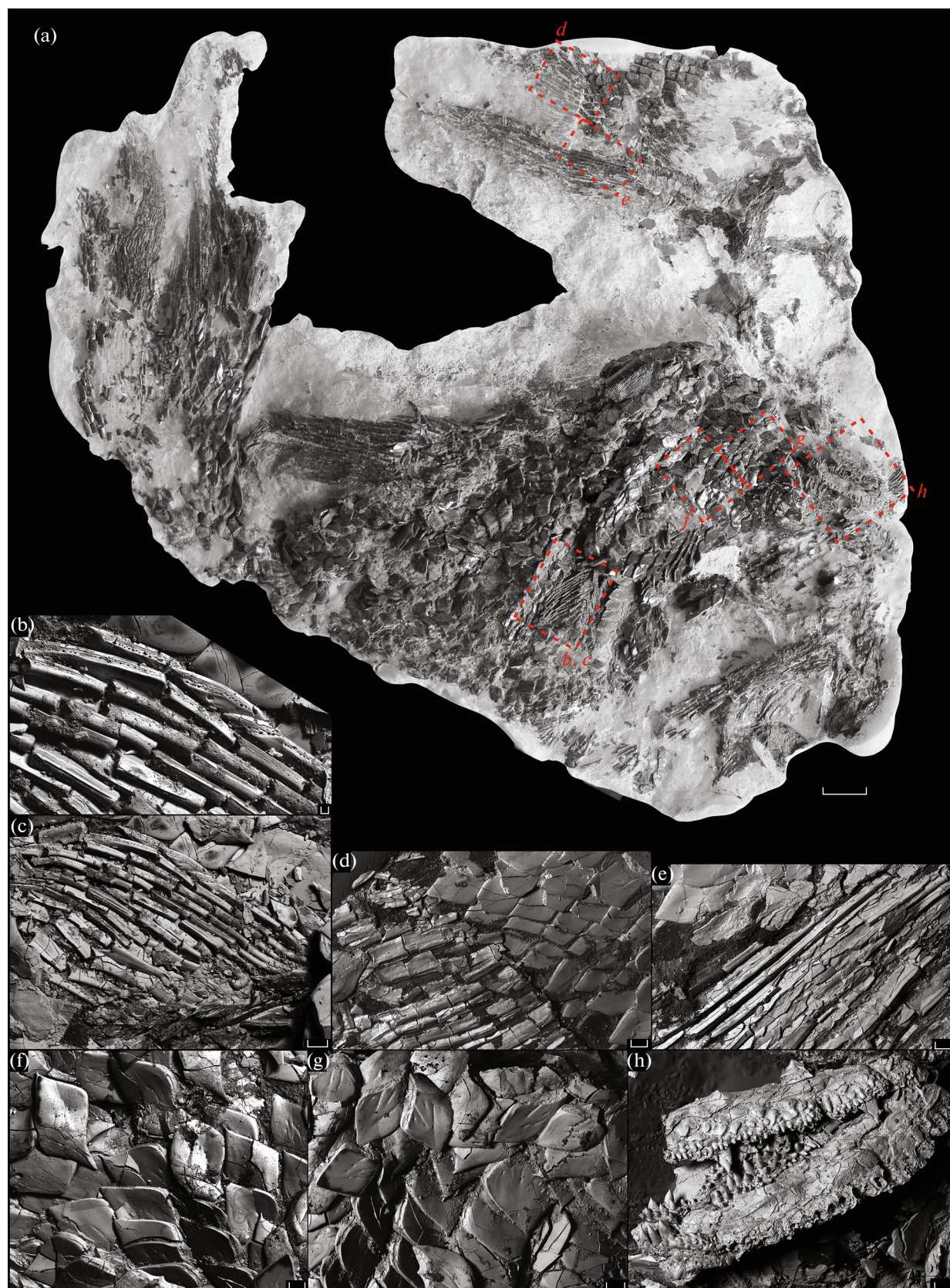


Fig. 2. *Kazanichthys viatkensis* Esin, 1995, holotype PIN, no. 5802/15: (a) general view; (b–h) details of the structure at a higher magnification; Shikhovo-Chirki locality, Slobodskoy District, Kirov Region; Middle Permian (Bairmian), Kazanian Stage, Upper Kazanian Substage, Upper Uslonian Beds. Scale bar 5 (a), 0.5 mm (b–h).

of the holotype allow unmistakable attribution of many scales from the type locality (Shikhovo-Chirki) to this species.

Family Boreolepididae Aldinger, 1937

Genus *Boreolepis* Aldinger, 1937

Boreolepis tataricus Esin, 1996

Plate 9, figs. 7–14

Boreolepis tataricus: Esin and Mashin, 1996, p. 282, text-fig. 5.5–9, pl. 5.5–II, figs. 8–10; Minikh and Minikh, 2009, p. 63, pl. 1, figs. 8–10.

Holotype. PIN, no. 5784/11 (previously, MGU, no. PR 203/1-2), scale of the area “B”; Orenburg Region, Sorochinsky District, Pronkino locality; Upper Permian (Tatarian), Vyatkian Stage, Kutuluk Formation.

Description (modified after Esin and Mashin, 1996). Scales are elongated-rhombic in shape. The surface is up to 1/3 scale (areas “A” and “B”). On scales from some areas (“A,” “B,” “C”) it stretches as a thin band also along upper margin of scale. There are distinct imprints of a blood vessel network on the surface. The surface of the free field is strongly dissected by more or less wide grooves, covered by numerous pores, and is actually represented only by twisting small ridges, the posterior ends of which are free or merge in pairs on the main diagonal of the scale. These ridges begin both at anterior margin of the free field, and at upper margin of scale. They are triangle or rounded-triangular in cross-section. Thin ridges of the 2nd order are usually observed on the surface of ridges. The peg and socket are usually small or absent. The anterior margin is straight. The anteroventral corner of the scales in the anterior part of the body is slightly oblique. The keel is flat and poorly defined.

Measurements. The holotype (isolated scale) is 1.7 cm long and 1.3 cm high. It is difficult to reconstruct the size of the whole fish. However, by comparison with the similar species *B. jenseni*, the complete skeletons of which have been found, a total body length of *B. tataricus* can be estimated at about 1 m.

Comparison. *B. tataricus* differs from *B. jenseni* Aldinger in the wider depressed field and also in the arrangement and orientation of the small ridges. These ridges in *B. tataricus* are directed from the anterior and upper margin of the free field to the posterior lower corner of the scale, often merging at a line of the main diagonal, and the grooves between the ridges are wider.

Occurrence. Upper Severodvinian Substage of the Severodvinian Stage and the entire Vyatkian Stage of the Upper Permian (Tatarian); East European Platform.

Material. Apart from the holotype, the MGU specimens, nos. PR 203/1-1, as well as from 203/1-3 to 203/1-29, inclusive were transferred to the PIN collection and received the PIN numbers, nos. 5784/12–

5784/39, respectively; all specimens are from the type locality.

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CONFLICT OF INTEREST

The author declares that he has no conflict of interest.

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