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Thelodont scales from the Lower Devonian of Novaya Zemlya Archipelago, Arctic Russia

Escamas de telodontos del Devónico Inferior del Archipiélago Novaya Zemlya, Rusia ártica

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Abstract: Scales of a new thelodont species, *Amaltheolepis terranovi* sp. nov., are described from the upper Emsian, Lower Devonian Shevchenkinskaya Formation of Novaya Zemlya, Arctic Russia. The new species shows strong resemblance with the Emsian "Verdalen assemblage" from Spitsbergen, supporting an Emsian age for the upper part of the Shevchenkinskaya Formation. This conclusion in the context of the various *Amaltheolepis* assemblages from Spitsbergen, allows for a more accurate comparison and correlation between assemblages from different regions in the Northern Hemisphere, suggesting that the type species, *Amaltheolepis winsnesi* from Spitsbergen, is Eifelian in age.

Resumen: Se describen escamas de una nueva especie de telodonto, *Amaltheolepis terranovi* sp. nov., de finales del Devónico Inferior de la Formación Shevchenkinskaya de Novaya Zemlya, Ártico Ruso. La nueva especie muestra un gran parecido con la "asociación Verdalen" del Emsiense de Spitsbergen, lo que confirma su edad Emsiense para la parte superior de la Shevchenkinskaya. Esta conclusión, en el contexto de la asociación de *Amaltheolepis* de Spitsbergen, permite una comparación y correlación más precisas entre las asociaciones de diferentes regiones del hemisferio norte, lo que sugiere que la especie tipo, *Amaltheolepis winsnesi* de Spitsbergen, es de edad Eifeliense.

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Palabras-clave:
Escamas de Telodontos, Sistemática, Correlación, Devónico, Emsiense, Novaya Zemlya

INTRODUCTION

The Emsian and Eifelian thelodont record is globally quite rare in comparison with older strata in the Devonian and the biostratigraphically well explored distribution in the Silurian. Only a handful of taxa from the Northern and Southern Hemispheres have been documented since Ørvig (1957) described the first *Amaltheolepis winsnesi* scales from Sörkapp Land, Spitsbergen as Thelodontida gen. et sp. indet. (Märss *et al*., 2007; Žigaitė *et al*., 2013; Hairapetian *et al*., 2016). Building on Ørvig's pioneering study, Žigaitė *et al*. (2013) described several species from the Lower and Middle Devonian Andrée Land Group, Spitsbergen, based on numerous assemblages considered to represent different depositional phases and stratigraphic levels. The study called for a comparison with similar faunas from other regions of the Northern Hemisphere. The addition to the Lower Devonian comparison between the Red Bay Group of Spitsbergen and sections of similar age from other parts of the Northern Hemisphere (Blom & Goujet, 2002) motivated further elaborations of suggested biozonal subdivision of the Lower Devonian, as presented by Talimaa (2000) based on the distribution data from northern Eurasia. For the Southern Hemisphere, or more specifically Gondwana, the biostratigraphical utility of thelodonts is even less elaborate, as the remains are rare and the few known faunas differ substantially from those of the Northern Hemisphere. The more elaborate temporal and spatial patterns of distribution presented by Hairapetian *et al*. (2016) will nevertheless provide a foundation for further work, but not until the thelodont record from Gondwana is improved considerably.

Although the record of thelodonts from the Russian Arctic is fairly good for the Silurian and lowermost Devonian, it is more limited for the Emsian and Eifelian (Talimaa, 2000; Karatajūtė-Talimaa & Märss, 2002; Märss & Karatajūtė-Talimaa, 2002). Most of these rare isolated thelodont scales were reported as belonging to the genus *Amaltheolepis* Ørvig, 1969a and are among the youngest found in the Northern Hemisphere (Karatajūtė-Talimaa, 1978; Talimaa, 1995, 2000; Märss *et al*., 2007). The full taxonomical context of these assemblages and other closely associated faunas from the Russian part of northern Eurasia has so far not been fully explored, but it has been suggested that the number of taxa is much higher than previously described (Karatajūtė-Talimaa, 1978; Talimaa, 2000). With a taxonomical revision of these assemblages in the light of the work by Žigaitė *et al*. (2013) on Spitsbergen, it is now possible to build on the potential of *Amaltheolepis* and its distribution and diversity to

explore a more detailed thelodont biostratigraphy also in the upper Lower–Middle Devonian.

In this paper we describe a new *Amaltheolepis* species represented by isolated scales from an assemblage from the Lower Devonian Shevchenkinskaya Formation of Novaya Zemlya, which have previously only been reported briefly (Karatajūtė-Talimaa, 1978; Talimaa, 2000). These studies in the context of unpublished data from Lower Devonian scales of similar types from the arctic regions of the Pechora Syncline and Circumpolar Urals (Karatajūtė-Talimaa & Tsyganko, 1997; Talimaa, 2000) and Canadian Arctic (Vieth, 1980), will be discussed in the context of biostratigraphy and global correlation in the Devonian.

GEOLOGICAL SETTING

The stratigraphical framework for this study lies within the Devonian succession of Novaya Zemlya. Except for the limited number of studied outcrops in the northern part, the best studied exposures are concentrated in the southern part of the Novaya Zemlya Archipelago (Guo *et al.*, 2010). According to these authors, the Lower Devonian succession, which is represented by sediments ranging from the Lochkovian to the Emsian, comprises non-marine and near-shore marine siliciclastic sedimentary rocks that grade upwards into shallow marine platform carbonates in the north eastern part, while the north western part is dominated by shallow marine carbonates with deeper water carbonate turbidite shales, and sandstones in intervals. The sample studied herein comes from the uppermost part of the Shevchenkinskaya Formation in the Shirokaya River section at the north east of the Northern Island (at the western coast of Kara Sea). This exposure of the formation is characterised by a 685 m thick succession of mainly fine-grained dolomitic limestones interbedded with siltstones. Vertebrate fauna is present in the topmost part of the formation, which is represented by 35 meters of bioclastic limestone with abundant intersections of coral and stromatolite detritus interbedded with argillaceous limestones (Platonov, 1991). The age of the formation ranges from the middle Pragian to the Emsian, with the late date supported by the late Emsian conodont *Polygnathus serotinus* (Platonov, 1991; Guo *et al.*, 2010).

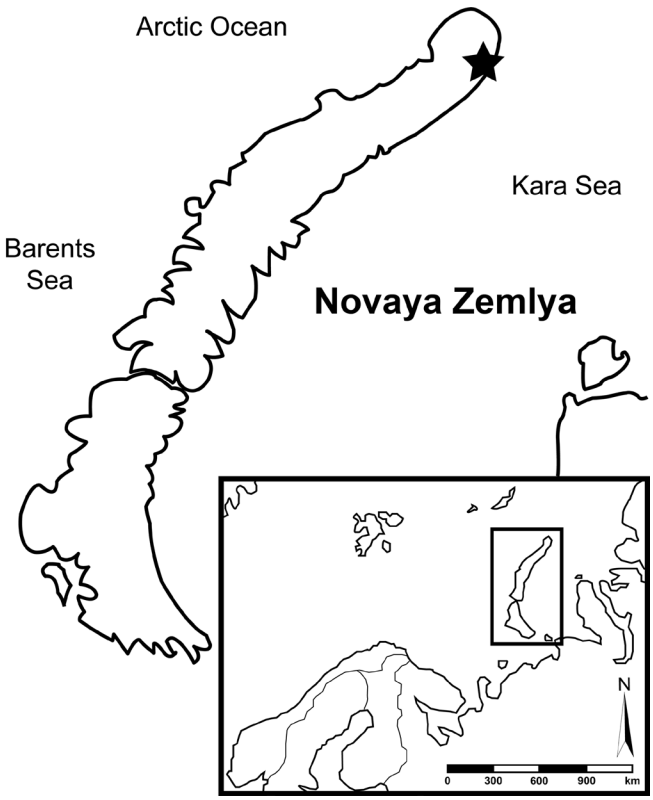

Figure 1. Schematic map of northern Europe with the position of Novaya Zemlya Archipelago, and the general location of the studied sample from the Shevchenkinskaya Formation.

MATERIAL AND METHODS

The present study includes thelodonts from one sample, 1617-4a, collected in 1989 from the Shevchenkinskaya Formation on the north east part of the Northern Island of Novaya Zemlya Archipelago, Arctic Russia (Fig. 1). This material was presented to us by one of the authors, the late Valentina Karatajūtė-Talimaa (07.12.1930-02.08.2022), and is here referred to by the collection number prefix of its home institution Institute of Geology of Lithuania, Vilnius (**LIG**). The thelodonts have been extracted by mechanical preparation and when appropriate by acetic acid preparation. Scanning electron microscopy (**SEM**) work on gold-coated specimens was completed at Uppsala University.

SYSTEMATIC PALAEONTOLOGY

Subclass THELODONTI Jaekel, 1911
Order THELODONTIFORMES Kiær & Heintz, 1932
Family TURINIIDAE Obruchev, 1964

Genus *Amaltheolepis* Ørvig, 1969a

Type-species. *Amaltheolepis winsnesi* Ørvig, 1969a. Early to Middle Devonian, Spitsbergen.

Diagnosis. Large elongate scales (1.5–3.0 mm long) with narrow sharp pointing elongated spine-, horn- or trumpet-like, tricuspid or leaf-like crown; crown flat or rising at a steep angle with distinct sharp-ribbed ornament on the crown surface, particularly the anterior part; neck shallow and constricted; base is small, anteriorly displaced, elliptical and rounded; pulp opening single and centrally placed; dentine tubules narrow, long but not straight, slightly and very gradually expanding towards the pulp opening (modified from Žigaitė *et al.*, 2013).

Remarks. Beside the new species and type species *Amaltheolepis winsnesi* Ørvig, 1969a, the genus also includes *A. montiwatsoni* Žigaitė *et al.*, 2013, *A. austfjordi* Žigaitė *et al.*, 2013, *A. bystrovi* Karatajūtė-Talimaa, 1978, and possibly *A.*? *baltica* Karatajūtė-Talimaa, 1978.

Amaltheolepis terranovi sp. nov.

Figure 2

Derivatio nominis. After *Novaya Zemlya* which means *New Land* and translates to *Terra nova* in Latin.

Holotype. LIG 20N-0019, postpectoral scale in crown view (Fig. 2S), from sample 1617-4a.

Type locality. Sample 1617-4a from the Shirokaya River section, Northern Island of Novaya Zemlya Archipelago, Arctic Russia.

Type horizon. Shevchenkinskaya Formation, upper Emsian, Lower Devonian, *Polygnathus serotinus* Zone.

Material. A few hundreds of scales from sample 1617-4a from the Shevchenkinskaya Formation, Novaya Zemlya Archipelago, Arctic Russia.

Diagnosis. Medium sized scales (0.5–1.5 mm), moderately elongated in general; crown elongated with distinct flat wedge-shaped median crown area and prominent lateral areas; sculpture weakly pronounced with few short ridges in the anterior part; base low, round or oval and distinctly broader than crown.

Description. The assemblage is characterised by, for the genus, rather small scales (rarely larger than 1 mm), and moderately narrow outline with some spiny, horn-like or tricuspid crowns. The ribbed ornament covers most of the crown. The neck is very shallow. The base is usually round or elliptical and displaced anteriorly, with a very large single pulp opening. The scales are generally well preserved, but they are heavily altered which prevents histological studies.

Head scales (Fig. 2A–2F) are small and oval, with a crown that extends very little outside the base of the scale. The relatively low crowns vary from triangular to more oval and elongated in shape. The more triangular crowns are characterized by a more pronounced sculpture of sharp ridges that merge at the posterior point of the crown (Fig. 2A, 2D), while the sculpture is much less pronounced or lacking in the more oval crowns (Fig. 2C, 2E, 2F). The neck is distinct, but low, as the basal part of the crown is markedly narrower than the base of the scales.

Cephalo-pectoral scales (Fig. 2G–2L) are small to medium in size (0.5–1.0 mm) with slightly elevated and curved crown with few longitudinal ridges. The lateral areas, on each side of the median crown area, are flat, smooth and wing-like, forming a more or less tricuspid posterior part of the crown. The ridged sculpture is restricted to the anterior part of the median crown area. The oval base is slightly broader than the crown and has a posteriorly displaced pulp opening.

Postpectoral scales (Fig. 2M–2S) are the largest, but still only small to medium sized (0.7–1.5 mm), with a proportionally short crown. The sculpture of the crown varies, probably depending on if the scales are on the dorsal or ventral side of the body. An elevated crown without distinct median crown area characterizes one type, in which the ridges are sharp and pronounced. More diagnostic is the type with a wedge-shaped, flat and smooth median crown area, with fine ridges only in the anterior part. The round base is slightly broader than the crown which extends only slightly posteriorly.

Precaudal and pinnal scales (Fig. 2T–2AF) are very similar and differ only by their size. They are wedge-shaped, elongated, with a distinct and flat wedge-shaped median crown area and pronounced lateral areas. Short fine ribs are weakly discernible in the most anterior part of the median crown area. Some additional ribs are also sometimes visible below or lateral to the main lateral areas. The base is distinctly broader and shorter than the crown, resulting in a clear rim-like base area.

Observations. Although most similar to the type species *A. winsnesi, A. terranovi* sp. nov. differs by being generally smaller, having generally shorter ribs on the anterior part of the median crown area and less pronounced lateral areas. The general outline is also more robust, with a proportionally larger base. This character is comparable to *A. montiwatsoni*, but that species is otherwise very different with its bulgy crown with very strong ribs and no distinct median crown area. Some scale types do overlap with other known species of *Amaltheolepis*, but *A. austfjordi* has narrower scales that often are higher and with a stronger angle on the downwardly inclining anterior part of the crown. *A. bystrovi* differs from this new species by its much more pronounced ribs on the crown.

Geographical and stratigraphic distribution. Upper Emsian, Lower Devonian, Shevchenkinskaya Formation, Northern Island of Novaya Zemlya Archipelago, Arctic Russia.

DISCUSSION

The analysis of the *Amaltheolepis* assemblage from Novaya Zemlya and the establishment of a new species, despite some similarity with the type species *Amaltheolepis winsnesi*, not only provides an updated taxonomical framework for the genus, but also calls for a discussion on spatial and temporal distribution of the genus in the Northern Hemisphere.

The first record of the Novaya Zemlya assemblage refers to the thelodont *Amaltheolepis bystrovi* along with three acanthodian species, *Watsonacanthus oervigi*, *Acanthodes*? sp. C and *Cheiracanthoides comptus*, as well as the osteostracan *Moelleritia egorovi* and several conodont taxa (Platonov, 1991). The type material of *A. bystrovi* from the Pioneer Island, Severnaya Zemlya Archipelago, Russia, shows a similar distribution by being broadly late Emsian in age and from Arctic Russia, which may explain the initial assignment by Platonov (1991). However, Talimaa (1995, 2000) soon noticed a morphological difference between the Novaya Zemlya and Severnaya Zemlya assemblages, which is concluded in the present study.

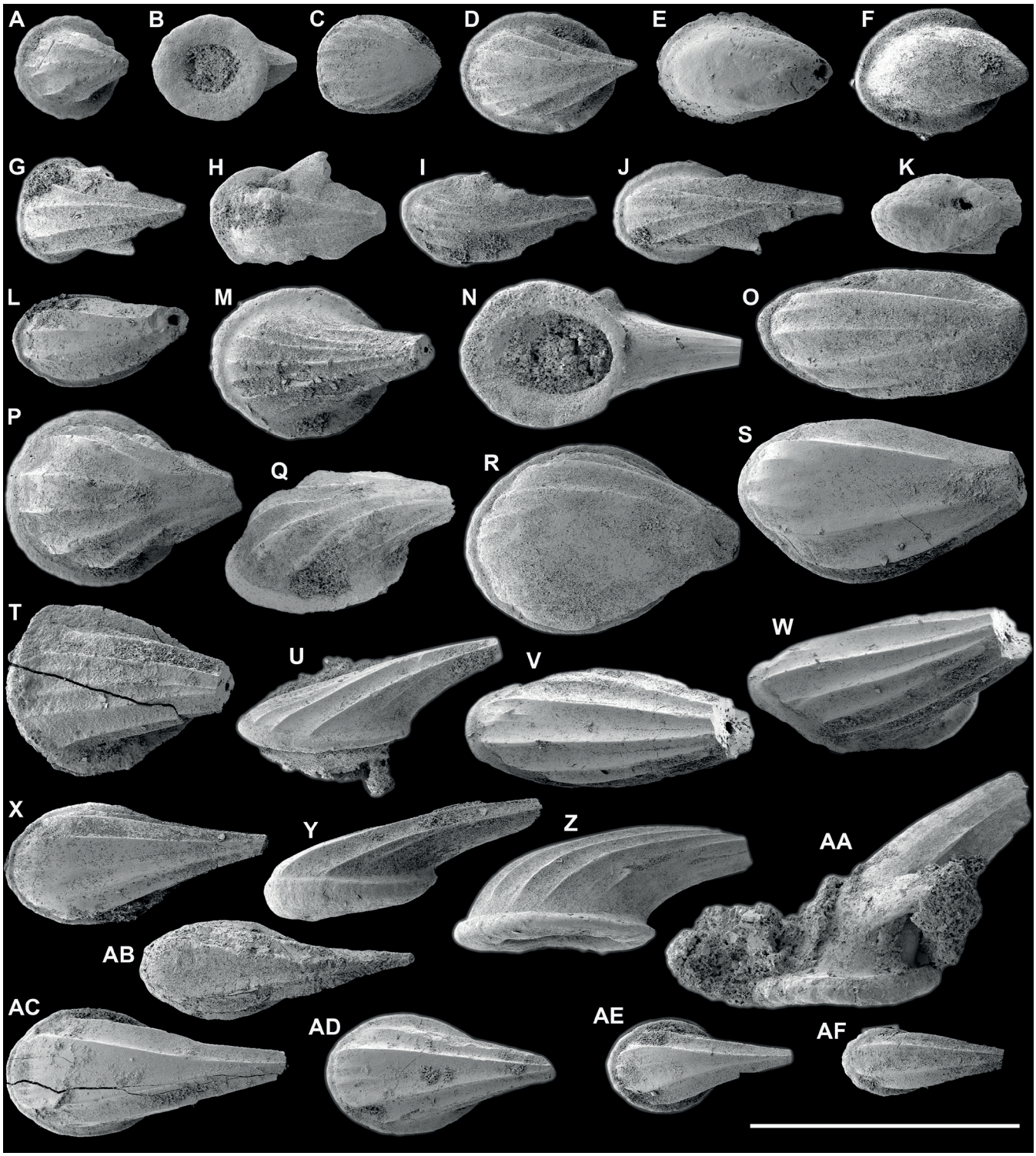

Figure 2. *Amaltheolepis terranovi* sp. nov., SEM photograph. **A**–**F,** Head scales; **G**–**L,** cephalo-pectoral scales; **M**–**S,** post-pectoral scales; **T**–**AF,** precaudal scales and/or pinnal scale; **A,** LIG 20N-0001, crown view; **B,** LIG 20N-0002, basal view; **C,** LIG 20N-0003, crown view; **D,** LIG 20N-0004, crown view; **E,** LIG 20N-0005, crown view; **F,** LIG 20N-0006, crown view; **G,** LIG 20N-0007, crown view; **H,** LIG 20N-0008, crown view**; I,** LIG 20N-0009, crown view: **J,** LIG 20N-0010, crown view; **K,** LIG 20N-0011, basal view; **L,** LIG 20N-00012, crown view; **M,** LIG 20N-0013, crown view; **N,** LIG 20N-0014, basal view; **O,** LIG 20N-0015, crown view; **P,** LIG 20N-0016, crown view; **Q,** LIG 20N-0017, oblique crown view; **R,** LIG 20N-00018, crown view; **S,** LIG 20N-0019, crown view; **T,** LIG 20N-0020, crown view; **U,** LIG 20N-0021, lateral view; **V,** LIG 20N-0022, crown view; **W,** LIG 20N-0023, oblique crown view; **X,** LIG 20N-0024, crown view; **Y,** LIG 20N-0025, lateral view; **Z,** LIG 20N-0026, lateral view; **AA,** LIG 20N-0027, lateral view; **AB,** LIG 20N-0028, crown view; **AC,** LIG 20N-0029, crown view; **AD,** LIG 20N-0030, crown view; **AE,** LIG 20N-0031, crown view; **AF,** LIG 20N-0032, crown view. All scales are from the Shevchenkinskaya Formation rocks cropping out in the locality on the north-east of the Northern Island of Novaya Zemlya Archipelago, Arctic Russia (see Fig. 1); scale bar = 1 mm.

Žigaitė *et al*. (2013), in their taxonomical review of *Amaltheolepis*, established two new species, *A*. *montiwatsoni* and *A*. *austfjordi*, and suggested that they may represent different biozones. The distribution of the type species *A*. *winsnesi*, however, is more problematic and Žigaitė *et al*. (2013) stated that the biostratigraphical utility of the type species needs to be revisited in the light of a broader Circum-Arctic context. With the introduction of the Novaya Zemlya assemblage, it is now possible to suggest a possible taxonomic explanation and stratigraphical resolution for the problematic and disparate assemblages previously assigned to *A*. *winsnesi*.

The stratigraphical control of the type assemblage of *A*. *winsnesi* from the north side of the nunatak Røykensåta on Sörkapp Land, Spitsbergen is poor, and the temporal range of all the other assemblages assigned to this species is unclear. Therefore, the temporal distribution of the type species has not been very well defined (Žigaitė *et al*., 2013). The strong morphological resemblance between the type material from Sörkapp land and the *A*. *winsnesi* assemblage from the Tavlefjellet member (Žigaitė *et al*., 2013), suggest these are indeed the same species, which open up a possibility that these also should have a similar stratigraphical distribution. Since the Tavelfjellet assemblage has a better controlled temporal affinity it is reasonable to suggest that the poorly controlled Sörkapp Land type assemblage also is middle Eifelian in age (Fig. 3).

The "Skamdalen assemblage" of Ørvig (1969b), which should be assigned to the slightly older Skamdalen member in Spitsbergen, is with its more extreme horn-like triscuspid end and distinct lateral extensions (Žigaitė *et al*., 2013; fig. 6D) loosely assigned to the type species, may be left in open nomenclature. A third assemblage was also illustrated by Ørvig (1969a) and is referred to its association with the potentially older (Emsian) Verdalen member. This assemblage now seems more similar to the new species from Novaya Zemlya, which is concluded to be Emsian in age by the conodont *Polygnathus serotinus* in the upper part of the formation (Guo *et al*., 2010). This affinity is thereby also supported by an upper Emsian correlation between the Verdalen assemblage and the Novaya Zemlya assemblage. However, this biostratigraphical conclusion is further complicated by the fact that the Skamdalen member has been considered, at least partly, a lateral equivalent of the Verdalen member (Blieck *et al*., 1987). Further exploration is needed for other known *Amaltheolepis* assemblages (Fig. 3) in order to get a broader understanding of the spatial and temporal distribution of this genus.

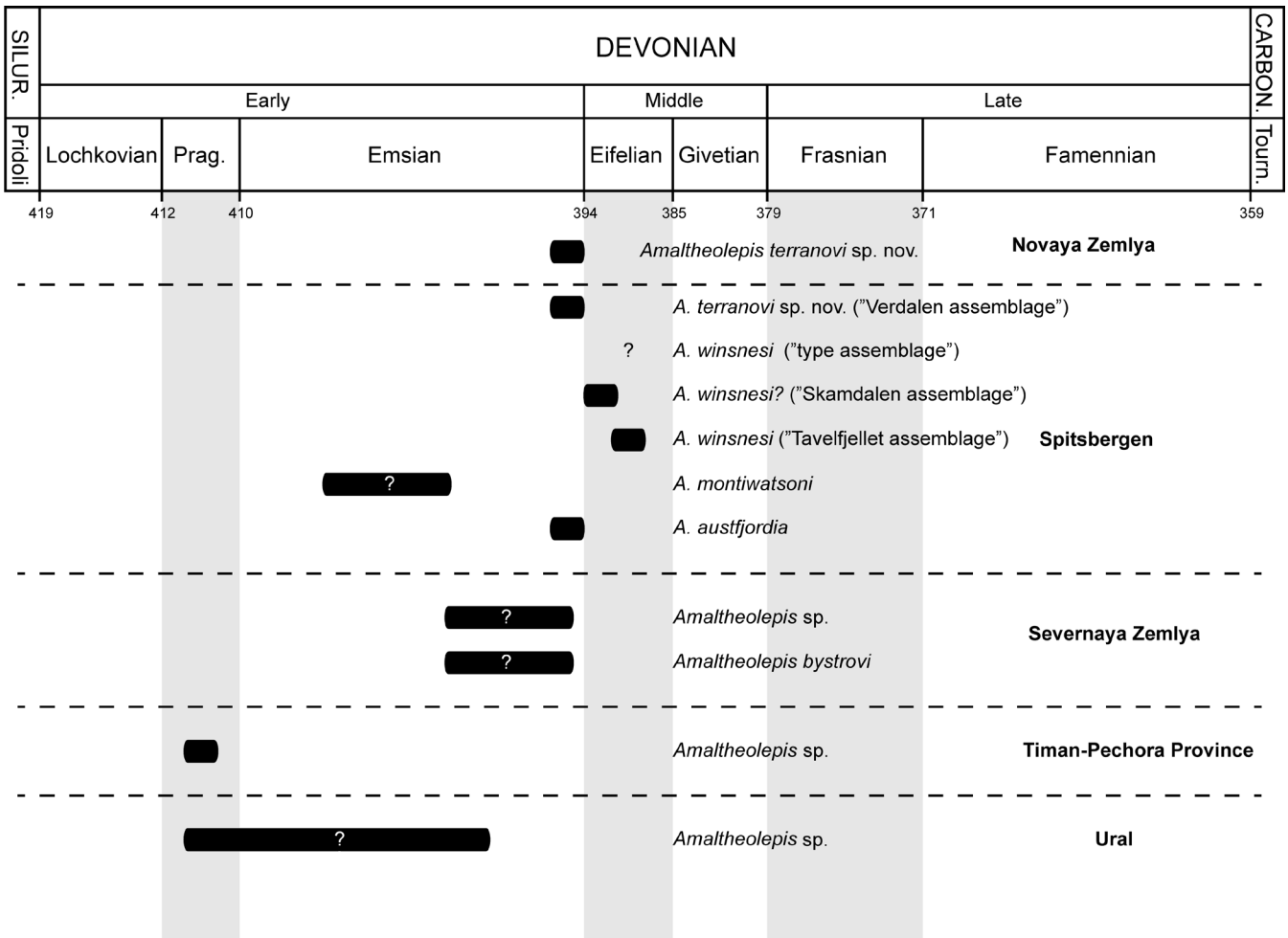

Figure 3. Stratigraphical ranges of all species and major assemblages of *Amaltheolepis* from the Northern Hemisphere.

CONCLUSIONS

The description of the new species, *Amaltheolepis terranovi* sp. nov., from the Shevchenkinskaya Formation of Novaya Zemlya Archipelago improves our understanding of the temporal and spatial distribution of the genus considerably.

The new species appears to be the same as the *Amaltheolepis* scales from the assemblage studied from the Emsian Verdalen Member from Spitsbergen, supporting the previously suggested Emsian age for the upper part of the Shevchenkinskaya Formation. This concluded affinity also puts some light on the other quite problematic assemblages from Spitsbergen, suggesting that the type species, *Amaltheolepis winsnesi*, is Eifelian in age.

Supplementary information. The new taxonomic name proposed in this paper, and the nomenclatural acts it contains, has been registered in ZooBank, the online registration system for the ICZN: https://zoobank.org/references/73e4bd08-5a3b-4a05-a775-6ae626e3b337

Author contributions. HB, conceptualization, project administration, investigation, visualization and writing original draft; VV, data acquisition, visualization, writing review and editing; VKT, conceptualization and specimen acquisition; ZZ, conceptualization, writing review and editing.

Competing Interest. We declare no competing interests.

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