



## FIRST RECORD OF THE STEM AMNIOTE *DISCOSAURISCUS* (SEYMOURIAMORPHA, DISCOSAURISCIDAE) FROM THE KRKONOŠE PIEDMONT BASIN (THE CZECH REPUBLIC)

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**Abstract:** The first record of the seymouriamorph stem amniote *Discosauriscus* from the Krkonoše Piedmont Basin (the Czech Republic) is described. The specimen is identified as *D. pulcherrimus* on the basis of the following features which are absent in *D. austriacus*: 1) the pointed tip of the ventrolateral process of the postorbital lies anteriorly to the tip of the wedge-shaped dorsomedial process of the jugal; and 2) the rows of small denticles diverge anteromedially and anterolaterally from the mid-width of the ventral surface of the palatal ramus of the pterygoid. This new record increases our knowledge of the occurrence of this seymouriamorph in the Permo-Carboniferous basins of Europe.

**Key words:** Seymouriamorpha, Discosauriscidae, skeleton, lower Permian, the Czech Republic

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### Introduction

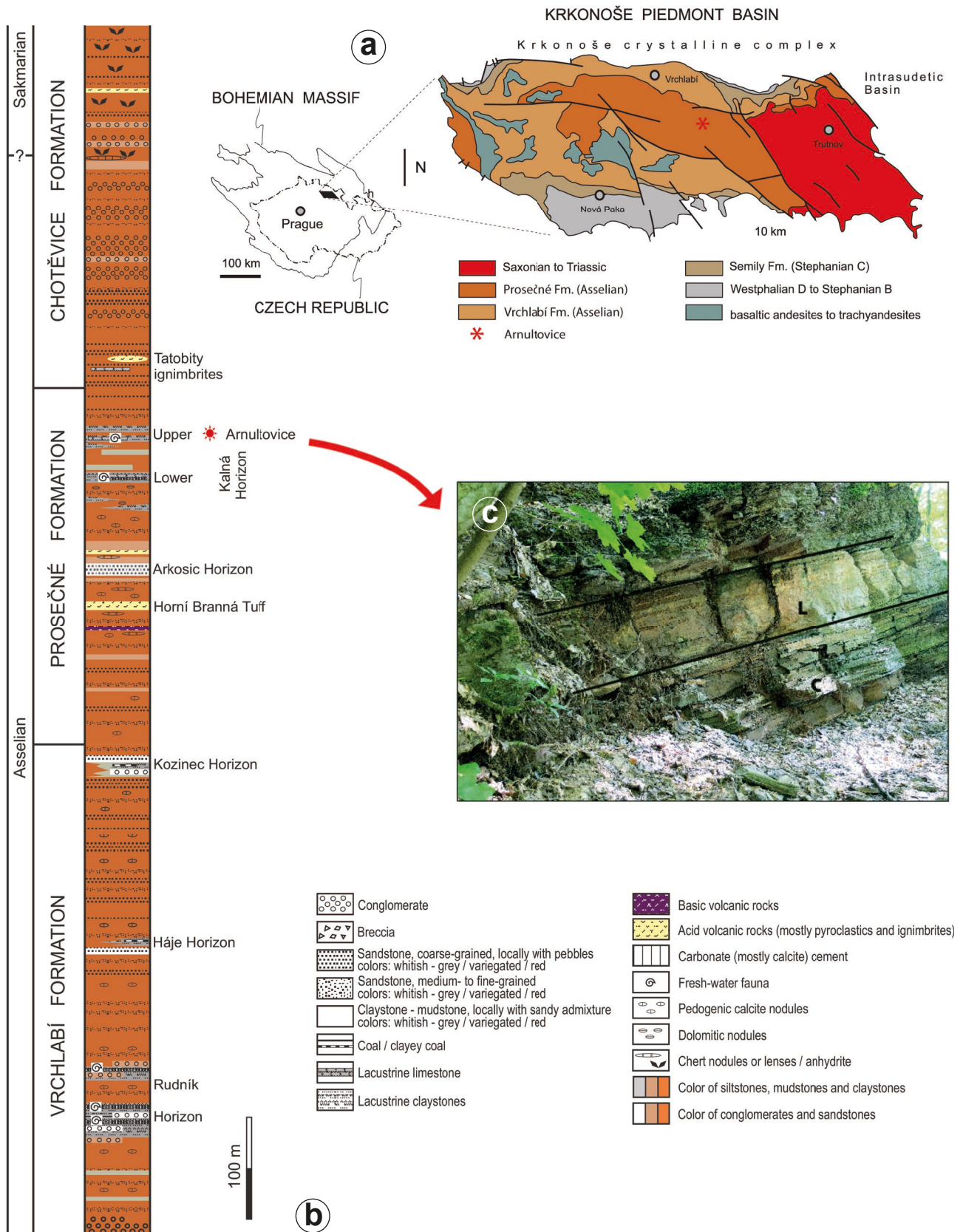
The Krkonoše Piedmont Basin belongs to the Permo-Carboniferous freshwater basins of the Bohemian Massif. The late Carboniferous and early Permian sediments contain several fossiliferous horizons with rich findings of vertebrate fauna. Fish vertebrates such as chondrichthyans, acanthodians and actinopterygians are the most abundant. Amphibians also occur in some localities and most abundant are branchiosaurids, while archegosaurids and stereospondylomorphs are unique. A new discovery of the seymouriamorph tetrapod *Discosauriscus pulcherrimus* (FRITSCH, 1880) from the lower Permian of the Krkonoše Piedmont Basin significantly complements the composition of tetrapods in the basin and is of great importance for biostratigraphic correlation of the Permian sediments (Text-figs 1, 2a).

The stem amniote *Discosauriscus pulcherrimus* was first described by Fritsch (1880) from the lower Permian locality Ruprechtice (Ruppersdorf) in the Intrasudetic Basin (north Bohemia, the Czech Republic), Ruprechtice horizon, zone 5 – upper Autunian (sensu Werneburg 1989). Later, *D. pulcherrimus* was described from several other

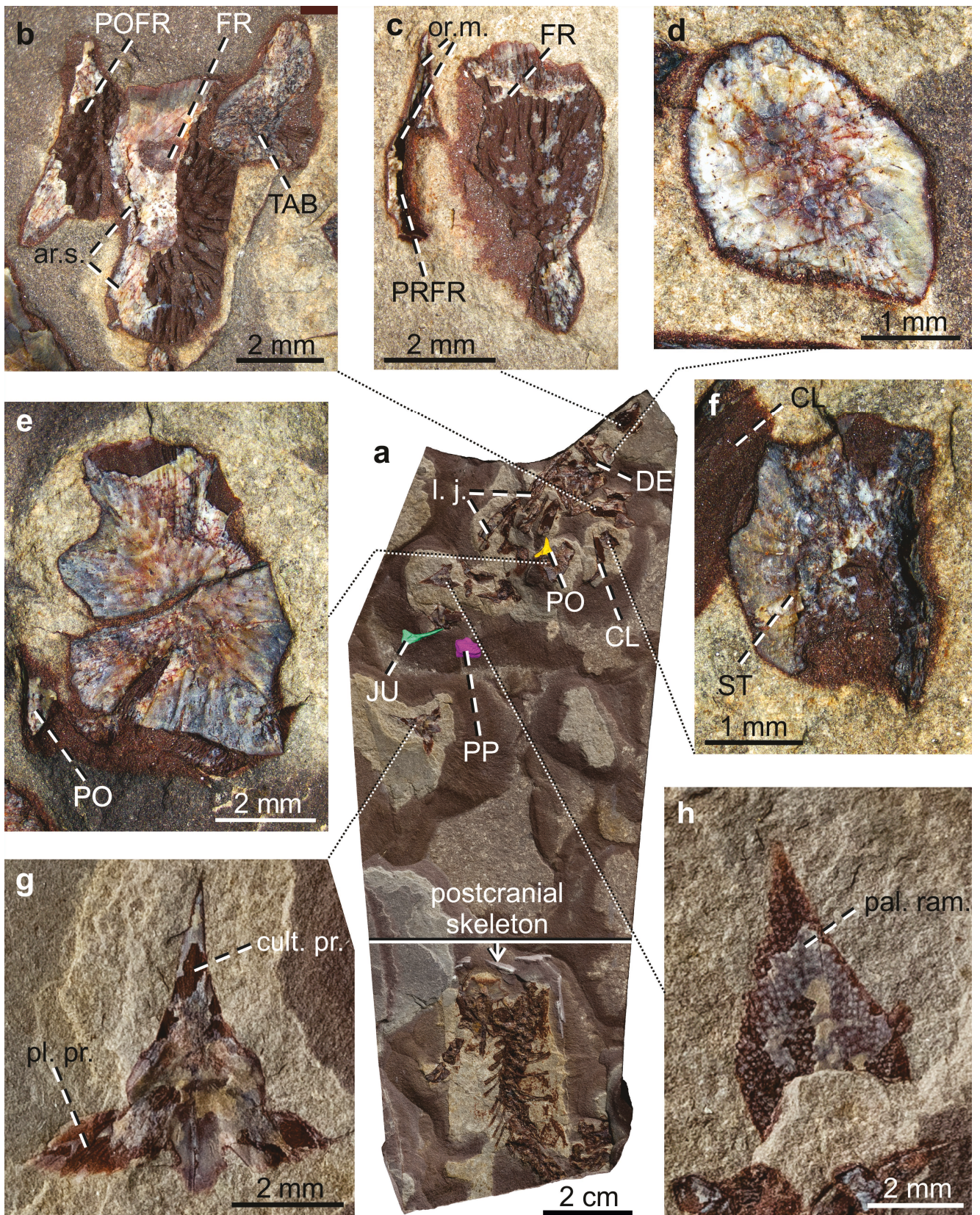
localities in the Czech Republic (Boskovice Basin: e.g., Klembara 1997, Klembara and Mikudíková 2019), Poland (Intrasudetic Basin: Werneburg and Kiersnowski 1996), Germany (Döhlen Basin, Saale Basin, Saar-Nahe Basin: Werneburg 1985, 1988, 1989, Boy 2007), and probably also from France (Autun, Sarre-Lorraine/Palatinat and Bourbon l'Archanbault Basins: Heyler 1969, Werneburg 1989). The specimen of *D. pulcherrimus* described here is the first record of this seymouriamorph from the Krkonoše Piedmont Basin.

### Materials and methods

The specimen of *Discosauriscus pulcherrimus*, G 151, is deposited in the Museum of Eastern Bohemia, Hradec Králové, the Czech Republic. It consists of the disarticulated skull and postcranial bones (Text-fig. 2a). Several skull bones and pelvic girdle elements are missing, and several skeletal elements are damaged. The skeletal elements are accumulated on two areas of the slab surface and are more-or-less embedded in the sediment. We suppose that all the bones represent one specimen. The length of the medial



**Text-fig. 1. a:** simplified geological map of the Krkonoše Piedmont Basin with position of the locality in Arnultovice (see asterisk; coordinates 50° 33' 58.599" N; 15° 43' 18.873" E). After Blecha et al. (1997). **b:** position of the finding locality Arnultovice "Track in ravine on the edge of the forest" in idealised section of the Permian sediments of the Krkonoše Piedmont Basin. Locality Arnultovice and dating of overlying ignimbrites in Tatobity are indicated. After Opluštil et al. (2016), based on data in Prouza and Tásler (2001), modified here. **c:** detail of the outcrop "Track in ravine on the edge of the forest" near Arnultovice with 40–50 cm thick massive badly cleavable pinkish dolomitic limestone (L) and laminated calcareous claystone (C) with fauna.



Text-fig. 2. *Discosaurus pulcherrimus* (FRITSCH, 1880). a: specimen G 151, cranial and postcranial skeleton (for details of postcranial skeleton, see Text-fig. 4) with highlighted virtual 3D models of postparietal and jugal (cf. Text-fig. 3c, d and 3e, f) originally embedded in sediment, b: frontal, c: frontal and prefrontal, d: intertemporal, e: parietal and postorbital, f: supratemporal and clavicle, g: parasphenoid, h: pterygoid. Abbreviations: ar.s. – articulating surface, CL – clavicle, cult. pr. – cultriform process, DE – dentary, FR – frontal, IT – intertemporal, JU – jugal, l. j. – lower jaw, or.m. – orbital margin, pal. ram. – palatal ramus, pl. pr. – posterolateral process, PO – postorbital, POFR – postfrontal, PP – postparietal, PRFR – prefrontal, ST – supratemporal, TAB – tabular.

margins of the frontal, parietal and postparietal is about 15 mm; the nasal and premaxilla are not preserved. The length of the skull may be estimated to be about 20 mm. It means that the specimen represents a larval ontogenetic stage (Klembara 1995, 2009).

We used high-resolution X-ray microcomputed tomography to access the most detailed anatomy of the individual bones, as well as to locate bones or parts of bones embedded in the sediment. The scan of *Discosauriscus pulcherrimus* was performed using X-ray micro CT tomography system Nanotom 180 (GE Phoenix). The X-ray tube was fitted with a tungsten target, microfocusing mode M0 was used, and no filtering was applied for outgoing X-ray radiation. Accelerating voltage was set to  $U = 160$  kV, beam current to  $I = 100$   $\mu$ A, and in total 1,800 X-ray projections were recorded. The detector timing was set to 750 ms, no binning was used ( $1 \times 1$ ), and the voxel size was 32  $\mu$ m. The 3D volume reconstruction was done using Phoenix Datos|x CT software utilising the Feldkamp filtered back-projection algorithm. The 3D volume data sets were filtered, rendered, and segmented using VGStudio MAX 2.1 software package and AVISO 8.1 software. For the volume data rendering (2D projection of 3D volume data), the isosurface rendering algorithm was applied. For the segmentation of volume data, the region growing method was mostly used along with opening/closing and erosion/dilation image processing techniques.

## Geological setting

The Krkonoše Piedmont Basin occupies the north-eastern region of the Bohemian Massif (Text-fig. 1a). It belongs to a system of intramontaneous basins which were formed in the early postorogenic phase during the Westphalian and Saxonian times (Martínek et al. 2006). Maximum thickness of the volcano-sedimentary fill in the central part of the basin is nearly 1,800 m and the area of the basin is more than 1,100 km<sup>2</sup>. The basin fill consists of continental sediments discontinuously deposited from Westphalian D (Moscovian) to the earliest Triassic.

Early Permian filling is formed by Vrchlabí Formation (Asselian), Prosečné Formation (Asselian or Sakmarian) and Chotěvice Formation (Asselian – Sakmarian or Sakmarian – Artinskian) (Prouza and Tásler 2001, Opluštil et al. 2016, Schneider et al. 2019). The upper part of the Prosečné Formation contains significant fossiliferous beds which are defined as the Kalná Horizon (Tásler et al. 1981) or Kalná Lake sediments (Blecha et al. 1999). The Kalná Lake extends the area by about 60 km<sup>2</sup> as documented by present outcrops, but the original extent of the lake was much larger. The Kalná Lake sediments are 10–20 m thick and are represented by grey or varicoloured marlstone, claystone, siltstone and limestone. The Kalná Lake sediments contain not only one fossiliferous layer, but two sets of layers which can be distinguished from each other by the presence of actinopterygians and amphibians (Štamberg 2014). Opluštil et al. (2016) used the term Upper and Lower Kalná Horizons (Text-fig. 1b) for these fossiliferous layers.

The below described skeleton of *Discosauriscus pulcherrimus* comes from the Upper Kalná Horizon,

from the village Arnultovice (3 km north of the town of Hostinné). The outcrop Arnultovice “Track in ravine on the edge of the forest” (coordinates 50° 33' 58.599" N, 15° 43' 18.873" E; Text-fig. 1c) exposes a 4 m thick set of sediments. The main layer with fossils is 90 cm thick, pinkish laminated calcareous claystone lying below the massive dolomitic limestone (Text-fig. 1c). Numerous finds of the actinopterygian fish *Paramblypterus* “Type B” (Štamberg 2014) and *Amblypterus vratislaviensis*, chondrichthyan *Xenacanthus decheni*, minute branchiosaurid amphibians, large stereospondylomorph amphibian, and a new seymouriamorph stem amniote described here form the taxonomic composition of the fauna from the locality in Arnultovice.

## Systematic palaeontology

**Order Seymouriamorpha** WATSON, 1917

**Family Discosauriscidae** ROMER, 1947

**Genus *Discosauriscus*** KUHN, 1933

***Discosauriscus pulcherrimus*** (FRITSCH, 1880)

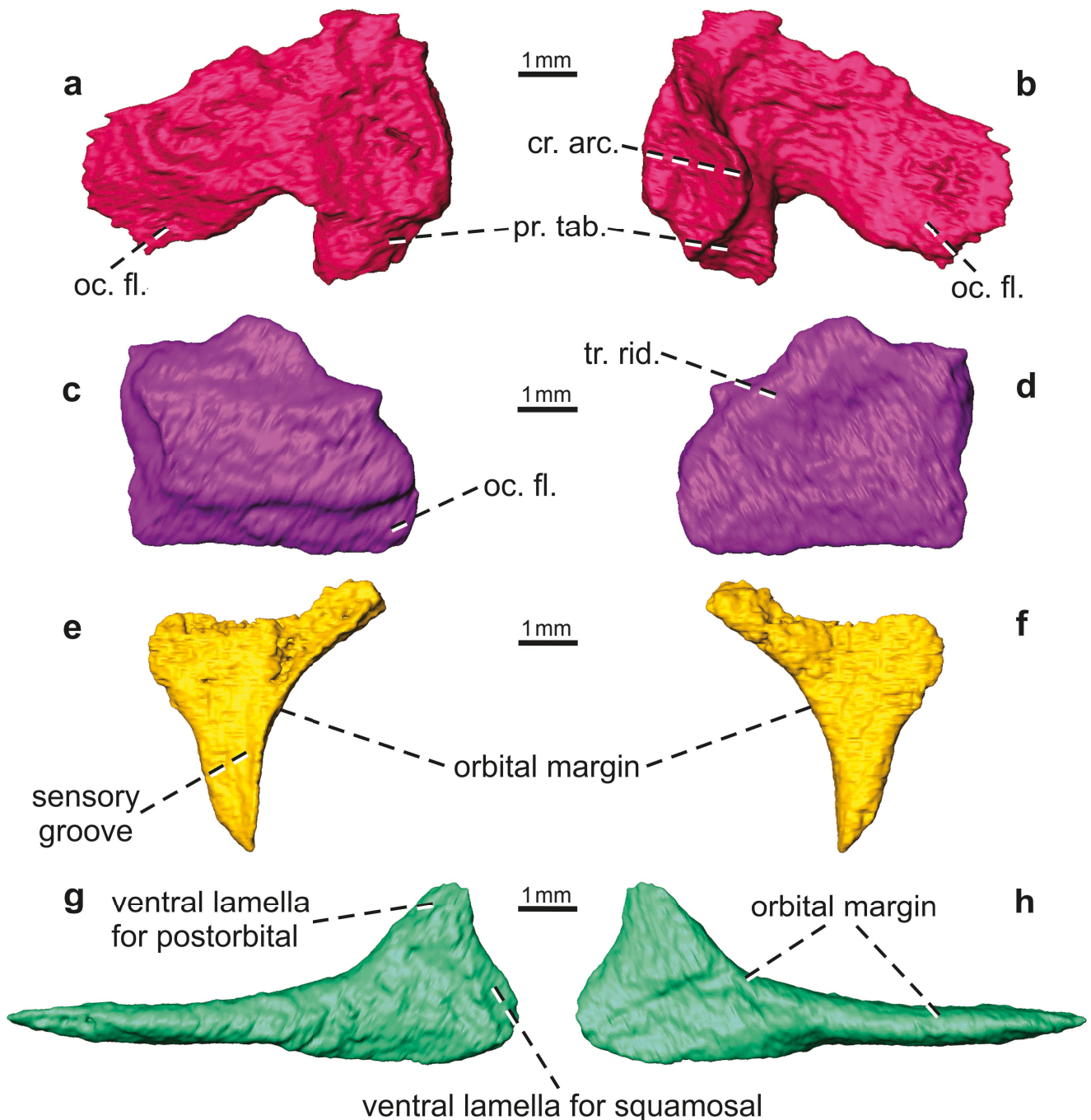
**Diagnosis.** *Discosauriscus pulcherrimus* is characterized by three diagnostic features: 1) the posterior ramus of the prefrontal is anteroposteriorly shorter than the anterior ramus of the postfrontal and both rami meet at the level of the anterior, middle third of the frontal length; 2) the ventrolateral ramus of the postorbital is narrow and pointed and lies anteriorly to the wedge-shaped dorsomedial ramus of the jugal; and 3) the rows of small densely arranged denticles diverge anteromedially and anterolaterally from the mid-width of the ventral surface of the palatal ramus of the pterygoid.

**Material.** G 151 – disarticulated specimen (Text-fig. 2a) deposited in the Museum of Eastern Bohemia, Hradec Králové, the Czech Republic.

**Locality and horizon.** Krkonoše Piedmont Basin (the Czech Republic), Upper Kalná Horizon, village Arnultovice (3 km north of the town of Hostinné).

**Description.** In the following description, the bones, which are identifiable and crucial for determination of the here investigated specimen, are described and figured (Text-figs 2–4).

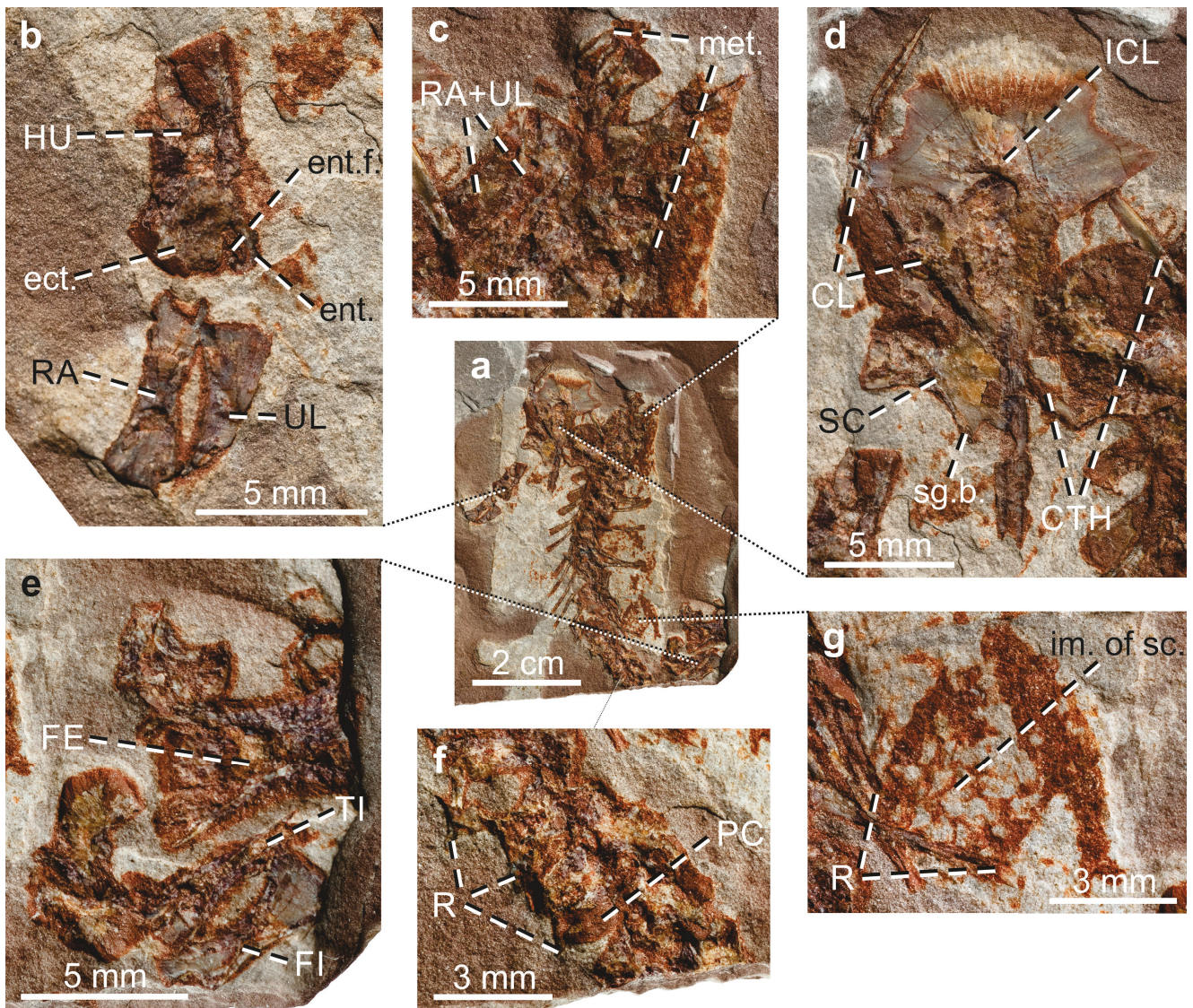
**Skull roof.** Both frontals and right postfrontal are preserved in ventral view, partially as the bones and partially as impressions of their ornamented surfaces (Text-fig. 2b, c). The ornamentation of the frontal consists of grooves and ridges radiating from the ossification centre lying at about mid-length of the bone. The ventral wall of the medial portion of the left frontal is well preserved. Its medial margin bears an anteroposteriorly long, narrow articulating surface for the ventral lamina of the right frontal (Text-fig. 2b). The medial margin of the left frontal is undulated slightly posteriorly to the mid-length of the bone. Only a small portions of the ventral wall of the right frontal are preserved (Text-fig. 2c). The posterolateral portion of the right frontal is missing, but its impression indicates that its lateral margin ran posteromedially. The medial margin of the right frontal



**Text-fig. 3.** *Discosaurus pulcherrimus* (FRITSCH, 1880), G 151. a–h: 3D virtual models of the selected dermal cranial bones; a, b: right tabular in dorsal (a) and ventral (b) views, c, d: right postparietal in dorsal (c) and ventral (d) views, e, f: right postorbital in dorsal (e) and ventral (f) views, g, h: left jugal in dorsal (g) and ventral (h) views. Abbreviations: cr. arc. – arcuate crest, oc. fl. – occipital flange, pr. tab. – tabular process, tr. rid. – transverse ridge.

is distinctly undulated and matches the undulated margin of the left frontal. The posterior two thirds of the left prefrontal with a distinct arch-like orbital margin is preserved in ventral view (Text-fig. 2c). The right intertemporal is well preserved (Text-fig. 2d). In addition to its straight lateral margin, the bone is approximately oval in shape. The ornamented surface is well preserved. Its ossification centre consists of tubercles and pits located around the central portion of the bone; from here, the ridges and grooves radiate towards the periphery of the bone. The right parietal is perfectly preserved (Text-fig. 2e). Its ornamentation consists of grooves and ridges which radiate from the ossification centre located around

the central portion of the bone. The right supratemporal is anteroposteriorly elongated and a rectangular shape (Text-fig. 2f). Its posterolateral corner extends into a distinct process. The ornamented surface is preserved only on the medial margin of the bone. The left tabular is well preserved in dorsal view (Text-fig. 2b). The right tabular was segmented and a virtual 3D model produced (Text-fig. 3a, b). In both tabulars the ornamented surfaces, smooth occipital flanges and tabular processes are well preserved. On the ventral surface of the tabular, the arcuate crest is distinctly developed (Text-fig. 3b). The right postparietal is completely preserved. Because it is completely embedded



**Text-fig. 4.** *Discosauriscus pulcherrimus* (FRITSCH, 1880), G 151. a: detail of the postcranial skeleton, b: left humerus, ulna and radius, c: right metacarpals, radius and ulna, d: pectoral girdle, e: hind limb elements, f: posteriormost presacral and sacral portion of the axial skeleton, g: imprints of scales in the posterior presacral region. Abbreviations: CL – clavicle, CTH – cleithrum, ect. – ectepicondyle, ent. – entepicondyle, ent.f. – entepicondyle foramen, FE – femur, FI – fibula, HU – humerus, ICL – interclavicle, im. of sc. – imprints of scales, met. – metacarpals, PC – pleurocentrum, sg.b. – supraglenoid buttress, R – ribs, RA – radius, RA+UL – radius and ulna, SC – scapula, TI – tibia, UL – ulna.

in the sediment, it was also digitally removed (Text-figs 2a, 3c, d). On its dorsal surface, the broad anterior and medial ventral lamellae are well preserved. Posterior to the ornamented surface, the smooth, mediolaterally elongated and anteroposteriorly short occipital flange is present. The right postorbital is well-preserved (Text-figs 2e, 3e, f). It has a well-developed, raised orbital margin. Below this margin, a shallow groove runs in a mediolateral direction. This groove probably represents a sensory groove (cf. Klembara 1994, 1995, 1996). The ventrolateral process is pointed. The medial process is more robustly constructed and has a short anteroposterior suture with the postfrontal. The posterior process is slightly mediolaterally expanded and its posterior tip rounded. However, the posterior portion of this process is not well preserved. The left jugal was digitally removed from the sediment and is completely preserved (Text-figs 2a, 3g, h). The suborbital ramus is long, narrow and anteriorly pointed; the dorsomedial ramus is much shorter and wedge-

shaped. Its anterior and posterior margins bear overlapped areas (ventral lamellae). The anterior ventral lamella was overlapped by the tip of the ventrolateral process of the postorbital. The posterior ventral lamella was overlapped by the squamosal (Text-fig. 3e, f).

**Palate.** Two palatal elements are preserved (Text-fig. 2g, h). The completely preserved parasphenoid is exposed in ventral view (Text-fig. 2g). The parasphenoidal plate extends anteriorly as a triangular, pointed wedge-like process extending anteriorly and slightly ventrally. The process lies anteriorly to the level of the anterior portions of the basiptyergoid processes. The surface of the wedge-like process bears several short rows of small denticles. The cultriform process is of triangular shape. Its broad posterior portion gradually narrows to a pointed anterior portion. The ventral surface of the posterior half of the cultriform process bears rows of small denticles radiating from its posterior portion anteriorly and laterally. The endochondral

basipterygoid processes lie at a level immediately posterior to the cultriform process. The posterolateral processes are stout and extend laterally and slightly posteriorly. The posteromedian process is rounded and bears a sharp straight median ridge.

Most of the palatal ramus of the right pterygoid is preserved (Text-fig. 2h). It shows a typical, autapomorphic feature of *Discosauriscus pulcherrimus*: the rows of small densely packed denticles diverging anteromedially and anterolaterally from mid-width of the ventral surface of the palatal ramus of the pterygoid. The rows of the denticles are straight, densely arranged and divided by narrow grooves.

**Lower jaw.** Partial dentary and several other lower jaw elements are also present, but they are fragmentary (Text-fig. 2a).

**Postcranial skeleton.** A sequence of poorly preserved anterior vertebrae is present (Text-fig. 4a). Only the crescent pleurocentra are identifiable in the posterior presacral portion of the vertebral column (Text-fig. 4f). Along the right side of the vertebral column, the ribs are well preserved. The anterior ribs are short, but more posteriorly become longer and progressively more spatulate. Still further posteriorly the ribs become progressively narrower and longer, and then again shorter (Text-fig. 4a, f).

The pectoral girdle is almost completely preserved (Text-fig. 4d). The interclavicle consists of a wide anterior plate and narrow posterior stem. The anterior portion of the stem is widened. The ventral surface of the anterior plate bears large areas for the ventral plates of the clavicles. Between these areas, the surface of the anterior plate bears radially diverging bony strips. The left (Text-fig. 2a) and right (Text-fig. 4d) clavicles are well-preserved. Their ventral plates are wide, and the ascending processes are narrow and pointed. The rod-like cleithra are slender (Text-fig. 4d). The right, crescent-shaped scapula is well-preserved (Text-fig. 4d). The supraglenoid buttress of the scapula is visible in its ventromedial portion. The scapula is of about the same length as the humerus (Text-fig. 4a). The right humerus is robustly constructed (Text-fig. 4a, b). It is possible to recognize the ectepicondyle and the entepicondyle with a large distally opened entepicondylar foramen (Text-fig. 4b). The radius and ulna are also preserved; they are slightly shorter than the humerus. The left manus is incomplete and only the metacarpals and several fragments of the proximal phalanges are recognizable (Text-fig. 4c).

The left hind limb is represented by incompletely preserved femur, tibia and fibula (Text-fig. 4e). All three elements are dorsoventrally compressed.

A small group of scales is preserved close to the pelvic girdle. The scales are small, more-or-less rounded elements (Text-fig. 4g).

**Comparisons and conclusion.** We can conclude that the specimen described here represents the species *Discosauriscus pulcherrimus*. There are two diagnostic features which allow us to assign the specimen to this species:

(1) The presence of the narrow pointed ventrolateral process of the postorbital, the tip of which lies anteriorly to the tip of the wedge-shaped dorsomedial process of the jugal. Such morphology of the postorbital and jugal

processes is typical for *D. pulcherrimus* (Klembara 1997, Klembara and Mikudíková 2019). In contrast, in *D. austriacus* (MAKOWSKY, 1876) the dorsomedial process of the jugal is anteroposteriorly broad and has an anteroposteriorly running suture with the anteroposteriorly broad ventrolateral process of the postorbital (Klembara 1997).

(2) The rows of small denticles diverge anteromedially and anterolaterally from the mid-width of the ventral surface of the palatal ramus of the pterygoid. In contrast, in *D. austriacus* there are more-or-less prominent ridges covered with small denticles which radiate from the posterior portion of the ventral surface of the palatal ramus of the pterygoid (Klembara 1997). The ridges are divided by deep wide grooves.

Furthermore, we can conclude that *Discosauriscus pulcherrimus* is recorded in three basins in the Czech Republic: the Intrasedimentary Basin, Krkonoše Piedmont Basin and Boskovice Basin. *Discosauriscus pulcherrimus* is rare in the Boskovice Basin where the dominant species is *D. austriacus* (Klembara and Meszároš 1992, Klembara 1997, Klembara and Bartík 2000, Klembara and Mikudíková 2019). The sediments with the fauna of the Upper Kalná Horizon (Opluštil et al. 2016) lie close to the locality in Arnultovice, and also in the environs of the villages Horní Kalná and Klášterská Lhota (Štamberg 2014). The type of sediments and composition of the fauna of the Upper Kalná Horizon are very similar to the Ruprechtice Horizon of the Olivětín Member present in the Intrasedimentary Basin. The occurrence of *D. pulcherrimus* in both horizons, and in Kochov and Bačov horizons of the Boskovice Basin, confirm the stratigraphic correspondence of these horizons. New radioisotopic data (Opluštil et al. 2016) from overlying ignimbrites in Tatobity ( $296.4 \pm 0.08$  Ma; Text-fig. 1b) in the Chotěvice Formation of the Krkonoše Piedmont Basin suggest that the age of the Upper Kalná Horizon is Asselian, similar to that of the Olivětín Member of the Intrasedimentary Basin and the Kochov and Bačov horizons of the Boskovice Basin. Schneider and Werneburg (2012) and Schneider et al. (2019) interpreted the Ruprechtice Horizon of the Olivětín Member, using different biostratigraphical scales (based on amphibians and insects), to be of Sakmarian to Artinskian age. Specimens of *D. pulcherrimus* are most abundant in the basins in Germany (Werneburg 1985, 1988, 1989, Boy 2007). We can also conclude that *D. pulcherrimus* is restricted to the early Permian basins in central and western Europe.

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