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# The first specimen of a Blind snake from the Middle Miocene of Western Serbia

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**Abstract.** This article describes the first find of blind snake remains from the Middle Miocene sediments in the Vračević locality (Western Serbia). The numerous snake remains were isolated from the fossil material of the Vračević site. Among the many fragmented vertebrae, only one has been identified as belonging to a 'scolecophidian'. This vertebra is characterized by the neural arches depressed dorsoventrally; the vestigial neural spine limited to the most posterior part of a neural arch; posterodorsal lamina of neural arch slightly concave; paradiapophyses developed above the ventral margin of cotylar rim; indistinct haemal keel visible only on the anterior part of vertebra centrum.

**Key words:**
*blind snakes, Scolecophidia, Middle Miocene, Vračević.*

**Апстракт.** У овом раду приказан је опис првих налазака фосилних остатака слепе змије, пронађене у седиментима средњег миоцена на локалитету Врачевић (западна Србија). Из фосилног материјала локалитета Врачевић изоловани су бројни остаци змија. Међу многим фрагментисаним пршљеновама, само један је идентификован као припадник Scolecophidia. Овај пршљен карактеришу дорзовентрално спљоштени неурални лукови; рудиментисани неурални гребен ограничен на завршни део нервног лука; благо конкавна задња ивица неуралних лукова, дорзално гледано; парадиапофизе развијене изнад вентралне ивице котиларног обода; нејасна хемална кобилица видљива само на предњем делу тела пршљена.

**Кључне речи:**
*слепе змије, Scolecophidia, средњи миоцен, Врачевић.*

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## Introduction

'Scolecophidia' (sensu Zaher et al., 2023), "blind snakes" or "worm snakes", are primitive non-caenophidian snakes that have most probably split from other Serpentes around the Early Cretaceous (e.g., Pyron & Burbrink, 2012; Zheng & Wiens, 2016; Miralles et al., 2018; Fachini et al. 2020; Zaher et al., 2023). At first glance, these extremely small snakes look more like worms than snakes. 'Scolecophidia' have long been considered lizards (Bonaparte, 1839; Gray, 1845) or a lineage of limbless lizards (McDowell & Bogert, 1954; Robb, 1960) but, without any doubts, ophidian origin of 'scolecophidians' is generally accepted today (Szyndlar & Georgalis, 2023).

Due to the predominantly fossorial way of life of 'scolecophidians', the eyes are stunted and covered by a large scale. The body has a cylindrical form, and the cranial and caudal regions are similar in appearance (Cundall & Irish, 2008; Fachini et al., 2020). The body is covered with small undifferentiated, smooth, cycloid scales (Vitt & Caldwell, 2009). The synapomorphies of the 'scolecophidians' have been studied in numerous articles (McDowell, 1987; Rieppel, 1988; Cundall et al., 1993; Holman, 2000; Lee & Scanlon, 2002; Vitt & Caldwell, 2009; Szyndlar & Georgalis, 2023). Until recently, scolecophidians were considered a monophyletic group, but according to several molecular data, this has been refuted. Extant Scolecophidia are divided into three clades: Leptotyphlopidae, Typhlopoidea and Anomalepididae, (e.g., Pyron et al., 2013; Burbrink et al., 2020; Szyndlar & Georgalis, 2023 and references therein). According to the latest analyses, the anomalepidids represent instead the sister group of alethinophidians than that of the remaining scolecophidianss (Zaher et al., 2023), or they are more basal compared to the remaining scolecophidians (Burbrink et al., 2020; Szyndlar & Georgalis, 2023). Today, scolecophinians are cosmopolitan in areas with warmer climates. The only modern European species, *Xerotyphlops vermicularis* (Merrem, 1820), is distributed in the eastern Mediterranean.

Fossil records of 'scolecophidians' consist only of isolated, often damaged vertebrae. The localities where they were found are few and primarily of Cenozoic age (Szyndlar, 1991; Mead, 2013; Georgalis et al., 2017, 2019; Ivanov, 2022; Smith & Georgalis, 2022). In Europe, the oldest find is from the Paleocene of Belgium (Folie, 2006; Mead, 2013; Rage et al., 2021). Molecular analyses signify that blind snakes are basal to other modern snakes. They are estimated to have originated from Gondwana during the Upper Jurassic or Lower Cretaceous (160–125 Ma) (Vidal, et al., 2010; Pyron & Wallach, 2014; Zheng & Wiens, 2016; Burbrink et al., 2020).

## Geological settings

Vračević is located in western Serbia, about 15 km southwest of Lazarevac and about 70 km from Belgrade. The locality is situated in the Mionica Basin on the southern margin of the Pannonian Basin (Neubauer, et al. 2016) (Fig.1). According to Stevanović (1953), during the middle–late Miocene it represented an isolated lacustrine basin that was occasionally flooded from the north by the Paratethys and the Lake Pannon (Neubauer, et al. 2016).

The Vračević locality has been known in paleontological research for more than 70 years. Laskarev (1948) described the first fossil found there (the proboscidean *Deinotherium giganteum*). In the following decades, during various geological investigations, a variety of fossil remains were collected, mainly brackish freshwater and terrestrial molluscs for more details see Bradić-Milinović, et al. 2021 and references therein. Increased research in the Vračević locality in the last 20 years has led to the identification of numerous microvertebrate fossils from the freshwater lake sediments. However, the precise stratigraphic position of these sediments is still unclear and requires a multidisciplinary approach. In several articles based on on the study of terrestrial molluscs and micromammals, it was estimated that the deposits can be assigned to the Sarmatian, MN 7+8 (Marković, 2003, 2008; Neubauer, et al. 2016). However, based on palynological data, Bradić-Milinović et al. (2021) extend the time frame of these layers to the Upper Badenian (MN 7).

## Material and Methods

During an excavation campaign from 1999–2002 in the outcrop 1 from the Vračević site, an abundant

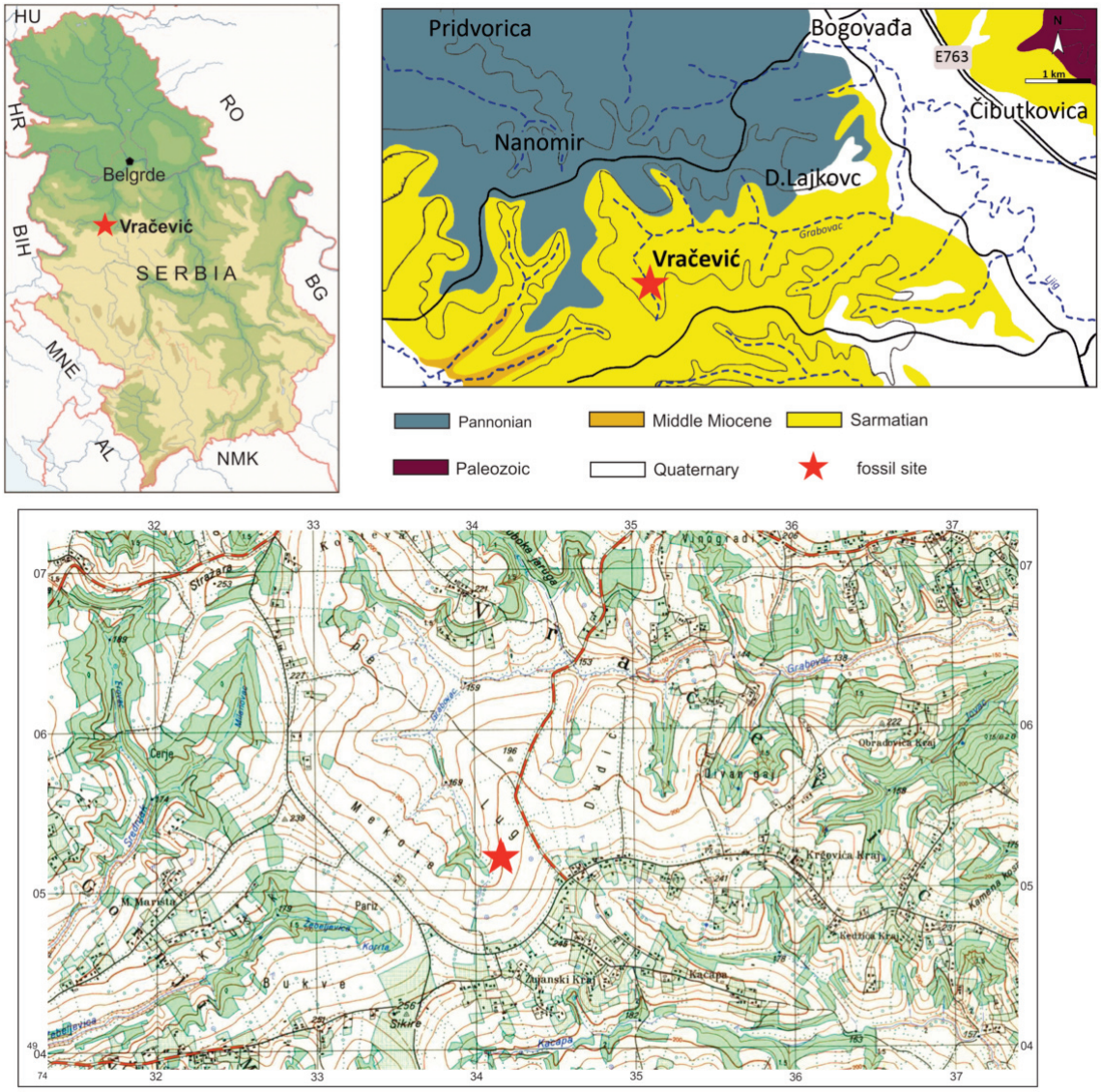


***Fig. 1**. Location of the Vračević site (**A, C**). Geological map of the study area, modified from Neubauer, et al. 2016 (**B**).*

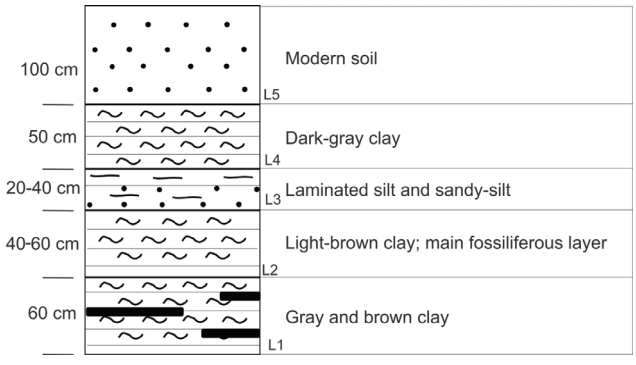


***Fig. 2.** Sedimentary column of Vračević, outcrop 1 (demolished site), modified from Marković, 2008.*

assemblage of small vertebrate fossils was collected. Unfortunately, this site has been demolished today. Layer 2 (Fig. 2) is composed of light-brown clay with accumulations of small vertebrates and molluscs, and represents the main fossiliferous layer. The vertebra described in this study originates from this layer. The samples were water-screened in the Laboratory of Natural History Museum Belgrade on screens of 2, 1 and 0.5 mm mesh. Among the many fragmented snake vertebrae, only one has been identified as belonging to Scolecophidia. The material is stored at the Natural History Museum Belgrade by the inventory number NHMBEO NH-176.

The photographs were taken with a Stereomicroscop BIO-OPTICA Type:1000 with attached microcamera OPTIKA C-H4K. The osteological terminology used to describe the vertebra was mainly taken from Rage (1984) and Szyndlar (1984).

## Systematic paleontology

Order Squamata Oppel, 1811
Suborder Serpentes Linnaeus, 1758
Infraorder Scolecophidia Duméril & Bibron, 1844

***Scolecophidia* indet.** (Fig. 3)

**Material.** one precloacal vertebra (NNMBEO NH-176)

**Description.** The vertebra is very small, smaller than 2 mm in centrum length, slightly elongated (ratio of centrum length/neural arch width is 1.28). The neural arch is depressed in posterior view, with a vaulting ratio (sensu Georgalis et al., 2021) equal to its posterior margin is slightly concave in dorsal view, without a posterior medial notch. The vestigial neural spine restricted to the posteriormost portion of neural arch. It looks like a small tubercle on the posterior edge of the neural arches. The interzygapophyseal constriction is well expressed. The zygosphene is completely broken, while the small remains of the prezygapophyseal accessory processes are directed anterolaterally in dorsal view, while these are directed dorsally in anterior view. Contrary, the direction of the long axis of the right prezygapophyseal articular facet is directed roughly anteroposterorly. The cotyle is slightly damaged, but moderately depressed same as is the condyle. Paracotylar foramina are absent. The paradiapophyses form a single articular surface. Lateral foramina are present as well as two small subcentral foramina. Haemal keel is barely noticeably visible on the front part of the centrum.

**Remarks.** The vertebral characters described above clearly indicate identification of the vertebra as belonging to 'scolecophidians' This vertebra is characterized by the neural arches depressed dorsoventrally; the vestigial neural spine restricted to the posterior most portion of the neural arch; the posterodorsal lamina of the neural arch slightly concave; paradiapophyses developed above the ventral margin of the cotylar rim; indistinct haemal keel visible only on the anterior portion of the centrum of vertebra. Unfortunately, the uniform morphology of their vertebrae makes precise identification impossible (Rage, 1984; Szyndlar, 1985, 1991; Rage et al., 2021; Szyndl & Georgalis, 2023). Some observed characters, such as vestigial neural spine, or a barely noticeable haemal keel may be a reflection of intracolumnar variability or a taxonomic significance (Fig. 3). However, current knowledge of the comparative anatomy of the Scolechophidian skeleton does not provide such a possibility.

## Discussion and conclusion

The skeletal study of Scolecophidiais is focused primarily on the cranial anatomy. Since the 19th century, numerous authors have identified significant differences between families (Müller, 1831; Jan & Sordelli, 1860–1866; Boulenger, 1893; Szyndlar & Georgalis, 2023 and references therein). However, the anatomy of the postcranial skeleton was initially neglected. New technologies stimulated interest in the study of vertebral morphology (Martins et al., 2019, 2021a, b; Herrel et al., 2021; Szyndlar & Georgalis, 2023 and references therein). The simplified vertebral anatomy is almost uniform and makes it difficult to differentiate members of families or lower taxonomic categories.

Scolecophidian vertebrae are characterized by: small and elongated centrum, depressed neural arch, depressed cotyle and condyle, long prezygapophyseal accessory processes, elongated prezygapophyseal articular facets with the direction of the major axis approaching the direction main axes of the vertebrae, absent haemal keels, absent or vestigial neural spine (except for a few anterior trunk vertebrae) (see Szyndlar & Georgalis 2023).

Differences in the morphology of vertebrae between families, described by some authors (List, 1966; Lee & Scanlon, 2002; Wallach, 2009, 2020; Fachini et al., 2020; Herrel et al., 2021) cannot be considered completely reliable (Szyndlar & Georgalis,

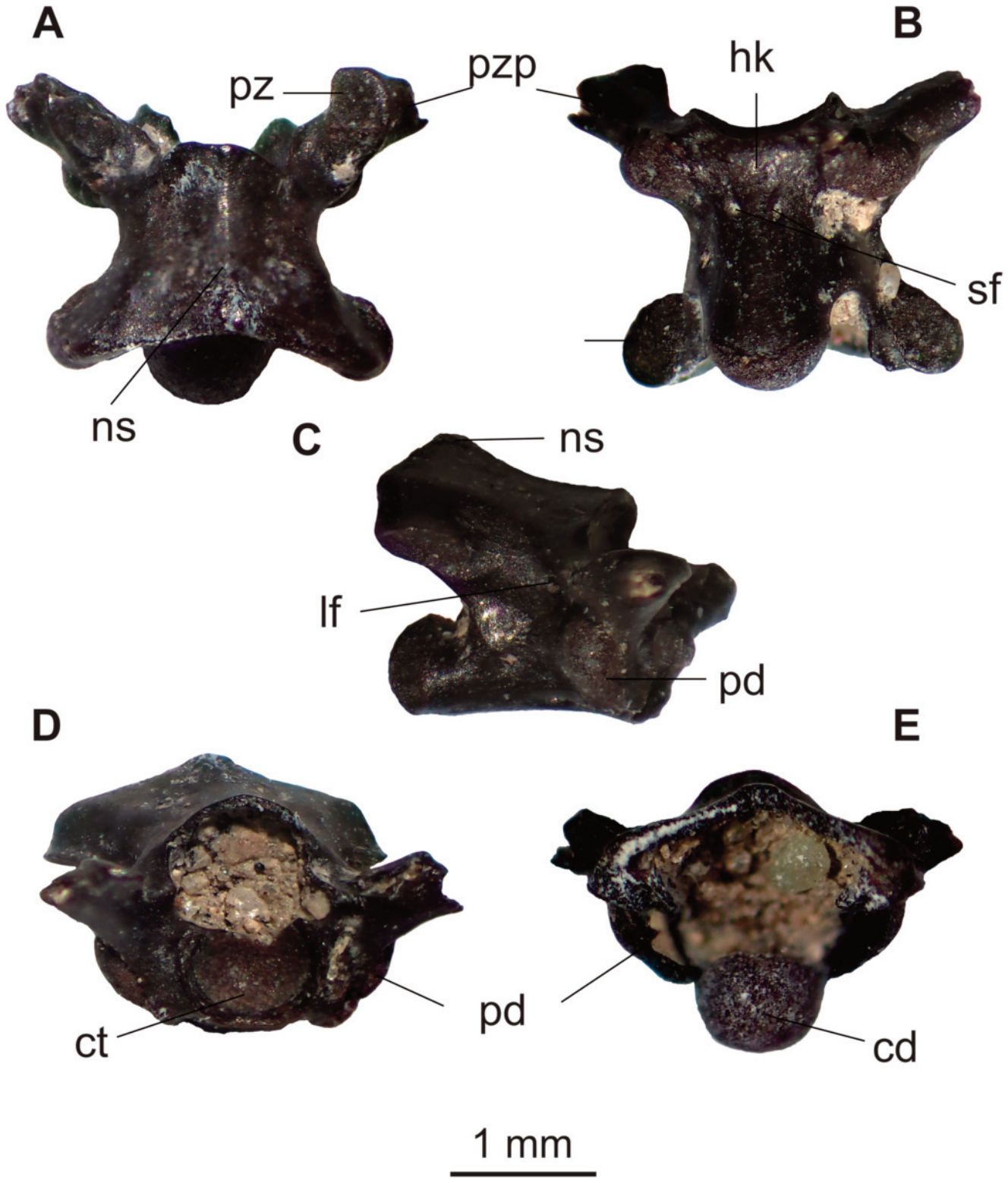


***Fig. 3.*** *Scolecophodia inet. from the Middle Miocene of Vračević, precloacal vertebra (NHMBEO NH-176) in dorsal (**A**), ventral (**B**), lateral (**C**), anterior (**D**) and posterior (**E**) view. Abbrevitations:* ***cd****, condyle;* ***ct****, cotyle;* ***lf****, lateral foramen;* ***ptz****, postzygapophysis;* ***pz****, prezygapophysis;* ***pzt****, prezygapophiseal process;* ***sf****, subcentral foramen;* ***pd****, paradiapophysis;* ***ns****, vestigial neural spine;* ***hk****, "barely noticeable haemal keel".*

2023). According to Szyndl & Georgalis, (2023), the observed intracolumnar variability in many scolecophidians requires further investigation and comparison between a large numbers of taxa.

Based on the above, the described vertebra from Vračević can be identified as Scolecophidia indet. Small differences described as a vestigial neural spine or a barely noticeable haemal keel will remain as a note for future studies.

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## Резиме

## Први примерак слепе змије из средњег миоцена западне Србије

'Scolecophidia' (према Zaher et al., 2023), „слепе змије" или „црволике змије", су примитивне змије које су се највероватније одвојиле од осталих змија (Serpentes) у време ране креде (Pyron & Burbrink, 2012; Zheng & Wiens, 2016; Miralles et al., 2018; Fachini et al. 2020; Zaher et al., 2023). Због претежно фосориалног начина живота очи ових змија су закржљале и прекривене крљуштима. Тело им је цилиндричног облика, малих димензија а главени и репни регион су сличног изгледа (Cundal & Irish, 2008; Fachini et al., 2020). 'Scolecophidia' су до недавно сматрани монофилетском групом, али према неким молекуларним анализама данас је већином прихваћено њихово полифилетско порекло. Савремене 'Scolecophidia' су подељене у три кладе: Leptotyphlopidae, Typhlopoidea и Anomalepididae (Pyron et al., 2013; Burbrink et al., 2020; Szyndlar & Georgalis, 2023).

Локалитет Врачевић се налази у западној Србији, у Ваљевско-мионичком басену који је детаљно описан у више радова (Neubauer, et al. 2016; Bradić-Milinović, et al. 2021). Палеонтолошка истраживања овог локалитета вршена су више од 70 година, а први описани фосил је *Deinotherium giganteum* (Јакшић, 1948). Прецизан стратиграфски положај ових седимената је још увек дискутабилан и захтева мултидисциплинарни приступ. У неколико чланака заснованих на анализи копнених мекушаца и ситних сисара процењено је да су наслаге сарматске старости, MN 7+8 (Marković, 2003, 2008; Neubauer, et al. 2016). Међутим Bradić-Milinović, et al. (2021) на основу палинолошких података проширују временски оквир ових слојева на горњи баден (MN 7). Детаљнија стратиграфска анализа налази се у поменутом раду. У кампањи ископавања од 1999-2002. године на локалитету Врачевић (профил 1) сакупљена је фосилна асоцијација ситних кичмењака. Нажалост, овај профил је данас урушен. Слој 2, овог профила (сл. 2) је састављен од светлосмеђе глине са накупинама ситних кичмењака и мекушаца и представља главни фосилоносни слој из ког потиче и пршљен који је у овом раду описан. Идентификовани пршљен је одређен као преклоакални и чува се у збирци Природњачког музеја у Београду под инвенрним бројем NHMBEO NH-176. Димензије пршљена су веома мале, дужина његовог тела је мања од 2 мм. Благо је издужен, неурални лукови су спљоштени гледано са задње стране, са односом сводова (према Georgalis et al. 2021) који су једнаки његовој задњој ивици. Гледано дорзално, ова ивица је благо конкавна без задњег медијалног зареза. Рудиментарни неурални гребен ограничен је на крајњи задњи део неуралног лука. Међузигапофизна констрикција је добро изражена. Зигосфена је потпуно оштећена, док су мали остаци

презигапофизних наставака усмерени антеролатерално у дорзалном погледу. Насупрот томе, правац главне осе презигапофизних зглобних површина је приближан правцу осе тела пршљена. Котил и кондил су благо дорзовентрално спљоштени. Паракотиларни отвори су одсутни. Парадиапофизе чине једну зглобну површину. Присутни су бочни отвори као и два мала субцентрална отвора. Хаемална кобилица је једва приметна на предњем делу тела пршљена.

Набројани карактери јасно указују на припадност овог пршљена клади Scolecophidia. Нажалост, уједначена морфологија пршљенова припадника ове кладе ограничава прецизну идентификацију (Rage, 1984; Szyndlar, 1985, 1991; Rage et al., 2021; Szyndl & Georgalis, 2023). Неки уочени карактери, као што је рудиментарни неурални гребен, или једва приметна хемална кобилица могу бити одраз варијабилности пршљенова унутар кичменог стуба или могу имати таксономски значаја (слика 3).

Анатомија посткранијалног скелета Scolecophidia је дуго била занемарена. Нове технологије су подстакле интересовање за проучавање морфологије пршљенова (Martins et al., 2019, 2021a, b; Herrel et al., 2021; Szyndlar & Georgalis, 2023 и референце у њима). Поједностављена анатомија пршљенова Scolecophidia је скоро уједначена и отежава разликовање чланова породица или нижих таксономских категорија.

Пршљенове Scolecophidia карактеришу: мало и издужено тело, спљоштени неурални луци, спљоштени котил и кондил, дуги презигапофизни наставци, издужене презигапофизне зглобне површине са смером главне осе која је приближна смеру осе кичмених пршљенова, неурални и хемални наставци углавном неразвијени (осим неколико предњих пршљенова) (видети у Szyndl & Georgalis, 2023). Према Szyndl & Georgalis, (2023), уочена варијабилност пршљенова унутар кичменог стуба код многих сколекофидија захтева даље истраживање и поређење између великог броја таксона.

На основу наведеног, описани пршљен из Врачевића се може идентификовати као Scolecophidia indet. Мале разлике описане као рудиментарни неурални гребен или једва приметна хемална кобилица остаће као напомена за будућа истраживања.

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