

Osteology of the skull of the blind snake *Helminthophis flavotermiatus* (Peters, 1857) (Serpentes, Anomalepididae)

Fidélis Júnio Marra Santos¹

¹ Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Laboratory of Vertebrate Systematics. Av. Ipiranga, 6681 Partenon; 90619-900, Porto Alegre, Rio Grande do Sul, Brazil

<https://zoobank.org/EDE9AABA-4D35-426C-B837-056E865E97F2>

Corresponding author: Fidélis Júnio Marra Santos (fidelismarra@gmail.com)

Academic editor: Johannes Penner ♦ Received 1 January 2024 ♦ Accepted 8 April 2024 ♦ Published 17 May 2024

Abstract

The blind snake *Helminthophis flavotermiatus* (Peters, 1857) is a species of Anomalepididae with distribution throughout northwestern Venezuela and western Colombia. Its osteology is poorly known, and thus this study presents information on its skull structure based on High-Resolution X-Ray Computed Tomography. The absence of the supraoccipital bone can be used for the determination of *H. flavotermiatus* in relation to its congeners, *Helminthophis frontalis* (Peters, 1860) and *Helminthophis praeocularis* Amaral, 1924.

Key Words

Helminthophis sp., HRXCT, reptiles, snakes, systematics, taxonomy

Introduction

Within the family Anomalepididae Taylor, 1939, the genus *Helminthophis* Peters, 1860, is a group of small blind snakes, distributed in the Neotropics, from lower Central America and northwestern South America: Costa Rica, Panama, Colombia, and Venezuela. *Helminthophis* is currently composed of three species (McDiarmid et al. 1999; Marra Santos and Reis 2018; Boundy 2021): *Helminthophis flavotermiatus* (Peters, 1857); *Helminthophis frontalis* (Peters, 1860); and *Helminthophis praeocularis* Amaral, 1924.

The osteology of the skull of some species of snakes Anomalepididae, for example *Anomalepis aspinosus* Taylor, 1939 and *Liotyphlops albirostris* (Peters, 1857), has already been very well studied and presented by other researchers (Tihen 1945; Haas 1964, 1968; List 1966), and, in recent years, the use of High-Resolution X-Ray Computed Tomography (HRXCT) has increased the knowledge of the osteology of Anomalepididae, for

example *Anomalepis colombia* Marx, 1953; *Liotyphlops albirostris* (Peters, 1857); *Liotyphlops anops* (Cope, 1899); *Liotyphlops palauophis* Marra Santos, 2023; *Liotyphlops taylori* Marra Santos & Reis, 2018; *Liotyphlops ternetzii* (Boulenger, 1896); and *Typhlophis squamosus* (Schlegel, 1839) (Rieppel et al. 2009; Marra Santos and Reis 2018; Marra Santos and Reis 2019; Marra Santos 2023; Szyndlar and Georgalis 2023). An interesting and important aspect of HRXCT is that, in important ways, it permits replication of many aspects of the traditional techniques, and the resulting digital models allow for three-dimensional and rotational investigation similar to traditional observations of dry skulls or skeletons in hand (Bell et al. 2021).

In this paper, the osteology of the skull of *Helminthophis flavotermiatus* is presented based on HRXCT data. This study is the first detailed description of the cranial osteology of *Helminthophis*, adding new information to the knowledge of the skull anatomy of Anomalepididae snakes.

Materials and methods

The head of *H. flavoterminalatus* (AMNH R 59407) was studied by HRXCT at the CT facility at Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS) using a SkyScan 1173. Additional information will be available on MorphoBank (<http://morphobank.org/permalink/?P5113>). The skull measures 4.6 mm in length, 2.4 mm in width, and 1.3 mm in height. The dataset is compared with HRXCT datasets for *Helminthophis frontalis* and *Helminthophis praeocularis*. The specimen of *H. praeocularis* (AMNH R 38125) was also scanned at PUCRS. The head of *Helminthophis flavoterminalatus* (AMNH R 59407) and the head of *H. praeocularis* (AMNH R 38125) were scanned at 46 kV and 55 μ A, and each reconstructed slice represents a thickness and spacing of 7.16 μ m. The head of *H. frontalis* (MCZ R-55117) was scanned at the CT facility of the University of Texas at Austin using an Xradia microCT scanner. This specimen was scanned at 80 kV and 10 W, and each reconstructed slice represents a thickness and spacing of 3.58 μ m. The datasets were rendered in three dimensions using CTVox v. 3.2 (Bruker MicroCT, Inc., Billerica, MA) for Windows. The terminology used for bones follows Rieppel et al. (2009) and Marra Santos (2023).

Results

Description of skull

High-Resolution X-Ray Computed Tomography of skull bones in Figs 1–5.

Neurocranium

Main body of premaxilla on ventral surface of snout. Maxilla-premaxilla contact widely separated. Lateral maxillary foramina absent. Maxilla alveolar row oriented transversely. Nasal fused. Nasal-frontal boundary convex posteriorly in a shallow W-shaped suture. Prefrontal separated from nasal. Prefrontal moveably articulated to frontal. Postorbital element present. Posterior orbital margin incomplete. Frontals gradually tapering anteriorly. Frontal fused. Frontal-parietal contact (dorsal aspect) anteriorly concave, i.e., frontals extending posteriorly into broad median embayment in parietals. Parietal paired. Posterior border of parietal in contact with otico-occipital. Supraoccipital absent. Supratemporal present. Posteromedial flange of septomaxilla short, not contacting frontal. Septomaxilla with lateral flange contributing to posterior border of external naris. Fenestra for duct of Jacobson's organ (fenestra vomeronasalis) posteroventrally positioned. Palatine not in contact with vomer, maxilla, or pterygoid. Ectopterygoid present.

Mandible and dentition

Splenial not present as discrete element. Coronoid and angular separated by prearticular portion of compound bone. Retroarticular process long, longer than articular facet. Teeth present in maxilla and dentary, but lacking in premaxilla, palatine, and pterygoid.

Discussion

The osteology of the skull of *Helminthophis* reveals to us a character that readily distinguishes this genus from the other three belonging to Anomalepididae, which is the fused frontal (Figs 1B, 4A–C). The frontal paired in *Anomalepis* Jan, 1860; *Liotyphlops* Peters, 1881; and *Typhlops* Fitzinger, 1843, has already been presented and discussed by other researchers (Haas 1964, 1968; List 1966; Rieppel et al. 2009; Marra Santos and Reis 2018; Marra Santos and Reis 2019; Marra Santos 2023). In addition to the frontal fused, which is a bony character of *Helminthophis* that distinguishes it from the other genera of Anomalepididae, *H. flavoterminalatus* is readily differentiated from *H. frontalis* and *H. praeocularis* by the absence of supraoccipital (Figs 1B, 4A, 5A). An important observation is that, if it were not for the presence of the fused frontal, the skull of *Helminthophis* could easily be confused with the skull of some of the species of *Liotyphlops* that also do not have the supraoccipital (for example, *Liotyphlops schubarti*, *Liotyphlops taylori*, *Liotyphlops ternetzii*, and *Liotyphlops wilderi*) or even with the skull of *Typhlops squamosus*.

With the exception of the fused frontal, *H. flavoterminalatus* presents other skull characters shared by other taxa Anomalepididae: (1) the nasal bone fused (Figs 1B, D, 4A); (2) absence of the lateral maxillary foramina (Fig. 1A); (3) absence of a prefrontal-nasal contact (Figs 1B, C, 4A); (4) presence of a discrete ossification (postorbital element) (Figs 1A–D, 2A, B); and (5) by having an ectopterygoid (Figs 1A, C, 2B, C).

One of the most interesting and novel consequences of HRXCT is that it has opened the door to the development and documentation of detailed data on the internal anatomy even of type specimens, which otherwise have historically remained immune to internal anatomical investigations that were, of necessity, invasive and destructive (Bell et al. 2021). In this sense, the information on the osteology of the skull of *H. flavoterminalatus* presented here, thanks to the use of HRXCT, can contribute to the knowledge of the anatomy and systematics of snakes, especially extant non-caenophidian snakes. It is important to note that the data presented here on the osteology of the skull of *H. flavoterminalatus* will contribute to future publications focused on the taxonomy of *Helminthophis*.

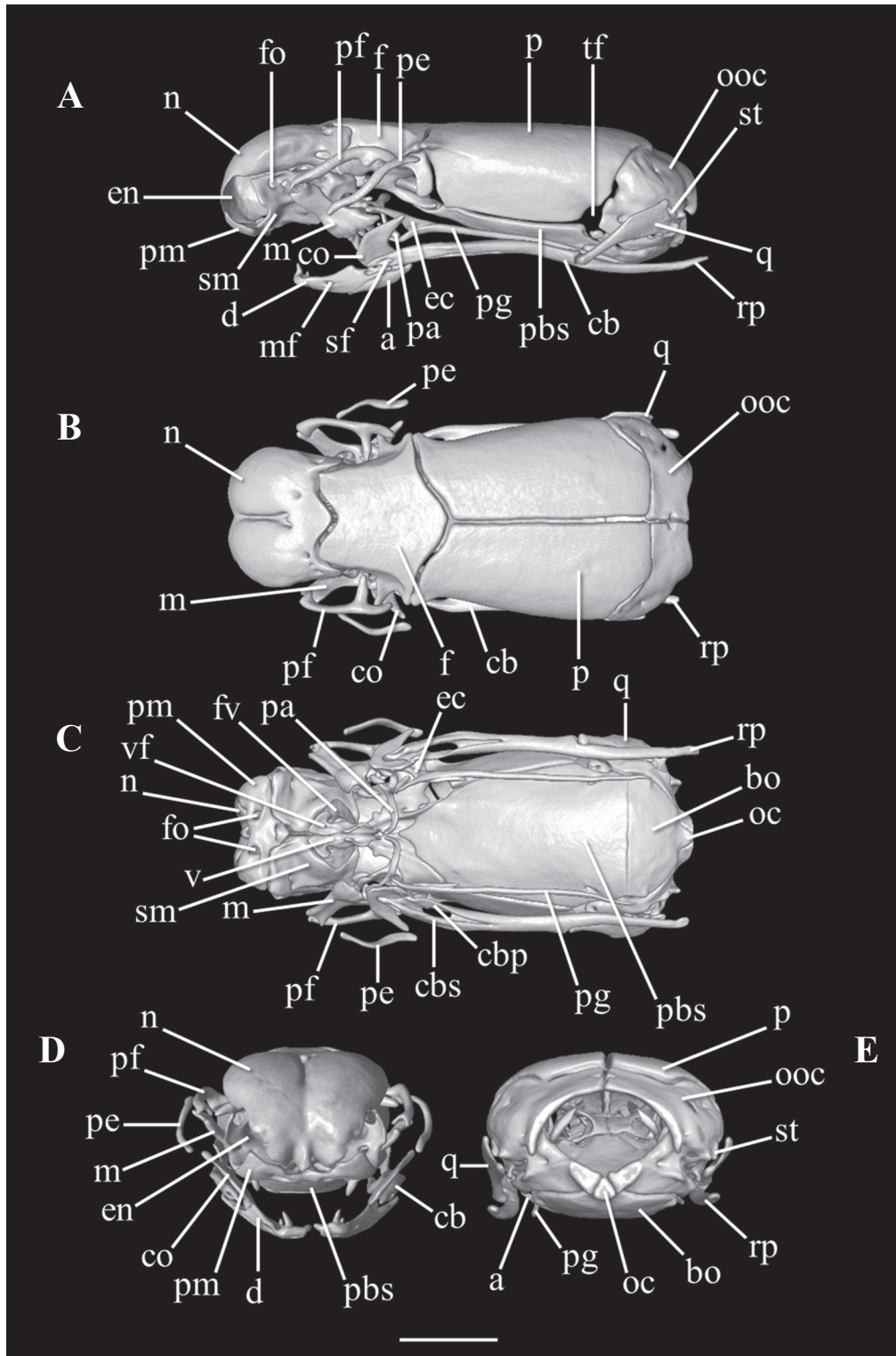


Figure 1. Three-dimensional reconstruction of the skull of *Helminthophis flavoterminalis* (AMNH R 59407), based on HRXCT data. **A.** Lateral view; **B.** Dorsal view; **C.** Ventral view with the lower jaw partially digitally removed; **D.** Anterior view; **E.** Posterior view. Scale bar: 1 mm. Anatomical abbreviations: **a**, angular; **bo**, basioccipital; **cb**, compound bone; **cbp**, compound bone prearticular component; **cbs**, compound bone surangular component; **co**, coronoid; **d**, dentary; **ec**, ectopterygoid; **en**, external naris; **f**, frontal; **fo**, foramen; **fv**, fenestra vomeronasalis; **m**, maxilla; **mf**, mental foramen; **n**, nasal; **oc**, occipital condyle; **ooc**, otico-occipital (fused prootic + opisthotic + exoccipital); **p**, parietal; **pa**, palatine; **pbs**, parabasisphenoid; **pe**, postorbital element; **pf**, prefrontal; **pg**, pterygoid; **pm**, premaxilla; **q**, quadrate; **rp**, retroarticular process; **sf**, surangular foramen; **sm**, septomaxilla; **st**, supratemporal; **tf**, trigeminal foramen; **v**, vomer; **vf**, vomerine foramen.

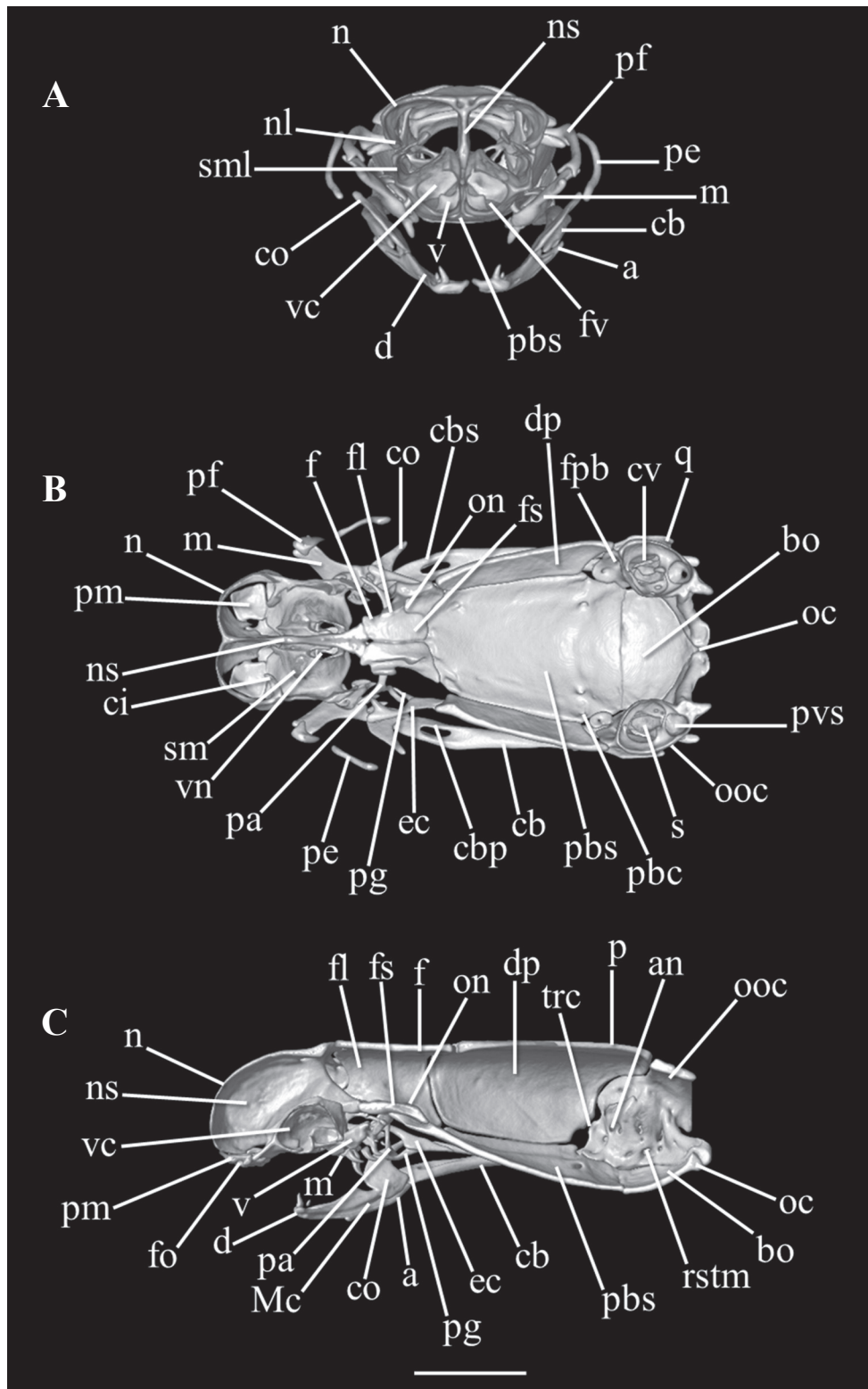


Figure 2. Three-dimensional reconstruction of the skull of *Helminthophis flavotermatus* (AMNH R 59407), based on HRXCT data. **A.** Transversal view; **B.** Frontal view; **C.** Sagittal view. Scale bar: 1 mm. Anatomical abbreviations: **a**, angular; **an**, acoustic nerve foramen; **bo**, basioccipital; **cb**, compound bone; **cbp**, compound bone prearticular component; **cbs**, compound bone surangular component; **ci**, conchal invagination; **co**, coronoid; **cv**, cavum vestibuli; **d**, dentary; **dp**, descensus parietalis; **ec**, ectopterygoid; **f**, frontal; **fl**, frontal laterally descending flange; **fo**, foramen; **fpb**, facial nerve palatine branch foramen; **fs**, frontal subolfactory process; **fv**, fenestra vomeronasalis; **m**, maxilla; **Mc**, Meckel's canal; **n**, nasal; **nl**, nasal lateral flange; **ns**, medial nasal septum; **oc**, occipital condyle; **on**, optic nerve foramen; **ooc**, otico-occipital (fused prootic + opisthotic + exoccipital); **p**, parietal; **pa**, palatine; **pbc**, parabasal (Vidian) canal; **pbs**, parabasisphenoid; **pe**, postorbital element; **pf**, prefrontal; **pg**, pterygoid; **pm**, premaxilla; **pvs**, posterior vertical semicircular canal; **q**, quadrate; **rstm**, recessus scalae tympani medial aperture; **s**, stapes; **sm**, septomaxilla; **sml**, septomaxilla lateral flange; **trc**, trigeminofacialis chamber; **v**, vomer; **vc**, vomeronasal cupola; **vn**, vomeronasal nerve passage.

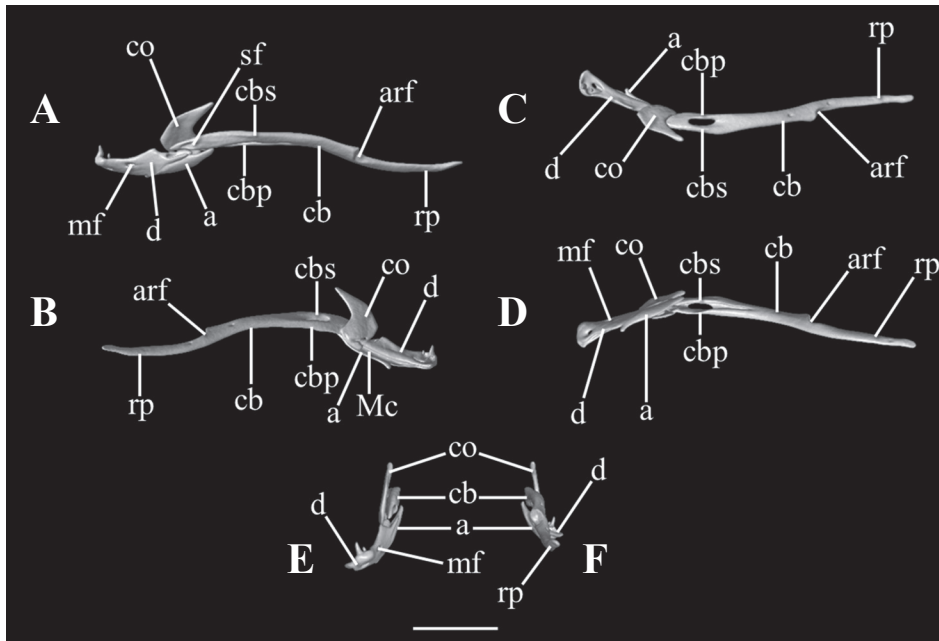


Figure 3. Three-dimensional reconstruction of the lower jaw of *Helminthophis flavotermatus* (AMNH R 59407), based on HRXCT data. **A.** Lateral view; **B.** Medial view; **C.** Dorsal view; **D.** Ventral view; **E.** Anterior view; **F.** Posterior view. Scale bar: 1 mm. Anatomical abbreviations: **a**, angular; **arf**, articular fossa; **cb**, compound bone; **cbp**, compound bone prearticular component; **cbs**, compound bone surangular component; **co**, coronoid; **d**, dentary; **Mc**, Meckel's canal; **mf**, mental foramen; **rp**, retroarticular process; **sf**, surangular foramen.

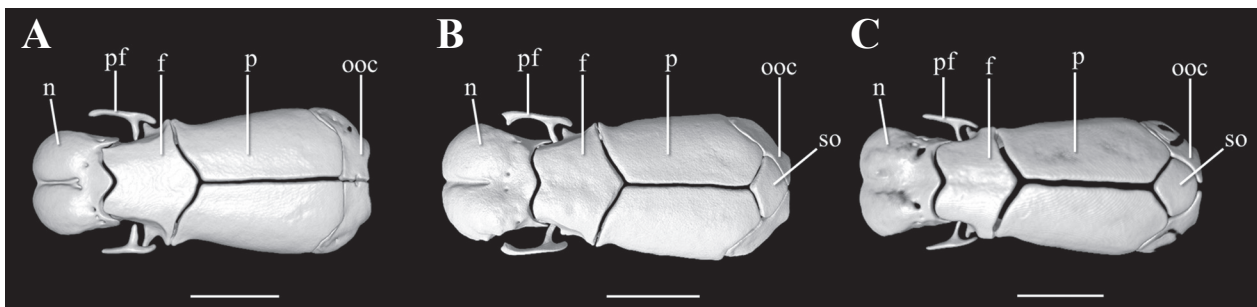


Figure 4. Incomplete dorsal view (some bones are not shown) of the three-dimensional reconstruction of the skulls of **A.** *Helminthophis flavotermatus* (AMNH R 59407); **B.** *Helminthophis frontalis* (MCZ R-55117); and **C.** *Helminthophis praeocularis* (AMNH R 38125), showing the absence of supraoccipital in *H. flavotermatus*. Scale bars: 1 mm. Anatomical abbreviations: **f**, frontal; **n**, nasal; **p**, parietal; **pf**, prefrontal; **ooc**, otico-occipital (fused prootic + opisthotic + exoccipital); **so**, supraoccipital.

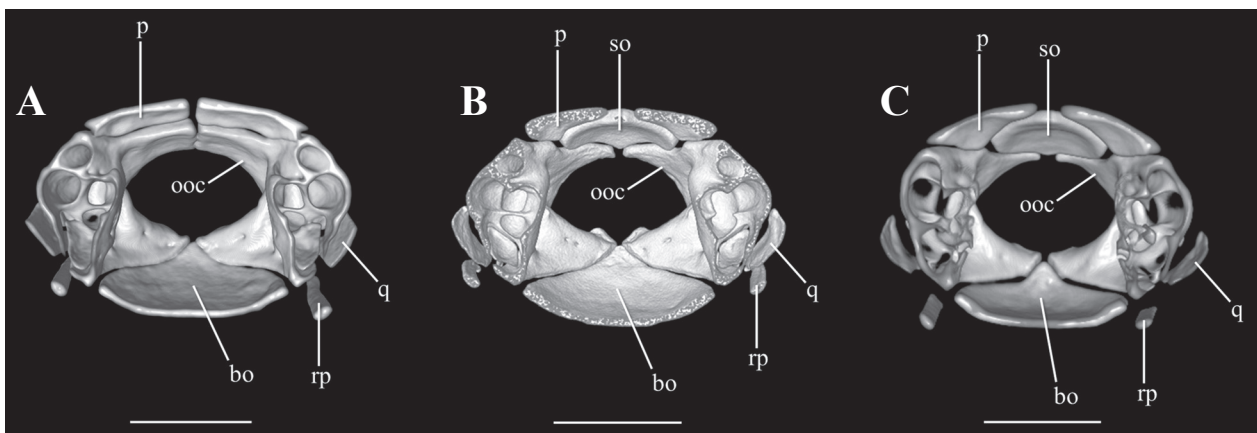


Figure 5. Transversal views of three-dimensional reconstruction of the posterior part of the skulls of **A.** *Helminthophis flavotermatus* (AMNH R 59407); **B.** *Helminthophis frontalis* (MCZ R-55117); and **C.** *Helminthophis praeocularis* (AMNH R 38125), showing the contribution of the supraoccipital to the internal sidewall of the neurocranium in *H. frontalis* and *H. praeocularis*. Scale bars: 1 mm. Anatomical abbreviations: **bo**, basioccipital; **p**, parietal; **ooc**, otico-occipital (fused prootic + opisthotic + exoccipital); **q**, quadrate; **rp**, retroarticular process; **so**, supraoccipital.

Acknowledgements

I am grateful to all curators, collection managers, and their respective institutions for the loan of specimens and for permission to examine specimens in their care: David A. Kizirian and Lauren Vonnahme (American Museum of Natural History, New York) and José Rosado (Museum of Comparative Zoology, Harvard University). I thank Christopher J. Bell, Jessie Maisano, and Patrick Stafford of the University of Texas at Austin for their support in the acquisition of specimens and CT scanning. I thank Adolpho Augustin of the Pontificia Universidade Católica do Rio Grande do Sul for help with CT scanning of specimens. I thank the Museum für Naturkunde, Berlin, for their support in the publication of this manuscript. I thank Johannes Penner, Polina Petrakieva, Vassil Peev (Zoosystematics and Evolution editors) and the reviewers, Van Wallach and Claudia Koch, for valuable suggestions during the review process.

References

- Amaral A (1924) *Helminthophis*. Proceedings of the New England Zoological Club 9: 25–30.
- Bell CJ, Daza JD, Stanley EL, Laver RJ (2021) Unveiling the elusive: X-rays bring scolecophidian snakes out of the dark. The Anatomical Record 304(10): 2110–2117. <https://doi.org/10.1002/ar.24729>
- Boulenger GA (1896) Catalogue of the snakes in the British Museum (Natural History). Vol. III, containing the Colubridae (Opisthoglyphae and Proteroglyphae), Amblycephalidae, and Viperidae. British Museum (Natural History), London, 727 pp.
- Boundy J (2021) Snakes of the World: a Supplement. CRC Press, Boca Raton, 273 pp. <https://doi.org/10.1201/9780429461354>
- Cope ED (1899) Contributions to the herpetology of New Granada and Argentina with descriptions of new forms. The Philadelphia Museums Scientific Bulletin 1: 3–26. <https://doi.org/10.5962/bhl.title.54674>
- Fitzinger L (1843) Systema Reptilium, fasciculus primus, Amblyglossae. Braumüller et Seidel, Wien, 1–106. <https://doi.org/10.5962/bhl.title.4694>
- Haas G (1964) Anatomical observations on the head of *Liotyphlops albirostris* (Typhlopidae, Ophidia). Acta Zoologica (Stockholm, Sweden) 45(1–2): 1–62. <https://doi.org/10.1111/j.1463-6395.1964.tb00709.x>
- Haas G (1968) Anatomical observations on the head of *Anomalepis aspinosus* (Typhlopidae, Ophidia). Acta Zoologica (Stockholm, Sweden) 49(1–2): 63–139. <https://doi.org/10.1111/j.1463-6395.1968.tb00147.x>
- Jan G (1860) Iconographie générale des ophiidiens. Première livraison. <https://doi.org/10.5962/bhl.title.4885>
- List JC (1966) Comparative osteology of the snake families Typhlopidae and Leptotyphlopidae. Illinois Biological Monographs (36) [6] + 112. <https://doi.org/10.5962/bhl.title.50341>
- Marra Santos FJ (2023) A new species of the genus *Liotyphlops* Peters, 1881 (Serpentes, Anomalepididae) from Colombia and the synonymization of *Liotyphlops beui* (Amaral, 1924) with *Liotyphlops ternetzii* (Boulenger, 1896). ZooKeys 1146: 87–114. <https://doi.org/10.3897/zookeys.1146.94607>
- Marra Santos FJ, Reis RE (2018) Two new blind snake species of the genus *Liotyphlops* Peters, 1881 (Serpentes: Anomalepididae), from Central and South Brazil. Copeia 106(3): 507–514. <https://doi.org/10.1643/CH-18-081>
- Marra Santos FJ, Reis RE (2019) Redescription of the blind snake *Anomalepis colombia* (Serpentes, Anomalepididae) using High-Resolution X-Ray Computed Tomography. Copeia 107(2): 239–243. <https://doi.org/10.1643/CH-19-181>
- Marx H (1953) A new worm snake from Colombia, genus *Anomalepis*. Fieldiana. Zoology 34: 197–198. <https://doi.org/10.5962/bhl.title.2876>
- McDiarmid RW, Campbell JA, Touré T (1999) Snake Species of the World. A Taxonomic and Geographic Reference. The Herpetologist's League, Washington DC, [xi +] 511 pp.
- Peters WCH (1857) Vier neue amerikanische Schlangen aus der Familie der Typhlopinen und darüber einige vorläufige Mittheilungen. Monatsberichte der Königlich Preussische Akademie des Wissenschaften zu Berlin 1857(8): 402–403.
- Peters WCH (1860) Drei neue Schlangen des k. zoologischen Museums aus America und Bemerkungen über die generelle Unterscheidung von anderen bereits bekannten Arten. Monatsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin 1860(10): 517–521.
- Peters WCH (1881) Einige herpetologische Mittheilungen, 1. Uebersicht der zu den Familien der Typhlopes und Stenostomi gehörigen Gattungen oder Untergattungen. Sitzungsberichte der Gesellschaft Naturforschender Freunde zu Berlin 1881(4): 69–71.
- Rieppel O, Kley NJ, Maisano JA (2009) Morphology of the skull of the White-Nosed Blindsnake, *Liotyphlops albirostris* (Scoleophidia, Anomalepididae). Journal of Morphology 270(5): 536–557. <https://doi.org/10.1002/jmor.10703>
- Schlegel H (1839) Abbildungen neuer oder unvollständig bekannter Amphibien, nach der Natur oder dem Leben entworfen und mit einem erläuternden Texte begleitet. Arne and Co., Düsseldorf, [xiv +] 141 pp.
- Szyndlar Z, Georgalis GL (2023) An illustrated atlas of the vertebral morphology of extant non-caenophidian snakes, with special emphasis on the cloacal and caudal portions of the column. Vertebrate Zoology 73: 717–886. <https://doi.org/10.3897/vz.73.e101372>
- Taylor EH (1939) Two new species of the genus *Anomalepis* Jan, with a proposal of a new family of snakes. Proceedings of the New England Zoological Club 17: 87–96.
- Tihen JA (1945) Notes on the osteology of typhlopoid snakes. Copeia 1945(4): 204–210. <https://doi.org/10.2307/1438352>

Appendix 1

Examined specimens:

Helminthophis flavoterminalatus. Venezuela. Distrito Capital: AMNH R 59407.

Helminthophis frontalis. Costa Rica. San José: MCZ R-55117.

Helminthophis praeocularis. Colombia. Tolima, Honda: AMNH R 38125.

ZOBODAT - www.zobodat.at

Zoologisch-Botanische Datenbank/Zoological-Botanical Database

Digitale Literatur/Digital Literature

Zeitschrift/Journal: [Zoosystematics and Evolution](#)

Jahr/Year: 2024

Band/Volume: [100](#)

Autor(en)/Author(s): Santos Fidelis Junio Marra

Artikel/Article: [Osteology of the skull of the blind snake *Helminthophis flavoterminalis* \(Peters, 1857\) \(Serpentes, Anomalepididae\) 597-602](#)