

Induszalim bala Mesoeucrocodile from Pakistan

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How to cite this paper: Malkani, M.S. (2019) *Induszalim bala* Mesoeucrocodile from Pakistan. *Open Journal of Geology*, 9, 623-626.

<https://doi.org/10.4236/ojg.2019.910058>

Received: August 16, 2019

Accepted: September 21, 2019

Published: September 24, 2019

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Abstract

Induszalim bala is the first diagnostic mesoeucrocodile from Indo-Pakistan subcontinent having rostrum articulated with dentary symphysis and associated vertebrae and limb bones and provides facility for comparison with other mesoeucrocodyles. *Induszalim* is a medium to large sized mesoeucrocodile found in the latest Maastrichtian Vitakri Lameta Formation of Fort Munro Group just below Cretaceous-Paleogene boundary line. *Induszalim* has sufficient skeletal elements and can be used for phylogenetic studies. *Induszalim* shows Gondwanan paleobiogeographic affinity with some endemic elements.

Keywords

Mesoeucrocodile, *Induszalim bala*, Latest Maastrichtian, Indo-Pakistan Subcontinent

1. Introduction

Induszalim bala mesoeucrocodile as the new genus and new species was first reported by [1] and formally published by [2]. Here *Induszalim* is being described for evolutionary study.

2. *Induszalim bala* Mesoeucrocodile from Pakistan

Systematic paleontology of *Induszalim bala* is as follows: Crocodyliformes, Mesoeucrocodylia, Induszalimidae [1], *Induszalim* [1] [2], *Induszalim bala* [1] [2] (**Figure 1**). *Induszalim bala* holotypic rostrum and lectotypic caudal vertebrae, proximal humerus and distal femur (**Figure 1**) from Alam 19 type locality found in latest Maastrichtian Vitakri Lameta Formation of Fort Munro Group, Barkhan District, Balochistan, Pakistan. *Induszalim bala* referred



Figure 1. *Induszalim bala* fossils. Row 1, holotypic rostrum MSM-155-19c in poaterior and left lateral views. Row 2, holotypic rostrum MSM-155-19c in anterior view, lectotypic caudal vertebrae un-number and MSM-65-19 in one view. Row 3, lectotypic caudal vertebra MSM-65-19 in one view, proximal humerus in one view, and distal femur MSM-66-19 in 2 views. Row 4, referred dorsal vertebra MSM-64-15 in 2 views, dentary MSM-63-4 in 4 view and proximal humerus in one view. Scale, each black or white digit is 1 cm.

dorsal vertebra from the Mari Bohri 15, dentary and humerus from the Kinwa 4 localities found also in the latest Maastrichtian (67-66 Million years ago) Vitakri Lameta Formation of Fort Munro Group, Barkhan District, Balochistan, central Pakistan. These fossils are housed in the museum of Geological Survey of Pakistan, Quetta. Genus *Induszalim* name is after Indus River of Pakistan and Zalim (Urdu and Saraiki word) meaning cruel, and species named *Induszalim bala* is after Saraiki word bala meaning big terrible animal.

2.1. Diagnosis of *Induszalim bala*

Induszalim bala secondary plate and age shared with mesoeucrocodyles. Indus-

zalimidae is based on *Induszalim bala* genus and species. *Induszalim* bony secondary plate is formed by premaxilla, maxilla and palatine while *Pabwehshi* secondary plate is formed by premaxilla and maxilla only; external nare sub-terminal (while vertical in *Pabwehshi*); anterior rostrum moderately inclined (while vertical in *Pabwehshi*); narial fossa anteriorly has stepped premaxilla strip (while *Pabwehshi* has no step); *Induszalim* has twice deep palatal cavity than *Pabwehshi*; in *Induszalim* the suture of nasal with premaxilla and maxilla is generally straight line with fine zigzag butt suture; splenial and dentary are united as concavo-convexo style with axis in mid while its axis is shifted ventrally in *Pabwehshi*; in *Induszalim*, the diverticulum in wall of internal naris is negligible while diverticulum is well developed in *Pabwehshi*; tooth bearing maxillary ramus is twice away from internal naris cavity in *Induszalim* than *Pabwehshi*; dorsoventrally oriented elongated large pneumatopores in maxilla; Dentary is thick with large pneumatopores in *Induszalim* while small pneumatopores in *Pabwehshi* dentary; *Induszalim* has relatively small internal naris cavity than *Pabwehshi*; large and deep palatal cavity than *Pabwehshi*; partial roof over the external naris; in *Induszalim* the palatine ramus shows elongated contact with maxilla while not found in *Pabwehshi*; first and second tooth of Dentary are small in diameter than *Pabwehshi*, while third is more but fourth is maximum in diameter of *Induszalim* than *Pabwehshi*; Neurocentrally straight suture opens in dorsal centrum; Caudal centra are strongly waisted.

2.2. Description of Fossils of *Induszalim bala*

Induszalim bala shows anterodorsally directed external nares, high or deep and narrow rostrum, the ziphodont type laterally compressed teeth (symmetric to asymmetric oval to asymmetric D shaped, subcircular and heterodont in size), and thick rostral elements. Deep D-shaped rostrum is ornamented with pitted and sculptured lines or grooves and ridges. Height of the rostrum is $\frac{3}{4}$ to its width like *Pabwehshi*. In *Induszalim* the external nares are subterminal while it is terminal in *Pabwehshi*. External narial fossa face anterolaterally and laterodorsally. Rostrum has many small and large internal pneumatic cavities (**Figure 1**). Premaxilla is sub-quadrangular in lateral views. It contacts with nasal posterodorsally and the maxilla posteriorly. Premaxilla and nasal enclose the external nares. Laterally the suture of maxilla and premaxilla is a butt joint. Dorsally the premaxillae contact with each other to form the midline contact and form the lip. Premaxillary lip forms more than $\frac{3}{5}$ of anteroposterior length of dorsal roof of external nares. Ventrally, the premaxillae may contact one another at the midline to form the anterior portion of the secondary palate. A diastema is found on the contact of maxilla and premaxilla (**Figure 1**).

Maxilla and premaxilla form side wall of rostrum, while palatines are separated bones. In *Induszalim* the palatine lateral torus has elongated contact with the maxilla while this contact is not found in *Pabwehshi*. It represents that

secondary palate formed by separate bones. Dorsally the maxilla meets with nasal forming contact subparallel to midline (with fine zigzag fine tuning). Maxilla, nasal and palatine bones enclose the internal naris. Nasal forms the dorsal and some dorsolateral margin of internal naris. Upper half of internal naris is bounded by maxilla while lower half of internal naris is bounded by palatine. A prominent and exceptionally very large elongated internal coel (dorsoventrally elongated) is found in maxilla (**Figure 1**). Nasal forms the roof of rostrum. Lower portion of bilaminae internarial bar is clearly formed by palatine while dorsal portion is damaged (**Figure 1**).

Holotypic dentary symphysis is preserved in interlocking with maxilla and premaxilla (**Figure 1**). Further both rami of dentary also articulated with the relevant splenial. Pitted structures on dentary are aligned anteroposteriorly with some random rough contouring. Dentary is pneumatic. Splenial joined with relevant dentary is concave-convex which axis found in the dorsoventrally centre of bones, while shifted ventrally in *Pabwehshi*. Induszalim referred mandible is D-shaped. Two diverse mandibles are found fragmentary, one belongs to *Pabwehshi* and other assigned to *Induszalim*. First and second tooth of dentary are small in diameter than *Pabwehshi*, while third is relatively more but the fourth is maximum in diameter of *Induszalim* than *Pabwehshi*, the fourth dentary tooth is large and shows a marked heterodonty in size and is more transversely compressed of *Induszalim* than *Pabwehshi*. A diastema is also found in the dentary at the level of dentary tooth 4. Splenial at cross section is thick robust four limbs X shaped or four rayed star shaped. Palatine meets on midline formed secondary plate. Dorsal centrum is amphicoelous, big in size than caudal vertebrae. Dorsal centrum is long, slightly tall and slightly waisted. Neurocentral suture open in dorsal vertebra. Caudal vertebrae are amphicoelous, long, strongly waisted and formed arched. Proximal humerus is broad. Femur tibial condyle is greater than fibular condyle, elliptical shaft is curved.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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