New fossil remains of Rhinocerotidae (Perissodactyla) from the early Late Miocene, Irrawaddy Formation of Tebingan Area, Myanmar

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Introduction

Fossil record of Rhinocerotidae in the world [1]:

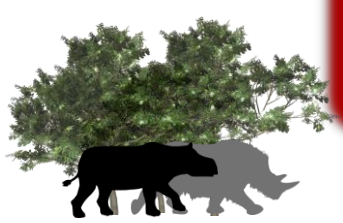
- Africa and Eurasia since the early Oligocene
- North America from the late Eocene to Pliocene.

Rhinocerotid fossils are commonly discovered from the Neogene sediments of southeast Asia but **their evolutionary history is still poorly known** due to the difficulty of the taxonomic identification of dental remains**.** The age of the Tebingan fauna is the early late Miocene (9-8Ma), and Rhinocerotidae are known only by 2 genera and 3 species [2]:

- *Brachypotherium* : *B. perimense* and «*B.*» *fatehjangense*
- *Rhinoceros*: *Rhinoceros* sp.

Contribution

- **First extensive systematic** description.
- Sheded light on the **evolutionary history and paleobiogeography** of Rhinocerotidae in Souteast Asia.



Materials and Methods

Fossils were collected between 2017 and 2020 from the **lowermost part of the Irrawaddy Formation** in the Tebingan area, SE of Magway (Fig. 1). Due to the lack of volcaniclastic sediments, the age of Tebingan was estimated by the combination of following mammals [2]:

Hipparion sp. (Equiidae) *Anisodon* sp. (Chalicotheriidae)

Bramatherium megacephalum (Giraffidae)

Hippopotamodon sivalense (Suidae) Ponginae gen. et sp. indet (Primates)

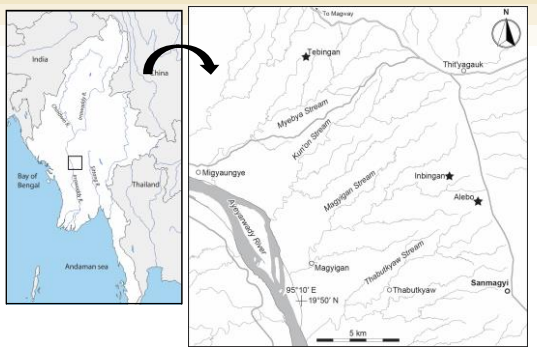


Fig. 1. Map of Tebingan area.

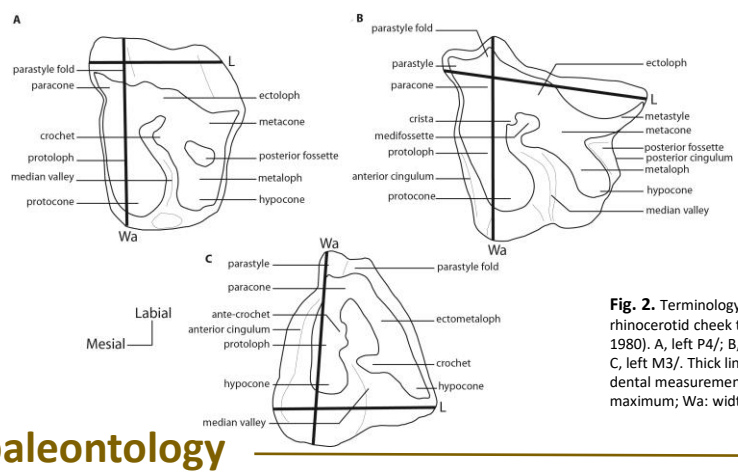


Fig. 2. Terminology of rhinocerotid cheek teeth (Guérin, 1980). A, left P4/; B, left M1/ and C, left M3/. Thick line represents dental measurements, L. length maximum; Wa: width anterior.

Systematic paleontology

Rhinoceros Linnaeus , 1758

***Rhinoceros* spp.** : developed parastyle, presence of the crochet, strong anterior cingulum and absence of a constricted protocone and ante-crochet. Rather deep and wide articular trochlea, low collum tali, posterior facet for the calcaneum triangular [3;4].

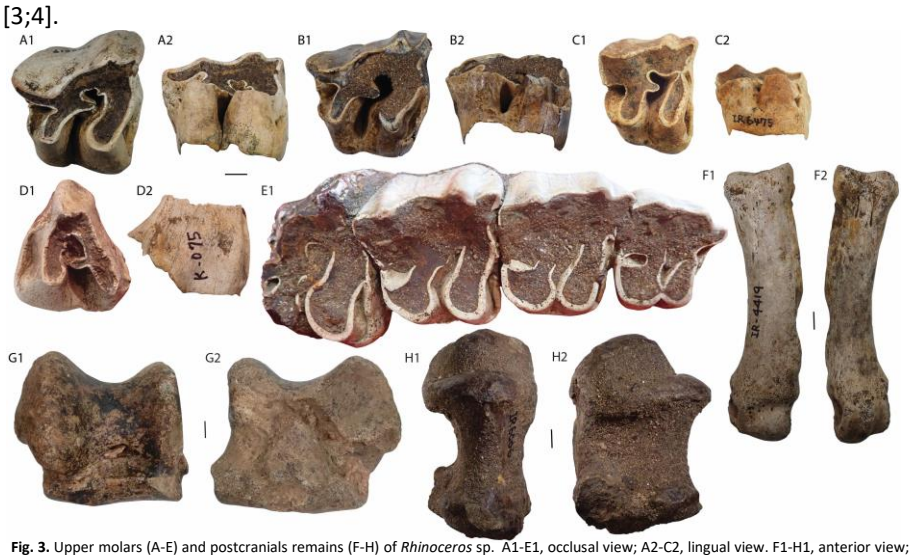


Fig. 3. Upper molars (A-E) and postcranials remains (F-H) of *Rhinoceros* sp. A1-E1, occlusal view; A2-C2, lingual view. F1-H1, anterior view; F2-G2, posterior view and H2, in medial view. A-C, right M1/; D, left M3/; E, right maxillary with P2/-M1/; F, left MtIV; G, right astragalus; H, left calcaneus. Scale bar = 1cm.

Diagnostic characters and dental size of specimens do not correspond to any fossils or current species of *Rhinoceros*.

Brachypotherium Roger, 1904

B. perimense : very broad teeth, a constricted protocone, a well-developed parastyle and metastyle, a convex ectometaloph on M3/ [3;4].

« *B.* » *fatehjangense* : flat ectoloph, a crochet and absence of tubercle at the entrance of the median valley [4].

***Brachypotherium* sp.** : Wide bones, central intercondylar eminence shallow on tibia. Articular surface for the magnum convex, hamatum orientated laterally and flat next the magnum articular on metacarpals [5]

Fig. 4. Upper molars of *B. perimense* (A-E) and « *B.* » *fatehjangense* (F) in occlusal (A1-F1), lingual (A2-B2,D2) and labial views (C2, F2). A and B, M2/; C, D and F, M3/; E, left maxillary of *B. perimense*. And postcranial remains of *Brachypotherium* sp. F, right proximal tibia; G, Right McIII; H, Right McII. Scale bar 1 cm.

Discussion

Table 1: Comparative table between *Rhinoceros* and *Brachypotherium.*

	Rhinoceros	**Note**	***Brachypotherium***	**Note**
Chronological distribution	Since early late Miocene	***Rhinoceros* replaced archaic rhinoceroses** such as *Brachypotherium*, **during the late Miocene** in Southeast Asia due to environmental change [6,7].	early Miocene – late Miocene.	More primitive than *Rhinoceros*. **Extinction due to environnemental change** during the late Miocene (drier climat) replaced by *Rhinoceros* [6].
Area	South and Southeast Asia [8].	**The oldest fossils of *Rhinoceros*** in Southeast Asia **recorded in Tebingan area** suggesting a dispersion from the Indian subcontinent.	Eurasia and Africa.	Asian *Brachypotherium* dispersed from Indian subcontinent to southeast Asia during the middle Miocene.
Environment	Humid forest and woodland.	-	Tropical forests or woodland, semi-aquatic dweller [4].	-
Body proportions	Graviportal	Thick limbs, heavy mass, one horn.	Hippo-like proportion, hornless, short legs.	*B. perimense*, the largest species.
Phylogenetic positions	Tribe Rhinocerotini Gray, 1821 Subtribe Rhinocerotina Owen, 1845 Sister-group of *Dicerorhinus.*	**Six species considered valid**: *R. platyrhinus*, *R. kendengindicus*, *R. sinensis*, *R. sivalensis* (+ current species *R. sondaicus* and *R. unicornis*).	Tribe Rhinocerotini Gray, 1821 Subtribe Teleoceratina Hay, 1902	Phylogeny among *Brachypotherium* not clear. **Attribution of « B ». fatehjangense to Brachypotherium dubious,** attribution according to authors to *Chilotherium*, *Aprotodon* or *Diaceratherium* [9].

References: [1] Nowak, 1991, Johns Hopkins University Press; [2] Takai et al. 2021, Anthropological science; [3] Colbert, 1943, American Philosophical Society; [4] Heissig, 1972, Abh Bayer Akad Wiss Math-Naturwiss Kl; [5] Zervanová et al. 2013, Acta Geologica slovaca; [6] Cerdeño, 1998, Elsevier; [7] Zin-Maung-Maung-Thein et al. 2021, Elsevier; [8] Antoine, 2012, Elsevier; [9] Handa et al. 2020, Historical Biology. This study was supported by JSPS (No. 22H02708 to MT) and by Yamada Science Foundation (No. 1071 to MT).