Rhinoceroses fossils and paleoenvironmental analysis of the early Late Miocene of Tebingan area, central Myanmar – Morgane Clodette LONGUET

Introduction

The early Late Miocene Tebingan site (Magway Region, central Myanmar), where the lowermost part of the Irrawaddy Formation is widely distributed, is known for producing many vertebrate fossils, including 5 orders, 14 families, 18 genera, and 28 different mammal species: Primates (Ponginae), Carnivora (Ursidae, Felidae, and Amphicyonidae), Proboscidea (Mammutidae, Stegodontidae, and Gomphotheridae) Perissodactyla (Rhinocerotidae, Equidae, and Chalicotheridae), and Artiodactyla (Bovidae, Suidae, Anthracotheridae, and Giraffidae). The faunal composition of the Tebingan mammal fauna corresponds to the Nagri and Dhok Pathan faunas of Middle Siwaliks in the Indian subcontinent, suggesting about 9–8 Ma. In this study, I examined the Tebingan mammal fauna, especially Rhinocerotidae, in the context of the paleoenvironmental change in central Myanmar during the Late Miocene.

Materials and Methods

In Chapters I and II, I reconsider identifying rhinocerotid fossils from the Tebingan fauna compared with rhinocerotid fossils from other localities in Myanmar and South/Southeast Asia. The specimens were collected by villagers during farm work between 2017 and 2022. The specimens consisted of isolated teeth, mandibles, maxillae, and post-cranial remains (femur, radius, tibia, metapodial, astragalus, and calcaneus).

Secondly, I tried to predict the environment in which Rhinocerotidae could live. In Chapter III, the paleoenvironment was predicted using the cenogram method. The body mass of the species found in the Tebingan area was estimated. The maximum length of

the first lower molar was measured in millimeters with a digital calipers and included in the allometric equations of Damuth and MacFadden (1990). Body mass was then ordered from largest to smallest. Thus, the type of environment (closed/open, arid/humid) can be deduced from the shape and the slope of large mammals. For more detailed information on the paleoenvironment, a second method was used, called ecometrics. After measuring the maximum length and the length of the calcaneus tuber in millimeters, the gear ratio could be calculated and thus compared with the data of extant artiodactyls.

Results

To date, only three species of Rhinocerotidae have been recognized in the Tebingan fauna: *Rhinoceros* sp., *Brachypotherium perimense*, and "*B*." *fatehjangense*, though the Siwaliks fauna of south Asia shows a greater diversity of Rhinocerotidae, with five genera reported at the same geological time. Based on craniodental remains (isolated teeth, mandible, and maxilla) and post-cranial remains (femur, humerus, tibia, etc.) of the Tebingan fauna, five species belonging to the Rhinocerotidae were newly identified: *Rhinoceros* sp., *B. perimense*, "*B*." *fatehjangense*, cf. *R. sondaicus,* and *Dicerorhinus* sp. (Chapters I and II). These discoveries show that *Rhinoceros* and *Dicerorhinus,* two endemic extant rhinoceroses in South/Southeast Asia, had already appeared in the early Late Miocene in central Myanmar.

In Chapter III, the preliminary results of the Tebingan cenogram indicate that the environment may be closed under humid conditions. Unfortunately, the cenogram of the Tebingan fauna is based on large-sized mammals only, as no middle- or small-sized mammals have yet been found.

In Chapter IV, I performed the ecometric analysis using the gear-ratio of the calcaneus of artiodactyl fossils of the Tebingan fauna, comparing with the data of extant artiodactyls. The results suggest higher precipitation in the early Late Miocene Tebingan area than in the latest Miocene Chaingzauk area in central Myanmar. This result confirms the previous works based on the stable carbon and oxygen isotope values of tooth enamel of the Chaingzauk mammals, which indicated that the floral transition from C_3 to C_4 plants had occurred in central Myanmar during the Late Miocene. The paleoenvironment of the Tebingan fauna was likely a predominantly evergreen environment with some grassland with relatively high precipitation throughout the year, indicating the start of environmental change in the early Late Miocene in central Myanmar. Additional revision of other mammal taxa including primates, proboscideans, artiodactyls, and carnivores, and the stable isotope analyses would shed light on the paleoenvironment of the Tebingan hominoid fauna.

Discussion

The reexamination of the Tebingan rhinocerotid fossils revealed the possible migration events of the Miocene rhinocerotids from South Asia toward Southeast Asia. The first migration of rhinocerotids, such as *Brachypotherium,* occurred during the middle Miocene from the South Asia Indian subcontinent. *Brachypotherium*, considered similar in habit to living hippos, likely lived in a humid environment close to the seacoast. The environmental change during the later Miocene may have led to the extinction of archaic genera, such as *Brachypotherium*. During the Late Miocene, modern rhinoceotids such as *Rhinoceros* and *Dicerohinus,* migrated from South Asia to Southeast Asia, including Myanmar. The southern retreating of the coastline in Myanmar during the Late Miocene may have produced new wetland environments favorable to rhinocerotids.

However, subsequent climate change during the Pleistocene caused *Rhinoceros* and *Dicerorhinus* to migrate once again to the islands of Southeast Asia, where they are known today.

Conclusion

The estimated paleoenvironment of the early Late Miocene Tebingan fauna is a closed forest combined with open grassland in a humid climate, where Asian monsoon seasonality may have already appeared. Precipitation was higher during the early Late Miocene but probably became lower during the Late Miocene. These environmental changes occurred progressively in central Myanmar from the early Late Miocene onwards.