The emergence of modern zoogeographic regions in Asia through the lens of climate–dental traits association patterns Appendix

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Abstract

The complex and contrasted distribution of terrestrial biota in Asia has been linked to active tectonics and dramatic climatic changes during the Neogene. However, the timings of how these distributional patterns arose and the underlying climatic and tectonic mechanisms remain disputed. Here, we apply a computational data analysis technique, called redescription mining, to track these spatiotemporal phenomena by studying the associations between the prevailing herbivore dental traits of mammalian communities and climatic conditions during the Neogene. Our results indicate that the modern latitudinal zoogeographic division emerged after the Middle Miocene climatic transition (ca. 14 million years ago), and that the modern monsoonal zoogeographic pattern emerged during the late Late Miocene (ca. 7 Ma). The presence of a montane forest biodiversity hotspot in the Hengduan Mountains alongside Alpine fauna on the Tibetan Plateau suggests that the modern distribution patterns may already have been established since the Pliocene (ca. 5 Ma). This work provides an advanced understanding of how tectonics and climate shape the distribution of terrestrial biota in Asia.

Keywords: Asia, Neogene, zoogeographic region, mammalian communities, dental traits, paleoclimate simulation, redescription mining

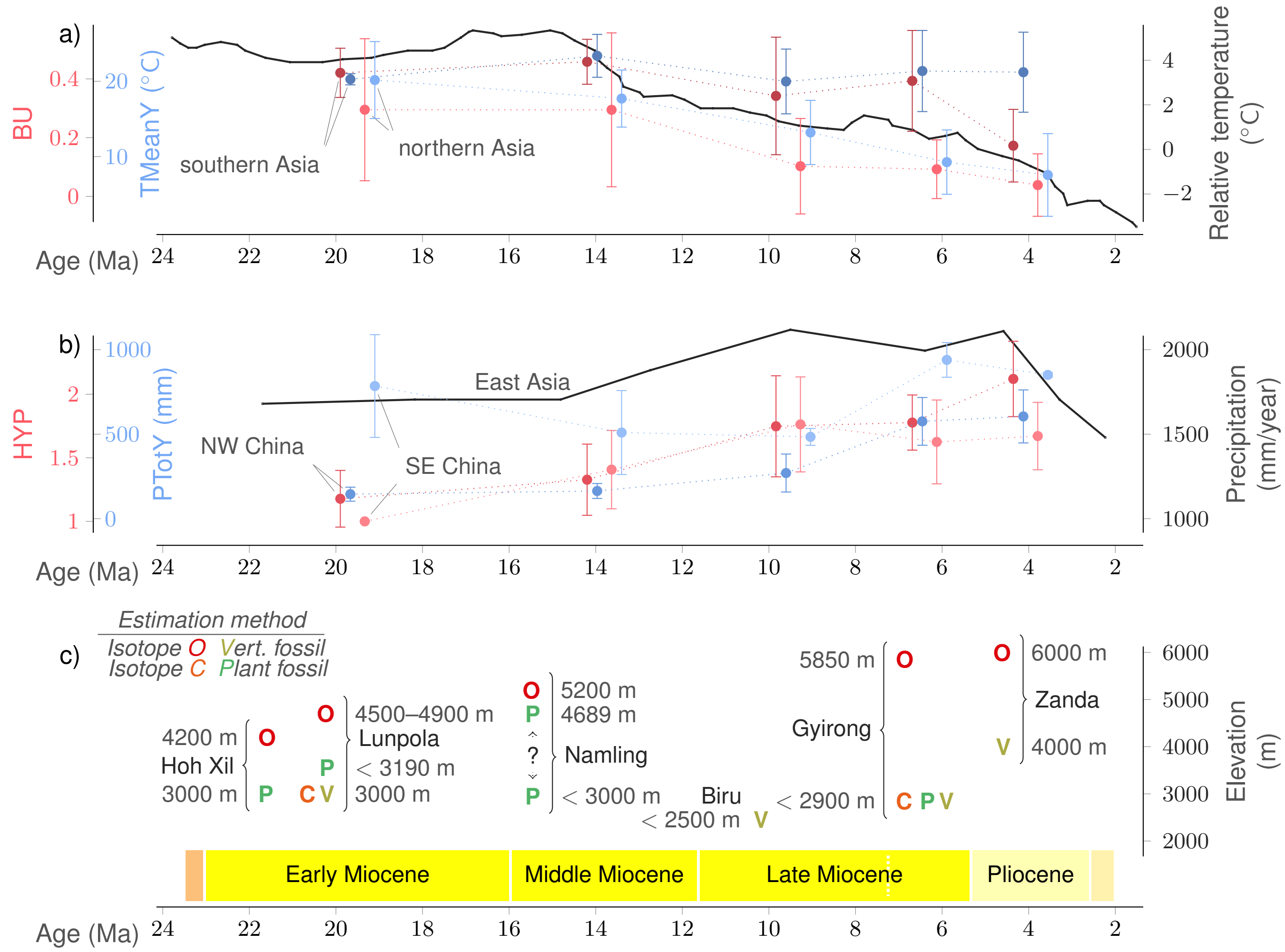

Fig. 1 Temperature, precipitation, elevation, bunodonty and hypsodonty trends through the Neogene. a) Global temperature trend (based on [1]) and average bunodonty values in northern and southern Asia. b) Modeled mean annual precipitation for East Asia (based on [2]) and average hypsodonty values in northwestern (NW) and southeastern (SE) China. c) Elevation estimates for the Tibetan Plateau (data resources in Supplementary Information).

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Table 1 Data sources for the elevation estimates for the Tibetan Plateau from Fig. 1.

Time interval	Site	Estimation method			
		Isotope O	Isotope C	Plant fossil	Vertebrate fossil
Early Miocene	Lunpola	4500–4900 m [3]	3000 m [4]	$<$ 3190 m [5]	3000 m [6]
	Hoh Xil	4200 m [3]		3000 m [7]	
Middle Miocene	Namling	5200 m [8]		4689 m [9] $<$ 3000 m [10]	
early Late Miocene	Biru				$<$ 2500 m [11]
late Late Miocene	Gyirong	5850 m [12]	$<$ 2900 m [13]	$<$ 2900 m [11]	$<$ 2900 m [13]
Pliocene	Zanda	6000 m [14]			4000 m [15]

Table 2 Coordinates of the corners of the rectangles used to define the study region. The first five formed the dataset considered in our previous study [16] whereas the last four have been added in the present study and constitute the northern extension of our dataset.

Name	south-west	north-east
South East	$10°$N, $90°$ E	$20°$ N, $115°$E
South West	$5°$N, $66°$ E	$28°$ N, $90°$E
North East	$20°$N, $80°$ E	$35°$ N, $125°$E
North West	$28°$N, $67°30'$E	$37°30'$N, $90°$E
North Mid	$35°$N, $80°$ E	$40°$ N, $120°$E
Extension North East	$42°$N, $130°$ E	$50°$ N, $142°$E
Extension North Mid	$42°$N, $125°$ E	$50°$ N, $130°$E
Extension Korea	$30°$N, $125°$ E	$42°$ N, $130°$E
Extension West	$36°$N, $67°30'$E	$50°$ N, $125°$E

Table 3 Geographic conditions defining the groups of localities for computing and comparing dental traits and climate trends in Fig. 1.

	x_1	x_2
(A)	$28°$N	
(B)	$18°$N, $106°$E	$36°$N, $70°$E
(C)	$43°$N, $124°$E	$24°$N, $87°$E

condition	group
north of (A)	northern Asia
south of (A)	southern Asia
north-east of (B) and south-east of (C)	northwestern (NW) China
north-east of (B) and north-west of (C)	southeastern (SE) China

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