

**Bharatihuda (Chalcolithic, Mahanadi Belt):
first discovery of *Rhinoceros* Linnaeus, 1758
(Mammalia, Rhinocerotidae) in the Odisha State, India**

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Bharatihuda (Chalcolithic, Mahanadi Belt): first discovery of *Rhinoceros* Linnaeus, 1758 (Mammalia, Rhinocerotidae) in the Odisha State, India

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ABSTRACT

An archaeological excavation of the Chalcolithic-Iron age site of Bharatihuda (1404–1000 BCE), in the Mahanadi delta, yielded the first discovery of skeletal elements of rhinoceros in the Odisha state, East India. After a short review of Pleistocene and archaeological records of *Rhinoceros* Linnaeus, 1758 in the Indian Subcontinent, the Bharatihuda mound and the rhinoceros remains are described. Six individuals of the greater one-horned rhinoceros, *Rhinoceros unicornis* Linnaeus, 1758, either juvenile, subadult, adult or very old, are recognised based on their morphological features and large dimensions. A single fragmentary humerus documents a smaller and slenderer form, *Rhinoceros* cf. *sondaicus*, close to the Javan rhinoceros, in the youngest archaeological layer (Mature Chalcolithic, c. 1072 BCE). Bharatihuda both testifies to the first occurrence of *Rhinoceros* in coastal areas west of the Bay of Bengal during Holocene times and potentially highlights the persistence of two sympatric *Rhinoceros* species, around 3 000 years ago, in a human-related context. In contrast to the huge amount of other wild mammalian remains found at Bharatihuda, very few chopping, cutting marks or other anthropogenic modifications were found on the 30 rhinoceros remains unearthed. Rhinoceroses were seemingly a particularly inconspicuous component in the Mahanadi delta ecosystems in those times, with vulnerable individuals seldomly hunted.

KEY WORDS

Late holocene,
fossil record,
zooarchaeology,
morphology,
Mahanadi delta,
human-megaherbivore
interactions.

RÉSUMÉ

Bharatihuda (Chalcolithique, delta de Mahanadi) : première découverte de Rhinoceros Linnaeus, 1758 (Mammalia, Rhinocerotidae) dans l'état d'Odisha (Inde).

Les fouilles archéologiques du site de Bharatihuda (Chalcolithique-Âge du fer ; 1404-1000 avant notre ère), dans le delta de Mahanadi, ont permis la première découverte d'éléments squelettiques de rhinocéros dans l'État d'Odisha, en Inde orientale. Après un bref aperçu des données archéologiques relatives aux rhinocéros dans le sous-continent indien, le tumulus de Bharatihuda et les restes de rhinocéros sont décrits. Six individus de rhinocéros unicolore (*Rhinoceros unicornis* Linnaeus, 1758), juvéniles, subadultes, adultes ou très âgés, ont été identifiés grâce à leurs caractéristiques morphologiques et à leur grande taille. Un humérus fragmentaire témoigne de l'existence d'une forme plus petite et plus élancée, *Rhinoceros* cf. *sondaicus*, proche du rhinocéros de Java, dans la couche archéologique la plus récente (Chalcolithique tardif, vers 1072 avant notre ère). Le site de Bharatihuda témoigne de la première présence de rhinocéros dans les zones côtières à l'ouest du golfe du Bengale durant l'Holocène et met potentiellement en lumière la persistance de deux espèces de rhinocéros sympatriques, il y a environ 3 000 ans, dans un contexte de présence humaine. Par contraste avec l'abondance d'autres restes de mammifères sauvages découverts à Bharatihuda, très peu de marques de découpe ou autres modifications anthropiques ont été relevées sur les 30 spécimens de rhinocéros exhumés. Les rhinocéros semblaient être un élément particulièrement discret des écosystèmes du delta du Mahanadi à cette époque, dont seuls les individus vulnérables étaient parfois chassés.

MOTS CLÉS
Holocène récent,
registre fossile,
archéozoologie,
morphologie,
delta du Mahanadi,
interactions humains-
mégaherbivores.

INTRODUCTION

In South and/or Southeast Asia, three living species of rhinoceroses are reported, namely the Greater one-horned rhinoceros, *Rhinoceros unicornis* Linnaeus, 1758, the Javan rhinoceros, *Rhinoceros sondaicus* Desmarest, 1822, and the Sumatran rhinoceros, *Dicerorhinus sumatrensis* (Fischer, 1814). Due to unlimited hunting and deforestation in the last century, these three species became highly endangered, like their African relatives (Melletti *et al.* 2025). The Javan and Sumatran rhinoceroses are now extinct from the Indian territory: only the Greater one-horned rhinoceros survives in protected areas in Assam and West Bengal in North-East India, and in the south of Nepal (Rookmaaker 2024).

As derived from the palaeontological, archaeological and recent historical records (Fig. 1), the greater one-horned rhinoceros, *Rhinoceros unicornis*, undoubtedly had its range in far larger areas of the Indian subcontinent during the Holocene (Bose 2020; Rookmaaker 2024). In particular, its presence is well established from rock art (Fig. 1), considered to span the 12000-4000 years BP interval in Uttar Pradesh and Madhya Pradesh, India (Manuel 2008; Neumayer 2011). Also, rhinoceros' artefacts and subfossil remains were uncovered in Harappan sites in Pakistan, Afghanistan, and India (mostly in Gujarat, but also in Rajasthan, Haryana, and Uttar Pradesh), all ranging from *c.* 2600-1900 BCE (Fig. 1; Bose 2018, 2020). A still wider Holocene range is revealed by (sub)fossil skeletal remains excavated in a wealth of Mesolithic and Neolithic localities from Gujarat, Madhya Pradesh, Uttar Pradesh, Bihar, Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu states in India (Fig. 1; Rookmaaker 2024: 114, table 8.17; Selvakumar *et al.* 2026).

A recent excavation of the Chalcolithic-Iron age site of Bharatihuda, in the Mahanadi delta of Odisha, East India (Fig. 2), allowed for the discovery of rhinoceros' skeletal

fragments, for the first time in the Odisha state, along with thousands of bone fragments of other wild and domestic mammalian species. The cultural sequence of the Bharatihuda site dates back to around 1404 BCE (Early Chalcolithic) for the earliest stratum and it spans the entire Chalcolithic and a part of the Iron Age (until 1000 BCE; Garhnayak *et al.* 2024). As indicated by the distinctive morphological features and the large dimensions of most rhinoceros remains, this site appears to yield *Rhinoceros unicornis*, while a smaller form (*Rhinoceros* cf. *sondaicus*) is suggested through a single postcranial remain. As such, Bharatihuda appears to represent one of the rare Holocene bispecific rhinoceros assemblages, comprising the Greater one-horned rhinoceros and the Javan rhino (Rookmaaker 2024). This is particularly true regarding skeletal remains (Fig. 1), as stated in the next section, dedicated to the state of the art.

More broadly, this article aims at: 1) presenting the Bharatihuda archaeological site; 2) describing and identifying the rhinoceros remains that it yields; and 3) discussing the implications of these unexpected Chalcolithic-Iron-age occurrences in Odisha, including in terms of taphonomy and relations to humans.

ARCHAEOLOGICAL RECORDS OF RHINOCEROS IN THE INDIAN SUBCONTINENT

A wealth of fossil rhinocerotids had been recovered from the Indian subcontinent between Oligocene and Pleistocene times (e.g., Pilgrim 1910; Heissig 1972; Antoine *et al.* 2003, 2013, 2025; Antoine 2012), particularly from the Bugti Hills in Pakistan and the Siwaliks in North West India and Pakistan (e.g., Patnaik 2013; Antoine 2025), but also South India in Tamil Nadu, Karnataka and Andhra Pradesh and Sri Lanka (e.g., Falconer & Cautley 1847; Sathe 2010; Geraads *et al.* 2026). Among them, *Rhinoceros unicornis* is recorded over

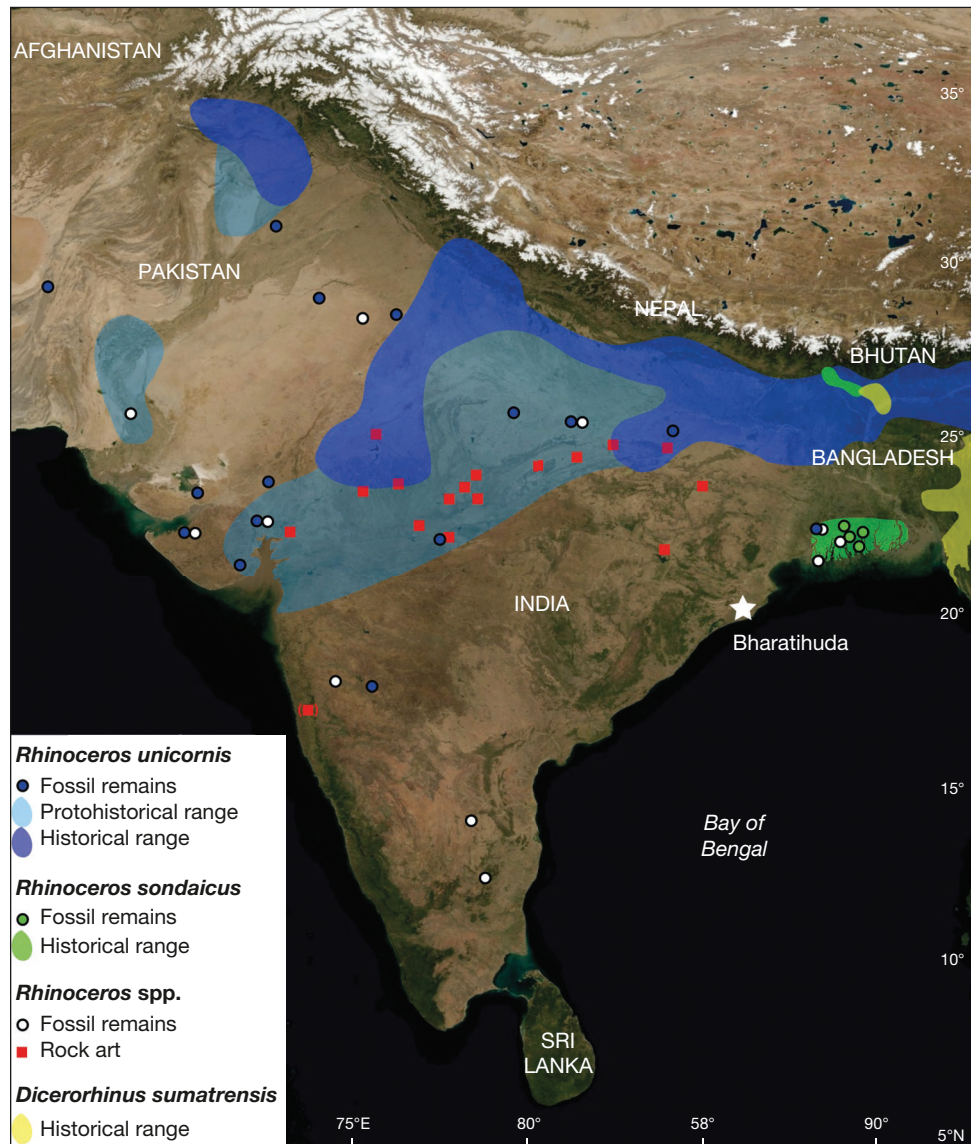


FIG. 1. — Distribution map of rhinoceroses in South Asia in the Holocene, including fossil remains, protohistorical records (until 1500 BCE), historical records (from 1500 BCE onwards), and rock art (petroglyphs). Modified and compiled from Divyabhanusinh *et al.* (2018), Bose (2020), and Rookmaaker (2024). Credits: background map based on https://upload.wikimedia.org/wikipedia/commons/d/df/Indian_Subcontinent.jpg

Pleistocene times, ranging from North and Northwest India, Gujarat, Madhya Pradesh, and Tamil Nadu (Rookmaaker 2024). In the Holocene epoch, this species was reported to be distributed in entire North India (Uttar Pradesh, Rajasthan and Gujarat), and also from Pakistan, based on archaeological findings of skeletal remains (see previous section and Figure 1).

Quite a number of Indus Valley Civilisation sites, both in Pakistan and India, yielded *Rhinoceros unicornis* bones. Mesolithic sites of Uttar Pradesh and Gujarat also provided skeletal parts of the Greater one-horned rhinoceros (Bose 2018; Rookmaaker 2024). This species is also reported in some younger, Microlithic and Neolithic, sites of Gujarat and Bihar (Rookmaaker 2024 and references therein). Conversely and until now, the Holocene rhinoceros record is particularly sparse all over the Eastern Ghats, be it through fossil specimens, artifacts, or rock art (see Fig. 1; Rookmaaker 2024: map 8.1).

The number of skeletal remains of *Rhinoceros unicornis* is extremely restricted in all the above-mentioned archaeological sites, with exception of some Mesolithic sites such as Damdama, Uttar Pradesh (Thomas *et al.* 1995). Nevertheless, the Indus Valley was well acquainted with this species as huge numbers of man-made artefacts like seals, sculptures, or figurines depicting one-horned rhinos had been recovered from the corresponding sites (Rookmaaker 2024 and references therein). Moreover, a number of rock-art sites with one-horned rhinoceroses were found around the Mirzapur district of Uttar Pradesh (Rookmaaker 2024 and references therein). In central India also, some rock art portraying one-horned rhinoceroses is reported as at Ratnagiri (Wathe & Ramani 2024) and Vidarbha (Pawar 2015) in Maharashtra and Bhimbetka caves and many other places of Madhya Pradesh (Rookmaaker 2024). Indeed, the species of rhinoceros depicted could not

TABLE 1. — Available ^{14}C datings from the Trench ZA6/III of the excavated mound of Bharatihuda archaeological site, dated by using Accelerator mass spectrometry (AMS) radiocarbon technique at Inter University Accelerator Centre (IUAC) facility, New Delhi. Credits: Archaeological Survey of India.

Bharatihuda excavated layers	Sample ID	Dates	
		BCE	BP
Layer 7 (Period IA; Early Chalcolithic)	IUACD#18C2180	1404	3132 $\pm$ 39
Layer 5 (Period IB; Mature Chalcolithic)	IUACD#18C2177	1269	3022 $\pm$ 31
Layer 4 (Period IB; Mature Chalcolithic)	IUACD#18C2176	1099	2909 $\pm$ 39
Layer 3 (Period IB; Mature Chalcolithic)	IUACD#18C2175	1072	2890 $\pm$ 34

be assigned properly and hence the Holocene occurrence of *Rhinoceros unicornis* is not authenticated in these regions, even if the presence of any other species is highly unlikely.

In the state of Odisha, no skeletal remains associated with any rhinoceros species were found thus far, despite the extensive exploration of a number of archaeological sites, including in the Mahanadi delta (Fig. 1). Although Jerdon (1867: 234) in the authoritative Mammals of India reported very few individuals of the Javan rhinoceros along the Mahanadi River, this was shown to be mistaken very soon after by Ball (1877), who extensively surveyed the region, supported by Blanford (1891). There is very limited evidence about the presence of any species of rhinoceros in Odisha (Rookmaaker 2024: 593). This includes an uncertain reference to Neolithic rock art at Vikramkhola (Manuel 2008), trade of rhino hide mentioned by the grammarian Panini in the 5th century BCE (Mishra 2003), some very small punch-marked coins embossed with rhino motif and a crystal pendant found in Asurgarh in 1st century BCE (Mishra 2003) and a rhino symbol on a statue Khandagiri caves in 2nd century BCE (Ganguly 1912). None of these items refer to any observations of rhinoceros in the region of Odisha state, and the presence of rhinoceros thus far remained unsubstantiated.

MATERIAL AND METHODS

The entire faunal remains unearthed during the large scale excavation of the archaeological mound of Bharatihuda by the Archaeological Survey of India, Excavation Branch IV, Bhubaneswar, Odisha in 2018 were handed over to the Zoological Survey of India, Kolkata (ZSI) for identification and study. The corresponding specimens (labelled BHD for Bharatihuda) are permanently stored at the Palaeozoology Division, ZSI.

Along with a large number of skeletal fragments of domestic mammals (such as cattle, buffalo, pig, goat, sheep and dog) and wild species (e.g., Nilgai, wild buffalo, wild boar, spotted deer, Sambar, Barasingha, wolf, hare, and many others), about 30 rhinoceros bones and teeth have been identified, deriving from different trenches and strata. These specimens, some being fragmentary, have been identified following standard zooarchaeological manual and literature. Measurements have been taken by calipers (straight line measurement) following the methodology of Guérin (1980), but also von den Driesch (1976) and Eisenmann (1986). The dimensions are given in mm.

In the descriptions, capital letters are used for the upper teeth (P, premolar; M, molar), while lower case letters indicate lower teeth (i, p, m). Dental terminology follows Heissig (1972) and Antoine (2002); cranio-mandibular, dental, and postcranial features here described primarily correspond to cladistic characters listed by Antoine *et al.* (2022). Mc denotes metacarpals, Mt metatarsals. Anatomical comparison was primarily performed with craniomandibular, dental, and postcranial specimens of all three Recent Asian rhinoceros species, on the basis of material stored in the comparative anatomy collections of the Muséum National d'Histoire Naturelle, Paris (MNHN-AC), of the osteology collections of the Université de Montpellier (UM) and the Zoological Survey of India (ZSI), fossil material from Naturalis, Leiden, and from dedicated literature (e.g., Pocock 1945; Guérin 1980; Antoine 2002).

Tooth ages are inferred through wear stages, based on Hillman-Smith *et al.* (1986) and Hullot & Antoine (2020).

THE BHARATIHUDA ARCHAEOLOGICAL SITE

The Bharatihuda archaeological site (20°06'47"N, 86°05'10"E) is situated near the Jallarpur village of Niali *tehsil* in the Cuttack District of Odisha, East India. The mound is located in between the left bank of river Prachi and the right bank of rivulet Tanala, 20 km away from the Bay of Bengal (Fig. 2A). Local geology is primarily characterised by Lower Holocene sediments of alluvial origin within a deltaic setting, making it one of the youngest marine-related layers at the regional scale (Mahalik *et al.* 1996).

The existing mound of Bharatihuda measures approximately 46,215 m² having heights of 4 m from the surrounding area. The large scale excavation by the Archaeological Survey of India during 2017-2018, revealed an ancient human culture dating back to c. 1500 years BCE (Garnayak *et al.* 2024). Around 750 m² were excavated in 30 quadrants in three pockets within the site (Fig. 2B, C). Out of them, only three quadrants have encountered natural strata having 5.50 m of habitational deposits divisible into 7 to 8 layers, and divisible into three cultural phases of human occupation without hiatuses being Early Chalcolithic, Mature Chalcolithic and Iron Age from bottom to top, determined based on the excavated material remains unearthed by excavation.

The deposit is divided into two major periods, i.e., Period I – Chalcolithic having two sub-phases in it as Period IA (Early Chalcolithic – layers 8-6) plus Period IB (Mature Chalcolithic – layers 5-3) and Period II

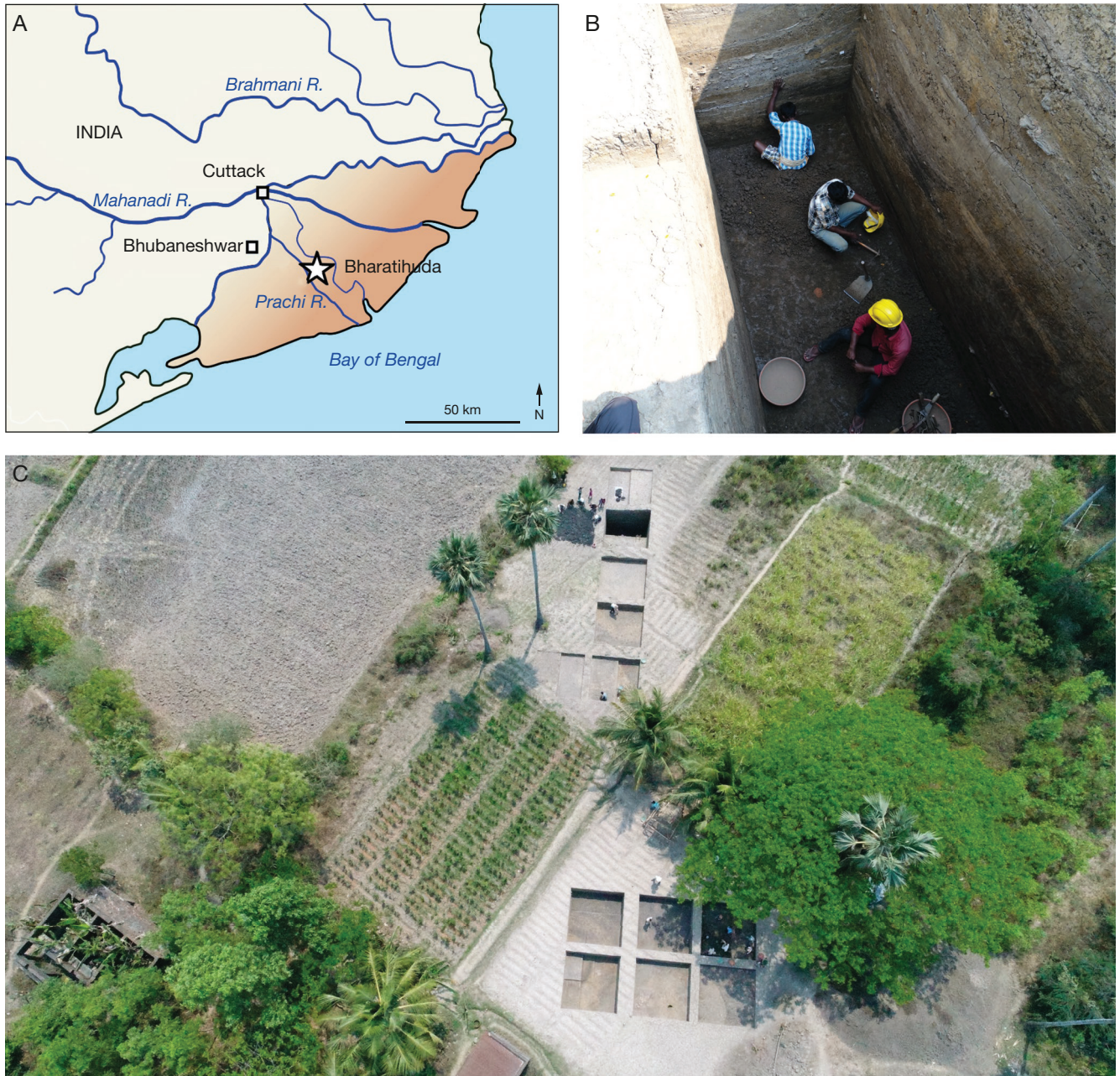


FIG. 2. — **A**, Bharatihuda archaeological site, in the Mahanadi Delta (**brown area**), Odisha State, East India; **B**, **C**, details of the excavation in 2017-2018. Credits: Archaeological Survey of India.

(Iron Age – layers 2-1). Radiocarbon dates available for different layers are detailed in the next subsection and in Table 1. The extensive excavation (Fig. 2C) uncovered numerous pottery pieces and potsherds across various layers. Traces of structural remains, such as mud huts and platforms, were found from the upper levels of layer 6 to layer 1. Over 300 diverse antiquities were unearthed, predominantly made of stone, followed by terracotta, bone, glass or wax, semi-precious stone beads, copper, iron, and tiny gold foil. In addition to these bone artefacts, a substantial number of animal remains like bones or teeth were unearthed throughout all strata of the site.

Faunal remains include wild mammalian species like Nilgai (*Boselaphus tragocamelus* (Pallas, 1766)), Wild water buffalo (*Bubalus arnee* (Kerr, 1792)), Wild boar (*Sus scrofa scrofa* Linnaeus, 1758), Spotted deer (*Axis axis* (Erxleben, 1777)), Hog deer (*Axis porcinus* (Zimmermann, 1780)), Barasingha (*Rucervus duvaucelii* (G.Cuvier, 1823)), Sambar deer (*Rusa unicolor* (Kerr, 1792)), Barking deer (*Muntiacus muntjak* (Zimmermann, 1780)), Wolf (*Canis lupus* Linnaeus, 1758), Feral cat (*Felis* sp.), Indian elephant (*Elephas maximus* Linnaeus, 1758), and Indian hare (*Lepus nigricollis* F.Cuvier, 1823); and domestic forms like Zebu (*Bos indicus* Linnaeus, 1758), Water buffalo (*Bubalus bubalis* (Linnaeus, 1758)), Goat (*Capra*

hircus Linnaeus, 1758), Sheep (*Ovis aries* Linnaeus, 1758), Pig (*Sus scrofa domesticus*), Dog (*Canis lupus familiaris* Linnaeus, 1758), fowl as well as huge numbers of fish and turtles. This is indicative of the hunting, farming and fishing community's existence over there in ancient time. Many of the bones bear chopping marks, cut marks and charring sign, showing that these vertebrates were part of local inhabitants' diet.

AGE MODEL

Several Chalcolithic layers of the Bharatihuda site were dated using AMS radiocarbon techniques in the trench ZA6/III (Table 1), at the Inter-University Accelerator Centre (IUAC), New Delhi. The ages obtained range between 1404 BCE and 1072 BCE. No radiocarbon dates are available for the Period II, but based on ceramic assemblage recovered, the topmost layers of Iron Age (Pd II), 2 and 1 are assigned to around 1000 BCE to 800 BCE (Garnayak *et al.* 2024).

The settlement was abandoned for an unknown reason towards the end of Period II. Natural shifting of the river channel over time or changing landform causing huge flooding have perhaps forced the inhabitants to abandon the place.

RESULTS

SYSTEMATIC PALAEONTOLOGY

Order PERISSODACTYLA Owen, 1848
Family RHINOCEROTIDAE Gray, 1821
Subfamily RHINOCEROTINAE Gray, 1821
Tribe RHINOCEROTINI Gray, 1821
Genus *Rhinoceros* Linnaeus, 1758

Rhinoceros unicornis Linnaeus, 1758
(Figs 3; 4)

Rhinoceros unicornis Linnaeus, 1758: 56.

REMAINS STUDIED. — Skeletal remains of *Rhinoceros* have been recovered from all cultural periods excavated at Bharatihuda (see below).

LOCALITY. — East India, Odisha, Bharatihuda archaeological mound.

EARLY CHALCOLITHIC AGE (PERIOD IA). — BHD 1470. Left M2 of a young individual; BHD 1916. Left P3 of a young individual, anterior fragment (trench A10, Qd-I, layer 6, depth 322-329 cm).

MATURE CHALCOLITHIC AGE (PERIOD IB). — BHD 59. Right mandibular angle of an old individual; BHD 60. Fragment of mandible with opening of mandibular foramen (trench ZA8, Qd-IV, layer 3, depth 35.5-44 cm); BHD 163. Right lower molar, worn fragment; BHD 164. Six root fragments of upper cheek teeth (trench YA8, Qd-II, layer 2 and 3, depth 52-105 cm); BHD 1321. Second phalanx, left Mc4 (trench ZA7, Qd-I, layer 3, depth 115-126 cm).

IRON AGE (PERIOD II). — BHD 33. Fragment of horizontal ramus of mandible (trench A6, Qd-IV, layer 1, depth 6-4 cm); BHD 43. Broken right astragalus of a subadult individual; BHD 44. Right calcaneus from the same individual (trench YA8, Qd-III, layer 1, depth 39-57 cm); BHD 137. First phalanx of a right Mt3; BHD 138. Second phalanx of a right Mt3 from the same individual (trench

YB8, Qd-III, layer 2, depth 72-80 cm); BHD 581. First phalanx of a left Mt4; BHD 582. Fragment of third phalanx of a left Mc2; BHD 1917. Right semilunate (trench XA6, Qd-IV, layer 2, depth 12-19 cm); BHD 981. First phalanx of a left Mt4; BHD 982. Third phalanx of a left Mt4 (trench YB8, Qd-III, layer 2, depth 80-90 cm); BHD 1205. Third phalanx of a right Mt3 (trench YA8, Qd-III, layer 2, depth 50-65 cm); BHD 98. Left i2 from an old individual (trench YA8, Qd-IV, layer 2, depth 88-96 cm); BHD 1915. Right i2 from the same individual as BHD 98 (trench YA8, Qd-III, layer 2, depth 89-94 cm); BHD 1834. Tip of (?right) i2 of a juvenile individual (trench ZA8, Qd-IV, layer 2, depth 21.5 cm); BHD 1850. Sesamoid (trench ZA8, Qd-IV, layer 2, depth 1-7 cm); BHD 53. Fragment of third phalanx of a left Mt2 (trench A6, Qd-II, layer 2, depth 88-96 cm); BHD 931. Right ulna, distal fragment (trench A6, Qd-III, layer 1, depth 36-47 cm); BHD 241. Right Mt2 (trench YB8, Qd-III, layer 2, depth 65-72 cm); BHD 855. Left Mc4 (trench YB8, Qd-II, layer 1, depth 74-82 cm); BHD 292. Right pisiform, proximal fragment (trench A6, Qd-IV, layer 1 and 2, depth 40-46 cm).

DESCRIPTION

Mandibular remains

A posteroventral fragment of a right mandibular angle is preserved (BHD 59). In lateral view, it forms a low strip (c. 45 mm high), with its medial and lateral margins particularly irregular. This is due to the presence of centimetric sharp-edged exostotic rugosities, subparallel and developed both medially and laterally (Fig. 3F), hence points to an old individual. In posterior view, the posteroventral margin is particularly wide, with a curved profile. By contrast to the rugose lateral edge, this margin is regularly convex, with a smooth aspect.

Associated to BHD 59, a 10 cm long fragment of a left corpus mandibulae was found, preserving the opening of the mandibular foramen (BHD 60), well below the tooth row, on its medial side. The surface of this side is irregular, with sharp horizontal ridges. The specimen is badly broken, but a shallow vascular/angular notch is visible on its ventral margin. We note the presence of fresh and straight broken facets on this mandibular fragment.

Another small fragment of corpus mandibulae is documented (BHD 33). Once again, the medial and lateral sides display sharp osseous ridges, disturbing the usually-flat aspect of the dentary. Other morphological features are not preserved and its laterality is not discernable.

Dental remains

No coronary cement is preserved on the dental specimens from Bharatihuda, except on the lower molar BHD 163.

BHD 1916 is an anterior fragment of a left P3, slightly worn, of a young individual (Fig. 3A, B; Table 2). The crown is higher than wide, corresponding to a hypsodont tooth. Enamel is thick and corrugated, especially on the strong and sinuous anterior cingulum. This cingulum is running obliquely all over the anterior side, from the apex of the paracone to the neck below the protocone, and it vanishes both lingually and labially: there was probably neither labial nor lingual cingulum. The protocone is constricted both anteriorly and posteriorly and isolated from the hypocone all over its height, defining a molariform pattern for the P3 (Fig. 3B).

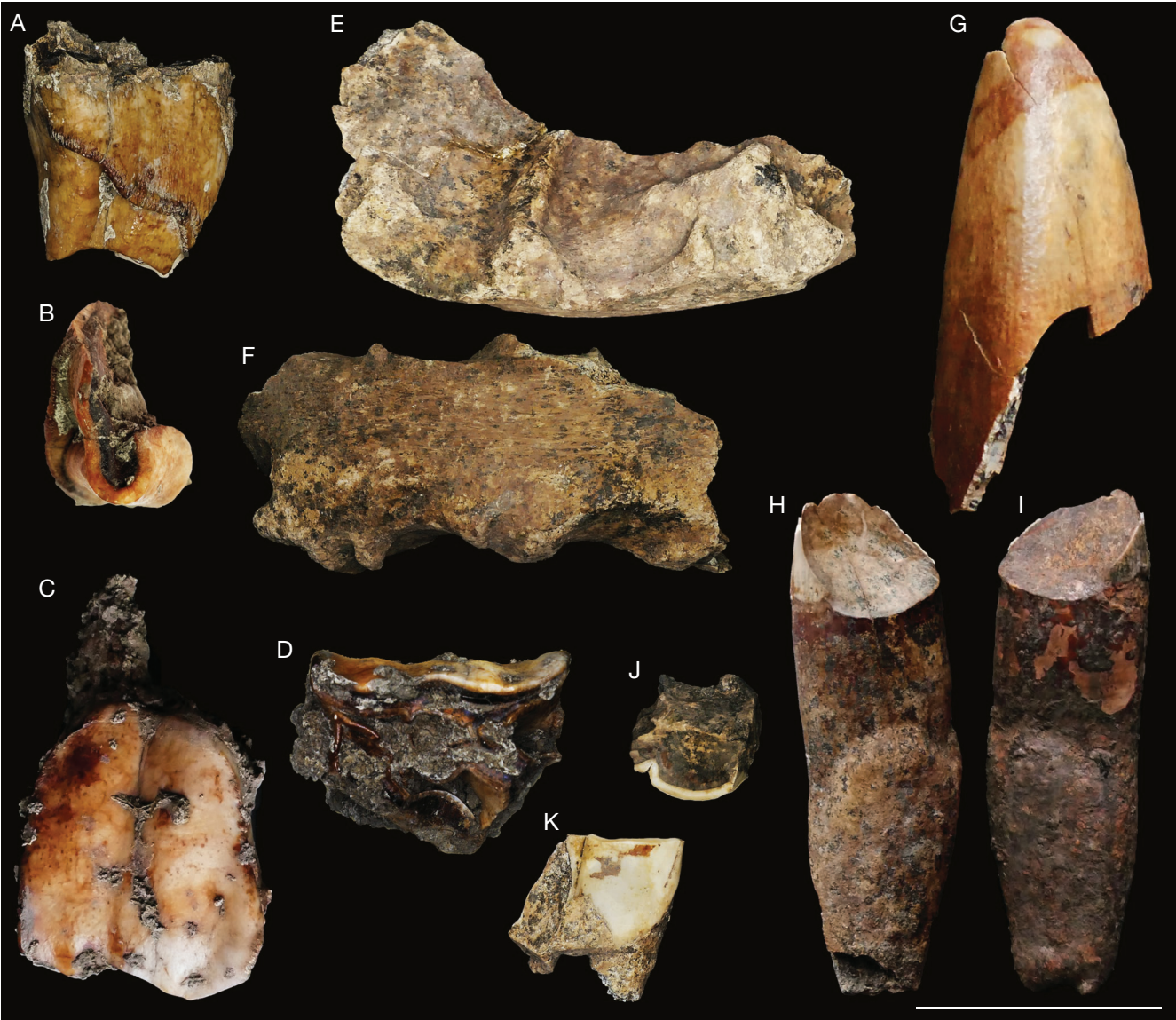


FIG. 3. — *Rhinoceros unicornis* Linnaeus, 1758, Mandibular and dental remains. Chalcolithic Age, Bharatihuda archaeological mound, Odisha, East India: **A, B**, BHD 1916, left fragmentary P3, in anterior (**A**) and occlusal views (**B**); **C, D**, BHD 1470, left M2, in labial (**C**) and occlusal views (**D**); **E, F**, BHD 59, right mandibular angle of an old individual in lateral (**E**) and ventral views (**F**); **G**, BHD 1834, tip of a ?right i2 of a juvenile individual, in labioventral view; **H**, BHD 98, left i2 of an old individual, in dorsal view; **I**, BHD 1915, right i2 from the same old individual as BHD 98, in dorsal view; **J, K**, BHD 163, left m1 of an old individual, in occlusal (**J**) and labial views (**K**). Scale bars: 50 mm. Credits: Supriya Nandy.

TABLE 2. — Measurements of *Rhinoceros unicornis* Linnaeus, 1758 teeth from the Chalcolithic–Iron Age site of Bharatihuda, Odisha, India and comparison with living species of Asian rhinoceroses (from Guérin 1980 and personal data).

	Min-max (mean)		
	<i>Rhinoceros unicornis</i> Linnaeus, 1758	<i>Rhinoceros sondaicus</i> Desmarest, 1822	<i>Dicerorhinus sumatrensis</i> (G.Fischer, 1814)
P3 (BHD 1916) Width: 42.0 Height: 46.1	43-50 (47.75) —	36.5-50 (62.86) —	34-47 (41.27) —
M2 (BHD 1470) Length: 53.7 Height: 65.8	53-62 (57.58) —	44.5-55 (50.5) —	47.5-55 (50.35) —

A left M2 is moderately worn and almost complete, only lacking its lingual part (BHD 1470; Table 2). In occlusal view, the ectoloph is undulated, with long and labially-oriented parastyle and metastyle, smooth paracone and metacone folds, and a smooth mesostyle (Fig. 3D). Although broken linguallly, the protoloph is very long and curved, with a protocone sagittally elongated and posteriorly constricted. The protoloph is disconnected from the ectoloph. The median valley is open linguallly but very narrow, with a long and sagittal crochet, a small crista and small enamel foldings on the lingual side of the ectoloph. There is no medifossette. The metaloph was seemingly very short with respect to the protoloph, and lacking an anterior groove. The posterior cingulum is high and thick, closing a deep and narrow postfossette. In labial view, there is no labial cingulum but sharp vertical ridges along the anterior and posterior margins of the ectoloph (Fig. 3C). The mesostyle is restricted to the apical half of the crown, whereas the paracone and metacone folds reach the neck, separated by a wide and shallow vertical groove.

BHD 98 and BHD 1915 are a left and a right i2 from the same individual (Fig. 3H-I). They are perfectly symmetrical and identical in all details of their aspect. Their crown is almost entirely worn, and only *c.* 2 cm of enamel are left on the ventral side. The root is straight and cylindrical in its apical half, with a smooth aspect, and conical and rugose in its basal half. Cement is broken in the ventro-basal region of the root.

Contrastingly, BHD 1834 is a fully-pristine tip of a germ of a (?right) i2, belonging to a juvenile individual. The enamel layer is thick and smoothly corrugated. The tip is round in ventral view (Fig. 3G), and the i2 forms a right triangle in cross section.

A single lower cheek tooth, much worn and fragmentary, is preserved (Fig. 3J, K). BHD 163 is a trigonid of a right lower molar. The enamel layer is thick (*c.* 2 mm). The anterior cingulum is smooth, forming an oblique ridge vanishing at mid-crown height in labial view. The ectolophid groove is shallow and V-shaped in occlusal view. It seemingly vanishes above the neck, but a thick layer of cement tapers it. The latter further discards observing the presence/absence of a labial cingulum. Roots are broken.

BHD 164 are six apical root fragments of at least two upper cheek teeth, with no features likely to be described, except for their grooved pattern, attesting to the fusion of two branches. One of them shows a conchoidally-fractured surface.

Postcranial remains

Most postcranial specimens do originate from the Iron Age layers.

BHD 931 is a fragment of a right large-sized and robust ulna, preserving half of the diaphysis and the distal articulation (Fig. 4A). The diaphysis is triangular in cross section, with sharp edges. The ulna belongs to an adult individual (epiphysis fused without any suture left) and it is not fused with the radius at the corresponding ontogenetic stage. On the medial side, the supra-articular area is particularly salient in anterior and posterior views (Transverse Diameter [TD] = 87.6 mm). In medial view, it forms a 10-cm high

plane and rugose isosceles triangle, overhanging a deep fossa just above the distal radius-facet. The latter facet is sagittally elongated, vertical, low and strip-like. There is no second facet for the radius. In distal view, a small lozenge-like and oblique facet responds to the semilunate. It is separate from the very large saddle-shaped pyramidal-facet (TD = 71 mm; Antero-Posterior Diameter [APD] = 55 mm) by a smooth ridge. This facet has a quarter-circle outline, and it is broken postero-laterally (Fig. 4B). The pyramidal-facet is not preserved. An oblique and conchoidally-fractured facet is visible on the posteromedial angle, at mid-shaft, while two pairs of horizontal grooves are observable on the distolateral side of the bone. These paired grooves are straight, parallel, *c.* 0.5 mm deep and at a *c.* 5 mm distance of each other.

A right semilunate is preserved (BHD 1917; Fig. 4C-E). The tip of its posterior process is broken. In proximal view, the bone is very wide anteriorly (59.15 mm) and it tapers abruptly posterior to the half-moon-shaped radius-facet, the anterior border of which is straight. Lateral to the latter facet is a smooth articular surface for the ulna, sagittally elongated and almond-shaped. In anterior view, the proximal articulation is particularly broad and high and it widely overhangs the anterior side (Fig. 4E). The latter has a smooth aspect. The distal margin is regularly convex, with no sharp tip. In medial view, the proximal scaphoid-facet is eight-shaped, elongate sagittally, and it runs all over the preserved antero-posterior diameter. It is distant from the almond-shaped and vertical distal scaphoid-facet. In lateral view, the small ulna-facet is visible and it is separate from the proximal pyramidal-facet by a smooth edge. This proximal facet is trapezoid and vertical. The distal pyramidal-facet is half-moon shaped, vertical and its proximal tip runs close to the former facet. The limit with the disto-lateral facet is a smooth and rounded area. Both pyramidal-facets are in the same vertical plane, forming a 60° angle with the sagittal plane (postero-medially). In distal view, the unciform-facet is widely developed and the magnum-facet is broken.

BHD 292 is a proximal fragment of a right pisiform with a smooth aspect. The lateral process is broken. In dorsal view, the ulna-facet is triangular, defining a triangle with concave edges. In ventral view, the pyramidal-facet has a half-moon outline. The antero-posterior constriction lateral to the articular area is not marked. The non-articular bone surface bears several large nutrient foramina.

A left Mc4 is preserved (BHD 855; Table 3). This metapodial is robust with a heavy proximal head, particularly developed transversally (Fig. 4G). The proximal side only comprises the unciform-facet, diamond-shaped, and broken in its posterior part. In medial view, the shaft is straight and flattened. The McIII-facets are only 4 mm one from another. The anterior one is low and almond-shaped, whereas the posterior one is mostly broken and high in its preserved part. The diaphysis is curved laterally, determining an abrupt 30° deviation at the proximal third of the bone (Fig. 4F). The *m. interosseus* area reaches the half of the diaphysis. It is not very salient. In distal view, the distal trochlea is wider than



FIG. 4. — *Rhinoceros unicornis* Linnaeus, 1758. Postcranial remains. Chalcolithic and Iron Ages, Bharatihuda archaeological mound, Odisha, East India: **A, B**, BHD 931, distal half of a right ulna, in anterior (**A**) and distal views (**B**); **C–E**, BHD 1917, right semilunate in lateral (**C**), medial (**D**), and anterior views (**E**); **F–H**, BHD 855, left Mc4, in posterior (**F**), anterior (**G**), and distal views (**H**); **I, J**, BHD 43, right astragalus of a young individual, in anterior (**I**) and posterior views (**J**); **K–M**, BHD 44, right calcaneus from the same individual, in anterior (**K**), medial (**L**), and posterodistal views (**M**); **N–Q**, BHD 241, right Mt2 in proximal (**N**), anterior (**O**), and lateral views (**P**); **Q**, BHD 137, first phalanx of a right Mt3 in anterior view; **R**, BHD 138, second phalanx of a right Mt3 in anterior view; **S**, BHD 1205, third phalanx of a right Mt3 in anterior view. All three phalanges belong to the same individual. Scale bars: 50 mm. Credits: Supriya Nandy.

TABLE 3. — Measurements of *Rhinoceros unicornis* Linnaeus, 1758 limb bones (in mm) from the Chalcolithic–Iron Age site of Bharatihuda, Odisha, India and comparison with living species of Asian rhinoceroses (from Guérin 1980 and personal data).

	Min-max (mean)		
	<i>Rhinoceros unicornis</i> Linnaeus, 1758	<i>Rhinoceros sondaicus</i> Desmarest, 1822	<i>Dicerorhinus sumatrensis</i> (G.Fischer, 1814)
Mc4 (BHD 855)			
L: 160.0	151.5–178.5 (167.3)	136–153 (143.6)	118–146 (131.1)
TD diaphysis: 33.2	34–43 (37.7)	38–45 (42)	23.5–31 (28.6)
TD distal: 43.7	45–53.5 (49.9)	42–51 (46.3)	36–42 (38.1)
APD distal: 37.0	38–45 (43.0)	37.5–51 (40.5)	33–43 (36.6)
Astragalus (BHD 43)			
TD: 95.0	103.5–112 (108.2)	87.5–100 (94.6)	67.5–87 (78.7)
H: 86.0	89–101 (94.2)	76–86.5 (78.5)	64.5–77 (70.7)
APD: 60.2	64–70.5 (67.7)	55–63 (59.9)	42.5–58 (52.3)
APD/H: 0.70	(0.72)	(0.76)	(0.74)
TD/H: 1.10	(1.15)	(1.21)	(1.11)
Calcaneus (BHD 44)			
H: 140.1	136.5–160 (145.75)	119.5–138 (128.44)	95–117.5 (103.38)
APD tuber: 74.8	72.5–85 (78.78)	65.5–77.5 (72.06)	50–61 (56.5)
APD beak: 82.5	80.5–92 (84.33)	65.5–74.5 (70.92)	52–62 (55.97)
TD sust: 80.7	74–91 (83.65)	73–88.5 (82.02)	58–71 (65.25)
TD tuber: 54.1	59–72.5 (64.63)	45.5–55 (50.38)	35–46 (42.63)
TD min post: >39.6	39–41 (40)	28–35 (31.57)	22.5–31 (27.44)
Mt2 (BHD 241)			
TD proximal: 30.4	148–175 (166.0)	133–150.5 (140.9)	114–141 (128.7)
APD proximal: 47.6	41–50 (46.2)	39.5–50 (45.4)	28.5–41 (34.6)
TD diaphysis: 32.4	35–48.5 (42.0)	33.5–45 (42.1)	23.5–37 (33.2)
TD distal: 39.7	40–45 (41.9)	35–48.5 (38.3)	31.5–40.5 (36.7)
APD distal: 43.5	30.5–35.5 (33.1)	29–37 (34.6)	26–32 (28.9)

deep, with a quarter-circle outline. The intermediate relief is both low and sharp, further restricted to the posterior side of the trochlea (Fig. 4H). The medial lip (almost flat) is narrower than the lateral one (concave).

The right astragalus BHD 43 and the right calcaneus BHD 44 belong to the same individual (Table 3).

BHD 43 is a large and robust bone, almost square in anterior view (TD/H ratio = 1.09; APD/H ratio = 0.70). It was broken in two pieces and it is damaged in some parts, especially the mid-trochlea and the latero-distal area (Fig. 4I). The posterior border of the trochlea is nearly straight in proximal view. In anterior view, the fibula-facet is flat and nearly vertical. In lateral view, it forms a broad strip. The trochlea is high, with acute borders. The lateral lip is higher, wider, and straighter transversally than the medial one, but the latter is much deeper. In medial view, the articular surface corresponding to the tibia is broad antero-distally and tapering proximally. The *collum tali* is low in its medial half and broken in its lateral part. The medial tubercle is high and smooth, not much salient medially from the trochlea, and with a vertical medial border in anterior view. In posterior view, only two facets for the calcaneus are preserved (Fig. 4J). The facet 1 (proximo-lateral) is slightly concave proximo-distally, with a wide and low latero-distal expansion deviating from the rest of the facet in lateral view (c. 45°). The facet 2 (central) is high, flat, and oval. The facet 3 (latero-distal) is completely broken (Fig. 4J). A smooth area, low and elongated transversally, separated from the calcaneus-facet 2 by a deep and narrow groove, has a crescent-like outline in the medio-distal corner. In distal

view, the trochlea is oblique with respect to the axis of the distal articulation (navicular and cuboid). The navicular-facet is lozengic. The cuboid-facet is mostly broken, except for the low and smooth posterior break.

BHD 44 is a large and robust calcaneus, with a massive *tuber calcanei*, partly broken (proximal area), and a rugose bone surface, with dozens of large nutrient foramina. There is no fibula-facet and the preserved part of the tibia-facet is low, wide and rounded, as a continuation of the astragalus-facet 1. This astragalus-facet 1 is almost flat in lateral view (Fig. 4K). The facet 2 is oval, higher than wide and flat. This facet slightly connects the facet 3, which is lower, almond-shaped. The *sustentaculum tali* is thick, but narrow with respect to the maximal length of the bone (Fig. 4M). In lateral view, the height of the *tuber calcanei* equals that of the beak, and the insertion for the *m. fibularis longus* is not discernable (no ridges). The cuboid-facet forms a right angle with the antero-proximal side of the calcaneus (Fig. 4L). This facet, on the distal side, is saddle-shaped (sigmoid and wide transversally, concave proximo-distally).

BHD 241 is a right Mt2, slender in its proximal half and thickening distally (Fig. 4N–P; Table 3). In proximal view, the proximal end forms a right triangle. The antero-medial side is flat, without a proximal tubercle. The proximal facet, for the mesocuneiform, is triangular and elongate antero-posteriorly (Fig. 4N). It is punctually in contact with the antero-lateral facet and more broadly connected to the postero-lateral one (both for the ectocuneiform). On the posterior side is a short process, with a very smooth entocuneiform-facet. In lateral view, the proximal facets are separate but close one from

TABLE 4. — Measurements of *Rhinoceros unicornis* Linnaeus, 1758 phalanges (in mm) from the Chalcolithic–Iron Age site of Bharatihuda, Odisha, India.

Specimen	BHD 582	BHD 1321	BHD 53	BHD 137	BHD 138	BHD 1205	BHD 581	BHD 981	BHD 982
TD	>72.7	46.2	>66.0	67.4	67.1	91.0	48.6	39.8	63.0
H	37.9	38.8	24.2	55.2	36.7	35.8	49.0	52.3	33.2
APD	27.5	33.2	37.8	47.9	35.2	26.1	46.3	39.9	28.1

another (Fig. 4P). The anterior one is vertical and circular. The posterior facet is heart-shaped, with most of its surface oblique with the vertical line (i.e., visible in proximal view), whereas its distal tip is vertical (sub-facet responding to the MtIII). The insertion for the *m. interossei dorsalis* reaches the half of the diaphysis. This diaphysis, with a circular cross section, is straight in lateral view, but concave medially in anterior view. The distal trochlea is deeper than wide, with parallel medial and lateral borders. In distal view, the anterior edge is rounded, while the posterior edge is sigmoid: the intermediate relief is low and smooth, located laterally.

The last ten out of seventeen postcranial remains documenting a rhinocerotid at Bharatihuda are nine phalanges (Table 4) and a sesamoid (BHD 1850), mostly from the Iron Age layers. Unfortunately, these bones are widely lacking diagnostic features, especially at the species level, and they are thus tentatively identified. Some of them are articulated and/or they match the size of autopodial elements found in the same layer and quarries, which eases their assignment: BHD 137, BHD 138, and BHD 1205 are interpreted as the first, second, and third phalanges of a right Mt3, respectively (Fig. 4Q–S; Table 4). Aside from these associated specimens, BHD 582 probably is a fragment of a third phalanx of a left Mc2 and BHD 1321 a second phalanx of a left Mc4 (fore limb). BHD 53 likely is a fragment of a third phalanx of a left Mt2. BHD 581 and BHD 981 are first phalanges of a left Mt4 (hence belonging to two distinct individuals), while BHD 982 is most likely a third phalanx of the same left Mt4 as BHD 981. The first phalanges are as high as wide. The relative height decreases, with second phalanges being lower, and third phalanges being at the same time very wide and low, whatever their assigned digit (BHD 53, BHD 582, BHD 982, and BHD 1205).

COMPARISON AND TAXONOMIC DISCUSSION

As for the mandibular fragments, the exostotic sharp-edged ridges of BHD 59 are compatible with old individuals of *Rhinoceros unicornis* (e.g., MNHN-AC-1967-101) and, to some extent, of *R. sondaicus*, but much less with *Dicerorhinus sumatrensis*. The size and the morphological features of the fragment BHD 59 are similar to those of the mandible ZSI PALZ 28, assigned to *R. unicornis*. Moreover, a widely-open foramen mandibulare, located low on the corpus, is observed in *R. unicornis* but not in *R. sondaicus* or *D. sumatrensis* (smaller dimensions and foramen located higher).

The morphological features of the Bharatihuda upper teeth perfectly match those of *R. unicornis* in terms of size (Table 2), complicated dental pattern, protoloph, ectoloph, and cingular shape, aspect of the enamel, crown height and hypsodonty

(Guérin 1980). A molariform pattern, as observed in the P3 fragment BHD 1916, often occurs in *R. unicornis* (Pocock 1945). All those features are not consistent with *R. sondaicus* and *D. sumatrensis*, species in which dimensions are smaller (Table 2), the dental pattern less complicated, and teeth are low-crowned. Lower incisors recall those of *Rhinoceros* in their shape, including large individuals of *R. sondaicus*.

The ulna BHD 931 is identical in all aspects to ulnae of *R. unicornis* (dimensions, robustness, relationship with the radius, bone aspect, and shape of the distal end, be it for the articulated areas or the non-articular regions). The cross section of the diaphysis may be similar in *R. sondaicus*, but the dimensions are too large and the bone is far too robust (MNHN-AC-A-7970). In *D. sumatrensis*, the ulna is much slenderer, with a distinct shape of the distal end (e.g., no sharp ridges). The semilunate BHD 1917 falls within the size and morphological range of *R. unicornis* (fused and eight-shaped proximal scaphoid-facets, wide proximal articulation, lateral facets with similar outlines). The proximal scaphoid-facets are usually separate in *R. sondaicus* and *D. sumatrensis*. In the latter species, the semilunate is much narrower, with a sharp-edged anterior aspect. Although broken, the pisiform is strongly reminiscent of *R. unicornis*, with its thick articular area, lacking a constriction, with the rapid widening of the process, and with non-articular regions full of large nutrient foramina, contrary to other Recent Asian species. With its large size, general shape (robustness, curved diaphysis, and distal articulation), and detailed morphological traits (transversely-developed proximal head, unciform- and Mc3-facets), the Mc4 BHD 855 strongly recalls *R. unicornis* (Table 3). In *R. sondaicus* and *D. sumatrensis*, the proximal head is comparatively smaller, narrower, and the diaphysis is much straighter in anterior view. As for the astragalus BHD 43, again large size and subquadrate proportions only match *R. unicornis* among Asian Holocene rhinocerotids for a subadult stage, with further traits such as the shape of the trochlea, the medial tubercle, the distal articulation, the pattern of the collum tali, and the calcaneus-facets 1 and 2. In *R. sondaicus* and *D. sumatrensis*, the bone is smaller, with a medial tubercle lower and more salient medially, and the calcaneus-facets are pretty distinct in their outlines. The calcaneus BHD 44 has dimensions and proportions fully compatible with *R. unicornis* and distinct from other species (Table 3). This is particularly true for the relative height and robustness of the beak, the sustentaculum, and the tuber calcanei. Astragalus-facets are further identical to those of MNHN-AC-1960-59 (of an old individual) in their outline and position. The calcaneus is smaller in *R. sondaicus*, with a slenderer and saddle-shaped tuber calcanei, and still smaller in *D. sumatrensis* (with a shorter beak). BHD 241 is

TABLE 5. — Measurements in mm of the distal humerus fragment assigned to *Rhinoceros* cf. *sondaicus* from the mature Chalcolithic Age layer at Bharatihuda, Odisha, India and comparison with living species of Asian rhinoceroses (from Guérin 1980 and personal data).

	<i>Rhinoceros unicornis</i> Linnaeus, 1758	<i>Rhinoceros sondaicus</i> Desmarest, 1822	<i>Dicerorhinus sumatrensis</i> (G.Fischer, 1814)
BHD 491	Min-max (mean)	Min-max (mean)	Min-max (mean)
TD min dia: 55.7	62-83.5 (73.3)	58.5-70 (62.9)	40-65 (52.4)
TD dist: 137.2	164-184 (173.0)	139-157 (147.0)	96-124 (112.8)
APD dia: 63.3	62-82 (76.1)	64.5-75 (68.7)	47-60 (51.2)
APD dist: 110.8	118-131.5 (125.8)	110.5-117 (114.5)	82-104 (94.4)

similar to Mt2s referred to as *R. unicornis* in most features (shape of the proximal and distal ends, orientation and cross section of the diaphysis, development of the insertion for the *m. interossei*). The only trait, usually absent in *R. unicornis*, is the contact between the (proximal) mesocuneiform-facet and the (proximo-lateral) ectocuneiform-facets. Dimensions are smaller in *R. sondaicus*, with ectocuneiform-facets much closer one from another (Table 3). The diaphysis is straight in *D. sumatrensis*, and the size ranges do not overlap either. To end with, the relative height contrast between the first, second, and third phalanges is particularly marked at Bharatihuda with respect to what is known in *D. sumatrensis* and *R. sondaicus* (in which third phalanges are much higher, relatively, both in the forelimbs and hind limbs).

To sum up, all these specimens can unambiguously be referred to as *Rhinoceros unicornis*, and they document at least four individuals ranging from juvenile (pristine i2 BHD 1834) and subadult (upper cheek teeth BHD 1916 and BHD 1470) to very old individuals (paired i2s BHD 98 and 1915). Some of these remains were further found associated, thus documenting partial skeletons (e.g., paired i2s, phalanges, or astragalus and calcaneus).

Rhinoceros cf. *sondaicus* Desmarest, 1822
(Fig. 5)

REMAIN STUDIED. — Mature Chalcolithic Age: BHD 491. Right humerus, distal end (trench ZA6 Qd-III, layer 3, depth 95 cm).

LOCALITY. — East India, Odisha, Bharatihuda archaeological mound.

DESCRIPTION

BHD 491 is a distal fragment of a right humerus. The diaphysis is broken by its mid-height and only the medial-most part of the distal trochlea is preserved.

The diaphysis is particularly slender (TD min diaphysis = 55.7 mm; APD diaphysis = 63.3 mm) and the distal end has moderate dimensions (TD = 137.2 mm; APD = 110.8 mm). In anterior view, the lateral epicondylar crest is high and wide, with a rounded tip at its proximo-lateral angle (Fig. 5A). The humeral crest is smooth and the radial fossa is shallow. In anterior and distal views, the medial lip of the trochlea tapers rapidly outward on its preserved part, pointing to a conical shape and a strong median narrowing (Fig. 5D). In posterior view, the medial epicondyle is very developed, with an acute distal tip ending above the

distal edge of the medial trochlear lip (Fig. 5C). The fossa olecrani is narrow transversally and deep antero-posteriorly, but its height cannot be asserted; the median edges of the medial and lateral epicondyles are parallel and oriented proximo-medially. All other features are not preserved, due to excavation-related breakage (broken surfaces lack any patina) (Fig. 5B).

COMPARISON AND TAXONOMIC DISCUSSION

As for dimensions, BHD 491 is too large for *D. sumatrensis* (10-15% larger than the largest specimens; Table 5), except for the transverse diameter of the diaphysis (matching large specimens; Guérin 1980). Contrastingly, it is too small for *R. unicornis* (10-20% smaller than the smallest specimens), except for the antero-posterior diameter of the diaphysis (only matching the smallest specimens; Guérin 1980). In contrast, this specimen would be compatible with a very small adult individual of *R. sondaicus* (Table 5; Guérin 1980).

Regarding morphological traits, the robustness, the shape of the lateral epicondylar crest (and its rounded tip), of the medial lip of the trochlea, of the radial fossa, and the development and orientation of the medial and lateral epicondyles are strikingly similar to what is known in *R. sondaicus*, as exemplified by the humerus MNHN-AC-A7970. Conversely, the diaphysis' robustness, the shape of the lateral epicondylar crest, the medial lip of the trochlea (ending above the medial epicondyle tip), and the shape and orientation of the medial and lateral epicondyles differ from BHD 491 in *R. unicornis*. Some features (especially on the posterior side: fossa olecrani, medial and lateral epicondyles) are compatible with *D. sumatrensis*, but other ones discard any referral to this species (lateral epicondylar crest, trochlear shape, robustness).

In summary, the most plausible taxonomic assignment for BHD 491 among living rhino species is *R. sondaicus*, but its fragmentary state impedes making a strong case of it, hence its provisional assignment to *R. cf. sondaicus*.

DISCUSSION

Based on the Bharatihuda findings analysed here, the presence of rhinoceroses is now firmly established in coastal areas to the west of the Bay of Bengal during Chalcolithic ages. This unexpected first occurrence has various implications, in terms of environment and biogeography, especially in the context of well-documented human occupation of the area.



FIG. 5. — *Rhinoceros* cf. *sondaicus* Desmarest, 1822, Mature Chalcolithic Age, Bharatihuda archaeological mound, Odisha, East India: **A-D**, BHD 491, distal fragment of a right humerus in anterior (**A**), lateral (**B**), posterior (**C**) and distal views (**D**). Scale bars: 50 mm. Credits: Supriya Nandy.

TABLE 6. — Hypothesised individual ages, associated remains, and inferred individuals, based on the rhinoceros specimens found in Chalcolithic–Iron Age layers at Bharatihuda, Odisha, India. Tooth ages, in years, are inferred through wear stages, based on Hillman-Smith *et al.* (1986) and Hullot & Antoine (2020). Individuals are denoted as numbers for *Rhinoceros unicornis* Linnaeus, 1758 (**R. u.**) and as capital letters for *R. cf. sondaicus* (**R. cf. s.**).

Period	Trench/Quarry/Layer/ Depth (cm)	Specimen	Ageing proxy	Inferred individual age (years)	Individual
IA	A10/Qd-1/6/322-329	Left M2 (BHD 1470) Left P3 (BHD 1916)	Wear stage: 5 Wear stage: 6	Young adult (8–20) Young adult (7–15)	Individual 1 (<i>R. u.</i>)
IB	ZA8/Qd-IV/3/35.5-44	Jaw fragment (BHD 59) Jaw fragment (BHD 60)	Exostoses –	Old adult (same specimen)	Individual 2 (<i>R. u.</i>)
	YA8/Qd-II/2&3/52-105	Right lower molar (BHD 163) Upper molar roots (BHD 164)	Wear stage: 9 Root senescence	Old adult (20–40) Old adult	Individual 2 (<i>R. u.</i>) Individual 2 (<i>R. u.</i>)
	ZA7/Qd-I/3/115-126	Second phalanx, left Mc4 (BHD 1321)	Epiphyses fused	Compatible with old adult	Individual 2? (<i>R. u.</i>)
	ZA6/Qd-III/3/95	Humerus, distal fragment (BHD 491)	Epiphysis fused	Young adult	Individual A (<i>R. cf. s.</i>)
II	A6/Qd-IV/1/6-4	Jaw fragment (BHD 33)	–	–	?
	YA8/Qd-III/1/39-57	Right astragalus (BHD 43) Right calcaneus (BHD 44)	Smooth aspect Smooth aspect	Subadult (same individual)	Individual 3 (<i>R. u.</i>)
	YB8/Qd-III/2/72-80	First phalanx, right Mt3 (BHD 137) Second phalanx, right Mt3 (BHD 138)	Epiphyses fused Epiphyses fused	Adult (same individual)	Individual 4 (<i>R. u.</i>)
	YA8/Qd-III/2/50-65	Third phalanx, right Mt3 (BHD 1205)	Epiphysis fused	Subadult	Individual 3? (<i>R. u.</i>)
	XA6/Qd-IV/2/12-19	First phalanx, left Mt4 (BHD 581) Third phalanx, left Mt2 (BHD 582)	Smooth aspect Epiphysis fused	Adult	Individual 4? (<i>R. u.</i>)
		Right semilunate (BHD 1917)	Smooth aspect	Subadult	Individual 3? (<i>R. u.</i>)
	YB8/Qd-III/2/80-90	First phalanx, left Mt4 (BHD 981) Third phalanx, left Mt4 (BHD 982)	Epiphyses fused Epiphysis fused	Adult (same individual)	Individual 4? (<i>R. u.</i>)
	YA8/Qd-IV/2/88-96	Left i2 (BHD 98)	Much worn	Old adult (paired)	Individual 5 (<i>R. u.</i>)
	YA8/Qd-III/2/89-94	Right i2 (BHD 1915)	Much worn		
	ZA8/Qd-IV/2/21.5	i2, pristine (BHD 1834)	Unworn	Juvenile	Individual 6 (<i>R. u.</i>)
	ZA8/Qd-IV/2/1-7	Sesamoid (BHD 1850)	–	–	?
	A6/Qd-II/2/88-96	Third phalanx, left Mt2 (BHD 53)	Epiphysis fused	Adult	Individual 4? (<i>R. u.</i>)
	A6/Qd-III/1/36-47	Right ulna, distal (BHD 931)	Epiphysis fused	Adult	Individual 4? (<i>R. u.</i>)
	YB8/Qd-III/2/65-72	Right Mt2 (BHD 241)	Epiphyses fused	Adult	Individual 4? (<i>R. u.</i>)
	YB8/Qd-II/1/74-82	Left Mc4 (BHD 855)	Epiphyses fused	Adult	Individual 4? (<i>R. u.</i>)
	A6/Qd-IV/1&2/40-46	Right pisiform (BHD 292)	Smooth aspect	Subadult	Individual 3? (<i>R. u.</i>)

RHINOCEROSES AT BHARATIHUDA: ECOLOGICAL AND BIOGEOGRAPHICAL IMPLICATIONS

Today, the surroundings of Bharatihuda consist of a vast floodplain within the Mahanadi delta (Mahalik *et al.* 1996). This floodplain landscape emerged from the accumulation of alluvial deposits from the Mahanadi and Prachi rivers approximately 5000–8000 years BP (Mahalik 2006). The formation of this landmass was primarily constrained by low-energy river waters and sea tides, resulting in a dynamic interplay between fluvial and marine processes, under the influence of wind (Mahalik *et al.* 1996; Mahalik 2006). The related deposition of silty clay, along with moderate to low-energy winds, generated fertile floodplains, ideal both for a wealth of organisms to thrive and for agricultural purposes, which attracted human populations to settle in the area around 3500 years BP. Moreover, major components of mammalian remains found in the Bharatihuda site (e.g., deer, wild boar and wild buffalo) allow to depict the presence of greener grasslands, deep forest patches and wetland by Chalcolithic and Iron Age times.

Bharatihuda testifies to the first occurrence of *Rhinoceros* in coastal areas west of the Bay of Bengal during Holocene times. This record is still more surprising in being dominated by the greater one-horned rhinoceros (*R. unicornis*), with remains of a minimum of four individuals unearthed from Early Chalcolithic, Mature Chalcolithic, and Iron Ages, i.e., over several centuries (at least between 1400–1000 BCE; Table 1).

The presence of *R. unicornis* in Central India, including Odisha, “at least until about 4000 years before the present” was raised by Rookmaaker (2024: 119). Indeed, the Javan rhino, *R. sondaicus*, was found hundreds km to the east, in the Sundarbans of West Bengal (Fig. 1). As such, and although its presence was questioned, it was considered as the most plausible candidate for a protohistorical rhinoceros to persist in what is today the Odisha State (see Rookmaaker 2024: 593). Thanks to the current work, its occurrence is likely recognised, through a single fragmentary humerus though, dating back to around 1072 BCE (Mature Chalcolithic).

In other words, the Bharatihuda site not only records the presence of rhinoceroses in the area, but it likely supports a potential sympatry of two *Rhinoceros* species there, around 3,000 years ago (Mature Chalcolithic). Sympatry of the two species was suspected in Moraghat, North Bengal in the late 19th century, but such a co-occurrence is not documented today (Rookmaaker 2024: 637). The main reason is the reduction and fragmentation of their geographical ranges in the last centuries, related to overhunting and disaggregation of their natural habitats under human pressure. In stark contrast, bi-specific or tri-specific rhinoceros assemblages are commonly reported in Middle and Upper Pleistocene deposits in South and Southeast Asia (e.g., Antoine 2012) and Bharatihuda therefore potentially highlights the persistence of two sympatric rhinoceros species as late as a few millennia ago in the Bay of Bengal.

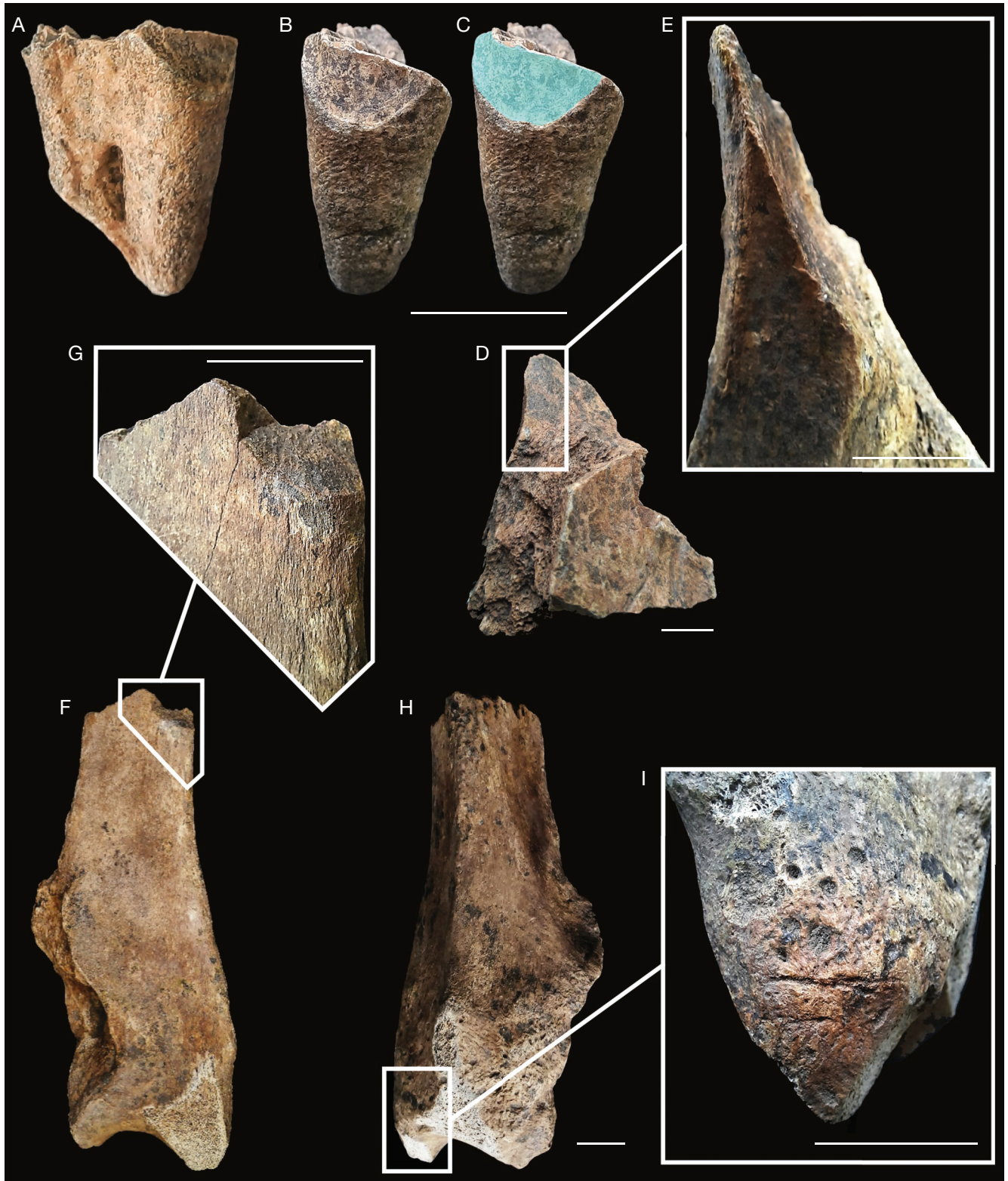


FIG. 6. — Human-induced transformations on *Rhinoceros unicornis* Linnaeus, 1758 remains from the Chalcolithic–Iron-aged Bharatihuda archaeological mound, Odisha, East India: **A–C**, BHD 164, anterior roots of an upper molar of an old individual in anterior (**A**) and labial views (**B**, **C**). The chopping mark is denoted by the **blue transparent area** in **C**; **D**, **E**, BHD 60, dentary fragment, with a sharp-edged area interpreted as a chopped surface (detail in **E**); **F–I**, BHD 931, distal half of a right ulna, in posterior (**F**, **G**) and anterior views (**H**, **I**). The sharp-edged flat area in **G** is interpreted as a chopped surface. Parallel cut marks, horizontal, are visible in **I**. Scale bars: 20 mm. Credits: Supriya Nandy.

TAPHONOMY AND INTERACTIONS WITH HUMANS AT BHARATIHUDA

Taphonomical clues

Regarding *Rhinoceros unicornis*, only two specimens were unearthed from the Early Chalcolithic layer (the left M2 BHD 1470 and the right P3 BHD 1976; layer 6, depth 322–329 cm; Table 6). Based on their wear stage, both fragmentary teeth are likely to document the Individual 1, a young adult, aged 7–20 years (Table 6).

Similarly, the Mature Chalcolithic layer (Table 6) yielded two exostotic jaw fragments (mandibular angle BHD 60 and corpus BHD 59) in the layer 3, at a depth of 35.5–44 cm, compatible with other remains found deeper in the same layer (layer 2&3, depth 52–105 cm): a worn right m1-2 (BHD 163; 20–40 years) and fragmentary upper molar roots (BHD 164) with obvious senescence clues (short, curved, with a raw aspect). All these specimens would document the Individual 2, aged 20–40 years. The second phalanx of a left Mc4 (BHD 1321) found in the layer 3 (depth 115–126 cm) could belong to the same individual.

All other specimens assigned to *R. unicornis* originate from the Iron Age layers 2 and 1 (Table 6), spanning a four-centuries timespan (*c.* 1400–1000 BCE). If we consider the assemblages to be distinct according to layer, i.e., excluding a differential post-depositional sinking of remains within the site's layers, these 20 specimens point to the presence of at least four other individuals of distinct individual ages. The Individual 3, subadult, is documented by associated right astragalus and calcaneus (BHD 43 and BHD 44) and perhaps a semilunate (BHD 1917), a right pisiform (BHD 292), and a first phalanx of a left Mt4 (BHD 581), all of them having a smooth aspect. The Individual 4, adult, is primarily identified through associated phalanges of a right Mt3 (BHD 137, BHD 138, and BHD 1205), the epiphyses of which are fully fused. The right ulna (BHD 931), the left Mc4 (BHD 855), the right Mt2 (BHD 241), and several more phalanges might belong to the same individual. The Individual 5 is denoted by a pair of worn i2s, typical of a very old individual, whereas the presence of the Individual 6 (juvenile) is only revealed by a pristine tip of i2.

A seventh adult individual originates from Mature Chalcolithic levels (layer 3). It is documented by a distal humerus, fully epiphysed and referred to as *R. sondaicus*.

To sum up, four rhinoceros individuals out of seven identified at Bharatihuda are either juvenile (Individual 6), subadult (Individual 3), or very old (Individuals 2 and 5), suggesting a vulnerable condition by the time of their death.

Archaeological clues

Contrary to the numerous other wild mammalian remains found at Bharatihuda [e.g., *Axis axis* (Erxleben, 1777), *Boselaphus tragocamelus* (Pallas, 1766)], only 30 rhinoceros specimens were unearthed. They further attest to the preservation of five individuals, a strikingly low figure for over half a millennium of human occupation. Moreover, very few chopping and cutting marks or other anthropogenic modifications were found on the specimens studied: potential chopping marks were identified on very few mandibular, dental and postcranial

remains (Fig. 6). More specifically, they were recognised through the presence of small facets on the mandibular fragment BHD 60 (Fig. 6D, E), the root of an upper cheek tooth BHD 164 (Fig. 6A–C), and at mid-shaft on the ulna BHD 931 (Fig. 6F, G). The suspicion that this latter specimen was transformed by humans is confirmed by the presence of two pairs of horizontal cut marks on the lateral side of its distal end (Fig. 6H, I). In any event, the low number of human-transformed rhino remains contrasts strikingly with the wealth of bone fragments of other edible species from Bharatihuda been charred, or showing chopping and cut marks. It should also be noted that given the thickness of the skin and muscles of rhinos, leaving cutmarks on bones is more unlikely in these big animals than in small mammals like deer and boar. Nevertheless, all of this suggests that rhinoceroses were a particularly inconspicuous component in the surrounding ecosystems, and that they were seldomly hunted, perhaps as a sweepstake resource, over Chalcolithic and Iron ages in the Bharatihuda area.

CONCLUSION

This study led to the description of 30 mandibular, dental, and postcranial remains belonging to at least seven individuals of rhinoceros during Chalcolithic and Iron Ages (1404–1000 BCE) in a human-related context in the Mahanadi delta, Eastern India. Most specimens were assigned to juvenile, subadult, adult or very old individuals of the greater one-horned rhinoceros, *Rhinoceros unicornis*. Contrastingly, a single fragmentary humerus documents *Rhinoceros cf. sondaicus*, a smaller form close to the living Javan rhinoceros. In any event, this record highlights the persistence of two sympatric *Rhinoceros* species in this coastal area in Late Holocene times, and testifies to interactions with humans over centuries, notably through chopping and cutting marks. Finally, it demonstrates the significant value of considering such discoveries from various complementary fields, including palaeontology, zoology, archaeology, and the history of science, and calls for similar works in the future.

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