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Cervus cf. rewati (Cervidae, Mammalia) from the Pliocene Dhok Pathan Formation (Middle Siwaliks), Pakistan

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Abstract

Four dentary fragments of the deer species, *Cervus* cf. *rewati* (Cervidae, Artiodactyla, Mammalia) are described from the Dhok Pathan Formation, Middle Siwaliks (Siwalik Group, Pliocene) of northern Pakistan. The specimens under study include the lower teeth and exhibit the basic characters of *Cervus rewati*. Arif et al. (1991) described this species for the first time from the Upper Siwaliks (Pleistocene) but our findings extend the range of this species from the Pliocene of the Middle Siwaliks to the Upper Siwaliks of the Indian subcontinent.

Es werden vier Unterkieferfragmente von der *Cervus* cf. *rewati* (Cervidae, Artiodactyla, Mammalia) aus der Dhok Pathan Formation, Mittlere Siwaliks (Siwalik-Gruppe, Pliozän) aus dem nördlichen Pakistan beschrieben. Die Unterkieferzähne zeigen die prinzipiellen Merkmale von *Cervus rewati*. Arif et al. (1991) beschrieben diesen Art zum ersten Mal aus den oberen Siwaliks (Pleistozän) und unsere Ergebnisse können diesen Art nun zum ersten Mal auch aus dem Pliozän der Mittleren bis Oberen Siwaliks des indischen Subkontinents belegen.

1. Introduction

Several species of the family Cervidae were so far identified in the Neogene of the Siwaliks succession (Siwalik Group, Neogene) of the Indian sub continent (Lydekker, 1876, 1880, 1884; Brown, 1926; Matthew, 1929; Colbert, 1935; Azzaroli, 1954; Arif et al, 1991). The number of species, taxonomy and validity, as well as the stratigraphic range of these species in the Siwaliks have already been considered as exaggerated (Azzaroli, 1954; Arif and Raza, 1991; Akhtar et al., 1999; Ghaffar, 2005) and needs precise taxonomic and paleobiological studies. The fossil fauna described here has been recovered from fossiliferous sediments in the Hasnot and the Dhok Pathan areas. Sediments in both areas belong to the Dhok Pathan Formation

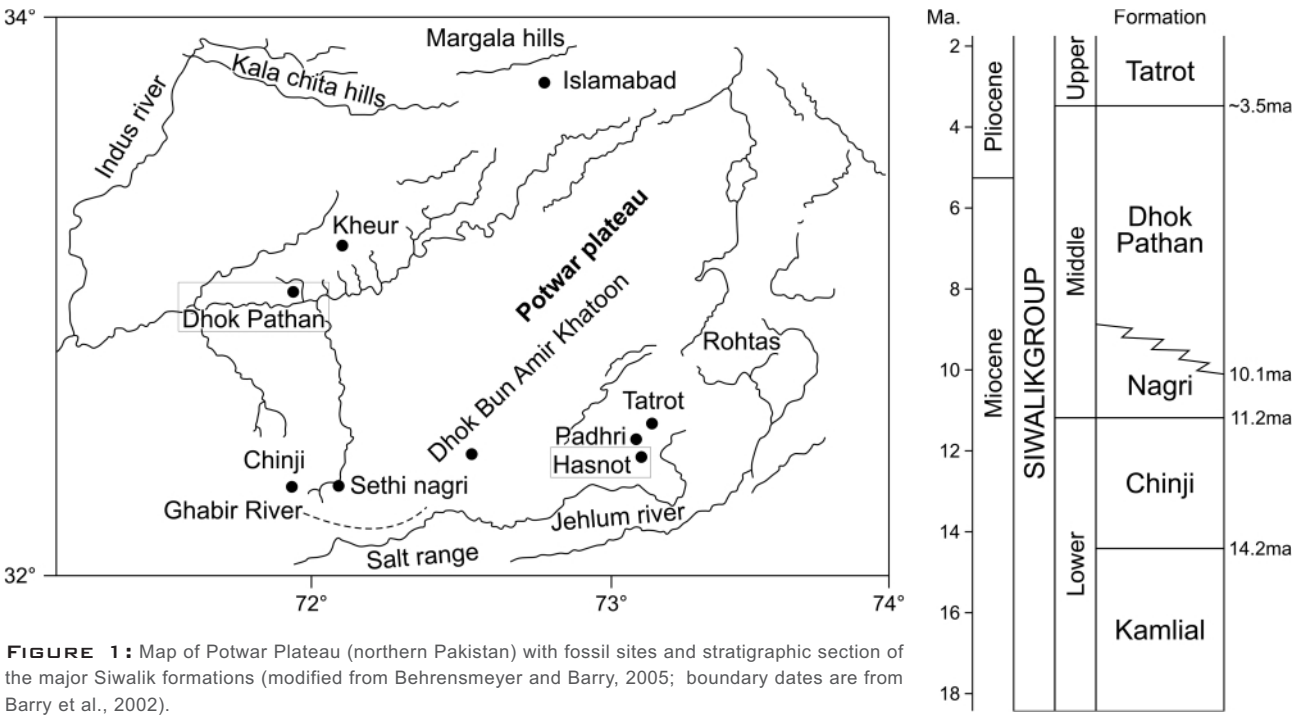


Figure 1: Map of Potwar Plateau (northern Pakistan) with fossil sites and stratigraphic section of the major Siwalik formations (modified from Behrensmeyer and Barry, 2005; boundary dates are from Barry et al., 2002).

(10.1-3.5 Ma), which is considered as the middle member of the Siwalik Group (Ojha et al., 2000). It is mainly composed of sandstones and paleosols deposited in the Himalayan foreland basin in response to uplift and erosion in the Himalayan fold thrust belt (Barry et al., 2002). According to Barry et al. (2002), paleosols of Dhok Pathan floodplains were not well drained, with smaller rivers having more seasonally variable flow and more frequent avulsions. Siwalik sediments span the time interval from about 18 Ma to younger than 2 Ma (Barry et al., 2002). Lithostratigraphically, the sediments belong to the upper Dhok Pathan Formation (Middle Siwaliks isochronous to the European Early Ruscinian), which is characterized by sandstones with alternate clays and scattered conglomerates in the lower part and conglomerate with sandstone and clays in the upper part. The clay is orange brown in color. The time of deposition ranges from 5.3-3.5 Ma (Pilbeam et al., 1977; Barry et al., 1982; Johnson et al., 1982). According to Dickinson et al. (2002), an angular unconformity (generally < 1–5° angularity) is present close to the Miocene – Pliocene boundary. Above the unconformity siliciclastic–rich sediments accumulated during the Pliocene. The upper Dhok Pathan Formation (5.3 – 3.5 Ma) is well exposed at the type locality of Dhok Pathan as well at the Hasnot area. Fossil remains of *Hipparion* (Ghaffar, 2005) and bovids (Khan et al., 2007) indicate an Early Pliocene age of the respective sites. There are 6 to 8 cervid species present (*Cervus triplidens*, *C. sivalensis*, *C. colberti*, *Rucervus simplicidens*, *Rucervus* sp. 1, *Rucervus* (?) sp. 11, *Rucervus* sp. 111, A*xis punjabiensis*), belonging to

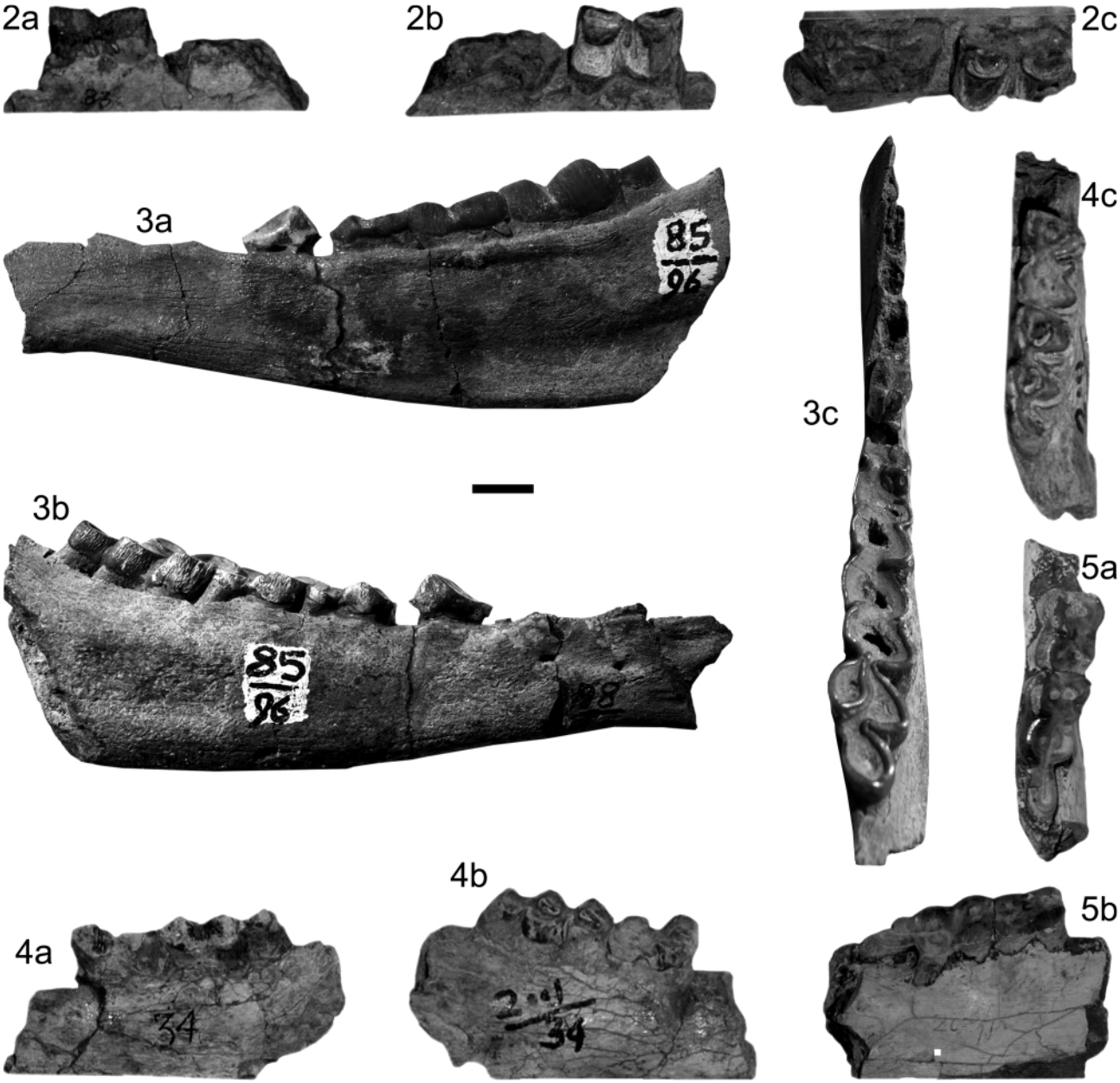


Figure 2-5: *C.* cf. *rewati*: PUPC 83/105 (2a-c); a = lingual view, b = buccal view, c = occlusal view. PUPC 85/96 (3a-c); a = lingual view, b = buccal view, c = occlusal view. PUPC 2001/34 (4a-c); a = lingual view, b = buccal view, c = occlusal view. PUPC 2002/1 (5a-b); a = occlusal view, b = buccal view. (Scale bar = 10mm).

three different genera. These species were reported from south Asia and are today mostly adapted to open woodland habitat (Azzaroli, 1954; Savage and Russell, 1983). These cervids also show the similar diversity in the fossil record (Savage and Russell, 1983; Arif and Raza 1991).

The main focus of this paper is to document *C.* cf. *rewati* from the above mentioned stratigraphic interval, the Early Pliocene, and to highlight its presence that was previously known only from the Upper Siwaliks (Upper Pliocene-Pleistocene) (Arif et al, 1991; Arif and Raza, 1991). The morphological and metrical characters of the specimens and their comparison with other related material are discussed in detail.

2. Material

Two specimens (PUPC 83/105 and PUPC 85/96; Fig. 2 & 3) were collected near Hasnot village (Lat. 32° 49′ 27.89 N: Long. 73° 07′ 52.68 E). The Hasnot village is situated about 54 km west of the Jhelum city in the Potwar Plateau of northern Pakistan (Fig. 1), surrounded by extensive Neogene freshwater sedimentary rocks. The region of the Hasnot exposes the most complete sequence of the Siwalik Group and yields a diversified fossil assemblage of the Dhok Pathan Formation. Similarly, two more specimens (PUPC. 2001/34 and PUPC 2002/1; Figs. 4 & 5) were collected from Dhok Pathan (Lat. 33° 33′ 32.09 N: Long. 73° 09′ 24.56 E) near Soan river. The locality Dhok Pathan (Fig. 1) is situated 65 km NE from Chakwal city and is considered as extremely rich in fossils. These two fossil sites represent lateral facies associations within the fine grained fossil-bearing floodplain deposits that are characteristic of fluvial depositional environment (Barry and Flynn, 1989; Behrensmeyer et al., 1995; Willis and Behrensmeyer, 1995; Barry et al., 2002). The family Cervidae is poorly known from the Siwaliks of Pakistan, thus, the material provides additional evidences of an Early Pliocene cervid fauna. Measurements are given in millimeters (mm). The catalogue numbers of the specimens consist of series i.e. numerator (yearly catalogue number) and denominator (serial number of that year), i.e. 2002/01.

Abbreviations: PUPC, Punjab University Paleontological Collection; H-GSP, Howard University, Geological Survey of Pakistan; Ma, million years ago; p4, fourth lower premolar; m1, first lower molar; m2, second lower molar; m3, third lower molar; L, largest length; W, width.

3. Systematic Paleontology

Order Artiodactyla Owen, 1848

Family CERVIDAE Goldfuss, 1820

Subfamily CERVINAE Goldfuss, 1820

Genus *CERVUS* Linnaeus, 1758

Cervus cf. *rewati*, Arif, Shah and De Vos 1991

(Figs. 2-5)

Referred Material: PUPC 83/105, PUPC 85/96, PUPC 2001/34 and PUPC 2002/1

Description: Specimen PUPC 83/105 is a right dentary fragment with strongly worn m2 and roots of m3 (Fig. 2a-c). The ectostylid is well preserved, touching the occlusal surface of the tooth. The accessory column in m2 is prominent. The protoconid is well preserved while the part of the metaconid and entoconid are missing. The metastylid and ectostylid are broken.

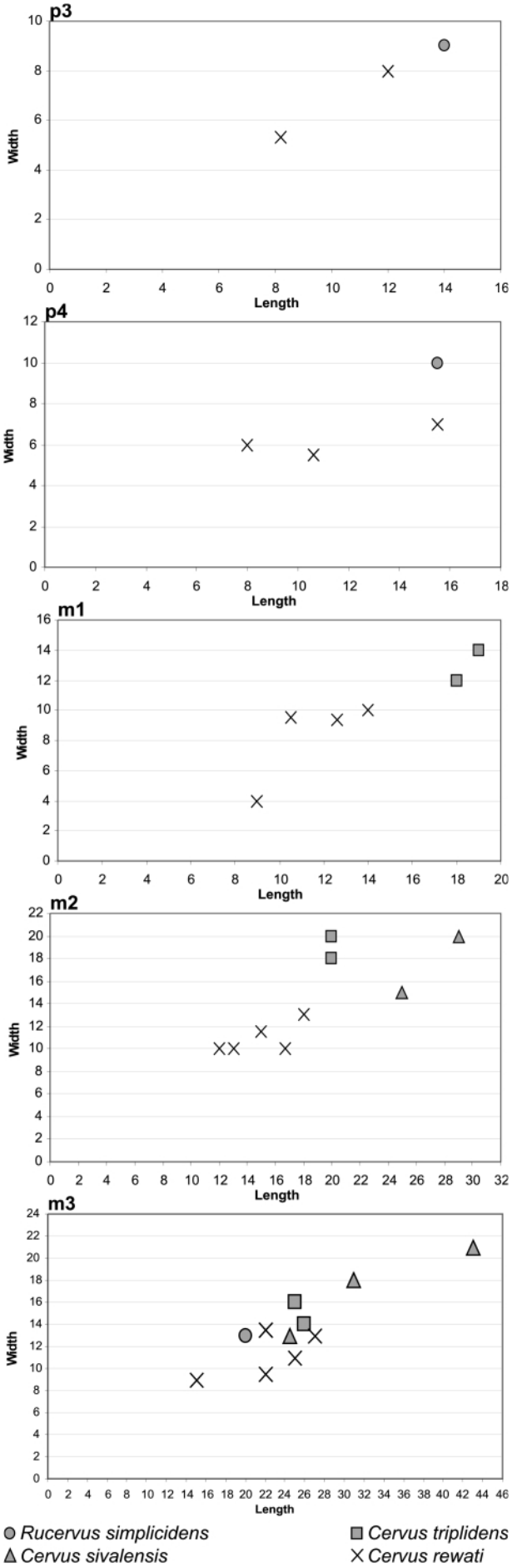
PUPC 85/96 includes a right dentary fragment with roots of p2-3 and well preserved p4-m3 (Fig. 3a-c). Teeth present a very late stage of wear. The diastema is also well preserved and the enamel is rugose. The ectostylid in m2 is well developed, while in m3 it is present at the base. The accessory columns in molars are well developed and prominent. Only the back fossette in m3 is preserved and is prominent, narrow anteriorly and broad posteriorly. In p4 and m3 the posterior median ribs are vertically higher than anterior ones while in p4 the posterior median rib is the strongest among all. The talonid in m3 is well preserved and is a posteroexternal extension of the entoconid and hypoconid. The maximum thickness of the mandible is 32mm. The length of molar series is 55mm. The height of ramus under p1, m1 and m3 is 18mm, 22mm and 29mm respectively.

PUPC 2001/34 comprises a right dentary fragment with m2-3 (Fig. 4 a-c). The teeth are in middle wear. The enamel is rugose. The ectostylid is more prominent in m3, as it is broad at the base, narrow to the occlusal surface of the tooth but hardly visible in m2 because of a thick layer of cement. The accessory columns are prominent. Labial conids, compared to m3, are broader in m2. The lingual conids are clearly broader in the middle while narrow anteroposteriorly. The posterior central cavity is missing in m2. The metastylid is poorly developed in the molars. In m2 it is straight and broad at the base. The median ribs in the molars are well developed. In m3 these are almost equal in size while in m2 the anterior median rib is vertically higher, compared to posterior one. Talonid in m3 is well preserved. It is the posteroexternal extension of the hypoconid and the entoconid and is triangular in its outline.

Specimen PUPC 2002/1 is a right dentary fragment with well preserved m2-3 (Fig. 5 a-b). Teeth are at a later stage of wear. The ectostylid is missing in both the molars, similarly the teeth are strongly worn and accessory columns are not prominent. The second molar (m2) is rectangular. The hypoconid in m2 and metaconid in m3 are broken near the occlusal surface while hypoconid in m3 is broken near the base of the crown. Being at later stage of wear anterior and posterior cavities disappeared. The talonid in m3 is broken in the middle on the lingual side. The anterior and posterior median ribs are well developed. The anterior ribs are strong as compared to posterior ones in both molars.

4. Discussion

Thorough comparison of the material under study (Figs. 2-5) with the bovid and cervid collection of the Dhok Pathan Formation (published and unpublished) available at Abu Bakr Fossil Display and Research Centre, Department of Zoology, University of the Punjab, Lahore, and with the type specimen (H-GSP 13388), led us to refer this material as a cervid spe-



cies (Table 1; Fig. 6). The material under study exhibits the weak median ribs and stylids, without goat fold and less rugose enamel as compared to bovid specimens and the smaller size as compared to the other Siwalik cervid species. For this purpose we compared the specimens under study with the available cervid taxa from the Siwaliks (Fig. 6). The diagnostic features of *C. rewati* Arif, Shah and De Vos (1991), are the small size of the teeth, the presence of accessory columns and pronounced anterior folds on the molars, that are absent in *C. sivalensis* and *C. sivalensis* has fairly big molars as compared to *C. rewati* (Ghaffar et al., 2004). The smaller size and presence of the ectostylid also distinguishes it from *Axis punjabiensis* (Brown, 1926). Similarly the structure of the ectostylid and the dental size of the studied specimens differ from *Rucervus simplicidens* and *C. triplidens* (Akhtar et al., 1999; Ghaffar, 2005). On the basis of recent taxonomic and genetic studies, it seems more appropriate to connect *C. punjabiensis* with the genus *Axis*, and *C. simplicidens* with the genus *Rucervus* (Azzaroli, 1954; Di Stefano and Petronio, 2003; Ludt, et al., 2004). So, *C.* cf. *rewati* differs from all other cervid species by its smaller size and from recent *Axis axis* by the presences of very pronounced anterior folds and ectostylids. The studied specimens have greater anteroposterior and transverse values than the type material (table, 1), but this difference has no taxonomic importance and is only because of differences between individuals and stages of wear.

One of the most important questions is the differentiation of the cervid fossil material from the other related taxa of ruminants. For this purpose we compared the studied specimens with the Siwalik bovids and the giraffids: In Early Pliocene bovids the molars are quadrate with strong divergent styles, the entostyle is strongly developed while the ectostylid is moderately developed. The median ribs are well developed and the enamel is rugose (Pilgrim, 1937, 1939; Khan et al., 2007). During the time in question, two small sized giraffid species were present in the upper Middle Siwaliks. The two small species *Giraffa punjabiensis* and *Bramatherium perimense* have strong median ribs and prominent enamel rugosity (Colbert, 1935). The other giraffid species that are not included for the comparison has greater tooth dimensions than those of the studied specimens. Moreover in the specimen PUPC 85/96, the lingual wall in p4 is connected to the labial wall by a transverse crest and in giraffes this central crest is suppressed. This diagnostic feature in the lower last premolar is also evident to separate the specimen from the giraffid collection (Hamilton, 1978; Janis and Lister, 1985). Moreover, the studied specimens are brachydont with weakly developed stylids and the enamel is less rugose and consequently the studied material is considered to be a cervid species (Gentry et al., 1999; Ghaffar et al., 2004; Ghaffar, 2005).

Studies determined from the mitochondrial DNA and multi-

Figure 6: Bivariate scatter diagram showing the size variation of *C.* cf. *rewati* with other Siwalik cervid species. Size measurements are in mm. Data are from Ghaffar (2005).

Number	position	length	width
PUPC 83/105	m2	18	13
PUPC 85/96	p4	15.5	7
	m1	14	10
	m2	15	11.5
	m3	27	13
PUPC 2001/34	m2	15	10
	m3	22	9.5
PUPC 2002/1	m2	13	10
	m3	25	11
H-GSP 18388 (Holotype)	p3	12	8
	p4	10.6	5.5
	m1	12.6	9.4
	m2	16.7	10
	m3	22	13.5

Table 1: Comparative dental measurements in millimeters (mm) of *Cervus* cf. *rewati* Arif, Shah and De Vos, 1991.

variate statistical analysis based on skulls from the Late Miocene indicate an important evolutionary split (Muntiacinae-Cervinae split) which separates Muntiacini from Cervini (Ludt, et al., 2004; Pitra et al., 2004). Subsequently, during the Latest Miocene – Early Pliocene a further separation is evident with two well- defined groups which comprise the genera *Axis* and *Rucervus* and the second group comprises of *Cervus* s.s, *Rusa* and *Dama* (Groves and Grubb, 1987; Janis and Scott, 1987; Di Stefano, and Petronio, 2003; Ludt, et al., 2004). It is supposed that red deer (*Cervus elaphus*) originated in Asia and migrated to Europe. The oldest fossil remains assignable to this deer appeared in Upper Miocene deposits (7 Ma) of Lufeng, China. According to Pitra et al. (2004), the evolutionary radiations of Old World deer occurred at the Miocene/ Pliocene transition. Petronio et al. (2007) named the Late Miocene Pliocervini, *Cervavitus novorossiae* (Khomenko, 1913), as the most primitive member of the Cervinae and also identified Early/Middle Pliocene *Cervus magnus* Zdansky, 1925 from Eurasia. The tribe Pliocervini in fact is an important evolutionary link between the Middle Miocene Dicrocerini and Plio-Pleistocene Cervini (Bubenik, 1990). The genera and species belonging to ploicervines show a wide geographical distribution covering most of Eurasia except arctic zones and the Indian subcontinent (Petronio et al., 2007).

From Early to Middle Pliocene, the first forms definitely referable to the subfamily Cervinae were found in central and western Asia. These forms are referable to the genera *Rucervus* Hadgson, 1838, *Cervus* Linnaeus, 1758, *Axis* Smith and Pedgeon, 1827, *Rusa* Smith and Pedgeon, 1827, *Elaphurus* Milne-Edwards, 1866 and *Pseudaxis* Gray, 1872. All the cervid forms are phyletically linked with red deer or with its ancestors must be referred to the genus *Cervus*. The most archaic remains referred to the genus *Cervus* were previously attributed to Early - Middle Pliocene *Pseudaxis* (Di Stefano, and Petronio, 2003). *Cervus magnus* is the most ancient species belonging to this genus. *Cervus warthae* Czyzewska, 1968 and *C. perrieri* Croizet and Jobert, 1828 represent two primitive European forms and evolved from an Asian species phyletically linked with *C. magnus*. *Cervus grayi* Zdansky, 1925 is very common in the Asian faunal assemblages; it occurs during late Early Pleistocene and appears modern compared to *C. magnus*. Overall morphological characteristics of this species are very similar to living Sika deer, *C. nippon* Temminck, 1838. The red deer (*C. elaphus*) is, however, the best known species of the genus *Cervus* (Di Stefano, and Petronio, 2003).

The Siwalik cervids were only known until now from deposits credited to the Tatrot Formation, suggesting Late Pliocene-Early Pleistocene age, probably no older than 3.4 Ma (Barry et al., 2002). If indeed the new material is correctly attributed to *C.* cf. *rewati*, then it might suggests a longer chronological range, as indicated from the Early Pliocene age of the Dhok Pathan Formation of the Middle Siwaliks, dated approximately between 5.3 -3.5 Ma. The presence of cervids in the Early Pliocene of the Siwaliks is not surprising. During the end of the Miocene and the Early Pliocene a land bridge between the Indian subcontinent and Europe existed (Hsü et al., 1977). Similar biotopes occurred in south east Europe and Pakistan in the Early Pliocene and suggest close affinity of the faunas (Van der Made, 1999). In this case, the cervids record in Pakistan would span from the Early Pliocene up to the Late Pleistocene, modifying previous concepts.

5. Conclusions

We report new material of *C.* cf. *rewati* from the Early Pliocene of the Siwaliks for the first time extending its stratigraphic range from Pleistocene - Early Pliocene. The material described here is therefore a significant discovery that improves our knowledge of Pliocene cervids. The material mentioned here, is morphologically and metrically distinguishable from the other cervid taxa, known from the Siwaliks. A better understanding of comparative morphology of cervids will shed light on the paleobiogeography in south Asia and these relationships remain to be confirmed later.

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