Pakistan J. Zool., vol. 48 (3), pp. 657-664, 2016.

New Fossils of *Rhinoceros* (Rhinocerotidae) from the Soan Formation (Plio-Pleistocene) of Northern Pakistan

Muhammad Khaled Siddiq,[1] Muhammad Akhtar,[1] Muhammad Akbar Khan,[1] Abdul Ghaffar,[2] Khadija Sarwar[1] and Abdul Majid Khan[1]*

[1]*Dr. Abu Bakr Fossil Display and Research Centre, Department of Zoology, University of the Punjab, Lahore.*

[2]*COMSATS Institute of Information Technology, Islamabad.*

ABSTRACT

New dental remains discovered from three different localities of the Upper Siwaliks of northern Pakistan are described in this paper. The fossil localities for the present collection include the fluvial sediments exposed near the Tatrot village (district Jhelum), Pabbi Hills near the Sardhok village (district Gujrat), and Jari Kas (district Mirpur, Azad Jammu and Kashmir, Pakistan). Stratigraphically the fossil locality in the vicinity of Tatrot village belongs to the Tatrot Stage (~3.5-~2.58 Ma) of the Soan Formation, whereas the Sardhok and the Jari Kas belong to the Pinjor Stage (~2.58- ~0.9 Ma) of the same Formation. The studied specimens are determinated as *Rhinoceros* sp. and *Rhinoceros* aff. *R. sondaicus*. The fossils of *Rhinocero* sp. are previously known from the Upper Siwaliks of Pakistan and India. However there is no previous record of *Rhinoceros* aff. *R. sondaicus* in the Upper Siwaliks of Pakistan. The fossil remains of *Rhinoceros* aff. *R. sondaicus* are reported for the first time from the Pinjor stage of the Soan Formation in Pakistan, hence increasing the geographic range of this taxon into Pakistan.

Article Information

Received 6 May 2014
Revised 30 October 2015
Accepted 5 November 2015
Available online 14 March 2016

Authors' Contributions

MA, AMK and MKS conceived and designed the project. MKS acquired the data. MAK analyzed and interpreted the data. AG and KS wrote the article.

Key words

***Rhinoceros*, Upper Siwaliks, Pleistocene, Tatrot, Pinjor, Punjab.**

INTRODUCTION

According to Nanda (1997) the Upper Siwaliks in the Indian subcontinent have a stratigraphic age spanning from the Late Pliocene to Middle Pleistocene, ca. 3.3–0.6 Ma, thus making them one of the longest fluvial sequences of their age in the world. The Upper Siwaliks have been subdivided by Pilgrim (1910, 1913) into three lithological and faunal stages: the Tatrot, Pinjor and Boulder Conglomerate. The Pilgrim's subdivisions have been considered valid by Azzaroli and Napoleone (1982) and Ranga Rao *et al.* (1988) in India, and by Corvinus and Nanda (1994) in Nepal. However these researchers have refined the Pilgrim's Upper Siwalik subdivisions through magnetic polarity zonation.

The Soan Formation, in Pakistan, is also subdivided into Tatrot (~3.2 to ~2.6 Ma), Pinjor (~2.2 to ~0.9 Ma) and Boulder Conglomerate (~0.9 to ~0.5 Ma) stages (Dennell *et al.*, 2006; Flynn *et al.*, 2013). The age of the subdivisions of the Soan Formation may vary at places locally as well as regionally throughout the length and breadth of the Upper Siwaliks. The Upper Siwaliks are characterized by the appearance of heavy minerals, sillimanite and hornblende (Dennell *et al.*, 2008). The lower bed of Tatrot is composed of rounded and sub-angular pebbles of pink granite, porphyrite, various quartzites, chert and purple sandstone (Barry *et al.*, 2013). The upper bed is similar and rather coarser in composition than the lower bed. Lithologically these beds contrast with the underlying Dhok Pathan rocks with prevailing orange and pink colors of the sediments (Cheema *et al.*, 1977). Barry *et al.* (2002) has recommended an age from ~3.5 to ~3.3 Ma for the Tatrot Stage and Hussain *et al.* (1992) suggested that the Tatrot Stage might be older than previously thought and could be in a range between ~3.4 and ~3.2 Ma.

The aim of this article is to describe new remains of rhinocerotids collected from the Upper Siwaliks of Pakistan.

MATERIAL AND METHODS

The fossil material described in this paper has been collected from Sardhok area in the Pabbi Hills of district Gujrat, the Tatrot village in district Jhelum and Jari Kas in district Mirpur, Azad Jammu and Kashmir (Fig. 1). The fossils were found partly exposed and excavated during field work by the authors and are kept in the Palaeontology Laboratory at the Department of Zoology,

* Corresponding author: majid.zool@pu.edu.pk; memorablefish123@gmail.com

0030-9923/2016/0003-0657 $ 8.00/0

Abbreviations: PUPC, Punjab University Palaeontological Collection; PMNH, Pakistan Museum of Natural History; AMNH, American Museum of Natural History; NHMUK, Natural History Museum, London; Fm, Formation; fig, figure; M, upper molar; m, lower molar; P, upper premolar; p, lower premolar; L, length; W, width; l, left; r, right; Ma, million years ago.

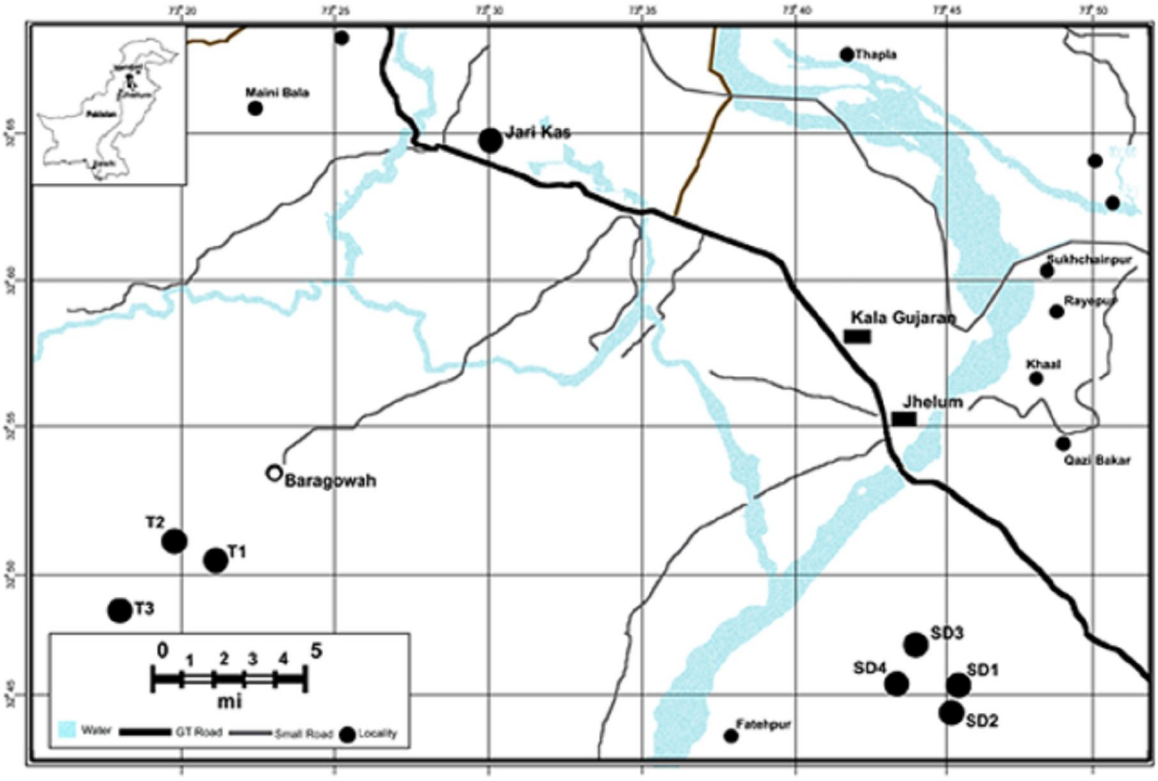

Fig. 1. Geographic location and chronostratigraphic framework of fossil yielding localities in Tatrot area, district Jhelum; Sardhok area, district Gujrat and Jari Kas area in district Mirpur AJ&K, northern Pakistan. (SD- Sardhok; T- Tatrot).

Punjab University, Lahore. The specimen catalogue numbers comprise the year catalogue number and the serial catalogue number. The upper figure denotes the collection year, while the lower one denotes the serial number of the particular specimen. The uppercase letter stands for upper dentition and lowercase for lower dentition. The measurements of the specimens are provided in millimeters (mm), and taken with the help of metric Vernier calipers. Tooth nomenclature follows Heissig (1972). Tooth length and breadth were measured at maximum level (Guérin, 1980). The fossil sample comprises broken maxillary and mandibular fragments along with isolated teeth. The studied specimens have been morphologically and metrically compared with the fossil *Rhinoceros* material previously described from several Upper Siwalik localities and other Pleistocene localities of South Asia by Falconer and Cautley (1846), Lydekker (1881), Matsumoto (1921), Colbert (1935, 1942, 1943), Hooijer (1946), Beden and Guerin (1973), Maung-Thein *et al*. (2006) and Bacon *et al*. (2008).

SYSTEMATIC PALAEONTOLOGY

Family Rhinocerotidae Gray, 1821
Subfamily Rhinocerotinae Gray, 1821
Tribe Rhinocerotini Gray, 1821
Subtribe Rhinocerotina Gray, 1821
Genus *Rhinoceros* Linnaeus, 1758

Rhinoceros sp.
(Fig. 2, Table I)

Geographic distribution

Indochinese Peninsula (Antoine, 2012).

Stratigraphic level of the studied material

Late Pliocene – Pleistocene Tatrot Stage of the Soan Formation in the Siwaliks of Pakistan and India.

Locality of the studied material

Tatrot in district Jhelum and Pabbi hills near Sar Dhok village, district Gujrat.

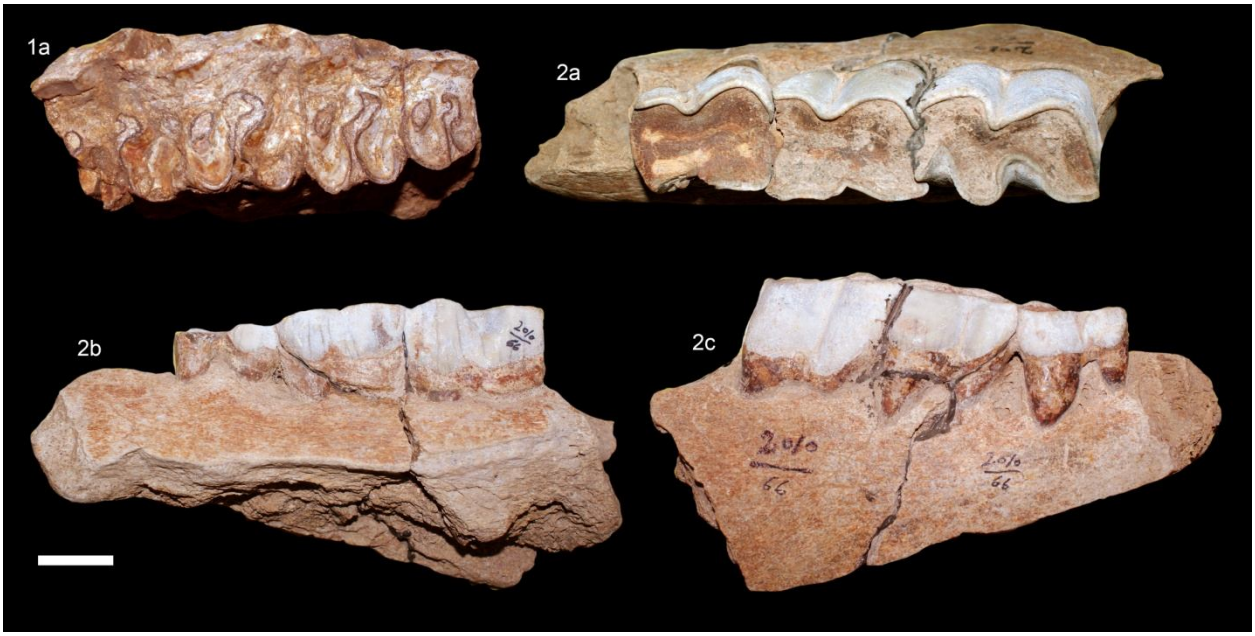

Fig. 2. *Rhonoceros* sp. (Rhinocerotini, Rhinocerotidae, Mammalia). 1a, broken maxillary fragment having rP2-M1; 2a-c, broken mandibular ramus with rp4-m2; a-occlusal; b –lingual; c – labial. Scale bar 30 mm.

Studied material

PUPC 09/115, maxillary fragment having rP2-M1 (Tatrot); PUPC 10/66, a broken mandibular fragment with rp4 –m2 (Pinjor).

Description

PUPC 09/115 is a relatively well preserved specimen having P2-M1 (Fig. 1). The premolars and the molar are in late wear. The teeth are damaged at various places. In premolars the parastyle is short and straight, but this character could be influenced by the stage of wear. The protoloph is directed backward. The metaloph is obliquely continuous with a crochet, thinner and shorter in premolars than in molar. There is abundant cement on the occlusal surface of the premolars. The P2 is roughly quadrate in outline. A narrow cingulum is present along the anterior side of the protocone. An oval postfossette is present. The crochet is moderately developed, and the antecrochet is weakly developed in P4 and M1. The crochet extends into the median valley but not strong enough to enclose it. The parastyle fold is absent. The protocone and hypocone in premolars are separate on the occlusal surface. The lingual cingulum is present in the form of a tubercle at the entrance of the median valley in P3. The median valley is filled with matrix and separates the protocone and hypocone. The M1 is relatively well preserved and in a late wear. The enamel is present at both anterior as well as the posterior side. The protocone is somewhat constricted. The ectoloph appears flat and the metacone rib appears absent. There is no buccal cingulum.

PUPC 10/66 is a broken right mandibular fragment with preserved p4-m2 (Fig. 2). The dentary is badly damaged from ventral, anterior and posterior side, and only the part having p4-m2 is preserved. The buccal profile of the preserved part of the dentary below the teeth is flat. The teeth are in middle wear. The p4 is in late wear and has lost occlusal morphology completely. The buccal groove is prominent in all the preserved teeth.

The fossil material of *Rhinoceros* from Tatrot is comparable with the material described by Matthew (1929) as *R. sivalensis*, from the Middle Siwaliks, in having unconstricted protocone, crochet moderately developed, no crista, postfossette retained on all teeth, median valley open on all the premolars and molars, premolars slightly shorter than molars, and with a concave external face. Matthew (1929) considered *R. palaeindicus* as a probable synonym of *R. sivalensis* and rejected the supposed differences in the skull proportions and dentition of both species, considering them within the limits of individual variation. The molar (rM1) AMNH 19793 described by Colbert (1935) as *R. sivalensis* resembles the studied material in having distinct crochet and absence of crista. However, the width of M1 described by Colbert (1935) is greater when compared to the M1 in the present material.

Fig. 3. *Rhinoceros* aff. *R. sondaicus* (Rhinocerotini, Rhinocerotidae, Mammalia). 1a-b, 67/145a, isolated rP2; 2a-b, 67/145b, isolated rP3; 3a-b, PUPC, 10/81, broken mandibular fragment having preserved roots of teeth from p2-m1; a-occlusal; b–lingual; c-labial, Scale bar equals 30 mm.

The lP4 in the present collection is closely comparable both in morphology and size to the lP4 (ANSP No.14630) described by Colbert (1943) from lower Pleistocene, Upper Siwaliks of Northern India. The crochet in P4 of the present collection is similar in appearance to ANSP 14630. Maung-Maung-Thein *et al.* (2010) recently revised this specimen and assigned it as *Rhinoceros* sp. The dimensions of the Tatrot material are also compared to other species of the genus *Rhinoceros* known from the Siwaliks and other localities in South Asia (Table I). However, the P4 of *Rhinoceros sivalensis* (ANSP 14630) described by Colbert (1943), and assigned as *Rhinoceros* sp. by Maung-Maung-Thein *et al*. (2010), is comparable in crown morphology and size to the P4 in the present material. Therefore the studied material is here attributed to *Rhinoceros* sp.

Rhinoceros aff. *R. Sondaicus* Desmarest, 1822
(Fig. 3, Table I)

Stratigraphic and geographic distribution

Rhinoceros sondaicus occurs from early Pleistocene to recent of Borneo; recent of the Sundarbans, Eastern Bengal, Assam, Burma, Malay Peninsula, Sumatra and Java.

Table I.- Comparative dental measurements of *Rhinoceros* sp. and *Rhinoceros* aff *R. sondaicus* (present study) from the Soan Formation. Referred data are taken from Colbert (1935, 1943)[1], Beden and Guerin (1973)[2], Bacon *et al*. (2008)[3], and Maung-Maung-Thein *et al*. (2010).

	Length	Length at base	Ant. Width	Post. Width
R. sp.*				
P2	29.0	X	38.0	X
P3	32.0	X	46.5	X
P4	41.0	X	53.0	X
M1	43.0	X	54.0	X
p4	43.5	31.0	33.0	X
m1	41.0	35.0	36.5	X
m2	54.0	37.5	35.7	X
R. sivalensis[1]				
P3 (*R* (*R*) *aff. sivalensis*103)	35.0	X	48.0	X
P4 (ANSP 14630)	43.5	X	56.0	X
M1 (AMNH 19793)	61.0	X	80.0	X
Rhinoceros aff. *R. sondaicus***				
P2	33.0	X	41.5	X
P3	44.0	X	55.5	X
~p3	35.9	25.0	X	X
~p4	38.8	24.9	X	X
~m1	41.0	29.0	X	X
R. sondaicus[2]				
P2	36.0	27.0-32.0	34.0-45.0	39.0-45.0
P3	42.0	34.0-47.0	48.0-57.0	45.0-53.0
P4	44.0	35.0-43.0	51.0-62.0	47.0-59.0
M1	49.0	35.0-46.0	51.0-65.0	45.0-56.0
R. unicornis[2]				
P2	37.5-39.0	26.0-32.0	40.0-48.0	40.0-49.0
P3	46.0-50.0	35.0-43.0	53.0-62.0	51.0-56.0
P4	41.5-48.5	37.0-39.0	62.0-70.0	56.0-60.0
M1	45.0-48.0	39.0-44.0	58.0-73.0	51.0-62.0
R. sinensis[2]				
P2	X	26.0-33.0	36.0-45.0	41.0-50.0
P3	47.0	32.0-42.0	51.0-63.0	49.0-58.0
P4	50.0-54.0	35.0-48.0	57.0-70.0	52.0-64.0
M1	65.0	41.0-55.0	63.0-81.0	58.0-78.0
R. sondaicus[3]				
p3	26.5–28.2	14.6–15.2	X	X
p4	34.5–36.7	21.7–22.0	X	X
m1	42.5	26.9	X	X

~ = inferred dimensions from the alveoli and roots.

Stratigraphic level of the studied material

Upper Pleistocene of the Soan Formation.

Studied material

PUPC 67/145a, isolated rP2 (Jari Kas); PUPC 67/145b, isolated rP3 (Jari Kas); PUPC 10/81, mandibular fragment having preserved roots of p2-m1 (Sardhok).

Description

Upper dentition

The premolars are sub-hypsodont and are in middle

wear. The crista is weakly developed in the premolars, and is confined to the upper part of the ectoloph. Anterior and posterior cingula are well developed. Lingual and buccal cingula are absent. Ectoloph is convex and has a paracone fold along the entire height of the tooth. The P2 (PUPC 67/145a; Fig. 3) is a well preserved tooth and is in early stage of wear. The anterior cingulum is present, approximately at the level of the middle of the crown height. Half of the metaloph along with the hypocone is broken. The internal pass of the median valley is very shallow. The protocone and paracone are separate from one another at the summit, but are united above the posterior cingular level. The anterior face of the tooth shows a vertical depression extending from the cingular level to the base of the crown, separating the protocone from the paracone. The protocone gradually increases in thickness from the top to the cingular level and becomes uniform in thickness from the cingular level to the base of the crown. The ectoloph is almost straight with a moderately developed parastyle fold, however metastyle is indistinct. A weakly developed crista projects into the median valley and joins the crochet a few millimeters below the occlusal surface to enclose a shallow medifossette. The crochet is bifurcated. A small tubercle is present at the antero-lingual face of the hypocone.

The P3 (PUPC 67/145b; Fig. 3) has a sinuous outline of the buccal wall in front of the metaloph. The paracone along with its style is broken. A tetra-lobed crochet projects into the median valley. The lobe of crochet that arises from the apex of metaloph joins the protoloph is about to enclose a medifossette. A fine and weakly developed crista projects into the medifossette as well as postfossette from the ectoloph. A small tubercle is present at the lingual side of the hypocone.

Mandible

PUPC10/81 is a broken left mandibular ramus having only roots of p2-m1 preserved (Fig. 3). The tooth pit for p1 is single which shows that the p1 is a single rooted tooth. The lower profile of the horizontal ramus is almost straight with slight elevation at the level of the symphysis. The ramus is thick, 56mm at the level of the p4/m1 boundary; and is positioned lower relative to the premolars than it is to the molars, so that the alveolar border forms a marked step at the p4/m1 boundary. The alveolus of i2 is oval in shape. A large nutrition foramen is also present on the ventral surface of the symphysis. The profile of the broken symphysis is slightly angularly raised with respect to the mandible. The broken symphysis is thick and slightly constricted at the diastema level. The posterior border of the symphysis reaches to the level of the middle of p3. The foramen mentale is large and deep and present at the level of p3.

The morphological characters of the rhinocerotid material from the Pleistocene of Pakistan revealed similarities to fossil dentition of *Rhinoceros sondaicus* reported from the Middle Pleistocene to recent of Java and Sumatra by Bacon *et al*. (2008), and from Pleistocene of northern Vietnam and Myanmar by Maung-Thein *et al*. (2006). Characteristics shared by the present material with the previously reported material of *Rhinoceros sondaicus* by Pocock (1945) and Hooijer (1946) includes the presence of the strong parastyle fold, absence of the antecrochet, and presence of a moderately developed crochet. Present material also shows a marked resemblance with *Rhinoceros sondaicus* described by Beden and Guerin (1973) from Pleistocene of Phnom Loang, Kampot (Cambodge) region. The dimensions of the present material are also similar to those described by Beden and Guérin (1973). Unfortunately, the studied material is too scare and poorly preserved; accordingly, it is assigned to *Rhinoceros* aff. *R. sondaicus.*

DISCUSSION AND CONCLUSIONS

Rhinoceros sondaicus differs from *Rhinoceros unicornis* in having: a weaker crista in the upper premolars and in lacking usually of crista in the upper molars; the parastyle fold is more prominent in *R. sondaicus* than in *R. unicornis*; the ectoloph is concave behind the paracone fold in *R. sondaicus*, being rather flat in *R. unicornis.* Moreover, the latter species usually displays a medifosette and a metacone fold on the premolars. In the premolars of the present material an enamel fold in the antero-external angle of the postfossette is present; however it is very different from the protocone groove of *Rhinoceros unicornis*. The fossil dentition of *Rhinoceros sinensis* described by Matsumoto (1921) from the Pleistocene of China resembles to the present material in having the backward extension of the protoloph, presence of the well-developed parastyle fold, and the sinuosity of the ectoloph. However the material published by Matsumoto (1921) differs from *Rhinoceros sondaicus* in having more hypsodont teeth and a developed crista in the upper molars.

The fossil rhinoceroses from the Upper Siwaliks is scanty and goes back to Colbert (1935), who recognized two species from the Upper Siwaliks of Chandigarh in India. Colbert (1935) described some remains housed at AMNH as *Coelodonta platyrhinus* (originally defined as *Rhinoceros*) and *Rhinoceros sivalensis*. Later Khan (1971) erected the genus *Punjabitherium* for the species *P. platyrhinum*, on the basis of a battered skull recovered from the Upper Siwaliks of India near the base of the Pinjor stage. Sarwar (1971) reported an isolated premolar of *Rhinoceros kendengindicus* from the Pinjor Zone of

Mirpur, Azad Kashmir, Pakistan.

Rhinoceros is previously reported from the upper Dhok Pathan beds, and also from the Tatrot and Pinjor stages of the Soan Formation (Khan, 2009). *Rhinoceros sivalensis* has been reported by Dennell *et al*. (2006) from the Pabbi Hills along with various mammalian species in the Pinjor stage of the Upper Siwalik fluvial sequence spanning 3.2–0.5 Ma. Colbert (1942) has considered *R. sivalensis* as a probable ancestor of the extant species of rhinoceros, considering *R. sinensis* from Pleistocene of China as a sister group of this *Rhinoceros* lineage having its probable origin in the Middle Miocene rhinocerotid *Gaindatherium Browni*.

Rhinoceros aff. *R. sondaicus* is reported for the first time from the Upper Siwalik Pinjor stage of Pakistan. In the present study on the basis of comparison of dental morphology and the dimensions of the dental remains of rhinocerotid material two taxa *Rhinoceros* sp. and *Rhinoceros* aff. *R. sondaicus*, have been identified from the Tatrot and Pinjor Stages of the Soan Formation of the Upper Siwaliks of Pakistan.

Statement of conflict of interest

The authors have no conflict of interest to declare.

REFERENCES

Antoine, P.O., 2012. Pleistocene and Holocene rhinocerotids (Mammalia, Perissodactyla) from the Indochinese Peninsula. *C. R. Palevol*. **11**: 159-168.

Azzaroli, A. and Napoleone, G., 1982. Magnetostratigraphic investigation of the Upper Siwaliks near Pinjor, India. *Riv. Ital. Paleont. Stratigr.*, **87**: 739-762.

Bacon, A., Demeter, F., Duringer, P., Helm, C., Bano, M., Long, V. T., Thuy, N. T. K., Antoine, P. O., Mai, B. T., Huong, N. T. M., Dodo, Y., Chabaux, F. and Rihs, S., 2008. The Late Pleistocene Duoi U'Oi cave in northern Vietnam. *Palaeontol. Sedimentol. Taphon. Palaeoenviron*., **27**: 1627-1654.

Barry, J.C., Morgan, M.E., Flynn, L.J., Pilbeam, D., Behrensmeyer, A.K., Raza, S.M., Khan, I., Badgely, C.E., Hicks, J. and Kelley, J., 2002. Faunal and environmental change in the late Miocene Siwaliks of Northern Pakistan, *Paleobiology*, **28**: 1-72.

Barry, J.C., Behrensmeyer, A.K., Badgley, C.E., Flynn, L.J., Peltonen, H., Cheema, I.U., Pilbeam, D., Lindsay, E.H., Raza, S.M., Rajpar, A.R. and Morgan, M.E., 2013. The Neogene Siwaliks of the Potwar Plateau, Pakistan. In: *Fossil mammals of Asia: Neogene biostratigraphy and chronology* (ed. X. Wang, L.J. Flynn and M. Fortelius), Coloumbia University Press, New York, USA, pp. 373-399.

Beden, M. and Guerin, C., 1973. Le gisement de vertébrés du Phnom Loang (Province de Kampot, Cambodge). Faune pléistocène moyen terminal (Loangien). *Trav. Docum. l'ORSTOM*, Paris, **27** : 6-97.

Cheema, M.R., Raza, S.M. and Ahmad, H., 1977. Coenozoic. In: *Stratigraphy of Pakistan* (ed. S.M.I. Shah), *Mem. Geol. Surv. Pak.*, **12**: 56-98.

Colbert, E.H., 1935. Siwalik mammals in the American Museum of Natural History. *Trans. Am. phil. Assoc.*, **26**: 1-401.

Colbert, E.H., 1942. The position of *Rhinoceros sondaicus* in the phylogeny of the genus *Rhinoceros*. *Am. Mus. Novit., N.Y.*, **1207**: 1-6.

Colbert, E.H., 1943. Pleistocene Vertebrates collected in Burma by the American Southeast Asiatic expedition. *Trans. Am. phil. Assoc.*, **32**: 395-429.

Corvinus, G. and Nanda, A.C., 1994. Stratigraphy and palaeontology of the Siwalik group of Surai Khola and Rato Khola in Nepal. *Neu. Jahr. Geol. Palaeontol. Abhandl.*, **191**: 250-268.

Dennell, R., Coard, R. and Turner, A., 2006. The biostratigraphy and magnetic polarity zonation of the Pabbi Hills, northern Pakistan: An Upper Siwalik (Pinjor stage) Upper Pliocene–Lower Pleistocene fluvial sequence. *Palaeogeogr. Palaeocl.*, **234**:168–185.

Dennell, R.W., Coard, R. and Turner, A., 2008. Predators and Scavengers in Early Pleistocene southern Asia. *Quart. Int.*, **192**: 78-88.

Falconer, H. and Cautley, P.T., 1846. *Fauna Antiqua Sivalensis*. Folio Atlas, Lond., pp. 72-75.

Flynn, L.J., Lindsay, E.H., Pilbeam, D., Raza, S.M., Morgan, M.E., Barry, J.C., Badgley, C.E., Behrensmeyer, A.K., Cheema, I.U., Rajpar, A.R. and Opdyke, N.D., 2013. South and Southeast Asia. In: *Fossil mammals of Asia: Neogene biostratigraphy and chronology* (eds. X. Wang, L.J. Flynn, and M. Fortelius), Colombia University Press, New York, USA, pp. 351-372.

Guérin, C., 1980. Les rhinocéros (Mammalia, Perissodactyla) du Miocène terminal au Pléistocène supérieur en Europe occidentale : comparaison avec les espèce actuelles. *Docum. Lab. Géol. Facul. Sci. Lyon*, **79**: 1-1182.

Heissig, K., 1972. Paläontologische und geologische Untersuchungen im Tertiär von Pakistan. 5. Rhinocerotidae (Mamm.) aus den unteren und mittleren Siwalik-Schichten. *Bayer. Akad. Wissen. Math. Naturw. Kla. Abhand. Neu. Fol.*, **152**: 1-112.

Hooijer, D.A., 1946. Prehistoric and fossil rhinoceroses from the Malay Archipelago and India. *Zool. Mededel. Leiden*, **26**: 1–138.

Hussain, S.T., Van Den Bergh, G.D., Steensma, K.J., Devisser, J.A., Devos, J., Arif, M., Van Dam, J., Sondaar, P.Y. and Malik, S.M., 1992. Biostratigraphy of the Plio-Pleistocene continental Sediments (Upper Siwaliks) of the Mangla-Samwal anticline, Azad Kashmir, Pakistan. *Proc. Konink. Nederl. Akad. Wetensch.*, Ser. B., **95**: 65-80.

Khan, A.M., 2009. *Taxonomy and distribution of rhinoceroses from the Siwalik Hills of Pakistan*. Ph.D. dissertation, University of the Punjab, Lahore, Pakistan, pp. 182.

Khan, E., 1971. *Punjabitherium* gen. nov., an extinct rhinocerotid of the Siwaliks, Punjab, India. *Proc. Ind. natl. Sci. Acad. A*, **37**: 105-109.

Lydekker, R., 1881. Siwalik Rhinocerotidae. *Palaentol. Ind.*, **10**: 1–62.

Matsumoto, H., 1921. On some fossil mammals from Honan, China. *Sci. Rep. Tohoku Imp. Univ. Sandai* 2, *Geol*., **3**: 1-28.

Matthew, W. D., 1929. Critical observations upon Siwalik Mammals. *Bull. Am. Mus. natl. Hist*., **56**: 435–560.

Maung-Thein, Z.M.M., Thaung, H., Takehisa, T., Masanaru, T., Naoko, E. and Maung, M., 2006. Early Pleistocene Javan rhinoceros from the Irrawaddy Formation, Myanmar. *Asian Paleoprimatol.*, **4**: 197-204.

Maung-Thein, Z.M.M., Takai, M., Tsubamoto, T., Egi, N., HTIKE, T., Nishimura, T., Maung, M. and Win, Z., 2010. A review of fossil rhinoceroses from the Neogene of Myanmar with description of new specimens from the Irrawaddy Sediments. *J. Asian Earth Sci.*, **37**: 154-165.

Nanda, A.C., 1997. Some biostratigraphic observations based on the Upper Siwalik mammalian faunas of the Siwalik Group of India and Nepal. In: *Geology in South Asia II*. (eds. N.P. Wijayananda, P.G. Cooray and P. Mosley), Geological Survey and Mines Bureau, *Prof. Pap*., **7**: 171–189 (Sri Lanka).

Pilgrim, G.E., 1910. Preliminary note on a revised classification of the Tertiary freshwater deposits of India. *Rec. Geol. Surv. India*, **40**:185-205.

Pilgrim, G.E., 1913. The correlation of the Siwaliks with the mammalian horizons of Europe. *Rec. Geol. Surv. India*, **43**: 264-326.

Pocock, R.I., 1945. Some cranial and dental characters of the existing species of Asiatic rhinoceroses. *Proc. zool. Soc. Lond.*, **114**: 437-450.

Ranga Rao, A., Agarwal, R.P., Sharma, U.N., Bhalla, M.S. and Nanda, A.C., 1988. Magnetic polarity stratigraphy and vertebrate palaeontology of the Upper Siwalik subgroup of Jammu Hills, India. *J, Geol. Soc. Ind*., **31**: 361-385.

Sarwar, M., 1971. A Javanese Rhinoceros recorded from the Upper Siwaliks of Azad Kashmir, Pakistan. *Geol. Bull. Univ. Peshawar*, **6**: 49-53.