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New fossil remains of *Dissopsalis* cf. *Carnifex* Pilgrim, 1910 from the Chinji Formation, Pakistan

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Abstract

New dental material of creodont *Dissopsalis* cf. *carnifex* Pilgrim, 1910 from the Chinji Formation of Pakistan is described and discussed. The fossil remains represent the rare creodont fauna from the Lower Siwaliks and are important for the taxonomic details and phylogenetic relationships of this taxon.

Keywords: Fossil remains; *Dissopsalis* cf. *carnifex;* Chinji Formation; Lower Siwaliks; Phylogenetic relationships

1. Introduction

A well-preserved dental material with P_4-M_3 of *D. carnifex* is collected from the Chinji Formation (Lat. 32° 40′ 525 N: Long. 72° 22′ 450 E), Chakwal district, Punjab province, Pakistan. This locality is one of the richest fossil site and is undoubtly the same from which many fossils fauna were recovered (Pilgrim, 1910). It is located in the type-section of the Chinji Formation (Fig. 1) and has been dated by paleomagnetic methods at between 14.2 − 11.2 Ma (Johnson et al., 1982). Other prominent mammal groups studied include several suids, bovids, giraffes, anthracotheres, tragulids, rodents, rhinoceros and dinothere (Pilbeam et al., 1977).

Chinji Formation (Late Miocene) of the Chinji Village area, has provided remarkable material to determine the architecture and time relationships of the channel sandstone bodies. This panel trends at a high angle to the flow direction of the Late Miocene river channels, and represents about 2 Ma of sediment accumulation (14.2 Ma − 11.2 Ma). The abrupt upwards increase in sandstone/mudstone proportions in the study area define the upper stratigraphic boundary of this Formation. The regional upward change from mudstone to sandstone domination at the top of the Chinji Formation resulted from a change in plan-view style of the river network, produced either by tectonic change in the mountain source area, or by climatic change. Smaller scale lithic variations within individual channel deposits reflect episodic deposition over multiple river floods. Overbank successions also have a complex internal architecture, related to shifting depositional environments and processes on floodplains.

Although it is generally assumed that overbank deposition is a gradual vertical aggradation of sediments from suspension following flood, the overbank sequences of the Chinji Formation suggest that patterns of sediment aggradation on these ancient floodplains were episodic, with periods of rapid deposition extending for at least several kilometers followed by long hiatuses and development of soils. As a result, the Chinji Formation is composed of fans of meters of thick sandstone bodies deposited by the river system and separated by mudstone-dominated overbank successions. The proportion of major sandstone bodies relative to mudstones-dominated overbank deposits increase from lower part to upper part of this Formation (Wills, 1993a, b; Willis and Behrensmeyer, 1994).

The Chinji Formation is divided into four units; the bottom unit consists of interbeded sandstone, silt clay and siltstone, followed by a unit predominantly composed of sandstone containing subordinate beds of siltstones and silty clay and the topmost unit is mostly silty clay, and claystone containing yellowish-gray medium to course-grained sandstone at the base (Willis and Behrensmeyer, 1994). The specimen under study is collected from the bottom unit of this Formation.

Pilgrim (1910) described two species of *Dissopsalis* (*D. carnifex and D. ruber*) from the Chinji Formation of Pakistan. He distinguished these on the basis of size and commented that all other morphological features of both are the same. Later on the fossil remains of *D. carnifex* were described by Pilbeam et al. (1977) and Barry (1980, 1988) from the Nagri and Chinji Formation, respectively. Later researchers (Pilbeam et al., 1977; Barry, 1988; this paper) noted that *D. ruber* is indistinguishable from *D. carnifex.* Savage (1965) described *D. pyroclasticus* and commented on the close similarities of *D. carnifex* and *D. pyroclasticus.* They are, however, sufficiently different from each other. The more pronounced metaconids on the molars, the difference in the length of P_4 and M_3, the tall talonid on M_3 and shallower mandible in *D. pyroclasticus* that differs it from *D. carnifex.* The identification of this specimen to *D.* cf. *carnifex* is based on the extreme carnassials shear of M_2 and M_3 as well as the reduced metaconid in $M_{1,}$ while metaconid as well the talonid are absent in $M_{3.}$ The objective of this paper is to report the new material of *D.* cf. *carnifex* from the lower part of Chinji Formation. Prior to this, a fair collection of *Dissopsalis carnifex* is referred from the upper Chinji Formation (Pilgrim, 1914, 1932; Colbert, 1933, 1935).

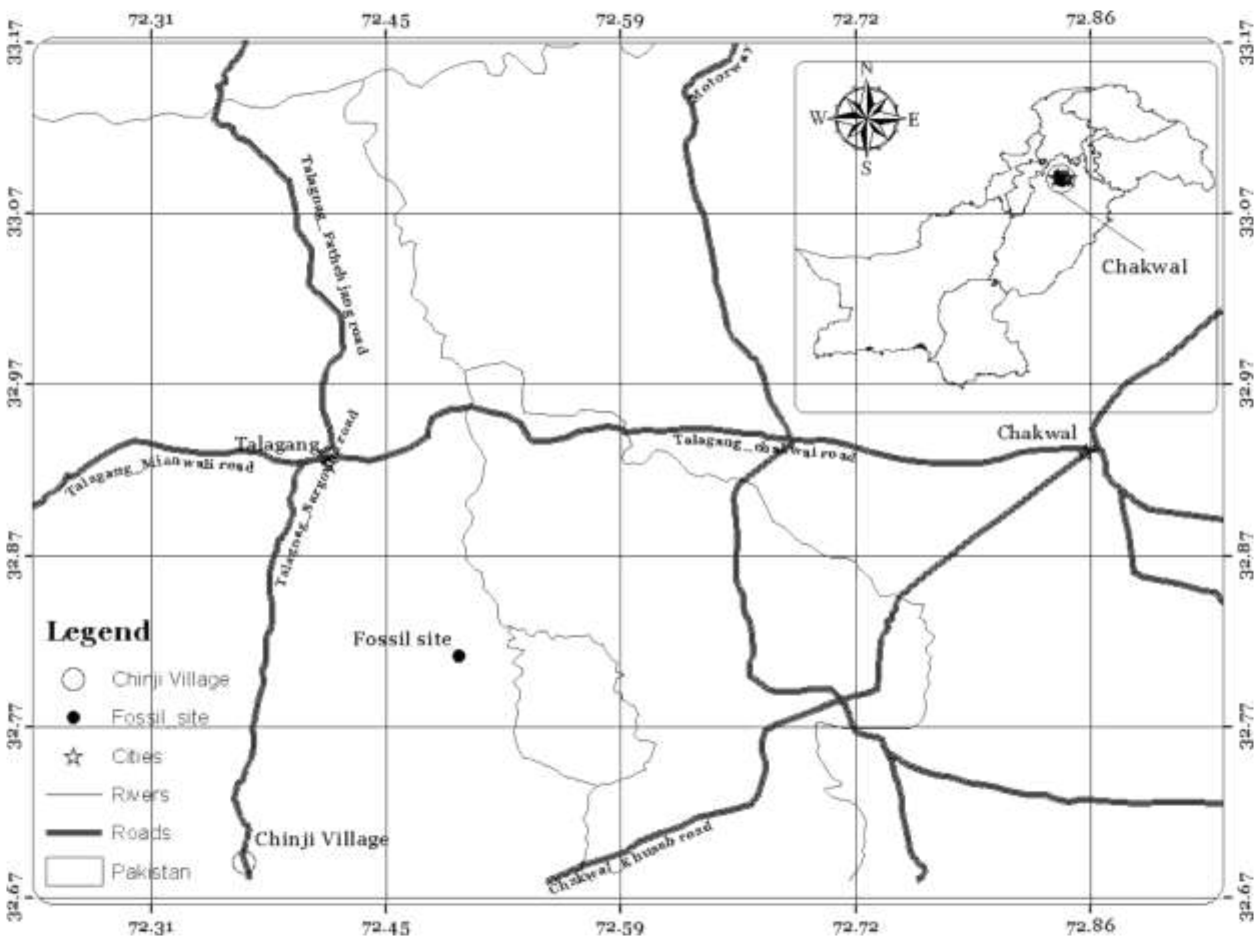

Fig. 1. Map of Pakistan (inset) with an enlargement of study area of Chakwal district.

1.1. *Abbreviations*

CU-PUPC, Comsats University - Punjab University Paleontological Collection; AMNH, American Museum of Natural History; YPM, Yale Peabody Museum; GSI, Geological Survey of India; GSP, Geological Survey of Pakistan; Ma, million years ago; P^4, fourth upper premolar; M^1, first upper molar; M^2, second upper molar; M^3, third upper molar; P_4, fourth lower premolar; M_1, first lower molar; M_2, second lower molar; M_3, third lower molar; L, largest length; W, width.

2. Material and Methods

Collection of the creodont material under study was carried out during the field of last winter season (February, 2009). The specimen was found partly exposed; thus, standard hand excavation methods had to be employed. In the laboratory, the material was carefully prepared, washed, and broken parts were reassembled with the use of multiple types of resins such as Araldite, Peligom, Magic stone, Elfy, Elite and Fixin. Various measurements of the studied specimen were taken to the nearest millimeters using Vernier Caliper. Tooth length and width were measured at the occlusal level. Comparisons were made with the specimens from the American Museum of Natural History (AMNH), Yale Peabody Museum (YPM); Geological Survey of India (GSI) and Geological Survey of Pakistan (GSP). The morphological and metrical characters and their systematic determination with other related material is discussed in detail. Measurements are given in millimeters (mm). The catalogue number of the specimen consists of series i-e numerator (yearly catalogue number) and denominator (serial number of that year), i-e 2009/04.

3. Systematic Paleontology

Order Creodonta Cope, 1875
Family Hyaenodontidae Leidy, 1869
Genus *Dissopsalis* Pilgrim, 1910
Dissopsalis cf. *carnifex* Pilgrim, 1910

Included Species: Dissopsalis carnifex Pilgrim, 1910 and *Dissopsalis pyroclasticus* Savage, 1965

Type (Lectotype): G.S.I. No. D 143, a right maxilla with P^3-M^2
Cotypes: G.S.I. No. D 144 – D 148, various maxillary and mandibular fragments
Horizon: Lower Siwaliks, Chinji Formation
Locality: From the vicinity of Chinji Rest House
Studied Material: A partial right mandibular ramus with P_4-M_3 collected from the lower part of Chinji Formation
Distribution: South Asia (Siwalik continental deposits) for *Dissopsalis carnifex* and East Africa (Kenya) for *Dissopsalis pyroclasticus*
Stratigraphic Range: Lower Siwaliks - lower part of the Middle Siwaliks (Kamlial – Nagri Formation)

3.1. Diagnosis

First three upper premolars longer than wide with central cone and encircling cingulum, P^4 with enlarged protocone, P_4 with enlarged, backward pointing cusp and a trenchant heel. M^{1-2} with large protocone and distinct para- and metacones. Metastyle shear short. M^3 large. M_{1-2} with high trigonid and basined talonid (Barry, 1988).

3.2. Description

CU-PUPC 2009/04 (Fig. 2) is a partial right mandibular ramus with P_4-M_3. The P_4 is much longer than M_1 and has a large talonid with a heavy lingual entocristed that forms a lingually facing basin. M_1 has a very small metaconid, while that on M_2 is vestigial. The protoconid on M_2 and M_3 is well-developed while that on M_1 is subdued. On the last molars the protocristed is on the lingual face of protoconid. The hypoconulid of the M_1 is fairly large, in M_2 it is not formed as a distinct cusp and the rear of the talonid is rounded. The P_4 is unworn while molars are slightly worn. On M_3 paraconid is higher than protoconid while protoconid is broad than paraconid and subequal in size. The mandibular ramus has been removed, except a small portion that is intact with M_{2-3}. M_{2-3} are well-developed sharing carnassials. M_2 has a much reduced metaconid and a talonid only one-fourth the total length of the tooth. The paraconid of the M_3 is only about half the height of the protoconid. The metaconid and the talonid is absent in M_3.

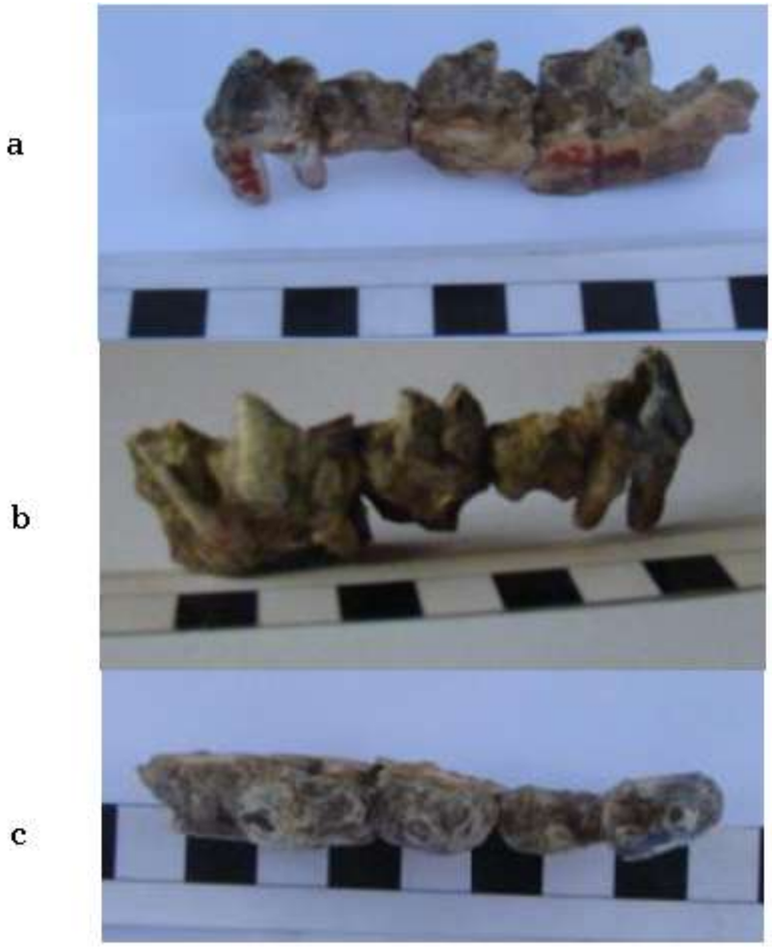

Fig. 2. *D.* cf. *carnifex*: CU- PUPC 2009/04 (2a-c); a = lingual view, b = buccal view, C= occlusal view. Scale bar is in millimeters (mm)

Table 1. Comparative dental measurements (mm) of *D. carnifex* with other *D. carnifex* material

	P_4		M_1		M_2		M_3	
Specimen # and species	L	W	L	W	L	W	L	W
CU-PUPC 2009/04 (Studied specimen)	14.5	9.5	12.0	7.5	17.0	9.0	15.5	7.5
AMNH 93027 (*D. carnifex*)	-	-	13.6	9.0	17.6	8.6	-	-
AMNH 19403 (*D. carnifex*)	-	-			15.1	9.0	18.5	9.5
YPM 20050 (*D. carnifex*)	16.7	10.1	14.4	8.0	16.1	8.4	-	-
GSI D 219 (*D. carnifex*)	-	-	-	-	-	-	20	9.4
GSP 27922 (*D. carnifex*)	-	-	13.7	6.9	-	-	-	-

Measurements taken from Barry, 1988.

4. Discussion

The oldest Siwaliks specimen (GSP 17532) is from the upper part of Kamlial Formation while the youngest (GSP 6459) is from the middle of the Nagri Formation. The second (YMP 20050) youngest specimen is from the upper part of the Chinji Formation. The specimen under study is from the lower part of the Chinji Formation.

The P_4 of the specimen under study has lesser anteroposterior and transverse values as compare to YPM 20050; similar is the case for M_1, that has lesser anteroposterior values when compared with AMNH 93027, YPM 20050 and GSP 27922 while lesser transverse values than AMNH 93027, YPM 20050 and greater values than GSP 27922. M_2 has lesser anteroposterior value than AMNH 93027 and greater than AMNH 19403 and YPM 20050. The transverse value of M_2 is lesser than AMNH 93027 and equal to AMNH 19403, greater than YPM 20050. M_3 has lesser anteroposterior and transverse values than AMNH 19403 and YPM 20050 (Table 1; Fig. 3). The differences in these values have no taxonomic importance, but are important for the age of the individual and the stage of wear.

Pilgrim (1932) and Colbert (1935) compared the material of *Dissopsalis* with either more primitive and much older genera, such as *Proviverra* and Tritemnodon or to more advanced hyaenodontines such as *Pterodon* and *Hyaenodon*. As a consequence, they tend to over-emphasize the primitive nature of *Dissopsalis* and ignored possible relationships to other taxa, with the result, that only a derivation from the most primitive hyaenodontids seemed reasonable. Subsequent discoveries of Oligocene and Miocene creodont fauna from Africa and Eurasia have helped bridge the temporal and morphological gap between *Dissopsalis* and various Paleogene and Holarctic forms. Out of 30 species in the Old World and 20 species in North America, thoseparticularly close to *Dissopsalis,* and relatively well known, were used to see the alternative phylogenetic relationships based on 40 dental characters. On the basis of these characters, Barry (1988) argued that it is not derived from a primitive provivirrine but related to Old World Miocene species from East Africa (*Anasinopa leake*yi and *Metasinopa fraasi*). He further argued that the *Dissopsalis* and hyaenidontines shares many derived features, but are not the sister taxa contrary to Pilgrim (1932) and Colbert (1935). They latter briefly discussed the affinities of *Dissopsalis,* comparing it to various North American and European species. Both these authors concluded that *Dissopsalis* was derived from a very primitive proviverrine lineage (*Sinopa*) from which it had diverged in the Eocene. An Alternative phylogenies discussed in detail suggests that *Dissopsalis* may have been evolved from an *Anasinopa* like species in Sub- Saharan Africa at the end of early Miocene (17Ma) or slight earlier, and the oldest known specimen from the Kamlial (16.1Ma) testifies this hypothesis but the dated specimen of *D. pyroclasticus* from Africa is 11.6Ma (Barry, 1988).

D. carnifex represents the last known survivor of the creodont stock and retains many characters typical of the early hyaenodonts. According to different researchers hyaenidontids apparently became extinct in North America during the early Arikareen Land Mammals age at approximately 27Ma (Macdonald, 1970; Mellet, 1977), in Europe during the middle Miocene (Helbing, 1925); and in Central Asia in the middle or late Oligocene (Mellet, 1968, 1977). In East Africa, creodonts were still present in the middle Miocene, ca 14Ma (Savage, 1965, 1978) while in North Africa till 12Ma (Cooke, 1978). In Pakistan the creodont fauna is already known from the Nagri Formation (Pilbeam et al., 1977), having the age range less than 10Ma. In subcontinent India, *Dissopsalis*, are Miocene survivors, showing geographic relationships to both Africa and Europe (Pilgrim, 1914, 1932; Colbert 1933, 1935; Barry 1980, 1988), but not to mainland Asia.

The temporal range of *D. carnifex* is from 16.1- 8.8Ma while that of *D. pyroclasticus* is from 19 - 11.6Ma. This can be tentatively supported by the new fossil finds for the oldest and youngest occurrences and also for the gap analysis. The specimen under study is important because the critical startigraphic range is not discussed by Pilgrim (1914, 1932) and Colbert (1933, 1935), while Barry (1980, 1988) only referred to the material available in different museums mentioned above. However, much more material is needed to confirm the origin, stratigraphic ranges as well the number of valid species of this rare creodont.

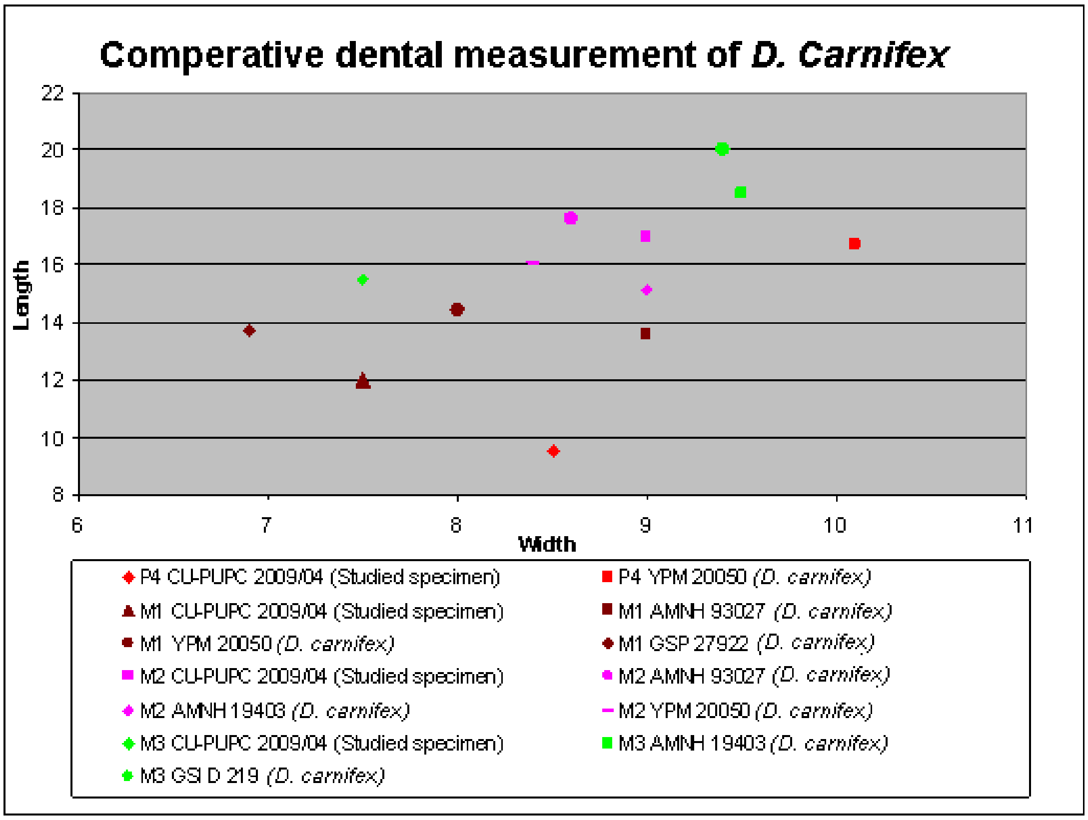

Fig. 3. Bivariate scatter diagram showing comparison of the studied specimen (mandibular teeth) with the already described material

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