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**A SMALL COLLECTION OF FOSSIL VERTEBRATES
FROM THE MIDDLE EOCENE KULDANA AND KOHAT
FORMATIONS OF PUNJAB (PAKISTAN)**

BY

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A SMALL COLLECTION OF FOSSIL VERTEBRATES FROM THE MIDDLE EOCENE KULDANA AND KOHAT FORMATIONS OF PUNJAB (PAKISTAN)

By

Philip D. Gingerich

Abstract.—In 1975 the author made a new collection of fossil vertebrates from the Middle Eocene Kuldana and Kohat Formations in the Kala Chitta mountains of the Punjab Province in Pakistan. Vertebrates were found at twelve localities in the vicinity of Lammidhan and Chharat. All of the identifiable mammals came from Lammidhan. Two additional mammal specimens from Lammidhan in the British Museum (Natural History) are also described and illustrated for the first time.

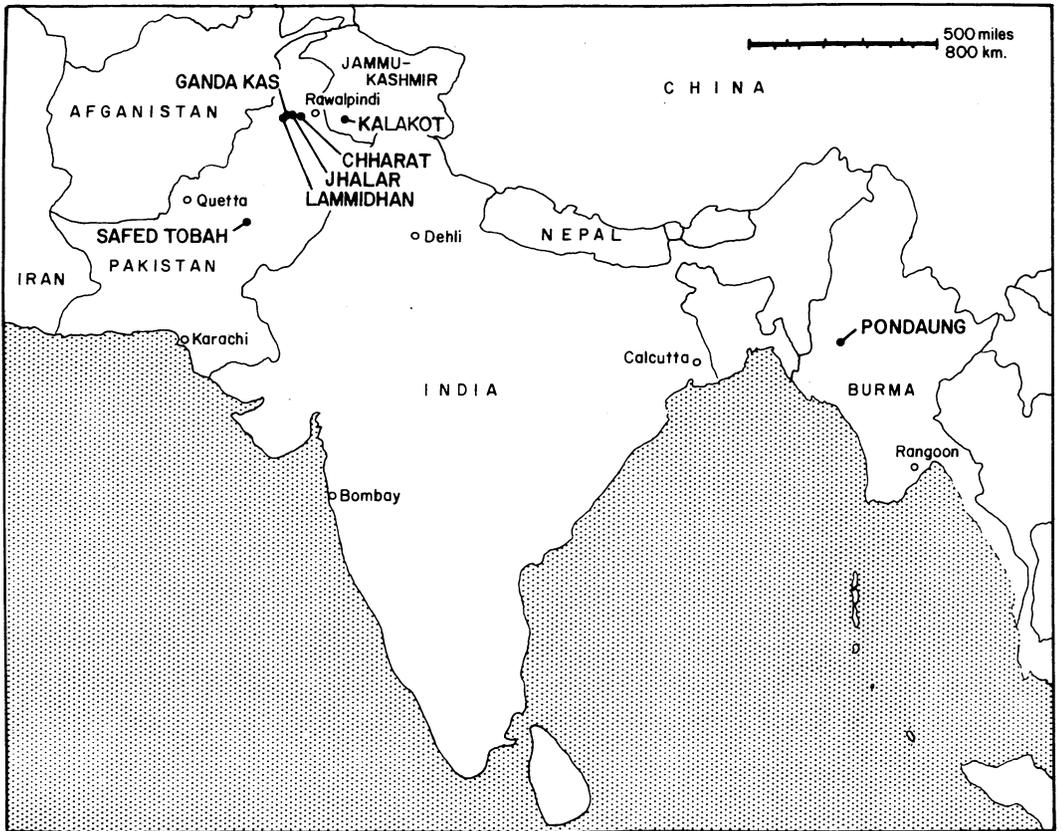
It is suggested that *Gandakasia* may be a primitive cetacean rather than a mesonychid condylarth. The new artiodactyl genus *Lammidhaniania* is proposed for the anthracothere species '*Anthracobune wardi* Pilgrim, 1940.

Discovery of a small concentration of mammal specimens at one locality suggests that there is very good potential for the discovery of additional middle Eocene mammals in the Kuldana Formation and its lateral equivalents.

INTRODUCTION

The Eocene vertebrate faunas of Europe and North America are now relatively well known, and our knowledge of the Eocene faunas of central Asia is increasing. It appears that a series of broad holarctic migrations took place at the beginning of the Eocene, establishing a relatively homogeneous fauna in North America, Europe, and central Asia just before these three continental areas became isolated from each other. This unified fauna diversified rapidly, with distinctive mammalian groups evolving to dominate each region. In the late Eocene and early Oligocene another series of migrations mixed elements of each of these faunas. The whole Tertiary history of mammals in the northern hemisphere can be seen as a series of five or so cycles of pangeographic migration, endemic development, followed by pangeographic migration, etc. Climate seems to have played an important role in the origin and dispersal of new mammalian groups, at the beginning of the Eocene at least (see Gingerich, 1976), and it is important, whenever possible, that mammalian faunas in equatorial regions be sampled, since these regions appear plausibly to be centers of origination for a majority of new higher taxa. Thus the faunas in the southern parts of each of the northern continents are of special interest. The Eocene mammalian fauna of the Indo-Pakistan subcontinent is one such example.

The Eocene fauna of Indo-Pakistan is of particular interest for another reason. It is generally agreed that the Indo-Pakistan subcontinent moved northward during the late Cretaceous and early Tertiary, joining the central Asian continent sometime during the Eocene. Better knowledge of the early Tertiary land mammal faunas of Indo-Pakistan should help to date the time of first substantial



TEXT-FIG. 1 Map of the Indo-Pakistan subcontinent showing Eocene localities yielding fossil mammals. Safed Tobah, Lammidhan, Ganda Kas, Jhalar, and Chharat are all middle Eocene localities in Pakistan. Kalakot is a middle or late Eocene locality in Jammu-Kashmir. Pondaung encompasses a series of late Eocene localities in Burma.

contact between the subcontinent and central Asia.

Relatively few Eocene fossil mammal localities are known from Indo-Pakistan, the known localities being listed in text-figure 1. No Paleocene or early Eocene mammal faunas have yet been discovered on the subcontinent, but there is good potential for finding Paleocene and early Eocene mammals in Pakistan, judging from lithological descriptions, and it is hoped that several areas can be visited in the near future to investigate this potential.

Lydekker (1887) first mentioned Eocene mammals from the Punjab, but these specimens were never described or figured, the only elements known being portions of a metatarsus and femur of a perissodactyl and the astragalus of an artiodactyl. Pilgrim and Cotter (1915) described a new late Eocene fauna from the Pondaung beds of Burma, a fauna later extensively reviewed by Colbert (1938). Middle Eocene mammals from Pakistan were first described by Pilgrim (1940), who named the following new taxa from three localities, Lammidhan, Jhalar, and Safed Tobah:

ARTIODACTYLA
ANTHRACOTHERIDAE

- Anthracobune pinfoldi* (from Lammidhan)
Anthracobune (?) daviesi (Lammidhan)

Anthracobune (?) wardi (Lammidhan, ?Jhalar)
 Anthracotheridae (?) indet. (Safed Tobah, Jhalar)

HELOHYIDAE (?)

Khirtharia dayi (Lammidhan, ?Jhalar)

“CREODONTA”

MESONYCHIDAE

Genus indet., sp. n. (Safed Tobah)

Additional fossil vertebrates were collected from the general vicinity of Lammidhan and Jhalar by a German expedition from Munich, all being described as coming from “Ganda Kas.” Unfortunately, no more precise locality or stratigraphic information has ever been published for any of these specimens. This collection was described by Dehm and Oettingen-Spielberg (1958), who expanded the fauna from the area to include the following species:

TAENIODONTA

STYLINODONTINAE (?)

Basalina basalensis gen. et sp. nov.
 Taeniodont indet.

“CREODONTA”

MESONYCHIDAE

Gandakasia potens gen. et sp. nov.
Ichthyolestes pinfoldi gen. et sp. nov.
 Creodont indet. (*Ichthyolestes?*)
 Creodont indet.

CONDYLARTHRA

HYOPSODONTIDAE

Promioclænus? gandaensis sp. nov.

PERISSODACTYLA

BRONTOTHERIIDAE

Eotitanops? dayi sp. nov.

HELALETIDAE

Teleolophus? daviesi sp. nov.
 Helaletid indet.

ARTIODACTYLA

DICHOBUNIDAE

Haqueina haquei gen. et sp. nov.
Khirtharia dayi Pilgrim
Pilgrimella pilgrimi gen. et sp. nov.
Pilgrimella wardi (Pilgrim)
Anthracobune pinfoldi Pilgrim
Anthracobune? daviesi Pilgrim

Van Valen (1965) subsequently transferred the above species “*Promioclænus?*” *gandaensis* to a new genus *Dulcidon*, which he placed in the insectivore or condylarth family Paroxyclaenidae.

Radinsky (1965) discussed the tapiroid perissodactyl *Teleolophis? daviesi*, and Szalay and Gould (1966) reviewed *Gandakasia* and *Ichthyolestes* briefly. It should be noted also that Sahni and Kumar (1974) have recently provided a very useful review of the paleogeography of the Indo-Pakistan sub-continent during the Paleogene.

In an effort to recover additional middle Eocene mammals from the above localities, the Ganda Kas area was visited briefly in 1973, and the author worked in the field for eight days at Lammidhan and Chharat in 1975. Results of the latter expedition are described below.

Museum abbreviations are as follows: BMNH, British Museum (Natural History), London; UM, University of Michigan Museum of Paleontology, Ann Arbor.

STRATIGRAPHY AND LOCALITIES

Exposures of the Middle Eocene Kuldana and Kohat Formations were searched during November, 1975 in two areas, Lammidhan and Chharat, in the Kala Chitta mountains on the Potwar plateau. This region is some 25 to 50 miles (40-80 kilometers) southwest of the city of Rawalpindi in the central Punjab Province of Pakistan. The lithostratigraphy of the Kohat-Potwar geological province has recently been reviewed by the Stratigraphic Committee of Pakistan in a report compiled by Fatmi (1974). The Kuldana Formation in the Kala Chitta range is approximately 500 feet (160 m) thick, and it consists predominantly of variegated purple, red, and green shales, with some beds of red calcareous clastic sediment that occasionally contain bone in situ. The Kohat Formation conformably overlies the Kuldana beds. In the study area the Kohat Formation is about 300 feet (95 m) thick and two distinct lithological units of the Kohat Formation are apparent, a lower series of platy limestones and shales overlain by a thick sequence of shales rich in nummulites.

Most of the mammal specimens found were in surface float derived from the Kuldana beds, but the tooth of *Gandakasia* described below clearly came from the platy limestone unit of the Kohat Formation. A mandible of an artiodactyl in the British Museum (Natural History), BMNH M-15806, remains embedded in red clastic carbonate characteristic of the Kuldana Formation.

The following localities were visited in 1975 (see maps in text-figs. 2 and 5):

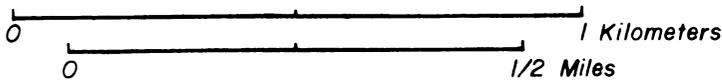
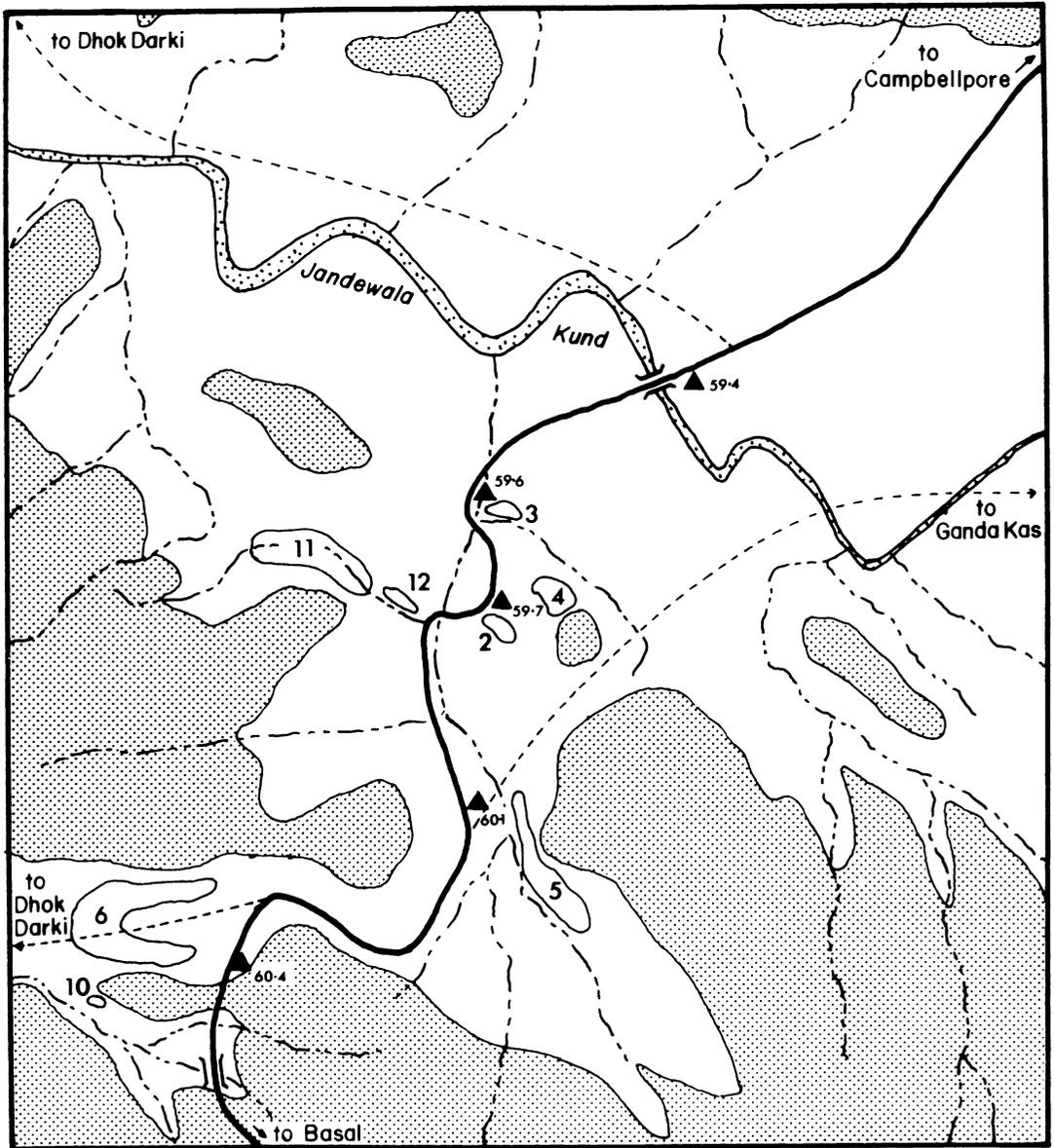
Locality 1: In the Murree Formation (Miocene), 100 meters west of milepost 62.1 on the Basal-Campbellpore road. Crocodile, turtle, coprolites, and some mammal remains are common in the clay pebble conglomerates at the base of sandstone beds.

Locality 2: In the Kohat Formation, just east of the Basal-Campbellpore road at milepost 59.7. The locality is in a small outcrop of gray to yellow limestone beds standing nearly vertically. The fauna includes brachiopods, pelecypods, gastropods (including some *Planorbis*), numerous bones of crocodilians and turtles, some crocodilian teeth, and numerous coprolites, a representative collection of which is catalogued as UM 65855. In addition, the trigonid of a molar of *Gandakasia potens* (UM 65868, see pl. 1, fig. 1) was found at this locality.

Locality 3: In the Kohat Formation, just east of the Basal-Campbellpore road at milepost 59.6. Vertical beds of limestone and shale yielded marine pelecypods, two broken shark's teeth, fragments of turtle, and coprolites (UM 65856).

Locality 4: In ?Kuldana beds. A crab claw, fish vertebra, turtle and crocodilian bone, coprolites, and a mammalian molar fragment and carpal bone (UM 65857) were found in red and green shale beds in the second small drainage to the southeast of Locality 3.

Locality 5: In the Kuldana Formation. Red beds to the southeast of milepost 60.1 on the Basal-Campbellpore road yielded a skull fragment of a fish, and unassociated fish dentary, crocodilian and turtle bone including several vertebral centra and the anterior portion of an edentulous croco-



- Streams
- Footpaths
- Paved Road
- ▲_{59.7} Milepost
- ◐ Land above 1500 ft.
- ◉ 2 Fossil Locality

TEXT-FIG. 2— Map showing middle Eocene fossil localities at Lammidhan on the road between Basal and Campbellpore (see text and text-fig. 4).

dilian dentary, and coprolites. Also, this locality yielded tooth fragments, an edentulous mandible fragment, a complete proximal end of a femur, and pieces of long bones of mammals. The collection from this locality is catalogued as UM 65858.

Locality 6: Kuldana Formation. This locality is in variegated red and violet beds in the valley west of milepost 60.4 on the Basal-Campbellpore road, and it has yielded *Planorbis*, a broken shark's tooth, broken bone of fish, turtles, and crocodilians, coprolites, and a tooth fragment, vertebrae, and broken phalanges of mammals (all catalogued as UM 65859).

Locality 7: Red, yellow, and green shales of the Kuldana Formation near the village of Chharat, type locality of the Chharat Series. Beds in this area are nearly vertical, and platy limestones of the Kohat Formation are exposed just to the north of this locality. The locality yielded fragments of crabs, turtle bone, crocodilian teeth and bone, and a fragment of a mammal tooth (all catalogued as UM 65860).

Locality 8: Kuldana Formation, about one-tenth of a mile west of Locality 7 and on the south side of the track. The stratigraphy in this area is complicated by faulting, and the relationship of this locality to Locality 7 is not clear. This locality yielded a large ?cranial bone fragment of a fish, reptilian bone fragments, coprolites, and a weathered mammalian phalanx (UM 65861).

Locality 9: Good exposures in the Kuldana Formation six-tenths of a mile west of Locality 8, on both sides of the track along a small dry streambed. Exposures farther west of this locality were prospected and some bone fragments were found. Locality 9 yielded only a crab claw, and bone fragments of fish and reptiles (UM 65862).

Locality 10: Kuldana Formation. This locality is in a bed of fine-to-coarse grained clastic carbonate that is about three feet (1 m) thick. The locality is on the south side of the hill straight west of milepost 60.4 on the Basal-Campbellpore road. A broken shark's tooth, fish and reptile bone, and coprolites (UM 65863) were found here, and a mammalian mandible with a deciduous premolar in the British Museum (BMNH M-15806) is preserved in a block of matrix of the same lithology.

Locality 11: Kuldana Formation. This locality is in a westward continuation of the same beds exposed at Locality 5, in an area straight west of Locality 2 and milepost 59.7 on the Basal-Campbellpore road. Locality 11 was the richest locality discovered, yielding *Planorbis*, a shark's tooth, reptilian bone, and a vertebra and carpal bones of mammals (all catalogued as UM 65865). In addition, associated fragments of a bony fish are catalogued as UM 65864, and the following mammal specimens were collected in a small area of sharply eroding red badlands near the west end of the exposure (see text-fig. 3). All were found within a square 15 feet (5 m) on a side, near the very highest level of the red beds:

Ichthyolestes pinfoldi Dehm and Oettingen, left P₂ (UM 65869)

Haqueina haquei Dehm and Oettingen, left M² (UM 65867)

Khirtharia dayi Pilgrim, left mandible with P₄ (UM 65870)

Lammidhanian wardi (Pilgrim), left astragalus (UM 65872)

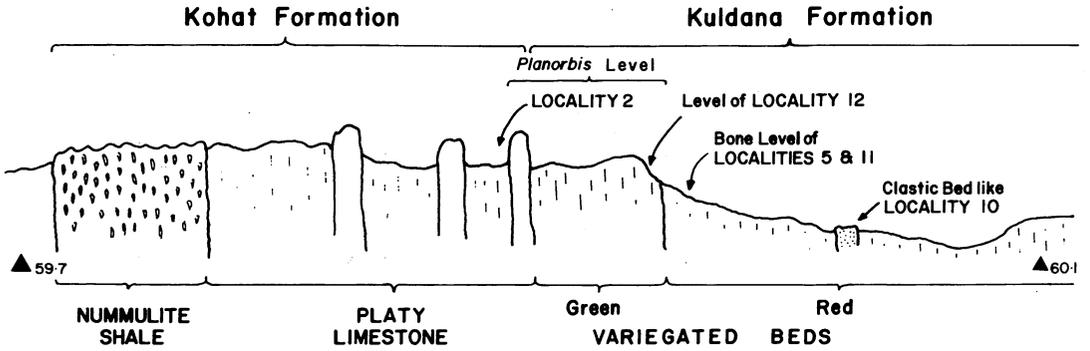
A small artiodactyl astragalus of ?*Haqueina haquei* (UM 65871) was found in the clastic carbonate bed forming a low ridge in the eastern part of Locality 11, about 50 (15 m) below the main mammal locality stratigraphically.

Locality 12: Kuldana Formation. Abundant bone was found coming out of green marls in a small exposure across the road to the west of Locality 2, near milepost 59.8 on the Basal-Campbellpore road. *Planorbis* and a high-spined gastropod, crocodilian and turtle bone, coprolites, and mammalian bone were found here (UM 65866).

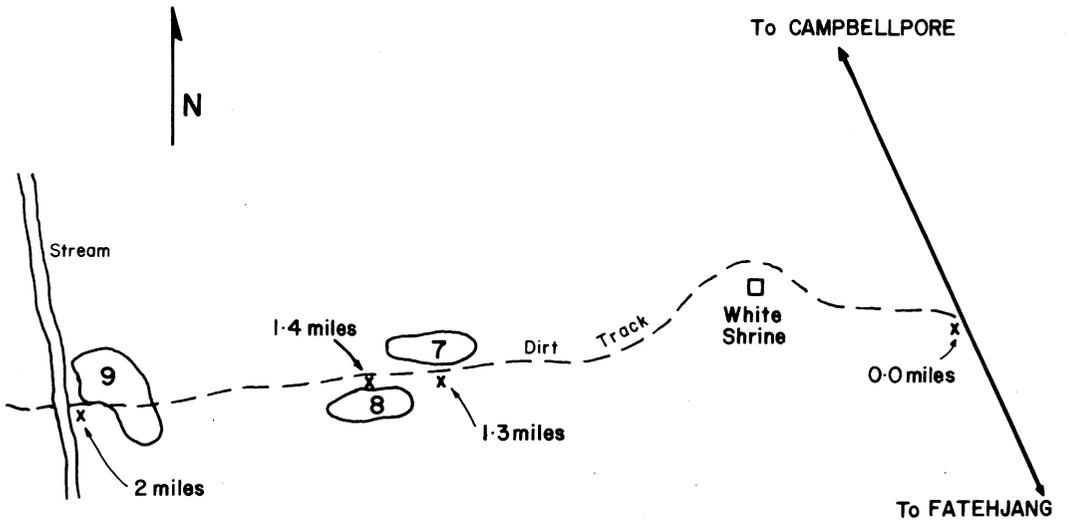
Localities 2-6 and 10-12 are in the Lammidhan area on the road between Basal and Campbellpore



TEXT-FIG. 3— Locality 11. Upper figure shows a general view looking northeast across the valley of Locality 11, toward the village of Ganda Kas in the distance. Area yielding a concentration of mammal specimens is in red beds in the lower left corner of the photograph. Lower figure, also looking northeast, shows a closer view of the area yielding mammalian teeth and bone. Specimens were found on the slope in the left center of the photograph.



TEXT-FIG. 4— Stratigraphic relationships of localities at Lammidhan. Diagrammatic section taken along the Basal-Campbellpore road between mileposts 59.7 and 60.1.



TEXT-FIG. 5— Map showing middle Eocene fossil localities along the track leading to Chharat, west of the Fatehjang-Campbellpore road. All are in the Kuldana Formation (see text).

(see text-fig. 2). The stratigraphic positions of the localities, where known, are shown in text-figure 4. Localities 7-9 are in the Chharat area and can be reached by driving north from Fatehjang on the road to Campbellpore for 3 miles, then driving west on a dirt track past the prominent white shrine for 1.3 miles (see text-fig. 5).

NOTES ON THE FOSSIL MAMMALS FROM LAMMIDHAN

The new collection from Lammidhan described here includes representatives of four genera: *Gandakasia*, *Ichthyolestes*, *Haqueina*, and *Khirtharia*. In addition, undescribed specimens of two additional genera, *Anthracobune* and *Lammidhanina* g. nov. were discovered in the British Museum (Natural History) collection from Lammidhan. Each of these is discussed briefly below.

Gandakasia potens Dehm and Oettingen-Spielberg, 1958

Pl. 1, figs. 1, 2

Gandakasia has very large, distinctive molars with a characteristic notch in the anterior margin. The specimen found at Locality 2 (UM 65868) preserves most of the crown, but the talonid has been broken off. The dentition of this genus is too poorly known to permit determination of which tooth in the molar series is represented. Because of breakage the length of the tooth cannot be estimated. Its maximum width is 8.6 mm.

Dehm and Oettingen-Spielberg (1958, p. 15) suggested that the maxilla of a mesonychid described by Pilgrim (1940, see pl. 1, fig. 10 here) from Safed Tobah might belong to *Gandakasia* but, having studied the specimens in question, it is difficult to see how the lower teeth of *Gandakasia* would occlude with teeth of the conformation suggested by the Safed Tobah specimen.

It is also worthy of note that this specimen of *Gandakasia* is the only mammal found in the Kohat Formation, which represents a distinctly more marine facies than the underlying Kuldana beds. The possibility exists that *Gandakasia* is a primitive archaeocete rather than a mesonychid condylarth.

Ichthyolestes pinfoldi Dehm and Oettingen-Spielberg, 1958

Pl. 1, fig. 3

UM 65869 is a partially erupted left lower premolar, probably P_2 . The length of the tooth is approximately 11 mm, and the width is 4.6 mm. Judging from its size and morphology, the tooth probably represents *Ichthyolestes pinfoldi*.

Haqueina haquei Dehm and Oettingen-Spielberg, 1958

Pl. 1, fig. 4

UM 65867 is a broken left upper molar, probably M^2 . The size of the tooth cannot be measured accurately, but it is of the correct size and morphology to occlude with the lower teeth of *Haqueina haquei*.

An astragalus, UM 65871 measuring approximately 8.2 mm in breadth across the proximal trochlea, is slightly narrower than the astragalus of *Khirtharia dayi* in the British Museum (BMNH 15800, measuring approximately 21 mm in length, 10 mm in breadth across the distal trochlea, and 10.5 mm across the proximal trochlea). The specimen was found several meters below the tooth of *Haqueina haquei* stratigraphically, but it probably belongs to this species.

Khirtharia dayi Pilgrim, 1940

Pl. 1, figs. 5-7

A newly discovered left mandible fragment (UM 65870) is the first specimen of *Khirtharia* preserving a premolar. The premolar, measuring 6.9 mm in length and 4.6 mm in width, was still in the process of erupting. An x-radiograph of the mandible revealed no erupting crown under the roots

preserved behind this tooth, confirming that the tooth in question is P_4 and the preserved roots were for M_1 . Comparison with molars of *Khirtharia dayi* described by Pilgrim (1940), and Dehm and Oettingen-Spielberg (1958) shows that P_4 was very small relative to molar size in this genus, as in the related *Bunodentus* from the ?middle Eocene locality of Kalakot in Jammu-Kashmir (see Ranga Rao, 1972).

Anthracobune pinfoldi Pilgrim, 1940

Pl. 2, figs. 1-4

The type specimen of *Anthracobune pinfoldi* includes left and right mandible fragments each preserving parts of M_{2-3} . While studying the type specimen in the British Museum (BMNH 15792), it was discovered that an isolated molar trigonid (BMNH 15794) fits onto the left M_2 of the type specimen (see pl. 2, figs. 1-2). An isolated M_1 (BMNH 32169) that undoubtedly belongs to this species was discovered in the collection from Lammidhan (see pl. 2, figs. 3-4). This M_1 measures 25.5 mm in length and 16.3 mm in width. Furthermore, comparison of the type specimen of *Anthracobune(?) daviesi* Pilgrim, 1940 (BMNH 15795, a left maxilla with P^{3-4} or P^{2-3}) indicates that it is surely conspecific with *Anthracobune pinfoldi*, and it may possibly be part of the same individual animal as the type specimen of *A. pinfoldi*.

Lammidhan new genus

Lammidhan wardi (Pilgrim, 1940)

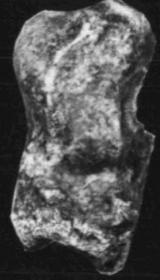
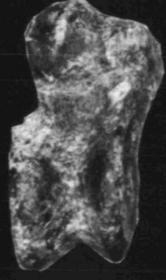
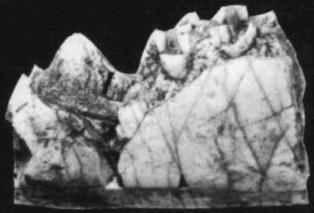
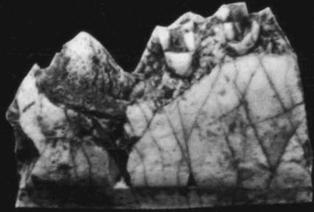
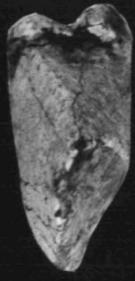
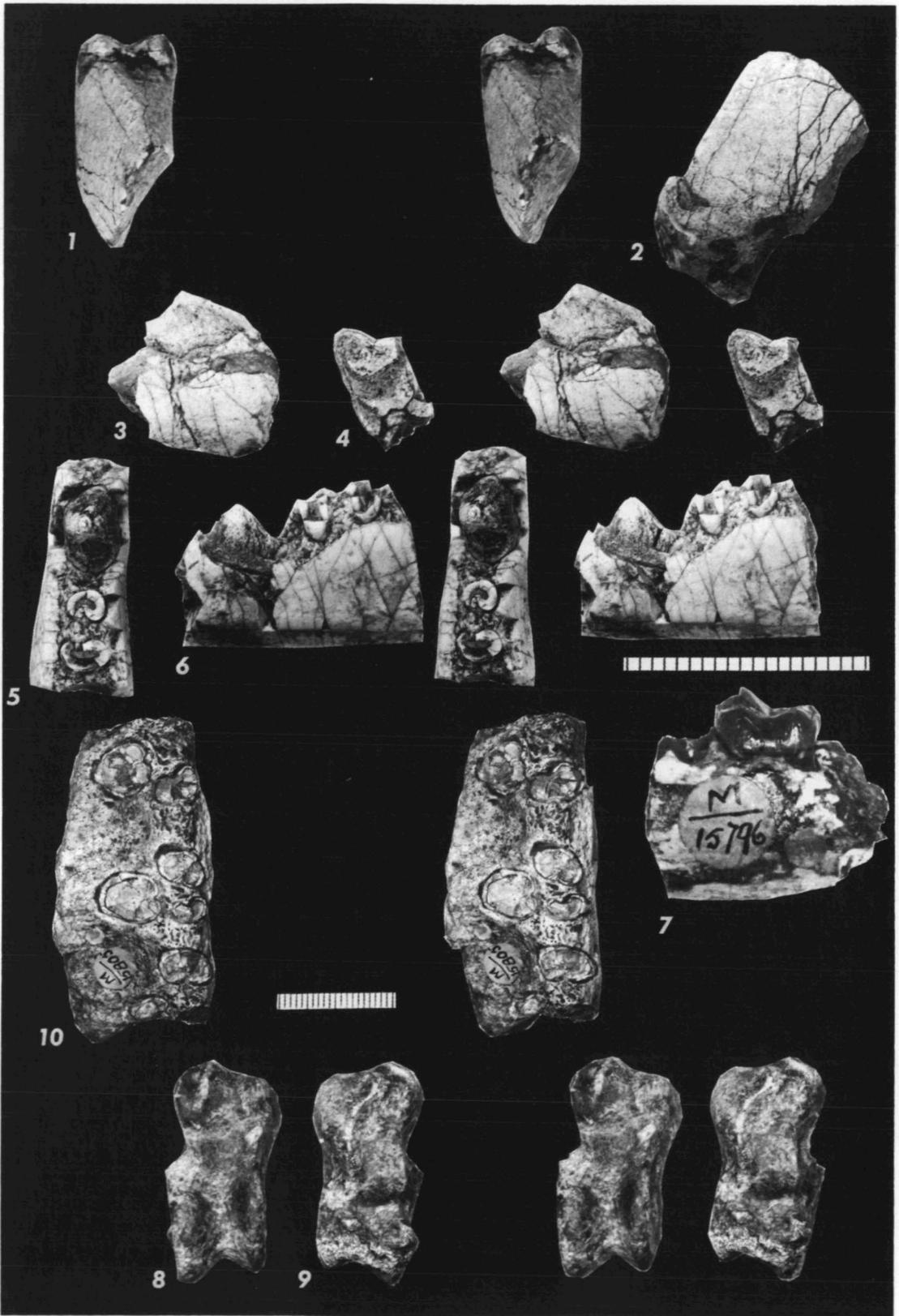
Pl. 2, figs. 5-6

Pilgrim (1940) referred a third Lammidhan species, "*Anthracobune(?) wardi*", questionably to the genus *Anthracobune*. Dehm and Oettingen-Spielberg (1958) recognized that this species certainly does not belong to *Anthracobune*, and placed it in their new genus *Pilgrimella*. An undescribed M_3 from Lammidhan in the British Museum almost certainly belongs to this species. The species was previously known only from the type specimen, the broken talonid of a lower molar, and thus the new M_3 adds considerably to our knowledge of the species. The M_3 (BMNH 32168) measures 32.7 mm in length and 15.6 mm in width. The type specimen (BMNH 15799), probably the talonid of M_1 , measures 12.7 mm in width. Considering the specimens now known, it is clear that this species does not belong in the genus *Pilgrimella*.

Dehm and Oettingen-Spielberg (1958) identified the type specimen of *Pilgrimella pilgrimi*, an isolated upper molar, as an M^1 . From the arrangement of the cusps on the specimen, it appears more likely that it is an M^3 . In either case, the new M_3 of "*A. wardi*" mentioned above indicates that the species *wardi* had teeth significantly larger than those of *Pilgrimella pilgrimi*. Furthermore, the lower molars of *wardi* are too selenodont to occlude with upper molars of the morphology of *Pilgrimella*. Thus Pilgrim's species *wardi* is here placed in the new genus *Lammidhan*. It differs from *Pilgrimella* in being more selenodont. *Lammidhan* appears to be a primitive anthracotherid. Additional more complete specimens are required to permit more detailed comparisons.

An isolated astragalus found at Locality 11 (UM 65872, pl. 1, figs. 8, 9) probably belongs to *Lammidhan wardi*, or possibly to *Pilgrimella pilgrimi*. The astragalus measures 35.7 mm in total length, 15.0 mm in width across the distal trochlea, and 14.6 mm in width across the proximal trochlea.

PLATE 1.— (Figs. 1-7 x2, 8-10 natural size) FIGS. 1, 2— *Gandakasia potens* from Lammidhan, UM 65868, trigonid of lower molar; 1, stereophotograph of occlusal view; 2, lateral view. 3— *Ichthyolestes pinfoldi* from Lammidhan, UM 65869, left lower premolar, stereophotograph of lateral view. 4— *Haqueina haquei* from Lammidhan, UM 65867, left upper molar, stereophotograph of occlusal view. 5, 6— *Khirtharia dayi* from Lammidhan, UM 65870, left mandible fragment with P_4 and roots of M_1 ; 5, stereophotograph of occlusal view; 6, stereophotograph of lateral view. 7— *Khirtharia dayi* TYPE from Lammidhan, BMNH 15796, left mandible fragment with M_2 , lateral view. 8, 9— *Lammidhan wardi* or *Pilgrimella pilgrimi* from Lammidhan, UM 65872, left astragalus; 8, stereophotograph of dorsal view; 9, stereophotograph of ventral view. 10— Mesonychid from Safed Tobah, BMNH 15805, edentulous maxilla, stereophotograph of occlusal view.



CONCLUSIONS

The following fauna of middle Eocene mammals is now known from Lammidhan. All except *Gandakasia* come from the Kuldana beds:

?CONDYLARTHRA

?MESONYCHIDAE

Ichthyolestes pinfoldi

?CETACEA

?PROTOCETIDAE

Gandakasia potens (Kohat Formation)

ARTIODACTYLA

DICHOBUNIDAE

Khirtharia dayi

Haqueina haquei

ANTHRACOTHERIDAE

Anthracobune pinfoldi

Lammidhanian wardi

?*Pilgrimella pilgrimi*

The most important conclusion, based on discovery of the small concentration of fossil mammals at Locality 11, is that there is very good potential for the discovery of additional middle Eocene mammals in the Kuldana Formation and its lateral equivalents.

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In Ann Arbor, Mr. T. Abdelnour made the x-radiograph of the mandible of *Khirtharia*, R. G. Habetler and G. Gunnell cleaned and catalogued the new collection, and Mrs. Gladys Newton typed the manuscript.

PLATE 2.— (All figures natural size) FIGS. 1, 2— *Anthracobune pinfoldi* TYPE from Lammidhan, BMNH 15792 and 15794, left mandible with M₂₋₃; 1, stereophotograph of occlusal view; 2, lateral view. 3, 4— *Anthracobune pinfoldi* from Lammidhan, BMNH 32169, right mandible fragment with M₁; 3, stereophotograph of occlusal view; 4, lateral view. 5, 6— *Lammidhanian wardi* from Lammidhan, BMNH 32168, left mandible fragment with M₃; 5, stereophotograph of occlusal view; 6, lateral view.



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