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LOWER TERTIARY VERTEBRATES
FROM
WESTERN INDIA

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ABSTRACT.—Palaeogene and Lower Miocene rocks of Kutch, Western India, have yielded a prolific vertebrate fauna from three separate horizons: Middle Eocene, Chattian (uppermost Oligocene) and Lower Miocene. The Middle Eocene fauna comprises of siluroid fishes, *Fajunia menoni* sp. nov., *Fajunia misrai* sp. nov., *Socnopaea horai* sp. nov. and *Arius kutchensis*; trionychid turtles; a new tomistomin, *Tomistoma tandoni* sp. nov. and crocodilian remains as well as the mammals represented by archaeocetes, odontocetes, a sirenian and a probable terrestrial mammal. Of the mammalian genera and species, the following taxa are new: *Protocetus harudiensis* sp. nov., *Indocetus ramani* gen. et sp. nov., *Andrewsiphius kutchensis* gen. et sp. nov., and *Andrewsiphius minor* sp. nov. *Indocetus ramani* gen. et sp. nov. suggests an intermediate stage between Mesonychidae and Archaeoceti. The Chattian mammalian fauna is marine with the predominance of the dugongid *Halitherium*. The Lower Miocene is a mixed facies fauna comprising of the sirenians, *Indosiren koenigswaldi* sp. nov., as well as definite terrestrial mammals represented by *Deinotherium* and the anthracotheriid *Brachyodus*.

The lower Tertiary vertebrate fauna from Kutch closely resembles corresponding faunas from Egypt and Nigeria.

INTRODUCTION

Tertiary vertebrates from Kutch, western India, were first reported by Grant (1840). For well over a century until the present time, little attention was paid to the investigation of Kutch vertebrates except for a few reports (Wynne 1872, Rao 1956, Tewari 1959 and Tandon 1971). The main emphasis was directed to the study of foraminifers and ostracodes (Sykes 1840, Sowerby 1840, Vredenburg 1906, Nuttall 1926, Tewari and others 1956-1968, Tandon 1966, Singh 1967, Mohan and others 1968-1970, Srivastava 1970). There are several other reports on invertebrates (D' Archiac and Haime 1853, Duncan and Sladen 1883, Vredenburg 1925, 1928).

Systematic collection of Tertiary vertebrates of Kutch was undertaken by Lucknow University field parties during the years 1970-1973. During six months of field prospecting, a large and varied collection was made from a number of localities (Fig. 1), and from horizons ranging in age from the Lower Eocene to the Lower Miocene (Fig. 2).

The Tertiaries of south-western Kutch are essentially a shallow water, coastal sequence, exposed in numerous nala sections in the area (Fig. 2). The Palaeocene Madh Series overlying the Deccan plateau basalts, consists of red lateritic and tuffaceous, trap-wash material containing plant fossils and representing non-marine deposition. These beds are overlain by the Eocene Berwali Series attaining a maximum thickness of 95 meters in south-western Kutch. The series is divisible into two stages, the Kakdi Stage comprising Lower Eocene, and Babia Stage comprising the Middle Eocene beds, and has been separated mainly on the basis of ostracodal and foraminiferal assemblages (Biswas 1965, 1971a). The Oligocene Bermoti Series are deposits of arenaceous marls, and are overlapped in several areas by a thick sequence of Mio-Pliocene sandstones and carbonates (Khari and Kankawati Series) which suggest the transition of marine conditions in Lower Miocene to terrestrial conditions in the Pliocene. The Pleistocene is represented by a thin bed of Miliolitic Limestone. In south-western Kutch, Recent and sub-Recent alluvium as well as wind-blown sand extensively blanket the Tertiary and Mesozoic sequences.

The Eocene fauna includes fish, turtles, crocodiles, primitive cetaceans, sirenians and a doubtful moeritheriid. The fishes are dominated by large siluroids comprising of three genera and five species. Elasmobranchs are represented by five species of sharks and one species of rays. The turtles are mostly estuarine forms, comprising the genera *Asperidites* and *Trionyx*. The crocodilian fauna is diversified and consists of a new species of a large tomistomid, and *Crocodylus*. The mammals consist of archaeocete cetaceans as well as doubtful odontocetes. The sirenians are represented by a single genus, *Protosiren*. The presence of land mammals during Middle Eocene times in Kutch is recorded by a sacrum presumably belonging to a moeritheriid.

The Chattian vertebrate fauna comprises mainly of sirenians represented by ribs, vertebrae and mandibular fragments of *Halitherium*.

The youngest vertebrate horizon has yielded a number of sharks, rays, batoids and other teleosts; trionychid turtles, crocodilian vertebrae and scutes; sirenians are represented by a new species of *Indosiren*. From the rocks of the same age (Burdigalian) but at a higher horizon, a femur of *Deinotherium* has been recovered.

The types and figured specimens are deposited in the laboratory of Vertebrate Palaeontology (L. U. V. P.), Geology Department, Lucknow University, Lucknow, India.

This study was undertaken as post-graduate research at University of Lucknow, India. We wish to thank Prof. R. C. Misra, Head of the Geology Department, Lucknow University for providing laboratory facilities and encouragement. Thanks are also due to Shri Sushil Kumar Khare, research scholar in Geology Department, Lucknow University for help during the preparation of the manuscript. We also wish to extend our thanks to Dr. Leigh Van Valen of Chicago University and Dr. F. S. Szalay of City University of New York for their comments and suggestions on the archaeocete cetaceans in the fauna. The junior author is also thankful to the University Grants Commission, and Council of Scientific and Industrial Research, Government of India, for financial assistance.

Kutch Tertiary Vertebrate localities (Fig. 1) yielding fossils described in this paper

Locality No.	Locality	Age	E Longitude	N Latitude
L. U. 2001	Matanomadh	? Chattian and Lower Miocene	68°57'	23°32'37"
L. U. 2002	Lakhpatt	Lower Miocene	68°47'	23°49'30"
L. U. 2003	Harudi	Middle Eocene	68°41'15"	23°30'20"
L. U. 2004	Naredi (locally known as Nareda)	Lower Eocene	68°39'	23°34'
L. U. 2005	Nareda (locally known as Naredi)	Middle Eocene	68°41'	23°39'10"
L. U. 2006	Godhatad	Middle Eocene	68°39'30"	23°39'
L. U. 2007	Denma	? Chattian	68°55'30"	23°31'15"
L. U. 2008	Jangadia	Lower Miocene	68°52'08"	23°26'35"
L. U. 2009	Buta	Lower Miocene	68°51'	23°23'
L. U. 2010	Aida	Lower Miocene	68°48'	23°24'10"
L. U. 2011	Samda	Lower Miocene	68°52'	23°28'40"
L. U. 2012	Junagia	Lower Miocene	68°49'30"	23°28'15"
L. U. 2013	Jhulrai	Middle Eocene	68°45'30"	23°29'42"
L. U. 2014	Pipar	Lower Miocene	68°31'45"	23°31'
L. U. 2015	Ratipar	? Chattian	68°34'10"	23°31'06"

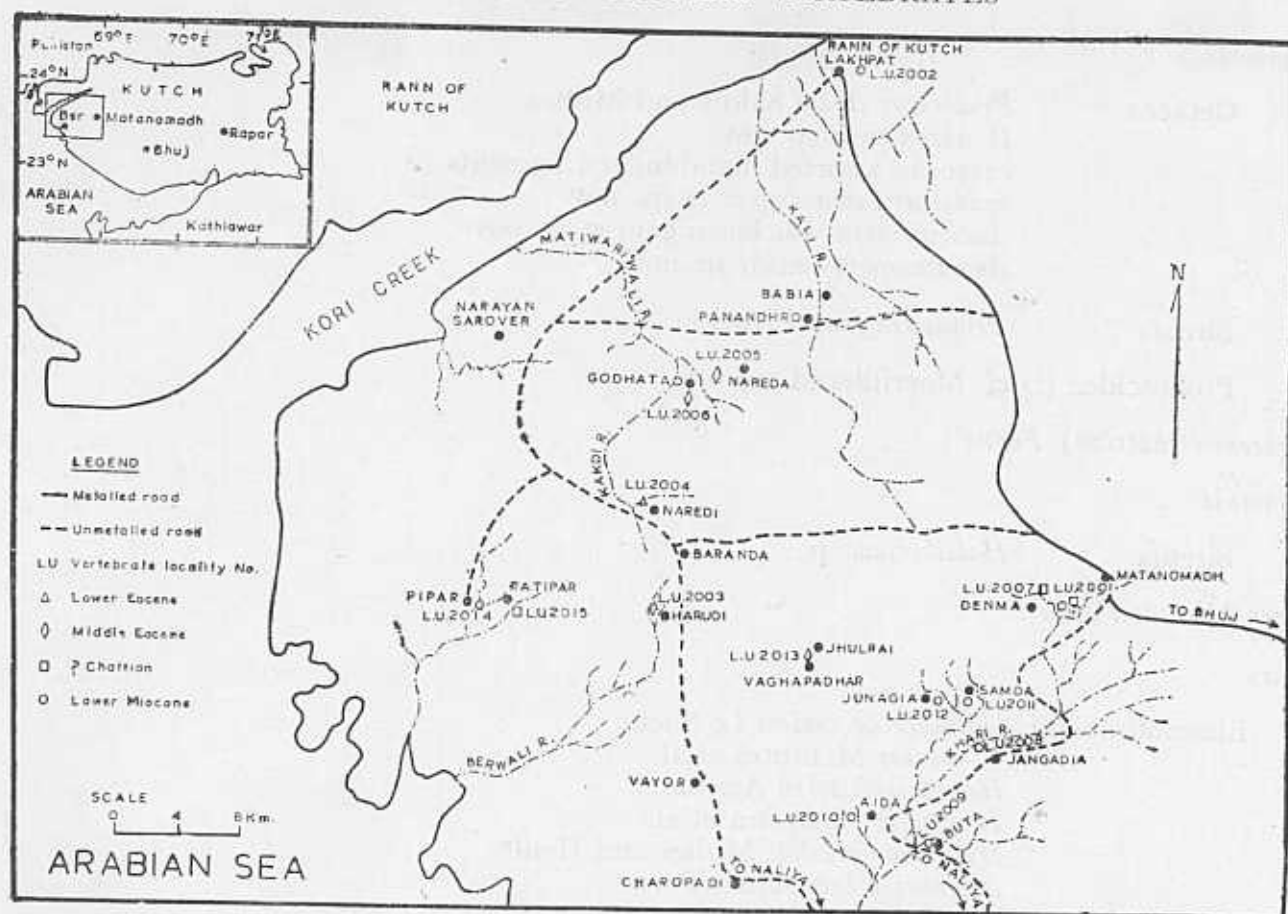


FIG. 1. Sketch map of western Kutch showing vertebrate fossil localities.

TERTIARY VERTEBRATE FAUNA OF KUTCH, WESTERN INDIA

Collected 1970-1973 by V. P. Mishra

Lower Eocene Fauna

Elasmobranchii *Scoliodon* sp.

Middle Eocene Fauna

Fishes

Elasmobranchii *Notidanus primigenius* Agassiz
Galaeocercdo cuvieri Le Sueur
G. aduncas Agassiz
Lamna sp.
Carcharias tricuspidatus Day
Myliobatis sp.

Actinopterygii *Fajumia menoni* sp. nov.
F. misrai sp. nov.
Socnopaia horai sp. nov.
Arius kutchensis Rao
Arius sp.
Cybbium sp.
Sphyræna sp.
Pycnodus sp.

Reptiles

Crocodylidae *Tomistoma tandoni* sp. nov.
Crocodylus sp.
crocodilian coprolites

Chelonia *Trionyx* sp.

Mammals

- Cetacea *Protocetus sloani* Sahni and Mishra
 P. harudiensis sp. nov.
 cetacean assorted mandibular fragments
 Indocetus ramani gen. et sp. nov.
 Andrewsiphium kutchensis gen. et sp. nov.
 Andrewsiphium minor sp. nov.

- Sirenia *Protosiren fraasi* Abel

- Proboscidea (?) cf. Moeritheriid sacrum

*Oligocene (Chattian) Fauna :**Mammals*

- Sirenia *Halitherium* sp.

*Lower Miocene Fauna :**Fishes*

- Elasmobranchii *Galaeocерdo cuvieri* Le Sueur
 G. wynnei Mehrotra et al.
 Hemipristis serra Agassiz
 H. sureshi Mehrotra et al.
 Hypoprion macloiti Muller and Henle
 Negaprion brevirostris Poey
 Scoliodon sorrakowah Cuvier
 Isurus spallanzanii Bonaparte
 Carcharodon megalodon robustus Davies
 C. angustidens Agassiz
 C. bigelowi Mehrotra et al.
 C. carcharias Linnaeus
 Alopias vulpes Gmelin
 Sphyrna prisca Springer
 Carcharias tricuspidatus Day
 C. heptacuspis Mehrotra et al.
 Myliobatis curvipalatus Lydekker
 Myliobatis sp.
 Aetobatis sp.
 Raja sp.

- Actinopterygii *Cybiu* sp.
 Sphyrna sp.
 Pseudoegertonia sp.
 Sparus (Chrysophrys) sp.
 Diodon sp.

Reptiles

- Crocodylidae crocodilian scutes & vertebrae

- Chelonia *Trionyx* sp.

Mammals

- Sirenia *Indosiren koenigswaldi* sp. nov.

- Proboscidea *Deinotherium pentapotamiae* Falconer

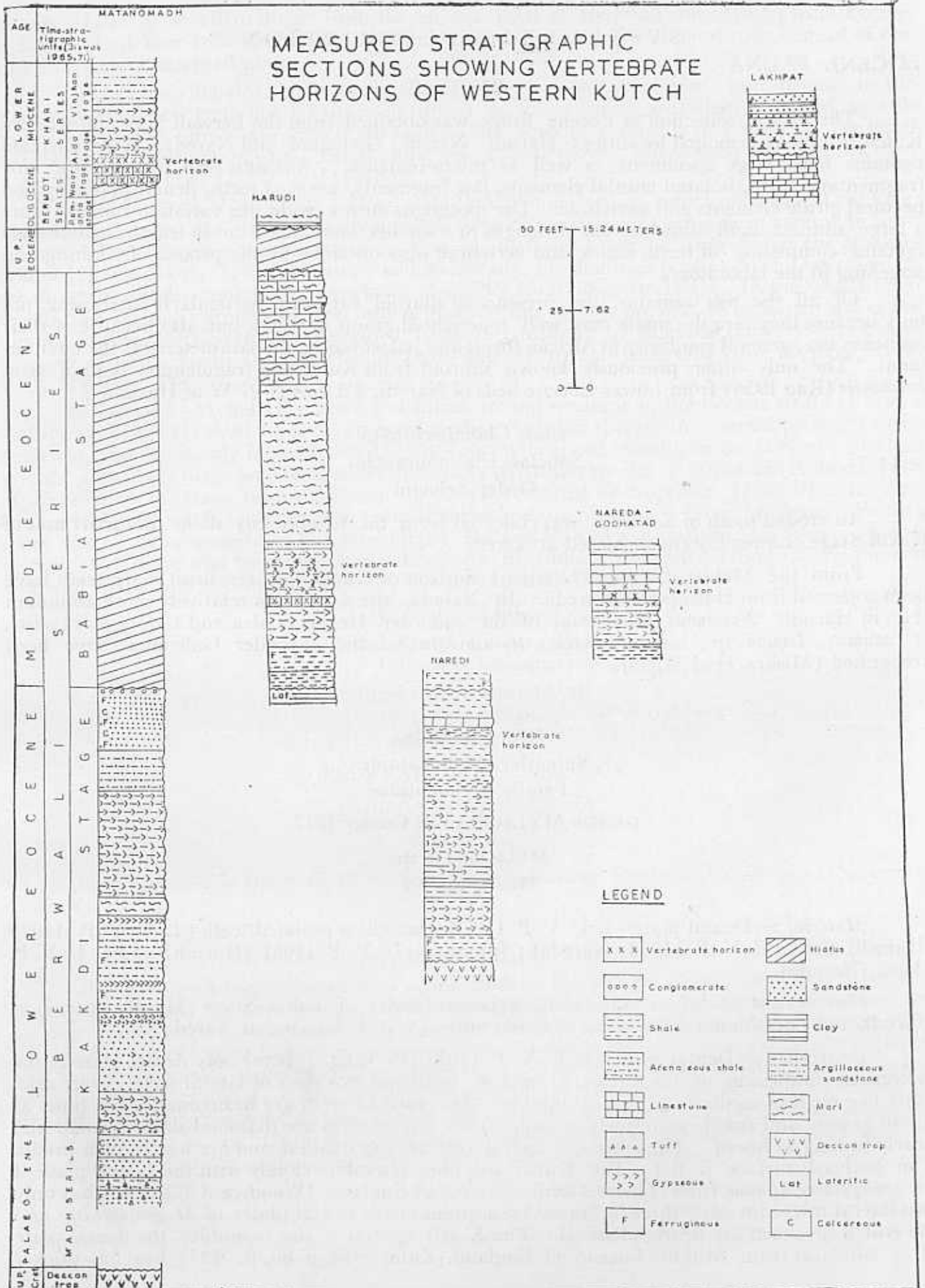


FIG. 2. Measured stratigraphic sections showing vertebrate horizons of western Kutch.

SYSTEMATIC DESCRIPTION

EOCENE FAUNA

FISHES

The present collection of Eocene fishes was obtained from the Berwali Series of western Kutch from four principal localities: Harudi, Naredi, Godhatad and Nareda. The collection contains both large specimens as well as micro-remains. Amongst the former are nine fragmentary skulls, isolated cranial elements, jaw fragments, assorted teeth, dental plates, spines, pectoral girdle elements and vertebrae. The specimens show a wide size variation ranging from a large siluroid skull some 40 cm in length to a smaller one some 8 cm in length. Micro-fish remains comprising of teeth, scales and vertebrae were obtained by the process of washing and screening in the laboratory.

Of all the fish remains, the presence of siluroid cat-fish is particularly interesting, not only because they are the single most well represented group of fishes, but also because of their immense size, general similarity to African forms and palaeoecological parameters of the environment. The only other previously known siluroid from Kutch is a fragmentary skull of *Arius kutchensis* (Rao 1956) from Lower Eocene beds of Naredi, 8.5 kms N 27°W of Harudi.

Class Chondrichthyes
Subclass Elasmobranchii
Order Selachii

An eroded tooth of *Scoliodon* was collected from the fossiliferous shale and marl unit of Kakdi Stage (Lower Eocene) exposed at Naredi.

From the Middle Eocene (Lutetian) horizon of Kutch only few fossil shark teeth have been collected from Harudi and Nareda. In Nareda, the sharks are relatively more abundant than in Harudi. *Notidanus primigenius* of the suborder Hexanchioidea and *Galaeocerdo cuvieri*, *G. aduncas*, *Lamna* sp., and *Carcharias tricuspidatus* of the suborder Galeoidea have been recognised (Mishra et al., 1973).

Order Batoidea
Suborder Myliobatoidea
Family Myliobatidae
GENUS MYLIOBATIS Cuvier 1817

MYLIOBATIS sp.
Plate I, figs. 1-2

Material:—Dental plate—L. U. V. P. 11078 (Harudi); isolated teeth—L. U. V. P. 11079 (Harudi) and L. U. V. P. 11083 (Nareda); Spines—L. U. V. P. 11081 (Harudi) and L. U. V. P. 11082 (Nareda).

Horizons and localities:—Ossiferous gypseous shales of Babia Stage (Middle Eocene) at Harudi, and Foraminiferal limestone of Babia Stage (Middle Eocene) at Nareda.

Description:—Dental plate—L. U. V. P. 11078 (Pl. I, fig. 1) is the only dental plate in the collection comprising of the 8 rows of median teeth and two rows of lateral teeth of one side. Only five teeth of median row are complete. The median teeth are hexagonal, seven times as broad as long and antero-posteriorly arched. Inner lateral teeth are diamond-shaped, small and nearly as long as broad. The outermost lateral teeth are the smallest and are longer than broad. The occlusal surface is flat. The Kutch specimen resembles closely with the dental plate of *M. goniopleurus* Agassiz from Lower-Middle Eocene of England (Woodward 1889) but has only two lateral rows instead of three. Transverse sections of the dental plates of *M. goniopleurus* and the Kutch specimen are nearly identical. The Kutch specimen also resembles the dental plate of *M. toliapicus* from Middle Eocene of England (Zittel 1932, p. 86, fig. 137) but has thicker

crowns. L. U. V. P. 11078 differs from the dental plate of *Myliobatis curvipalatus* from Eocene of Kutch (Lydekker 1886 b) in being smaller in size and having two lateral rows instead of one and possessing a flattened plate.

The other myliobatid teeth in our collection are isolated specimens, and belong to the median row. These teeth are 3-7 times as broad as long; some are slightly arched antero-posteriorly, while others are nearly straight. The coronal surface is smooth, while the basal surfaces of the roots show distinct longitudinal ridges and grooves. The crowns are less thick than in the median teeth of L. U. V. P. 11078.

Spines:—L. U. V. P. 11082 a (Pl. I, fig. 2) is a caudal spine which is nearly 5 cm long. The spine is narrow and longitudinally striated, some of the striations being deep enough to form grooves. The cross-section is similar to that of *Myliobatis serratus* from Oligocene of Alzey (Zittel 1932, p. 86, fig. 138). The spine widens distally, the denticles present on the lateral edges are directed distally making an angle of about 35° from the central axis. In the distal 1/3rd region the denticles are absent, and only a fine cutting edge is present. The Kutch spines are similar to that of *Myliobatis* sp. described from the Miocene of Balasore (Hora 1939), Lower Miocene of Mayurbhanj, Orissa (Ghosh 1959) and *M. serratus* from Oligocene of Alzey (Zittel 1932, p. 86, fig. 138).

Discussion:—Myliobatoid teeth and spines are not common in the Eocene strata of Kutch and dental plates are even rarer because the median and lateral teeth in a dental plate get easily detached, and are mostly found isolated. The few myliobatoid remains in the present collection are not sufficiently diagnostic to be referable to any particular species of *Myliobatis*. A dental plate of *Myliobatis curvipalatus* from the Eocene of Kutch described by Lydekker (1886 b) is the only species of *Myliobatis* so far described from Eocene horizon of India. From Miocene, a median tooth and a caudal spine from Balasore, Orissa (Hora 1939) and a spine from Mayurbhanj, Orissa (Ghosh 1952) have also been described. Presently in India, *Myliobatis* is found along the east and west coasts, and also in the mouth of Ganges and Chilka Lake.

Class Osteichthyes

Subclass Actinopterygii

Infraclass Teleostei

Superorder Ostariophysi

Order Siluriformes

Family Bagridae

GENUS FAJUMIA Stromer 1904

FAJUMIA MENONI sp. nov.

Plate I, fig. 3

Etymology:—For Dr. A. G. K. Menon, Superintending Zoologist, Zoological Survey of India, Calcutta.

Holotype:—L. U. V. P. 11140, a skull.

Horizon and locality:—Bluish-grey shales of Babia Stage (Middle Eocene) at Godhatad.

Diagnosis:—A large siluroid with skull similar to that in *Arius* but differs in neither having the complex vertebra fused with the basioccipital nor in possessing the median supraoccipital depression; in these two characters it resembles *Fajumia schweinfurthi* Stromer (Andrews 1906, pp. 313-314) from Upper Eocene of Fayum (Egypt). It differs from *F. schweinfurthi* in being wider and having no rows of specially enlarged tubercles on the sides of the fontanelle; also the anterior border of the ethmoid is concave and not straight as in *F. schweinfurthi*. It differs from the skull of *Socnopaia grandis* Stromer from Upper Eocene of Fayum (Egypt) in being smaller in length and lower in height; also the tubercles are bigger and not arranged in radiating rows. The median depression is smaller with only one fontanelle instead of two as is *Socnopaia*.

Description:—Skull long and wide within the size variation of *Fajumia schweinfurthi*, the type species. Only the following bones are preserved in the skull: the interneural plate, supraoccipital, pteriotics, sphenotics, frontals, left prefrontal, left part of ethmoid, basioccipital, parasphenoid and complex vertebra.

The skull-roof is flat but elevated in the posterior part of supraoccipital as in the type species. The interneural plate at the dorsal posterior extremity of the skull is large, its anterior end being firmly attached in between the posterior extensions of supraoccipital; the length of the plate is 9 cm. Anteriorly the plate is narrow but widens posteriorly. Skull-roof is ornamented with large, prominent, coalesced tubercles, without any regular pattern on any cephalic plate. The supraoccipital is small, sloping anteriorly as well as laterally; its posterior part along with the interneural plate forms a median longitudinal ridge. Posteriorly the processes of the supraoccipital enclose firmly the narrow anterior part of interneural plate; anteriorly the supraoccipital wedges in between the backwardly directed processes of the frontals; laterally it is bounded by the sphenotics, pteriotics and epiotics. Dorsal surface of the supraoccipital is ornamented by rounded tubercles. There is no median depression or posterior fontanelle on the supraoccipital. Sensory grooves are shallow on the anterior side of the bone.

Pteriotics are small, subtriangular, attached internally with the supraoccipital, anteriorly with sphenotics, and posteriorly with epiotics. Their junction with sphenotics and supraoccipital is convex, while that with epiotic is almost a straight line.

Sphenotics are elongated and about 9 cm. long, their posterior extremity makes the shape of a V, one arm of which is in contact with the supraoccipital and the other with the pteriotic.

The frontals are elongated with a median depression anteriorly, leading into a fontanelle. Posteriorly the frontal is narrow and its junction with the supraoccipital is a simple zigzag line. The tubercles on the frontal are small and isolated and are neither arranged in a linear manner nor do they form two double rows of specially enlarged tubercles on either side of the fontanelle as in *F. schweinfurthi*. Frontals are bounded posterolaterally by sphenotics and anterolaterally by prefrontals. Only the left prefrontal is preserved in the specimen bearing large, closely spaced tubercles. The anteriormost bone is the ethmoid which is T-shaped, having a small anterior process and a long posterior process enclosed in between the anteriorly directed processes of the frontal. The anterior border of the ethmoid is slightly concave and not straight as in *F. schweinfurthi*. The dorsal surface of the ethmoid is without tubercles.

Basioccipital is broad, thick and swollen at its posterior side bearing two condyles; anteriorly this bone narrows and joins the parasphenoid with a convex suture. The "crucifix" is not complete, as the post-temporal bars are not preserved. Anterior to the position of the right post-temporal bar, adjacent to the basioccipital condyle, a roughly circular but deeply eroded otolith is present. The parasphenoid, situated anterior to basioccipital is almost as broad as basioccipital but more compressed dorsoventrally. The complex vertebra is not fused with the basioccipital, differentiating the skull from that of *Arius*. The complex vertebra is long and narrow. The anterior face of the centrum is wide and concave, the ventral surface of the vertebra is deeply grooved for the dorsal aorta as in genotype.

FAJUMIA MISRAI sp. nov.

Plate I, figs. 4-5

Etymology:—For Prof. R. C. Misra, Head of Geology Department, Lucknow University.

Holotype:—L.U.V.P. 11142, a skull.

Paratype:—L.U.V.P. 11142 a, a part of the left pectoral girdle, found associated with the holotype.

Horizon and locality:—Bluish-grey shales of Babia Stage (Middle Eocene) at Nareda.

Diagnosis:—A large siluroid with skull similar to *Arius* but differs in not having the complex vertebra fused with the basioccipital or a median depression arising from the supraoccipital region. Skull nearly of the same size as in *F. menoni* sp. nov. but slightly shorter and wider than in *F. schweinfurthi*. Unlike in *F. schweinfurthi*, no row of especially large tubercles on either side of median fontanelle as in *F. menoni* sp. nov. *F. misrai* sp. nov. differs from *F. menoni* sp. nov. in having a lower supraoccipital, more compressed and wider basioccipital, and in the presence of continuous longitudinal ridges of tubercles on the dorsal surface of the skull. It differs from *Socnopaea grandis* from Upper Eocene of Fayum (Egypt) in having a smaller and lower skull, larger tubercles joined only along mid-dorsal line of skull, and in having only one median fontanelle.

Description :—Skull is long, similar in size to that of the *F. menoni* sp. nov., but slightly shorter in length and a little wider than *F. schweinfurthi*. Only the following bones are preserved in the skull: the interneural plate, supraoccipital, post-temporal, pteriotics, sphenotics, frontals, basioccipital and parasphenoid. The skull roof is almost flat except for being slightly higher in the supraoccipital region; it is lower in this part than in *F. menoni* sp. nov. The interneural plate is firmly attached in between the posterior processes of the supraoccipital, the suture being the same as in *F. menoni* sp. nov. Supraoccipital nearly as long as in *F. menoni* sp. nov., longer than wide, sloping very gently towards the anterior and marginal sides. Tubercles on the supraoccipital are prominent and are joined on the mid-dorsal line forming continuous longitudinal ridges running from the interneural plate through the supraoccipital towards the frontals. There is no posterior fontanelle or median depression on the supraoccipital. A pair of sensory grooves starts from the supraoccipital and extends towards the frontal becoming deeper at the posterior margin of the frontal.

Only the right post-temporal is preserved, and consists of a small, nearly quadrangular bone. The tubercles on its dorsal surface are prominent, rounded but unjoined. The post-temporal slopes towards the lateral margin of skull, and at its outer extremity there is a distinct tuberosity for the articulation of the upper part of supraclavicular. The parietal is a small bone placed in between the supraoccipital and the post-temporal, anterior to which is the pteriotic which is broken along the outer margins, the suture between the pteriotic and supraoccipital is a straight line. The tubercles on the pteriotic are distinct and unjoined. The sphenotic which is situated anterior to the pteriotic and external to the frontal, is an elongated bone, the posterior extremity of which is 'V'-shaped as in *F. menoni* sp. nov.

The frontals are elongated with a median depression at the junction of their anterior side which leads into a fontanelle. The median depression is slightly anterior in position than in *F. menoni* sp. nov. The tubercles on the dorsal surface of the frontal are slightly smaller than on posterior bones but distinct and form continuous ridges on the median side. On the side of the fontanelle coalesced tubercles also form continuous low ridges, but tubercles are neither enlarged nor placed in two rows as in *F. schweinfurthi*. The prefrontal and ethmoid bones are not preserved.

On the ventral side of the skull, posterior to the basioccipital, the complex vertebra is not fused with the basioccipital as in other species of *Fajumia*. The basioccipital is more dorso-ventrally compressed than in *F. menoni* sp. nov. but wider. The basioccipital condyles, though weathered, appear to be smaller than in *F. menoni* sp. nov. The post-temporal bar is not preserved, thus the crucifix is not seen on the specimen. The otolith of right side is in its position in the depression formed between the basioccipital and the post-temporal bar. The otolith has a diameter of about 2.5 cm but is quite weathered and no details can be made out. The parasphenoid, anterior to basioccipital, is also wide and dorso-ventrally compressed but incomplete on its anterior side.

Measurements in centimeters

Maximum length of the preserved skull	...	29.5
Length from basioccipital to the anterior part preserved	...	24.5
Length from supraoccipital to the anterior part preserved	...	23.5

Pectoral girdle :—L.U.V.P. 11142 a is a part of the pectoral girdle of the left side with the head of pectoral spine attached. It was also found associated with the skull (L.U.V.P. 11142), the holotype. Of pectoral girdle, only the cleithrum is preserved, the dorsal surface of which is ornamented with prominent tubercles, some of which are joined but without any regular pattern. The arm of cleithrum which articulates with the post-temporal bone is incomplete and without any ornamentation. The glenoid facet is weathered and partially contains the head of the pectoral spine. The shaft of the spine is broken but appears to be strong and stout, the articulating facet (head) of the spine bears two condyles. There is a small opening on the ventral side of the head of the spine.

Family Bagridae

GENUS SOCNOPAEA Stromer 1904

SOCNOPAEA HORAI sp. nov.

Plate II, fig. 1

Etymology :—For late Dr. S.L. Hora, a leading Indian ichthyologist.

Holotype :—L.U.V.P. 11145, a skull, the only known specimen.

Horizon and locality :—Ossiferous gypseous shales of Babia Stage (Middle Eocene) at Harudi.

Diagnosis :—A large siluroid, resembles *Socnopaea grandis* Stromer from Upper Eocene of Egypt. It differs *Fajumia* in the same characters as *S. grandis*, i.e. in having a larger size, a different type of ornamentation consisting of many small tubercles arranged in low and thin radiating ridges; in having no rows of specially enlarged tubercles lateral to the median depression and has a posteriorly projecting supraoccipital. Supraoccipital is high in the posteromedial part sloping steeply on the lateral sides; the basioccipital is wider than in *Fajumia*. The skull differs from that of *S. grandis* in being slightly smaller in length and wider posteriorly, also the median depression does not possess two fontanelles. The sculpturing on the cranial plates also resembles *Macrones aor* (*Bagrus aor*) from Siwalik Formation of India (Lydekker 1886b) to some extent, but *Macrones aor* is more than 50 percent smaller in length having a median depression extending the length of the frontals and posteriorly to the anteriormost part of the supraoccipital, in contrast to the restriction of median depression only to frontals in the new species.

Description :—The skull is long and wide, larger than *Fajumia* but slightly smaller than *S. grandis*. The skull is gypsified and the sutures between the cephalic plates are obscure. The cephalic plates are thinner than in the species of *Fajumia* and *Arius*. The skull roof slopes anteriorly and considerably on the lateral sides from the median part of the supraoccipital. The tubercles are small, usually coalesced, forming continuous longitudinal and radiating ridges from the supraoccipital towards the frontals, thus the ornamentation differs from that of the species of the *Fajumia* and *Arius* in the collection. In ornamentation the skull resembles with that of *Macrones aor* from the Pliocene Siwalik rocks of India (Lydekker 1886b), but the skull of *S. horai* sp. nov. is more than 50 percent longer and does not bear a median depression on supraoccipital.

The supraoccipital is elongated, longer than wide, sloping anteriorly and on the lateral sides, having a high median ridge on the posterior side formed by an internal keel. The supraoccipital projects posterior to the rest of the skull as in *S. grandis*. On the right side, the parts of the post-temporal, parietal, pteriotic and sphenotic are preserved but gypsification has obscured the sutures and the details of the bones cannot be made out.

Anterior to the supraoccipital, the paired frontals are present, which are long and wide but broken laterally in the specimen. The median depression in between the two frontals is wide, long and deep and there is only one fontanelle on its anterior side unlike two in the type species. The frontals are characteristically ornamented: on each of the frontals the tubercles join to form low and fine radiating ridges somewhat assuming an acicular pattern on the anterior side.

On ventral side, the skull is more gypsified than on the dorsal side. The basioccipital and parasphenoid are wide, wider than in *Fajumia* and are dorso-ventrally compressed.

Remarks :—The familial status of *Fajumia* and *Socnopaea* described originally by Stromer (1904) from Qasr-el-Sagha Formation (Upper Eocene) of Fayum (Egypt) is uncertain. Andrews (1906, pp. 313-315) and Zittel (1932, p. 158) placed these genera in the family Siluridae. Later, Peyer (1928) while discussing the validity of these genera included them in the family Tachysuridae, a suggestion which was later accepted by Jayaram (1955). Jordan (1923) and recently Romer (1966) classified these genera in the family Bagridae, an assignation which has been followed in the present work.

Family Ariidae

GENUS *ARIUS* Cuvier and Valenciennes 1840*ARIUS KUTCHENSIS* Rao 1956

Plate II, figs. 2-4

Material :—L.U.V.P. 11036, impression of the dorsal surface of skull from Harudi; L.U.V.P. 11047 and L.U.V.P. 11048 a and b, the skull and pectoral spine and part of pectoral girdle from Nareda; and L.U.V.P. 11148, the posterior part of skull from Godhatad.

Horizons and localities :—L.U.V.P. 11036 from shell limestone of Babia Stage (Middle Eocene) exposed near Harudi; L.U.V.P. 11047 and L.U.V.P. 11048 from bluish-grey shales of Babia Stage (Middle Eocene) exposed near Nareda; and L.U.V.P. 11148 from bluish-grey shales of Babia Stage (Middle Eocene) exposed near Godhatad.

Revised Diagnosis :—Skull large, much larger than of *Arius crassus* from Upper Eocene of Barton, England (Newton 1889), *A. iheringi* from Upper Eocene of Tertiary lignite of Brazil (Woodward 1901), *A. egertoni* from Middle Eocene of Bracklesham, England (Woodward 1901), as well as the Recent species *A. gagarides* from India (Newton 1889), but nearly of the same size as of the species of *Arius* from the Siwalik Formation of India (Lydekker 1886b), from which it differs in the pattern of ornamentation.

Skull flat but elevated in the supraoccipital region by a high triangular keel. Dorsal surface ornamented with prominent and rounded tubercles, usually so arranged as to form radiating ridges. Supraoccipital longer than wide, projecting far behind the rest of the skull. Median depression quite prominent and deep, starting from the middle of the supraoccipital region running towards the frontals. Orbits large; basioccipital robust; crucifix present.

Description :—L.U.V.P. 11047 is a partially preserved skull nearly of the same size as the holotype (Rao 1956) but slightly higher. The following cephalic plates are preserved in the specimen: supraoccipital, epiotics, pteriotics, sphenotics, frontal, basioccipital and part of parasphenoid bone. The ornamentation consists of small rounded tubercles, most of which have got eroded. Supraoccipital is slightly smaller than of the type specimen (GSI type no 17539, stored in Indian Museum, Calcutta). The anterior contact of supraoccipital with the frontal is somewhat a zigzag suture as in *A. iheringi* (Woodward 1901). The median depression arises from nearly the middle of supraoccipital being narrow posteriorly, widening anteriorly, continuing towards the frontals leading into a fontanelle anteriorly. A pair of sensory grooves for slime canal extends on the side of median depression from supraoccipital towards frontal having a divergent angle of 35°. Epiotics and pteriotics are smaller than other cephalic plates. The sphenotics, situated antero-lateral to supraoccipital, are elongated enclosing the backwardly directed processes of the frontals in between them. Frontals are slightly wider posteriorly than in holotype. Basioccipital is robust, but condyles are broken. The crucifix is not seen as the complex vertebra and the post-temporal bars are not preserved.

Associated with L.U.V.P. 11047, the skull, were found a fragment of cleithrum of pectoral girdle (L.U.V.P. 11048 a), and an isolated pectoral spine (L.U.V.P. 11048 b), both of right side. Pectoral spine is strong, the head has two articulating condylar facets; the shaft is laterally compressed with well-marked longitudinal striations. Both the anterior and posterior edges are with backwardly directed denticles. In the head region, the median fossa is situated on the posterior side.

L.U.V.P. 11036 is the impression of another skull of this species which is larger in size than the holotype. The impression of the skull possesses supraoccipital, epiotic, pteriotic, sphenotic and frontals; part of circum-orbital series on the outer side is also preserved showing the position of a large orbit. The skull is ornamented with prominent rounded tubercles, arranged in a radiating pattern. Supraoccipital is longer than wide, projecting behind the rest of the skull. The median depression arises from the middle of supraoccipital continuing towards the frontals and is deeper than in holotype and L.U.V.P. 11047, described above. A sensory groove on each side of the median depression arises from the supraoccipital diverging at an angle of 40°.

Still another specimen, L.U.V.P. 11148 shows only the hinder part of the skull; the dorsal surface of skull has weathered off, exposing the internal keel on the posterior side in between the V-shaped ridge on the ventral side of supraoccipital. The basioccipital is nearly of the same size and shape as in L.U.V.P. 11047.

Discussion :—The larger number of the specimens in the present collection makes it possible to clarify certain points which were obscure in the holotype (Rao 1956). In Rao's (1956, pl. 28) original description of the holotype, the bone marked 'FR' is actually sphenotic, and anterior to the supraoccipital, only a part of the frontals is present which has been supposed by Rao (1956, p. 181) as ethmoid; furthermore the ethmoid is never in contact with supraoccipital, as supposed by Rao. Also, the bones marked 'SPHOT' and 'PTOT' are a single unit, the pteriotic bone.

Arius is found both in fresh and marine water conditions. In India the living species (*A. dussumieri*) is more abundant on the Malabar coast.

Infraclass Holostei
Order Pycnodontoformes
Family Pycnodontidae
GENUS PYCNODUS Agassiz 1833
PYCNODUS sp.

Plate II, fig. 5

Material :—Isolated splenial teeth (L.U.V.P. 11173).

Horizon and locality :—Shell limestone of Babia Stage (Middle Eocene) at Harudi.

Description :—The splenial tooth of *Pycnodus* from Kutch is small and discoidal. Its oral surface is rugose and indented. The basal surface is round with concentric growth lines and a small pulp cavity. The tooth resembles with that of *Pycnodus toliapicus* Agassiz (figured in Woodward 1908, pl. 1, fig. 11), but is smaller in size. The vomerine teeth of *Pycnodus lametae* described from Lameta beds (Woodward, *op. cit.*) are bigger in size than the splenial tooth from Kutch.

Remarks :—A skull and three vomerine teeth of *Pycnodus lametae* have been described from the Lameta beds (Cretaceous) of Dongargaon in Madhya Pradesh (Woodward 1908), and teeth of *Pycnodus* sp. have been described from the Uttattur beds (Cretaceous) of South India (Stoliczka 1873). The report from Kutch extends the geological distribution of the genus into the Eocene in India. The only other genus of Family Pycnodontidae described from India is *Coelodus*, from the Middle Eocene of Siju Limestone, Garo Hills, Assam (Menon and Prasad 1958), and from Upper Cretaceous of Ranikot and Sind (Prasad and Rao 1958). It is of interest to note that the pycnodont fishes are not found in the beds younger than latest Eocene period.

Class Reptilia
Order Crocodilia

Prior to current work, fragmentary reptilian remains were reported by Grant (1857), Wynne (1872), Feistmantel (1876), and Lydekker (1876b, 1877, 1879) from the Mesozoic and Tertiary rocks of Kutch. During the present investigation, a large number of crocodilian fossil remains were recovered from the rocks of Babia Stage (Middle Eocene) exposed near Harudi and Nareda. Crocodilian remains which are gypsified but retain their original structure, are represented in the collection by skull, mandibles, vertebrae, and coprolites; Eocene crocodiles in Kutch are referable to the genera *Tomistoma* and *Crocodylus*. Previously, only a few fossil tomistomin genera were known from Asia; *Eotomistoma multidentata* from Upper Cretaceous of China (Young 1964), *Tomistoma petrolica* from Upper Eocene of China (Yeh 1958) and *Rhamphosuchus crassidens* from Siwaliks (Pliocene) of India (Lydekker 1886b). The presence of *Tomistoma* in Middle Eocene of Kutch is interesting in as much as the Palaeogene species of the genus were so far known only from Egypt. *T. petrolica* from Upper Eocene of China, though originally described as a tomistomin, is probably a juvenile gavial.

The following features have been taken as the basis for the generic and specific differentiation of the Kutch crocodilian remains : size and shape of the cranium, shapes of premaxillae and narial opening, articulation of nasals with premaxillae, number and structure of teeth, length and the width of the mandibular symphysis, and the function of the splenials in the formation of the symphysis.

Suborder Eusuchia

Family Crocodylidae Cuvier 1807

Subfamily Tomistominae Woodward 1932

GENUS TOMISTOMA Muller 1846

TOMISTOMA TANDONI sp. nov.

Plate III, figs. 1-3

Etymology :—For Dr. K. K. Tandon, Department of Geology, Lucknow University.

Holotype :—L.U.V.P. 11062, mandible with 14 alveoli, containing symphysis.

Paratypes :—L.U.V.P. 11062 a, the skull lacking the premaxillae and portion posterior to orbits; and L.U.V.P. 11062b, ten vertebrae. The holotype and the paratypes belong to the same individual.

Horizon and locality :—Bluish-grey shales of Babia Stage (Lutetian) at Nareda.

Diagnosis :—Skull and the mandible tomistomid; skull elongated, longer than *T. gavialoides* (Andrews 1906) and *T. schlegeli* (Konjukova in Orlov's treatise 1964, p. 522), but slightly smaller than *T. eggenburgense* (Toula and Kail 1885), while the Portuguese Miocene form *T. lusitanica* (Antunes 1961) is 20 percent longer than Kutch species. The rostrum gradually tapers anteriorly as in *T. eggenburgense*, *T. gavialoides* and *T. lusitanica*. Width of the cranium at the level of the anterior border of the orbits is greater than in *T. kerunense* and *T. americana*; but slightly smaller than in *T. eggenburgense*, while in *T. lusitanica* it is one and a half times wider at this level than in the Kutch species. Nasals deeply penetrating as in *T. champsoides* (Lydekker 1886 a) between the premaxillae, and not reaching the external narial opening. Estimated number of the total teeth 20-21. Upper and lower teeth interlocking. Mandible shorter in length than in *T. lusitanica*, *T. americana* (Sellards 1915), *T. africanum* (Andrews 1906) and *T. champsoides*. The mandible is nearly as wide as in *T. lusitanica*. The mandibular symphysis shorter in length than in *T. lusitanica*, *T. africanum*, and *T. americana*, and extends posteriorly up to 11th/12th tooth as in *T. lusitanica*, unlike in *T. schlegeli* and *T. africanum*, in which the symphysis extends posteriorly up to the 14th tooth. Splenials enter into mandibular symphysis extending anteriorly upto 8th tooth. 4th mandibular tooth is largest and is situated at a higher level than the others.

Description :—L.U.V.P. 11062, the mandible, is complete on the anterior side, comprising of both the rami along with the mandibular symphysis; the right ramus is preserved upto the 14th tooth, while the left ramus is preserved upto the 10th tooth. The articular region comprising the right surangular and left surangular-articular bones, though undoubtedly of the same individual, was found detached from the dentary and is also preserved. The mandible is shorter in length than in *T. lusitanica*, *T. americana*, *T. africanum* and *T. champsoides*. The lateral margins of the mandible are nearly parallel from the anterior end up to the 8th tooth, posterior to which both the rami start diverging, the actual separation takes place posterior to 11th tooth with a divergence angle of about 30° as in *T. africanum*. The anterior extremity of the mandible is bluntly rounded. Sockets for the first mandibular teeth occupy most of the area of the anterior end of the mandible and are large, nearly of the same size as the second and third mandibular teeth, being smaller than the fourth mandibular teeth. Positions of the alveoli show that the anteriormost two teeth were large, projecting forward and outward towards the upper jaw. Mandible widens slightly at the point of the second tooth which is situated after a diastema of 1.5 cm from the first tooth. There is a prominent notch after the second tooth, which probably received the third premaxillary tooth. The socket for the fourth mandibular tooth is largest, circular in outline and placed at a higher level than the others. Alveoli for 5th to 8th teeth are equidistantly situated and are nearly equal in size. The

mandible starts widening and diverging posterior to the 8th tooth. As in *T. lusitanica*, the mandibular symphysis extends posteriorly up to the 11th tooth, after which both the rami separate out. The splenials form part of the symphysis, and extend more anteriorly, i.e. up to the 8th tooth than in *T. schlegeli* and *T. lusitanica*, where splenials extend anteriorly only up to 9th or the diastema between the 8th and 9th tooth; in *T. africanum* the splenials project anteriorly only up to the 10th tooth. The mandibular symphysis is shorter in length than in *T. lusitanica*, *T. africanum* and *T. americana*. The mandibular alveoli posterior to 10th tooth are not prominently seen on the specimen.

The left surangular, angular and articular bones are preserved (Pl. III, fig. 3), but the fragment containing the external mandibular opening is wanting. The surangular is long, thin and high bone being about 12.5 cm high, a little more than in *T. africanum*. The angular, lying postero-ventrally, forms a shelf-like border on the internal side of the mandible. The articular is situated internal to the surangular bone and dorsal to the angular bone. The glenoid fossa forming the articular surface for the quadrate is quite thickened, it is longer and wider than in *T. africanum*. The articular surface is divided by a ridge into an inner and an outer portions as in *T. schlegeli* (Andrews 1906, pp. 270-271) and differs from the condition in *T. africanum* where the articular surface is simply concave. The articular is produced posteriorly into a narrow process which is incomplete at its posterior extremity.

In ventral view the junction of the two rami is prominent. The lateral margin of the alveolar border of the mandible is sinuous, the concavities on the mandibular border are for the reception of the upper teeth. The mandible is shallow anteriorly, becoming about 8.0 cm high at the posterior extremity of the symphysis, while at the surangular region it is about 12.5 cm high.

Skull:—L.U.V.P. 11062a, the skull (Pl. III, figs. 1a, b) is partially preserved. The specimen consists of the posterior extensions of premaxillae, maxillae, nasals, prefrontals, lachrymals, frontal and palatine bones. Anteriorly, the skull is broken from the point where the notch or constriction in the rostrum occurs for the reception of the fourth mandibular tooth; and thus the anterior part of premaxillaries along with the external narial opening is wanting. Posterior to the orbital region, the major part of the dorsal cranium is wanting, except for the median part of the pterygoid, the internal narial opening and the occipital condyle.

The estimated length of the skull from its anterior extremity to the occipital condyle is about 83 cm; thus the skull of the Kutch species is longer than the skulls of Recent *T. schlegeli* (Konjukova 1964, p. 522; in Orlov's treatise) and of Egyptian Eocene *T. gavialoides* (Andrews 1906), but the skull of *T. eggenburgense* from the Miocene of Austria (Toula and Kail 1885 in Zittel 1932, p. 365 and Antunes 1961, p. 41) is only slightly longer, while the Portuguese Miocene form *T. lusitanica* (Antunes 1961) is 20 percent longer. The width of the cranium at the level of the anterior border of the orbits is greater than in *T. kerunense* and *T. gavialoides*; only slightly more than in *T. schlegeli* and *T. americana*, while *T. lusitanica* is one and a half times wider at the pre-orbital level than the Kutch species. The rostrum gradually tapers anteriorly somewhat as in *T. schlegeli* and is not suddenly constricted in front of the orbits as in *T. eggenburgense*, *T. gavialoides* and *T. lusitanica*. Between the 4th and 5th maxillary teeth the margin is convex, posterior to which there is a slight concavity in the border of the rostrum. The premaxillaries were long, nearly of the same size as in *T. gavialoides*, but are shorter in length than in *T. lusitanica*, *T. champsoides*, *T. americana*, *T. eggenburgense* and even *T. schlegeli*. The premaxillaries extend back to the level of the 2nd maxillary tooth. The posterior junction of the premaxillaries with the nasals is of "champsoides" type (Kalin 1955, p. 773), i.e. the nasals deeply enter in between the posterior processes of the premaxillaries. Nasals are long, their posterior junction with the frontal bone is not clear, but they appear to be longer than in *T. schlegeli*, *T. gavialoides* and *T. eggenburgense*, but are shorter in length than in *T. lusitanica* and *T. americana* (Mook 1921). The nasals are nearly as wide as in *T. lusitanica*, and are wider than in *T. gavialoides*, *T. schlegeli* and *T. eggenburgense*. The nasals reach anteriorly up to the 1st maxillary tooth, and do not appear to be touching the external narial opening. Posteriorly the sutures between the nasals, lachrymals, prefrontals, and frontal are not clear. The inter-orbital space of the frontal is about 4.75 cm, and is wider than in *T. schlegeli*, *T. gavialoides*, and even *T. lusitanica*, but it is slightly narrower than in *T. americana* and *T. eggenburgense* (the measurements given by Antunes 1961, p. 42). The maxillaries are long and broad, their sutures with the nasals are nearly straight lines.

On the ventral side of the skull the premaxillaries reach posteriorly upto the diastema between 1st and 2nd maxillary teeth; the junction between the maxillary and premaxillary appears to be similar to the prevailing condition in *T. schlegeli*. Only 12 sockets of the maxillary teeth are present, which are nearly equal in size. Assuming the presence of atleast 5 premaxillary teeth, together with 12 existing sockets of the maxillary teeth, and at least 3 more teeth on the broken posterior part of the maxillae which is not fully preserved, the total number of teeth estimated is 20; the number is identical to that found in *T. eggenburgense*, but is less by one maxillary tooth from the *T. schlegeli* and 2 to 3 maxillary teeth less from *T. gavialoides*.

The maxillo-palatine suture is at the level of the 10th maxillary teeth but its exact orientation cannot be made out. The palatine forming the inner margin of the pterygoid fossae is narrow. Posterior to the palatine, the median part of the pterygoid bone is preserved at the posterior extremity of which is seen a semi-circular opening, the internal narial opening. Posterior to this opening are the occipital condyles, nearly 7 cm wide.

Vertebrae.—There are ten vertebrae (L.U.V.P. 11062b) in collection, which were found in close association with the mandible (L.U.V.P. 11062) and the skull (L.U.V.P. 11062a) of *T. tandoni* sp. nov. Of the vertebrae, only the centra are well preserved except for three, in which the region dorsal to centra is also preserved (Pl. II, fig. 10). The vertebrae are robust and belong to the cervical region, resembling in size and shape to the cervical vertebra of *T. africanum* figured by Andrews (1906, pl. XIII, figs. 2, 2a) which is slightly larger and with a shorter centra. The centra are procoelous, longer than wide, spool-shaped; anterior end is concave, while the posterior end is a convex projecting dome. In the middle, the centra are narrower than at their extremities, the width on anterior side of the centrum being 4.5 to 5.1 cm. Ventrally the centrum bears a narrow and small keel-like structure, the hypapophysis. Dorsal to the centrum is the neural canal, nearly circular in cross-section; the cross-section of neural canal in *T. africanum* is triangular. The neural arches enclosing the neural canal are stout and project anteriorly as pre-zygapophysis, posteriorly as post-zygapophysis, and dorsally as a backwardly directed strong but narrow neural spine. The pre-zygapophysis has two articulating facets. In one vertebra, the articulating facets for the head and tubercle of the rib are preserved on the lateral side of the centrum.

Measurements in centimeters

Mandible

Length from the anterior extremity to the 14th tooth	48.0
Width at the anterior end of mandible	6.5
Width at the anterior extremity of the splenials	10.0
Width at the posterior part of the symphysis	16.5
Depth at the anterior end of the mandible	3.0
Depth at the posterior end of symphysis	8.0
Length of the symphysis	38.0
Depth at surangular region	12.5
Angle between left and right rami after symphysis	30°

Skull

Length of the skull from the basioccipital to the anterior part preserved	72.0
Estimated length of premaxillae broken anteriorly	11.0
Estimated length of the skull from the basioccipital to the anterior extremity of the rostrum	83.0
Length of the skull from the anterior extremity of the orbit to the tip of rostrum (estimated)	57.0
Width of skull at the pre-orbital region	20.0
Width of skull at the anterior end of maxillae	8.0
Width of skull at the level of 10 tooth	14.0
Estimated length of the premaxillaries (incl. posterior extensions)	18.0
Length of the nasals	38.0
Maximum width of the nasals	3.5
Width of the inter-orbital bar	4.75

Vertebrae

	(1)	(2)	(3)	<i>T. africanum</i>
Length of centrum	7.2	8.0	8.5	7.8
Width of centrum	5.1	4.5	5.0 (approx.)	5.8
Height of vertebrae from tip of hypapophysis to tip of neural spine	13.5	12.5	...	15.0 (approx.)

Discussion:—The genus *Tomistoma* was restricted in its distribution during the Eocene, being found only in Africa (Egypt), and now from Kutch in India. An Eocene species from China (*T. petrolica* Yeh 1958) may well not be a tomistomin, mainly on the grounds that in this species the nasals do not articulate with the premaxillaries, a character similar to the condition found in gavials and mentioned by Yeh (1958, p.242). Also the skull of the Chinese species is much smaller in length than all the other known species of *Tomistoma* and may belong to a young individual of the gavials. Thus the Kutch occurrence is the first report of *Tomistoma* from the Palaeogene rocks outside Africa.

The only other fossil tomistomin genus known from Neogene of Asian continent is *Rhamphosuchus crassidens* (Lydekker 1886b) from the Pliocene Siwalik beds of India. The present distribution of *Tomistoma* is restricted only into the streams of Borneo, Sumatra and Malayan Peninsula.

Antunes (1961) has discussed in detail the origin and evolution of the genera of Tomistominae, and has also given their distribution in time and space. Recently, Sill (1968) discussing the zoogeography of the Crocodylia, has shown the radiation pattern of the Tomistominae. Sill (*op. cit.*) maintains Eurasia as the centre of first radiation of Tomistominae, and the Indian tomistomin confirms this hypothesis. From Eurasia the subfamily diversified from the main crocodilian line during late Cretaceous and migrated to Europe, Asia, Africa and North America. The second radiation of Tomistominae took place during Oligocene or early Miocene, the centre of radiation this time being Africa, from where five species of *Tomistoma* have been found in Palaeogene rocks.

Family Crocodylidae

Subfamily Crocodylinae

GENUS CROCODYLUS Laurenti 1768

CROCODYLUS sp.

Plate II, fig. 6

Referred Specimen:—L.U.V.P. 11135, an isolated premaxilla with alveoli for three teeth.

Horizon and locality:—Ossiferous gypseous shales of Babia Stage (Middle Eocene) at Harudi.

Description:—Premaxilla is large. The anterior narial opening is large and triangular with apex directed posteriorly. Sockets for three premaxillary teeth are present. Proximal end of premaxilla is blunt and broad, and nearly 11.5 cm wide. The sockets of the teeth are small and placed close to each other on the sides of the mid-line of the premaxilla. The positions of alveoli show that the first premaxillary teeth were small. The sockets of second premaxillary teeth are situated after a diastema of 2.2 cm from the sockets of the first premaxillary teeth. These sockets are larger and placed at a higher elevation than the first. Sockets of 3rd premaxillary teeth are very close to the second and are the largest. The nasal does not appear to enter the anterior narial aperture, but abuts at the posterior margin of this opening.

CROCODYLIAN COPROLITES

Plate II, figs. 7-8

Four crocodilian coprolites (L.U.V.P. 11139) were collected from ossiferous gypseous shales (Lutetian) exposed near Harudi. Three coprolites are gypsified, while the fourth one is impregnated with iron oxide. The smallest coprolite is 8.5 cm long, while the largest one is 13.5 cm long. All are curved, three of them having distinct tapering ends. Surfaces of the coprolites are smooth except that of ferruginous one which shows sphincter-pinched marks developed during excretion. Longitudinal striations are not seen on any of the specimen. The coprolites from Kutch were identified as crocodilian from the illustrations and the description of the crocodilian coprolites from the Palaeocene rocks of China (Young 1964).

Class Mammalia

Order Cetacea

Suborder Archaeoceti

The bulk of the collection obtained from the Middle Eocene (Lutetian) rocks of western Kutch consists of the remains of primitive cetaceans—the Archaeoceti and Odontoceti. Of these groups—the Archaeoceti is a dominant and diversified group making taxonomic identification a difficult task. In all 16 skulls and mandibular fragments as well as numerous post-cranial elements have been recovered from the Babia Stage (Lutetian) from three separate localities—Harudi, Nareda and Godhatad (Fig. 1).

For the most part, the remains of cetaceans are highly gypsified, so much so that in many cases the cranial sutures have been completely obliterated and teeth completely replaced by gypsum. However, a large number of specimens are still available particularly from the hard fossiliferous shell limestone, which are well preserved. This is in sharp contrast to the specimens recovered from the overlying gypsiferous shales which are more susceptible to the effects of gypsification.

In general, the Kutch cetaceans resemble those from the Cairo and Fayum region in Egypt and from southern Nigeria. However, there are some important differences. Apart from the presence of the common genus *Protocetus*, the Indian archaeocetes are characterised by rather primitive characteristics in retention of the third molar, three-rooted posterior premolars and molars, retention of inner cusp (protocone) and in possessing unserrated premolars and molars. One of the puzzling features of the Indian archaeocetes is the variation in the length of the mandibular symphysis. In previously described archaeocete genera, nowhere does the mandibular symphysis extend posterior to P_3 : anterior root of P_3 in *Pappocetus lugardi*, posterior root of P_2 in *Prozeuglodon isis* (*Prozeuglodon atrox* Andrews 1906) and *Zeuglodon osiris* Andrews 1906. In Kutch archaeocetes on the other hand, the symphysis is found to be highly variable in character. Only the mandibular fragment, L. U. V. P. 11002, *Protocetus sloani* (Sahni and Mishra 1972) has a symphysis extending posteriorly to the second premolar. In the remaining Kutch archaeocetes, the symphysis extends up to the posterior root of P_3 and in some cases even more posteriorly.

There are three mandibular fragments whose familial status is uncertain because of the variable extension of mandibular symphysis, extending posteriorly at least until P_4 , after which the right and left rami diverge and separate out. These specimens may indicate an intermediate position between Archaeoceti and Odontoceti. The symphysis extends posteriorly in L. U. V. P. 11061 (Pl. V, figs. 3 a, b) from bluish grey shales of Babia Stage at Nareda till anterior border of P_4 ; in L. U. V. P. 11138 (Pl. V, figs. 4 a, b) from bluish-grey shales of Babia Stage at Godhatad till anterior border of P_4 as in L. U. V. P. 11061, and in L. U. V. P. 11132 (Pl. V, figs. 5 a, b, c) from foraminiferal limestones at Nareda till the posterior root of P_4 dorsally and till posterior root of M_1 ventrally. The extended symphysis is obviously a cetacean specialisation diverging sharply from the condition in the ancestral mesonychid stock. It is interesting to note, however, that in those instances, where the skull and mandibular fragments have been found together, the dentition still retains a primitive character in that the protocone is still a distinct cusp, the teeth do not possess secondary cusps and the molars still retain three roots, with no proliferation in the number of the teeth.

The following features are of the taxonomic value in archaeocetes: in *skull*, the size, shape and elongation of the rostrum, relative position of the external nares, relative heights of the sagittal and lambdoidal crests, width of the occipital region and shape and size of tympanic bulla; in *mandible*, the size, degree of convexity of the rami, presence or absence of the groove near the ventral border of ramus, length of the symphysis and diversion and separation of the individual rami; and in *dentition*, length of dental series, number of the teeth, degree of molari-sation of premolar, dimensions of teeth, diastem in between them, relative heights of different cusps, length/width ratios of teeth, number of cusps and roots, presence or absence of serrations and degree of heterodonty.

Family Protocetidae Stromer 1908
GENUS INDOCETUS gen. nov.

Type Species:—*Indocetus ramani* sp. nov.

Diagnosis:—Medium-sized primitive protocetid; frontal and parietal not in one plane as in archaeocetes, but meet at an obtuse angle as in the mesonychids (e. g. *Harpagolestes*). Frontal not as wide anteriorly as in *Protocetus*, maximum width of frontal at supraorbital process greater than that of *Protocetus atavus* and *Harpagolestes orientalis* but less so than in later zeuglodontids and dorudontids. Post-orbital bar of frontal intermediate in prominence between mesonychids and protocetids. Maxillo-palatine suture nearly at the same position as in *P. atavus* and *H. orientalis*, but arched and not transverse.

Upper dentition primitive, close to the condition in mesonychids; the known dentition P^3-M^2 three-rooted, and with a rather well-developed protocone in contrast to later archaeocetes and even protocetids where it is not so prominent. M^1 with a rather massive paracone, with a slightly lower appressed metacone on its posterior slope.

Tympanic bulla large, massive and typically whale-like.

INDOCETUS RAMANI sp. nov.

Plate IV, figs. 1-3

Etymology:—After Mr. Raman V. Raste of Baranda (Kutch), who helped greatly during field investigations.

Holotype:—L. U. V. P. 11034, the skull, only known specimen.

Horizon and locality:—Shell limestone of Babia Stage (Lutetian) at Harudi.

Diagnosis:—Only species of the genus.

Description:—Skull is well-preserved, large, wide and high, sloping anteriorly and lacks the portion anterior to the third premolars. Of the occipital region, only the portion of right side with the tympanic bulla, occipital condyle and mastoid process is present. Parietals are incomplete while the zygomatic arch is wanting.

Rostrum is broad and massive, diverging posterior to the third premolar. Posteriorly the parietal is high corresponding to a high sagittal crest probably higher than in *Protocetus atavus* and in *Prozeuglodon isis* (*Prozeuglodon atrox* Andrews 1906). Frontals widen out suddenly to form the broad and massive supraorbital process overhanging the orbits, at which point the skull is the widest (20 cm), being broader than in *P. atavus* (16 cm) and *Harpagolestes orientalis*, but narrower than in *Zeuglodon osiris* and *Prozeuglodon isis*. The skull roof is flat to gently convex. The supraorbital process is more thickened, deflected downwards nearly at right angles to the skull roof in contrast to the condition in *P. isis*, where the process is thinner and only slightly deflected. This post-orbital process of frontal is not as prominent as in *Protocetus atavus*, but is stronger than in mesonychids.

A small and subtriangular lachrymal is present antero-ventral to frontal, dorsal to the anterior part of jugal, and posterior to maxilla, being concave at its posterior margin forming the anterior border of orbits. Anterior part of jugal, which is narrow, is thrust in between the lachrymal and the maxilla.

In the maxillae, only the roots for the third premolar to 2nd molar are present; the lingual side of the crown of the right first molar is also preserved.

Lachrymal foramen opens posteriorly at the upper end of the maxilla at the level of the anterior root of M^2 , having a diameter of 6 mm.

The maxillaries are large and posteriorly join the frontal and lachrymal; anteriorly they are incomplete and the groove for the posteriorly directed facial processes of the premaxillae cannot be determined, hence the premaxillae were restricted posteriorly to the level of the first or second premolar somewhat as in *Protocetus atavus* (posterior to P^2), differing from *Prozeuglodon isis* (Andrews) in which the premaxillae extend to the level of P^4 .

The ventral sides of maxillae are nearly flat in the palatal region. Roots for the P^3-M^2 are present. Of the crowns, only the greater part of the right first molar is preserved. The

maxilla of right side preserves the remanant of the bases of the crowns, but the left maxilla is more eroded exposing the roots. The maxillo-palatine suture is anteriorly convex rather than transverse as in *P. atavus* and *Harpagolestes orientalis* though occurring nearly at the same position, i.e. at P^4 in all three genera. The anterior border of the orbit is at the level of M^2 .

The occipital surface is broad, nearly 21-22 cm across at the mastoid process, approaching the width at the same region in *P. atavus* (24 cm) but narrower than in later basilsaurids. Occipital surface nearly as high as in *P. atavus*. Supraoccipital is broken. The parietals slope laterally. Occipital conyles are nearly of the same size as in *P. atavus* but smaller than in *Prozeuglodon isis*, convex, wider at the upper end, narrowing towards the ventral border as in *P. atavus*. Foramen magnum with a diameter of about 3.5 cm is larger than in *P. atavus* (2.6 cm), but smaller than in *Prozeuglodon isis* (Andrews) (5 cm).

The tympanic bulla is big, massive, bladder-like and typically cetacean. The bulla is attenuated anteriorly and widened towards the posterior side. The ventral surface of the bulla is smooth and a broad shallow groove separates the smaller postero-internal and larger postero-external lobes. The size of tympanic bulla of *Indocetus ramani* gen. et sp. nov. is nearly the same as in *Protocetus atavus*, having a maximum antero-posterior diameter of 7 cm and maximum transverse diameter of 4.5 cm. The middle lacerate foramen lies on antero-internal side of the bulla at the posterior side of alisphenoid. The posterior lacerate foramen lies on the postero-internal side of bulla and is deep.

Upper Dentition:—The dentition is primitive, close to the condition in the Mesonychidae. The known dentition P^3 - M^2 is three-rooted possessing an inner root. Crowns of all the teeth are broken except the lingual side of the right first molar.

P^3 is triangular and with three roots. Length of the labial alveoli is 3 cm. Antero-labial root is exposed, the depth of the root being 2.5 cm. Posterior roots are in transverse plane, having a width of 2 cm. Postero-lingual root has a little larger surface area than the postero-labial root, and is somewhat rounded. The border of the postero-lingual root is 2.65 cm from the mid-line of the skull. Between the inner roots of the third and fourth premolar, there is a distinct pit for the reception of the protoconid of the lower premolar (probably P_4).

P^4 is situated after a diastema of 3 mm from P^3 . The tooth is three-rooted, elongate and fully molariform with a l/w ratio of 1.16, being wider than P^3 , having an internal alveolar border 2.45 cm from the mid-line of skull. Judging from the area of the internal root exposed, the protocone appears to have been a rather prominent cusp occupying a rather internal position. As in P^3 , the root of the protocone is situated in the transverse plane of the metacone.

M^1 is situated after a diastema of 4 mm from P^4 . The tooth is three-rooted, triangular, wider than long with a length/width ratio of 0.85 and is smaller than P^4 . The protocone is situated lingually. Only the lingual side of the crown is preserved, the edges of the crown do not show any serrations. As the labial border of the crown is broken it is not possible to state with certainty whether there were only one or two principal cusps on the labial side, but from the general appearance of the broken apical part, it appears that both paracone and metacone were present though closely appressed to each other and had an undivided base. Protocone is less posterolingually directed than in P^4 , low, heavily worn but distinct and the enamel at the base is slightly wrinkled. Two pronounced smooth wear facets are present, one in the mid-line, and the other on anterior side of the tooth, arising from the lingual slope of the paracone towards the protocone.

A thin serrated cingulum encircles the preserved crown, becoming narrower lingually. On the antero-lingual border towards base, the cingulum is also effected by the wear from M_1 . A deep pit is situated in between protocones of M^1 and M^2 for the reception of the protoconid of M_2 .

M^2 is situated after a diastema of 3 mm from M^1 . The tooth is triangular, three-rooted and smaller than M^1 with a length/width ratio of 0.89. Base of the protocone is posterolingually directed. The postero-labial root is reduced.

Measurements in centimeters

Length of the P ³ —M ² series of the right side	10.0
Diastema between P ³ and P ⁴ (Right maxilla)	0.2
Diastema between P ⁴ and M ¹ („ „)	0.25
Diastema between M ¹ and M ² („ „)	0.3
Width of the skull at the point of the supraorbital process	20.0
Width of the skull at the level of the anterior root of P ³	8.0
Maximum width of the occipital surface (at the mastoid process)	22.0
Height of the skull at the anteriormost preserved part, i.e. at the level of P ³	5.4
Height of the skull at the end of the frontals	13.0

Dimensions of the alveoli in centimeters

	Length	Width
P ³	3.0	2.0
P ⁴	2.85	2.45
M ¹	1.7	2.2
M ²	1.7	1.9

Discussion:—*Indocetus ramani* gen. et sp. nov. is a rather primitive archaeocete retaining some primitive characters related with supposed mesonychid ancestry. Unmistakable cetacean modifications are found in the elongation of the skull, the structure of tympanic bulla, the presence of an elongated nasio-turbinal passage, the shape of "Turk's Saddle" and the atrophy of the protocone in the upper dentition. Its affinity with the Mesonychidae particularly the genera *Harpagolestes* and *Andrewsarchus* lies mainly in the general pattern of the cheek teeth: transverse teeth, three-rooted, unserrated crowns, absence of hypocone and a reduced metacone on M². The general shape of skull also resembles with that of *Andrewsarchus* and *Harpagolestes*.

There has been much controversy regarding the origin of the Cetacea with reference to their monophyletic or polyphyletic origin. Also the ancestral stock is believed by some to be the mesonychid condylarths (Van Valen 1966, 1968) and by others to be the creodonts or insectivores (Dechaseaux 1961, pp. 856-857). The material from Kutch particularly *Indocetus ramani* gen. et sp. nov. would tend to support the mesonychid ancestry of the archaeocetes. The Mesonychidae was fairly a well-entrenched group during Eocene in central, south and east Asia. This group has been recorded from Middle Eocene Chharat Series (Dehm and Oettingen-Spielberg 1958) and lower Kirthar bed (Pilgrim 1940) in Pakistan; from basal Murree beds (lower Upper Eocene) in Jammu and Kashmir (Ranga Rao 1973); from Nanshung Basin (Palaeocene) in South China (Young and Chow 1963) and from Yuanchu Formation (upper part of Upper Eocene) in Honan, China (Chow 1965) as well as from a number of localities and horizons in Mongolia (Szalay and Gould 1966): Naran Bulak Beds of Early Eocene, Irдин Manha Formation and Ulan Shireh Formation of Upper Eocene and Shara Murun Formation and "Ulan Gochu" Formation of latest Eocene.

The widespread occurrence of Mesonychidae in the early Palaeogene strongly suggests stable corridors for dispersal. The Indian and Pakistan occurrences could only be possible after the abutment of Indian plate on Sino-Siberian platform sometimes in the early Lutetian. It is also reasonable to surmise that terrestrial mammals reached Kutch from their northern dispersal point at least by the end of Middle Eocene, thus providing a suitable stock for such a radiation as represented by *Indocetus ramani* gen. et sp. nov.

Family Protocetidae Stromer 1908

GENUS PROTOCETUS Fraas 1904

PROTOCETUS SLOANI Sahni and Mishra 1972

Plate V, figs. 1-2

Material:—L.U.V.P. 11002 (holotype), the anterior mandibular fragment containing the symphysis and the alveoli for C-P₃; L.U.V.P. 11003, left mandibular fragment with alveoli for P₄,

M₁ and anterior alveolus for M₂; L.U.V.P. 11001, partial skull; L.U.V.P. 11043, anterior part of the rostrum and L.U.V.P. 11146, posterior part of skull.

Horizons and locality:—Shell limestone and ossiferous gypseous shales of Babia Stage (Middle Eocene) at Harudi.

Description:—The species has been described previously (Sahni and Mishra 1972) including the specimens L.U.V.P. 11001, L.U.V.P. 11002 and L.U.V.P. 11003. Additional material obtained after the publication of the paper is described herein.

L.U.V.P. 11043 (Pl. V, fig. 1) is an anterior rostral fragment containing external narial opening. The P¹ and P² have a diastema of 2.2 cm in between them. P¹ is single-rooted while the P² is two-rooted. P³ though not preserved, would have been situated at least after a diastema of about 2 cm from P². Snout is constricted between P¹ and P². On dorsal surface, the posterior margins of the premaxillae extend to form the lateral sides of the posteriorly widening external narial opening which extends backwards up to the level of P² unlike upto P¹ as in *Protocetus atavus* (Fraas 1904) and *Prozeuglodon isis* (*Prozeuglodon atrox*, Andrews 1906). The length and the breadth of the narial opening is greater than that of *P. atavus* (vide measurements given by Andrews 1906, p. 256). The length of the preserved part of L.U.V.P. 11043 is nearly equal to the corresponding length in *P. atavus* but is wider.

L.U.V.P. 11146 (Pl. V, figs. 2 a, b, c) is a posterior portion of the skull lacking the portion anterior to parietals. The occipital surface is nearly as broad (26 cm) as in the paratype of *P. sloani* (L.U.V.P. 11001) and *Zeuglodon osiris* Andrews 1906 (28.8 cm), but is broader than in *Protocetus atavus* (22.5–24 cm) and narrower than in *Prozeuglodon isis* (34 cm). In contrast to L.U.V.P. 11001, the sagittal crest is lower, the occipital condyles are larger while the foramen magnum is nearly of the same size. Supraoccipital though broken dorsally, appears to be narrower than in *Prozeuglodon isis*. Though the occipital condyles are weathered, it can be judged that these were slightly larger than in L.U.V.P. 11001 and in *Protocetus atavus* and nearly as large as in *Prozeuglodon isis*; the ventral border of the occipital condyle is narrow. Exoccipitals on the sides of the condyles run out into a broadly expanded projection as in *P. atavus* (Dechaseaux 1961, p. 843, fig. 12), and in *Prozeuglodon isis* (Andrews 1906, p. 245, fig. 81), the upper edge on outer side of the exoccipital unites with the posterior border of the squamosal. The basioccipital is broad, the weathered tympanic bullae are placed on its outer angles. The mastoid process is strong. Antero-dorsally the parietals are narrow.

PROTOCETUS HARUDIENSIS sp. nov.

Plate IV, figs. 4–7

Holotype:—L.U.V.P. 11037, incomplete skull with the roots for P³–M².

Paratypes:—L.U.V.P. 11037 a, left mandibular ramus with roots for P₄–M₃; L. U. V. P. 11037 b, left M₁ and M₂; L.U.V.P. 11037 c, isolated cusps of upper teeth. The paratypes were found close to the holotype, and in all probability belong to the same individual.

Horizon and locality:—Shell limestone of Babia Stage (Middle Eocene) at Harudi.

Diagnosis:—Dental formula $\frac{I ? C1 P4 M2}{I ? C1 P4 M3}$ Skull narrow, narrowing suddenly anterior to P³ as in *Protocetus atavus*; nearly as high as in *Prozeuglodon isis* but slightly higher than in *Protocetus atavus*. The length of the P³–M² series nearly equal to the corresponding distance in *Indocetus ramani* gen. et sp. nov. from Kutch but smaller than in *Protocetus atavus*, *Prozeuglodon isis* and *Basilosaurus*. P³–M² three-rooted, closely spaced and unserrated. Maxilla extending 3 cm posterior to the last molar for the reception of M₃.

Mandibular symphysis extending posteriorly to P₂ as in *Protocetus sloani*. P₄–M₃ two rooted; M₁ and M₂ bicuspid.

Description and Comparisons:—The skull (Pl. IV, figs. 4 a, b) is narrow, narrowing anterior to P^3 as in *Protocetus atavus*. The skull is nearly as high as in *Prozeuglodon isis* but slightly higher than in *Protocetus atavus*. The length of the left $P^3 - M^2$ series preserved (9.5 cm) is nearly the same as the corresponding distance in *Indocetus ramani* gen. et sp. nov. (10 cm), but smaller than in *Protocetus atavus* (12.5 cm), *Prozeuglodon isis* (more than 15 cm) and *Basilosaurus cetoides* (21.6 cm). The skull slopes steeply on lateral sides in the preserved part. Dorsally the frontals, nasals and upper part of left maxilla have been eroded off exposing the fillings of the narial canal. Ventrally also, the long, tubular fillings of the narial canals are exposed as the central part of maxillae and the palatine are completely eroded off. A longitudinal groove on the external side of the maxilla lodged the posteriorly directed facial processes of premaxillae which extended posteriorly to the level of the posterior root of fourth premolar, a condition found in *Prozeuglodon isis*.

The left maxilla with the roots for $P^3 - M^2$ is preserved. The maxilla extends posteriorly beyond M^2 for the reception of M_3 . The teeth are three-rooted and closely spaced. The antero-labial roots in $P^4 - M^2$ have larger surface areas than of postero-labial and lingual roots. Isolated cusps of upper teeth (L.U.V.P. 11037 c) show that the teeth are not serrated.

P^3 is the longest in the series having a l/w ratio of 2.3. The lingual root is situated nearer to the postero-labial root, thus the protocone would have been posteriorly placed.

P^4 is closely appressed to P^3 having a l/w ratio of 1.8. The lingual root is situated nearer to the postero-labial root. Two prominent and deep pits are present posterior to P^4 and M^1 on lingual side for the reception of the protoconids of M_1 and M_2 which are preserved (L.U.V.P. 11037 b).

M^1 is closely appressed to P^4 having a l/w ratio of 1.9. In surface area, the postero-labial root is small and reduced; antero-labial root is largest of all; the lingual root is smaller than the antero-labial root and situated close to the postero-labial root.

M^2 is similar to M^1 but smaller in size. The postero-labial root is reduced and close to the lingual root which is 3.7 cm from the mid-line of skull.

The maxilla extends posteriorly beyond M^2 for the reception of M_3 .

Left mandibular ramus (L.U.V.P. 11037 a) consists of the roots for $P_4 - M_3$ as well as crowns of first and second molars (L.U.V.P. 11037 b). $P_4 - M_3$ are two rooted and closely spaced. The ramus is laterally compressed, narrow and deepens posteriorly. As in *Pappocetus lugardi*, *Prozeuglodon isis*, and *Zeuglodon osiris*, there is no groove on external side towards the ventral border. The left and right mandibular rami in collection are separate and it is reasonable to suppose that the symphysis must have extended much further forward probably to the posterior root of P_2 as in *Protocetus sloani* or what is more unlikely to the anterior root of P_3 as in *Pappocetus lugardi* (Andrews 1919).

The apical parts of the protoconids of M_1 and M_2 (L.U.V.P. 11037 b) fit well into the pits situated posterior and lingual to P^4 and M^1 in the left maxilla. M_1 is antero-posteriorly elongated, two-rooted and bicuspid. The anterior cusp (protoconid) is large and high, the posterior cusp is smaller and lower by 50 percent than anterior cusp. Apex of the anterior cusp is worn. Edges of the cusp are not serrated; the anterior edge bears two shallow wear facets, the one towards apical side is larger than the other ventral to it. The anterior edge is steeply sloping from protoconid. One wear facet is present on antero-labial and the other on postero-labial border of the protoconid. The broken basal part of metaconid bears a cingulum on lingual side which continues anteriorly upto the protoconid and also on the posterior side of metaconid.

M_2 is also antero-posteriorly elongated, two-rooted and bicuspid. Apex of larger anterior cusp is bluntly conical and unworn. There are two wear facets on the protoconid, the one on antero-labial border is more prominent than the other trending towards postero-labial border. Posterior cusp is small, low and unworn. Apex of posterior cusp is linked with the posterior margin of the protoconid by a ridge. The lingual cingulum is prominent on the posterior cusp continuing towards lingual side of protoconid; posteriorly on the hypoconid the cingulum

becomes thick and forms a shelf-like structure. The labial cingulum is absent, this is in contrast to condition in *Pappocetus lugardi* where the cingulum encircles the M_1 on all sides.

Dimensions of the alveoli in centimeters

	Length	Width
P^3	2.9	1.3
P^4	2.3	1.3
M^1	2.1	1.1
M^2	1.9	1.0
P_4	3.0	1.1
M_1	2.3	1.0
M_2	2.2	1.0
M_3	2.1	1.0

Suborder Odontoceti

There are two mandibular rami in the collection which cannot be included in Archaeoceti and have been placed in the Eocene family Agorophiidae of the Odontoceti. *Agorophius* Cope and *Xenorophus* Kellogg, the previously known genera of the family Agorophiidae, are the only odontocetes found in Upper Eocene rocks of North America, and are represented by skulls. The Kutch odontocetes are represented by mandibular fragments. These rami are distinct from all other in the collection in being long and narrow having extreme lateral compression, and extremely long symphysis—the separation of the left and right rami taking place at least as far back as M_3 . Such a long symphysis is not found in archaeocetes and is characteristic of more advanced cetaceans. Another characteristic is the sharp divergence of the rami posterior to M_3 , in contrast to the gradual and anterior divergence in archaeocetes. The dentition, however, retained its primitive number, the only specialisation being that the teeth have a tendency to become homodont.

Family Agorophiidae Abel 1913

GENUS ANDREWSIPHIUS gen. nov.

Etymology :—After C.W. Andrews, the foremost worker on the Fayum vertebrate fauna.

Type species :—*Andrewsiphius kutchensis* sp. nov.

Diagnosis :—Mandible narrow, elongated and with a longer symphysis than that prevailing in more primitive archaeocetes, in which group the symphysis extends posteriorly till P_1 and never to the molar series. Symphysis extending posteriorly at least up to the M_3 . Depth of ramus low as compared to archaeocetes. Teeth tending towards homodonty but number remains the same as in Archaeoceti. Shallow longitudinal groove present near the ventral border; in cross-section ventral border obtuse anteriorly, becoming acute posteriorly.

ANDREWSIPHIUS KUTCHENSIS sp. nov.

Plate V, fig. 6

Holotype :—L.U.V.P. 11060, mandible with alveoli for I_2 - M_1 .

Horizon and locality :—Bluish grey shales of Babia Stage (Middle Eocene) at Nareda.

Diagnosis :—Mandible long, compressed laterally, symphysis extends posteriorly at least up to the last molar, i.e. M_1 . Depth of ramus low as compared to archaeocetes. The spacing between anterior teeth nearly equal; posterior teeth closely spaced, teeth tending towards homodonty but their number remains the same as in Archaeoceti. Like in most of archaeocetes the ventral border straight but with a slight concavity at the level of canine, *c.f.* *Pappocetus lugardi* with a step-like appearance below M_2 .

Description:—The mandible is gypsified consisting of both the rami with alveoli from the second incisor to the first molar (Fig. 3). Though the alveoli for M_2 and M_3 are not preserved, the ventral portion of the jaw is preserved. The jaw is smaller in length than in *Pappocetus lugardi*, *Zeuglodon osiris* Andrews 1906, *Zygorhiza kochii*, *Prozeuglodon isis* (*Zeuglodon isis* Andrews 1906), but is nearly of the same length as of the young individual of *Prozeuglodon isis* (*Prozeuglodon atrox* Andrews 1906). The mandible gradually increases in depth, anteriorly it is 2.2 cm and towards the molars it is 6.5 cm.

The most important feature of the mandible is its long symphysis, extending posteriorly at least up to M_3 . Among the archaeocetes, nowhere does the symphysis extend posterior to P_3 , and is up to the anterior root of P_3 in *Pappocetus lugardi* (Andrews 1919). The symphyseal junction is well defined by a shallow groove from the anterior end of the mandible up to the middle of the P_4 , after which the symphyseal region widens and the right and left rami diverge dorsally, but remain ventrally united at least up to the M_3 .

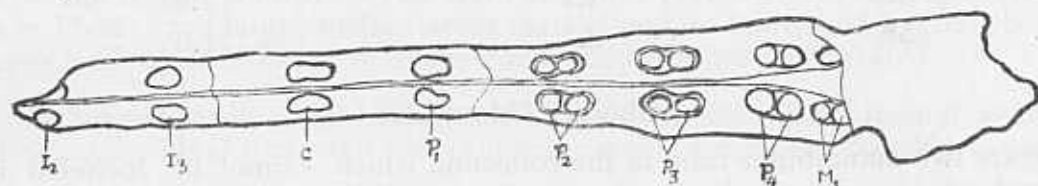


Fig. 3. *Andrewsiphius kutchensis* gen. et sp. nov., Holotype, the mandible (L.U.V.P. 11060), occlusal view $\times \frac{1}{3}$.

The lateral sides of the rami are slightly convex. On the lateral side near the ventral border of each ramus, there is a shallow, wide groove running from the anterior end, posteriorly up to M_3 . This ventral groove is absent in most of the archaeocetes except for in *Protocetus sloani* from Kutch, where the groove fades out posteriorly at P_2 . In later cetaceans (e.g. *Hesperoinea dalpiazii* Moncharmont Zei 1956) this groove is also present. The ventral border of the mandible is rounded anteriorly up to the first premolar, posterior to which the border is acute. The cross-sectional profile of the mandible anteriorly is nearly oval while at M_1 it is triangular. Like most of archaeocetes the ventral border is straight but with a slight concavity at the level of canine. In *Pappocetus lugardi* also there is a step-like appearance below M_2 (Andrews 1919).

The crowns of none of the teeth are preserved. The alveolus of first incisor is also wanting. I_2 to P_1 are single-rooted, the teeth posterior to P_1 are two-rooted. The alveoli of anterior teeth from second incisor to second premolar are separated from each other by nearly equal diastema of 3.5 cm. The alveoli of P_2 from P_3 and P_3 from P_4 are separated from each other by the diastema of 1.8 cm. P_4 and M_2 are closely spaced. The pits caused by the occlusion of cusps of upper teeth are seen only posterior to P_2 and P_3 . The alveolar border deepens posteriorly with a concavity between C and P_1 which received the upper canine. The alveoli are smaller than those of archaeocetes.

Measurements in centimeters

Total measured length of the mandible	40
Length from anterior border of I_2 to the middle of M_1	30
Depth of jaw beneath I_2	2.2
" " C	4
" " P_1	5
" " P_3	5.9
" " P_4	6.3
" " M_1	6.5

Dimensions of the alveoli in centimeters

	Length	Width
I ₂ (alveolus only)	1.2	0.7
I ₃ (" ")	1.3	0.8
C (" ")	1.9	0.8
P ₁ (" ")	1.5	0.9
P ₂ (alveoli only)	2.0	0.8
P ₃ (" ")	2.25	1.0
P ₄ (" ")	2.0	0.9
M ₁ (" ")	1.75	0.85

ANDREWSIPHIUS MINOR sp. nov.

Plate V, fig. 7

Holotype:—L. U. V. P. 11165, incomplete mandibular fragment with the alveoli of P₁–M₁.

Horizon and locality:—Ossiferous gypseous shales of Babia Stage (Middle Eocene) at Harudi.

Diagnosis:—Mandible small, smaller than *Andrewsiphium kutchensis* gen. et sp. nov., narrow anteriorly but differing from *A. kutchensis* gen. et sp. nov. in diverging abruptly posterior to P₃. Ventrally, the rami remain united at least up to M₂ and hence the mandibular symphysis extends up to M₂. P₃–M₂ closely spaced. Depth of the ramus less than in archaeocetes. The teeth are transversely compressed.

Description:—L.U.V.P. 11165 is an anterior mandibular fragment of a small species of *Andrewsiphium*, consisting both the right and left rami. Mandible is narrow anteriorly till P₃, posterior to which it abruptly broadens. The mandible differs from *A. kutchensis* gen. et sp. nov. in the sudden divergence and widening of rami posterior to third premolar. The two rami diverge posterior to third premolar but do not separate away from each other at least up to M₂ and are united ventrally.

The mandible is broken anterior to P₁. Crowns of P₁ and P₂ are not preserved. P₁ is single rooted and appears to be a small tooth. P₂ is situated after a diastema of 4 mm from P₁. P₂ is two rooted, the length of alveoli being 2 cm. Anterior alveolus is antero-posteriorly elongated and compressed; the posterior alveolus is circular and external with respect to the anterior one. Diastema between P₂ and P₃ is 1.2 cm. The mandible starts widening and deepening posterior to P₃. P₃ is two rooted and 1.8 cm long. Posterior to P₃, the teeth are situated close to each other without any diastema. P₄ is two rooted, elongated, laterally compressed and wider posteriorly, the length of tooth being 1.8 cm. M₁ is two rooted and transversely compressed, the posterior root being much wider than anterior one; base of the crown is also preserved; the length of the tooth is about 2.0 cm. At M₂, the jaw is dorsally eroded and the boundaries of the alveoli are not clear. Posterior to M₂ the jaw is broken. Both lingually and labially the roots of P₃–M₁ are exposed due to the erosion of the rami. The depth of ramus is less than in archaeocetes, and even slightly less than in *A. kutchensis* gen. et sp. nov. A groove is present near the ventral border on the external sides of the mandible which fades posteriorly at the level of anterior border of P₄. Anteriorly the cross-section of mandible is nearly oval, but posteriorly it becomes triangular.

Judging from the development of the molar series L.U.V.P. 11165 does not appear to be a juvenile individual of *Andrewsiphium kutchensis* gen. et sp. nov.

Measurements in centimeters

Length of preserved specimen	13.8
Depth of mandible at P ₂	4
" " P ₃	5
" " P ₄	6–6.5
Width of mandible at P ₂	2.5
" " M ₂	6

Dimensions of the alveoli in centimeters

	Length	Width
P ₁ (alveolus only)	0.7	0.6
P ₂ (alveoli only)	2.0	0.6 (post.)
P ₃ (" ")	1.8	
P ₄ (" ")	1.8	
M ₁ (" ")	2.0	

Discussion :—Primitive odontocetes are represented by the Family Agorophiidae, consisting of two genera : *Agorophius* and *Xenorophus* from the Upper Eocene of North America. Both the genera were described on the basis of skulls (Leidy 1869, Cope 1895, True 1907, Kellogg 1923) and hence there is no data on the morphology of the mandibles. However, judging from the rather long and narrow rostra of both these genera, it can be reasonably presumed that the corresponding mandibles would be narrow, elongated and with a longer symphysis than that prevailing in more primitive archaeocetes, in which group the symphysis extends posteriorly till the P₃ and never to the molar series. These Kutch mandibles have been placed in Family Agorophiidae in view of the obvious specialisations in comparison to the archaeocete mandibles.

There is as much controversy as to the ancestral stock of odontocetes as there is to that of archaeocetes. Some workers maintain at present (Gidley 1913, Miller 1925, Kellogg 1928, Kleinenberg 1958, 1959, Dechaseaux 1961, Yabalakov 1964) that the odontocetes did not originate from archaeocetes but from a closely related group. Romer (1966, p.299) is of the view that,

“although the odontocetes presumably derive from a stock related to the archaeocetes, the two groups must have diverged at an early stage”.

but some authors favour the monophyletic origin of the cetaceans. This concept has been aptly stated by Gregory (1951, p.450) that,

“...the skulls of the archaeocetes form an ideal structural ground plan for the divergent paths leading perhaps through *Archaeodelphis* on the one hand to the mysticetes and on the other to odontocetes”.

Gregory (*op. cit.*, p.443) also remarks that,

“...after long study, the evidence still seems to me to support the view of C.W. Andrews (1906) and O. Abel (1902), who pointed out essential features in which the skull of *Zeuglodon* fore-shadowed those of the odontocetes (toothed whales)”.

Gregory (*op. cit.*, pp.443-444) further expresses that the agorophiid skull is more or less intermediate between the archaeocete and odontocete stages, and even some authors include agorophiids in the archaeocetes.

However, Van Valen (1968) in his recent discussion on the origin of the whales has reviewed the data and is of the opinion that among the archaeocetes, the Protocetidae may have given rise to recent whales. Van Valen (*op. cit.*) mentions following points which are common to the archaeocetes and odontocetes :—

1. Teeth present.
2. Lower jaws meet at symphysis.
3. Cervical vertebrae somewhat movable.
4. Manus is usually pentadactyl.
5. Sternum has several bones.
6. Three or more pairs of ribs attached to the sternum.
7. In *Agorophius* the external nares in a position intermediate to that found in recent genera and archaeocetes.
8. Fusiform body in Protocetidae, Dorudontidae and Odontoceti.
9. Tympanic bulla with same structure in all the three suborders.

The position of *Andrewsiphium kutchensis* gen. et sp. nov. may be significant in the context of odontocete evolution and may form an intermediate stage between the archaeocetes and odontocetes.

The Kutch odontocete mandibles have following characters which show their advanced specialisation over archaeocetes: narrowness of the mandible, longer symphysis, nearly regular spacing of the teeth except in molar series and teeth tending towards homodonty strongly favour their agorophiid affinities, but the number of teeth remains the same as in Archaeoceti.

The age of Kutch odontocetes also raises some interesting questions. Previously described earliest known specimens are Upper Eocene in age, no odontocete up to the present was reported from the Middle Eocene (Lutetian). The recovery of Lutetian odontocetes from Kutch provides evidence that primitive cetaceans had started diversifying by the Middle Eocene rather than the Upper Eocene.

Order Sirenia

The shell limestone of Babia Stage (Lutetian) exposed near Harudi is the only horizon to provide Eocene sirenian remains which are interesting inasmuch as they show close similarity with the pelvis of *Eotherium aegypticum* described by Abel (1904) from Middle Eocene of Egypt. Later Sickenberg put the remains described by Abel (*op. cit.*) under the synonymy of *Protosiren fraasi* on the basis of associated vertebrae. There appears to be a discrepancy regarding the locality of the skull and pelvis of the *Protosiren fraasi* Abel 1904. Andrews (1906, pp. 119, 197, 204, 215) mentions that Abel (1904) described *Eotherium aegypticum* from White Limestone of Lower Mokattam Series exposed in Mokattam Hills near Cairo, corresponding to the Wadi Rayan Formation (lower part of Middle Eocene) of Fayum. However, Dechaseaux (in Piveteau 1958, pp. 344-345) states that the occurrence of the cranium and the pelvis of *Protosiren fraasi* (*Eotherium aegypticum*) described by Abel (1904) is from the Lutetian of the Fayum (Egypt). In view of Andrews' familiarity with the Egyptian localities, it is more likely that the pelvis of *Protosiren* was recovered from Mokattam Hills, Cairo and not from Fayum.

Family Protosirenidae Sickenberg 1934

GENUS PROTOSIREN Abel 1904

PROTOSIREN FRAASI Abel 1904

Plate VI, fig. 1

Material:—L.U.V.P. 11038, left fragmentary pelvis and L.U.V.P. 11039, the ilium were found very close to each other and probably belong the same individual.

Horizon and locality:—Shell limestone of Babia Stage (Middle Eocene) at Harudi.

Description:—The left pelvis (Fig. 4) is one of the few sirenian skeletal elements in the collection from the Eocene of Kutch. The specimen resembles very closely with the corresponding bone in *Protosiren fraasi* described under *Eotherium aegypticum* by Abel (1904) from the Middle Eocene (Lutetian) of Mokattam Hills, Cairo (Egypt).

The specimen is incomplete as the ischium and pubis are broken distally; the ilium is also not complete distally. The estimated length of pelvis of Kutch sirenian is nearly twice than that of the same elements in *Eotheroides libyca*, *Prototherium veronense* and *Halitherium schinzi* figured by Dechaseaux (1958, pp. 348, 350), but judging from the pelvis figured by Andrews (1906, p. 214), the Kutch specimen is only longer by 50 percent than of *Eotheroides* (*Eosiren*) *libyca* and nearly by 30 percent than of *Halitherium schinzi*. The Kutch specimen is longer than the same element in *P. fraasi* from Egypt by 33 percent and approaches the length of the pelvis of *Moeritherium* (Andrews 1906, p.214).

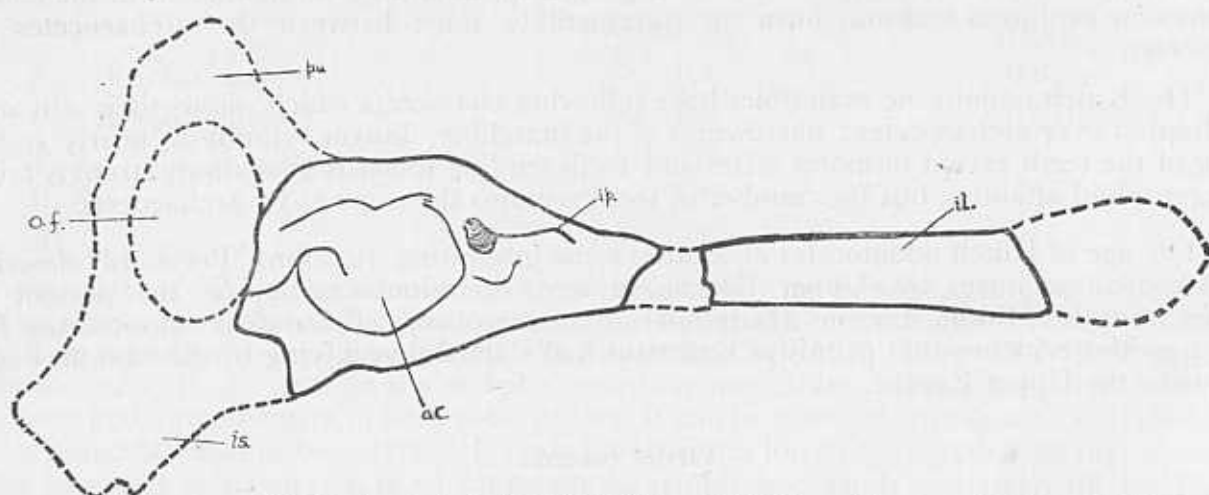


Fig. 4. *Protosiren fraasi* Abel, left pelvis (L.U.V.P. 11038 and 11039), $\times \frac{1}{2}$ ac.-acetabulum, il.-ilium, ip.-ilio-pectinal tubercle, is.-ischium, o. f.-obturator foramen, pu.-pubis.

The acetabulum formed by the fusion of ilium, pubis and cotyloid bone is nearly oval and elongated antero-posteriorly having a longer diameter of 4.6 cm and smaller diameter of 3.5 cm. It is larger than in the *Eotheroides libyca*, *Prototherium veronense*, *Halitherium schinzi*, as well as *P. fraasi* from Egypt, approaching in size to the acetabulum of the *Moeritherium* from which it differs in antero-posterior elongation of the acetabulum as opposed to a dorso-ventral one in *Moeritherium*. The acetabular border particularly on the dorsal side is prominent and elevated and has a greater curvature than on ventral side. Postero-dorsally, the acetabular border bears a prominence providing ventrally a notch, the acetabular notch, situated postero-medially as in pelvis of *P. fraasi* from Egypt. The acetabular notch is the point of the origin of rectus femoris muscle. The acetabular region of the pelvis is quite broad, having a width of 5.2 cm, being broader than in the known pelvic girdles of other sirenians, but is 20 percent narrower than that of *Moeritherium*. The ventral side of the acetabular region bears a wide shallow groove arising from the obturator foramen fading away towards the ilium after a short distance; this groove apparently divides the acetabular region into a wider dorsal and a narrower ventral part. Anterior to acetabulum on the ventro-internal side of the ilium, there is a triangular projection, the ilio-pectinal tubercle, 7 mm high and 1.7 cm long. The ilio-pectinal tubercle is better developed than in *Prototherium veronense*, *Halitherium schinzi* as well as in *P. fraasi* from Egypt but is less developed than in *Moeritherium*; in *Eotheroides* the ilio-pectinal tubercle is absent. There lies a shallow fossa in between the ilio-pectinal tubercle and the acetabulum.

Anterior to the acetabular region, the iliac region suddenly becomes more slender as in the Egyptian specimen. The ilium (L.U.V.P. 11039) was found less than a metre away from the L.U.V.P. 11038 and in all probability is a part of the pelvis described. It is a narrow and slender bone longer than the Egyptian specimen. Distally it is trihedral in section, gradually becoming oval towards its proximal side. The ischium, though not preserved at its point of attachment with acetabular part, shows that it was quite broad, broader than in Egyptian specimen, but slightly less so than in *Moeritherium*. The width of the pubis is similar to that of *P. fraasi*. The obturator foramen though not preserved, appears to be complete and was almost of the same size as in the *P. fraasi* from Egypt. In *Eotheroides*, *Prototherium* and *Halitherium* the obturator foramen is partially or completely absent.

Discussion:—The remains of Eocene sirenian are fairly cosmopolitan in distribution: *Eotheroides* (*Eosiren*, *Archaeosiren*, *Eotherium*) is known by skulls, mandibles, vertebrae, and pelvic girdle elements from the Middle to Upper Eocene of North Africa; *Prorastomus* is known by skull and mandible from Jamaica (West Indies); *Prototherium* by skull and pelvic elements from Upper Eocene of Italy and *Protosiren* by skulls, a pelvis and vertebrae from North Africa and France and now from the Middle Eocene of Kutch. This is the first record of a sirenian from Eocene horizon in India and also from the Asian sub-continent. The material from Kutch is rather scanty and consists of girdle elements and a few fragmentary vertebrae. As already

mentioned, the pelvic girdle is specifically indistinguishable from that of *Protosiren fraasi*. It possesses a number of primitive features common to terrestrial mammals but later atrophying or becoming absent in later sirenians. Primatively the pelvis is elongated with a long ilium and having a well-developed acetabulum indicating the presence of a large functional femur with a complete obturator foramen. As pointed out by Andrews (1906) the pelvic girdle of *Protosiren* is morphologically indistinguishable from that of *Moeritherium* except on being smaller in length, possessing a less distinctly developed sacral surface on ilium and slightly thicker pubis and suggested that early proboscideans and sirenians are closely related and had a common ancestor in early Tertiary times, probably in the Lower Eocene. The primitive sirenian-moeritheriid stock was coastal, marsh-dwelling, equally adaptable to the life in coastal marshes as well as near shore conditions. The material from Kutch at this stage cannot throw much light on the origin of sirenians. The presence of a well-developed sacrum described hereafter and probably a moeritheriid, supports the close similarity of Eocene sirenians and moeritheriids.

Order Proboscidea

Suborder Moeritheroidea

Family Moeritheriidae

The existence of terrestrial mammal in the Middle Eocene fauna of Kutch is suggested by the presence of a moderately large and robust sacrum, L.U.V.P. 11069. The development of a sacrum, in which sacral vertebrae ankylose to form a single composite bone, has been attributed by many authors (Weichert 1958, pp. 393-394, Goodrich 1958, p. 200, Kent 1965, pp. 141, 191) as a necessary modification for a life on the land. There is certainly a marked tendency amongst aquatic mammals to lose this structure, which is primarily useful in forming a firm skeletal support in the movement of land mammals. Modern whales lack sacral vertebrae (Zittel 1925, p. 80, Parker and Haswell 1897, p. 499) and in archaeocetes also only one or two sacral vertebrae were present (Dechaseaux 1961, p. 843). Similarly, sirenians also do not possess a massive sacrum and the element is represented by one or two sacral vertebrae (Zittel 1925, p. 264). In early sirenians also sacrum is lacking as *Eotheroides* (*Eosiren* Andrews 1906, pp. 212-213). possesses a sacral vertebra and in *Protosiren* (*Eotherium aegypticum* Andrews 1906, p. 119) the ilium shows a less distinctly developed (more developed in *Moeritherium*) sacral surface, indicating only a single sacral vertebra rather than a sacrum. In both archaeocetes and sirenians, the structure of the pelvic girdle excludes the possibility that the ilium was firmly attached to the sacrum. In other mammalian orders, such as the proboscideans the sacrum was robust and firmly ankylosed for stability.

cf. MOERITHERIID SACRUM

Plate VI, fig. 2

Material:—L.U.V.P. 11069, a sacrum.

Horizon and locality:—Shell limestone of Babia Stage, Middle Eocene (Lutetian) at Harudi.

Characteristic Features:—Sacrum consisting of three fused vertebrae, bears some interesting points of similarity with the same element of *Moeritherium* (Andrews 1906, pp. 115-117, fig. 47, a, b, c), particularly in general shape, in the common number of vertebrae (3), in the transversely elongated articular surface of the centrum, broad and low neural spines, isosceles triangle-shaped neural canal and in a long iliac surface; but differs from the sacrum of *Moeritherium* in having a smaller size, the l/w ratio being 1.35 as against 1.5 in *Moeritherium*, in having the ventral surface raised in the central region and not flat, in possessing a less developed iliac surface, interosseous foramina smaller and circular and not antero-posteriorly elongated and the pleurapophysis protuding anterior to the centrum a condition not found in *Moeritherium*.

Description:—L.U.V.P. 11069 is a nearly complete sacrum, consisting of three fused vertebrae. The sacrum resembles in general shape the corresponding element of *Moeritherium* but is of smaller dimensions. Anteriorly the sacrum is wide, the width being slightly more than 2/3rd of the length, the l/w ratio being 1.35; unfortunately the postero-lateral margins are

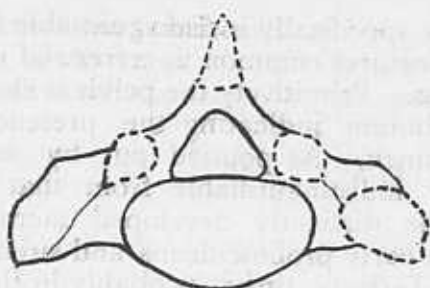


Fig. 5. cf. Moeritheriid sacrum (L. U. V. P. 11069), anterior view $\times \frac{1}{2}$.

broken, and so it is not possible to conjecture whether the width decreased posteriorly, but the thinness of the bone posteriorly, however, seems to suggest that the width did decrease. The articular surface of the anterior centrum is a transversely elongated oval as in *Moeritherium*, while that of the posterior centrum is considerably less so. The anterior zygapophyses are well-developed, but the anteriorly directed metapophyses are broken. The neural canal is shaped like an isosceles triangle as in *Moeritherium* but of smaller dimensions. The walls of the neural canal are sloping somewhat posteriorly and bear a low but massive neural spine as in *Moeritherium*, the anterior neural spine is more prominent than the posterior one. Anteriorly, the transverse processes (pleurapophyses) of the fused first sacral vertebra project beyond the anterior surface of centrum while in *Moeritherium* the pleurapophyses do not project anterior to centrum. Pleurapophyses possess an obliquely trending ridge, lateral to which the bone is deflected downwards, this forms a roughened surface for attachment with the ilium. The iliac surface is broken laterally on both sides. It was well-developed and extended at least up to the middle of second sacral vertebra. There is a pair of nearly circular intervertebral foramina (sacral foramina) for sacral nerves in between the junctions of the broad pleurapophyses of the first and second and second and third vertebrae. The intervertebral foramina in *Moeritherium* are larger and antero-posteriorly elongated. The second and third vertebrae are elongated with low neural spines and small post-zygapophyses (except the posteriormost in which the structure is broken but appears to be better developed).

Ventrally the surface is not flat as in *Moeritherium*, but in the centre there is a raised region formed by the three fused centra which are very strongly convex transversely and concave antero-posteriorly. The lateral margins, particularly those bearing the anterior iliac surface, are prominently raised.

The sacrum also resembles the same element found in carnivores in general shape, in having a wide lateral expanse anteriorly and narrowing posteriorly.

Measurements in centimeters

	L.U.V.P. 11069	<i>Moeritherium</i>
Length	14.8 (measured)	21.4
Length from anterior to posterior faces of centrum	12.2 (measured)	20.4
Width of the right half of sacrum anteriorly	5.5	7.2
Length/Width Ratio	1.35	1.5
Width of centrum (anteriorly)	5.0	6.2
Height of centrum (anteriorly)	2.7	3.8
Width of neural canal (anteriorly)	2.5	3.8
Height of Neural canal (anteriorly)	1.6	1.8
Diameter of intervertebral foramina	1.2	2.5
Height of sacrum	7.0 (estimated)	8.8

Discussion:—With the possible exception of *Indocetus ramani* gen. et sp. nov., no other Kutch marine mammal known at present would have possessed such a well-developed sacrum. The sacrum strongly suggests the presence of a terrestrial mammal. In view of its morphological similarity with the sacrum of *Moeritherium*, the authors feel that the sacrum is more conveniently placed in the Moeritheriidae than in any other systematic position. The sacrum possibly represents a primitive mammal differentiating from the ancestral condylarth stock.

MIOCENE FAUNA

Class Chondrichthyes
 Subclass Elasmobranchii
 Order Selachii
 Suborder Galeoidea

The selachian teeth belonging to the suborder Galeoidea are very abundant in the grey coloured gypseous shales of Khari Series (Lower Miocene) in the vicinity of Matanomadh and Lakhpatt, while in Pipar and Jangadia, the teeth are not so abundant. Prior to present investigation shark teeth from Kutch have been described by Tewari (1959) and Tewari *et al.* (1964) from the Burdigalian horizon. Following species of Miocene sharks from Kutch have been already described by V.P. Mishra in a separate paper (Mehrotra, Mishra and Srivastava 1973) :—

Family Carcharinidae

- Galaeocерdo cuvieri* Le Sueur
G. wynnei Mehrotra *et al.*
Hemipristis serra Agassiz
H. sureshi Mehrotra *et al.*
Hypoprion macloiti Muller and Henle
Negaprion brevirostris Poey
Scoliodon sorrakowah Cuvier

Family Isuridae

- Isurus spallanzanii* Bonaparte
Carcharodon megalodon robustus Davies
C. angustidens Agassiz
C. bigelowi Mehrotra *et al.*
C. carcharias Linnaeus

Family Alopiidae

- Alopias vulpes* Gmelin

Family Sphyrnidae

- Sphyrna diplana* Rafinesque

Family Carchariidae

- Carcharias tricuspidatus* Day
C. heptacuspatus Mehrotra *et al.*

Among the shark genera found in the Miocene of Kutch, *Galaeocерdo*, *Hemipristis* and *Negaprion* of the family Carcharinidae, and *Isurus* and *Carcharodon* of the family Isuridae were found to predominate.

Order Batoidea

Suborder Rajoidea

Family Rajidae

GENUS RAJA Linnaeus 1758

RAJA sp.

Plate VI, fig. 3

Material :—Isolated teeth, L.U.V.P. 11099.

Horizon and locality :—Grey coloured arenaceous shales of Khari Series (Lower Miocene) at Lakhpatt.

Description :—The tooth is small with a height/width ratio of nearly one. The crown is rhombic in outline in oral view with feeble rugose ornamentation. A shallow and wide

groove is present towards the anterior side of crown, the border of the groove is slightly raised. On the postero-ventral side, a small vertical groove divides the crown into two. A triangular enamelled lip extends downwardly from the crown on the external side.

The root is small, vertical to the crown and bifid, the two halves being separated by a root canal. Two small foramen are present in the root canal, one going into each half of the root.

In India, the family Rajidae (skates) is presently represented by a single genus *Raja*, the species of which (*R. andamanica*, *R. johannis-davisi*, *R. mamillidens*, *R. reversa*, *R. powelli*) are found in Bay of Bengal, Andaman Sea, Arabian sea, Travancore coast and Gulf of Manar. Prior to present work, there has been no fossil record of *Raja* from India.

Suborder Myliobatoidea
Family Myliobatidae
GENUS MYLIOBATIS Cuvier 1817
MYLIOBATIS sp.
Plate VI, figs. 4-6

Material:—Isolated median and lateral teeth—L.U.V.P. 11096 (Lakhpat), L.U.V.P. 11102 (Matanomadh) and L.U.V.P. 11181 (Pipar); Spines—L.U.V.P. 11093 (Matanomadh) and 11097 (Lakhpat).

Horizons and localities:—Grey coloured gypseous shales at Matanomadh; Grey coloured arenaceous shales at Lakhpat; and Foraminiferal limestone at Pipar; Khari Series (Lower Miocene).

Description:—There are a large number of isolated median and lateral teeth of *Myliobatis* in the collection from Lower Miocene beds. The median teeth are transverse, hexagonal, 4-6 times as broad as long and slightly arched antero-posteriorly. The coronal surface of the crown is smooth. The basal surface of the root is divided into 20-25 ridges and grooves at right angles to the transverse axis of crown. A shelf-like projection is present between the junction of root and crown on anterior side, which fits into a corresponding groove on the posterior side in the adjacent anterior tooth. A similar groove is present on the posterior side of the tooth figured, for the reception of the ledge in the next posterior tooth.

The lateral tooth (Pl. VI, figs. 5 a,b) is smaller than median tooth, and nearly twice as broad as long. The lateral tooth is hexagonal, transverse and straight. The crown is smooth and higher than root which is divisible into 6-7 longitudinal ridges and grooves.

Dental plate and isolated teeth of *Myliobatis* have also been found in the Middle Eocene rocks at Harudi and Nareda in Kutch. The specimens from Miocene of Kutch are larger in size than those from Middle Eocene horizon. Some median teeth from Lower Miocene beds of Matanomadh resemble with *M. curvipalatus* (Lydekker 1886b) from Eocene of Kutch, in the characteristic curved contour of tooth in transverse section.

Isolated median teeth of *Myliobatis* have been reported from Miocene of Balasore (Hora 1939) which are shorter in length than the Kutch specimen.

L.U.V.P. 11097 (Pl. VI, fig. 6) is a fragment of spine of *Myliobatis*. The spine is longitudinally striated. The edges of spine bear fine denticles directed distally; the spine widens distally, the denticles being absent in the distal region. The spine resembles the caudal spine of *M. meridionalis* (Leriche 1957). Myliobatid spines have been described from Miocene of Orissa (Hora 1939, Ghosh 1959) in India.

Presently, three species of *Myliobatis* (*M. nichofi*, *M. milvus* and *M. maculatus*) are found in India along the east and west coasts, and also at the mouth of Ganges and Chilka Lake.

GENUS AETOBATUS Blainville 1816

AETOBATUS sp.

Plate VI, fig. 7

Material :—Isolated teeth, L.U.V.P. 11169, L.U.V.P. 11170 and L.U.V.P. 11171.

Horizon and locality :—Grey coloured gypseous shales of Khari Series (Lower Miocene) at Matanomadh.

Description :—There are few isolated teeth of *Aetobatus* in collection from Lower Miocene beds of Matanomadh. L.U.V.P. 11170 (Pl. VI, fig. 7) is a small, hexagonal tooth, nearly twice as broad as long. The occlusal surface is smooth. The root is divided longitudinally into ridges and grooves, the number of ridges being 13. The root is nearly as high as the crown. The ledge between the junction of the crown and root is prominent, and fits into the corresponding groove on the posterior side of next anterior tooth. The tooth is slightly curved, the curvature is well-exhibited in the basal view.

A tooth of *A. arcuatus baripadensis* has been described from the Miocene of Mayurbhanj, Orissa in eastern India (Ghosh 1959) from which the Kutch specimen differs in being narrower, less curved and in possessing a smaller number of unbifurcated root ridges not continuing to the posterior border of enamelled surface. The Kutch specimen of *Aetobatus* differs from the tooth of *A. arcuatus* (Leriche 1957) in being smaller in size and less arched.

At present in India, the family Myliobatidae (Eagle Rays) is represented by only two genera, *Aetobatus* and *Myliobatis*. Only two species (*A. flagellum* and *A. ocellatus*) of *Aetobatus* (Duck-Billed Ray) are presently found in Indian region.

Class Osteichthyes

Subclass Actinopterygii

Infraclass Teleostei

Superorder Acanthopterygii

Order Tetraodontiformes

Suborder Tetraodontoidei

Family Diodontidae

GENUS DIODON Linnaeus 1758

DIODON sp.

Plate VI, figs. 8-9

Material :—A large number of dental plates : L.U.V.P. 11095 (Lakhpat) and L.U.V.P. 11087, L.U.V.P. 11088 and L.V.V.P. 11089 (Matanomadh).

Horizons and localities :—Grey coloured gypseous shales at Matanomadh, and grey coloured arenaceous shales at Lakhpat; Khari Series (Lower Miocene).

Descriptions :—A large number of dental plates of *Diodon* were collected from Lower Miocene of Kutch. Dental plates in collection range in size from 0.8 to 4 cm in their longer diameter. The dental plates consist of a number of sub-triangular to oval lamellar plates, piled one over the other. In L. U. V. P. 11095 (Pl. VI, figs. 8 a, b) there are seven thick lamellae, while in L. U. V. P. 11089 (Pl. VI, figs. 9 a, b) there are four thin lamellae. A vertical plane divides every plate into symmetrical halves. The plates on the apical side are smaller while those in the mid-region are bigger. The edges of the dental lamellae are not crenulated as in *D. scillae* (Woodward 1901, pp. 572-573, fig. 20). Every dental plate possesses 9 to 10 teeth on the superior side which is concave as in *D. foley* (Lydekker 1880).

In upper view, the teeth of all the lamellae are seen arranged in transverse rows. The median teeth are larger than the marginal ones.

Discussion:—The record of the fossil diodontids from India is meagre. Dental plate of *Diodon foleyi* has been described from the Eocene of Ramri Island, Burma (Lydekker 1880, 1886 b) and dental plates of *Diodon* sp. from Nicobar Island though the horizon is uncertain (Nair 1945). The Kutch species is slightly smaller in size and has less number of lamellae than in *D. foleyi* and differs from the species of *Diodon* from Nicobar Island in having less number of lamellae with a concave upper surface. The Recent *D. hystrix* inhabiting Indian Ocean is smaller in size with a flat upper surface. The presence of fossil *Diodon* in Ramri and Nicobar Islands and now from Kutch, and the living species in Bay of Bengal indicates that the genus inhabited the Indian Ocean throughout the Tertiary.

Order Perciformes

Suborder Mugiloidei

Family Sphyraenidae

GENUS SPHYRAENA Bloch and Schneider 1801

SPHYRAENA sp.

Plate VI, figs. 10-11

Material:—A large number of isolated teeth: anterior teeth (L.U.V.P. 11174 and L.U.V.P. 11175), lateral teeth (L.U.V.P. 11178 and L.U.V.P. 11179).

Horizon and locality:—Grey coloured gypseous shales of Khari Series (Lower Miocene) at Matanomadh.

Description:—The anterior teeth (Pl. VI, fig. 10) are small and laterally compressed; their anterior edges are sharp with worn serrations, 9-11 per mm. The posterior edge is straight forming a hook-like structure towards the apical part of crown. The cross-section of tooth is asymmetrical, the anterior side is acute, while posterior is rounded. Both external and internal faces of the crown possess longitudinal striations, 2-3 per mm, up to the middle length of tooth. The anterior side is convex with a marked sigmoidal curve as in *S. olisiponensis* (Jonet 1967, pp. 189-190, pl. 1) described from the Miocene of Portugal. There is no pulp cavity.

Measurements in millimeters

	Height	Width
L.U.V.P. 11174	11	5
L.U.V.P. 11175	15	7

Lateral teeth:—L.U.V.P. 11179 (Pl. VI, figs. 11 a, b) is compressed and straight with sharp edges having 8-9 serrations per mm. The cross-section of tooth is sub-elliptical, the internal face is convex, while the external is less so. External face is smooth, the internal face is with finer striations running up to the middle of tooth. There is no pulp cavity.

As far as fossil record of *Sphyraena* in India is concerned, Hora (1939) described two isolated teeth as *Sphyraena incertae sedis* from Miocene of Balasore but Hora himself was doubtful about the identification.

Foraminiferal limestone (Middle Eocene) at Nareda in Kutch has also produced teeth of *Sphyraena*, which are slightly smaller in size.

Suborder Scombroidei

Family Scombridae

GENUS CYBIUM Cuvier 1829

CYBIUM sp.

Plate VI, fig. 12

Material:—Isolated teeth, L.U.V.P. 11177, L.U.V.P. 11178 and L.U.V.P. 11180.

Horizons and localities:—Grey coloured gypseous shales at Matanomadh, and grey coloured arenaceous shales at Lakhpatt; Khari Series (Lower Miocene).

Description :—Teeth are small, symmetrical and laterally compressed with acute apices. The height/width ratio is 1.8 to 2.0; in *C. serrallheiroi* (Jonet 1967) from Miocene of Portugal the h/w ratio is slightly more than one, being equilateral in shape. The Kutch specimens have sharp cutting edges with serrations, 10-11 per mm. The pulp cavity is absent. Both the faces possess longitudinal striations, 10-12 per mm, limited to crown's base. Kutch specimens of *Cybium* differ in shape from those of *C. angustidens* from Eocene of Africa in which the sides are parallel curving sharply at apex. Cross-section of tooth is biconvex in contrast to hexagonal in *C. bottei* from Miocene of Italy and plano-convex in *C. serrallheiroi* from Miocene of Portugal.

Though presently *Cybium* or seer-fishes are common in Bay of Bengal and Arabian Sea (*C. commersonii*, *C. guttatus*, *C. kuhli* and *C. interruptus*), there has been no record of their fossil forms in India prior to the present investigation.

The Middle Eocene foraminiferal limestone at Nareda in Kutch has also yielded smaller teeth of *Cybium*.

Class Reptilia Order Crocodilia

Crocodilian scutes (Pl. II, fig. 9) :—Three crocodilian scutes (L.U.V.P. 11161 a, b, c) from Pipar and one scute (L.U.V.P. 11166) from Matanomadh were collected from the rocks of the Khari Series (Miocene). The specimens are small in size, the biggest being 7 cm long. Maximum thickness of the scutes is nearly 1 cm. The upper surfaces are deeply pitted, only at a few places the pits are expanded into elongated grooves.

Crocodilian vertebrae :—Five crocodilian vertebrae have been recovered from Lower Miocene (Aida Stage) at Samda (L.U.V.P. 11152, 11153), Buta (L.U.V.P. 11154), Junagia (L.U.V.P. 11155) and Pipar (L.U.V.P. 11158). Only the centra of vertebrae are preserved which have characteristic crocodilian procoelous, spool-shaped structure.

Class Mammalia Order Sirenia

The Miocene sirenian fragments were recovered from the Aida Stage and lower part of Vinjhan Stage (Lower Miocene) from a number of localities, viz. Matanomadh, Lakhpatt, Aida, Jangadia, Junagia, Samda and Pipar (*vide* locality index, p. 2 and Fig. 1). Bioclastic limestone unit has produced sirenians from the village of Matanomadh and Denma, and is probably Chattian (uppermost Oligocene) in age. Sirenian ribs collected from Ratipar, 26 km. west of Matanomadh are also from the Bermoti Series (Oligocene). Poorly preserved skull fragments, and a few mandibular fragments were recovered from Matanomadh, and a premaxilla from Samda. Well preserved ribs and vertebrae (Pl. VI, Fig. 16-17) were recovered from all the above mentioned localities. Mandibular fragments have been assigned to the genus *Halitherium*, while the cranial elements have been included within a new species of the *Indosiren* described herein, the genotype of which is *I. javanense* described from the Upper Miocene of Java (Koenigswald 1952).

The first record of fossil sirenian from India was by Grant (1840) who recorded the occurrence of rib bones from the Nummulitic limestone and marl unit exposed near Aida in Kutch; the rib bones were believed by Cleft and Owen in Grant (1840) similar to those of *Manatus* but flatter. The Nummulitic limestone and marl unit of Grant is equivalent to Wynne's Nummulitic Group which in Biswas' (1965, 1971 a) classification is represented by Babia Stage (Lutetian) and Bermoti Series (Oligocene). During present investigation in Aida, the sirenian rib bones were collected from the Aida Stage (Chattian-Aquitian), and probably Grant's collection was also from the same beds.

Wynne (1872) reported the occurrence of vertebrae and large rib bones which he believed to be mammalian from the beds he had designated as the Arenaceous and Argillaceous Groups, which are now regarded as Aida and Vinjhan Stages respectively, of Miocene age (Biswas 1965). Wynne collected these vertebrae and rib bones from Buta, Joonagia, Jangadia, Lakhpur, Pipar and Samda. Our investigations of these localities have also led to the recovery of vertebrae and rib bones which are definitely sirenian. Biswas (1971b) also collected a large number of rib bones from the upper part of rocks of Waior Stage (Chattian) exposed near Dedhapar and Walasara, which he believes to be of some reptile, but our examination of these bones revealed them to be sirenian.

Prior to present investigation, only a few fossil sirenian genera were known from Asia: *Anomotherium* from Upper Oligocene of Eastern Asia; *Indosiren javanense* from Upper Miocene of Java (Koenigswald 1952) and *Miodugong brevicranius* from the Miocene of Ceylon (Deraniyagala 1969).

Family Dugongidae
Subfamily Halitheriinae
GENUS HALITHERIUM Kaup 1838

HALITHERIUM sp.

Plate VI, fig. 13

Material :—L.U.V.P. 11122, left and right rami of the mandible with the alveoli for I_1 to M_3 .

Horizon and locality :—Bioclastic limestone of Chattian (upper part of Waior Stage) at Matanomadh.

Description :—The mandible is robust with a length of 19 cm; the rami are slightly incomplete both on their anterior and posterior sides. The estimated length of the Kutch specimen is about the same as in *Dugong*, *Halianassa*, *Protosiren fraasi* (*Eotherium aegypticum*), and *Eotheroides* (*Eosiren*) but less than in *Manatus*, *Rhytina*, *Felsinootherium*, *Halitherium* and *Desmostylus*.

The rami are long, high and laterally compressed, being narrowest at the position of P_1 - P_2 , dorsal to mental foramen, after which the rami gradually widen posteriorly. The symphyseal region is decurved to the same degree as in *Halitherium schinzi*, *Eotheroides* (*Eosiren*) and *Protosiren fraasi*, more decurved than in *Manatus*, *Prorastomus* and *Desmostylus*, but less so than in *Dugong*, *Rhytina* and *Felsinootherium*. The symphyseal region is thickened, each ramus becoming somewhat swollen at its antero-ventral border. The symphysis is shorter and narrower than in *Manatus* and *Eotheroides* (*Eosiren*) but nearly of the same length and width as in *Protosiren fraasi* (*Eotherium aegypticum*). The mandible of *Prorastomus sirenoideus* from the Eocene of Jamaica (Owen 1855) with a very long symphysis is narrower than the Kutch specimen. At the posterior end of the symphysis, the rami are raised both dorsally and ventrally.

The mental foramen opening anteriorly, lies nearly in the mid-line of the ramus and is oval in shape, 4 cm long, antero-posteriorly elongated and narrowing posteriorly. Its anterior border is 2.5 to 3 cm from the anterior margin of the mandible. In the Kutch specimen the anterior margin of the mental foramen is entire with no grooved antero-ventral extension which is seen in *Dugong*, *Manatus*, *Prorastomus*, *Felsinootherium*, *Halianassa*, *Eotheroides* (*Eosiren*), and *Protosiren fraasi*. In *Halitherium schinzi* there are 6 to 7 small mental foramina and in *Rhytina* the mental foramen is absent.

The alveolar border is slightly convex as in *Halitherium schinzi*, *Protosiren fraasi* and *Eotheroides*, less convex than in *Dugong* and *Rhytina* but more convex than in *Prorastomus* and *Manatus*, the last two belonging to the family Trichechidae. The occlusal border of mandible posterior to P_3 is wider than in *Manatus* and *Protosiren*, but ventral border is narrower than in *Prorastomus* and *Eotheroides*. The ventral border is concave forming an arch in between the bulbous symphyseal region and enlarged angular region. The Kutch specimen is less arched than in *Dugong*, *Felsinootherium* and *Halitherium*, more arched than in *Manatus* and *Prorastomus* and similar to the condition found in *Protosiren* and *Eotheroides*.

The coronoid process arises externally and sharply from the ramus, posterior to the last molar as in *H. schinzi*. The upper portion of the coronoid process, the articular region and posterior portion of the angular region are broken in both the rami.

Crowns of none of the teeth are preserved. Alveoli for single-rooted three incisors and a canine occur on the decurved symphyseal region. The alveolus for first incisor is constricted laterally, the tooth was directed forward. The alveolus for second incisor is after a diastema of 5 mm from I_1 and is nearly circular in outline; I_2 was also directed forward. The alveolus for third incisor lies close to I_2 , and is nearly of the same size and shape as I_2 , but the tooth was directed obliquely upward. The alveolus for canine is situated after a diastema of 3 mm from I_3 and is smaller than the alveoli for all the three incisors. Canine was also directed obliquely upward.

Posterior to the canines the dorsal margins of the mandibular rami are heavily worn and the presence of P_1 and P_2 cannot be determined. The rami broaden posteriorly from the position of P_3 . P_3 is two-rooted, the anterior root is smaller and narrower. Posterior to third premolar the alveoli for two-rooted P_4 and $M_1 - M_3$ are closely spaced, having nearly square outlines and are of the same size except for M_3 which is smaller by nearly 33 percent than M_2 .

Measurements in centimeters

Measured length of the mandible	19.0
Estimated length of the mandible	25.0
Depth of the mandible at C/ P_1	7.5
" " " M_1	6.0
" " " M_3	8.0
Length of the mental foramen	4.0

Dimensions of the alveoli in millimeters

	Length	Width
I_1 (alveolus only)	4	10
I_2 (" ")	12	10
I_3 (" ")	11	12
C (" ")	10	6
P_3 (alveoli)	15	13 (post.)
P_4 (")	15	16
M_1 (")	15	14
M_2 (")	16	16
M_3 (")	10	11

Subfamily Halitheriinae

GENUS INDOSIREN Koenigswald 1952

INDOSIREN KOENIGSWALDI sp. nov.

Plate VI, figs. 14-15

Etymology :—After Prof. G.H.R. von Koenigswald, Geological Institute, Rijks University of Utrecht, Netherlands.

Holotype :—L.U.V.P. 11149, part of the left maxilla having last three molars.

Paratypes :—L.U.V.P. 11149a, incomplete premaxillae, L.U.V.P. 11149 b, fragments of skull bones, and isolated teeth. Holotype and the paratypes belong to the one and same individual.

Referred specimen :—L.U.V.P. 11150, premaxillae from Samda.

Horizons and localities :—The holotype and paratypes are from the grey coloured shales of Aida Stage (Lower Miocene) at Matanomadh; L.U.V.P. 11150, the referred specimen is from the ferruginous ossiferous conglomerate of Khari Series (Lower Miocene-probably Burdigalian) at Samda.

Diagnosis:—Snout moderately decurved; a pair of enlarged incisors forming tusks present; incisors cylindrical in outline anteriorly becoming laterally compressed posteriorly. Narial opening large, nearly as wide as in Recent *Dugong*, but narrower than in *Protosiren fraasi* from Upper Eocene of Egypt, *Prototherium veronense* from Auversian of Italy and *Halitherium schinzi* from Oligocene of Europe. The anterior height of skull greater than in *Manatus* and *Protosiren fraasi*, but less so than in *Dugong*, *Rhytina*, *Halitherium* and *Felsinotherium*.

The cheek teeth (M^1 – M^3) resemble in shape with the molar of *Indosiren javanense* described from the Upper Miocene of Java (Koenigswald 1952), but are 50 to 75 percent larger in size. Molars are elongated in shape and longer than in *I. javanense*; labial cusps higher than lingual cusps and also higher than the labial cusps of *I. javanense*; bilophodont, anterior loph higher than posterior loph in contrast to *I. javanense* where the lophs are of equal heights; each loph has three cusps; transverse valley dividing protoloph from metaloph shallower than in *I. javanense* and divides M^2 into anterior larger and posterior smaller subdivisions in comparison to nearly equal areas in *I. javanense*. Anterior and posterior cingula of *I. javanense* represented by high ramparts (ridges) in the Kutch species, separated from protoloph and metaloph respectively by sharper valleys.

Description:—Although the major portion of the skull is present in the collection, it is too poorly preserved to be completely reconstructed.

L.U.V.P. 11149, the holotype, is the posterior part of left maxilla containing three molars, which are interesting inasmuch as they show certain similarities with *Indosiren javanense* described from the Upper Miocene of Java (Koenigswald 1952). The maxilla is robust with a convex buccal edge. The palatal surface of the maxilla is eroded. The premolar dentition is not preserved.

In general, the molars are longer than wide being 50-75 percent larger than *I. javanense*, and bilophodont, the anterior loph is higher than posterior loph; anterior and posterior lophs in *I. javanense* are nearly equal in height. Molars are three-rooted; roots are deep, being nearly 23 cm deep in an isolated molar (L.U.V.P. 11149 b). The anteriormost molar is a rather transverse tooth with 1/w ratio of about one. The crown of the first molar is broken. The roots are thick, stout and deep. The lingual root is slightly shifted internally.

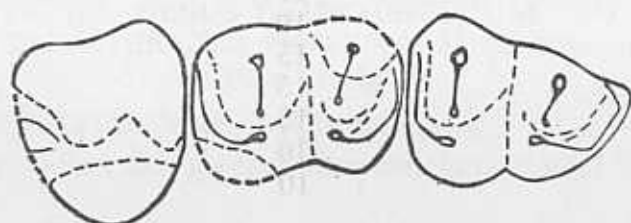


Fig. 6. *Indosiren koenigswaldi* sp. nov., Holotype, left M^1 - M^3 (L.U.V.P. 11149) $\times 1$.

The penultimate molar (M^2) is elongated, oval in shape and constricted in the middle. What remains of the labial cusps suggest that as in *I. javanense*, the labial cusps, paracone and metacone were higher than their lingual counterparts, protocone and hypocone. The paracone was the highest cusp and was linked to the protocone by a high ridge, except for a short valley separating protocone from protoconule. Another ridge arises from the protocone descending anterolabially and forming a high rampart on the anterior side of the crown. The protoloph is separated from the metaloph by a shallower valley than in *I. javanense*. This valley in M^2 divides the tooth into two unequal portions, the anterior being larger than the posterior; in *I. javanense* the transverse valley divides tooth (M^2) into two nearly equal halves. This is in contrast to condition in M^3 , where the median valley divides the crown into two nearly equal halves. The metaloph is transversely oriented and not obliquely as in M^3 . Another ridge arises from hypocone trending postero-labially forming a rampart on the posterior side of the crown. Both the anterior and posterior ramparts are separated from protoloph and metaloph respectively by sharper valleys than in *I. javanense*. Anterior and posterior ramparts represent the cingula in *Indosiren javanense*.

Based on the morphological characters outlined above, the holotype of *Indosiren javanense* from the Upper Miocene of Java (Koenigswald 1952) is believed to be a second left molar.

The last molar is elongated with rounded anterior and posterior margins and constricted in the middle. The paracone which is a high and conical cusp, is joined to a smaller protoconule by a descending ridge (protoloph). Lingually the protoloph does not connect with the protocone, which though higher than protoconule, is smaller than paracone, being separated from the protoloph by a deep sharp valley. In the metaloph as well, the metacone is the highest cusp and in turn joins the metaconule, being separated from the hypocone by an internal valley. There are two sets of ridges representing cingula arising from the protocone and hypocone and trending anteriorly and posteriorly respectively. The anterior ridge is well-developed, being more prominent than the posterior rampart, which terminates in a smaller accessory cusp.

The cheek teeth of *I. koenigswaldi* sp. nov. resemble those of living *Manatus* but have better developed lophs with distinct cones, separated by valleys. *Manatus* also lacks the upper tusks. In *Dugong* (Recent), *Felsinotherium* (Pliocene) and *Halitherium schinzi* (Oligocene) the molars are bunodont. In *Halitherium schinzi*, the internal cusps are prominent in contrast to the external ones in *I. koenigswaldi*; also the third molar possesses 3-4 accessory cusps on posterior side. In *Miosiren* (Pliocene) and *Metaxytherium* (Miocene) the molars are less bilophodont, while in *Desmostylus* (Miocene of California and Java) the cusps in the molars are in the form of the parallel cylindrical columns arranged in three successive pairs and a median posterior one. In primitive sirenians (*Protosiren*, *Eotheroides*, *Prototherium*) the molars are also bilophodont as in *Indosiren* from Miocene beds.

An incomplete premaxillae (L.U.V.P. 11149 a) formed the greater part of the slightly downwardly curved rostrum having an angle of 135° as in *Manatus*. The rostrum in *Dugong* (115°) is more downwardly turned, while in *Halitherium* (125°), *Halianassa* (130°), *Felsinotherium* (130°), *Miosiren* (130°), *Rhytina* (125°) and *Desmostylus* (125°) the rostrum is markedly decurved, more so than in *I. koenigswaldi* sp. nov., but less so than in *Dugong*. In Eocene forms *Protosiren* (145°) and *Eotheroides* (140°) the rostrum is less decurved than in *I. koenigswaldi* sp. nov. The narial opening is large, elongated and widened posteriorly. The anterior portion of the narial opening preserved is nearly as wide as in *Dugong*, but less so than in *Protosiren*, *Prototherium* and *Halitherium*. In front of the narial opening, the snout is quite broad, broader than in *Halitherium*, *Miosiren*, *Eotheroides* and *Prototherium*, but narrower than in *Dugong* and *Felsinotherium* and rounded from side to side as in *Protosiren fraasi*; the lateral sides of snout are steeply sloping. The rostrum is higher at the anterior end of narial opening in the new species than in *Manatus* and *Protosiren fraasi*, but lower than in *Dugong*, *Eotheroides libyca*, *Rhytina*, *Felsinotherium* and *Halitherium schinzi*. Anteriorly the premaxillae become laterally compressed enclosing the enlarged first incisors. The first incisor is large, elongated, laterally compressed and downwardly directed, assuming the shape of a tusk having a cylindrical anterior cross-section. In surviving sirenians, only *Dugong* possesses tusks while *Manatus*, and *Rhytina* (Sub-Recent—extinct by 1768 A.D.) lack tusks.

Discussion:—*Halitherium* was fairly a cosmopolitan genus found during the Lower Oligocene to Lower Miocene from Europe, Oligocene of Madagascar and ?Miocene of North America, and now from Kutch. *Indosiren* on the other hand appears to be confined to southern Asia having been reported previously only from Java, and now from western India. In following essential characters *Indosiren* differs from *Halitherium*: molars are bilophodont with external cusps larger than internal counterparts, rostrum is less decurved, snout broader and narial opening narrower.

Although *Indosiren* has been recovered from a relatively younger horizon, it bears a number of features more primitive than those of *Halitherium*. The cheek teeth in contrast to *Halitherium* and later sirenians are devoid of accessory cusps and crestlets. In the bilophodont nature, they are remarkably similar to Eocene Sirenians such as *Protosiren*, and *Eotheroides* and *Prototherium*; in *Protosiren* the molars are square with larger inner cusps, while in *Eotheroides* there are only two cusps on proto- and metalophs without any accessory tubercles. The decurvature of the rostrum is also less marked than in later sirenians but is nevertheless more so than in *Eotheroides* and *Protosiren*.

The distribution of fossil sirenians follows closely the present day distribution of the order which comprises of two families Dugongidae and Trichechidae represented respectively by *Dugong* (Sub-family Dugonginae) found in West Pacific, Red Sea and Indian Ocean (as well as in Gulf of Kutch) and *Manatus* (*Trichechus*) inhabiting Atlantic shores of Africa and America. Another genus *Rhytina* (*Hydrodamites*) constituting the sub-family Hydrodamalinae under Family Dugongidae, inhabiting North Pacific became extinct by 1768 (Zittel 1925, p. 266). As far as fossil forms are concerned, the Eocene genera *Protosiren* from Egypt and France, and *Prorastomus* from Jamaica have been given separate family status namely Protosirenidae and Prorastomidae respectively. Dugongidae comprises of three more sub-families: Rytiodinae Abel 1928 represented by *Rytiodus* from Upper Oligocene in Europe; Miosireninae Abel 1919 represented by *Miosiren* from Lower Pliocene of Europe; the third sub-family Halitheriinae comprises of fossil genera indicating the main evolutionary trends leading their present day descendants *Rhytina* and *Dugong*. *Eotheroides* from Middle-Upper Eocene of Egypt and *Prototherium* from the Upper Eocene of Italy are the earliest known representatives of the sub-family Halitheriinae. Later halitheriids are represented by *Halitherium* from Lower Oligocene to Lower Miocene of Europe, Oligocene of Madagascar, Miocene of North America and now from upper Oligocene of Kutch; *Halianassa* from Miocene of Europe, Upper Miocene and Lower Pliocene of Western North America, *Thalattosiren* from Middle Miocene of Europe; *Hesperosiren* from Middle Miocene of North America; *Indosiren* from Upper Miocene of Java and now from Lower Miocene of Kutch, and by *Felsinotherium* from Pliocene of Europe, and Lower Pliocene of North Africa and North America.

The diet of present day Kutch dugongs are mainly angiospermic plants growing in shallow waters on the basis of which it can be inferred that the fossil sirenians also subsisted on sea grasses. Crabs and calms (pelecypods) have also been found in Dugong's stomachs (Kingdon 1971, p. 395); this is of interest in context that in the Miocene beds of Matanomadh and Lakhpat in which sirenian remains are in abundance, the fossil crabs have also been recovered in large numbers. Kutch fossil sirenians probably occupied the same coastal marshland that they occupy today indicating the relative stability of the environments.

Order Proboscidea
Suborder Deinotheroidea
Family Deinotheriidae
GENUS DEINOTHERIUM
DEINOTHERIUM PENTAPOTAMIAE Falconer
Plate VI, fig. 18

Material:—L.U.V.P. 11130, head of right humerus.

Horizon and locality:—Ferruginous ossiferous conglomerates of Vinjhan Stage (Burdigalian) at Samda,

Description:—L.U.V.P. 11130 represents a massive and rounded head of the right humerus of a large proboscidean, nearly that of the size of the present day Indian elephant. The greater tuberosity present laterally on the external side of head is broken. The lesser tuberosity situated medially on outer (anterior) side of the head is separated from greater tuberosity by a bicipital groove at the proximal end of the bone. The head is robust, rounded, larger posteriorly and sloping anteriorly towards the lesser tuberosity. The deltoid ridge is broken.

Measurements in centimeters

Estimated length of humerus	80.0
Width of the head of the humerus	14.5

Remarks:—Two molars of *Deinotherium pentapotamiae* were described by Lydekker (1876a) from the ossiferous conglomerates exposed near the village of Samda, from where this head of humerus (L.U.V.P. 11130) has been collected. Thus this proboscidean humerus may be tentatively assigned to *Deinotherium pentapotamiae*. *D. pentapotamiae* was the first undoubted mammalian remain to be described from Kutch.

The presence of *Deinotherium* in the Vinjhan Stage is suggestive of the commencement of land conditions during the upper part of Miocene era in western Kutch. This view is in agreement with the presence of land mammals: an anthracotherid, *Brachyodus manchharenensis* and

the suid, *Dicoryphochoerus fategadensis* from Fategad (70°51' : 23°42') in eastern Kutch (Prasad 1964, 1967) in grits and conglomerates, equivalents of the horizon providing *Deinotherium* from Samda. This indicates that for the greater part of Kutch, land conditions prevailed during Lower Miocene, as expected, this coincided with a period of marine regression. In the Lower-Middle Miocene of Indian sub-continent, there occur a number of similar faunas comprising of anthracotheriids, suids and proboscideans in Bugti Beds and Fatehjang zone in Pakistan, Vinjhan Stage in Kutch, upper Boka Bil Stage in Assam, and Kama Stage near Prome in Burma.

SUMMARY AND CONCLUSIONS

1. Palaeogene and Lower Miocene deposits of western Kutch are mainly nearshore marine deposits with minor non-marine intercalations.
2. Vertebrate faunas have been collected from three horizons: the oldest of Lower Eocene and Middle Eocene (Lutetian) age, the intermediate of Upper Oligocene (Chattian) age and the youngest of Lower Miocene (Aquitanian—Burdigalian) age.
3. The Eocene vertebrate fauna is essentially marine comprising of large siluroids, trionychid turtles, tomistomid crocodiles, as well as *Crocodylus*. Mammals are represented by primitive archaeocetes, probable odontocetes, sirenians as well as a land mammal represented by a moeritheriid sacrum.
4. The siluroids are generically indistinguishable from corresponding forms found in Egypt and Nigeria.
5. Although tomistomins are fairly wide-spread in the Eocene, the genus *Tomistoma* s. s. is restricted to Africa and now western India.
6. *Indocetus ramani* gen. et sp. nov. is a primitive archaeocete possessing a number of features in common with mesonychid condylarths.
7. Additional material of *Protocetus sloani*, and *P. harudiensis* sp. nov. reconfirm our earlier conclusion (Sahni and Mishra 1972) that the genera *Protocetus* and *Pappocetus* are not congeneric but distinct.
8. *Andrewsiphium kutchensis* gen. et sp. nov. and *Andrewsiphium minor* sp. nov. are characterised by an extremely long symphysis extending up to the molars and probably represent the oldest record of odontocetes.
9. The Eocene sirenian from Kutch are represented by a pelvic girdle which is specifically indistinguishable from that of *Protosiren fraasi* from Middle Eocene of Cairo (Egypt).
10. The existence of terrestrial mammal during Middle Eocene in Kutch is suggested by the presence of a moderately large and robust sacrum presumably belonging to a moeritheriid.
11. Chattian vertebrate assemblage is also marine and consists exclusively of sirenian remains of the genus *Halitherium*.
12. Lower Miocene horizon has yielded *Indosiren koenigswaldi* sp. nov., closely allied to *Indosiren javanense* from Upper Miocene of Java.
13. The youngest vertebrate producing unit (Burdigalian) is non-marine and has yielded terrestrial mammal represented by *Deinotherium*.
14. The early Palaeogene faunas of western India show a remarkable similarity to those of Africa, lasting at least until Lower Miocene. Unrestricted migration of Palaeogene marine mammals was possible across the sea extending from western India to Africa. The more northerly, Lutetian mammal faunas of Kashmir are terrestrial representing a different facies and are quite distinct from the Kutch Lutetian mammals.
15. In the Lower Miocene, there occur a number of similar faunas comprising of anthracotheriids, suids and proboscideans in Egypt (Africa), Bugti-Fatehjang (Pakistan), Kutch and Assam (India) and Prome (Burma).

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EXPLANATION OF PLATE I

FIGS. 1-2 MYLIOBATIS sp.

- Fig. 1—Basal view of dental plate, L.U.V.P. 11078 x 1.2
 2—Caudal spine, L.U.V.P. 11082 x 1.55

FIG. 3 FAJUMIA MENONI sp. nov.

- Fig. 3 a—Dorsal view of skull, L.U.V.P. 11140 (Holotype) x 0.35
 3 b—Ventral view x 0.35
 3 c—Left lateral view x 0.35

FIGS. 4-5 FAJUMIA MISRAI sp. nov.

- Fig. 4 a—Dorsal view of skull, L.U.V.P. 11142 (Holotype) x 0.35
 4 b—Ventral view x 0.35
 4 c—Right lateral view x 0.35
 5 a—Dorsal view of cleithral part of pectoral girdle, L.U.V.P. 11142 a x 0.5
 5 b—Ventral view x 0.5

EXPLANATION OF PLATE II

FIG. 1 SOGNOPAEA HORAI sp. nov.

- Fig. 1—Dorsal view of skull, L.U.V.P. 11145 (Holotype) x 0.3

FIGS. 2-4 ARIUS KUTCHENSIS Rao

- Fig. 2—Dorsal view of skull, L.U.V.P. 11036 x 0.3
 3 a—Dorsal view of skull, L.U.V.P. 11047 x 0.4
 3 b—Ventral view x 0.4
 4 a—Dorsal view of pectoral spine, L.U.V.P. 11048 a x 0.5
 4 b—Ventral view x 0.5
 4 c—Anterior view x 0.5

FIG. 5 PYCNODUS sp.

- Fig. 5 a—Oral view of splenial tooth, L.U.V.P. 11173 x 10
 5 b—Basal view x 10

FIG. 6 CROCODYLUS sp.

- Fig. 6 a—Dorsal view of premaxillae, L.U.V.P. 11135 x 0.33
 6 b—Ventral view x 0.33

FIGS. 7-8 CROCODILIAN COPROLITES

- Fig. 7—Coprolite, L.U.V.P. 11139 a x 0.5
 8—Coprolite, L.U.V.P. 11139 b x 0.4

FIG. 9 CROCODILIAN SCUTE

- Fig. 9—Crocodilian scute, L.U.V.P. 11161 x 0.5

FIG. 10 TOMISTOMA TANDONI sp. nov.

- Fig. 10 a—Side view of cervical vertebra, L.U.V.P. 11062 b x 0.55
 10 b—Posterior view x 0.55

EXPLANATION OF PLATE III

FIGS. 1-3 TOMISTOMA TANDONI sp. nov.

- Fig. 1 a—Dorsal view of skull, L.U.V.P. 11062a x 0.25
 1 b—Ventral view x 0.25
 2 a—Dorsal view of mandible, L.U.V.P. 11062 (Holotype) x 0.25
 2 b—Ventral view x 0.25
 3—Dorsal view of left articular part of mandible, L.U.V.P. 11062 x 0.25

FIGS. 4-6 *TRIONYX* sp.

- Fig. 4 a—Dorsal view of carapace, L.U.V.P. 11077 x 0.5 (From Khari Series at Matanomadh).
 4 b—Ventral view x 0.5
 5—Dorsal view of carapace, L.U.V.P. 11182 x 1.2 (From Babia Stage at Harudi).
 6—Dorsal view of carapace, L.U.V.P. 11172 x 0.33 (From Khari Series at Aida).

EXPLANATION OF PLATE IV

FIGS. 1-3 *INDOCETUS RAMANI* gen. et sp. nov.

- Fig. 1 a—Dorsal view of skull, L.U.V.P. 11034 (Holotype) x 0.33
 1 b—Ventral view x 0.33
 1 c—Left lateral view x 0.33
 2 a—Dorsal view of the right posterior side of skull x 0.33
 2 b—Ventral view x 0.33
 2 c—Posterior view x 0.33
 3—Lingual view of right M^1 , L.U.V.P. 11034 b x 1

FIGS. 4-7 *PROTOCETUS HARUDIENSIS* sp. nov.

- Fig. 4 a—Left lateral view of skull, L.U.V.P. 11037 (Holotype) x 0.5
 4 b—Ventral view x 0.5
 4 c—Occlusal view of left maxilla x 1
 5 a—Occlusal view of left mandibular ramus, L.U.V.P. 11037 a x 0.5
 5 b—Left lateral view x 0.5
 6 a—Labial view of left M^1 – M^2 , L.U.V.P. 11037 b x 1.2
 6 b—Occlusal view of left M^2 x 1.5
 6 c—Lingual view of left M^2 x 1.5
 6 d—Labial view of left M^2 x 1.5
 6 e—Occlusal view of left M^1 x 1.2
 7 a—Lingual view of isolated upper tooth, L.U.V.P. 11037 c x 1.25
 7 b—Occlusal view x 1.25

EXPLANATION OF PLATE V

FIGS. 1-2 *PROTOCETUS SLOANI* Sahni and Mishra

- Fig. 1—Occlusal view of anterior rostral fragment, L.U.V.P. 11043 x 0.5
 2 a—Dorsal view of skull, L.U.V.P. 11146 x 0.3
 2 b—Ventral view x 0.3
 2 c—Posterior view x 0.3

FIGS. 3-5 ASSORTED CETACEAN MANDIBULAR FRAGMENTS

- Fig. 3 a—Occlusal view of mandible, L.U.V.P. 11061 x 0.33
 3 b—Left lateral view x 0.33
 4 a—Occlusal view of mandible, L.U.V.P. 11138 x 0.33
 4 b—Left lateral view x 0.33
 5 a—Occlusal view of mandible, L.U.V.P. 11132 x 0.33
 5 b—Left lateral view x 0.33
 5 c—Ventral view x 0.33

FIG. 6 *ANDREWSIPHIUS KUTCHENSIS* gen. et sp. nov.

- Fig. 6 a—Occlusal view of mandible, L.U.V.P. 11060 (Holotype) x 0.33
 6 b—Left lateral view x 0.33

FIG. 7 ANDREWSIPHUS MINOR sp. nov.

- Fig. 7 a—Occlusal view of mandible, L.U.V.P. 11165 (Holotype) x 0.5
 7 b—Right lateral view x 0.5

EXPLANATION OF PLATE VI

FIG. 1 PROTOSIREN FRAASI Abel

- Fig. 1 a—External view of left pelvis, L.U.V.P. 11038 and L.U.V.P. 11039 x 0.5
 1 b—Internal view x 0.5

FIG. 2 cf. MOERITHERIID SACRUM

- Fig. 2 a—Dorsal view of sacrum, L.U.V.P. 11069 x 0.4
 2 b—Ventral view x 0.4
 2 c—Left lateral view x 0.4

FIG. 3 RAJA sp.

- Fig. 3 a—Dorsal view of tooth, L.U.V.P. 11099 x 4.2
 3 b—Ventral view x 4.2

FIGS. 4-6 MYLIOBATIS sp.

- Fig. 4 a—Basal view of median tooth, L.U.V.P. 11096 x 1.2
 4 b—Oral view x 1.2
 4 c—Lateral view x 1.2
 5 a—Basal view of lateral tooth, L.U.V.P. 11102 x 2
 5 b—Oral view x 2
 6—Spine, L.U.V.P. 11097 x 1.3

FIG. 7 AETOBATUS sp.

- Fig. 7 a—Basal view of tooth, L.U.V.P. 11170 x 0.75
 7 b—Oral view x 0.75

FIGS. 8-9 DIODON sp.

- Fig. 8 a—Posterior view of dental plate, L.U.V.P. 11095 x 1.1
 8 b—Anterior view x 1.1
 9 a—Posterior view of dental plate, L.U.V.P. 11089 x 2
 9 b—Anterior view x 2

FIGS. 10-11 SPHYRAENA sp.

- Fig. 10—External view of anterior tooth, L.U.V.P. 11175 x 1.5
 11 a—Internal view of lateral tooth, L.U.V.P. 11179 x 1.3
 11 b—Side view x 1.3

FIG. 12 CYBIUM sp.

- Fig. 12—Internal view of tooth, L.U.V.P. 11177 x 1.3

FIG. 13 HALITHERIUM

- Fig. 13 a—Occlusal view of mandible, L.U.V.P. 11122 x 0.3
 13 b—Left lateral view x 0.3

FIGS. 14-15 INDOSIREN KOENIGSWALDI sp. nov.

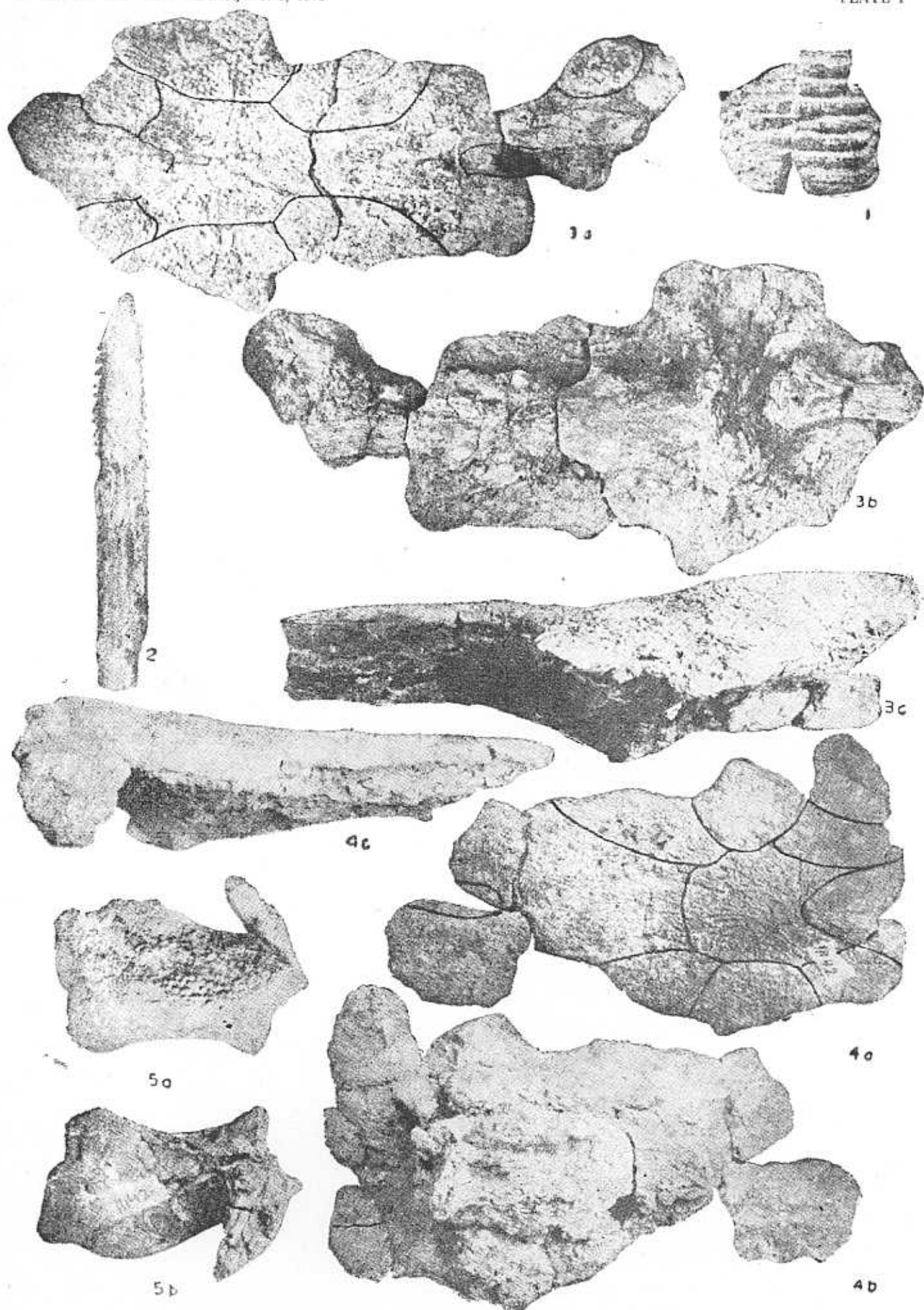
- Fig. 14 a—Dorsal view of premaxillae, L.U.V.P. 11149 a x 0.51
 14 b—Lateral view x 0.51
 15 a—Occlusal view of left maxilla with M¹-M³, L.U.V.P. 11149 (Holotype) x 1
 15 b—Lingual view x 1

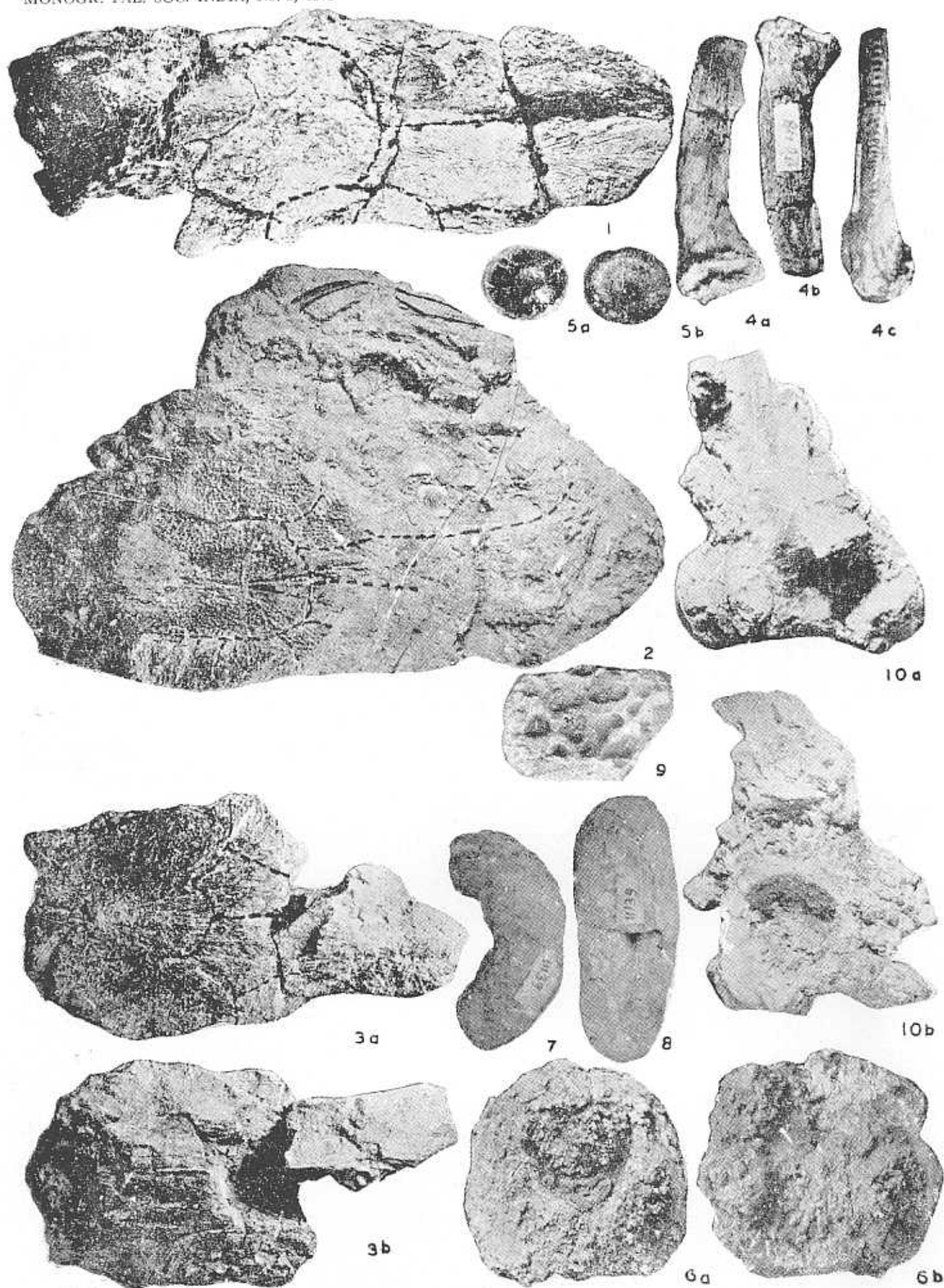
FIGS. 16-17 SIRENIAN VERTEBRA AND RIB

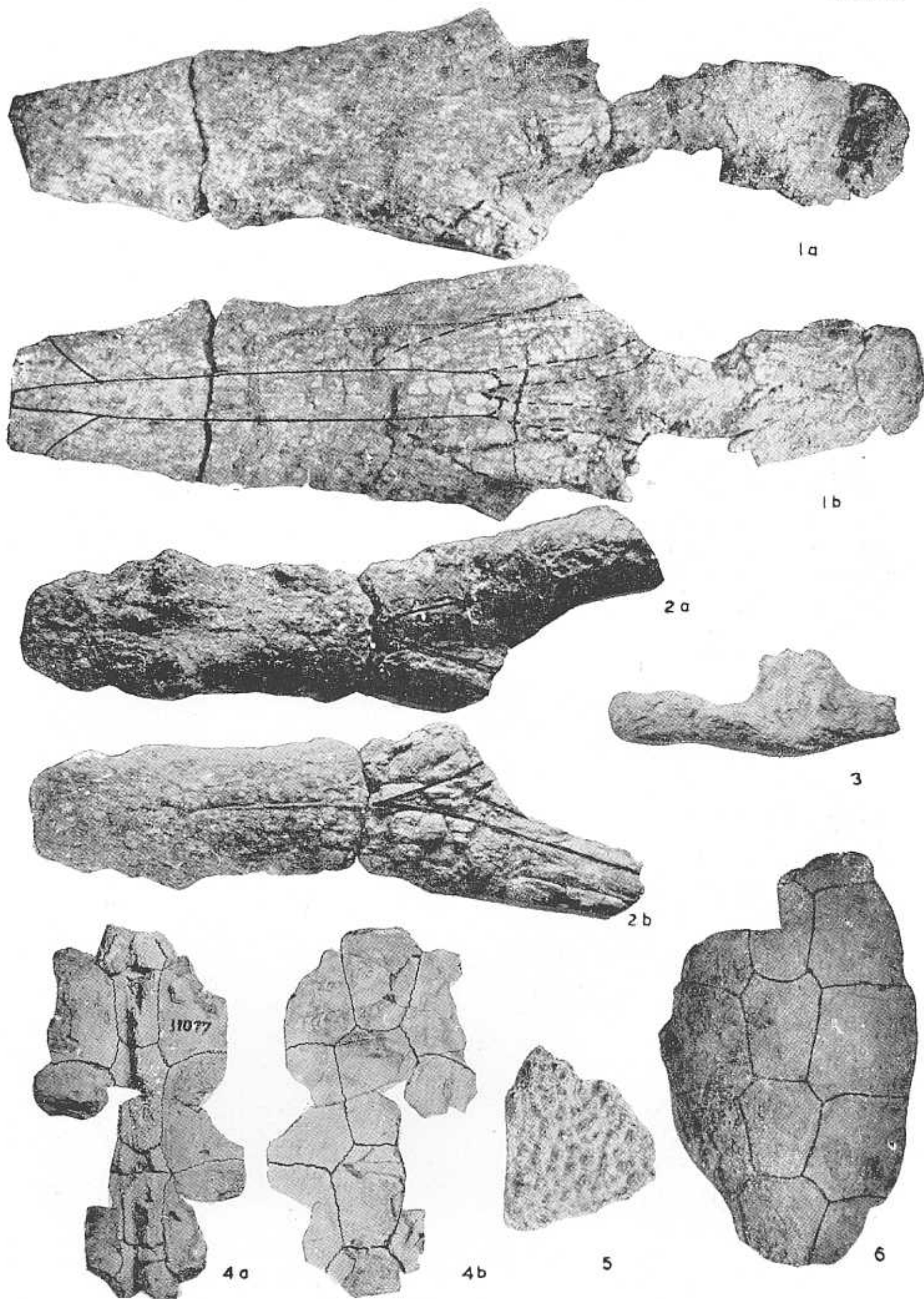
- Fig. 16—Vertebra, L.U.V.P. 11128 x 0.33
 17—Rib, L.U.V.P. 11121 x 0.5

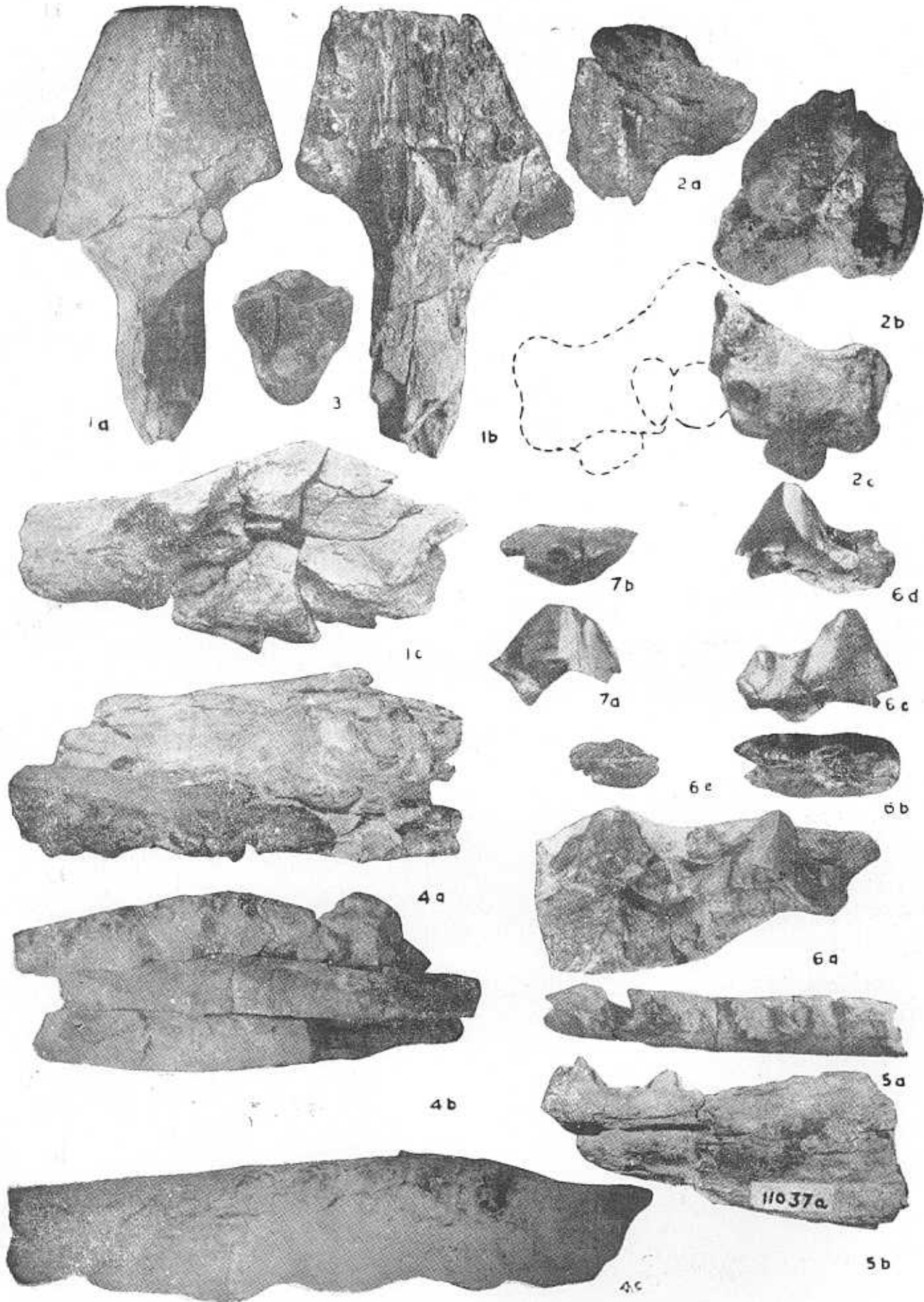
FIG. 18 DEINOTHERIUM PENTAPOTAMIAE Falconer

- Fig. 18—Head of right humerus, L.U.V.P. 11130 x 0.27









SAHNI AND MISHRA: WESTERN INDIA TERTIARY VERTEBRATES.

