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EOCENE ICHTHYOFAUNA FROM THE SUBATHU FORMATION, NORTHWESTERN HIMALAYA, INDIA.

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ABSTRACT

A diverse assemblage of fish consisting of 8 genera and 10 species of selachians (sharks), 4 genera and 5 species of batois (rays and skates) including *Subathunura casieri* gen. et sp. nov. and *Dasyatis rafinesquei* sp. nov., 1 genus and 3 species of holosteans including *Pycnodus bicresta* sp. nov., and 4 genera and 4 species of teleosteans including *Kankatodus cappettai* gen. et sp. nov., is described from the Type Subathu Formation, Subathu, Solan District, Himachal Pradesh and from its lateral extensions at Dharampur (Solan) and Kalakot, Rajauri District, Jammu and Kashmir. At Subathu and the main ossiferous horizon is Greyish Black Limestone at the base of the Subathu Formation (Ypresian) which is considered as an equivalent of Mathur's (1978) Zone III C and Singh *et al.* 's (1978) *Cleistosphaeridium* Palyno Zone. This horizon has also yielded the remains of marine mammals. At Kalakot and Subathu, fish have been found in marine beds (Ypresian) as well as in continental red beds (Lutetian), associated with mammals and pristichampsine crocodiles.

The Subathu fish assemblage has close affinity with the Late Cretaceous-Palaeocene microfish assemblage from Infra and Intertrappean beds of peninsular India and a few taxa including dasyatids, pycnodonts and tetraodonts are common to Himalayan and peninsular regions. The Subathu Ichthyofauna is very similar to that known from the Thanetian beds of Niger and from Palaeocene-Eocene beds of northern Africa.

INTRODUCTION

The record of Eocene fish in peninsular India is well documented for over a century (Egerton, 1845), but no Ecoene fish were known from the Himalayan region until recently. Khare (1976) for the first time described an assemblage of holostean and teleostean fish from the topmost part of the Subathu Group of Kalakot, Kashmir Himalaya. In the Upper Subathu sequence, fish were found associated with a rich terrestrial mammalian fauna. Following the recovery of prolific vertebrate assemblages from Upper Subathu of Jammu and Kashmir (Ranga Rao, 1971, 1972, 1973; Ranga Rao and Obergfell, 1973; Sahni and Khare, 1972, 1973; Khare, 1976) and from the coeval beds in Pakistan (Dehm and Oettingen-Spielberg, 1958; Prasad and Rao, 1958; Gingerich, 1977; Hussain *et al.*, 1978; Gingerich *et al.*, 1979) an intensive search for Eocene marine and terrestrial vertebrates was launched in the Subathu of the Type Area (Subathu, Himachal Pradesh), and of the Bilaspur localities. This resulted in the retrieval of a variety of fish elements associated with mammalian and reptilian fossils. From the Type Area, the fish were first found associated with a marine mammal (Sirenia), *Ishatherium subathuensis,* which establishes the oldest global record of marine mammals (Sahni and Kumar, 1980). Subsequent finds were reported by Sahni *et al.* (1981), Kumar (1982) and Loyal (1984a, 1984b). From Bilaspur localities fish have been reported by Sahni *et al.* (1984) and Singh (1985), and from Kalakot by Khare (1976) and Kumar (1982).

The Subathu vertebrates comprise fish, reptiles (chelonians, crocodilians and squamates) and mammals. The fish assemblage described in this paper was recovered from the Type Area of the Subathu Formation in the environs of Subathu, Solan District, Himachal Pradesh (H.P.) and partly from its lateral extensions in Dharampur, and Kalakot, Rajauri District, Jammu and Kashmir (J&K). In the Type Area of Subathu, in Dharampur and in the Bilaspur localities, the fish elements are much more abundant than the fossils of other vertebrates, while in J&K localities mammals predominate. Among the fish, sharks are most diverse followed by rays, teleosteans and holosteans.

In the Type Area, H.P., the ossiferous horizons occur in the lower, middle and upper portions of the Subathu Formation. In comparison to the upper transitional and middle portions of the Subathu, the lower marine portion has proved to be more promising for vertebrates. This is in contrast to J&K localities where the upper portion of Subathu is richer in vertebrates. The Type Subathu sediments have yielded vertebrates in the following main localities: Kuthar Bridge (KBL), Water Mill (WML), Rifle Range (RRL), Muddy Boots (MBL) and Easy Access (EAL) (Fig.1). Most of these vertebrate-producing localities are situated along the Kuthar River which flows in conformity with the axis of an anticline which in turn coincides with strike of the Subathu Formation. The base of the Subathu Formation is exposed in the core of this anticline. In the transitional sequence, only one locality has yielded vertebrates (mammals and crocodiles) in a gritty level near Subathu (Easy Access Locality). Another locality which has produced a mammalian limb bone from the transitional purple shales

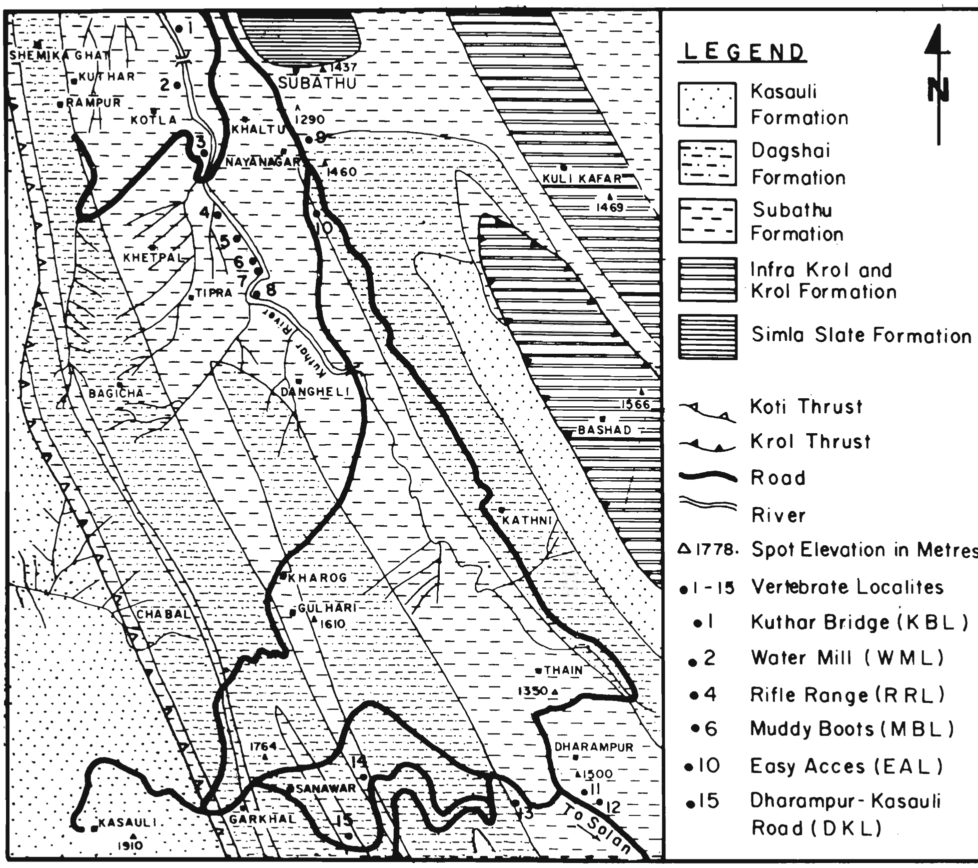

Fig. 1: Map of Subathu-Dharampur area (Solan District, Himachal Pradesh) showing geology and vertebrate fossil localities.

lies in the Dharampur area (Sahni, 1979). In the middle portion of the Subathu, Oyster-bearing limestone and occasionally Olive shales are ossiferous.

A major portion of the fish material that is described in this paper was obtained from the lower part of the Type Subathu Formation. Though fish have been found in varying horizons and lithologies, the Greyish Black Limestone has been the main source for fish elements (Fig. 2). Occasionally, mammalian bones and teeth also occur in this horizon. The Greyish Black Limestone occurs in the form of bands of varying thickness between the grey and green shales. At places (e.g., near Muddy Boots Locality) this limestone becomes pebbly or microconglomeratic consisting of black iron oxide concretions and phosphatic nodules embedded in a grey to black matrix. This pebbly rock is rich in oysters and bone fragments and the calcareous matrix is recrystallized. Thin quartz veins are very common. At least 5 to 8 percent weight of the total composition of this pebbly rock is calcified tissue (bone and teeth). Besides Greyish Black Limestone, Grey Limestone, Olive Shale and *Ishatherium* yielding Grey Sandstone have also yielded fish remains. These horizons are considered as equivalents of Mathur's (1978) Zone III and Singh *et al.*'s (1978) *Cleistosphaeridium* Palyno Zone (Sahni *et al.*, 1983; Loyal, 1986).

In Subathu of Kalakot area, J&K the following main localities have yielded vertebrates: Sindkhatuti (SKL), Jigni (JL), Sair West (SWL), West Babbian Gala (WBGL), East Babbian Gala (EBGL) and Moghla West (MWL) (For geological map and lithologs see Kumar and Sahni, 1985). Most of the vertebrate-producing sections in the vicinity of Kalakot, Metka and Moghla, are exposed on the road. In the upper Subathu of Kalakot, fish were found in Clay, Purple Shales and in Pink Claystone at Sindkhatuti, West Babbian Gala and East Babbian Gala localities. In the middle Subathu, Coquinoid Limestone has yielded sharks, rays and pycnodonts at Sair West, Khargala, Sindkhatuti and West Babbian Gala. The lower portion of Subathu at Kalakot has not produced any vertebrate fossil so far.

The following is a list of the Subathu fish taxa described in this paper:-

Selachii

Hexanchus sp.
Procarcharodon sp.
Isurus cf. I. spallanzani Rafinesque 1810
Alopias cf. *A. vulpinus* Bonnaterre 1780
Galeocerdo latidens Agassiz 1843
?*Galeocerdo* sp. 1
?*Galeocerdo* sp. 2
Hemipristis sp.
Galeorhinus sp.

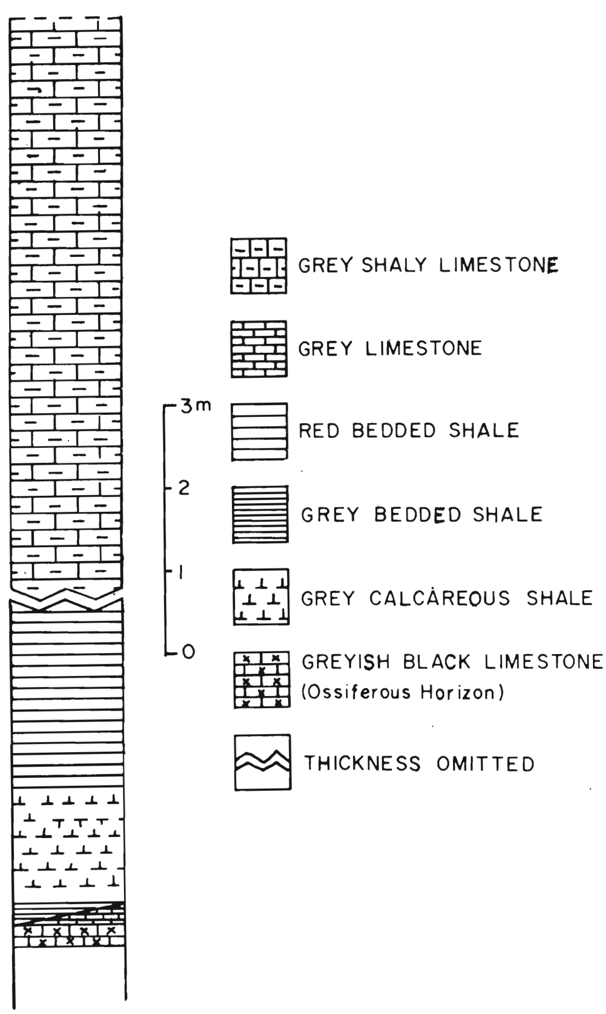

Fig 2: Measured stratigraphic section at Muddy Boots Locality (MBL), Kuthar River, Subathu, showing ossiferous horizon.

Gen. *et* sp. *indet.*, Placoid scales

Batoidea

Rhinobatos sp.
Dasyatis rafinesquei n.sp.
D. vicaryi Loyal 1984
Subathunura casieri gen. & n.sp.
Myliobatis sp.

Holostei

Pycnodus bicresta n.sp.
P. toliapicus Agassiz 1833
P. lametae Woodward 1908

Teleostei

Kankatodus cappettai gen. & n.sp.
Stephanodus libycus (Dames) 1883
Eotrigonodon indicus new combination
Diodon sp.
Enchodontidae *indet.*

The larger specimens (e.g., sharks and some of the pycnodonts and tetraodonts) described in this paper were collected *in situ* from the surface exposures in road-cuttings and stream-cuttings by manual picking with the help of small hammers and chisels, while a major part of the microvertebrate fauna was collected by examining the fossiliferous matrix under the microscope. However, a part of the microvertebrate fauna was obtained by applying some special techniques for the maceration. of the fossiliferous sediments. These techniques included screen-washing, sorting, acid-etching, dry-heating, boiling and gasoline treatment. Hard ossiferous sediments (e.g., Greyish Black Limestone of the Type Subathu Formation) were boiled and treated with acetic acid. The rock samples were broken into small pieces and immersed in 10 to 15 percent acetic acid for about a week. The disintegrated material was then screened through 20 to 100 ASTM meshes. In some cases, the samples were dry-heated and then cooled in liquid Nitrogen. The concentrate obtained by screening the disintegrated material yields microfossils, e.g. dasyatids, pycnodonts, tetraodonts, etc. Most of the placoid scales of sharks and ray teeth were recovered by this technique.

KEY TO HORIZONS AND LOCALITIES

Horizons:

GBLH	Greyish Black Limestone, Lower Subathu Formation (Ypresian) of the Type Area, Subathu.
GSLH	Green Shaly Limestone, Lower Subathu Formation (Ypresian) of the Type Area.
OBLH	Oyster-bearing Limestone of Lower Subathu Formation (Ypresian) of the Type Area, and of lower portion of the middle Subathu (Ypresian) of Kalakot.
OGSH	Olive Green Shale, basal Upper Subathu Formation (Ypresian-Lutetian), Dharampur-Kasauli Road.
GASH	Grey Argillaceous shale, upper Subathu (Lutetian) of Kalakot.

Localities:

DKL	Dharampur-Kasauli Road, Solan District, H.P.
KBL	Kuthar Bridge Locality, Kuthar River, Subathu.
MBL	Muddy Boots Locality, Kuthar River, Subathu.
WML	Water Mill Locality, Kuthar River, Subathu.
EBGL	East Babbian Gala Locality, Metka-Moghla Road, Rajauri District, J&K.
SKL	Sindkhatuti Locality, Kalakot, Rajauri District.
SWL	Sair West Locality, Kalakot.

REPOSITORY OF MATERIAL

All the fossil material described in this paper is stored in the Laboratory of Vertebrate Palaeontology, Department of Geology, Panjab University, Chandigarh.

SYSTEMATIC PALAEONTOLOGY

Class	Chondrichthyes
Subclass	Elasmobranchii
Order	Selachii
Suborder	Hexanchoidea
Family	Hexanchidae GRAY, 1851
Genus	*Hexanchus* RAFINESQUE, 1810

Hexanchus sp.
(Plate I — 1-3)

Material: VPL/K 808 and 844, isolated lower teeth; VPL/K 813, an isolated upper tooth.
Horizon and Locality: GBLH, MBL.

Description: VPL/K 808 and 844, fragmentary lower teeth, have a posteriorly directed principal cusp and 5 to 6 regularly placed distal cusplets. The height of all the distal cusplets is nearly the same in VPL/K 844, while in VPL/K 808 it gradually decreases away from the principal cusp. The mesial portion of the principal cusp that may have possessed mesial serrations is broken in both the specimens. The root is broad and flat and is nearly as deep as the crown is high.

VPL/K 813, probably an upper tooth, has a slightly posteriorly oriented principal cusp much larger than the distal cusplets which are at least three in number. The junction between the root and the crown is marked by a distinct ridge. Near the base of the crown, there exists a shallow depression which extends up to some distance along the height of the tooth. The root is broader than the crown.

Remarks: In India, hexanchids are known from the early Middle Eocene sediments of Kalakot, about 360 km northwest of the present locality in the northwestern Himalaya (Khare, 1976) and from the southwestern Kutch in the Peninsula (Mishra *et al.*, 1973; Sahni and Mishra, 1975). Although a number of shark genera are known from the Miocene coastal sediments of Baripada, Orissa, no hexanchid has been reported so far. Their absence in Baripada assemblage can be attributed to the fact that Miocene basin was much shallower while the hexanchids normally thrive in deeper waters. The Eocene fossil material of hexanchids in India, although represented by two genera, viz., *Notorynchus* Ayres, 1855 and *Hexanchus* Rafinesque, 1810, is meager; only a few teeth have been found. This is again because of the shallow nature of the Eocene Sea which may have restricted the growth of hexanchids. Hexanchids from Kalakot and Kutch were described as *'Notidanus' primigenius* Agassiz, 1835. Since the genus *Notidanus* has been synonymized with *Notorynchus,* the Kalakot and Kutch material is here transferred into *Notorynchus primigenius* (Agassiz, 1835).

The present teeth of *Hexanchus* from the Type Subathu Formation differ from those of *Notorynchus* in being mesio-distally elongated and in possessing shallower root. Of the three known extinct species of *Hexanchus,* the present specimens are comparable only to *H. hookeri* Ward, 1979, the lower antero-lateral teeth of both species having a principal cusp distinctly larger than the first distal cusplet. *H. agassizi* Cappetta, 1976 and *H. collinsonae* Ward, 1979 have principal cusps barely larger than the first distal cusplet. Of the two extant species, the Subathu material has resemblance with *H. vitulus* Springer and Waller, 1969. More detailed comparisons are not possible due to the inadequate data, hence the specific identification of present material is not attempted. *Hexanchus,* a sluggish shark ranges in age from Jurassic to Recent and occurs today in subtropical to temperate oceans worldover.

Family Isuridae GARMAN, 1913
Genus *Procarcharodon* CAPPETTA, 1970
Procarcharodon sp.
(Plate I — 4-6)

Material: VPL/K 805 and 810, complete upper teeth; VPL/K 809 and 811, isolated fragmentary teeth.
Horizon and Locality: GBLH, MBL.

Description: VPL/K 810, a well preserved triangular tooth, probably an upper, has a single cusp and no serrations or cusplets. The root is broad and undivided with its lower margin curved in the centre. A continuous groove exists all along and immediately above the lower margin of the root. There is no sharp differentiation between the root and the crown. VPL/K 805 is smaller with a broad root. In VPL/K 809, the margins of the crown are smooth except for a single crenulation seen on the posterior margin near the base of the cusp.

Remarks: The genus *Procarcharodon* includes Eocene to Miocene species of *Carcharodon* while *Carcharodon* now comprises only Miocene and later species (Cappetta, 1970). In view of the erection of genus *Procarcharodon,* all existing Eocene to Miocene material described earlier as *Carcharodon* is now referred to *Procarcharodon. Procarcharodon* is not as widespread as the genus *Carcharodon* and is known from Eocene of Africa, North America and India. The present specimens cannot be compared with *Procarcharodon* of other areas because of the lack of data. However, comparisons with *Carcharodon* material have indicated resemblance with *C. tandoni* Mehrotra *et al.*, 1973 (specimen no LUVP 5016) from the Miocene of Baripada, Orissa (Mehrotra *et al.*, 1973), but they differ from this species in possessing a straight principal cusp and in lacking serrations on mesial and distal margins. An indeterminate species of *'Carcharodon' (Procarcharodon)* represented by a single tooth has recently been reported from the Upper Subathu Formation of Bilaspur area, H.P., about 50 to 60 km northwest of the present localities (Sahni *et al.*, 1984, Plate I, Fig. 1). This tooth compares very well with one described as *C. tandoni* from the Lower Miocene Limestone of Baripada (Mehrotra *et al.*, 1973, Plate 2, Figs. 4a and 4b). The Bilaspur specimen differs from the Subathu specimen in possessing serrations on both margins of the principal cusp.

Genus *Isurus* RAFINESQUE, 1810
Isurus cf. *I. spallanzani* RAFINESQUE, 1810
(Plate I — 7)

Material: VPL/K 845, an isolated lower tooth.

Horizon and Locality: GBLH, MBL.

Description: VPL/K 845 is a small tooth with a high and nearly straight principal cusp that has smooth margins and an acute apex. The lingual face of the crown is strongly convex. Accessory denticles and serrations are entirely lacking. The root is damaged, but its preserved portion indicates that it was fairly deep and broader than the crown.

Remarks: The tooth of *I* cf. *I. spallanzani* resembles those of *Alopias* cf. *A. vulpinus* (VPL/K 815) in the present collection, but differs in its smaller size and in being slenderer with less developed root. *Isurus* is a cosmopolitan taxon; presently it occurs in the Atlantic and other oceans. In India, it is known from Eocene (present work) and Miocene (Mehrotra *et al.*, 1973; Sahni and Mishra, 1975; Sahni and Mehrotra, 1981).

Family Alopiidae GILL, 1885
Genus *Alopias* RAFINESQUE, 1810
Alopias cf. *A. vulpinus* BONNATERRE, 1780
(Plate I—8)

Material: VPL/K 815 and 956, isolated lower anterior teeth.

Horizon and Locality: GBLH, MBL.

Description: VPL/K 815, an anterior tooth, is triangular and higher than broad. Acutely pointed crown is fairly high with entire margins. Paired lateral denticles and serrations are absent. On the labial side, the crown extends laterally and downwardly covering a large portion of the root, but it is much shorter and narrower on the lingual side. The root is bilobed with a deeply curved lower margin and a distinct median groove. Its lingual aspect is highly inflated and massive while the labial aspect is much more reduced due to the expansion of the crown. VPL/K 956 is slightly smaller than VPL/K 815 with less inflated lingual aspect.

Remarks: *Alopias* is a swift moving extant thresher shark presently dwelling in the shallow to moderately deep and temperate to tropical sea waters worldover. It has wide geological and geographical ranges. Its fossil record ranges from Eocene to Pliocene.

The present specimens do not resemble any of the known Eocene taxa. They differ from *A. smithwoodwardi* (known from Eocene of Namibia, Bohm, 1926) in lacking lateral denticles; from *A. hassei* (Upper Eocene of Samland, USSR, Noetling, 1885) in possessing slenderer crown and root; from *A. denticulatus* (Lower Eocene of Ouled Abdoun basin, Morocco, Cappetta, 1981) in smaller size and in lacking lateral denticles; from *A. chrochardi* (Eocene, London Clay of Essex, Ward, 1978) in 25 percent smaller size, much less robust crown and in lacking plications near the crown-root junction and swellings in the lower portion of the posterior cutting edge; and from *A. leeensis* (Lutetian of Hampshire, England, Ward, 1978) in more than 50 percent smaller size, in possessing a distinct median groove and an acutely pointed crown. Among the younger and recent taxa, the dentition of *A. vulpinus* (Bonnaterre, 1788) has a close resemblance with the present material in respect of size as well as the morphological details.

An indeterminate species of *Alopias*, represented by a solitary fragmentary tooth, is also known from the Subathu of Bilaspur area (Sahni *et al.*, 1984). It differs from the present specimen in slightly smaller size, in possessing a lower crown and broader but shallower root and in being much compressed. *A. vulpinus* is also known from the coastal Miocene sediments of Baripada, Orissa and Gogha, Gujarat (Sahni and Mehrotra, 1981). Miocene teeth of *A. vulpinus* as described by Sahni and Mehrotra appear to be more robust and compressed than the present teeth.

Family Carcharhinidae BERG, 1940
Genus *Galeocerdo* MULLER AND HENLE, 1837
Galeocerdo latidens AGASSIZ, 1843
(Plate I—9; Fig. 3)

Material: VPL/L 2420 and VPL/K 847, isolated teeth.

Horizon and Locality : OGSH, DKL (VPL/L 2420); GSLH, WML (VPL/K 847).

Description : VPL/L 2420 is a well preserved anterior lateral tooth. A low principal cusp with a subhorizontal and sharply pointed distal end is inclined posteriorly. Its medial region on the anterior margin is depressed and bears feeble serrations. On the posterior side of the principal cusp, two small lateral denticles are present. The root is well developed, wide and low with a characteristic root incision in the middle. Its anterior and posterior edges are blunt and sharp respectively.

VPL/K 847 is another lateral tooth but of a posterior position in the jaw. Its crown has a hook-shaped apical portion and bears several minute serrations on parts of its anterior and posterior margins. The shallow root is slightly broader than the crown; its lower margin is concave making a wide arch. A root incision, which is prominent in VPL/L 2420, is not differentiated in this specimen.

? *Galeocerdo* sp. 1
(Plate I—10-16)

Material : VPL/K 816, 817, 843, 848 and 957, all isolated teeth.

Horizon and Locality : GBLH, MBL.

Description : All the teeth are subtriangular, broad and characteristically low with a principal cusp and 3 to 5 small distal cusplets. Anterior margin of the crown in various specimens is nearly straight (e.g. in VPL/K 817, 848) to gently convex (e.g. in VPL/K 816, 843). Its lower portion, in VPL/K 817 and 848, shows incipient crenulations, and in VPL/K 816 and 843, it is smooth. The lingual face of all the teeth is highly convex while the

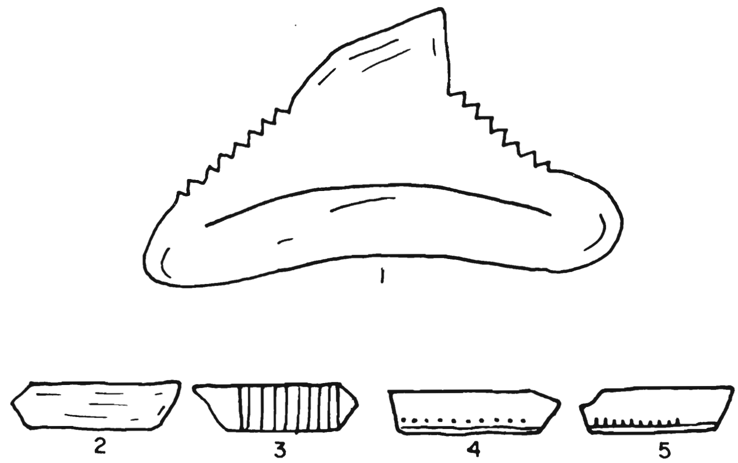

Fig. 3: 1, *Galeocerdo latidens* tooth, X4 (VPL/K 847); 205, *Myliobatis* sp. tooth (VPL/K 849), oral, basal and side views, X17.

labial face is nearly flat. The broad and bilobed root is nearly as deep as the crown is high; a distinct median groove is present between the two root lobes, of which the posterior lobe is broader. In VPL/K. 816 and 843, the junction between the root and the crown is marked by the presence of a groove. A nerve opening is visible in VPL/K 816. All the teeth are very similar to one another indicating that they probably held more or less same position in a jaw.

? Galeocerdo sp. 2
(Plate I — 17-18)

Material : VPL/K 807, an isolated tooth.
Horizon and Locality : GBLH, MBL.

Description : VPL/K 807 is a small triangular tooth with a low and very compressed crown. The crown comprises a large principal cusp and a tiny cusplet which is situated posterior to the principal cusp near the neck of the crown. The anterior margin of the principal cusp is gently convex and smooth while the posterior margin is straight and smooth. The angle between the posterior margin of the principal cusp and rest of the crown is 90 degrees while that between the anterior margin and the root base is about 50 degrees. The root is broad and deep.

Remarks : Galeocerdo is a common taxon in the Eocene sediments of the Himalayan as well as peninsular India. In the present collection it is represented by *G. latidens* and two indeterminate species, species 1 and species 2, whose assignment to *Galeocerdo* is doubtful. *G. latidens* is also known form the Eocene sediments of Pakistan (Gingerich *et al.*,1979). The Middle Eocene beds of Kutch (Gujarat) also yield *Galeocerdo,* two species, viz., *G. aduncus* Agassiz, 1843 and *G. cuvieri* Lesueur, 1822 have been reported (Mishra, 1975). *Galeocerdo* is also a very common shark in the Miocene sediments of Baripada, Orissa.

The teeth of ? *Galeocerdo* sp. 1 and ? *Galeocerdo* sp. 2 do not fit in any of the known species of *Galeocerdo* or in any other known selachian taxon for that matter. Presently they have been assigned questionably to *Galeocerdo* because they do have some resemblance to it. Althogh the most diagnostic character of a *Galeocerdo* tooth, i.e., the presence of a deep notch posteriorly, is absent in the present specimens, the apices of the teeth are nearly as sharply inclined as in *Galeocerdo.* Also both the margins of present teeth show crenulations as in *Galeocerdo. ? Galeocerdo* sp. 1 teeth differ from a typical *Galeocerdo* tooth in lacking a notch, possessing a very robust and nearly blunt principal cusp, and very coarse serrations or crenulations in the form of distal cusplets and faint crenulations on the mesial side. A longitudinal section of a *? Galeocerdo* sp. 1 tooth shows that it is an orthodont type with a pulp cavity surrounded by orthodentine. This implies that the tooth certainly belongs to a carcharhinid shark and that it could be *Galeocerdo.* This, howerver, cannot be ascertained unless additional material is forthcoming. *? Galeocerdo* sp. 2 is differentiated by its small crown (smaller than the root), a principal cusp inclined posteriorly at a very low angle and by the presence of incipient accessory cuspuls.

Genus *Hemipristis* AGASSIZ, 1843
Hemipristis sp.
(Plate I — 19-20)

Material: VPL/K 806, an isolated tooth.
Horizon and Locality: GBLH, MBL.

Description: The tooth has a single cusp and a nearly flat and highly convex lingual surface. The anterior and posterior margins of the crown are straight and concave respectively; their lower portion (roughly 35 to 40 percent of the total crown height) is coarsely serrated. The apical portion of the crown possesses smooth and sharp margins. A shallow and narrow root is characteristically inflated forming a distinct bifurcated structure on the lingual side of the tooth. On the labial side, the lower edge of the root is concave and curved in the centre. A nerve opening is seen at the point of bifurcation of root on the lingual side of the tooth.

Remarks: Hemipristis, a cosmopolitan shark is relatively less common in Eocene sediments and is predominantly a Miocene form. An isolated tooth (CASG MF 1370) described as *Hemipristis* sp. from the Subathu Formation of Bilaspur area by Singh (1985) is more than 80 percent smaller than the present specimen and it lacks serrations. The presence of coarse serrations on the cutting edges of teeth is one of the diagnostic characters of *Hemipristis* and their absence in the Bilaspur specimen renders its identification doubtful. The nonavailability of comparative material and literature on the known Eocene *Hemipristis* taxa of other areas has hampered the identification of Subathu specimen to a specific level. However, its comparisons with some of the younger species from India and other countries indicate a close resemblance with a Miocene species, *H. serra* Agassiz, 1843. One of the diagnostic features of *H. serra,* i.e., the presence of a deeply cleft median boss on the inner face of the root, is also a prominent character in the present specimen but the marginal serrations which are large and extend almost to the apex in *H. serra,* are not as well differentiated and are restricted only in the lower 35 to 40 percent of the total crown height in the present specimen. The specific identification of the present material will be attempted when more complete fossils are collected.

Hemipristis is a long ranging taxon known from Eocene to Miocene of India, North America and Africa, Eocene-Pliocene of Europe, Miocene of Australia and South America and Miocene-Pleistocene of East Indies. Its modern representative *H. elongatus* occurs in the Indian Ocean.

Genus *Paragaleus* BUDKER, 1935
Paragaleus sp.
(Plate I — 21-22)

Material: VPL/K 804 and 846, isolated teeth.
Horizon and Locality: GBLH, MBL.

Description: VPL/K 804 is a triangular labiolingually compressed anterior tooth approximately as broad as high. A centrally placed principal cusp is slightly lingually inclined. In the lower portion of the crown near the base of the principal cusp the lateral margins of the tooth bear 4 to 5 small cusplets or serrations. The labial face of the crown is slightly convex and its lower edge is arched. The root is very shallow. VPL/K 846 is an anterior lateral tooth. The anterior margin of the crown is very extensive and straight. The arched root is very shallow and narrow.

Remarks: Paragaleus is reported for the first time from India. The present material resembles closely to that described from Tortonian of Lisbon by Antunes and Jonet (1970, Plate 12, Fig. 71.)

Genus *Galeorhinus* BLAINVILLE, 1816
Galeorhinus sp.
(Plate I — 23-24)

Material: VPL/K 801 and 802, nearly complete isolated teeth; VPL/K 803 and 823, fragmentary teeth.
Horizon and Locality: GBLH, MBL.

Description: Subtriangular and labiolingually compressed teeth are nearly as high as broad. The crown has a principal cusp and 5 to 6 distinct accessory cusplets that lie on its posterior margin and are all directed posteriorly. The labial face of the tooth is flat to gently concave. The root is broader than the crown, it is clearly bilobed on the lingual side with a distinct median groove. An arched lower margin of the root has distinct median incision on the labial side.

Remarks: The present teeth clearly resemble those of *Galeorhinus* sp. described from the Auversian (early Late Eocene) of Ronquerolles, Paris basin (Cappetta and Nolf, 1981; Plate 2, Figs. 14-14', specimen no. RON 31). They also have considerable parity with the teeth of *G. affinis* Probst, 1878 from the Tortonian (Late Miocene) of Lisbon (Antunes and Jonet, 1970, Plate 12, Figs. 78-79).

Table 1 — Comparative measurements in millimeters of shark teeth from the subathu formation (Ypresian Lutetian) northwestern Himalaya.

Dimensions	*Hexanchus sp.*			*Procarcharodon sp.*		*Isurus cf. I. Spallanzan*	*Alopias cf. A. vulpinus*		*Galeocerdo latidens*		*?Galeocerdo sp. 1*		*?Galeocerdo sp. 2*	*Hemipristis sp.*	*Paragaleus sp.*		*Galeorhinus sp.*	
	VPL/ K 813	VPL/ K 808	VPL/ K 844	VPL/ K 805	VPL/ K 810	VPL/ K 845	VPL/ K 815	VPL/ K 956	VPL/ L 2040	VPL/ K 847	VPL/ K 816	VPL/ K 817	VPL/ K 807	VPL/ K 806	VPL/ K 804	VPL/ K 846	VPL/ K 801	VPL/ K 802
Tooth height (Complete or reconstructed)	-	11	-	5	8.3	2.5	5.5	4.6	6	8	5.5	6.5	3	12.2	9	12.5	9.5	10.5
Tooth height (Preserved)	7	8	4	-	-	-	-	4	-	-	-	-	-	9.5	-	-	-	-
Tooth width (complete or reconstructed)	-	14	4.5	5.3	11.5	-	4.7	4	11	16	7.5	5.7	6	8.4	10	11	10	11
Tooth width (Preserved)	9.2	-	-	-	10	-	-	4	-	-	-	-	-	7.4	-	-	-	-
Root depth	-	4	1.8	1.8	2.3	-	1.5	1.2	2	-	2.5	1.5	1.3	3	1.5	2	-	-

Galeorhinus is also known from the Subathu Formation of Bilaspur, but the material described is too meagre to allow any detailed comparisons (Sahni *et al.*, 1984). However, the present specimens can be easily distinguished from those of the Bilaspur area by their more than 50 percent larger size. *Galeorhinus* ranges in age from Palaeocene to Recent and is known from North America, North Africa, Europe and India.

Selachii *indet.*, Placoid scales
(Plate I — 25-28)

Several microscopic placoid scales or dermal denticles of some indeterminable shark taxa were recovered from the Greyish Black Limestone exposed at the Muddy Boots Locality, Subathu. The scales are of two types, viz., the cuspidate type and the platform type. Their width and height range from 0.5mm and 0.27mm to 0.39mm and 0.45mm respectively. Each scale consists of a basal plate and a spine. The basal plate is well preserved in VPL/K 942, but in most of other specimens it is missing. The spine, in most cases, is slightly curved and makes an acute angle to the axis of the basal plate. In VPL/K 942 (a cuspidate type scale), however, the spine is positioned perpendicular to the basal plate and also it is very elongate in contrast to more or less rhomboid spines in other specimens. In VPL/K 943 (a platform type scale), the spine is curved at an obtuse angle near its posterior end. The posterior margin of the spine possesses cusps varying in number between three (in VPL/K 944) and five (in VPL/K 942, 943). The median cusp is usually the best developed and the longest (highest). A ridge originates from the apex of each cusp and runs up to the base of the spine. The number of these ridges corresponds to the number of cusps in a spine. The shape of the basal plate, in VPL/K 942, is rectangular and elongated; the corners of the plate are blunt. The height and width of the basal plate correspond to the length of shorter and longer diameters of the plate respectively. On the basal surface of the plate, an opening for the pulp cavity is present in the centre. The height and width of a spine are measured along its median ridge and posterior margin respectively.

Table 2 — Measurements in millimeters of placoid scales/dermal denticles of selachii indet. from subathu Formation

Dimensions	VPL/K 942	VPL/K 943	VPl/K 944
Height of a scale	0.3	-	-
Height of spine		0.27	0.45
Width of spins	0.5	0.39	0.38
Height of basal plate (shorter diameter)	0.2		
Width of basal plate (longer diameter	0.5		

Order Batoidea
Suborder Rhinobatoidea
Family Rhinbatidae MULLER AND HENLE, 1838

Genus *Rhinobatos* LINCK, 1790
Rhinobatos sp.
(Plate II — 1-3)

Material: VPL/K 401, an isolated lateral tooth and a few fragmentary specimens.
Horizon and Locality: GBLH, MBL.

Description: The present tooth is very small and is covered by a very thin layer of enamel. The crown is wider than long; it is subelliptical in shape and slightly convex. The posterior face of the tooth is characterized by one medioposterior prolongation and two lateral prolongations. The former is long and straight with a rounded distal end. The root is small with two subtriangular lobes, which are separated by a narrow root furrow.

Remarks: *Rhinobatos* is reported for the first time from the Subathu Formation. However, no specific assignment can be made for want of material. The differentiation of *Rhinobatos* teeth from those of dasyatid taxa is based on the tri-lobe aspect of their posterior face. *Rhinobatos* ranges in age from Early Cretaceous to Recent and is known from Europe, North Africa and southwest Asia.

Suborder Myliobatoidea
Family Dasyatidae JORDAN, 1888
Genus *Dasyatis* RAFINESQUE, 1810
Dasyatis rafinesquei n. sp.
(Plate II — 4-16; Fig. 4)

Holotype: VPL/L 1220 (male), VPL/L 1214 (female), isolated teeth.
Paratypes: VPL/L 1221 to 1226, 7341 to 7395 (male); VPL/L 1201 to1213, 1215 to 1218, 7301 to 7340 (female), all isolated teeth.
Etymology: This species is named after C.S. Rafinesque who introduced the genus *Dasyatis.*
Horizon and Locality: GBLH, MBL
Specific Diagnosis: Male teeth small; labial portion subelliptical to subovate; lingual part cuspidate; crown finely pitted; root reduced. Female teeth small; low crowned; lateral angles blunt; anterior face flat, subelliptical to subovate; ornamentation pitted; basal face flat, subtriangular.

Description: In male teeth, the crown consists of subelliptical or subovate labial region and a cuspidate lingual region. In the holotype VPL/L 1220, the labial region is elliptical and bears more or less sharp lateral angles. The contact of the labial portion of the crown is marked by prominent concavities. The cusp is long and inclined at an acute angle from the vertical. The surface of the crown is covered with fine rounded pits. The root is reduced and bilobate. The root furrow is short with subtriangular or subrounded lobes. A central foramen is prominent.

The female teeth are 0.61 to 0.68mm in length and 1.1 to 1.5mm in width. The crown is low and thin-enamelled.

The lateral edges of the teeth are blunt. The anterior face is flat and subelliptical to subovate in shape. The ornamentation consists of fine rounded pits, which are present uniformely on the anterior face. The posterior face is smooth, straight and bears a shallow lip. The basal face is flat and subelliptical to subovate in shape. The root lobes are flat and subtriangular.

Remarks: The teeth of the present species can be easily distinguished from those of *D. vicaryi* Loyal, 1984 by their small size, blunt lateral angles, flat and subovate anterior face, finer ornamentation, elliptical and flat basal face, flat root lobes and a shorter root furrow. However, *D rafinesquei* sp. nov. bears close resemblance to the Palaeocene form from Niger, *D. russelli* Cappetta, 1972, in that both these species bear flat crowns and blunt lateral angles. But, the African taxon possesses a more massive crown and a sinuous anterior lip. A median concavity is also present in this lip. In contrast, the Indian species bears a thin crown and the anterior lip possesses smooth, convex and an elliptical contour. The ornamentation is coarser and the root lobes are more massive in *D. russelli.*

The male teeth of the present species are morphologically close to those of *Merabatis praealba* (Arambourg, 1952) described by Cappetta (1983) from the Ypresian beds of Ouled Abdoun, Morocco. But in the African taxon the teeth are larger, reaching 2.5mm in width, while in the present species the width does not exceed 1.5mm. The median concavity present in the anterior lip in *M. praealba* is absent in *D. rafinesquei* sp. nov. The ridge which is sometimes present in the former is always absent in the latter. The contact of the cusp with the labial region of the crown is more gradual in *M. praealba,* while it is abrupt and marked by concavities in the present species. The ornamentation is coarser in the former than that present in the latter.

Dasyatis vicaryi LOYAL, 1984
(Plate II — 17-22)

Material: VPL/L 1949 to 2048, VPL/K 851 to 860, all isolated teeth.
Horizon and Locality: GBLH, MBL.

Description: This species is characterized by high-crowned robust teeth with brilliant enamel. In general, they are wider than long. The width of the teeth ranges from 1.5 to 2.0 mm.

In occlusal view, the crown is slightly convex with elliptical to subelliptical contour. The lateral angles are sharp and well defined. The anterior face is well developed and convex. It is divided into two segments by a blunt medioexternal ridge. The segment in front of the ridge is ornamented with coarse pits, while the segment towards the posterior side is smooth. The posterior face is reduced and is divided into two feebly developed lateroposterior depressions. The basal face is irregularly rounded. The root is low and inclined posteriorly. The root furrow is narrow with a wide central foramen.

Remarks: This taxon was first reported by Loyal (1984b) from the Subathu Type Section. Later Jolly and Loyal (1985) recorded it from the Lutetian beds of Marh Stage of Sri Kolayatji, Rajasthan. *D. vicaryi* is distinguished from *D. rafinesquei* and other related taxa on the basis of its highly elevated oral surface with sharp lateral angles and a transverse ridge that divides the oral surface into two segments.

Family Gymnuridae FOWLER, 1934
Genus *Subathunura n.* gen.

Etymology: This genus is named after Subathu town.
Type Species: Subathunura casieri n.sp.
Generic Diagnosis: Male teeth cuspidate; crown with subrectangular labial apron; lingual cusp short, laterally compressed; root massive, bilobate; lobes squarish and subrounded. Female teeth small; crown thin, wide, elliptical or ovate; lateral margins smooth or crenulated; median furrow smooth or granulated; root massive bilobate; lobes subovate, subrounded.

Subathunura casieri n. sp.
(Plate II — 23-38; Fig. 4)

Holotype: VPL/L 2301, an isolated male tooth; VPL/L 2361, an isolated female tooth.
Paratypes: VPL/L 2302 to 2330, isolated male teeth; VPL/L, 2362 to 2388, isolated female teeth.
Etymology: Named after the late Dr. E. Casier, who conducted pioneering work on fossil fish.
Horizon and Locality: GBLH, MBL.
Specific Diagnosis: As for the genus.

Description: In the male teeth, the crown and root are well differentiated. The crown consists of a small labial apron, which is generally vertical and subrectangular in shape. This labial apron is wide in lateral teeth, VPL/L 2301 to 2305, 2308 to 2311, 2313 to 2319 and laterally compressed in anterior teeth, VPL/L 2306, 2312, 2320 and 2321. The upper margin of the labial apron is lingually produced to form a cusp. The root is well developed and is wider than the crown. It is robust with squarish or subrounded lobes. A root furrow is short and wide.

The female teeth bear a thin elliptical or ovate crown, which is much wider than long. The lateral angles of the crown are more or less sharp or blunt. A wide furrow is generally present on the occlusal surface of the crown. This furrow is either smooth or granulated. The lingual and labial margins of this furrow are either irregular or straight. In a few specimens, a faint crenulation is observed on these margins. Below the crown, a faint depression is seen. The root is bilobate, wide and massive. It is wider than the crown. The root lobes are subovate or subrounded.

Remarks: The teeth of *Subathunura* gen. nov. are remotely related to those of *Gymnura* Van Hasselt,

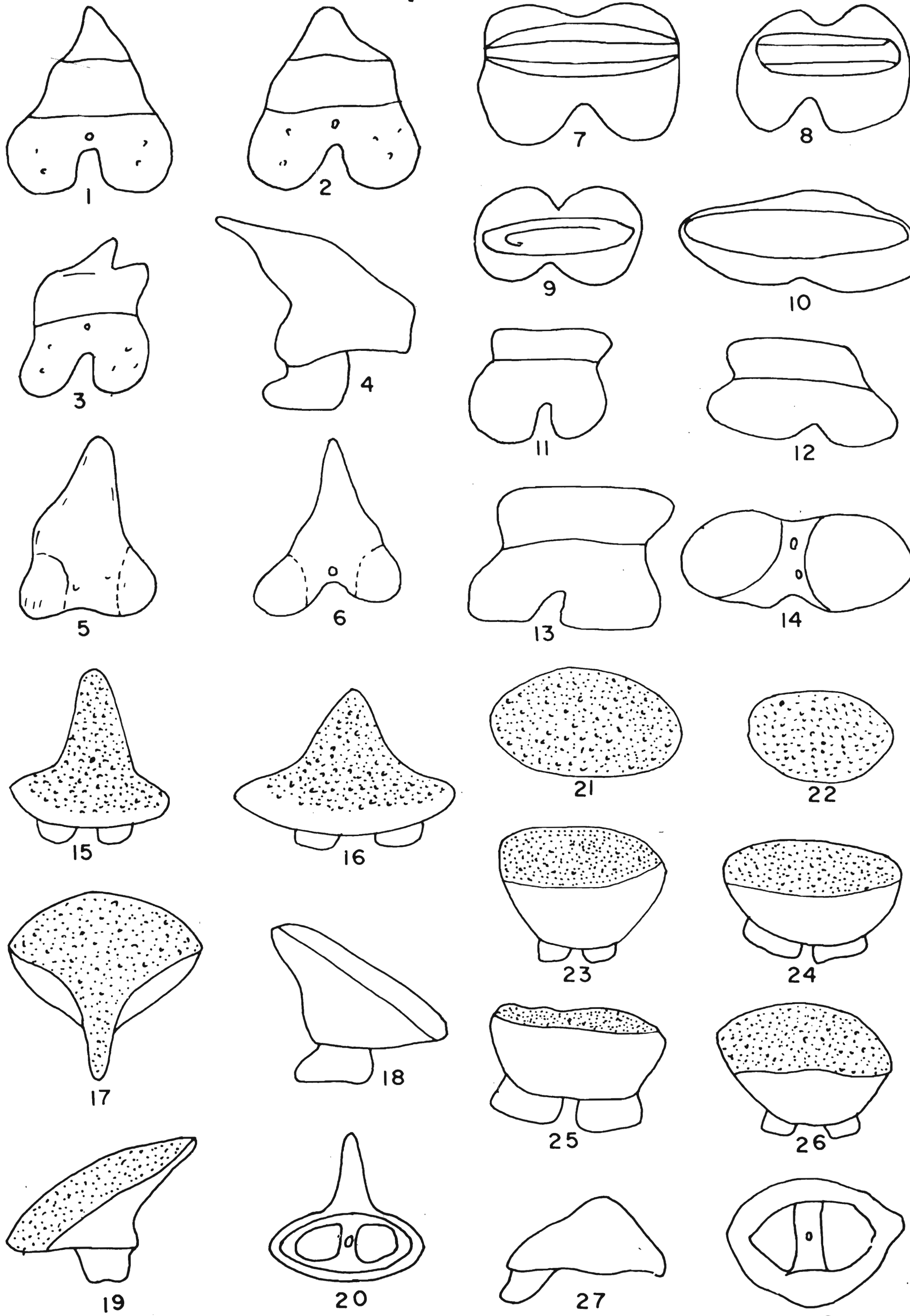

Fig. 4: 1-14, *Subathunura casieri* gen. et sp. nov., 1-6, teeth of male individuals (approximately X25) in labial (1-3), lateral (4) and lingual (5-6) views; 7-14, teeth of female individuals (approximately X40) in occlusal (7-10), labial (11-13) and basal (14) views; 15-28, *Dasyatis rafinesquei* sp. nov., 15-20, teeth of male individuals (approximately X25) in labial (15-17), lateral (18-19) and basal (20) views; 21-28, teeth of female individuals (approximately X20) in occlusal (21-22), posterior (23-26), lateral (27) and basal (28) views.

1823, which is known from Eocene and Oligocene beds of Belgium (Herman, 1984), Palaeocene beds of Morocco (Cappetta, 1984) and Miocene beds of North America (vide Herman, 1984). In *Gymnura* the labial apron is produced laterally to form very prominent labial protuberances giving a typical 'three-cornered hat' appearance to the crown (Herman, 1984, p. 50). These labial protuberances are wider than the root and hang over it. The lingual cusp is quite long with a sharp distal end. The root lobes are triangular or subtriangular. In contrast, the male teeth of *Subathunura* gen. nov. bear a more or less subrectangular labial apron, whose edges do not spread beyond the lateral edges of the root lobes. The cusp is smaller with a more or less blunt distal end. The root is more massive than in *Gymnura*. The root lobes are squarish, subovate or subrounded in shape in the present species.

Family Myliobatidate MULLER AND HENLE, 1837
Genus *Myliobatis* DUMERIL (IN CUVIER, 1817: 137)

Myliobatis sp.
(Plate III — 1-5; Fig. 3)

Material: VPL/K 849, VPL/L 2049, isolated median teeth; VPL/K 824 to 826 and VPL/L 2050, fragmentary caudal spines.
Horizon and Locality: GBLH, MBL

Description: VPL/K 849 is a tiny median tooth, about three times wider than long. Its occlusal surface is slightly convex and basal surface is marked with antero-posteriorly running ridges and grooves representing an eroded root. In side view, tiny nerve openings are clearly seen arranged linearly below the crown along the breadth of the tooth. The tooth is nearly flat and not curved indicating that it could be a lower tooth.

VPL/L 2049 is another median tooth. It is much larger than VPL/K 849 (about 25 times) and almost certainly represents a distinct species. The occlusal surface is smooth and convex on the posterior side. The lateral edges of the crown are sharp and angular. The crown-root junction is slightly arcuate. The root is partly broken and only a few ridges are seen. The proximal ends of these ridges are subrectangular, but their distal ends are pointed.

VPL/K 824 to 826 are fragments of caudal spines. The spines gradually widen towards the distal end; their lateral edges are ornamented with small denticles. The surfaces of the spines, in some cases, are marked with deep grooves, in others with longitudinal striations.

Remarks: Although the Subathu myliobatids are represented by at least two species, they are more poorly preserved than the associated elasmobranchs, holosteans and teleosteans. One of the teeth (VPL/K 849) is very small and nearly flat differing in these respects from all other known species of *Myliobatis*, thereby indicating a possible new species. VPL/L 2049 is comparable in size to *M. tewarii* Mishra, 1980 from the Eocene of Kutch, but its specific identification cannot be attempted until more complete material is forthcoming. Fragmentary caudal spines of myliobatids are also known from the Bilaspur area (Singh, 1985).

Class Osteichthyes
Subclass Actinopterygii
Infraclass Holostei
Order Pycnodontiformes
Family Pycnodontidae AGASSIZ, 1832
Genus *Pycnodus* AGASSIZ, 1833

Pycnodus bicresta n. sp.
(Plate III — 6-9)

Holotype: VPL/K 593, an isolated tooth of the principal series of the splenial.
Paratypes: VPL/K 517 and 518, fragmentary vomers with teeth of lateral rows; VPL/K 592, 594 and 599, isolated splenial teeth; VPL/K 596 to 598, 652 and 709, all isolated teeth.
Etymology: 'bicresta' refers to the two ridges present on the occlusal surface of the tooth of the principal series of splenial.

Table 3 — Comparative measurements in millimeters of dentitions of batids (rays and skates) from the Subathu Formation.

	Myliobatis sp.		*Rhinobatos* sp.	Dasyatis vicaryi			Dasyatis rafinesquie sp. nov.								*Subathunura casieri* gen. et sp. nov.							
							Male				Female				Male				Female			
Dimensions	VPL/L 2049	VPL/K 849	VPL/K 401	VPL/L 1950	VPL/L 1951	VPL/L 1952	VPL/L 1220	VPL/L 1222	VPL/L 1223	VPL/L 1224	VPL/L 1214	VPL/L 1215	VPL/L 1216	VPL/L 1217	VPL/L 2301	VPL/L 2302	VPL/L 2303	VPL/L 2304	VPL/L 2361	VPL/L 2362	VPL/L 2363	VPL/L 2365
Crown length	5.0	0.4	0.91	1.0	1.1	0.9	1.1	1.2	.13.	0.68	0.63	0.62	0.63	0.62	—	—	—	—	—	—	—	—
Crown width	32	1.3	1.1	1.6	1.8	.1.5	1.2	1.5	1.0	1.1	1.5	1.5	1.4	1.5	0.64	0.62	0.59	0.63	0.71	0.69	0.73	0.65
Crown height	1.2	0.3	1.1	0.89	0.90	0.87	0.41	0.4	0.42	0.43	0.89	0.93	0.94	0.91	0.5	0.37	0.38	0.4	0.1	0.12	0.1	0.17
Root depth	1.9	—	0.5	0.78	0.78	0.8	0.35	0.38	0.34	0.49	0.46	0.42	0.47	0.56	0.46	0.38	0.36	0.49	0.2	0.17	0.23	0.25
Root width	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.1	0.94	0.83	0.93	0.79	0.75	0.81	0.77

Horizon and Locality: GASH, EBGL.

Specific Diagnosis: Splenial teeth of the principal series very small, three times wider than long; crown with inwardly concave transverse ridges meeting each other at the lateral ends of the teeth; occlusal surface marked with minute wrinkles or protuberances. Vomerine teeth smaller than the splenial teeth and rounded to elliptical in shape; a wrinkled ridge encircles the surface of vomerine teeth. *P. bicresta* sp. nov. differs from all other known species of *Pycnodus* except *P. gibbus* and *Palaeobalistum,* in its more than 50 percent smaller teeth and in splenial teeth with distinct crests. *P. gibbus,* the smallest known species of *Pycnodus* has oval teeth in the median rows of splenial, while *Palaeobalistum* another small pycnodontid has subcircular median teeth.

Description:

Splenial Dentition: The splenial dentition of the new species is represented by isolated teeth only. The teeth of the principal series (median row) are transversely elongated and at least three times as wide as long. In comparison to those of the other species, the teeth of the present species are more than 50 percent smaller and their maximum diameter ranges between 0.5 and 3mm. They are characterized by possessing two ridges, one each on the lingual and outer sides of the occlusal surface. The ridges are crenulated and concave towards each other meeting at the lateral ends of the crown. In between the two ridges, there is a slight narrow depression marked with minute wrinkles or protuberances. The height of the teeth is generally smaller than their length (antero-posterior diameter) and their lateral ends are acute with one end (probably the outer end) extended in the form of an alar projection. The anterior and posterior borders of the teeth are slightly convex and concave respectively. In some of the teeth, the occlusal surface has been worn to give a flat surface. The basal surfaces of teeth are concave with a transversely elongated pulp cavity. The teeth of the lateral rows of the splenial are generally similar to those of the median row, and differ only in their subrounded shape and smaller size.

Vomerine Dentition: VPL/K 517 and 518 are vomer fragments. VPL/K 518 contains 6 small elliptical teeth arranged in two rows in such a way that the teeth of one row alternate with those of the other row. The teeth are slightly wider than long; their one side is blunt, while the other is acute and pointed. The occlusal surface is slightly concave. It bears minute wrinkles and is encircled by a crenulated ridge. The anterior teeth are more worn than those placed posteriorly.

Pycnodus cf. *P. Pracecursor* KUMAR, 1982
Pycnodus cf. *P. Praecursor* RANA, 1984
Pycondus cf. *P. Praecursor* PRASAD, 1985
Pycnodus toliapicus AGASSIZ, 1833
(Plate III — 10-20)

Material: VPL/K 868, a portion of splenial containing teeth of the median as well as lateral rows; VPL/K 869 to 875, isolated teeth of the splenial; VPL/K 876, 880 to 892, isolated vomerine teeth; VPL/K 877 to 879, isolated teeth (all from Subathu Type Area); VPL/K 590 and 591, isolated vomerine teeth; VPL/K 600, an isolated splenial tooth (all from Kalakot).

Horizons and Localities: OBLH, KBL; GBLH, MBL; OBLH, SWL.

Description: VPL/K 868, a portion of the right splenial has 4 rows of teeth: one median row on the symphyseal side consisting of transversely elongated teeth, and two lateral rows on the outer side containing elongated to subrounded and rounded teeth. On the symphyseal side of the median row there is another row of very small rounded teeth. This row has one small tooth preserved and alveoli for the other two. The occlusal surface of the preserved tooth has a shallow depression marked with wrinkles. The medial teeth are the largest, nearly three times wider than long, and more or less elliptical in shape but with a slightly convex anterior border and a slightly concave posterior border, particularly towards the outer side where the ends of the teeth turn posteriorly. The teeth in the first lateral row are also very wide compared to their length but slightly less so than the medial teeth. They are relatively smaller ranging in shape from elliptical to subrounded with a slightly concave anterior border and a slightly convex posterior border. They have blunt symphyseal and acute outer ends. The second lateral row consists of 6 teeth that tend to become rounded anteriorly. Of these, 4 posterior teeth are transversely elongated with acute symphyseal ends and blunt outer ends; they are larger than the two subrounded to rounded anterior teeth. The occlusal surfaces in all the teeth of the median and first and second lateral rows are smooth. The teeth of the first lateral row are shorter than those of the median row so that there are more lateral teeth per unit length. Due to this some of the first lateral teeth are aligned with median teeth and some alternate with them. The teeth in the second lateral row tend to alternate with those in the first lateral row. The splenial tapers anteriorly due to which the size of the teeth also gradually decreases anteriorly. The anterior teeth are relatively more worn than the posterior teeth. VPL/K 869 to 875 are isolated splenial teeth morphologically similar to those in the splenial described above (VPL/K 868). VPL/K 600 is an isolated median tooth from Kalakot. Its occlusal surface is partly smooth and partly pitted.

VPL/K 876 and 880 to 892 are isolated vomerine teeth. They are smaller than the splenial teeth and are elliptical to rounded in shape with a smooth occlusal surface. Presently, it is not possible to recognize whether these teeth belong to a median row or to lateral row because most of the teeth in the collection are of nearly the same size and shape and also because a single vomer may contain teeth of varying shapes and sizes. However, the teeth of a median row are usually larger and slightly elongate while those of the lateral rows are smaller and nearly rounded.

VPL/K 877 to 879 are isolated teeth characterized by their highly convex occlusal surfaces which bear a distinct pit in the centre. In this respect, these teeth differ from others in the collection and it is not clear whether they belong to a splenial or to a vomer.

VPL/K 590 and 591 are isolated vomerine teeth from Kalakot. They are elliptical to rounded in shape, their occlusal surfaces are nearly flat to convex with ornamentation of radial lines emerging from the centre of the crown and merging below the summit of the occlusal surface. The width-height ratio of these teeth is 5:2.

Pycondus lametae WOODWARD, 1908
(Plate III — 21)

Material: VPL/L 1048, 1049, 1053, 1079 and 1092, all isolated vomerine teeth.
Horizon and Locality: GBLH MBL.

Description: The oval or elliptical teeth, sometimes with circular outlines, are characterized by their occlusal surface that bears a shallow depression with convex margins. This depression is conspicuous in VPL/L 1048, 1059 and 1092, while in 1049, 1053 and 1079, it is faint. It is ornamented with tubercles in VPL/L 1059 and 1092, while in VPL/L 1048 very fine granules are present in the depression. In VPL/L 1049 and 1079, radial ornamentation is seen, but it is better developed in the former. In VPL/L 1053, the depression is covered with prominent rugosity. As in other pycnodonts, the base of these teeth is hollow and no distinct root is discernible.

Remarks: The Subathu pycnodonts are represented by three species, viz., *Pycnodus bicresta* sp. nov., *P. toliapicus* and *P. lametae*. Among these, *P. toliapicus* is the most abundant and also probably the largest followed by *P. lametae* and *P. bicresta*.

The teeth of *P. bicresta* have a close morphological resemblance with those of *P. lametae*, but are half the size. Also, height-width ratio of teeth is 50 percent more than in *P. lametae*.It differs from all other species of *Pycnodus* and also from *Coelodus* Heckel, 1856 in its much smaller size. In respect of size *P. bicresta* is comparable only to *P. gibbus* Agassiz, 1833 and *Palaeobalistum* Blainville, 1818 but differs from them in dental morphology.

P. toliapicus can be differentiated from other related taxa, e.g., *Coelodus* on the basis of its medium size range. Its vomerine teeth differ from those of *C. jacobi* Menon and Prasad, 1958 from the Eocene beds of Garo Hills, Assam (Menon and Prasad, 1958), but are more than 50 percent smaller. Some of the *P. toliapicus* material described here was earlier referred to *P.* cf.*P praecursor* Dartevelle and Casier, 1949, but because of the recent synonymization of *P. praecursor* with *P. toliapicus* by Longbottom (1984), it has now been included in *P. toliapicus*. Similar material described as *P.* cf. *P. praecursor* from the Late Cretaceous-Palaeocene Intertrappean beds of peninsular India (Rana, 1984; Prasad, 1985) is also here transferred into *P. toliapicus*.

All of the presently described species of *Pycnodus*, including *P. bicresta* sp. nov., have also been found in

Table 4 — Comparative measurements in millimeters of teeth of different species of Pyconodus from Subathu Formation.

Taxa	*Pycnodus bicresta* sp. nov.				*P. lametae*			*P. toliapicus*					
Dimensions	VPL/ K 518	VPL/ K 592	VPL/ K 593	VPL/ K 599	VPL/ L 1049	VPL/ L 1053	VPL/ L 1048	VPL/ K 591	VPL/ K 600	VPL/ K 868	VPL/ K 870	VPL/ K 876
Splenial dentition:												
Preserved length of splenial	-	-	-	-	-	-	-	-	-	14	-	-
Preserved width of splenial	-	-	-	-	-	-	-	-	-	16	-	-
Longer diameter of a medial tooth	-	-	-	-	-	-	-	-	-	6.8	-	-
Shorter diameter of a medial tooth	-	-	-	-	-	-	-	-	-	2.3	-	-
Isolated splenial teeth:												
Longer diameter	-	2.8	2.2	2.4	-	-	-	-	13.2	-	9.7	5.8
Shorter diameter	-	1.3	1.0	1.4	-	-	-	-	6.8	-	4.7	4.0
Tooth height	-	-	-	-	-	-	-	-	5.0	-	3.4	2.5
Vomerine dentition:												
Length of vomerine series (3 teeth preserved)	5.2	-	-	-	-	-	-	-	-	-	-	-
Width of vomerine series (2 rows of teeth)	3.0	-	-	-	-	-	-	-	-	-	-	-
Isolated vomerine teeth:												
Longer diameter	-	-	-	-	1.9	1.4	1.6	5.8	-	-	-	-
Shorter diameter	-	-	-	-	-	-	-	4.3	-	-	-	-
Tooth height	-	-	-	-	0.38	0.35	0.36	2.5	-	-	-	-

the Late Cretaceous-Palaeocene Intertrappeans of peninsular India (Rana, 1984; Prasad, 1985; Rana and Prasad, Pers. comm., August, 1986). Although all these species have been found in marine sediments of Subathu Formation associated with sharks, rays and oysters, *P. bicresta* and *P. toliapicus* have also been found at Kalakot in a red facies with mainly terrestrial vertebrates including rodents, artiodactyls, and crocodiles.

Infraclass Teleostei
Order Tetraodontiformes
Suborder Balistoidei
Family Eotrigonodontidae
Genus *Kankatodus* n. gen.

Etymology: 'Kankat' (Sanskrit)-Comb, comb refers to the comblike structure of the oral teeth.
Type Species: Kankatodus cappettai n.sp.
Diagnosis: Oral teeth large and elongated (largest among those of the known Indian eotrigonodontids); their estimated length, width and height vary between 10 and 18 mm, 2 and 3 mm, and 3 and 6 mm respectively and length/height ratio varies between 3 and 4; longitudinally curved teeth about 7 times as long as broad with their apical edges regularly serrated like a comb; serrations deeper on the labial side than on the lingual. Root entire, as deep as the crown is high, but not as elongated. Oral teeth differ from those of *Stephanodus libycus* (Dames) 1883, *Eotrigonodon indicus* (Lydekker) 1886, and *E. wardhaensis* Jain and Sahni, 1983 in being 30 to 50 percent larger with greater length/height ratio. In *E. indicus,* the teeth are either smooth or have very feeble and fewer serrations; in *E. wardhaensis* they have fine vertical radiations; in *S. libycus* the serrations are much coarser and irregular, and in *Indotrigonodon ovatus* Jain and Sahni, 1983, only faint crenulations are present.

Kankatodus cappettai n. sp.
(Plate III — 22-27)

Holotype: VPL/K 894, an isloated oral tooth.
Paratypes: VPL/K 893, 895 to 897, all isloated oral teeth fragments.
Etymology: For Dr. H. Cappetta, Laboratory of Paleontology, University of Science and Technology, Montpellier, France.
*Horizon and Locality:*GBLH, MBL.
Specific Diagnosis: As for the genus.

Description: Oral teeth are much elongated and longitudinally curved; their obverse (labial) and invert (lingual) aspects are convex and concave respectively due to the curvature of teeth. As in other known Eocene eotrigonodontids, one of the lateral sides of the tooth is more acute and prolonged than the other. The crown and the root are well differentiated. However, none of the specimens in the present collection is complete and parts of root or crown are missing in every specimen. The cutting edge of the crown is finely serrated; the serrations are regular and more closely-spaced in the median portion of the edge than on its extremities where they gradually fade out or are some times absent. The depth of serrations is not uniform on the outer and the inner surfaces of the crown and the serrations are relatively much deeper on the outer side than those on the lingual side. On the lingual side, they are so faint and shallow that the cutting edge viewed from this side appears just crenulated. The difference in depth of serrations on the two sides has also been noted in *S. libycus.* All the serrations are approximately parallel to one another. Variations in the height of teeth and the depth of serrations in various specimens could be due to the positional difference of the teeth and to the varying degree of wear that different teeth might have suffered. A fairly thick layer of enameloid covers the crown. On the lingual side of the teeth, the crown-root border is slightly raised and along the border, there runs a narrow groove. The root is entire and narrower than the crown but, nearly as deep as the crown is high.

Genus *Stephanodus* ZITTEL, 1888
Stephanodus libycus (DAMES) 1883
(Plate III — 28-32; Plate IV — 1-3)

Ancistrodon libycus Dames, Zittel (1888, p. 259).
Stephanodus lybicus (Dames), Cappetta, 1972

Material: VPL/K 899 to 903, 838, 842, 945 and 710, isolated pharyngeal teeth; VPL/K 898, an isolated fragmentary oral tooth and numerous unnumbered isloated teeth.
Horizons and Localities: GBLH, MBL; OBLH, SKL, SWL and EBGL.

Description: S. libycus, in the present collection, is represented by several pharyngeal and oral teeth. The pharyngeals are sickle-shaped, laterally compressed cuspidate teeth with well differentiated root and crown. The crown is covered with a definite, nearly translucent enameloid. The main cusp is terminal, claw-shaped and the highest. Secondary cusps are much smaller and may be one or two in number. A close study of a large number of pharyngeal teeth reveals that there is a lot of intraspecific variation. This is evident from the fact that in some teeth the terminal cusp is very low, while in others it is much higher. The degree of its inward curvature also varies considerably. The root is fairly deep; in some cases, its depth exceeds the height of the crown, but it is comparatively narrower. It is made up of an osseous tissue.

VPL/K 898 represents an oral tooth of *S. libycus.* It is comparable to MEN 18 described by Cappetta (1972, plate 13, fig. 3) from the Late Palaeocene of Niger. It also has some general morphological resemblance with teeth of *K. cappettai* gen. et sp. nov. *Stephanodus* molars are relatively smaller and have greater crown height. Their crown is more closely serrated than in *K. cappettai* and the serrations are irregular and not parallel to one another unlike the condition in *K. cappettai*. The apical edge of the crown is highly convex in contrast to a flat or gently convex one in *K. cappettai*.

Genus Eotrigonodon WEILER, 1929

Eotrigonodon indicus new combination (LYDEKKER, 1886)

(Plate IV — 4-25)

Capitodus indicus Lydekker, 1886

Material: VPL/K 914 to 926 and 711, isolated complete and fragmentary oral teeth.

Horizon and Locality: GBLH, MBL.

Description: E. indicus new comb; in the present collection, is represented by numerous pharyngeal and oral teeth. The dentition shows a great degreee of morphological variation and similarity to the related taxa. The classification of pharyngeal and oral teeth into one species is based on the frequency of occurrences and involves some degree of uncertainty. The pharyngeals of the present species differ from those of *S. libycus* in possessing a characteristically broader crown, less curved terminal cusp (sometimes nearly straight) and a secondary cusp which is connected to the main cusp by a weak ridge. The secondary cusp of pharyngeals, in most cases, is not as well differentiated as in *S. libycus*. Other morphological features are more or less similar to those of *S. libycus*.

The oral teeth of *E. indicus* are elongated and slightly curved (not as elongated and curved as those of *K. cappettai*). Their size (longer diameter) varies from 2 mm (smallest in the present collection) to 11 mm (the largest in the present collection). The teeth are in the form of cutting plates with their anterior ends slightly more extended upwards. The length and height (L/H) ratio of the crown varies between 1.5 and 2.5; in *K. cappettai*, the L/H ratio ranges between 3 and 4. The height and width of the teeth are not uniform all along the length and usually auteior portion of a tooth is the widest and highest. The labial side of a tooth is flat to gently convex while its lingual side is deeply concave in the upper portion of the crown and more or less flat at its base. The apex of the crown is in the form of an edge, which is entire and smooth in contrast to serrated apical edges in *K. cappettai* and *S. libycus*. However, a few specimens (e.g., VPL/K 915) do show incipient crenulations on the lingual edge of the crown. The root is not as well developed as in the pharyngeal teeth and is largely missing in most of the specimens.

Remarks: The taxonomy of fossil eotrigonodontid fish is hard to deal with because of the lack of complete fossilized jaws, recent comparative material and literature and also because their dental remains that are found fossilized show a large degree of morphological variations and similarity to the allied taxa. The Subathu eotrigonodontids are represented by at least 3 taxa, viz., *K. cappettai, S. libycus* and *E. indicus*. Of these, the last two taxa are known by pharyngeal as well oral teeth, while the first taxon is known only by its oral teeth. Although it is possible that the pharyngeal teeth of *K. cappettai* are present in our collection, they have not yet been recognized due to the inadequate data. In some cases (e.g., *E. indicus*). the classification of pharyngeal and oral teeth into one species is based on the frequency of occurrence and involves some degree of uncertainty.

The genus *Eotrigonodon* Weiler, 1929 was proposed for the serrated teeth of *Trigonodon* Sismonda, 1849. Later Zittel (1932) assigned the serrated or pectinated teeth to *Eotrigonodon,* while the smooth ones were referred to *Trigonodon*. However, the differentiation of these two genera on the basis of serrations or smoothness of the crown does not seem to be valid, and this feature is a function of positional difference in the jaw. This is also supported by the work of Casier (1946), who described isolated serrated oral teeth of upper jaw and smooth oral teeth of lower jaw and referred them to *E. serratus*. The assignment of some of the present eotrigonodontid material to *Eotrigonodon* is based on consideration of the morphological character of dentition and age of the associated rocks. On the basis of specific similarities in the dentitions of Subathu *Eotrigonodon* and *Capitodus indicus* from the Eocene beds of Kohat (Pakistan), the two taxa have been combined in the present work and a new combination *E. indicus* is proposed. *E. indicus, E. wardhaensis* and two allied taxa, *Indotrigonodon ovatus* and *Pisdurodon spatulatus* Jain and Sahni, 1983 are known from the Late Cretaceous-Palaeocene beds of peninsular India (Jain and Sahni, 1983; Prasad, 1985)

S. libycus, in peninsular India, is known from Lameta Formation (Late Cretaceous) at Pisdura, Maharashtra (Jain and Sahni, 1983), Takli Formation (Late Cretaceous-Palaeocene) at Nagpur (Rana, 1984) and from the equivalent beds at Asifabad, Adilabad District, Andhra Pradesh (Prasad, 1985), and from Himalayan region it is known from Subathu, Dharampur and Kalakot (this paper) and from Bilaspur (Sahni *et al.,* 1984). It is also known from the Maast richtian of Roseifa, Jordan and Rotbah, Iraq (Arambourg *et al.,* 1959), Israel, Libya, Nigeria, Niger, Congo, Tunisia (Cappetta, 1972), Morocco (Arambourg, 1952) and Holmdel, USA (Jain and Sahni, 1983). The pharyngeal teeth of *S. libycus* have close affinity with those of *E. indicus* new comb., but differ in having a narrower crown with more strongly curved main cusp and in lacking a shelf-like structure below the apex of the main cusp. In *S. libycus,* the main cusp continues downward into a secondary cusp, while in *Eotrigonodon* the secondary cusp is usually separate and it is linked to the main cusp by a weak ridge. This is, however, not a regular feature. *Eotrigonodon* and *Stephanodus* range in age from Early Cretaceous to Eocene.

The oral teeth of *K. cappettai* gen. et sp. nov. are identical to that described by Cappetta (1972) as genus *indet.* (IGD 28, Plate 13, fig. 1) from the Maastrichtian of Niger. They are also close to those of *S, libycus,* but differ in their larger size, greater length/height ratio and in crown morphology. In *S. libycus,* the teeth have very deep serrations all along the crown edge, while in the new genus the serrations are comparatively shallower and restricted to the middle 2/3rd of the crown edge. In *K. cappettai,* the upper edge of the tooth is horizontal or slightly convex, but in *S. libycus,* it is highly convex. In the latter taxon, the margins of teeth have irregular serrations and in the former, the serrations are of uniform depth all along the crown edge. *Kankatodus* is the largest eotrigonodontid in the Subathu collection; its oral teeth have highest length/height ratio followed by *S. libycus* and *E. indicus.*

VPL/K 834, there are only three lamellae. The thickness of all the lamellae in one dental plate is not necessarily uniform; usually the middle lamellae are thicker than the basal and the apical ones and the thickness of all the lamellae gradually decreases laterally. The lamellar edges are entire and smooth. In VPL/K 833, one half of the plate is slightly larger than the other; VPL/K 834 represents only one half of a dental plate.

Remarks: In India, *Diodon* was previously known from the Lower Miocene of Kutch (Sahni and Mishra, 1975) and Baripada, Orissa (Mehrotra, 1979). Lydekker (1880, 1886) had described *D. foleyi* from the Eocene of Ramri Island. Dental plates of *Diodon* are also known from an unknown horizon in Nicobar Island (Nair, 1945).

The present *Diodon* specimens are morphologically very closely related to *Diodon* sp. (LUVP 11088) described by Mishra (1975) from the Miocene sediments of Matanomadh, Kutch, but are 30 percent smaller. They differ from *D. foleyi* in smaller size, in possessing fewer number of lamellae, a concave superior surface and

Table 5 - Comparative measurements in millimeters of dentitions of eotrigonodontids from the Subathu Formation.

Dimensions (Pharyngeal teeth)	*Stephanodus libycus* VPL/K 710	VPL/K 842	VPL/K 838	VPL/K 945	*Eotrigonodon indicus* new comb. VPL/K 904	VPL/K 905	VPL/K 906	VPL/K 907	VPL/K 946
Crown height	5.2	5.6	6.0	4.5	6.0	6.1	6.0	6.0	5.3
Crown width	5.3	6.6	5.8	5.3	9.0	8.3	8.2	8.0	7.7
Crown length (thickness)	1.3	1.0		1.3	1.7	2.0	1.5	1.6	2.0
Root depth (preserved)	2.5	3.0	4.0	2.8	4.0		2.5	5.0	5.5

Dimensions (Oral teeth)	*Kankatodus cappettai* gen. et sp. nov. VPL/K 893	VPL/K 894	VPL/K 895	VPL/K 926	*Eotriqondon indicus* new combination VPL/K 925	VPL/K 914	VPL/K 915	VPL/K 922	*Stephanodus* VPL/K 898
Crown length (complete/reconstructed)	16.0	15.5	10.5	15.5	10.0	7.5	9.0	3.8	7.5
Crown length (preserved)	11.5	9.5	6.7	7.0	10.0	7.5	6.0	3.8	4.9
Crown height	5.0	3.0	2.2	3.5	3.5	4.5	3.0	2.3	3.7
Crown width	2.5	1.5	1.2	2.5	1.7	2.1	2.2	1.0	1.8
Depth of serrations (maximum)	2.0	1.3	0.9	2.8	-	-	-	-	2.0
Root depth (preserved)	-	-	-	-	3.2	2.5	-	-	-

Suborder Tetraodontoidei
Family Diodontidae BIBRON, 1855
Genus *Diodon* LINNAEUS, 1758
Diodon sp.
Plate IV, 26-27)

Material: VPL /K 833 and 834, isolated dental plates.
Horizon and Locality: GBLH, MBL.

Description: The present dental plates of *Diodon* range in size between 5 mm and 7 mm along their longer diameter. Along a vertical plane, each dental plate is divided into two subequal parts which are subtriangular to elliptical in shape. Each half of a dental plate consists of 3 to 5 lamellae placed one over the other. The number of these lamellae varies in individuals and also in different species. In VPL/K 833, there are four lamellae, while in

smooth and entire edges in contrast to crenulated edges in *D. foleyi*. *Diodon* has a wide distribution in tropical and subtropical regions particularly in the Indo-Pacific and Atlantic region. It ranges in age from Eocene to Recent.

Table 6 — Measurements in millimeters of dental plates of Diodon sp.

Dimensions	VPL/K 833	VPL/K 834
Longer diameter of a full plate	8.5	
Longer diameter of one half of a plate	4.25	3.5
Shorter diameter of a plate	2.2	1.7
Thickness of lamellae	1.3	1.0

Order Salmoniformes
Suborder Myctophoidei
Family Enchodontidae LYDEKKER, 1889
Gen. & sp. *indet.*
(Plate IV — 28-36)

Material: VPL/L 1604, 1611 to 1616, 1619, 1626, 1635; VPL/K 949 to 955, all isolated teeth.
Horizon and Locality: GBLH, MBL.

Description: At least two types of teeth almost certainly representing distinct species are found at Subathu. However, their identification has not been attempted presently owing to the inadequate data. For convenience in describing these teeth, they are being referred as Type A and Type B. Type A teeth are laterally compressed, narrow at the apex and broaden gently towards the base. Their lateral margins are generally straight and subparallel. Both the internal and external surfaces of the teeth are generally smooth, but sometimes they possess feeble striations towards the base. The base of teeth is usually rounded. The root is rarely preserved.

Type B teeth are usually higher with sharp to blunt apices and are distinctly conical. Their crown is narrow at the apex and brodens very rapidly towards the base. The cross-section of the crown is circular. The crown surface is characteristically smooth. The root is usually well preserved and circular.

Remarks: The present specimens have considerable resemblance with those of *Enchodus* described from the Late Cretaceous-Palaeocene beds of Nagpur (Gayet *et al.*, 1984) and Asifabad, Andhra Pradesh (Prasad, 1985). Enchodontids, *E. elegans* and *E.* cf. *E. bursaxi* are also known from the Subathus of Bilaspur, H.P. (Singh, 1985).

DISCUSSION

Vertebrate palaeontological investigations in the Subathu Type Section and in Kalakot region have revealed the presence of rich horizons of fossil fish. In the Muddy Boots Locality (MBL) at Subathu, the vertebrate horizon is limited to the basal Greyish Black Limestone (GBLH), which has been assigned Ypresian age on the basis of micropalaeontological studies. The other fossiliferous section comprising Olive Green Shale (OGSH) is exposed on the Dharampur-Kasauli Road (DKL) and forms the basal upper part (?Ypresian-Lutetian) of the Subathu Formation. At Kalakot, Oyster-bearing Limestone (OBLH) of Ypresian age (lower portion of Middle Subathu) and Grey Argillaceous Shale (GASH) of Lutetian age (Upper Subathu) are particularly rich in vertebrates.

The vertebrate fauna comprises dental elements of Selachii, Batoidea, Holostei and Teleostei. These groups are represented by seventeen genera and twenty two species. Of these vertebrate elements selachians are the

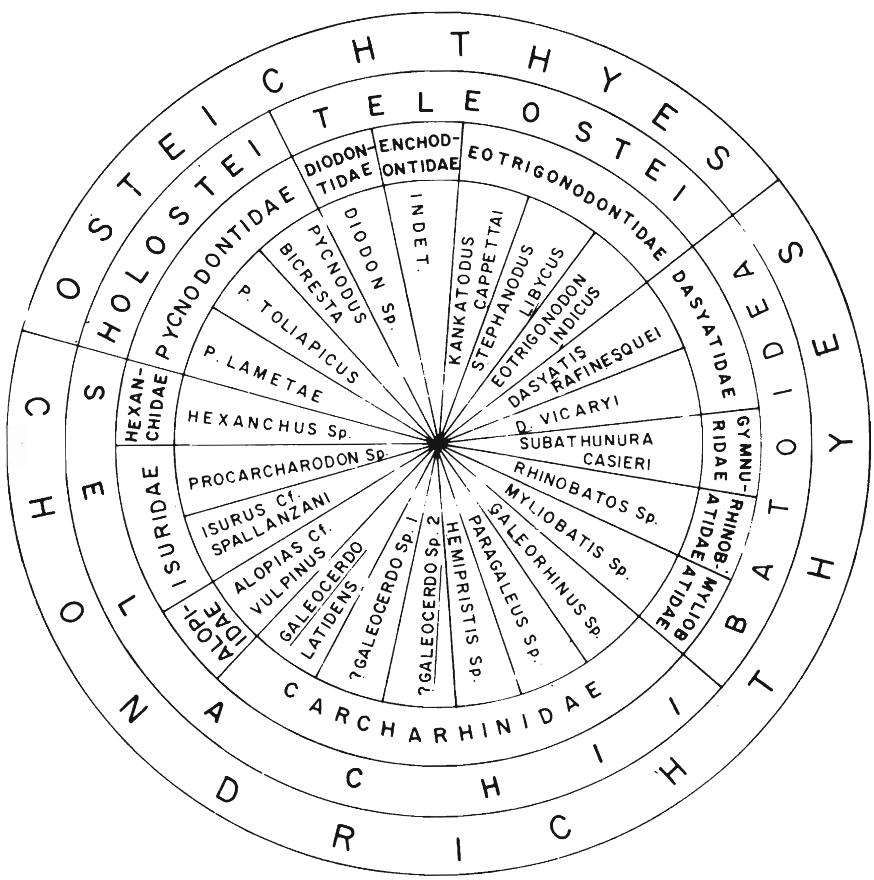

Fig. 5: Relative composition of Ichthyofauna from Subathu Formation (based on number of taxon).

most abundant and diversified as these are represented by eight genera and ten species of sharks: *Hexanchus* sp., *Procarcharodon* sp.,*Isurus* cf. *I. spallanzani, Alopias* cf. *A. vulpinus, Galeocerdo latidens,* ? *Galeocerdo* sp. 1, ?*Galeocerdo* sp. 2, *Hemipristis* sp. *Paragaleus* sp. *Galeorhinus* sp., and rays: *Rhinobatos* sp., *Dasyatis rafinesquei* sp. nov., *D. vicaryi, Subathunura casieri* gen. et sp. nov. and *Myliobatis* sp. The sharks in the present collection are also known from the Eocene and Miocene beds of peninsular India (Sahni and Mishra, 1975; Mishra, 1980; Sahni and Mehrotra, 1981). However, *Galeocerdo latidens* is known only from the Middle Eocene beds of Domanda Formation of Pakistan (Gingerich *et al.,* 1979). *Hexanchus* sp. and *Paragaleus* sp. are reported for the first time from India. Of the rays, *Rhinobatos* sp., *Subathunura* gen. nov, and *D. rafinesquei* sp. nov. are reported for the first time, while *D. vicaryi* is also known from the Middle Eocene beds of Marh Stage of Sri Kolayatji, Rajasthan (Jolly and Loyal, 1985). Myliobatids, which are extremely common in the Cretaceous-Eocene marine Tethyan regions of the world are very poorly preserved in the Subathu Formation.

The holosteans comprise only one genus, viz., *Pycnodus,* which is represented by three species, *P. bicresta* sp. nov., *P. toliapicus* and *P. lametae. P. toliapicus* is also known from the Late Cretaceous Lameta Formation of Dongargaon (Madhya Pradesh) and Eocene beds of Europe. *P. lametae* occurs in the Lametas of Dongagaon, Central India (Woodward, 1908) and Late Cretaceous-Palaeocene beds of Gitti Khadan, Nagpur and Asifabad (Gayet *et al.,* 1984; Prasad, 1985).

The teleosteans represented by *Stephanodus libycus, Eotrigonodon indicus* new comb., *Diodon* sp. and Enchodontidae *indet.* are common in the Late Cretaceous-Palaeocene Intertrappean localities of Central India and also in contemporaneous and Eocene horizons of Africa and Europe. However, *Kankatodus cappettai* is a new form and is known from the Subathu Type Section and from Maastrichtian of Niger.

Palaeoecologically, the Subathu fish fauna represents deposition in a transgressive marine basin which became a depocentre during Palaeocene-Eocene times. A narrow branch of Tethys extended as a shallow embayment from the westerly region of Pakistan towards the Arunachal Pradesh, along the main Himalayan axis. The shallow depth of this basin is evidenced by sedimentary structures such as laminations, ripple marks, current bedding, graded bedding and load casts as well as by the contained vertebrate and invertebrate fauna. This basin was characterized by a low energy environment which was protected from strong waves resulting in the formation of mud flats and marshes. The presence of bars, rills and small island arcs led to the formation of stagnant basins, where the basal carbonaceous shales and coal seams were deposited. Simultaneously, along the submerged ridges, fossiliferous limestones and shales were deposited near the shore, probably within the intertidal to epineritic zones.

The Subathu vertebrate fauna provides a convincing evidence for free bilateral migrations of the marine vertebrates along the marine corridors of the Tethys, which by Early Eocene had narrowed tremendously with the northward movement of the Indian plate. This is corroborated from the geophysical models of Norton and Sclater (1979), Barron *et al.* (1981) and Smith *et al.* (1981), which envisage Indian plate close to and at almost similar palaeolatitude as Africa, Arabia and southwestern Europe during the Early Eocene (Fig. 6). However, the common presence of the marine assemblages in the Early Eocene of Subathu Formation and those from Central Indian Late Cretaceous-Palaeocene Intertrappean localities is indicative of survival of primitive forms in north India. This, in turn, reflects the extensions of the Subathu Sea which had spread southwards towards the Indian shield region (Loyal, 1984b). This is further corroborated by the fact that similar marine assemblages have been recovered from the Middle Eocene of Sri Kolayatji, Rajasthan, a region which lies geographically at an intermediate place between the northern and southern extremities of the Indian plate (Jolly and Loyal, 1985).

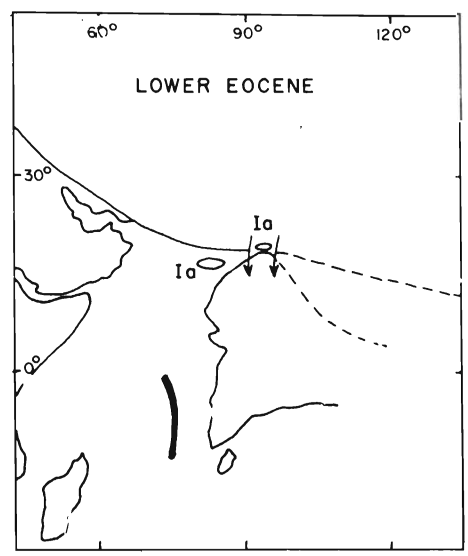

Fig. 6: Initial contact of the Indian plate with the Sino-Siberian plate occured during the Early Eocene. Southward migration of Laurasiatic forms is shown by arrows. la, Island arc. (Modified after Powell, 1979).

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EXPLANATION OF PLATES

PLATE I

Figs. 1-3 *Hexanchus* sp.,
1, VPL/K 813, upper tooth in lingual view X 5; 2, VPL/K 808, lower tooth in lingual view X 4; 3, VPL/K 844, lower tooth in labial view X9.

Figs. 4-6 *Procarcharodon* sp.,
4, VPL/K 810, isolated tooth in labial view X 3.2; 5, VPL/K 809, isolated tooth in labial view X 3.2; 6, VPL/K 805, isolated tooth in labial view X 6.

Figs. 7 *Isurus* cf. *I. spallanzani,*
VPL/K 845, isolated tooth in lingual view X 10.

Figs. 8. *Alopias* cf. *A. vulpinus,*
VPL/K 815, isolated tooth in labial view X 7.

Figs. 9. *Galeocerdo latidens,* VPL/L 2040, isolated tooth in labial view X 4.

Figs. 10-16 *?Galeocerdo* sp. 1,
10-11, VPL/K 817, isolated tooth in labial and lingual views X 7; 12-13, VPL/K 848, isolated tooth in labial and lingual views X 7.5; 14-15, VPL/K 816, isolated tooth in labial and lingual views X 6; 16, VPL/K 843, isolated tooth in lingual view X 6.5.

Figs. 17-18 *Galeocerdo* sp. 2,
VPL/K 807, isolated tooth in lingual and labial views X 8.

Figs. 19-20 *Hemipristis* sp.,
VPL/K 806, isolated fragmentary tooth in labial and lingual views X 3.5.

Figs. 21-22 *Paraqaleus* sp.,
21, VPL/K 846, isolated tooth in labial view X 4; 22, VPL/K 804, isolated tooth in labial view X 4.

Figs. 23-24 *Galeorhinus,* sp.,
VPL/K 801 and 802, isloated teeth, labial views X 3.3.

Figs. 25-28 Selachii *indet.* placoid scales;
25, VPL/L 1418, platform type scale in front view X 35; 26, VPL/K 942, cuspidate type scale in front view X 45; 27, VPL/K 943, platform type scale in front view X 45; 28, VPL/K 944, cuspidate type scale in front view X 45.

PLATE II

Figs. 1-3 *Rhinobatos* sp.
VPL/K 401, labial, lateral and occlusal (also showing labial

portion) views X 30.

Figs. 4-16 *Dasyatis rafinesquei* sp. nov.,
4-8, teeth of male individuals; 4, VPL/L 1220 (holotype), labial view X 28; 5, VPL/L 1224 (paratype), lingual view X 24; 6, VPL/L 1222 (paratype), lingual view X 26; 7, VPL/L 1223(paratype), basal view X 25; 8, VPL/L 1221 (paratype), basal view X 25; 9-16, teeth of female individuals; 9, VPL/L 1214 (holotype), labial view X 19; 10, VPL/L 1205 (paratype), labial view X 25; 11, VPL/L 1215 (paratype), labial view X 32; 12, VPL/L 1211 (paratype), labial view X 23; 13, VPL/L 1213 (paratype), labial view X 25; 14, VPL/L 1216 (paratype), basal view X 22.5; 15, VPL/L 1217 (paratype), basal view X 19; 16, VPL/L 1218 (paratype), lingual view X 25.

Figs. 17-22 *Dasyatis vicaryi*, teeth of female individuals;
17, VPL/L 1977, labial view X 19; 18, VPL/L 1974, labial view X 18; 19, VPL/L 1956, occlusal view X 18; 20, VPL/L 2001 basal view X 20; 21, VPL/L 2010, basal view X 19; 22, VPL/L 2002, lingual view X 17.

Figs. 23-38 *Subathunura casieri* gen et sp. nov.,
23-29, teeth of male individuals; 23, VPL/L 2301 (holotype), labial view X29; 24, VPL/L 2302 (paratype), labial view X 35; 25, VPL/L 2303 (paratype), labial view X 36; 26, VPL/L 2315 (paratype), labial view X 38; 27, VPL/L 2306 (paratype), labial view X 30; 28, VPL/L 2321 (paratype), lingual view X 30; 29, VPL/L 2320 (paratype), lingual view X 32; 30-38, teeth of female individuals, 30, VPL/L 2361 (holotype), occlusal view X 40; 31, VPL/L 2362 (paratype), occlusal view X 40; 32, VPL/L 2367 (paratype), occlusal view X 40; 33, VPL/L 2364 (paratype), occlusal view X 40; 34, VPL/L 2372 (paratype), lingual view X 40; 35, VPL/L 2371 (paratype), labial view X 42; 36, VPL/L 2374 (paratype), lingulal view X 40; 37, VPL/L 2370 (paratype), basal view X 40; 38, VPL/L 2373 (paratype), basal view X 40.

PLATE III

Figs. 1-5: *Myliobatis* sp.; 1, VPL/L 2049, isolated tooth in coronal view X1.4; 2-3, VPL/K 849, isolated tooth, coronal and basal views X28; 4, VPL/K 824, fragmentary caudal spine X4.4; 5, VPL/K 825, fragmentary caudal spine X2.

Figs. 6-9: *Pycnodus bicresta* sp. nov, 6, VPL/K 593, an isolated medial tooth (holotype) of the splenial X35; 7, VPL/K 517, fragmentary vomer (paratype) X8; 8, VPL/K 518, fragmentary vomer (Paratype) X11; 9, VPL/K 709, an isolated vomerine tooth (Paratype) X 30 (all are occlusal views).

Figs. 10-20: *Pycnodus toliapicus*, 10, VPL/K 868, fragmentary splenial palate X4.4; 11, VPL/K 870, isolated splenial tooth X4. 8; 12, VPL/K 869, isolated splenial tooth X7; 13, VPL/K 871, isolated tooth X8; 14, VPL/K 876, isolated splenisl tooth X5; 15, VPL/K 877, isolated vomerine tooth X5; 16, VPL/K 600, isolated splenical tooth x3.6; 17, VPL/K 879, isolated vomerine tooth X8.5; 18, VPL/K 601, isolated splenial tooth X3.6; 19, VPL/K 590, isolated vomerine tooth X5.4; 20, VPL/K 591, isolated vomerine tooth X5.4. (all occlusal views).

Fig. 21: *Pycnodus lametae*, VPL/L 1049, isolated vomerine tooth, occlusal view X12.

Figs. 22-27: *Kankatodus cappettai* gen. et sp. nov., 22-23, VPL/K 893, fragmentary oral tooth (paratype), lingual and labial views X3.5; 24-25, VPL/K 894, fragmentary oral tooth (holotype), labial and lingual views X5.3; 26, VPL/K 895, fragmentary oral tooth (paratype), labial view X7.5; 27, VPL/K 926, fragmentary oral tooth, lingual view X6.1.

Figs. 28-32: *Stephanodus libycus*, pharyngeal teeth; 28, VPL/K 838,X5.5; 29-30, VPL/K 842,X5; 31-32, VPL/K 945,X5.5

PLATE IV

Figs. 1-3: *Stephanodus libycus*, 1-2, VPl/K 710, pharyngeal tooth X5.5; 3, VPL/K 998, fragmentary oral tooth, labial view X6.9.

Figs. 4-25: *Eotriqonodon indicus* new combination, 4-15, pharyngeal teeth; 4-5, VPL/K 946, X4.3; 6-7, VPL/K 906, X3.7; 8-9, VPL/K 904, X3.4; 10-11, VPL/K 905, X3.3; 12-13, VPL/K 827, X5.3; 14-15, VPL/K 907, X3.6; 16-25, oral teeth, 16-17, VPL/K 925, labial and lingual views X5.4; 18-19, VPL/K 915, labial and lingual views X6; 20-21, VPL/K 923, labial and lingual views X19; 22-23, VPL/K 914, lingual and labial views X5.5; 24-25, VPL/K 922, lingual and labial views X9.

Figs. 26-27: *Diodon* sp., VPL/K 833, dental plate in posterior and occlusal views X6.

Figs. 28-36: Enchodontidae gen. et sp. *indet.*, all isolated teeth in side views (approximately X35). 28, VPL/L 1611; 29, VPL/L 1610; 30, VPL/L 1614; 31, VPL/L 1615; 32, VPL/L 1616; 33, VPL/L 1609; 34, VPL/L 1605; 35, VPL/L 1606; 36, VPL/L 1607.

JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL. 32, 1987.

Plate I

KUMAR AND LOYAL

Plate II


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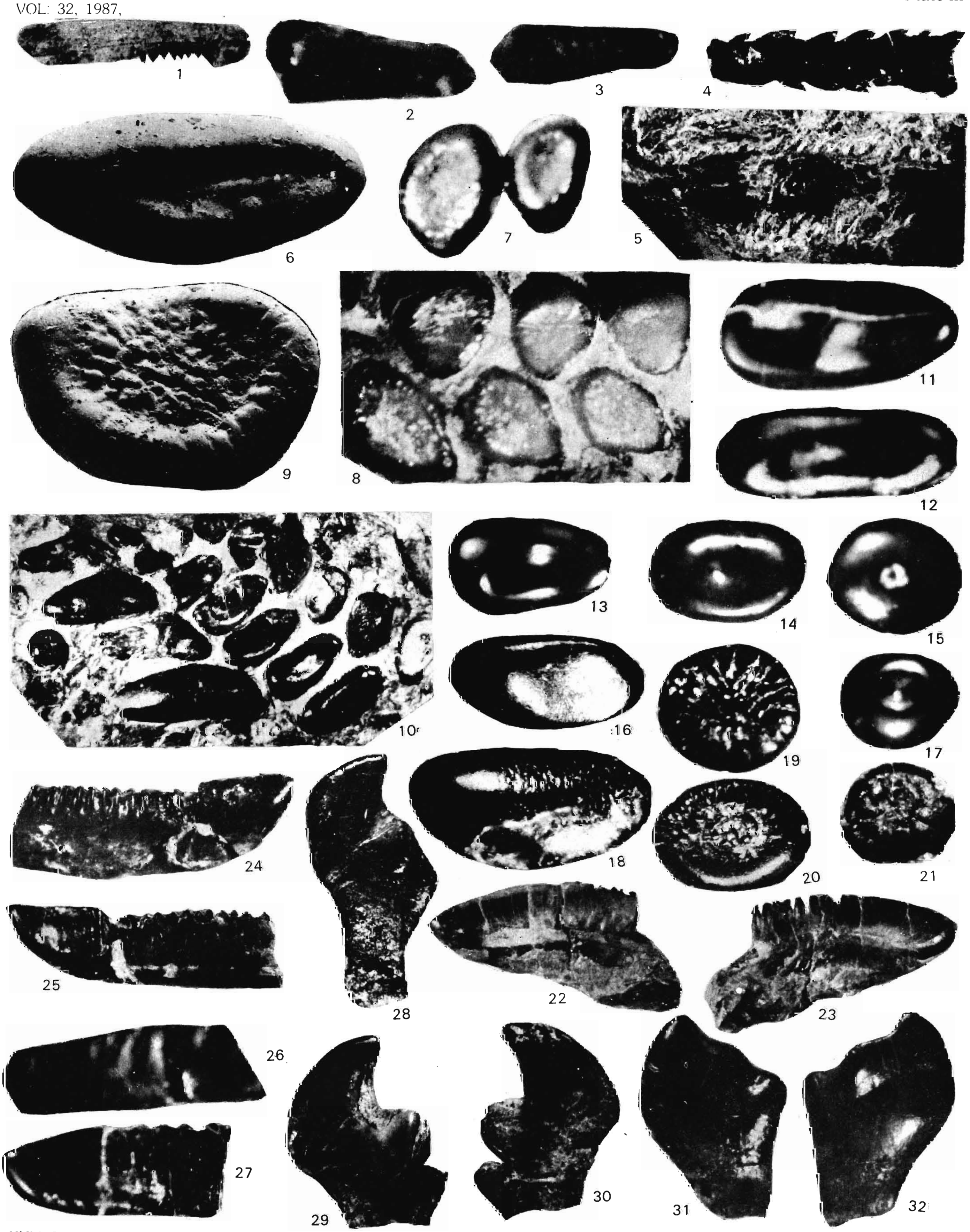
JOURNAL OF THE PALAEONTOLOGICAL SOCIETY OF INDIA
VOL: 32, 1987,

Plate III



KUMAR AND LOYAL

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VOL. 32 1987.

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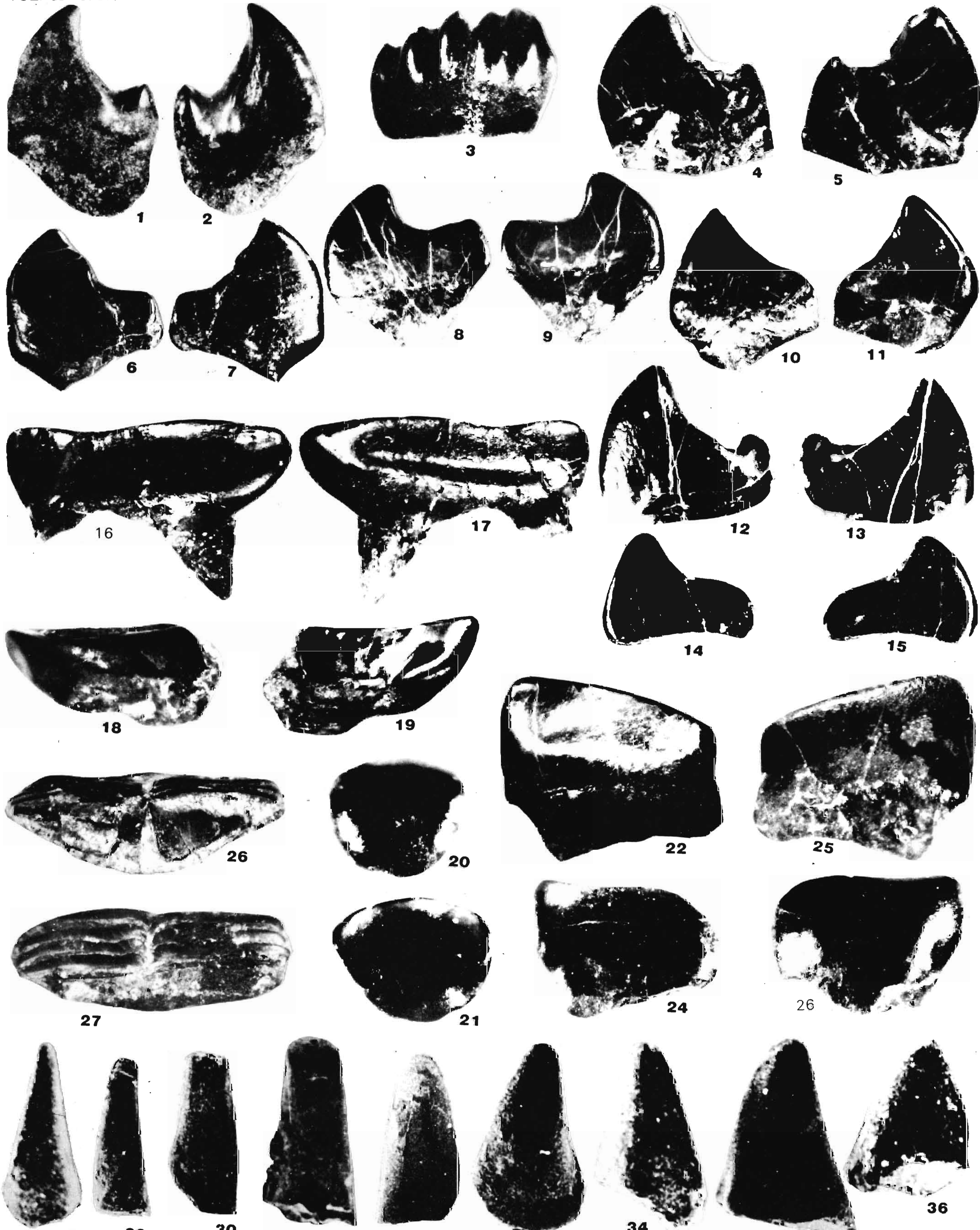

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