CHAPTER -4

SYSTEMATIC DESCRIPTION

OF

VERTEBRATES
4. SYSTEMATIC DESCRIPTION OF VERTEBRATES

4.1 SYSTEMATIC DESCRIPTION OF FISHES

Fish remains in the form of isolated teeth, dental plates, spines and vertebrae are the only representative of the vertebrate fossil group in the study area. These have been found in the intraformational conglomeratic bands of Upper Bhuban unit, Bhuban Formation of Localities 1 and 2 only. These two localities are very rich in the fish remains. Preservation is rather good as compared with the other associated fossils. However, the hard and compact nature of the fish yielding bands makes the recovery of the complete specimens difficult, especially of the root parts. Teeth of selachians (shark) are by far, the most abundant group of fishes in the study area and this group accounts for more than 80 per cent of the total fish fauna. Batoids (Ray-skates) and Teleosts represent the other groups of fishes.

It is pertinent to mention that the abundance of shark as fossil is due to their denseness and mineral composition and to their rapid, continual replacement in the shark’s jaws. Further, the morphology of teeth exhibit several types of variation with their position in the jaws and also due to ontogenetic heterodonty and sexual heterodonty (Purdy, 1990 and 1996; Applegate, 1965). This makes the identification rather difficult. However enough care has been taken in order to avoid misleading identity arising due to differing teeth morphology in the same species.

The classification of Chondrichthyes followed in this thesis is after Cappetta (1987).

- **Class**: CHONDRICHTHYES Huxley, 1880
- **Subclass**: ELASMOBRANCHII Bonaparte, 1838
- **Cohort**: EUSELACHII Hay, 1902
- **Subcohort**: NEOSELACHII Compagno, 1977
- **Order**: LAMNIFORMES Berg, 1958
- **Family**: LAMNIDAE Muller and Henle, 1838
- **Genus**: *Lamna* Cuvier 1817
**Lamna sp.**

(Pl – 10, figs. 1 – 2)

**Material:** Two isolated teeth with broken roots.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 32</td>
<td>9.50</td>
<td>-</td>
<td>6.50</td>
</tr>
<tr>
<td>V/F/B - 33</td>
<td>8.20</td>
<td>-</td>
<td>6.00</td>
</tr>
</tbody>
</table>

**Description:** Teeth medium in size; crown erect, high, narrow with pointed apex, broader at the base, sharp cutting edges without serrations, internal surface highly convex whereas external one is nearly flat or little convex; a small denticle is found on one side of the lateral cusp in specimen no. V/F/B - 33 while denticle on the other side is not preserved. Roots poorly preserved but appear to contain a median groove on the highly convex internal surface.

**Remarks:** The present specimens are comparable with those of the species *Lamna* sp. figured by Mishra (1980) from the Ossiferous limestones of Babia stage, Middle Eocene at Nareda, Kachchh. Due to the incomplete nature of the present specimens, the characteristic information needed for identification up to the species level is lacking. This may be the first record of *Lamna* sp. from the Tertiary rocks of the Northeastern region of India.

**Genus Carcharodon** Muller and Henle, 1838

*Carcharodon carcharias* Linnaeus, 1758

(Pl – 10, figs. 3 – 14)

The partial synonymy of the species is:


Material: Twelve isolated teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
<th>Height / Breath Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 16</td>
<td>10.00</td>
<td>9.00</td>
<td>8.00</td>
<td>1.1</td>
</tr>
<tr>
<td>V/F/B - 17</td>
<td>8.00</td>
<td>8.00</td>
<td>6.00</td>
<td>1</td>
</tr>
<tr>
<td>V/F/B - 18</td>
<td>10.00</td>
<td>-</td>
<td>8.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 19</td>
<td>11.00</td>
<td>-</td>
<td>8.50</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 20</td>
<td>11.00</td>
<td>-</td>
<td>9.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 21</td>
<td>10.00</td>
<td>-</td>
<td>7.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 43</td>
<td>10.00</td>
<td>9.00</td>
<td>7.00</td>
<td>1.1</td>
</tr>
<tr>
<td>V/F/B - 44</td>
<td>10.00</td>
<td>9.00</td>
<td>7.00</td>
<td>1.1</td>
</tr>
<tr>
<td>V/F/B - 45</td>
<td>12.00</td>
<td>-</td>
<td>10.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 46</td>
<td>11.00</td>
<td>11.00</td>
<td>8.00</td>
<td>1</td>
</tr>
<tr>
<td>V/F/B - 47</td>
<td>10.00</td>
<td>-</td>
<td>8.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 79</td>
<td>15.00</td>
<td>-</td>
<td>9.00</td>
<td>-</td>
</tr>
</tbody>
</table>

Description: Teeth medium in size, nearly as high as broad; crowns compressed, triangular in outline with pointed apex, thick in the middle and becoming thinner towards the edges, erect or slightly inclined towards posterior or distal side, sharp cutting edges with fine regular serrations that are bigger at the base of the cusp, both mesial and distal margins almost straight; external surface flat, internal one slightly convex. No lateral denticles present at the cusps. Roots broader than high, basal margin of the roots feebly to moderately concave. Root canal or median furrow at the internal surface of the root is clearly visible in specimen no. V/F/B - 16.

Remarks: The present specimens are identified as *Carcharodon carcharias* by their medium sized crown, triangular shape, serrated cutting edges and moderately bilobate roots. These bear close resemblance with the specimens of the same species described from the Miocene of Kachchh (Mehrotra et al. 1973) and Baripada (Sahni and Mehrotra,
1981) and Pliocene of Piram Island (Prasad, 1974). This species has already been recorded from the Bhuban Formation of Mizoram (Tiwari et al., 1998).

*Carcharodon angustidens* Agassiz, 1843

(Pl – 10, figs. 15 – 16)

1910. *Carcharodon angustidens* Agassiz, 1843: Stuart, p 300, Pl - 26, figs. 3 a - c.

1973. *Carcharodon angustidens* Agassiz, 1843: Mehrotra et al. p 190, Pl - 2, fig. 3.

1981. *Carcharodon angustidens* Agassiz, 1843: Sahni and Mehrotra, p 121, Pl - 1, fig. 11.

**Material:** Two isolated fragmentary teeth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

**Measurements:** Fragmentary nature of the teeth does not allow measurement of dimensions.

**Description:** Teeth large in size; crowns erect, thick, broad and having the shape of an isosceles triangle; sharp cutting edges having uniformly coarse serrations; both mesial and distal edges are straight; generally with two denticles on either side of the cusp, but only one denticle is preserved in specimen no. V/F/R - 08. This denticle is in turn finely and uniformly serrated. A series of prominent longitudinal striations extend from base to apex at the enamel surfaces of the cusps. Crown thickens or bulges at the center and gradually tapers towards edges. Internal surface strongly convex while the external one flattened or slightly convex. Collar prominent between root and cusp at the internal surface in specimen no. V/F/B - 07. Roots not well preserved but seem to be broad, low and weakly bilobate.

**Remarks:** The two specimens at hand show close resemblance with the *Carcharodon angustidens* described and figured by Stuart (1910) from the Miocene sediments of Pagan Hills, Burma. These can also be compared well with the species collected and figured by Mehrotra et al. (1973) from the Lower Miocene shales of Lakhpat (Kachchh). They are also more or less similar with the same species reported from the Miocene sediments of
Kachchh (Sahni and Mehrotra, 1981). This form is being recorded for the first time from the Northeastern India.

_Carcharodon sp._

(Pl – 11, figs. 1 a – b)

**Material:** One isolated incomplete tooth (Specimen no. V/F/R - 27).

**Location:** Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

**Horizon:** Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm): Height of tooth and crown measures 22.00mm and 18.00mm respectively, breadth of tooth could not be measured due to its incompleteness.

**Description:** Tooth large in size; crown thick, somewhat broad, acutely triangular in shape and directed posteriorly or distally with pointed apex; sharp cutting edges bearing serrations that are coarser towards the base and finer towards the apex; mesial edge slightly convex and distal edge straight or slightly concave; internal surface strongly convex and external surface flat; a collar preserved at the internal surface near the junction of crown and root; root low, appear to be broad and with a shallow bifurcation.

**Remarks:** The lone specimen at hand has a close resemblance with the species _Carcharodon carcharias_ from the Upper Miocene of Senhata Formation, Boso Peninsula, Central Japan (Yabe and Hirayama, 1994, p 41, figs 8 a-c). This specimen also compares well with those illustrated as _Carcharodon_ sp. by Donovan and Gunter (2001) from the unknown locality and horizon of Jamaica. The material described is too meager and incomplete to allow any detailed comparison and identification up to the species level. However, on the basis of the morphological characters and geometry of the crown, it undoubtedly belongs to the genus _Carcharodon_.

**Genus**  
_Isurus_ Rafinesque, 1810

_Isurus spallanzanii_ Bonaparte, 1839

(Pl – 11, figs. 2 – 4, 6 – 13)

1901. _Oxyrhina spallanzanii_ Bonaparte: Noetling, p 372, Pl - 25, figs. 4 - 6.

1910. _Oxyrhina spallanzanii_ Bonaparte: Stuart, Pl-25, fig. 9 and Pl - 26, figs. 1 - 2.
1973. *Isurus (oxyrhina) spallanzanii* Bonaparte: Mehrotra *et al.* p 182, Pl - 1, fig. 10a and b.
1987. *Isurus (oxyrhina) spallanzanii* Bonaparte: Kumar and Loyal, p 121, Pl - 1, fig. 7.

**Material:** Thirteen isolated teeth- one complete and 12 broken ones.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

**Measurements (mm):**

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 43</td>
<td>8.00</td>
<td>6.00</td>
<td>6.00</td>
</tr>
<tr>
<td>V/F/B - 44</td>
<td>-</td>
<td>-</td>
<td>9.00</td>
</tr>
<tr>
<td>V/F/B - 48</td>
<td>-</td>
<td>-</td>
<td>10.00</td>
</tr>
<tr>
<td>V/F/B - 49</td>
<td>-</td>
<td>-</td>
<td>8.00</td>
</tr>
<tr>
<td>V/F/R - 50</td>
<td>-</td>
<td>-</td>
<td>8.50</td>
</tr>
<tr>
<td>V/F/R - 28</td>
<td>-</td>
<td>14.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 51</td>
<td>-</td>
<td>-</td>
<td>9.00</td>
</tr>
<tr>
<td>V/F/B - 52</td>
<td>-</td>
<td>-</td>
<td>9.00</td>
</tr>
<tr>
<td>V/F/B - 53</td>
<td>-</td>
<td>-</td>
<td>8.00</td>
</tr>
<tr>
<td>V/F/B - 54</td>
<td>-</td>
<td>-</td>
<td>7.00</td>
</tr>
<tr>
<td>V/F/B - 55</td>
<td>-</td>
<td>8.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 56</td>
<td>-</td>
<td>7.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 57</td>
<td>-</td>
<td>6.00</td>
<td>-</td>
</tr>
</tbody>
</table>

**Description:** Teeth small to medium in size; crowns erect, narrow, slender and lanceolate with pointed apex; median teeth (Sp. nos. V/F/B - 29 and 43) easily distinguished by narrow, deeply bifurcated roots, and cutting edges of crowns being sharp only for the upper two-thirds and rounded at the base; sub-rounded or almost circular shape in cross-section; cutting edges without serrations; crown slightly curved inward at the base and outwards at the apical part; internal surface convex, external one nearly flat; Roots thick
and low, externally flat, internally strongly convex. Lateral teeth (Sp. nos. V/F/R - 8 and V/F/B - 44) are characterized by broad bifurcated roots with sharp cutting edges of crowns from base to the apex; crown in general has more or less similar morphological characters with that of median teeth, but the cross-section at the base is elliptical; Roots are low but broad, forming deeply bifurcated lateral branches; externally flattened and internally strongly convex.

**Remarks:** These specimens can be identified as *Isurus spallanzanii* based on the above mentioned morphological features of the crown and root. They have close resemblance with *Oxyrhina spallanzanii* of Noetling (1901) and Stuart (1910) from the different localities of Miocene beds of Myanmar. These can also be compared with the same species reported by Mehrotra *et al.* (1973) and Sahni and Mehrotra (1981) from the coastal Miocene sediments of Peninsular India. This species has also been recorded and described by Tiwari *et al.* (1998) from the same formation but from a different locality.

**Isurus pagoda** Noetling, 1901

(Pl – 11, figs. 5a – b)

1901. *Oxyrhina pagoda* Noetling: Noetling, p 372, Pl - 25, figs. 1 a-e, 2 a-e and 3 a-b.
1981. *Isurus pagoda* Noetling: Sahni and Mehrotra, p 120, Pl - 1, fig. 1.

**Material:** One isolated tooth with partially broken root.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of crown</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 49</td>
<td>-</td>
<td>3.50</td>
<td>8.00</td>
</tr>
</tbody>
</table>

**Description:** Tooth small in size; crown erect, narrow, slender and lanceolate with a broad arrow-head like apex; crown much higher than root; Margins un-serrated, sharp in the apical part and rounded in basal part, internal surface strongly convex and external one somewhat flat. Root seems to be low and thick, bifurcated with short lateral branches.
Remarks: The lone specimen at hand, though smaller in size, closely resembles with the species *Oxyrina pagoda* (Noetling, 1910, pl - 25, figs. 1- 3) in its broad arrow-head shape of the upper part of the cusp. It can also be compared with the same species reported by Mehrotra *et al.* (1973) and Sahni and Mehrotra (1981) from the coastal Miocene sediments of Peninsular India. This species is being recorded for the first time from the Northeastern region of India.

**Family**
**ALOPIIDAE**

**Genus**
**Alopias** Rafinesque, 1810

*Alopias sp.*

(Pl – 13, figs. 12 – 13)

**Material:** Two isolated crowns.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 86</td>
<td>-</td>
<td>-</td>
<td>6.00</td>
</tr>
<tr>
<td>V/F/B - 87</td>
<td>-</td>
<td>-</td>
<td>7.00</td>
</tr>
</tbody>
</table>

**Description:** Crowns small in size, narrow, elongated with pointed apex, oblique towards inner edge; the cutting edges are sharp and without serrations through out. Both the surfaces of crowns convex, internal one more so. Anterior edges nearly straight whereas posterior ones somewhat concave and with a notch towards the base.

**Remarks:** The specimens resembles *Alopias vulpes* described from the Lower Miocene shales of Matanumadh, Kachchh (Mehrotra *et al.*, 1973). However, the specimens described herein cannot be compared with the Kachchh material due to the absence of the root parts. This is the first record of genus from the Bhuban Formation of Mizoram.

**Family**
**ODONTASPIDIDAE**

**Genus**
**Odontaspis** Agassiz, 1843
**Odontaspis cf. taurus** Rafinesque 1810

(Pl – 11, figs. 14a – c)


**Material:** One isolated tooth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements:** Specimen no. V/F/B - 59 has the following dimension: Height of tooth - 14.00mm; breadth of tooth – 10.00 mm; Height of crown – 10.00 mm.

**Description:** Tooth medium in size; crown narrow, erect, elongated, slender and lanceolate with pointed apex; cutting edges sharp throughout from apex to the base of the crown and are without serrations; crown much higher than the root, curved inward at the base and outward at the apical part; internal surface highly convex and external one flat or little convex. Root broader than high, deeply forked in the middle and only one denticle could be seen on the mesial edge of the cusp.

**Remarks:** The lone specimen described above is comparable with the species *Odontaspis taurus* figured and described by Antunes and Jonet (1970) from the Miocene beds of Algrave Coast, Portugal. However, crown of the latter is erect and the root is strongly bifid. Hence, present specimen is referred to as the comparable form of *Odontaspis cf. taurus* Rafinesque.

**Odontaspis cf. tricuspidatus** Day, 1888

(Pl – 2, figs. 19 a – b)


**Material:** One isolated incomplete tooth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.
Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of crown</th>
<th>Height of crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 61</td>
<td>-</td>
<td>7.00</td>
<td>21.00</td>
</tr>
</tbody>
</table>

Description: Tooth large; crown erect or slightly oblique towards inner edge, lanceolate, higher than broad, inner and outer margins sharp and without serrations. Internal and external surfaces of crown convex. Root seems to be low and broad with prominent medial projection on the internal side.

Remarks: The crown of the available specimen bears close resemblance with the species Odontaspis tricuspidatus reported and figured by Mehrotra et al. (1973) and Sahni and Mehrotra (1981) from the Lower Miocene shales of Matanumad, Kachchh, Gujarat on accounts of its large size and nearly erect and lanceolate outline, unserrated cutting edges and convex internal and external surfaces. But the presence of lateral denticles and deeply forked nature of the root could not be ascertained due to the ill-preserved nature of the present specimen. Hence, it is referred to as Odontaspis cf. tricuspidatus Day.

Odontaspis sp.

(PI – 2, figs. 15 – 18)

Material: Four isolated broken teeth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic horizon, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of crown</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 58</td>
<td>-</td>
<td>-</td>
<td>8.00</td>
</tr>
<tr>
<td>V/F/B - 30</td>
<td>-</td>
<td>-</td>
<td>10.00</td>
</tr>
<tr>
<td>V/F/B - 60</td>
<td>-</td>
<td>-</td>
<td>6.00</td>
</tr>
<tr>
<td>V/F/B - 31</td>
<td>-</td>
<td>-</td>
<td>6.50</td>
</tr>
</tbody>
</table>

Description: Teeth small in size; crowns narrow, erect, elongated, slender and lanceolate with pointed apex, edges of the crown sharp throughout and without serrations; crowns curved inward at the base and outward at the apical part; lateral denticles not preserved;
internal surface highly convex and external one flat or a little convex. Roots not preserved.

**Remarks:** The morphological features and outline of the crowns is typical of the Odontaspids. But the incomplete materials especially the root parts do not allow precise determination of the specimens.

**Family**  
**CARCHARHINIDAE** Jordan and Evermann 1896

**Genus**  
**Carcharhinus** Blainville, 1816

**Carcharhinus egertoni** Agassiz, 1843

(Pl – 12, figs. 1 – 4)

1910. *Carcharías (Prionodon) egertoni* Agassiz: Stuart, p 300, Pl - 26, figs. 8 and 8a.  

**Material:** Four isolated teeth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 64</td>
<td>24.00</td>
<td>22.00</td>
<td>20.00</td>
<td>1.09</td>
</tr>
<tr>
<td>V/F/R - 4</td>
<td>-</td>
<td>-</td>
<td>18.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 24</td>
<td>13.00</td>
<td>16.00</td>
<td>11.00</td>
<td>0.80</td>
</tr>
<tr>
<td>V/F/B - 35</td>
<td>-</td>
<td>-</td>
<td>10.00</td>
<td>-</td>
</tr>
</tbody>
</table>

**Descriptions:** Teeth medium to large in size; crowns with pointed apex, obliquely triangular in outline, broad, slightly oblique towards distal side, cutting edges sharp with
fine serrations at the apex becoming slightly coarser towards the base, mesial or outer margins moderately convex and distal margins straight or slightly concave; internal surfaces or lingual faces moderately convex and external surfaces or labial faces nearly flat or little convex, collar present between root and cusp in specimen no. V/F/B - 64. Roots broader than high with moderately bilobed nature.

**Remarks:** Specimen numbers V/F/R - 4 and V/F/B - 64 have close resemblance with the upper tooth of *Carcharhinus egertoni* described and figured by Karasawa (1989) from the Miocene sequences of Hokuriku district, Central Japan excepting that the former are slightly larger in size. These are also more or less similar with the same species described and illustrated by Antunes and Jonet (1970) from the Miocene Formations of Algarve coast, Portugal. These also tally well with the species under consideration described and figured by Stuart (1910) from the Pegu beds exposed in the Singu Oilfield (Miocene), Pakokku district, Myanmar. Specimen no. V/F/B - 24 can be well compared with the lower tooth of the same species described and illustrated by Karasawa (1989) from the Miocene beds of Hokuriku district, central Japan. It also has a close affinity to the *Carcharhinus egertoni* described by Antunes *et al.* (1981) from the Miocene beds of Algarve coast, Portugal. Hence, these specimens are unhesitatingly assigned to *Carcharhinus egertoni*.

*Carcharhinus priscus* Agassiz 1843

(Pl – 12, figs. 5 – 8)


**Material:** Four isolated teeth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.
Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 65</td>
<td>-</td>
<td>-</td>
<td>7.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 66</td>
<td>9.00</td>
<td>8.00</td>
<td>9.50</td>
<td>1.1</td>
</tr>
<tr>
<td>V/F/B - 25</td>
<td>11.00</td>
<td>-</td>
<td>9.50</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 26</td>
<td>8.00</td>
<td>9.00</td>
<td>6.50</td>
<td>0.88</td>
</tr>
</tbody>
</table>

**Description:** Teeth medium in size; crown narrow with pointed apex, acutely triangular, oblique distally or posteriorly; cutting edges sharp bearing fine and uniform serrations at the base of cusps while upper part of cusps are with a few or no serrations; mesial or outer margins moderately convex and distal or inner margins straight or little concave; internal surface convex and external one flat; crowns slightly higher than roots and cover entire roots. Roots broader than high and the lateral branches of roots moderately bifurcated.

**Remarks:** The specimens presently described can be compared reasonably well with the upper tooth of the same species described and figured by Karasawa (1989) from the Miocene sequences of Hokuriku district, central Japan (Plate VII, figures 9 and 11). This species has also been described and figured by Antunes and Jonet (1970) and Antunes et al. (1981) from the Miocene Formations of Algarve coast, Portugal to which collection at hand matches well.

*Carcharhinus cf. macloti* Muller and Henle 1873

(Pl – 13, figs.15 a – b)

**Material:** One isolated tooth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 78</td>
<td>12.00</td>
<td>12.00</td>
<td>8.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Description: Tooth small; crown thick, oblique posteriorly with pointed apex, both inner and outer edges straight and without serrations, moderately deep notch near the base of cusp. Internal surface strongly convex while external one flattened. Root low, broader than high, internal surface convex, external one flat, basal margin of root slightly concave.

Remarks: The specimen resembles *Hypoprion macloti* (which has been redesignated as *Carcharhinus macloti*) reported from the Lower Miocene sediments of Baripada, Orissa and Matanumadh of Kachchh (Sahni and Mehrotra, 1981). However, the specimen at hand is not sufficient for precise specific assignment. Hence, it has been considered as the comparable form of *Carcharhinus cf. macloti*.

*Carcharhinus bhubanicus* n. sp.

(Pl – 14, figs. 9 a – b)

Material: One tooth (Specimen no. V/F/R - 77).
Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).
Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.
Measurements: A single but well preserved specimen measures 12.00 mm in height, 14.00 mm in breadth and height of crown is ~ 7.00 mm.
Diagnostic characters: Strongly convex outer edge, strongly concave inner cutting edge and more or less rectangular unlobed root.
Descriptions: Tooth medium in size, thick at the centre and becoming thinner towards the edges as well as the apex and base; crown broad, strongly oblique distally with pointed apex, cutting edges sharp with fine and more or less uniform serrations from apex to base, outer edge strongly convex, inner edge strongly concave; internal surface highly convex, external surface flattened. Root low, broader than high, internal surface convex while external one flattened. Basal margin of root straight or little concave.
Remarks: The lone but well preserved specimen undoubtedly belong to the genus *Carcharhinus* owing to the overall geometry of the tooth and prominent and uniform serrations at both the margins. It can be easily distinguished from the other species of *Carcharhinus* hitherto reported on account of higher convexity of the outer edge and strongly concave nature of the inner cutting edge. In addition, its root is more or less
rectangular and is without bifurcation. Therefore, it is given a new name from its occurrence in the Bhuban Formation.

*Carcharhinus (Prionodon) sp.*

(Pl - 14, figs.1 - 4)

**Material:** Four isolated teeth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 83</td>
<td>8.00</td>
<td>9.00</td>
<td>5.50</td>
</tr>
<tr>
<td>V/F/B - 84</td>
<td>6.00</td>
<td>9.00</td>
<td>4.50</td>
</tr>
<tr>
<td>V/F/B - 85</td>
<td>8.00</td>
<td>-</td>
<td>5.50</td>
</tr>
<tr>
<td>V/F/B - 90</td>
<td>-</td>
<td>-</td>
<td>7.00</td>
</tr>
</tbody>
</table>

**Description:** Teeth medium in size, broader than high; crowns compressed, sub-triangular in outline, directed posteriorly with pointed apex, outer edges slightly convex, inner edges straight or little concave, cutting edges sharp bearing fine serrations, somewhat coarser at the base. Internal surface slightly convex while external surface flattened. Root low, broader than high, internal surface weakly convex, external one flat, basal margin of root straight or slightly concave.

Sp. no. V/F/B - 90 differs from the other specimens of the present collection in the erect nature of the crown, triangular outline and somewhat blunt apex.

**Remarks:** The material described above has close resemblance with the *Prionodon* sp. described and illustrated by Hora (1939) from the Eocene sediments of Balasore, Orissa. However, the genus *Prionodon* was latter on considered as the sub-genus of the genus *Carcharhinus* under the family Carcharhinidae by Ghosh (1967). Hence, it has been named accordingly.
**Carcharhinus sp. A (indet)**

(P1 – 12, figs.9 – 13)

**Material:** Five isolated incomplete teeth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 42</td>
<td>-</td>
<td>-</td>
<td>13.00</td>
</tr>
<tr>
<td>V/F/B - 74</td>
<td>20.00</td>
<td>-</td>
<td>15.00</td>
</tr>
<tr>
<td>V/F/B - 107</td>
<td>12.00</td>
<td>-</td>
<td>8.50</td>
</tr>
<tr>
<td>V/F/B - 108</td>
<td>11.50</td>
<td>-</td>
<td>8.00</td>
</tr>
<tr>
<td>V/F/B - 109</td>
<td>-</td>
<td>-</td>
<td>8.00</td>
</tr>
</tbody>
</table>

**Descriptions:** Teeth medium to large in size; crowns erect or slightly oblique towards the posterior, sub-triangular in shape with pointed apex, higher than broad; sharp cutting edges bearing fine serrations throughout; serrations coarser at the base becoming finer towards the apex, crowns thicker in the middle and thinner towards the edges; outer margins slightly convex and distal or inner margins somewhat straight or fairly concave; Surface strongly convex internally and flattened externally. Roots ill preserved.

**Remarks:** Specimen no. V/F/B - 42 from the present collection can be compared well, on the basis of the morphological features and geometry of the crown, with the upper tooth of the species *Charcharhinus egertoni* (Plate - 2, fig. 10) described and figured by Stuart (1910) from the Miocene sediments of Myanmar. Another specimen (V/F/B - 74) also bears a close resemblance with the upper tooth of the species *Charcharhinus egertoni* (Plate - XV, fig. 111) described and illustrated by Antunes and Jonet (1970) from the Miocene beds of Algrave coast of Portugal. Specimen nos. V/F/B - 107, 108 and 109 are more or less similar with the previously described specimens (Nos. V/F/B - 24 and 35) under the species *Carcharhinus egertoni*. Since the present specimens are incomplete and poorly preserved, specific assignment is not attempted and these are referred to as *Carcharhinus sp. indet.*
**Carcharhinus sp. B (indet)**

(Pl – 12, fig.14 a – b)

**Material:** One complete tooth (Specimen no. V/F/B - 88).

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm): Height of tooth - 6.00mm, breadth – 8.00mm, height of crown-4.50mm.

**Description:** Tooth small; crown erect, triangular in shape with somewhat blunt apex, broader than high, sharp cutting edge with fine serrations only at the base of the crown; crown runs all over along the root, outer edge moderately convex, inner edge straight or slightly concave; internal surface convex while external surface flat. Root low, broad and weakly bifid with a median groove in its inner surface.

**Remarks:** The lone specimen at hand can be grouped under the genus *Carcharhinus* on the basis of morphological characteristics of the tooth and geometry of the crown. This can be distinguished from *Carcharhinus* sp. A described above on account of its small size, erect nature, serrated margins at the base only, somewhat blunt apex and weakly bifid root.

**Carcharhinus sp. C**

(Pl – 12, fig.15 – 16)

**Material:** Two isolated teeth; one complete and another with broken root.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 75</td>
<td>24</td>
<td>18</td>
<td>16</td>
<td>1.33</td>
</tr>
<tr>
<td>V/F/B - 76</td>
<td>14</td>
<td>-</td>
<td>10</td>
<td>-</td>
</tr>
</tbody>
</table>
Description: Specimen no. V/F/B - 75 is large in size; crown directed posteriorly with pointed apex, sharp cutting edges with fine and more or less uniform serrations from base to apex, outer or distal margin convex and inner or mesial margin straight; crown curved inward at the base and outward at the tip; internal surface strongly convex while the external one flattened. Root high, broad and thick, internally strongly covex and externally flattened with strong bifid nature.

Specimen no. V/F/B - 76 is medium in size; crown erect, thick, higher than broad, apex pointed, cutting edges sharp, fine and uniformly serrated throughout, both outer and inner margins slightly convex; Internal surface strongly convex while external one flattened. Root broader than high, internal surface strongly convex, external surface flat, lateral branches of root weakly bifurcated.

Remarks: On account of medium to large size, almost equilateral triangular outline, regularly serrated margins and thick and bifurcated root, these specimens are assigned to *Carcharhinus* sp. However, additional specimens and information would be desirable in order to have a precise determination. These specimens differ from the species described above as *Carcharhinus* sp. A and B on account of slender nature of crown and more bifid root.

*Carcharhinus* sp. D

(PI – 13, figs.16 a – b)

Material: One isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 80</td>
<td>12.00</td>
<td>-</td>
<td>08.00</td>
</tr>
</tbody>
</table>

Description: Tooth small to medium; crowns thick and erect with pointed apex, both inner and outer edges straight or little convex, cutting edges sharp bearing fine and uniform serrations from base to the tip of the cusp. Internal surface strongly convex while external surface flattened; no lateral denticles observed at the base of cusp. Root low,
broader than high, internal surface convex, external one flat, basal margin of root slightly concave.

Remarks: The specimens, inspite of their smaller size, are somewhat similar with *Hypoprion minidenticulata* described and figured by Sahni and Mehrotra, (1981) from the Lower Miocene gypseous shales of Matanumadh, Kachchh and unconsolidated conglomerates of Akwara, Bhavnagar in the shape of crown and root. The only discernible difference is the absence of small denticles on the lateral cusp of the present specimen. *Hypoprion* is now considered as the synonym of *Carcharhinus*. Specific assignment is deferred for the want of more and better preserved materials.

**Genus** *Galeocerdo* Muller and Henle, 1873

**Galeocerdo aduncus** Agassiz 1843

(Pl – 13, figs. 1 – 4)


Material: Four isolated teeth; two complete and two broken and are embedded in the matrix.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).


Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/R - 09</td>
<td>10.00</td>
<td>16.00</td>
<td>9.00</td>
<td>0.62</td>
</tr>
<tr>
<td>V/F/B -10</td>
<td>10.00</td>
<td>-</td>
<td>9.00</td>
<td></td>
</tr>
<tr>
<td>V/F/B - 67</td>
<td>12.00</td>
<td>16.00</td>
<td>9.00</td>
<td>0.75</td>
</tr>
<tr>
<td>V/F/B - 68</td>
<td>11.00</td>
<td>-</td>
<td>9.00</td>
<td></td>
</tr>
</tbody>
</table>
Description: Teeth medium in size; upper part of the crowns obliquely triangular with pointed apex and thicker at the centre, lower part compressed and broad covering entire roots, strongly oblique posteriorly; cutting edges sharp with fine and uniform serrations at the mesial or outer margin excepting near the apex that is smooth, serrations prominent at the inner margin with largest ones in the proximity of the notch thereafter gradually becoming smaller towards the posterior end of the crowns, serration absent from the notch towards the apical end; outer margins moderately convex and distal or inner margins strongly concave giving a V-shaped geometry with a deep notch at the centre. External surface nearly flat and internal one moderately convex. Root low and broad, strongly bilobed excepting in Sp. nos. 9 and 10, and sub- rectangular in outline.

Remarks: *Galeocerdo aduncus* Agassiz has been recorded and described by many workers from within the country and abroad. The specimens described herein can be compared reasonably well with the collections made by Antunes and Jonet (1970) and Antunes *et al.* (1981) from the Miocene beds of Portugal. Sahni and Mehrotra (1981) also described and figured this species from the Miocene sediments of Gogha coast of Orissa. Karasawa (1981) has also reported the occurrence of this species from the Miocene sequences at Hokuriku district of central Japan.

Genus *Negaprion* Whitley, 1940

*Negaprion brevirostris* Poey, 1868

(Pl – 13, figs. 10 a – b)


Material: One isolated tooth.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 71</td>
<td>06</td>
<td>7.5</td>
<td>05</td>
<td>0.80</td>
</tr>
</tbody>
</table>
**Description:** Tooth small, broader than high; crown oblique posteriorly with pointed apex, nearly as high as broad, outer margin slightly convex and inner margin straight, cutting edges sharp and without serrations excepting few ones at the base of the cusp. Internal surface convex and external surface flattened. Root low, straight or feebly bilobed, broader than high, convex on internal side while little concave on external side.

**Remarks:** Though, the specimen presently described is smaller, it can be compared reasonably well with the one described and figured by Mehrotra *et al.* (1973) under the name *Negaprion brevirostris* from the Lower Miocene shales of Lakhpat and Matanumadh, Kachchh.

*Negaprion cf. eurybathrodon* Blake

(Pl – 13, figs. 11 a – b)

**Material:** One isolated tooth with broken apical part.

**Location:** Locality 1 (Bika Quarry, University Road, Tuiramit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 72</td>
<td>-</td>
<td>24.00</td>
<td>-</td>
</tr>
</tbody>
</table>

**Description:** Tooth medium sized; crown erect or slightly oblique posteriorly, broader than high, outer cutting edge convex and inner one straight or slightly concave, irregularly serrated, serrations bigger at the middle and decrease in size towards the basal and apical portions of the cusp, crown goes all over along the root. Internal surface convex and external surface flattened or little convex. Root low, broader than high, internal surface convex while external one concave. Basal part of root straight or feebly bilobed.

**Remarks:** The specimen at hand has a close affinity with the species *Negaprion cf eurybathrodon* described and figured by Antunes *et al.* (1981) from the Miocene beds of Algarve coast, Portugal. Though the appearance and geometry of the above two are quite similar, the serrated margins and smaller size of the present specimen distinguishes it from the species described by Antunes *et al.* (1981). It cannot be compared very well with
the *Negaprion* sp. reported from the conglomeratic horizon of Upper Bhuban unit of Bhuban Formation, Lunglei by Tiwari *et al* (1998), because the latter is much smaller in size and its cutting edges are not serrated.

**Genus** *Scoliodon* Muller and Henle, 1837  
*Scoliodon sorraakah* Cuvier, 1829  
(Pl – 13, figs.14 a – b)  

**Material**: One isolated tooth with parts of root broken.  
**Location**: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).  
**Horizon**: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):  
<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 73</td>
<td>7.00</td>
<td>-</td>
<td>5.50</td>
</tr>
</tbody>
</table>

**Description**: Tooth small; crown narrow, oblique posteriorly with pointed apex. Inner and outer edges straight and without serrations, moderately deep notch near the base of cusp. Internal surface convex while external surface flattened. Root low, broader than high and its basal margin is weakly concave.

**Remarks**: The specimen resembles *Scoliodon sorraakah* reported from the Lower Miocene shale and limestone of Matanumadh, Kachchh and Bariapad, Orissa respectively (Mehrotra *et al.* 1973). The distinctive characters such as its small size, posteriorly oblique crown, unserrated cutting edges and low root allow it to be assigned to the species *Scoliodon sorraakah*.

**Order** CARCHARINIFORMES Compagno, 1973  
**Family** HEMIGALEIDAE Hasse, 1879 (1885)  
**Genus** *Hemipristis* Agassiz, 1843
**Hemipristis serra** Agassiz, 1843

(Pl – 13, figs.5 – 8)


1973. *Hemipristis serra* Agassiz, 1843: Mehrotra et al., p 182, Pl - 1, fig. 5.


**Material:** Four isolated teeth; two specimens with broken apex and two with parts of the root embedded in the matrix.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
<th>Height/Breadth Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/R - 01</td>
<td>17.00</td>
<td>14.00</td>
<td>15.00</td>
<td>1.2</td>
</tr>
<tr>
<td>V/F/R - 02</td>
<td>15.00</td>
<td>14.00</td>
<td>13.00</td>
<td>1.1</td>
</tr>
<tr>
<td>V/F/R - 03</td>
<td>-</td>
<td>20</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 69</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Description:** Teeth large and broad; crowns obliquely triangular to lanceolate, higher than broad with pointed apex and directed towards posterior end, thicker at the base and center portions, thinning out towards apex and edges. Internal surfaces of crowns strongly convex, external surfaces flat or little convex. Both the edges sharp, bearing irregular and obtuse serrations excepting near the apex where they end abruptly; serrations at the inner margin smaller at the base and become larger towards the apex whereas at the outer edges these are smaller and somewhat uniform. Inner edges strongly concave, outer edges convex. Roots very low, swollen in the middle forming prominent bilobed structure on
the internal side that is more prominent in Sp. nos. V/F/R - 03 and V/F/B - 69.

**Remarks:** The specimens under study resemble *Hemipristis serra* reported and described by many workers from within and outside the country. Specimen nos. V/F/R - 01 and 02 can be compared reasonably well with the same species reported and described by Stuart (1910) from the Pegu beds exposed in the Singu Oilfield of Burma. Sp. nos. V/F/R - 03 and V/F/B - 69 bear close resemblance with the *Hemipristis serra* recorded and figured by Sahni and Mehrotra (1981) from the Miocene sediments of Kachchh (Gujarat) and Gogha coast (Orissa). They can also be compared well with the same species collected and described by Tiwari *et al* (1998) from the Middle Bhuban Formation of Mizoram (Lower Miocene).

The present specimens are identified as *Hemipristis serra* on account of their large size, stout and awl-shaped crown, differently serrated margins i.e. serrations smaller at the base, becoming larger towards apex and abruptly ending a little before reaching the apex, and low, swollen and bifid root.

**Hemipristis unidenticulata n. sp.**

(Pl – 13, figs. 9a – c)

**Material:** One complete isolated tooth (Specimen no. V/F/B - 70).

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements:** Height of tooth – 10 mm, Breadth of tooth – 8 mm; Height of crown – 8 mm.

**Diagnostic characters:** Somewhat blunt apex, 5 – 6 serrations in the inner margin, unserrated outer margin with a prominent denticle, and weakly bilobed root.

**Description:** Tooth medium in size; crown triangular in shape with somewhat blunt and posteriorly directed apex, higher than broad, thicker at the base and central portion, thinning towards the apex and edges. Internal surface strongly convex, external surface flat or with slight convexity. Internal edge bears 5 – 6 obtuse serrations which are smaller at the base and larger towards apex and end abruptly leaving nearly one-third of crown unserrated. Only one large serration or denticle present near the base of the cusp at the
outer edge. Inner margin slightly concave, outer margin straight or slightly convex. Root low and thick, swollen in the middle, and the lateral branches weakly bilobed.

**Remarks:** The lone but well preserved specimen at hand is distinct from the *Hemipristis serra* in less number of serrations in the inner margin and in the unserrated outer margin bearing a prominent denticle near the base of the cusp. It also differs from *Hemipristis simplex* Stuart (1901, Pl - 26, figs. 13a - b) that has un-serrated marginal edges, stout and narrow outline and convex outer and inner faces. Other forms of *Hemipristis* are not available for comparison. Hence, present specimen is assigned to a new species. It is named as *Hemipristis unidenticulata* n. sp. due to the presence of a prominent denticle near the base of the cusp at the outer cutting edge.

**Family** SPHYRNIDAE Gill, 1872

**Genus** Sphyrna Rafinesque, 1810

*Sphyrna diplana* Springer, 1941

(Pl – 14, fig. 5)


**Material:** One isolated tooth with external surface embedded in matrix (Specimen no. V/F/B - 40).

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Description:** Tooth small, about 7.00 mm in height and 9.00 mm in breadth; crown as high as root with pointed apex and is strongly directed posteriorly, apical portion of the cusp narrow and the base goes all along over the root; cutting edges without serrations; inner cutting edge straight, outer cutting edge little convex; internal surface somewhat convex, external surface not observable. Root as high as broad, internal surface strongly convex with prominent bilobed structure. It is bifurcated by a deep median furrow at the internal surface.

**Remarks:** A single but well preserved specimen described herein is more or less similar with the one figured by Sahni and Mehrotra (1981) from the Miocene sediments of Baripada, Orissa and Kachchh.
**Sphyrna zygaena** Linnaeus, 1758

(Pl – 14, fig. 6)


**Material:** One isolated tooth with external surface embedded in matrix (Specimen no. V/F/B - 39).  
**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).  
**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.  
**Measurements:** Height of tooth – 6.00 mm; Breadth of tooth – 7.00; Height of crown – 4.50 mm.

**Description:** Tooth small; crown narrow, sharp, slightly oblique with pointed apex. Inner margin nearly straight while outer margin slanted with slight convexity. Edges are without serrations. Base of the crown goes all along over the root. Crown much higher than the root. Internal surface slightly convex, thickened in the middle and becoming thinner towards the edges. Root low, broader than high and sub-rectangular in shape.

**Remarks:** The present specimen compares well with the collection and description made by Tiwari *et al.* (1998) from the Upper Bhuban Formation of Mizoram. It also has a close resemblance with the lower lateral anterior tooth of *Sphyrna zygaena* described and figured by Antunes and Jonet (1981) from the Miocene beds of Algarve Coast, Portugal.

**Family**  
**Genus**  
*Galeorhinus* Blainville, 1816  
*Galeorhinus sp.*

(Pl – 14, figs.7 a – b)

**Material:** One incomplete isolated tooth.  
**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl)  
**Horizon:** Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.
Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Height of Tooth</th>
<th>Breadth of Tooth</th>
<th>Height of Crown</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B -23</td>
<td>-</td>
<td>-</td>
<td>6.00</td>
</tr>
</tbody>
</table>

**Description:** Tooth though slightly broken, appears to be very small. Crown thick, as high as broad, sub-triangular in shape, labiolingually compressed with pointed apex and slightly directed distally; four to five obtuse serrations at the inner or distal cutting edge, serrations decrease in size from the apex to the base of crown; mesial margin smooth and little convex; internal surface more convex than the external one.

**Remarks:** Tooth is incomplete and the root part is not fully preserved. It belongs to the genus *Galeorhinus* on account of its small size, well developed cusp, absence of mesial serrations and sub-erect mesial margin. It has close resemblance with the species *Galeorhinus* sp. described and figured by Kumar and Loyal (1987) from the Subathu Formation of Lower Eocene age, Northwestern Himalaya. It also has considerable similarity with the same species described and reported by Yabe and Hirayama (1994) from the Upper Miocene sediments of Sehhatta Formation, Boso Peninsula, Central Japan. Incomplete nature of the specimen, however, does not warrant specific identification.

**Order**  SQUALIFORMES Goodrich, 1909  
**Family**  SQUALIDAE  
**Genus**  *Squalus* Linnaeus, 1758  
  *Squalus* sp. (Pl – 14, fig. 8)

**Material:** Isolated tooth with external surface embedded in the matrix (Specimen no. V/F/B - 91).

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Description:** Tooth small, about 3.50 mm in height and 8.50 mm in breadth; crown as high as root and strongly inclined towards the inner edge, apical portion of the cusp narrow and the base goes all along over the root; cutting edges without serrations, inner cutting edge straight, outer cutting edge little convex; internal surface slightly convex,
external surface embedded in the matrix. Root much broader than high, basal margin not observable.

**Remarks:** The specimen resembles with *Squalus* sp. reported and figured by Sahni and Mehrotra (1981) from the Miocene sediments of Baripada, Orissa. Specific identification is however deferred for the want of additional material.

**Carcharhinidae gen. et sp. indet.**

(Pl – 14, figs. 12 a – b)

**Material:** One vertebra (Specimen no. V/F/R - 105).

**Location:** Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Descriptions:** Cranial and caudal surfaces of vertebral column with scripted ring groups, column nearly rounded and concave; canals of haemal arches at dorsal surface and neural arches at ventral surface not observable; lateral faces nearly flat; vertebral plate 15 mm in thickness, 40 mm in diameter or breadth.

**Remarks:** The specimen under consideration belongs to the family Carcharhinidae because cranial and caudal surfaces are rounded with concentric ring groups and its lateral surface is nearly flat. The same species is reported from the Miocene sediments of the Hokuriku district, central Japan by Karasawa (1989). The features of this specimen is also similar to the one of *Carcharhinus egertoni* from the Higashibessho Formation (Nishimoto *et al.* 1980 as *C. aff. egertoni*). Specific identification is not being attempted because the available specimen is only a small part of the vertebral column.

**Indeterminate vertebral centra of selachians**

(Pl – 14, figs. 11 a – b)

**Material:** One vertebra (Specimen no. V/F/R - 104).

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Descriptions:** Vertebra small in size; both its cranial and caudal surfaces are concave with numerous concentric growth lines whereas lateral and dorsal surfaces are concave
and smooth. It has a thickness of about 10 mm and diameter of about 8mm.

**Remarks:** The described specimen is too meager and poorly preserved to allow precise determination. No form of this genus is available to the author for comparison.

**Superorder**  
BATOIDEA

**Order**  
MYLIOBATIFORMES Compagno 1973

**Superfamily**  
MYLIOBATOIDEA Compagno 1973

**Family**  
MYLIOBATIDAE Bonaparte 1838

**Genus**  
*Myliobatis* Cuvier, 1817

*Myliobatis* sp.

(Pl – 14, figs. 13 – 17; Pl – 15, figs. 1 a – b)

**Material:** Five isolated median teeth; three complete and two broken, and one fragmentary caudal spine.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl)

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Length of Tooth</th>
<th>Breadth of Tooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 05a</td>
<td>4.00</td>
<td>22.00</td>
</tr>
<tr>
<td>V/F/B - 91</td>
<td>5.00</td>
<td>19.00</td>
</tr>
<tr>
<td>V/F/B - 92</td>
<td>5.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/B - 93</td>
<td>4.00</td>
<td>25.00</td>
</tr>
<tr>
<td>V/F/R - 94</td>
<td>5.00</td>
<td>-</td>
</tr>
<tr>
<td>V/F/R - 5b</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

**Description:** The described specimens belong to the median teeth of *Myliobatis*. They are medium in size, transversely elongated, more or less straight, hexagonal in outline; the coronal surface of crown is smooth, the basal surface of root is divided into 19-20 ridges and grooves at right angle to the transverse axis of crown as observed in sp. no. V/F/B - 05a. A straight ridge or shelf-like projection is present at the junction of crown and root on both the anterior and posterior sides.
Specimen no. V/F/R - 05b is the claudal spine. Its dimensions could not be measured due to fragmentary nature of the material. The spine is narrow, about 5 mm in breadth, longitudinally striated, some of the striations being deep enough to form grooves. The anterior is straight with denticles on the lateral edges which are directed distally making an angle of 30 to 40 degrees from the central axis. The presence of these denticles imparts a saw-tooth appearance.

**Remarks:** These specimens have a clear resemblance with the *Myliobatis* sp. described and reported by Sahni and Mishra (1975) from Lower Miocene of Matanomadh, and Lakhpat, Kachchh, Gujarat. These also resemble well with the same species from the Eocene sediments of Subathu Formation, Northwestern Himalaya (Loyal, 1987). Identification of *Myliobatids* spines at a specific level seems difficult, as all of them are nearly alike. Moreover, the present specimen is poorly preserved. Thus no specific name has been proposed.

**Genus** *Aetobatus* Muller and Henle, 1841

*Aetobatus* sp.

(Pl – 15, figs. 2 – 3)

**Material:** Two poorly preserved isolated teeth.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements** (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Length of Tooth</th>
<th>Breadth of Tooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 95</td>
<td>7.00</td>
<td>21.00</td>
</tr>
<tr>
<td>V/F/B - 96</td>
<td>6.00</td>
<td>21.00</td>
</tr>
</tbody>
</table>

**Description:** Teeth medium in size, hexagonal in shape and arched laterally which is well-exhibited in the basal view. The occlusal surface is smooth. The root is divided longitudinally into 20 to 25 ridges and grooves, which continue from the under side to the posterior boarders of the enameled surface. Further details could not be deciphered.
Remarks: The present specimens can be compared reasonably well with the species *Aetobatus (= Aetobatis) arcuatus baripadensis* reported from the Tertiary deposits of Mayurbhanj by Ghosh (1959). The species reported by Sahni and Mishra (1975) from the gray colored gypseous shales of Khari Series, Matanomadh, Kachchh is slightly smaller than the present one. However, the materials at hand are poorly preserved and their specific assignment is not possible.

Class: OSTEICHTHYES
Subclass: ACTINOPTERYGII
Infraclass: TELEOSTEI
Superorder: ACANTHOPTERYGII
Order: TETRADONTOIDEI
Family: DIODONTIDAE
Genus: *Diodon* Linnaeus 1758

*Diodon* sp. 1

(Material) (Pl 15, figs. 4 – 8)

Material: Five isolated dental plates.
Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).
Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Breadth</th>
<th>Length</th>
<th>Thickness</th>
<th>No. of Lamellar Plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 12</td>
<td>12.7</td>
<td>18.00</td>
<td>6.00</td>
<td>09</td>
</tr>
<tr>
<td>V/F/B - 97</td>
<td>10.00</td>
<td>14.50</td>
<td>5.00</td>
<td>08</td>
</tr>
<tr>
<td>V/F/B - 98</td>
<td>11.00</td>
<td>15.00</td>
<td>4.00</td>
<td>06</td>
</tr>
<tr>
<td>V/F/B - 99</td>
<td>7.00</td>
<td>8.50</td>
<td>2.50</td>
<td>04</td>
</tr>
<tr>
<td>V/F/B - 100</td>
<td>6.00</td>
<td>9.50</td>
<td>3.00</td>
<td>04</td>
</tr>
</tbody>
</table>

Description: Dental plates are medium to large, oval to sub-rounded and consist of 4 to 10 lamellar plates. The individual lamellar plates have different shapes - ranging from oval to sub-angular- and sizes and are piled up one over another. The first plate on the apical side is the smallest and the sizes of the subsequent plates increase towards the base. All the dental plates are cut into two more or less similar halves by a vertical plane.
Remarks: The record of the fossil diodontids from India is meager and the present specimens could not be well compared with any of the collections made by the earlier workers. Based on the shape and the arrangement of the lamellar plates, the present specimens undoubtedly belong to the genus *Diodon*. These cannot be identified at the specific level due to inadequate details.

*Diodon sp. 2*

(Pl – 15, figs. 9 – 10)

Material: Two complete dental plates.

Location: Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

Measurements (mm):

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Breadth</th>
<th>Length</th>
<th>Thickness</th>
<th>No. of Lamellar Plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 101</td>
<td>3.00</td>
<td>5.50</td>
<td>1.50</td>
<td>04</td>
</tr>
<tr>
<td>V/F/B - 102</td>
<td>5.50</td>
<td>4.60</td>
<td>1.50</td>
<td>04</td>
</tr>
</tbody>
</table>

Description: The dental plate is small in size and sub-triangular in shape. Lamellar plates are piled up on top of one another and vary in shapes and sizes. The sizes of the individual plates progressively increases from the apex to the base. A vertical line divides the dental plate into two symmetrical halves.

Remarks: The present speimens differ widely in shape, size and over all geometry from the earlier known species of *Diodon* and also from the *Diodon* forms described herewith. However, christening is deffered for the want of more material and information.

*Diodon sp. 3*

(Pl – 15, figs.11 a – b)

Material: One complete isolated dental plate.

Location: Locality 1 (Bika Quarry, University road, Tuivamit, Aizawl).

Horizon: Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.
**Measurements (mm):**

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Breadth</th>
<th>Length</th>
<th>Thickness</th>
<th>No. of Lamellar Plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B -13</td>
<td>16.00</td>
<td>20.00</td>
<td>4.00</td>
<td>06</td>
</tr>
</tbody>
</table>

**Description:** Dental plate medium in size and ‘heart shaped’. It consists of 6 lamellar plates. The lamellar plates at the apex and base are very thin while the four lamellae in between these are comparatively thicker. These plates have more or less equal size from the apex to the base. A vertical line divides the plates into two asymmetrical halves. The outer edge of the plate is somewhat crenulated. The dental plate is slightly concave at the apex and slightly convex at the base.

**Remarks:** The present specimen is markedly different from all other specimens on account of its shape, size, number of lamellar plates and slightly crenulated plate margin. However, a new species is not christened owing to solitary specimen.

**Diodon sp. 4**

(Pl – 15, fig. 12 – 13)

**Material:** Two dental plates.

**Location:** Locality 1 (Bika Quarry, University Road, Tuivamit, Aizawl) and Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Lower intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 1 and upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation of Locality 2.

**Measurements (mm):**

<table>
<thead>
<tr>
<th>Sp. no.</th>
<th>Breadth</th>
<th>Length</th>
<th>Thickness</th>
<th>No. of Lamellar Plates</th>
</tr>
</thead>
<tbody>
<tr>
<td>V/F/B - 103</td>
<td>9.00</td>
<td>20.00</td>
<td>6.00</td>
<td>06</td>
</tr>
<tr>
<td>V/F/R - 15</td>
<td>10.00</td>
<td>22.00</td>
<td>6.00</td>
<td>07</td>
</tr>
</tbody>
</table>

**Description:** The dental plate is medium in size, laterally elongated, sub-rectangular to sub-oval in shape; dental plates are formed by more or less oblique piles of 6 to 7 lamellae of unequal sizes; the biggest one lies at the base and the smallest one at the apex. The lamellar plates are divided by a median vertical line into two similar halves. Margins of the plates are not crenulated.
Remarks: The transversely elongated nature of the dental plates of the present specimens distinguishes these from the previously described species. Though Diodon is reported from several fossil localities from the Eocene and Miocene sediments of the Indian subcontinent, the material described here is too meager to allow any detailed comparison and identification at the specific level.

**Indeterminate tooth of Crocodylidae**

(Pl – 14, figs. 10 a – b)

**Material:** One isolated incomplete tooth (Sp. no. V/C/R - 90).

**Location:** Locality 2 (Ruata Quarry, near Ramrikawn, Tuivamit, Aizawl).

**Horizon:** Upper intraformational conglomeratic band, Upper Bhuban unit, Bhuban Formation.

**Measurements:** The specimen has the following dimensions: Height of crown - 16.00, breadth of crown – 8.00 mm; height and breadth of tooth cannot be measured because the root is embedded in the matrix.

**Description:** Tooth medium in size; crown narrow, thick and erect with arc-shaped apex, cutting edges sharp with fine and uniform serrations throught out, both the inner and outer edges little convex; internal surface highly convex, external surface flattened with slight depression near the junction of crown and root. Root seems to be very low, and could not be described further due to poorly preserved material.

**Remarks:** The specimen at hand completely differs from the teeth of the elasmobranch forms on account of its blunt apex and almost an arc-shaped crown. Furthermore, the internal surface of the crown is highly convex while the outer surface is flat. Owing to the possession of these morphological features, it may be a tooth of Crocodylidae. The identification is not ascertained due to the lack of enough details.