CHAPTER IV

DISCUSSION

In an adult *Nandus marmoratus* the cranium forms an elongated wedge-shaped structure. Its anterior end is thin and the posterior end is thick. The cranium is not fully ossified as some portions of the ethmoid plate, the trabecula communis, the taenia tecti medialis and the prootic bridge remain cartilagenous. Mc Murrich as far back as (1884, 1884b) reported the occurrence of cartilages in the skull of *Amiurus*. Later on Kindred (1919) also studying the cranium of *Amiurus* confirmed the presence of a number of cartilages in the adult skull, but not reaching the condition as found in *Amia* (Pehrson, 1940). Ridewood (1904c) and Joseph (1960) reported the retention of small cartilagenous portions in *Hyodon* and *Wallago* respectively. On the other hand, Srinivasachar (1958) reports the absence of any cartilagenous remnanta in *Heterocephalus*.

The significance and relationships of the cartilagenous
remnants in fishes offer a wide scope for research and need a more detailed study in the different groups of teleostei.

In the description of the skull of teleostomi, there is a great deal of confusion as regards the nomenclature adopted by the various authors. The different bones in the skull of Nandus have been discussed under the following heads:

1. Neurocranium and
2. Splanchnocranium.

In the neurocranium of Nandus five sharp ridges are found. The two laterals are paired and the median one runs lengthwise along it. The median one is formed by the frontal and the supra-occipital bones, the upper lateral by the frontal, the parietal and the epiotic bones, and the lower lateral by the sphenotic and the pterotic bones.

In this respect Nandus resembles Eleutheronema and Polynemus (Marathe & Bal, 1958) and Tilapia (Rao, 1967). It differs from Notopterus (Ridewood, 1904c) in which the lower cranial ridge is formed by the frontal and the squamosal bones. In most of the fishes like Rasbora, Labeo, Barbus, Catla, Dania, Notropis etc. (Ramaswami, 1955b), the skull is smooth.

In the neurocranium the various bones have been discussed under the following four heads:
1. Ethmoid region.
2. Orbito-temporal region.
3. Auditory region, and
4. Occipital region.

1. Ethmoid Region:

This region includes the four bones named as under:

(i) the Prevomer,
(ii) the Nasal,
(iii) the Ethmoid, and
(iv) the Lateral Ethmoid.

(i) Prevomer:

The prevomer bone in fishes arises as a median or paired dermal ossification below the ethmoid plate.

In Polypterus (Allis, 1922), Lepidosteus (Hammerberg, 1937), and Galeichthys (Bamford, 1948) etc. the prevomer is a paired rudimentary bone formed below the ethmoid plate while in Acipenser (Sewertzoff, 1926), Gasterosteus (Swinerton, 1902; Hammerberg, 1937), Sygnathus (Kindred, 1922, 1924), Amiurus (Kindred, 1919), Abbottina, Saurogobio, Gobio, Corius, Sarcocheilechthys, Gnathopogon, Chilogobio (Ramaswami, 1955b) Heteropneustes (Srinivasachar, 1958), Clarias (Nawar, 1954;
Kumar, 1954) and in a majority of Ostariophysi (Ramaswami, 1955c), Ophiocephalus (Swarup, 1959), Tilapia (Rao, 1967), Osteogeniosus (Shringi, 1969) and Rasbora (Tiwari, 1971-73) it is a prominent median unpaired bone. In Nandus also it is a prominent, median and unpaired bone.

The shape of the prevomer, however, is greatly variable in different teleostei. In Labio (Sarbahi, 1932) it is rectangular and in Heterophéustes (Srinivasachar, 1958) it is 'T' shaped bearing two patches of teeth. In Clarias (Nawar, 1954) it is crescent-shaped with a single patch of teeth. This bone is edentulous in Mormyridae, Hyodontidae (Ridewood, 1904c), Amiurus (Kindred, 1919), Pseudodoras, Pimelodus (Alexander, 1964), Sisor robdophorus (Mahajan, 1966), and Osteogeniosus (Shringi, 1969), while in Arapaima (Ridewood, 1904c) this bone is flat and bears a large number of teeth packed very close together but, in Osteoglossum (Ridewood, 1905), it bears only two large and two small teeth.

In cobotidae (Ramaswami, 1955c), the prevomer unites with the 'ethmoid bone' to form an 'ethmo-prevomer', a feature also recorded earlier by Sagemhl (1891) in some cyprinoids. Such a condition is not met with in Nandus.

In Nandus, the prevomer is a single median 'T' shaped bone and resembles Sisor robdophorus (Mahajan, 1966) and bears two
patches of teeth. One group, which is situated on its antero-ventral surface, is \('A'\)-shaped and consists of villiform teeth. Behind this group is the other patch which is oval in shape. It also consists of villiform teeth. According to Regan (1913), it is a characteristic feature of the family Nandidae.

(ii) Nasal:

In most of the teleostomi the two nasals lie on either side of the ethmoid bone, but in Osteoglossum, Heterotis and Arapiama (Ridewood, 1905) the nasals of the two sides meet each other along the mid-dorsal line. In Polypterus (Pehrson, 1922) it is represented by three elements the terminale, the nasal and the adnasal, whereas in Amia (Pehrson, 1940) a single nasal is present but contains three neuromast sense organs, thereby denoting the fusion of the three elements. In Lepidosteus (Aumonier, 1942) the nasal is absent but an adnasal is present. Working on Lepidosteus, Hammerberg (1937) suggested that the original nasal might have fused with the anterior premaxilla. The nasals lie on either side of the ethmoid plate and have a single centre of ossification in Ophioccephalus (Swarup, 1959) and Sisor robophorus (Mahajan, 1966). In Nandus also the nasals occupy the same position as in Ophioccephalus (Swarup, 1959) and S. robophorus (Mahajan, 1966).
In Mormyridae (Ridewood, 1904c) the nasals are long and tubular bones with anterior sharp downward curves, while in Notopterus and Petrocephalus (Ridewood, 1904c) they are large and curved but with dorsal grooves. In Osteoglossum (Ridewood, 1905) they are rectangular and sculptured. In Heterodontis (Ridewood, 1905) they are large, united with each other by a mid-dorsal suture and articulated posteriorly with the frontals. In Perciformes (Kesteven, 1928) the nasals are long and narrow and posteriorly connected with the frontals. However, they are elongated and spatulate in Cheilodactylus (Kesteven, 1928).

The two nasals are small and flat bones in Centrarchidae (Blair & Brown, 1961), Heterobranchus (Gregory, 1933) and Clarias (Nawar, 1954). In Belone (Durga Das, 1957) they are united anteriorly, but diverge posteriorly. In Tilapia (Rao, 1967) they are small and triangular paired bones. In Osteogeniosus (Shringi, 1969) they are simple elongated bones. In Nandus the two nasals are elongated and lie on either side of the ethmoid bone and resemble more or less with those of the percoid fishes like Pagrosomus and Cheilodactylus (Kesteven, 1928) in having posterior fibrous connection with the frontals.

(iii) Ethmoid:

The ethmoid has been variously named as 'ethmoid', 'supraethmoid', 'dermoethmoid', and 'mesoethmoid' etc.
In Ganoids the bone develops as purely dermal ossification as in *Amia* (Pehrson, 1940) and has been termed as 'ethmoid' by Sagemehl (1884). Srinivasachar (1958) has called the perichondral ossification as 'ethmoid' in *Heteropneustes*, and McMurrich (1884b) described it as 'mesethmoid' in *Amiurus*. Allis (1909) and later Kindred (1919) described this bone as 'supra-ethmoid' in *Loricata*. Rao (1967) and Shringi (1969) have also called this bone as 'supra-ethmoid' in *Tilapia* and *Osteogoneosus* respectively. It has been designated as 'dermo-ethmoid' by Gregory (1933) in *Heterobranchus* and *Chrysichthys*, and Nawar (1954) did the same in *Clarias*. In my opinion the term 'supra-ethmoid' should be used where both the dermal and parachondral ossifications fuse with each other to form a mixed ossification as in *Amiurus* (Kindred, 1919) and *Salmo* (de Beer, 1937). In *Nandus* it is an oval bone which arises as a median dermal ossification and has no association with the surrounding bones. In my opinion in *Nandus* this bone should be called as 'ethmoid'.

(iv) **Lateral Ethmoid:**

The lateral ethmoid develops as a perichondral ossification on the lateral surface of the lamina-orbito-nasalis as in *Salmo* (de Beer, 1937). Some workers like Kindred (1919) in *Amiurus*, and Bhimachar (1933) in *Rita, Wallago, Arius, Plotosus,*
Macrones, Silundia etc. have called this bone 'ect ethmoid', while Harrington (1955) in Notropis, Srinivasachar (1958) in Heteropneustes, Rastogi (1963a) in Silonia and Clupisoma, Tilak (1961, 1964) in some siluroids, Khandelwal and Rastogi (1965) in Rinomugil, and Mahajan (1966) in Sisor robdophosus have called this bone as 'lateral ethmoid'. Huxley (1864) in Esox, Goodrich (1909) in Clarias and Gregory (1933) in Heterobranchus etc. have used the term pre-frontal for this bone. Gegenbaur (1878) in Alcepocephalus termed it as 'Ethmoidie laterale' or 'pre-frontale'.


In most of the teleostei, the lateral ethmoid is a mixed bone in the formation of which both the dermal as well as the perichondral elements take part and therefore, should be known as lateral ethmoid + pre-frontal as described by Shringi (1969) in Osteogeniosus. If the bone is developed purely as a cartilage or purely as dermal then the lateral and pre-frontal terms should be used. The term 'ect-ethmoid' is not useful as it does not denote whether the bone is of mixed origin or purely as a cartilage or a membrane bone.
In teleostomi the lateral ethmoid is always formed as perichondral ossification. The pre-frontal, however, may either be absent as in Gasterosteus (Swinerton, 1902), Salmo (de Beer, 1937) etc., or may be present as an independent bone as in Acipenser (Sewertzoff, 1926), but in most of the teleostei it is found as a mixed bone as in Amiurus (Kindred, 1919) and Notropis (Harrington, 1955). In Pleuronectes (Mayhoff, 1914), Cyclopterus (Uhlmann, 1921) and Syngnathus (Kindred, 1924) this bone develops as an extension of the lateral ethmoid. Following Harrington (1955) the present author has used the term 'lateral ethmoid' in Nandus, where it develops as a perichondral ossification on the lateral surface of the lamino-orbito-nasalis. These are paired bones having dorsal and lateral processes.

2. Orbite-temporal Region:

This region includes the following bones:

(i) Parasphenoid,
(ii) Frontal,
(iii) Parietal,
(iv) Basisphenoid,
(v) Pleurosphenoid, and
(vi) Bones of the orbital region.
(1) **Parasphenoid:**

In all the teleostomi the parasphenoid is a long, flat and unpaired bone extending from the prevomer to the basioccipital and forms the floor of the neurocranium.

In the majority of fishes like the *Salmo* (Parker, 1873), *Gasterosteus* (Swinnerton, 1902), *Exocoetus* (Lasdin, 1913), *Amiurus* (Kindred, 1919), *Acipenser* (Sewertzoff, 1926), *Amia* (Pehrson, 1940), *Lepidosteus* (Hammerberg, 1937), the parasphenoid arises as a single, median bone on the ventral side of the skull, and the same condition is found in *Nandus*.

In *Salmo* (Parker, 1873), *Scomber* (Allis, 1903), *Loricati* (Allis, 1909) the parasphenoid is separated from the pro-otics by the lumen of the eye-muscle canal, while in *Amiurus* (Kindred, 1919) it is fused with the ventral surface of the pro-otics.

In the anterior region of the prootics, the parasphenoid bears on each side a small wing-like lateral process. It is a characteristic feature of the parasphenoid in teleostomi.

In many teleostei the suprasphenoid is indistinguishably fused with the lateral process of the parasphenoid to form a mixed bone, the parasphenoid + suprasphenoid as in *Osteogeniosus* (Shringi, 1969). In *Nandus* the (suprasphenoid)
basisphenoid articulates ventrally with the parasphenoid.

In a number of fishes like *Heterotis* (Ridewood, 1905), *Amiurus* (Kindred, 1919), *Rita, Arios, Pilotosus* and *Macrones* (Bhimachar, 1933), *Salmo* (de Beer, 1937), *Clarias* (Nawar, 1954), *Labeo* (Ramaswami, 1955c), *Heteropneustes* (Srinivasachar, 1958), *Catastomus* (Weisel, 1960), *Tilapia* (Rao, 1967), *Osteogeniosus* (Shrangi, 1969) the parasphenoid does not bear teeth, while in others like *Hyodontidae, Mormyridae, Albulidae, Pantodontidae, Notopterus, Arapiama, Petrocephalus* and *Osteoglossum* (Ridewood, 1904a, b, c) the teeth are present and *Nandus marmoratus* resembles the second group of fishes.

The parasphenoid extends forwards anteriorly up to the premaxillae, and posteriorly up to the basi-occipital, but in exceptional cases as in *Notopterus* (Ridewood, 1904c) and *Catastomus* (Weisel, 1960) it extends even beyond the basi-occipital. In *Amiurus* (Kindred, 1919) the posterior end of the parasphenoid is inserted in the groove on the ventral surface of the basi-occipital. In *Micropterus* (Blair & Brown, 1961) the posterior end is fused with the ventral surface of the basi-occipital. In *Nandus* the bifurcated posterior ends articulate with the inner surface of the basi-occipital.

(ii) **Frontals:**

The frontals in fishes form the roof of the skull in the
anterior half of the cranium.

Amongst the Mormyridae, the Hyodontidae and the Osteoglossidae (Ridewood, 1904c) the frontals are short and broad, while in *Arapaima* (Ridewood, 1904c) they are elongated, and amongst the percids in *Pagrosomus* (Kesteven, 1928) they are swollen and appear as tongue-shaped bones. In *Nandus* the frontals are large and broad with two characteristic ridges on their mid-dorsal surfaces as are seen in some Polynemids (Marathe and Bal, 1958) and *Tilapia* (Rao, 1967). In certain fishes like *Salmo* (Parker, 1873) and *Esox* (Pehrson, 1944a) the frontals lie superficial to the tegmen cranii and do not take any part in the formation of the orbital roof but in *Nandus* the frontals form the roof of the orbits as in *Nemachilus, Carrio sus, Cyprinus, Diplophysa, Cobitis, Nemachilichthys* (Ramaswami, 1955a) and *Tilapia* (Rao, 1967). Amongst the percids in *Pagrosomus* (Kesteven, 1928) the frontals are fused together along their mesial surfaces but in *Nandus* the two frontals meet only by their medial surfaces medially and partially covering the taenia tecti medialis and postero-medially they are separated by a wide gap as in *Amiurus* (Kindred, 1919), and *Tilapia* (Rao, 1967). In most of the Siluroids, however, as in *Amiurus* (Kindred, 1919), *Rita, Protosus, Pangasius, Silundia, Macrones* (Bhimachar, 1933) etc. the two frontanelles are present, a large anterior and a small posterior one. In *Arius sagere* (Bhimachar, 1933) only a single
anterior fontanelle is present and *Nandus marmoratus* resembles the same.

(iii) **Parietals:**

The parietals are situated behind the frontal bones. They are absent in Siluridae but Goodrich (1909) and de Beer (1937) thought that they had fused with the supraoccipital in these fishes. Srinivasachar (1958) denies to have seen the existence of a separate parietal ossification in *Heteropeustes*. In Cyprinidae (Ramaswami, 1955a, b), Mormyridae and Osteoglossidae (Ridewood, 1904c) the parietals are well developed and articulate with each other by a complete median suture. In Hyodontidae (Ridewood, 1904c) the parietals meet with each other only for a short distance anteriorly. In *Nandus* the two parietals are separated by a wide gap which is interdigitated by the supraoccipital bone and bears vertical ridges on their dorsal surfaces as also seen in the *Salmo* (Parker, 1837), *Gasterosteus* (Swinerton, 1902) and the Polynemid fishes (Marathe and Bal, 1958), in *Mastacembelus* (Bhargava, 1962) in *Rhinomugil* (Khandelwal and Rastogi, 1965), in *Centropomus* (Fraser, 1968). The parietal is irregular in shape in *Cheilodactylus* (Kesteven, 1928), triangular in *Pegrosomus* and *Epinephelus* (Kesteven, 1928), rhomboides in *Tilapia* (Rao, 1967), while in *Nandus marmoratus* it is thin, and flat bone and romboidal in shape.
(iv) **Basisphenoid:**

The basisphenoid normally forms the floor of the cranial cavity and lies above the parasphenoid and below the ventral end of the pleurospheoid. In teleostomi this bone ossifies in the membranous floor of the cranial cavity and Huxley (1864), Allis (1897b) etc. have regarded it as a membrane bone. Hallmann (1837) and Kindred (1919) have called it as 'suprasphenoid', and Ramaswami (1955c), Harrington (1955), Rao (1967) and Shringi (1969) have done the same.

In Ostariophysi this bone is not well developed (Ramaswami, 1955b) and Regan (1911), however, has mentioned that basisphenoid (suprasphenoid) is absent in Siluroids which is also reported as absent in *Clarias* (Mawar, 1954), *Heteropneustes* (Srinivasachar, 1958), *Eutropiichthys* (Tilak, 1961), *Silonia* and *Clupisoma* (Rastogi, 1963 a & b). It is also absent in Mormyridae (Ridewood, 1904) and Cyprinidae (Ramaswami, 1955 a & b), Basisphenoid (suprasphenoid of Hallmann) is fused with parasphenoid in *Silundia*, *Plotosus*, *Pangasius*, *Macrones*, *Arius* (Bhimachar, 1933), in *Wallago* (Sinha, 1959), in *Bagarius* (Gauba, 1962). In *Nandus* the basisphenoid is a 'Y' shaped, small but well developed bone and resembles with that of *Hoptoptyx lewesiensis* (Regan, 1913).
(v) Pleurosphephinoid:

The bone which forms the lateral wall of the cranial cavity behind the orbitosphenoid has been variously termed as the 'alisphenoid' by Owen (1848), Kindred (1919), Bhimachar (1933) and others; Pleurosphephinoid by Goodrich (1930) and de Beer (1937), Ramaswami (1955c) and Srinivasachar (1958), and pterosphenoid by Harrington (1955).

In certain fishes such as Anguilla (Norman, 1926) and Lepidocephalichthys (Bhandari, 1962) the pleurosphephinoid are dermal in origin as in Nandus also. In Salmo (Parker, 1873), Acipenser (Sewertzoff, 1926), Amia and Polypterus (Pehrson, 1922, 1940), and Lepidosteus (Swinnerton, 1902) it is developed as a perichondral ossification of the orbital cartilage while in most of the teleostei like Amiurus (Kindred, 1919), Salmo (de Beer, 1937), Heteropneustes (Srinivasachar, 1958) etc. it is of mixed ossification.

Pleurosphephinoid is almost always present excepting a few as in Gasterosteus (Swinnerton, 1902) it is absent, and very little developed in Loricati (Allis, 1909), Scomber (Allis, 1903), Alepocephalus (Gegenbaur, 1878). In Nandus the pleurosphephinoids are paired, small, flattened and very well developed.
(vi) **Bones of the Orbital Series:**

In the triassic genera of protospondyli like *Dapsedius* (Gregory, 1933 after Tate Regan) the orbit is surrounded by a ring of several small bones. On the dorsal side, it is bounded by a supraorbital series consisting of two bones - a prefrontal and a supraorbital while on the ventral side by a suborbital (circum orbital) series of six bones which have been termed as the lachrymal, suborbitals (1 to 4 in number) and dermosphenotic, of which the last may be replaced in the more advanced forms by a mixed bone - the sphenotic. Fundamentally this arrangement is found in all teleostomi with some modifications in their number which may be either due to fusion of adjacent bones or due to their disappearance. In *Amia* (Pehrson, 1940) there is an ant-orbital bone between the nasal and the lachrymal but it does not reach the orbit. The supraorbital series in *Amia* (Pehrson, 1940) is represented by the prefrontal + parietmoid and the supraorbital, which are absent in *Nandus marmoratus*.

In some fishes such as *Salmo* (Parker, 1873), *Gobiobotia*, *Rasbora*, *Esomus*, *Labeo*, *Garra*, *Gnathopogon*, *Hemibarbus* (Ramaswami, 1955b), *Hydrocyon*, *Brycon*, *Cyprinus* (Gregory, 1933) etc. a well developed supraorbital is present which forms the roof of the orbit, while it is absent in *Mormyridae*, *Hyodontidae*, *Notopterygidae*, *Osteoglossidae*, *Pantodontidae*, *Phractolaemidae*.
etc. In *Tilapia* (Rao, 1967) the roof of the orbit is formed by the frontals and *Nandus marmoratus* resembles it.

Some workers like Kindred (1919), Gregory (1933) etc. have included the lachrymal bone in the orbital series whereas Kesteven (1928) starts the count from the nasal and others like Smith and Bailey (1962) exclude even the lachrymal from the count.

In modern teleosts, the number of the bones in the sub-orbital (circum orbital) series is remarkably constant and is usually six, but in some fishes a secondary multiplication of the bony elements has taken place while in others the bones of the series have undergone a reduction due to the union of the primary infraorbital elements. McMurrich (1884b) has described six elements in the orbital in *Amiurus* (Kindred, 1919) Gegenbaur (1878) has recognised seven elements in the infra-orbital series of *Alepocephalus*. Kesteven (1928) has described seven infra-orbital elements in *Notopterus kapirat* and nine to twelve in Mormyridae. In all cyprinoids (Ramaswami, 1955b) six elements described as in *Tilapia* (Rao, 1967). The number of the suborbital series excluding the lachrymal and the dermosphenetic in a number of cases is reduced, which is probably due to the fusion of the phylogenetically distinct bones, for example, there are three of these in *Heterotis*, *Notopterus* (Ridewood, 1904c), *Catastomus* (Gregory, 1933) etc. and two in
Clarias (Nawar, 1954). In a number of cases there is a single large circumorbital bone as in Ganes, Chaetodon (Gregory, 1933) etc. and it is fused with dermosphenotic in Echeneis, Lycodontis (Gregory, 1933) etc.

In Centropomus (Fraser, 1968) and Osteogenosus (Shringi, 1969), the lachrymal is the first bone in the suborbital series in addition to this there are only three bones, the first two as infraorbitals and the third as the postorbital. Nandus marmoratus resembles with the same.

The anteriormost bone of the suborbital series in Salmo (Parker, 1873) has been called the lachrymal-anorbital by Holmgren and Stensio (1936), but Devilliers (1947) does not agree with this nomenclature and according to him the bone does not show any of the characters of the antorbital. Lakander (1949) has called the teleostean lachrymal as antorbital but it seems to be inappropriate because it does not correspond to the antorbital found in Amia (Pehrson, 1940) and other primitive fishes. Lachrymal is recognised by Cuvier (1926), Stannius (1846), Hallmann (1837), Wegner (1922) and Huxley (1858) as the anteriormost element of the suborbital series.

In Mormyridae (Ridewood, 1904c) the lachrymal is oval in shape. In Amia (Pehrson, 1940), it is broad and is situated behind the antorbital. In Heteropneustes (Srinivasachar, 1958),
it is very small and reduced. In the percomorphs (Ridewood, 1904a, 1904b, 1904c), the lachrymal in Osteoglossum (Ridewood, 1905) is sculptured and in Heterotis (Ridewood, 1905) it has a prominent ridge running upwards along its inner surface. In Nandus it is a well developed cylindrical and tube-like bone.

3. **Auditory Region:**

This region includes five bones:

(i) Sphenotic
(ii) Pterotic
(iii) Prootic
(iv) Epiotic
(v) Opisthotic

(i) **Sphenotic:**

The sphenotic bone has been called as 'autosphenotic' by Gregory (1933), Holmgren and Stensio (1936), de Beer (1937), Ramaswami (1948), and Lakander (1949) etc, while it has been referred to as 'post frontal' by Cuvier (1826), Kindred (1919) and Parker (1973). Ridewood (1904) and Goodrich (1904) called it as the 'sphenotic' (autosphenotic Harrington, 1955) and
the same has been followed in the present description. The dermal component of the sphenotic was referred as 'prefrontal' by Kindred (1919), and dermosphenotic by Gregory (1933).

In *Amia* (Allis, 1897b, 1899), *Syngnathus* (McMurrich, 1884a), and *Polypterus* (Pehrson, 1922) the sphenotic ossifies as perichondral lamellae on the outer side of the postorbital processes. In *Gadus* (Brooks, 1884), it ossifies both on the inner as well as the outer side of the auditory capsule, but in *Nandus* the sphenotic arises as a perichondral ossification behind the postorbital process, on the antero-lateral wall of the auditory capsule as is the case in most of the Cyprinoids (Ramaswami, 1955b), *Heteropneustes* (Srinivasachar, 1958) and *Tilapia* (Rao, 1967).

In *Amiurus* (Kindred, 1919), *Dactylopterus* (Allis, 1909) and *Polypterus* (Allis, 1922) the sphenotic and the intertemporal are represented by a fused ossification, while in *Amia* (Pehrson, 1940), *Lepidosteus* (Hammerberg, 1937) and *Exocoetus* (Lasdin, 1913), they are present as two separate ossifications which do not fuse. In *Pleuronectes* (Cole and Johnston, 1901), *Heteropneustes* (Srinivasachar, 1958), *Tilapia* (Rao, 1967) the sphenotic and intertemporal bones arise as independent ossifications but fuse in the later stages of development. In *Osteoglossus* (Shringi, 1969) dermosphenotic, autosphenotic and intertemporal all the three elements take part in the
formation of skull, while in *Nandus* the single element, sphenotic arises as a perichondral ossification of the antero-lateral wall of the auditory capsule.

(ii) **Pterotic:**

In *Salmo*, the bone, which Parker (1873) named as 'pterotic', did not have any dermal elements which were, however, recognised later by Gaupp (1902) and Schleip (1903) who following the suggestion of Van Wijhe (1882), termed the pterotic element of Parker as 'autosquamosal' and the dermal element as 'dermo-squamosal'. Sagemehl (1891) also found these elements in Characidae, but called the bone formed by the fusion of both the elements as squamosal, while others like Kindred (1919) and Bhimachar (1933) called it the squamoso-pterotic. Srinivasachar (1958) has not agreed with Kindred (1919) and Bhimachar (1933) in calling it as squamoso-pterotic and according to him it is the suprastemal which is fused with the pterotic and not the squamosal and hence the name pterotic and suprastemal.

The perichondral ossification behind the sphenotic on the postero-lateral wall of the auditory capsule has been called as 'autopterotic' by Harrington (1955) and pterotic by Blair and Brown (1961) whereas the dermal ossification around the
supratemporal canal has been called the dermopterotic by Harrington (1955) and supratemporal by Blair and Brown (1961). The terminology adopted here is the one followed by Blair and Brown (1961).

The pterotic shows some variations in its shape and in the relations with neighbouring bones in the teleostei, de Beer (1937) has discussed the relationship of the autopterotic (pterotic), intertemporal and supratemporal, in a number of fishes. According to him in *Amia, Acipenser, Polypterus* and *Lepidosteus* a perichondral ossification representing the pterotic, is absent but the supratemporals are present which in the latter two are probably fused with the intertemporal, while in *Salmo* and *Anguilla* the pterotic is fused with the intertemporal. In *Pagrosomus* (Kesteven, 1928) the pterotic and the epiotic have fused together to form the opistho-pterotic. In *Cheilodactylus* (Kesteven, 1928) the pterotic is a dorsoventrally elongated bone with the cartilage retained in the adult condition. In *Epinephelus* (Kesteven, 1928) the pterotic extends underneath the supraoccipital. In *Gadus* (Allis, 1909) the pterotic and sphenotic appear to be continuous due to the development of the inter- and supratemporal bones along their sides. In *Mandus* the pterotic is an irregular bone lying on the postero-lateral wall of the auditory capsule behind the sphenotic and is laterally covering the supratemporal ossicle.
The pterotic forms the articular surface for the hyomandibular in a number of teleostei like Elops (Ridewood, 1904a), Gregory, 1933), Gobio, Labeo, Garra, Rasbora, Gobiodon, Esox, Chilagobio (Ramaswami, 1955 a & b), Amiurus (Kindred, 1919), Silundia, Macronus, Ria, Arias, Protosusa (Bhimachar, 1933), Clarus (Nawar, 1954), Heteropneustes (Srinivasachar, 1958), Clupisoma, Silonia (Rastogi, 1963 a & b), Alia, Eutropichthys, Pseudotropius, Neotropius (Tilak, 1961 and 1964), while in Engralis (Ridewood, 1904b), Pangasius (Bhimachar, 1933), Wallago (Joseph, 1960) it does not take part in the articulation for the hyomandibular. In Nandus the pterotic has a well developed elongated facet for the articulation of hyomandibular and it resembles the former group of fishes.

(iii) Pprootic:

The prootic forms the floor of the auditory capsule of the cranium. Cuvier established prootic as being the homologue of the human 'Ala Magna', while Meckel (1820) printed out this bone as the homologue of petrosal. Stannius (1853) called it the Ala temporalis because of its resemblance with the mammalian temporalis. Finally Huxley (1864) homologised this bone in Esox with one of the three ossifying centres of petrosal part of the temporalis in Man, and called it as 'Prootic'.
In teleostomi the prootic develops around the ventral part of the anterior perachordals and the ventral part of the auditory capsules and meet each other along the median line of the cranial floor above the hinder part of the parasphenoid except in a few cases like *Silundia* (Bhimachar, 1933). It may ossify in the lateral commissure and sides of the prootic bridge as in *Amia* (Pehrson, 1940), or in the anterior part of the ventral wall of the auditory capsule, lateral commissures and sides of the prootic bridge as in *Gasterosteus* (Swinnerton, 1902) or it ossifies on the anterior wall of the auditory capsule and on the lateral commissure as in *Salmo* (de Beer, 1937) or in the anterior part of the parachordal and the ventral portion of the auditory capsule behind the hypophysial fenestra as in *Amiurus* (Kindred, 1919) and *Heteropneustes* (Srinivasachar, 1958) in which case a lateral commissure is never formed.

The origin of the prootic bone is greatly variable in fishes. In *Gasterosteus* (Swinnerton, 1902) it appears in the anterior part of the auditory capsule, lateral commissure and on the sides of the prootic bridge and forms the lateral wall of the trigeminofacialis chamber while in *Salmo* (Schleip, 1903) it reaches up to the basal plate, sides of the prootic bridge and parachordals. In *Amia* (Pehrson, 1940) it ossifies in the lateral commissure and in the sides of the prootic bridge. In
*Syngnathus* (Kindred, 1924) it forms a single centre of ossification in the anterodorsal wall of the prootic bridge, but in *Tilapia* (Rao, 1967) the prootic has two centres of ossification, the anterior one is around the lateral commissure, trigeminofacialis chamber and slightly over the parachordals indicating a tendency to invade the prootic bridge and the posterior part appears on the parachordals along the sides of the posterior portion of the parasphenoid bone. In *Osteognathus* (Shringi, 1969) the prootic ossifies in the ventral wall of the auditory capsule and of the prootic bridge, the lateral commissure being absent. In *Nandus* the lateral is absent and the prootics ossify in the form of perichondral lamellae in the ventral wall of the anterior region of the auditory capsule and of the prootic bridge.

The prootic is well developed in a number of fishes like *Amia* (Allis, 1897b, 1898), *Syngnathus* (McMurrich, 1884a), *Gasterosteus* (Swinerton, 1902), *Salmo* (Schleip, 1903), *Acipenser* (Sewertzoff, 1926), *Lepidophthalichthys* (Bhandari, 1962), *Tilapia* (Rao, 1967) and a similar condition is found in *Nandus*, but it is altogether absent in *Polypterus* (Fehrson, 1922).

In Siluroids the posterior myodome is absent. The facial nerve passes out through a notch at the anterior end of the prootic and not along with the trigeminal nerve. In other
fishes the posterior myodome is well developed, the facial nerve passes out through the prootic separately form the trigeminal nerve as in Scomber, Loricati (Allis, 1903, 1909) and Salmo (de Beer, 1937).

The prootics form an articular facet for the hyomandibular in a number of teleostei like Elops, Hyodon, Notopterus (Ridewood, 1904), Pleuronectes, Corphio, Perca (Kindred, 1919), Labeo, Saurogobio, Rasbora, Garra, Esomus, Coreius (Ramaswami, 1955 a & b), Nematochosa (Moona, 1963), Silonia (Rastogi, 1963a), but in others like Amiurus (Kindred, 1919), Eutropichthys, Allia, Pseudotropius, Neotropius, Pangasius (Tilak, 1961 & 1964), and Clupisoma (Rastogi, 1963b) the prootic does not take any part in the formation of the articular surface for the hyomandibular. In Nandus the prootic takes part in the formation of the hyomandibular facet and resembles the former group of teleostei like Elops and Hyodon (Ridewood, 1904 a & c).

(iv) Epiotic:

The epiotic bone has been called as such by Cuvier (1826) as occipitale externum and later on Sagemehl (1884) called it as exoccipitale in Amia, Cyprinidae and Characiniidae. According to Huxley (1858), Parker (1873), Gaupp (1902), Schleip (1903),
in the teleostei it is developed as a perichondral ossification on the postero-dorsal part of the auditory capsule. Allis in an earlier paper has used the term 'exoccipitale', but in the later papers, however, he has termed it as epiotic.

Normally the epiotic develops on the postero-dorsal angle of the cranium, but in some fishes a part of the epiotic bone extends downwards to form the hinder wall of the semicircular canal. The epiotic is absent in a number of fishes like Acanthopsis, Acanthophilus (Ramaswami, 1953), Lepidocephalichthys (Bhandari, 1962), Heteropneustes (Srinivasachar, 1958) etc., but is well developed in Amiaurus (Kindred, 1919), Anguilla (Norman, 1926), Cheirodactylus and Epinephelus (Kesteven, 1928), Rasbora, Garra, Esox, Pseudogobio, Saurogobio, Labeo (Ramaswami, 1955 a & b), Silundia, Plectosus, Rota, Arius, Pangasius (Bhimachar, 1933), Wallago (Joseph, 1960), Silonia, Clupisoma (Rastogi, 1963 a & b), Ailia, Neotropius, Pseudotropisus (Tilak, 1964), Tilapia (Rao, 1967), Osteoglossus (Shringi, 1969). In Nandus the epiotic is well developed resembling the later group of teleostei.

The epiotics of the two sides meet in the median line just in front of the exoccipitals in Anguilla (Norman, 1926), whereas in Nandus they are separated from each other by the median supraoccipital bone.

The epiotic is normally connected antero-dorsally with the extrascapular, mesially with the supraoccipital, antero-ventrally with the squamoso-pterotic and postero-ventrally with the
ex-occipital, while in Nandus it articulates antero-dorsally with the parietal, antero-ventrally with the pterotic, postero-ventrally with the exoccipital and mesially with the supraoccipital bones.

(v) Opisthotic:

The opisthotic bone has been named as intercalary by Stensio (1947), Lakander (1949) and Holmgren (1949). The opisthotic is situated on the postero-ventral margin of the auditory capsule and is a bone of varying origin. Phylogenetically, it is a cartilage bone but often it ossifies from the ligamentous extension and gets completely excluded from the otic region.

In Salmo (Schleip, 1903) the opisthotic originates as a ligamentous ossification on the ventral side of the exoccipital, whereas in Polypterus (Pehrson, 1922), Lepidocephalichthys (Bhandari, 1962) it arises as a perichondral ossification on the postero-lateral corner of the auditory capsule. In Nandus it arises as a perichondral ossification on the postero-lateral sides of the pterotic and does not take any part in the formation of the auditory capsule.

The opisthotics are absent in the families Siluridae, Mormyridae and Pantodontidae but are present in a great majority of other fishes. The opisthotic is a square-shaped bone in Epinephelus (Kesteven, 1928), irregular in Chilodactylus (Kesteven,
1928), large in *Osteoglossum* (Ridewood, 1905), medium size in *Arapaima* and *Notopterus* (Ridewood, 1904c), oval in *Tilapia* (Rao, 1967), *Orienus*, *Schizothorax* (Ramaswami, 1955), whereas in *Nandus* it is an irregular and a flat bone. As in *Epinephelus* (Kesteven, 1928) and other percoids the opisthotic in *Nandus* has a facet for the articulation with the opisthotic limb of the post-temporal bone.

4. **Occipital Region:**

The occipital region includes the following bones, namely

(i) Supraoccipital,

(ii) Basioccipital,

(iii) Exoccipital, and

(iv) Post-temporal.

(i) **Supraoccipital:**

The supraoccipital is one of the best developed bones of the teleost cranium usually with a prominent occipital spine projecting vertically.

Parker (1873) was the first to describe it in teleosts in which the bone arises as a perichondral ossification on the occipital arch and the tectum synoticum, between the two parietals and touching the frontals anteriorly. According to Kindred (1919)
the supraoccipital must be regarded as a new formation, and is not a homologue of the neural processes of the anterior vertebrae of the Ganoids as was suggested earlier by Sagemehl (1885). The homologue of supraoccipital spine of Polypterus (Allis, 1922) is the spine which has developed from the connective tissue above the occipital arch and is fused with the underlying supraoccipital ossification. In Perca, Cuvier (1826) has called it as 'interparietal' but homologised it with the reptilian supraoccipital spine. Woodland (1898), Loomis (1900) and Kindred (1919) have shown that in the fossil ganoids a supraoccipital is absent, although it is present in the fossil teleosts.

In Salmo (Parker, 1873), Schleip (1903) the supraoccipital arises as an unpaired dorsal and ventral perichondral lamellae on both the taenia-tecti-medialis and tectum-synoticum. In Syngnathus (McMurrich, 1884a) the supraoccipital arises in relation with the taenia-tecti-medialis and for the most part it is intramembranous, while in Amiurus (Kindred, 1919), Cyclopterus (de Beer, 1937), and Heteropneustes (Srinivasasachar, 1958) it ossifies as a perichondral ossification on the inner and outer sides of the tectum-synoticum and extends to fuse with the parietal. In Nandus also it ossifies as a perichondral ossification on the tectum-synoticum as in most teleostei and its occipital spine is due to the addition of dermal lamellae and hence can be called as a dermo-supraoccipital as described
in *Netropsis* (Harrington, 1955) and in many Cyprinids (Ramaswami, 1955).

The supraoccipital normally takes part in the formation of the foramen magnum but in some cases it is excluded from it due to the two exoccipitals fusing above it. It takes part in the formation of foramen magnum in *Amiurus* (Kindred, 1919), *Pangusius* (Bhimachar, 1933), *Clupisoma* and *Ailia* (Tilak, 1964) *Tilapia* (Rao, 1967). In *Nandus* also it forms a small portion of the roof of the foramen magnum.

The occipital crest is well developed in *Mormyrops*, *Petrocephalus* (Ridewood, 1904c), *Ictalurus* (Gregory, 1933), *Lates*, *Haemulon*, *Calamus*, *Archosargus*, *Micropogon*, *Genes*, *Chaetodon* (Gregory, 1933), *Tilapia* (Rao, 1967) etc., while it is totally absent in *Gymnarchus* (Ridewood, 1904), *Amiurus* (Kindred, 1919), *Rita*, *Arius* (Bhimachar, 1933), *Clarias* (Nawar, 1954), *Heteropneustes* (Srinivasachar, 1958) and *Ailia*, *Clupisoma*, *Pseudotropius* (Tilak, 1964). In *Nandus* also the occipital crest is well developed as in a number of teleostei.

In *Salmo*, *Alepocephalus*, Characinidae and Cyprinidae (Kindred, 1919) the supraoccipital is small, but in these families its ossification is denser, interdigitating into the posterior space of the frontals anteriorly, in this character *Nandus* resembles Cyprinidae, but differs from them in being larger in size and with
a prominent supraoccipital spine recalling the typical percoid condition.

In the majority of teleostei the posteriorly directed spine of the supraoccipital does not extend back over the anterior vertebrae but it is present in *Brycon*, *Distichodon* (Gregory, 1933). It shows wide variations of size. It is moderate in size in *Amiurus* (Kindred, 1919), *Silundia*, *Plotosus* (Bhimachar, 1933), *Heteropneustes* (Srinivasachar, 1958), *Eutrophiichthys* (Tilak, 1961), *Silondia* (Rastogi, 1963a). It is elongated and broad in *Rita*, *Pangasius* (Bhimachar, 1933), and *Pimelodus* (Alexander, 1964), elongated and narrow in *Macrones* (Bhimachar, 1933), *Clupisoma* (Rastogi, 1963b), *Neotropius*, *Pseudotropius* (Tilak, 1964) and *Schilbe* (Alexander, 1966) and it is absent in *Wallago* (Joseph, 1960), *Pseudotropius* (Alexander, 1964), *Arius* (Bhimachar, 1933) and *Clarias* (Nawar, 1954) etc. In *Nandus* it is elongated and narrow.

(ii) Basioccipital:

The basioccipital ossifies as the perichondral ossification in the ventral wall of the basal plate in the hinder region of the neurocranium. It lies above the hinder portion of the parasphenoid. In *Amiurus* (Kindred, 1919) the basioccipital ossifies in the posterior region of the basal plate and forms the floor of the Saccus-Recess and the floor and the side walls of the cavum-impar. In *Gasterостeus* (Swinnerton, 1902) it ossifies as a
dorsal and ventral lamella to the basal plate and forms the floor of the posterior myodome, but in Salmo (Parker, 1973) the basioccipital extends up to the basicranial fenestra and forms the roof of the anterior myodome. In Nandus the basioccipital ossifies in the ventral wall of the basal plate and forms the floor of the posterior myodome.

According to Ramaswami (1955b) in Cyprininae the basioccipital shows ventrally a masticatory and a posterior process (which may be bifid as in Hsemus) together called as pharyngeal processes. In Siluroids masticatory process is represented by two postero-ventrally directed accessory processes as in Amiurus (Kindred, 1919), Clarias (Nawar, 1954), Heteropneustes (Srinivasachar, 1958) Rita, Macrones, Pangasius (Bhimachar, 1933), Wallago (Joseph, 1960), Eutropiichthys (Tilak, 1961) etc. which articulate with the corresponding processes of the first vertebra. In Arias (Bhimachar, 1933) these processes are fused together forming a ventral keel-like process which is pierced by a canal through which the haemal artery passes. In Nandus these processes are totally absent.

(iii) Exoccipital:

The exoccipitals ossify as perichondral ossification on the occipital arches as in Amia (Pehrson, 1922), Salmo (de Beer, 1937).
Amiurus (Kindred, 1919) etc. and form the sides of the foramen-magnum. In some fishes both the exoccipitals fuse with each other dorsally and form the dorsal margin of the foramen magnum as in Amia (Pehrson, 1922), Polypterus, Salmo, Cyclopterus (de Beer, 1937), Notopterus, Arapaima (Ridewood, 1904c and 1905) Gobioninae and Cyprininae (Ramaswami, 1955 a & b), Rita, Plotosus, Silundia (Bhimchar, 1933), Wallago (Joseph, 1960), Anguilla (Norman, 1926), Neotropius, Pseudotropius (Tilak, 1964) etc. while in Nandus the two exoccipitals fuse with each other dorsally as well as ventrally and form the foramen magnum. In Notropis (Harrington, 1955) it originates on the outer side of the occipital arch as in Tilapia (Rao, 1967), whereas in Salmo (Parker, 1873) it originates on inner as well as on outer sides of the occipital arch.

The Osteniophysi have a median horizontal process on each occipital, which unites with its counterpart of the opposite side and forms the cranial floor above the carum-sinus-impars as in Amiurus (Kindred, 1919), Rita, Silundia, Plotosus, (Bhimchar, 1933), Wallago (Joseph, 1960), Eutropicalichthys, Pseudotropius, Neotropius (Tilak, 1961, 1964), whereas in Ailia, Pangasius (Tilak, 1964) the horizontal plate does not extend over the cavum-sinus-impars. In Cyprininae like Labeo, Esomus (Ramaswami, 1955b) the horizontal process of the occipital forms the dorsal covering over the sacculus and lagenae and also forms the roof over the cavum-sinus-impars. In Nandus the horizontal processes are formed
the floor, above the cavum-sinus-impar like the first group of fishes.

In many fishes like Gadus (Allis, 1909), Gobio, Saurogobio, Pseudogobio, Labeo, Rasbora, Esomus, Garra (Ramaswami, 1955 a & b), Amiurus (Kindred, 1919), Riga, Arius, Silundia (Bhimachar, 1933), Clarias (Nawar, 1954), Silonia (Rastogi, 1963a), the exoccipitals enclose the three foramina, whereas in Catla, Coreius (Ramaswami, 1955 a & b) only the single foramen is enclosed by them. In Nandus they enclose only two foramina.

(iv) Post-temporal:

The post-temporal is actually not a bone of the skull but is a bone of the pectoral girdle which has become fused with the posterior lateral region of the skull. de Beer (1937) has variously termed it as suprascapular, supracleithrum and post-temporal in Amia, Salmo, Amiurus etc. This confusion has probably arisen from the nomenclature given by Haller (1905) in which the upper of the two bones traversed by the post-temporal sensory canal was called the second supracleithrum and the lower one as first supracleithrum. Most of the authors like Gregory (1933), Ridwood (1904 & 1905) etc. now retain the name supracleithrum for the first supracleithrum of Haller and call the second supracleithrum which is attached to the skull as post-temporal. In Notopterus the post-temporal is a small tubular
bone, in Plotosus and Wallago it is a weak bone while in Nandus it is 'Y' shaped dorsally and well developed. In Notopterus both the epiotic as well as opisthotic limbs are absent. In Heteropneustes and Clarias an opisthotic limb is absent. In Hyodon, Osteoglossum, Leichhardtii (Ridewood, 1904 & 1905) both the limbs are present and attached directly to the epiotic and opisthotic bones, while in Heterotis (Ridewood, 1905) they are attached by a ligament to the bones. In Siluroid and Phrectolaemidae the opisthotic limb is absent. In Nandus both the epiotic and opisthotic limbs are well developed and they are directly attached to the epiotic and opisthotic bones of the skull.

2. Splanchnocranium:

In the splanchnocranium the various bones have been discussed under the following heads:

(A) Oromandibular region
(B) Hyoid region
(C) Branchial region

(A) Oromandibular Region:

This region includes the bones of the two jaws, the upper and the lower.
(a) **Bones of the upper jaw:**

This includes the premaxilla, maxilla, palatine, ectopterygoid, endopterygoid, metapterygoid, quadrate and symplectic bones.

(i) **Premaxilla:** The premaxillae are dermal bones which ossify in front of the ethmoid plate. In most of the teleostomi the two premaxillae are connected with each other, but in some like *Mormyrops*, *Petrocephalus* (Ridewood, 1904c) and *Amiurus* (Kindred, 1919) etc., they are fused with each other along the median line. In *Heterotis* (Ridewood, 1905), however, the two premaxillae are separated from each other by the vomer. In *Nandus* the two premaxillae are connected with each other along the mid line.

The shape and size of the premaxillae show a wide range of variations. In *Hyodon* (Ridewood, 1904c), *Belone* (Durga Das, 1957) the premaxillae are exceptionally long, while in Siluroids they may be stout, flattened and elongated as in *Wallago* (Joseph, 1960), *Silonia* (Rastogi, M. 1963 a) etc. or they may be rod-like and elongated as in *Clupisoma* (Rastogi, 1963b), *Ailuia*, *Pseudotropia* (Tilak, 1964) etc. or rectangular as in *Macrones*, *Arius*, *Rita*, *Silundia* (Bhimachar, 1933), *Clarias* (Nawar, 1954), *Heteropneustes* (Srinivasachar, 1958), while in *Nandus* they are large curved bones.
In Osteoglossidae, the premaxillae are small and intimately connected with the mesethmoid exhibiting limited movement but in *Nandus* they are large without any connection with the ethmoid and freely movable. In Hyodontidae (Ridewood, 1904c) the premaxillae are exceptionally long and bear a single row of teeth, whereas in *Nandus* they possess several rows of teeth.

Each premaxilla has well developed ascending and horizontal limbs but in a few cases it is represented only by small bult-like structure as in *Abbottina*, *Pseudogobia* and *Corcius* (Ramaswami, 1955). The ascending limbs are absent in *Pseudorasbora*, *Dipticus*, *Ptychidio* (Ramaswami, 1955 a and b).

The ascending limbs of the premaxilla are longer than the horizontal limbs in fishes like *Mormyrops*, *Heterotis*, *Petrocephalus*, *Epinephelus*, *Rasbora*, *Barbus*, *Mystacoleucus*, *Barilius*, *Crosseceillus*, *Hemibarbus*, *Chela*, *Gnathopogon*, *Gobiobotia* (Ramaswami, 1955b), *Ophicephalus* (Swarup, 1959), *Schizothorax* (Das and Daftari, 1966), *Tilapia* (Rao, 1967), but are shorter in *Labeo*, *Cirrhina*, *Scaphiodon*, *Gobio*, *Saurogobia*, *Garra*, *Orienus*, *Chilegobio* (Ramaswami, 1955b), *Centropomus* (Fraser, 1968) etc. Regan (1913) noted protrudible premaxillae with long ascending processes in *Holocentruas* (Berycidae) large and short ascending processes of premaxilla have been observed in the whole group of perciformes (Gregory, 1933). In *Nandus* the ascending processes
are very large and reach almost up to the posterior end of the frontals and resemble with those of *Holocentrus* (Regan, 1913).

(ii) **Maxilla:** In most of the teleostomi the maxilla may be edentulous, where it forms the hinder part of the gap of the mouth. In a few cases the maxilla is excluded from the gap of the mouth and is edentulous as in *Albula* (Gregory, 1933) *Mormyridae* (Ridewood, 1904c), *Cyprinidae* (Regan, 1911). In *Hyodontidae* and *Osteoglossidae* (Ridewood, 1904c) the maxilla bears a single row of teeth, whereas in *Salmo* (Schleip, 1903), *Wallago* (Joseph, 1960) and other Siluroids (Bhimachar, 1933) it bears several rows of teeth. In *Nandus* it is edentulous as in *Albula* (Gregory, 1933), *Mormyridae* (Ridewood, 1904c), *Cyprinoids* (Regan, 1911), *Ophiocephalus punctatus* (Swarup, 1956), *Tilapia* (Rao, 1967) and the percoid fishes.

**Maxillae** are short and broad in some fishes like *Chilogobia*, *Pseudorasbora*, *Sarcocheilichthys* (Ramaswami, 1955c); in *Tilapia* (Rao, 1967) they are elongated and rod-like as in *Syngnathus* (Kindred, 1922, 1924), *Hyodontidae*, and *Osteoglossidae* (Ridewood, 1904c and Kesteven, 1928). However, in *Centropomus* (Fraser, 1968) the maxillae are long, narrow, bones which are rounded anteriorly and curved posteriorly. In *Nandus* the maxillae arise quite early in the maxillary fold as dermal ossifications and lie behind the premaxilla, they are elongated bones with very broad and flattened posterior ends.
In many teleostei, the maxilla is provided with a number of processes for articulation with the premaxilla and palatine. In Catastomus (Weisel, 1960) it has three projections on its dorsal end, while in Cyprininae (Ramaswami, 1955b) each maxilla shows as many as five processes, but some of these processes may be absent or reduced in different members of the family. In Siluroids the articular processes are reduced. In Rita (Bhimachar, 1933) it articulates with the palatine by two knobs. In Amiurus (Kindred, 1919) it articulates with the palatine by a single knob. In Nandus there are only two processes the dorsal and the ventral of which the former articulates with the nasal and the latter fits into the submaxillary cartilage.

(iii) Palatine:

According to de Beer (1937) the palatine is a mixed bone as in Amia, Polypterus, and Salmo. It consists of two elements the dermal and Chondral. The dermal element has been termed as dermopalatine while chondral element has been termed as autopalatine. The dermal element develops below the anterior region of the pterygoid process of the pterygoquadrate cartilage. In the beginning it is separated but later on fuses with the chondral ossification of the pterygoid process. In Nandus both the elements are well developed. In some fishes as in Cyprininae, Siluridae and Cobitidae the bone is edentulous but in Nandus the
palatine bears a number of teeth as in *Salmo*, *Amia* (de Beer, 1937), *Scomber* (Allis, 1903), *Hyodon* (Ridewood, 1904c), and *Macrosemius*, *Alepocephalus*, *Roccus* (Gregory, 1933).

In teleostomi the palatine is connected posteriorly with the ectopterygoid or the endopterygoid of the pterygoid series as in *Amia*, *Polypterus*, *Salmo* (de Beer, 1937), *Characinidae* (Kindred, 1919) etc., while it is fused with the ectopterygoid in *Scomber* (Allis, 1903), *Notopterus* (Ridewood, 1904c). In *Cyprininae* (Ramaswami, 1955b) its rounded head fits into a facet of the endopterygoid posteriorly. In Siluroids the palatine is not connected with any bone of the pterygoid series (Jordon, 1905) except in *Diplomytes* (Alexander, 1964) in which it is attached posteriorly with the ectopterygoid. In *Nandus* it is posteriorly connected with the ectopterygoid and endopterygoid of the pterygoid series. In *Cyprininae* (Ramaswami, 1955b) the palatine anteriorly shows a facet for articulation with the pre-ethmoid, or the cartilaginous epiphysis as in *Esomus* (Ramaswami, 1955b). In these fishes it is connected to the projection of the median ethmoid projection and the dorsal premaxillary process of the maxilla by large ligaments. In *Esomus*, *Cirrhina* (Ramaswami, 1955b) the palatine shows a facet laterally for articulation with the lachrymal but it is absent in *Leucicus* and *Phoxinus* (Lekander, 1949). The palatine articulates with the prevomer by a single head in some teleostei like *Notopterus*, *Hyodon* and *Mormyridae*. 
(Ridewood, 1904c) it is fused with it. In most of the Siluroids like Amiurus (Kindred, 1919) Plotosus, Macrones, Rita, Arius, Silundia, Pangasius (Bhimachar, 1933), Clarias (Nawar, 1954), Clupisoma (Rastogi, 1963b) etc., the palatine is connected with the premaxilla by ligament and articulates with the maxilla as well as the lateral ethmoid. In Nandus it adjoins with the maxilla and the nasal anteriorly and articulates with the lachrymal and the lateral ethmoid.

(iv) Ectopterygoid:

The ectopterygoid typically develops as a dermal ossification ventrally to the palatine by the side of pterygoquadrate cartilage as in Amiurus (Kindred, 1919). It may bear teeth as in Notopterus (Ridewood, 1904c), Amia (de Beer, 1937), Arias, Silundia (Bhimachar, 1933), Selonia, Clupisoma (Rastogi, 1963 a & b), Ailia (Tilak, 1964), Osteogeniosus (Shringi, 1969), or may be edentulous as in Mormyridæ (Ridewood, 1904), Amiurus (Kindred, 1919), Rita, Macrones, Pangasius (Bhimachar, 1933), Salmo (de Beer, 1937), Diplomystes (Alexander, 1964), Neotropius (Tilak, 1964). In Nandus the bone bears 3 or 4 rows of pointed teeth on its inner surface.

In Carassius (Koh, 1931) and Notropis (Harrington, 1955) the ectopterygoid is somewhat leaf-like in shape with a dorsally directed petiole. In Catastomus (Seissel, 1960) it is a broad,
flat, plate-like bone with a blunt dorsal projection, while in
Nandus it is a slender bone. In Heteropneustes (Srinivasachar,
1958) the endopterygoid is absent.

In Clupisoma (Rastogi, 1963b) the bone is firmly attached
to the anterior end of the metapterygoid. In Arias, it is
connected with the metapterygoid by connective tissue only. In
Abbottina (Ramaswami, 1955a) it is fused with the endopterygoid.
In Nandus it is articulating with the endopterygoid and slightly
overlaps the anterior portion of the quadrate bone.

(v) Endopterygoid:

In teleostomi, according to Goodrich (1930) the endopterygoid
termed as pterygoid bone arise as dermal ossification in the
mesial sides of the pterygoquadrate bar. This bone is normally
present in teleostomi, but is absent in Amiurus (Kindred, 1919),
Rita, Plotosus, Arius, Macrines (Bhimachar, 1933), Clarias
(Nawar, 1954), Ailia, Neotrophius (Tilak, 1964) etc. However,
Boulenger (1904) noted the absence of endopterygoid bone in
Nandus and suggested its absence as one of the diagnostic feature
of the family Nandidae but the present investigations reveal that
the endopterygoid is not only present but well developed in Nandus.

Endopterygoid is small in size in Salmo (Parker, 1873) and
Pleuronectes (Cole and Johnstone, 1901) but large in Nandus as
in *Megalops* (Ridewood, 1904b) and *Tilapia* (Rao, 1967). In *Catastomus* the endopterygoid is plate-like and articulates with the autopalatine. In *Micropterus* (Blair and Brown, 1961) it is very thin and nearly transparent bony plate and is attached with the palatine, pterygoid and metapterygoid. In *Tilapia* (Rao, 1967) it is triangular and attached with the palatine, eptopterygoid, metapterygoid and ventrally overlapped by the quadrate, in *Nandus* it is slender bone and articulating with the dermopalatine, the eptopterygoid, the metapterygoid and the quadrate bones. Endopterygoid is separate from the eptopterygoid as in *Tilapia* (Rao, 1967), while fused together forming a V-shaped bone in *Gasterosteus* (Swinnerton, 1902).

(vi) **Metapterygoid:**

In most of the teleostomi the metapterygoid is developed as a perichondral ossification on the postero-dorsal surface of the pterygoquadrate. In *Heteropneustes* (Srinivasachar, 1958) it develops partly as membranous and partly as perichondral ossification while in *Nandus* it is developed only as a perichondral ossification of pterygoquadrate cartilage.

In *Salmo* (Parker, 1873) and *Scomber* (Allis, 1903b) a small strip of cartilage intervenes between the quadrate and the metaapterygoid. There is a large gap between the metapterygoid and the quadrate in *Chela, Opsariichthys* (Regan, 1911), *Acanthiopsis*
and *Acanthopthalmus* (Ramaswami, 1953) etc. In Characinidae (Segemehl, 1885; Kindred, 1919) the metapterygoid is small and separated from the quadrate and the endopterygoid by membranous cartilage, while, in *Nandus* the metapterygoid is well developed and a very small cartilage is present in between the quadrate and the metapterygoid as in *Centropomus* (Fraser, 1968), *Salmo* and *Scomber* (Parker, 1873 and Allis, 1903b).

The metapterygoid articulates anteriorly with the ectopterygoid in *Amiurus* (Kindred, 1919), *Wallago, Rita, Macrones* (Bhimachar, 1933), *Clupisoma* (Rastogi, 1963b), while in *Nandus* it is articulating with the endopterygoid, but in fishes like *Osteogeniosus, Arius* (Bhimachar, 1933), *Pangasius* (Tilak, 1964) etc., it is connected with the endopterygoid by some connective tissue only. In Siluroids it is connected posteriorly with the quadrate. In most of the Siluroids the metapterygoid is not connected with the hyomandibular but in *Amiurus* (Kindred, 1919), *Plotosus* (Bhimachar, 1933), *Wallago* (Joseph, 1960), *Clupisoma* (Rastogi, 1963b), *Pseudotropius* and *Naeotropius* (Tilak, 1964), *Osteogeniosus* (Shringi, 1969) the metapterygoid is firmly connected with the hyomandibulae and similar is the condition in *Nandus*.

(vii) **Quadrato**:

The quadrato generally ossifies as perichondrual ossification in the quadrato portion of the pterygoquadrate cartilage. In
Sygnathus (Kindred, 1924) it is of mixed ossification arising both from the perichondral as well as the dermal layers.

In teleostomi the quadrate articulates with the metapterygoid and the symplectic, but in Heteropneustes (Srinivasachar, 1958) it is associated with a membranous extension dorsally. In Sygnathus (de Beer, 1937) the quadrate fuses with a membranous ossification around the tip of the symplectic and with a vertical plate of infra-membranous bone dorsal to the symplectic. In Nandus the posterior margin of quadrate is deeply incised with a slot into which the symplectic is wedged as in Micropterus (Blair and Brown, 1961).

In Salmo (de Beer, 1937) the quadrate is connected with the opercular bones by ossified ligaments. In Balitora (Ramaswami, 1948), the quadrate interdigitates with the preopercular. In some Siluroids like Amiurus (Kindred, 1919), Rota, Plotosus (Bhimachar, 1933), Wallegra (Joseph, 1960) the posterior face of the quadrate interdigitates with the preopercular bone. In Nandus also it is articulating with the preopercular bone.

(viii) Symplectic:

The symplectic develops as a perichondral ossification, which in Amiurus (Kindred, 1919), Silundia, Rota, Plotosus, Macrones Pangasius, Arius (Bhimachar, 1933) is a cartilagenous area
occurring between the quadrate and the hyomandibular which remained unossified according to McMurrich (1884) and Bhimachar (1933).

It is less conspicuous in certain fishes like *Heterotis* (Ridewood, 1904c) but exhibits the tendency to become extensive in *Osteoglossum* and *Arapaima* (Ridewood, 1905).

In *Micropterus* (Blair and Brown, 1961) it lies exactly ventral to the metapterygoid. It is very small in *Sarcocheilichthys* (Ramaswami, 1955b) and well developed in *Wallago* (Joseph, 1960). In *Micropterus* (Blair and Brown, 1961) the posterior margin of the quadrate is deeply incised with a slot into which the symplectic is wedged. In Siluroïds the symplectic is absent. In *Tilapia* (Rao, 1967) it is bounding the posterior surface of the quadrate. The symplectics are thin slender bones in *Nandus* and are wedged in between the quadrate and the metapterygoid process of quadrate bone.

(b) **Bones of the lower jaw:**

There is a lot of confusion as regards the nomenclature adopted by the different authors in respect of the bones of the lower jaw especially in the teleostei.

Goodrich (1930) while discussing this has stated, "In the early
forms, there are numerous bones, while in the modern teleostei, they are reduced to three by the disappearance of some, and fusion of others. These three are 'dentary', 'articular' and 'angular'." He further adds that in the primitive teleostomes (Crossopterygii), it was covered externally by the dentary, supra-angular and angular, below by the splenial and internally by the prearticular, while the Meckalian fossa was roofed over by the coronoid. The angular and splenial seem to be the enlarged posterior and anterior elements of a series of extend infradentaries, several of which were present in the fossil forms. In Amioidae in addition to the dentary, angular and supra-angular a series of toothed coronoid and a large posterior bone generally called the splenial, which seems to be prearticularis present, in teleostei the coronoids have disappeared and even the angular may vanish.

According to Gregory (1933) the bones found in the lower jaw of the teleosts are (i) the angular, (ii) the dermarticular (often fused with the articular), (iii) the prearticular (spleenial), and (iv) the dentary. The supra-angular is found in the proximal part and the coronoids (spleenial) present in the distal part are usually lost in teleostei. In addition a sesamoid articular is also present in the teleostei, which has been called the articular (Ridewood, 1904 and Hains, 1937) coronomeckelian (de Beer, 1937), and sesamoid angular (Ramaswami, 1955 a & b).
According to Hains (1937) in the higher teleosts like *Sardinia* the 'articular' (cartilage bone) is absent and the 'angular' (membrane bone) is present in the hinder portion of the lower jaw in the adult. Lakander (1949) called the 'angular' of Hains as 'articular' as has been described earlier by Goodrich (1930), Gregory (1933) and Berg (1940) etc.

The following list, which is not an exhaustive one, however, shows how the confusion in the terminology persists even up to the present day:

<table>
<thead>
<tr>
<th>Terminology after Kindred (1919)</th>
<th>Terminology after Sarabahi (1932)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodrich (1930)</td>
<td>Hains (1937)</td>
</tr>
<tr>
<td>Gregory (1933)</td>
<td>Harrington (1955)</td>
</tr>
<tr>
<td>Bhimachar (1933)</td>
<td>Ramaswami (1955b)</td>
</tr>
<tr>
<td>Nawar (1954)</td>
<td>Srinivasachar (1958)</td>
</tr>
<tr>
<td>Swarup (1959)</td>
<td>Joseph (1960)</td>
</tr>
<tr>
<td>Alexander (1966)</td>
<td>Rastogi (1963 a &amp; b)</td>
</tr>
<tr>
<td>Articular</td>
<td>Moona (1963)</td>
</tr>
<tr>
<td>Angular</td>
<td>Angular</td>
</tr>
<tr>
<td>Retroarticular</td>
<td></td>
</tr>
</tbody>
</table>
Though Ramaswami (1955b) has used the terms angular and retroarticular, he has put the term articular autt and angular autt respectively within brackets after the two terms.

The angular, however, is a complex bone composed of angular and underlying splenial elements especially among the lower teleostomi like Amia and Polypterus and called by Pehrson (1947) as angular-splenial.

The present worker, however, feels that the term angular should be used in the case of the teleostei in preference to term articular and the articular be used for the bone labelled and described as angular by Gregory and others.

The angular is small in certain fishes like Labeo, Catastomus Cyprinus, Carpiodes (Ramaswami, 1955c) but in Nandus like Acanthophthalmus (Ramaswami, 1953), Tilapia (Rao, 1967) it is large and almost of the same size as the dentary.

In Mugil, Sardina, Trigla (Hains, 1937), Heteropneustes (Srinivasachar, 1958), Tilapia (Rao, 1967), the angular invades the developing articular bone and in this respect Nandus resembles the above named fishes.

The dentary is the largest bone of the lower jaw possessing almost the same topographical relations throughout the piscine series. It is short in Garra and Orienus (Ramaswami, 1955a),
whereas in Nandus it is large as in Notropis (Harrington, 1955), Cyprinus, Saurogobio, Pseudogobio, Sarcocheilichthys, Abbottina, (Ramaswami, 1955a), Tilapia (Rao, 1967). In Cyprinoids like Aphyocypris and Aristichthys etc. (Ramaswami, 1955a), Sisor (Mahajan, 1966) the dentaries are edentulous and a gap is noticed between the anterior tips, whereas in Amiurus (Kindred, 1919), Notropis (Harrington, 1955), Tilapia (Rao, 1967), Centropomus (Fraser, 1968) the tips are joined by median symphysis and bones are toothed, while in Nandus the dentaries bear teeth and their anterior tips are fused together mesially. Prominent anteroventrally directed processes of the dentary are present in Labeo rohita and Orienus (Ramaswami, 1955c) and the coronoid process in Barbus, Chela etc., whereas in Nandus these are absent but the bone is bifurcated and the two limbs are well developed as in Centropomus (Fraser, 1968).

2. Hyoid Region:

This region includes the hyomandibular, interhyal, epihyal, ceratohyal, hypohyal, basihyal, urohyal, branchiostegal rays and bones of the opercular series. Of these the urohyal, branchiostegal rays and bones of the opercular series are membrane bones while the rest are cartilage bones.
(i) **Hyomandibular:**

The hyomandibular is a well developed bone among the teleostomi and articulates dorsally with the cranium and distally with the quadrate through the symplectic. In Siluroids where the symplectic is absent a strip of cartilage intervenes between the hyomandibular and the quadrate. Normally the hyomandibular has two heads, sphenotic and the pterotic, which articulate with the sphenotic bone and pterotic bone respectively as in *Gasterosteus* (Swinnerton, 1902), *Hyodon*, Mormyridae (Ridewood, 1904c), Gobioninae and Cyprininae (Ramaswami, 1955 a & b) etc. In *Labeo* these two heads closely approximate with each other so as to show only a single head. In *Engraulis* (Gregory, 1933), *Pangasius* (Bhimachar, 1933) there is a single head which articulates with the sphenotic bone only, while in *Catastomus* (Weisel, 1960) and *Polynemids* (Marathe and Bal, 1958) two articular facets are present. In *Gasterosteus* (Swinnerton, 1902), *Arapaima* (Ridewood, 1905), *Micropterus* (Blair and Brown, 1961), *Tilapia* (Rao, 1967) and other teleosts three articular facets are present; and *Nandus* is no exception to it and resembles with latter group of fishes.

(ii) **Interhyal:**

It is represented by a bony element in most of the teleostei but in some fishes like *Mormyrops* and *Notopterus* (Ridewood, 1904c) the original cartilage remains unossified. In *Heteropneustes*
(Srinivasachar, 1958) it is absent.

In **Nandus** it is present as a small cartilage bone as in most of the teleostei.

(iii) & (iv) **Epiphyal and Ceratohyal**:

In all the teleostei they ossify as cartilage bones and **Nandus** is no exception to the group.

(v) **Hypohyal**:

In most of the teleostei the hypohyal is represented by small paired bones which are separated from each other by the median basihyal. In Cyprinids there are usually two pairs of hypohyal, which according to Ramaswami (1955a) are "Sometimes termed as basihyal and hypohyal, when the median piece of bone called as entoglossum or glossohyal." They are also termed as hypohyal first and second by Ramaswami (1955 a & b), upper and lower hypohyals by Harrington (1955), dorsal and ventral hypohyals by Joseph (1960).

In **Nandus** each hypohyal is a double piece of bone, which are attached to both the dorsal and ventral sides of the articular surface of ceratohyal and the ventral piece of hypohyal reaches up to the urohyal in the mid-line below the basihyal.
(vi) Basihyal:

The basihyal is present as a single median cartilage bone in most of the teleostei and the hypohyals are attached to it. In Siluroidea it is absent.

In Nandus the anterior portion of the basihyal is unossified even in the adult like Tilapia (Rao, 1967), while in other fishes it is completely ossified. The upper surface of the bone bears small villiform teeth.

(vii) Urohyal:

The urohyal is a median membrane bone situated beneath the first copula. In Nandus it is thin and somewhat triangular in shape and articulates with the lower hypohyals on each side by two strong and short ligaments which are present on the apex of the thickened rounded tuberosily bone.

(viii) Branchiostegal rays:

The branchiostegal rays are greatly variable both with regard to their number and place of attachment. Their number varies from three in Plactolaemus (Ridewood, 1905) to twenty one in Wallago (Joseph, 1960). They are six in Mastacembelus (Bhargava, 1962), Hilsa ilisa (Moona, 1959), Sisor robdophorous (Mahajan,
1966), Aplocueilus (Kulkarni, 1948), and seven in Centropomus (Fraser, 1968). Nandus resembles Hilsa ilisa (Moona, 1959), Aplocheilus (Kulkarni, 1948), Sisor (Mahajan, 1966), and Mastacembelus (Bhargava, 1962) in the presence of six branchiostegal rays.

Branchiostegal rays are usually attached to the ceratohyal and epihyals as in Mormyrops, Arapaima, Osteoglossum, Heterotis, and Petrocephalus (Ridewood, 1904c & 1905) etc. In Heterotis (Ridewood, 1905) one of them is attached at the junction of the two bones. In Notopterus, Mormyrops, Petrocephalus (Ridewood, 1904c), a few of the branchiostegal rays are unattached and lie freely in the branchiostegal membrane close to the opercular, while in Nandus the first five are attached to the ceratohyal and the sixth one to the epihyal.

(ix) Opercular Series:

The opercular series comprising the opercular, the interopercular, the preopercular and the subopercular bones which form dermal ossification in teleostei. The subopercular is absent in Notopterus, Heterotis (Ridewood, 1904c & 1905), Sisor robdophorus (Mahajan, 1966), while the preopercular is absent in Bhavana, Gastromyzon (Ramaswami, 1948). The subopercular is apparently lost in the Siluroids (Gregory, 1933), but it is
reported to be present as a small bone in *Amiurus* (Kindred, 1919), and as a rudimentary bone in *Plotosus* and *Osteogeniosus* (Bhimachar, 1933).

In *Gasterosteus* (Swinnerton, 1902), *Amiurus* (Kindred, 1919) and in the majority of Cyprinoids (Ramaswami, 1955 a & b), the bones of the opercular series are thick and sculptured whereas in *Notopterus* (Ridewood, 1904c), *Ophioccephalus* (Swarup, 1956), *Tilapia* (Rao, 1967) it is thin and smooth.

In *Nandus* all the bones of opercular series are thick and well developed. The preopercular and interopercular bones are serrated.

3. **Branchial Region:**

This region includes the pharyngobranchials, epibranchial, ceratobranchial, hypobranchial, basibranchial bones.

1. **Pharyngobranchials:**

The pharyngobranchials of the first four arches may be either free or fused with one another in some cases; some of them may be even absent. In *Perca* (Sedgwick, 1932) the pharyngobranchials are dilated and more or less confluent to form the upper pharyngeal bones which are beset with fine teeth. In Cyprinoids
(Ramaswami, 1955b) two pairs of pharyngobranchials are present, the first is small and free and belongs to the first arch, the second is large and represents the fused pharyngobranchials of the second and the third arch. Fourth is absent. Sarbahi (1952) described a fourth pharyngobranchial in Labeo rohita. In Esomus (Ramaswami, 1955b) a calcification in the epiphysial cartilage of the fourth pharyngobranchial occurs. According to Ramaswami (1955c) in Labeo it is not the fourth pharyngobranchial but a calcification in the hypophysis of the fourth arch as seen in Esomus. In Nandus the pharyngobranchials are four in number and out of which the first and the second are partially ossified. The first is fused with the first epibranchial while the second is free. The third and the fourth pharyngobranchials are fused together forming a single bone. In Cyprinoids the pharyngobranchials are edentulous while in Nandus they bear teeth.

(ii) Epibranchial:

The epibranchials are small bones and in some cases one or more of them may be fused with the corresponding pharyngobranchials as has been mentioned above. In Osteogogenius (Shringi, 1969) the first epibranchial and the first pharyngobranchials are fused with each other but the remaining three are free while in Nandus all the four epibranchials are present and they articulate anteriorly with the ceratobranchials and posteriorly with the
pharyngobranchial.

(iii) **Ceratobranchials:**

The ceratobranchials are the largest bones in the branchial arches. The fifth branchial arch which is formed by a pair of ceratobranchials only; the bone of the two sides may sometimes be ankylosed to form a single bone as in *Tilapia* (Rao and Kulshrestha, 1966). They form the inferior pharyngeal bone (Ospharyngeus inferior or pharyngeus inferior) and normally bear a number of teeth. In *Nandus* the fifth ceratobranchials are free from each other bear teeth and form the infrapharyngeal bone.

(iv) **Hypobranchials:**

The hypobranchials are attached anteriorly to the varying number of median basibranchials and posteriorly to the ceratobranchials. In most of the teleostei, however, like *Salmo* (de Beer, 1937), *Labec*, *Gobiobota*, *Pseudogobia*, *Saurogobia*, *Leuciscus*, *Orienus* (Ramaswami, 1955 a & b) etc., only three pairs of hypobranchials are present, the fourth pair being absent. In *Clarias* (Nawar, 1954), *Wallago* (Joseph, 1960), *Silonia*, *Clupisoma* (Rastogi, 1963 a & b), *Hutropichthys*, *Pseudotropius*, *Neotropius* (Tilak, 1961 & 1964) the hypobranchials are ossified only in the first and second arches. In *Heteropneustes* (Srinivasachar, 1958),
Centropomus (Fraser, 1968) three hypobranchials are ossified. In Nandus all the three pairs of hypobranchials are ossified. The first hypobranchial is articulating with the first basibranchial while the second and the third articulate with the second basibranchial.

(v) Basibranchials:

The basibranchials or copulas are represented by a chain of ossicles whose number is variable. In a number of teleostei like Gasterosteus (Swinnerton, 1902), Salmo (de Beer, 1937), Perca (Sedgwick, 1932), Gobiobotia, Saurogobia, Orienus, Pseudogobia, Leuciscus (Ramaswami, 1955 a & b) and Centropomus (Fraser, 1968), there are three basibranchials but in others like Mormyridae and Hyodon (Ridewood, 1904c), Labeo (Ramaswami, 1955c) only two pairs are ossified, while in Nandus three pairs of basibranchials are present, the first two are ossified while the third one remains unossified.