RESULTS

- Stage I (4 mm larva):

I. The neurocranium:

This stage represents the smallest stage studied. The larva retains a large amount of yolk and morphologically is not differentiated, i.e. the mouth, gills and fins have not developed. The eyes which are unpigmented can be seen easily on either side and the tail is partially elongated.

The chondral neurocranium is partially developed in a procartilaginous state, i.e. true chondrocytes are not yet formed. The floor of the neurocranium is represented by the trabeculae cranii and the parachordals.

In this stage, the trabeculae cranii are present in the form of a pair of thin elongated curved bars still separate from each other. They developed in continuation with the parachordals and not independent. They were lying in a medio-lateral direction ventral to the brain and in between the two eyes and extend parallel to the notochord (Fig. 1A & B and 2C). This shows that trabeculae cranii grow in the anterior direction. The posterior ends of the trabecular bars lie in direct contact with the antero-ventral ends of the parachordals (Fig. 1B and 2C). Laterally, the trabecula cranii extend horizontally at a slightly lower level than the parachordals (Fig. 1A).

The hypophysial fenestra, which is normally present in a "tropitrabic" neurocranium *(De Beer, 1937 and Daget, 1964)* appears as a medial small space between the two arms of the trabeculae cranii (Figs. 1B and 2C). Anteriorly, the fenestra is still opened since the trabeculae cranii are not yet fused but lie far from each other. Posteriorly, the notochord projects freely approximately to the middle of the hypophysial fenestra (Figs. 1B and 2C).

The parachordals appear as two narrow plates one on each side of the notochord and they have extended anteriorly to become fused with the trabeculae cranii; forming a continuous procartilaginous bar (Figs. 1A & B and 2 A & C).

The auditory capsules of the present stage are in the form of two independent procartilaginous plates (Fig. 1A & B) lying ventro-lateral to the brain and representing a part of its side wall (Fig. 2A,B & C). The auditory capsules are at a lower level than the parachordals (Figs. 1A and 2A).

The occipital region of the neurocranium consists of one pair of independent procartilaginous plates which appears as more or less rectangular structure on each side of the notochord (Figs. 1A & B and 2A, B & C).

The notochord is extending between the two trabeculae, parachordals and the occipital plates. It is naked dorsally and ventrally. The notochord in the present stage shows a gradual decrease in thickness from posterior to anterior. The anterior tip of the notochord extends more or less anteriorly to project in the hypophysial fenestra (Figs. 1B and 2C).

- Stage II (5 mm larva)

I. The neurocranium:

The first indication of cartilage is recognized in the neurocranium of the present stage of *Ctenopharyngodon idella*. The olfactory organs and the eyes are well developed, but, the mouth does not appear yet. The neurocranial elements exceed a considerable progress in growth and development than the previous stage due to their anterior and posterior extensions.

The neurocranial base is well chondrified and is represented by the trabeculae cranii anteriorly and the parachordals posteriorly (Figs. 3 A & B, 4A&C and 7A&B). The trabeculae cranii extend forward as two elongated rods situated between the posterior parts of the two eyes (Figs. 3 B and 4C). In lateral view, the trabecula cranii appears as irregular elongated rod which is continuous posteriorly with the corresponding parachordal plate as previously mentioned (Figs. 3A & 7A) in stage 4 mm. In transverse sections, the trabeculae are more or less rounded in shape (Pl. 1 B & C).

The two trabeculae cranii have joined together anteriorly thus forming a short cartilaginous plate representing the trabecula communis (Figs. 3B, 4C and 7B). The latter has its first appearance in this stage and appears as a slightly curved cartilaginous bar with a convex dorsal surface and a concave ventral one lying ventral to the brain (Fig. 3A, 7A and Pl. 1A). Both trabecula cranii and trabecula communis have slightly lower level from that of the parachordals and the occipital plates (Figs. 3A and 7A).

The parachordals are represented by broad plates of cartilage, on both sides of the notochord (Figs. 3B, 4C and Pl. 1D). Anteriorly, they fused with the posterior extremities of the trabeculae cranii and posteriorly with the occipital plates (Figs. 3 A & B, 4C and 7A).

The hypophysial fenestra is now approximately surrounded by cartilage; it is limited anteriorly by the trabecula communis, laterally by the trabeculae cranii and the anterior ends of the parachordal plates and posteriorly is still opened due to the tip projection of the notochord (Figs. 3B, 4C and 7B). The middle part of the fenestra is wider than its anterior and posterior ends.

The two auditory capsules have no major differences than previous stage, except that they are slightly developed and appear as independent kidney-shaped structure (Figs. 3A & B, 4A & C and 7A). The two capsules lie ventro-lateral to the brain representing a part of its side wall (Fig. 4A&B).

The posterior extremities of the chondral neurocranium are narrow and represented by the occipital plates. These plates are now continuous with the parachordal plates and are separated medially by the notochord (Figs. 3A & B, 4A & C, 7A and Pl. 1E).

In this stage, the notochord is extending between the posterior extremities of the two trabeculae, the parachordals and the occipital plates, and has approximately the same thickness along its whole length (Figs. 3B, 4C and 7B).

II. The splanchnocranium:

This stage is the earliest stage at which the elements of the viscerocranium are partially developed in procartilaginous stage.

1. The mandibular arch:

The mandibular arch is represented, on each side, by the palatoquadrate and Meckel's cartilage, which are in procartilaginous state. They are developed independent from each other (Figs. 5A and 7A).

The palatoquadrate appears as an independent slightly curved narrow plate with a relatively narrow anterior end and wide posterior one (Figs. 5A, 6A and 7A). In cross sections the palatoquadrate appears as a short rod lying between the trabecula cranii and Meckel's cartilage (Pl. 1C).

Meckel's cartilage appears laterally as a more or less spoon-shaped with an anterior broad end and a posterior narrow end (Figs. 5A and 7A), lying ventro-lateral and approximately parallel to the trabecula cranii of the neurocranium (Fig. 7A). The two rami of Meckels' elements are represented by slightly short curved rods and are separated anteriorly from each other (Figs. 6A and 7B). In the transverse sections, they appear as two rounded structures (Pl. 1B & C).

In this stage no articulation occurs between Meckel's cartilage and the palatoquadrate, nor between the quadrate and the neurocranium.

2. The hyoid arch:

The hyoid arch is represented by a procartilaginous two paired elements; the hyosymplectics and the hypoceratohyals (Figs. 5B, 6B and

7A&B). The former appears as rounded-shaped, representing hyomandibular process which is free from any articulation with other elements of the neurocranium (Figs. 5B and 7A), with an anterior short process representing the symplectic process which lying just behind and slightly ventral to the posterior part of the palatoquadrate, (Figs. 5B and 7A) and a posterior broad one. In the dorsal view, the hyosymplectic appears, on each side, as a short curved plate (Figs. 6B and 7B). It is interesting to mention that, the two components of the hyosymplectic; the symplectic process and the hyomandibular are arised in continuation with each other (Figs. 5B, 6B and 7A & B). In transverse sections, the hyosymplectic appears as a vertical short rod (Pl. 1D).

The hypoceratohyal appears as a more or less trapezoid shaped, not articulated with any other structure of the hyoid arch (Figs. 5B, 6B and 7A&B). It extends below the hyosymplectic. In cross sections, the hypohyal and the ceratohyal of the hyoid arch are not differentiated and appear as a continuous mass represented by a horizontal short rod; the hypoceratohyal (Pl. 1D).

3. The branchial arches:

The branchial arches are partially developed situated one behind the other in the buccal cavity. They are represented on both side, by three short rods of ceratobranchials lying approximately parallel to each other (Figs. 5C, 6C and 7B). In cross sections the ceratobranchials (I, II) appear as more or less rounded cartilagenous structures (Pl. 1E).

- Stage III (6 mm larva):

I. The neurocranium:

In the present stage, the mouth is just appeared, olfactory organs are formed and the eyes are pigmented. The cartilaginous neurocranium shows a remarkable elongation, enlargment and further development than that of 5 mm larval stage. All parts forming the neurocranium floor, i.e. trabecula communis, trabeculae cranii and the parachordal plates exhibit further increase in length and thickness than the previous stage (Figs. 8 A & B, 9 A & C and 12 A & B).

The trabecula communis has expanded forward into a short flattened cartilaginous plate; ethmoid plate (Figs. 8 A & B, 9 C and 12B) which makes its first appearance in this stage. The external borders of the ethmoid plate, however, extend slightly below the medial borders of the olfactory capsules thus forming a protection for the olfactory organs (Fig.9A&C). In lateral view, such plate appears as a slightly curved rod (Figs. 8A and 12A) lying just below the olfactory organ and project just anterior to the eye (Fig. 9A). In a transverse section, the ethmoid plate appears as a curved narrow cartilaginous plate, which has a slightly dorsal convex surface and a ventral concave one (Pl. 2A).

The auditory capsules of the present stage are more developed than those of the previous one. The auditory capsules are represented by two cartilaginous plates lying ventro-lateral to the brain (Pl. 2E), each of which is connected with the corresponding parachordal plate by means of a basicabsular commissure, i.e. the anterior basicabsular commissure. Thus the posterior comissure is not developed as a

result of the basicapsular fenestra is opened posteriorly (Fig. 8B). The auditory capsule, on each side, projects anteriorly giving a narrow postorbital process just behind the eye region (Figs. 8 A & B,9A,B&C and 12A). The hyomandibular part of the hyoid arch is in contact with the ventro-lateral surface of the auditory capsule (Fig. 12A and Pl. 2E).

The parachordal plates in this stage do not show any major differences than those of previously studied stage except that they increase in length and size. The parachordals are continuous anteriorly with the trabecula communis, laterally with the floor of the auditory capsules and postero-laterally with the occipital arches (Figs. 8 A & B and 9A & C). The latters are remarkably enlarged than those of the previous stage. The bases of the arches are broad while their free ends are slightly narrow (Figs. 8A, 9A and 12A). In transverse section, the parachordals appear as more or less triangular structures (Pl. 2F).

The notochord is still extending between the two parachordals and so it is naked dorsally and ventrally (Figs. 8 B and 9C). The notochord in the present stage shows a gradual decrease in thickness from posterior to anterior. The anterior tip of the notochord is still extended, more or less, anteriorly to project in the hypophysial fenestra (Figs. 8B and 9C).

II. The splanchnocranium:

1. The mandibular arch:

In 6 mm larval stage the two components of the mandibular arch; palatoquadrate and Meckel's cartilage show further elongation in an antero-posterior direction more than the previous one (Figs. 10A, 11A and 12 A & B). Moreover condrification is seen in this arch.

The palatoquadrate extends, in an antero-posterior direction with an anterior narrow tapered tip, i.e. pterygoid process and a posterior relatively wide extremity representing the quadrate and metapterygoid, process (Figs. 10A, 11A and 12A). The latter process lies at a slightly higher level than the former (Fig. 10A and 12A) with a slight sloping upwards (Fig. 12A). It is closely applied to the anterior part of the symplectic process of the hyoid arch (Fig. 12A). The thick part of the palatoquadrate, viz. quadrate part develops a ventral short cylindrical rod representing the apophysis process for the articulation with Meckel's cartilage (Figs. 10A and 12A). In cross sections, the palatoquadrate varies in its shapes; anteriorly and posteriorly. It appears as a more or less oval-shaped representing the pterygoid (Pl. 2C) and metapterygoid processes (Pl. 2E), while medially, the quadrate part is in the form of a more or less hammer-shaped (Pl. 2D).

The two rami of Meckels' cartilages are still separated from each other anteriorly, lying, just in front of the hyoid arch (Figs. 11A and 12B). They appear as oblique elongated rods (Figs. 10A, 11A and 12A & B). The retroarticular process which articulated with the apophysis process of the palatoquadrate appears firstly as a short-posterior process from Meckel's cartilage (Figs. 10 A and 12A). In cross sections, Meckel's cartilage appears anteriorly as a more or less rounded structure

(Pl. 2A & B), however, posteriorly it appears as a triangular structure (Pl. 2C & D).

2. The hyoid arch:

As previously mentioned, the hyoid arch is still incomplete; it is represented by paired hyosymplectics and hypoceratohyals which become chondrified in addition to a median structure, i.e. basihyal which is ventro-median in position and has its first appearance in this stage in a procartilaginous state (Fig. 10B, 11B and 12A&B).

The hyosymplectic has grown in size and length than that of the previous stage. In a lateral view, it appears as a slightly horizontal curved plate differentiated into an upper broad triangular cartilaginous plate, the hyomandibular, and a lower cylindrical symplectic process (Figs. 10B and 12A). The former is pierced by a crescent-shaped foramen through which the truncus hyomandibularis of the facial nerve VII passes out (Figs. 10B and 12A). The hyomandibular lies in contact dorsally with the latero-ventral margin of the auditory capsule of the neurocranium (Fig. 12A). Dorsally and ventrally the hyosymplectic, on each side, appear as two vertical irregular narrow plates parallel to each other and they in turn parallel to the trabeculae cranii and the parachordals of the neurocranium (Figs. 11B and 12B).

The hypoceratohyal shows further growth than that of the previous stage and now is well chondrified. It appears as elongated plate-like structure with approximately the same thickness along its whole length (Figs. 10 B and 12A) but slightly tapering at their anterior ends (Figs. 11B and 12B). The hypoceratohyal, on each side, lying approximately parallel to the ceratobranchials of the branchial arches (Fig. 12B).

Anteriorly the hypoceratohyals lie close to one another on both sides of the basihyal but without any contact (Figs. 11B and 12B).

The basihyal appears as a short procartilaginous rod, lying between the two hypoceratohyals (Figs. 10B, 11B and 12A & B). In cross sections it appears as a rounded piece, lying between the two ceratohyals (Pl. 2E).

3. The branchial arches:

The branchial arches of this stage become chondrified and are represented by four short rods ceratobranchials (I, II, III, IV) and a small rounded ceratobranchial (V) (Figs. 10C, 11C and 12A & B). The first ceratobranchial which is the longest of the series is continuous anteriorly with a broad plate representing the anterior copula (Figs. 11C and 12B). The latter has its first appearance in this stage. The anterior tips of the ceratobrnchials (II, III & IV) converge while the posterior ends diverge (Figs. 11C and 12B). They lying parallel to each other where the length of them decreases from the 2nd to the 4th. In transverse sections, the ceratobranchials appear as more or less small rounded structures observed in the buccopharangeal cavity ventral to the cartilaginous neurocranial base (Pl. 2F).

- Stage IV (7mm larva):

I. The neurocraniuim:

The cartilaginous neurocranium is more advanced than that of the previous stage. It exhibits further increase in length and thickness. Moreover, new cartilages have their first appearance in this stage (Figs. 13A, B & C, 14A, B & C and 17 A& B).

The trabecula cranii and the trabecula communis show no marked differences than those of the previously, described stage except that they have relatively increased in length and width.

In the ethmoid region, the ethmoid plate is broader than before. A dorso-medial small process develops from it giving rise to the internasal septum which ends freely (Figs. 13A & B, 14B, 17A and Pl. 3A).

In the orbito-temporal region of the neurocranium, the taenia marginalis and the epiphysial bridge make their first appearance in this stage and are partially developed (Figs. 13A, B & C and 17A). The taenia marginalis anterior is represented, on each side, by two processes : a small rounded independent cartilage not continuous with the ethmoid plate and a finger-like caudal process which is continuous with the taenia marginalis posterior. The latter appears as a slightly broad process which is continuous with the antero-dorsal edge of the auditory capsule (Figs. 13A, B & C and 17A). In transverse sections, on the other hand, the taenia marginalis appears as a more or less triangular cartilaginous mass situated dorso-lateral to the brain (Pl. 3 C&D).

The epiphysial bridge appears as a narrow incomplete bar projecting from the taenia marginalis over the brain (Figs. 13B and 14B). In lateral view, the epiphysial bridge together with the caudal part of the taenia marginalis anterior and taenia marginalis posterior appear as curved or slightly arched bar (Figs. 13A and 17A).

In comparison with the previous stage, the auditory capsule have considerably enlarged laterally, and ventrally with respect to the whole enlargement of the cartilaginous neurocranium. The lateral wall of the

auditory capsule is irregularly developed (Figs. 13A, 14A and 17A). The roof of the auditory capsule however, is not yet developed, so that the brain and membranous labryinth are still not covered dorsally with cartilage (Figs. 13A & B, 14A & B and 17A). Ventrally, the auditory capsule, on each side, exhibits a new connection with the corresponding parachordal plate representing the posterior basicapsular commissure which is narrower than the anterior basicapsular commissure (Figs. 13B & C and 14C). Thus the basicapsular fenestra which was opened posteriorly in the 6 mm larval stage is closed now and represented by a more or less oval-shaped appearance (Figs. 13 B & C and 14C). The basicapsular fenestra is followed by a more or less inverted pear-shaped foramen; the vagus foramen through which the vagus nerve emerges out of the neuro-cranial cavity (Figs. 13B &C and 14 C). Internally, each auditory capsule is provided with three cartilaginous incomplete semicircular septa; an anterior semicirclar septum, a median semicircular septum and a posterior semicircular septum (Pl. 4A, B & C). Anteriorly the lateral commissure is partially developed, so that the facial fissure is still not covered dorsally with cartilage (Figs. 13 B, C and 14C).

The occipital region consists of two enlarged curved plates supporting the hinder part of the brain (Figs. 13A, B & C and 14 A & B). On each side, the occipital plate fuses with the posterior extremity of the corresponding auditory capsule by its dorsal end. Further posteriorly the occipital plates gradually diminish in extent.

In comparison with 6 mm stage, the anterior tip of the notochord makes further posterior regression as it projects through the posterior part of the hypophysial fenestra (Figs. 13 B & C and 14C).

II. The splanchnocranium:

1. The mandibular arch:

The mandibular arch; by its upper and lower jaws shows further elongation in an antero-posterior direction more than the previous one, 6 mm larval stage, (Figs. 15A, 16A and 17A&B).

The palatoquadrate has increased in length and in width compared with the previous stage. The pterygoid process runs obliquely forward and upwards extending below the olfactory organs, where it articulates laterally with the ethmoid plate (Fig. 17A and Pl. 3A), thus forming an ethmopalatine articulation.

Meckel's cartilage becomes longer and thicker. Posteriorly, it has a small coronoid process which firstly appears in this stage and a retroarticular process which was described previously. Between the two processes a concave surface for the true articulation with the apophysis of the cartilaginous upper jaw (Figs. 15A and 17A). The two Meckels' cartilages are still separate from each other anteriorly, they lie slightly in front of the cartilaginous neurocranium (Fig. 17A & B). In cross sectiosn Meckel's cartilage appears as a more or less oval-shaped cartilaginous structure (Pl. 3A, B & C).

2. The hyoid arch:

The hyoid arch acquired certain changes. It further increases in size, differs in shape and a new element appears which is the interhyal (Figs. 15B, 16B and 17A & B). As a result, it could be stated that the hyoid arch of the present stage is complete and is represented by paired hyosymplectic, interhyal and hypoceratohyal, in addition to a single median basihyal (Figs. 15B, 16B and 17 A & B).

The hyosymplectic has grown in size than that of the previous stage. The dorsal edge of the hyomandibular part is now articulate with the auditory capsule, by an anterior and a posterior neurocranial condyles ***(Barel et al., 1976)*** with a relatively shallow concavity in between (Figs. 15B and 17A). Posteriorly it has a slight projection representing the opercular process, on which the opercular bone articulates (Figs. 15B and 17A). The sympletic portion does not show any major differences as compared with that of the previous stage, except that it slightly increased in length and width and runs ventrally below the posterior part of the palatoquadrate of the mandibular arch (Figs. 15B, 16B and 17A).

The interhyal makes its first appearance in this stage as an independent triangular cartilaginous structure. It is articulated dorsally with the ventral margin of the hyosymplectic and ventrally with the postero-dorsal margin of the hypoceratohyal (Figs. 15 B and 17A). dorsally and ventrally, such structure appears as a more or less trapezaid structure (Figs. 16B and 17B).

The hypohyal is still not distinct from the ceratohyal. Thus in the reconstruction sections, they appear as a cartilaginous mass articulating anteriorly with the basihyal and posteriorly with the interhyal (Figs. 15B, 16B and 17 A & B). The hypoceratohyal appears laterally as flattened cartilaginous plate running approximately horizontally from an antero-medial to a postero-lateral direction (Figs. 15B and 17A). In dorsal and ventral views the two hypoceratohyals of both sides are in the form of two oblique plates making approximately an inverted V-shaped structure and articulated with the basihyal (Figs. 16B and 17B). In cross sections, it appears as a rounded structure anteriorly and being triangular-shaped posteriorly (Pl. 3C & D).

The basihyal has become much longer compared with that of the previous stage. Dorsally and ventrally it is in the form of racket-shaped with a broad rounded rostral end and a narrow slender caudal one (Figs. 16B and 17B). Posteriorly, it is in contact with the developing anterior copula of the branchial arches (Fig. 17B). Laterally it appears as a horizontal elongated rod (Figs. 15B and 17A). In cross sections, it appears as a curved plate with a concave dorsal part and a ventral convex one anteriorly, being pear-shaped with a deep concavity in the lateral surface which receives the anterior end of the hypoceratohyal which is located posteriorly (Pl. 3 B & C).

3. The branchial arch:

One of the characteristic features of the branchial arches of the 7mm stage, is the first appearance of the hypobranchials (I – III) and the epibranchials (I – IV). The Infrapharyngobranchials are not yet developed (Figs. 15C, 16C and 17A & B). Thus, the branchial arches are still incomplete. The arches I-III are represented by hypobranchials, ceratobranchials and epibranchials. However, the fourth arch has no hypobranchial. The fifth arch is represented only by the ceratobranchial (Figs. 15C, 16C and 17A & B).

The hypobranchials I-III are found at a regular manner. The hypobranchials (II-III) articulate medially with the anterior copula (Figs. 16C and 17C), and laterally with the corresponding ceratobranchials where they appear as elongated rods (Figs. 15C, 16C and 17B). The first hypobranchial is in the form of slightly curved rod not articulating with any element of the branchial arch (Figs. 15C, 16C and 17B).

The five pairs of ceratobranchials show a relative increase in size than those of the previous stage. The ceratobranchials I-II are long and are nearly equal in length, but the fifth is the shortest (Figs. 15C, 16C and 17B). Dorsally, they appear as oblique elongated rods (Fig. 16C), and laterally as slightly curved cylindrical rods (Fig. 15C). The ceratobranchial II-III articulate ventrally with the corresponding hypobranchials, while the fourth ceratobranchial articualtes directly with the posterior copula, due to the absence of the fourth hypobranchial (Figs. 15C, 16C and 17B). The fifth ceratobranchials of both sides do not articulate with any median structures. Their free anterior tips face one another, and diverge posteriorly forming together an inverted V-shape (Fig. 16C). The ceratobranchials I-II articulate with the corresponding epibranchials, while the third and fourth ceratabranchials are still separate from the corresponding epibranchials (Fig. 15C). The epibranchials (I, III and IV) appear as slightly curved rods while the second epibranchial is in the form of scythe-shaped (Figs. 15C, 16C and 17A&B).

The anterior copula appears as an independent elongated structure. Its anterior end lies in contact with the posterior extremity of the basihyal (Fig. 16C), it articulates medially with the hypobranchials (II-III). The posterior copula firstly appeared as an elongated rod, which is constricted medially above the site of its articulation with the fourth ceratobranchial (Figs. 16C and 17B).

- Stage V (8mm larva):

I. The neurocranium:

The chondral neurocranium shows relative elongation in length and width. Moreover, it shows several developmental changes as compared with that of the previous stage (Figs. 18A, B & C, 19A, B & C and 22A).

The trabecula cranii and trabecula communis show no marked differences from those of the 7mm stage (Figs. 18 A, B & C, 19C and 22A).

The ethmoid region is more developed than that of the previous stage. The ethmoid plate appears as a thick wide cartilaginous plate (Figs. 18B & C, 19C and 22B). Anteriorly, it is continuous dorso-medially with the internasal septum which extended for a short distance in front of the brain (Figs. 18A, 19B and 22A). This septum is still free from the taenia marginalis anterior, i.e. the sphenoseptal commissure has not yet formed.

In the present stage, the hinder part of the ethmoid plate acquires, on each side, a process which rises upwards to form the lamina orbitonasalis. The latter appears as two small, wings projecting laterally from the ethmoid plate and lying ventral to the olfactory organs and lateral to the eyes (Figs. 18A, B & C, 19C and Pl. 5A). According to ***Holmgren (1943)***, the lamina orbitonasalis originates from a visceral part representing the supra-pharyngopremandibular of the mandibular arch.

In the orbitotemporal region, the taeniae marginales are well developed than those of the previous stage and are extended between the ethmoid and auditory regions of the neurocranium as two longitudinal cartilaginous bars where the rostral and caudal parts of the taenia marginalis anterior have expanded further posteriorly and anteriorly, respectively and are now continuous with each other (Figs. 18A, B & C and 22A). In lateral view, the taeniae marginales show some variation in their shape and size throughout their whole length. Anteriorly they appear in the form of long narrow slightly curved plates and become gradually wide and broad posteriorly (Figs. 18A and 22A). Laterally along the

orbito-temporal region, a wide sphenoidal fenestra (= orbit) exists between the ethmoid region anteriorly and the auditory region posteriorly. This fenestra is bordered ventrally by the trabecula communis and the trabecula cranii and dorsally by the taeniae marginales (Figs. 18A and 22A). The taenia marginalis anterior is connected laterally with the corresponding lamina orbitorasalis by sphenethmoid commissure (Figs. 18B).

The epiphysial bridge of the present stage is completely developed. Medially, the finger-like processes of the epiphysial bridge, on each side, that previously described are now connected with each other forming a transverse cartilaginous epiphysial bridge which forms a part of the neurocranial roof over the brain (Figs. 18A &B, 19A &B, 22A and Pl.5B). Such bridge joins the two taeniae marginales of both sides with each other (Figs. 18B&C, 19B and Pl. 5B).

The epiphysial bridge divides the dorsal neurocranial cavity into two fontanellae: an anterior small fontanella prepinealis and a posterior wide fontanella postpinealis (Fig. 18B). The anterior fontanella is limited anteriorly by the internasal septum, laterally by the taenia marginalis anterior and dorso-lateral borders of the sphenethmoid commissure and posteriorly by the epiphysial bridge. The posterior fontanella, however is limited anteriorly by the epiphysial bridge, laterally by the taenia marginalis posterior and the dorso-lateral borders of the auditory capsules and posteriorly by the tectum synoticum of the auditory capsules (Fig. 18B).

In the present stage the auditory capsules are more developed than previously. The floor of the auditory capsule on each side, is more

developed but is still connected with the corresponding parachordal by means of the anterior and posterior basicapsular commissures (Figs. 18B&C and 19C).

The facial fissure which described previously is now converted into a foramen through which the facial nerve comes out the neurocranium, due to complete development of the lateral commissure (Figs. 18A, B & C and 19A&C). Dorsally, the auditory capsules have further grown over the brain and meet each other medially, forming a tectum synoticum which represents a part of the neurocranial roof (Fig. 18A&B, 19A&B, 22A and Pl. 5D). As previously mentioned, each auditory capsule is provided with three cartilaginous semicircular septa: an anterior, a median and a posterior cartilaginous septa. In this stage, the anterior and posterior septa are complete (Pl. 5D) while the middle one is still incomplete. Laterally, the auditory capsule, on each side, shows a prominent longitudinal cartilaginous swelling representing the crista parotica ***(Daget, 1964 & Verraes, 1973)***, in which the horizontal semicircular canal of the membranous labyrinth fits (Pl. 5D).

The occipital plates show no marked differences than in the 7 mm stage, except that they become further broad and thicker (Figs. 18A & C and 19 A & C). they are still separated by the notochord. Both are continuous ventrally with the neurocranial base and laterally with the auditory capsules (Figs. 18 C and 19C).

II-The splanchnocranium:

A. The mandibular arch:

The mandibular arch by its cartilaginous upper and lower jaws does not show remarkable differences than in the 7mm stage (Figs. 20A,

21A and 22 A & B), except that they become relatively broad and decrease in their length due to cartilage resorption. In dorsal and ventral views, the two rami of Meckel's cartilage lie in contact with each other in front of the hyoid arch (Fig. 21A and 22B), by their anterior ends which are large and triangular in shape (Figs. 21A and 22B).

B. The hyoid arch:

All the constituent parts of the hyoid arch have no considerable differences than previously, except for its relative elongation and thickness. Laterally the rostral and caudal neurocranial condyles of the hyomandibular part of the hyosymplectic become more pointed and the groove in between becomes distinct and much deeper (Figs. 20B and 22A). The symplectic part runs ventrally below the quadrate part and metaptregoid process of the mandibular arch (Figs. 22A and Pl. 5 B & C).

The interhyal appears as a more or less trapizoid shaped structure, articulating dorsally with the postero-ventral margin of the hyomandibular portion of the hyosymplectic and ventrally with the postero-dorsal of the hypoceratohyal (Figs. 20 B, 21 B and 22A&B).

The hypoceratohyal has slightly changed in shape. Its middle part is broad in shape, while its anterior and posterior one, is selender (Fig. 20B). Dorsally and ventrally, the two hypoceratohyals of both sides appear as inverted V-shaped structure with wide anterior end and relatively narrow posterior ones (Figs. 21B and 22B). The hypoceratohyals contact each other anteriorly and are articulated with the medial basihyal above the anterior copula of the branchial arches (Figs. 21B and 22B). In transverse sections, the hypoceratohyal varies in shape; it appears rounded anteriorly (Pl. 5B) and foot-shaped posteriorly (Pl.5C).

The basihyal has the same features described in the previous stage (Figs. 20B, 21B and 22A, B). Laterally it appears as a slightly curved rod lying at a more dorsal level than the symplectic process of the hyosymplectic (Figs. 20 B and 22A).

C. The branchial arches:

The branchial arches are still incomplete. The arches I-IV are represented by hypobranchials, ceratobranchials and epibranchials. The infrapharyngobranchials, however, are still not developed (Figs. 20C, 21C and 22B). The hypobranchials II and III become relatively longer, while the first hypobranchial remains the smallest of the series (Figs. 20C, 21C and 22B). The hypobranchials II and III are more or less short rods in shape while the first is oval in shape. All the hypobranchials articulate laterally with the corresponding ceratobranchials, and medially with the anterior copula (Figs. 20C, 21C and 22B).

The ceratobranchials I-IV show slight elongation in an antero-posterior direction compared with the 7 mm larval stage (Figs. 20 C, 21C and 22B). The first and second pairs of ceratobranchial are more or less equal in length and longer than the third and fourth ceratobranchials. The fifth, however, is the shortest (Figs. 20C and 21C). The ceratobranchials I-III articulate ventrally with the corresponding hypobranchials while the ceratobranchial IV articulates directly with the posterior copula. The fifth ceratobranchial, which is the shortest one lies free from its fellow of the opposite side and the posterior end of the posterior copula (Figs. 21C and 22B).

The first epibranchial is the smallest of the series and appears as a more or less rounded shape. The epibranchials (II, III, IV) appear as

slightly curved rods (Figs. 20C and 21C). The first and second epibranchials articulated with the corresponding ceratobranchials. however, the third and fourth epibranchials free from the ceratobranchials (III, IV) as in the 7 mm stage (Fig. 20C).

The copulae do not show a great difference from the previous stage, except that they increase slightly in length and in thickness (Fig. 21C and 22B). Such copulae (anterior and posterior) extend medially in the floor of the buccopharyngeal cavity to articulate with the hypobranchials I-III and ceratobranchials IV respectively (Figs. 21C and 22B).

- Stage VI (10 mm larva):

I. The neurocranium:

The chondral neurocranium of this stage shows several developmental changes than that of the previous stage, not only in their enlargement in length and size but also cartilage resorption is noticed especially at the level of the neurocranial floor, between the trabeculae and the parachordals. As a results, the continuity of the cartilaginous neurocranial floor, trabecula cranii, which is seen in the previous stage (8 mm stage) is now broken due to the absorption of cartilages (Figs. 23 A, B & C, 24 C and 27A).

The two trabeculae cranii appear as two short rods with posterior pointed end (Figs. 23 A, B & C, 24C and 27A).

The parachordal plates which were separated from each other medially in the previous stage, are now connected together in front of the notochord and as a result a prootic bridge is now formed (Figs. 23 B, C

and 24C). A similar condition has been described in *Anguilla vulgaris (Norman, 1926)*; *Salmo gardneri (Verraes, 1973)* and *Haplochromis elegans (Ismail, 1979)*. Posteriorly, the parachordals are still separated medially by the notochord (Figs. 23 C and 24C) which shows a further regression compared with the previous stage.

The ethmoid region of the neurocranium shows an obvious enlargement compared with the 8 mm stage. The ethmoid plate is continuous dorsally with the internasal septum which extends for a short distance in front of the brain (Figs. 23A&B, 24B, 27A&B and Pl. 6B). The ethmoid plate extends further laterally, thus providing a ventral protection for the olfactory organ, on each side, (Figs. 24 C and Pl. 6B). The postero-lateral sides of the ethmoid plate are raised upwards to form the laminae orbitonasales. The latter appear as two small wings projecting laterally from the ethmoid plat (Fig. 23 B & C). Anteriorly, the ethmoid plate has a concave dorsal surface for receiving a small cartilaginous mass representing the rostral cartilage (Figs. 23 A, B & C, 24 A, B & C, 27A &B and Pl. 6A).

The taeniae marginales, forming the neurocranial lateral wall, on each side, of the orbitotemporal region, are more developed; they are much thicker and wider than those of the previous stage and are connected with the ethmoid region of the neurocranium anteriorly and with the auditory capsule posteriorly (Figs. 23 A, B & C and 27A), thus providing more protection for the brain (Fig. 24B and Pl. 6C).

The taenia marginalis anterior is connected laterally with the corresponding lamina orbitoinasalis by a sphenethmoid commissure (Fig.23A&B). Posteriorly the taenia marginalis anterior is provided with

a narrow foramen (Figs. 23A and 27A). In a lateral view, the taeniae marginales together with the epidphysial bridge appear as arched plate extending between the ethmoid and auditory regions of the neurocranium (Figs. 23 A and 27 A).

The epiphysial bridge has become much thicker and wider compared with those in 8 mm stage (Figs. 23A & B, 24 A &B and 27A). Such a structure with the taeniae marginales appear as H-shape forming the neurocranial roof in the orbitotemporal region over the brain (Fig. 24B).

The auditory capsules show further increase in length and width. They are well developed laterally, dorsally and ventrally. Moreover, they show vacuities resulting from cartilage resorption; that is firstly noticed in this stage (Figs. 23A, B & C, 24 A, B & C and 27A). Ventrally, the basicapsular fenestra seen in the previous stage is now completely invaded by cartilage, leaving only a small foramen for the exit of the glossopharyngeal nerve (Figs. 13C and 14C). As previously mentioned, dorsally, the auditory capsules have further grown over the brain and meet each other medially, forming a tectum synoticum which represents a part of the chondral neurocranial roof (Figs. 23 B, 24B and 27A). In lateral view, it appears as finger-like process parallel to the occipital plate (Figs. 23A, 24A and 27A).

The occipital plate, on each side, showed no marked differences from that of the 8 mm stage, except that they have relatively increased both in length and in width (Figs. 23 A, B & C, 24 A, B & C and 27A).

II. The splanchnorcanium:

1. The mandibular arch:

The constituent elements of the mandibular arch have considerably increased in length and in thickness (Figs. 25A, 26A and 27 A & B). The pterygoid process becomes very long and runs obliquely to articulate with the anterior part of the neurocranium by the ethmopalatine articulation (Figs. 25A, 26A and 27 A & B). The quadrate part is broader than in the 8 mm stage. The posterior part of the palatoquadrate is the broadest process of the cartilaginous upper jaw, the metaptregoid (Figs. 25A, 26A and 27A). Dorsally, it has two processes; an anterior and a posterior one, which may represent the basal and otic process respectively (Fig. 25 A).

The cartilaginous lower jaw becomes more elongated than in the previous stage, (Figs. 25 A, 26A and 27A, B). Anteriorly, the two rami of Meckel's cartilage extend in front of the hyoid arch as narrow curved rods (Figs. 26 A and 27B) with slightly thick posterior ends which articulated with the apophysis of the palatoquadrate (Figs. 25 A and 27A).

2. The hyoid arch:

The hyomandibular part of the hyosymplectic has differentiated into a broad part articulating with the neurocranium and cylindrical narrow shaft which is continuous ventrally with the symplectic process (Figs. 25 B, 26B and 27A). The latter appears as a slightly curved rod and the anterior part of it lies ventral to the posterior process of the palatoquadrate (Figs. 25B, 26B and 27A). The hyomandibular foramen, in this stage, becomes wide due to cartilage resorption (Fig. 25 B and 27A).

The interhyal acquired a more or less rectangular-shaped (Figs. 25 B, 26 B and 27 A, B). As in the previous stage, it articulates with the hyomandibular dorsally and the hypoceratohyal ventrally (Fig. 25B, 26B and 27A).

The hypoceratohyal does not show any major difference than in the previous stage, except that it has relatively increased in length and width. It appears as an elongated rod with a relatively wide anterior and posterior parts, and a narrow middle one (Figs. 25 B, 26 B and 27B).

The basihyal has the same features described in the previous stage. It has slightly increased in length and shows some thickness (Figs. 25B, 26B and 27B). In lateral view, it appears as a slightly curved horizontal rod lying at a more dorsal level than the symplectic process of the hyosymplectic (Figs. 25 B and 27A).

C. The branchial arches:

The branchial arches are composed of five pairs of complete arches, situated one behind the other in the buccal cavity. The first three branchial arches consist each of a hypobranchial, a ceratobranchial, an epibranchial and an infrapharyngobranchial. The fourth pair is represented by a ceratobranchial, an epibranchial and an infrapharyngobranchial. The fifth arch is represented by the ceratobranchial only (Figs. 25C, 26C and 27 A & B).

The hypobranchials I-III have enlarged and slightly changed their shape. The first and second are more or less lozenge in shape, the third is an elongated rod. Medially and laterally, the hypobranchials articulate with the anterior copula and the corresponding ceratobranchials, respectively (Figs. 25C, 26C and 27B).

The ceratobranchials I-V show slightly elongation in an antero-posterior direction. The ceratobranchials I-IV are broad dorsally at their junction with the corresponding epibranchials and narrow ventrally at their articulation with the hypobranchials (Figs. 25C and 27A). The fifth ceratobranchial appear as slightly curved rod. Anteriorly, they articulate with the posterior end of the posterior copula forming together an inverted Y-shape (Figs. 26C and 27B). The most anterior ends of the fifth ceratobranchials are in contact with each other (Figs. 26C and 27B).

The epibranchials I-IV become much more elongated and thicker than in the previous stage (Figs. 25C and 26C). They appear as more or less elongated rods and articulate with the corresponding ceratobranchials laterally and with the infrapharyngobranchials ventrally (Fig. 25 C and 27A). The epibranchial II-III have elongated free anterior end (Fig. 25C).

The infrapharyngobranchials I-IV make their first appearance in the present stage. The fourth is the smallest of the series while the first is the largest (Figs. 25C, 26C and 27A). Laterally, the first infrapharyngobranchial appears a more or less broad plate and articulates laterally with the corresponding epibranchial (Figs. 25C and 27A). The second infrapharyngobranchial is slightly curved rod and articulates laterally with the corresponding epibranchial (Fig. 25C). The third infrapharyngobranchial is a more or less scythe shaped that is directed downwards anteriorly to articulate with the corresponding epibranchial (Figs. 25C and 27A). The fourth infrapharyngobranchial appears triangular-shaped and articulates at its base with the anterior part of the fourth epibranchial (Figs. 25C and 27A). Seen dorsally, the infrapharyngobranchials I-II, appear as broad cartilaginous structures (Fig. 26 C). The third infrapharyngobranchial is a slightly curved rod that

articulates laterally with the corresponding epibranchial. The fourth infrapharyngobranchial has the same shape that described laterally and articulates with the corresponding epibranchial (Fig. 26C). The first infrapharyngobranchial articulates laterally with the first epibranchial and posteriorly with the second epibranchial (Fig. 26C). The second infrapharyngobranchial articulates at its anterior part with the corresponding epibranchial and at its middle and posterior parts articulates with the third epibranchial (Fig. 26C). The third infrapharyngobranchial articulates antero-laterally and postero-laterally with the third and fourth epibranchials, respectively (Fig. 26C).

The anterior copula extends medially in the floor of the buccopharyngeal cavity and articulates with the hypobranchials I-III (Figs. 26C and 27B). Posteriorly, the anterior copula overlaps the anterior end of the posterior copula (Figs. 26 C and 27B). The latter articulates with the posterior part of the hypobranchial III and with the anterior ends of the ceratobranchials IV and V (Figs. 26 C and 27B).