Anatomical Studies on the Cranial Nerves of Fully Formed Embryonic Stage of *Gambusia affinis affinis* (Baird & Girard, 1853) I. The eye muscle nerves and ciliary ganglion

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Abstract: This study deals with the eye muscle nerves and the ciliary ganglion of the bony fish *Gambusia affinis affinis*. The eye muscle nerves include the nervi oculomotorius, trochlearis and abducens. The oculomotor nerve leaves the cranial cavity through its own foramen. It innervates the rectus superior, rectus inferior, rectus medialis and the obliquus inferior muscles. It carries pure somatic motor fibres and visceromotor (parasympathetic) ones. The ciliary ganglion is small and has no radix ciliaris brevis. There is only one ciliary nerve arising from the ciliary ganglion. The radix ciliaris longa originates from the truncus ciliaris. The nervus trochlearis passes outside the cranial cavity through its own foramen. It has no connection with the other cranial nerves. It carries pure somatic motor fibres to the obliquus inferior muscle. The nervus abducens leaves the cranial cavity through its own foramen. It enters the posterior eye muscle canal (myodome) and it has no connection with the other cranial nerves. It carries pure somatic motor fibres to the rectus lateralis muscle.

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1. Introduction

The sensory system of fishes (receptors, their nerves as well as their centres) play a major and sometimes a decisive role in many fish behavioral patterns (feeding, defense, spawning, schooling orientation, migration, etc..).

The study of the cranial nerves is important because their distribution is correlated to the habits and habitats of animals and also because they show an evolutionary trend among the animals of the same group.

Of the very early works done on the cranial nerves of bony fishes were those of Stannius (1849) and Goronowitsch (1888); these classical studies are still useful to investigators. Similar work on the morphology and structure of the cranial nerves in the genus *Pleuronectes* was done by Cole and Johnston (1901). The most valuable works of these early ones were those carried out by Allis (1903, 1909 & 1922) and Herrick (1899 & 1901).

Northcutt and Bemis (1993) on *Latimeria chalumnae*, Piotrowski and Northcutt (1996) on *Polypterus senegalus*, Dakrory (2000) on *Ctenopharyngodon idellus,* Ali (2005) on *Tilapia zilli*, Hussein (2010) on *Mugil cephalus* and Taha (2010) on *Hypophthalmichthys molitrix* have presented detailed works on the morphology of the cranial nerves.

Although the previously mentioned studies of different authors may threw light on the subject of the cranial nerves of fishes, yet it cannot be stated that the cranial nerves of a poeciliid fish is similar to other fishes; and what are the differences if present? Thus it was suggested that a detailed microscopic study on the eye muscle nerves in *Gambusia affins affins* will be very useful.

The main and fine branches of these cranial nerves, their distribution, their relations with other nerves and with the other structures of the head, their analysis and the organs they innervate are studied thoroughly, hoping that they may add some knowledge on this important subject and also to the behaviour and phylogeny of this group of fishes.

2. Material and Methods

The species chosen for this study is the fully formed larvae of *Gambusia affinis affinis* (Mosquito fish) which is a fresh water bony fish. The larvae were fixed in aqueous bouin for 24 hours. After washing several days with 70% ethyl alcohol, the heads were stained with borax carmine method (Galigher & Kozloff, 1964). Decalcification was necessary before sectioning and staining in toto for the speciments. After stainig in toto, the heads were prepared for blocking and then sectioning transversely at 10 micron by microtome. The serial sections were mounted on slides and counterstained in picroindigo carmine. The serial sections were drawn by projector. From these drawings an accurate graphic reconstructions for the eye muscle nerves and the ciliary ganglion are made in a lateral view. Also, parts of certain sections were photomicrographed to demonstrate the relation of these nerves with the other cranial structures.

3. Results

Nervus Oculomotorius

In *Gambusia affinis affinis*, the oculomotor nerve arises from the midlateral side of the mesencephalon by a single root (Figs 1 & 2, RO.III). Immediately after its emergence, it runs anteroventrally within the cranial cavity, passing lateral to the brain, ventral and then ventromedial to the nervus trochlearis and medial to the Gasserian ganglion of the nervus trigeminus. It continues anteroventrally running ventral to the brain and dorsal to both the pleurosphenoid bone and the vena capites lateralis (anterior cardinal vein). Shortly after that, the nervus oculomotorius leaves the cranial cavity and enters the posterior myodome by penetrating the meninx rimitive through its own foramen; the foramen oculomotorium (Fig.4, F.III). Shortly anterior, the nervus oculomotorius divides into a dorsal ramus superior (Figs.1 & 5, R.SP) and a ventral ramus inferior (Figs.1 & 5, R.IF).

Ramus superior

Immediately after its separation from the nervus oculomotorius, the ramus superior (Figs.1 & 6, R.SP) extends anteriorly in a ventromedial direction. It runs dorsal to the ramus inferior of the nervus oculomotorius, dorsomedial to the rectus lateralis muscle and ventral to the lateral edge of the prootic bone. Shortly forwards, it continues passing dorsomedial and then medial to the ramus inferior of the nervus oculomotorius and dorsolateral to the rectus superior muscle (Fig.6, M.RSP). At this position, it divides into two fine branches, one ventral to the other. The ventral branch enters the rectus superior muscle from its dorsolateral side where it ends between its fibres. The dorsal branch enters the latter muscle from its dorsal side and terminates between its fibres.

Ramus inferior

Directly after its separation from the nervus oculomotorius, the ramus inferior (Figs.1,5 & 6, R.IF) extends forwards in a ventromedial direction passing ventral to the ramus superior, dorsomedial to the rectus lateralis muscle and ventrolateral to the rectus superior muscle. Thereafter, it (Fig.7) shifts ventrally passing lateral to the rectus superior muscle (M.RSP) and medial to both the rectus lateralis muscle (M.RL) and the ciliary ganglion (G.CIL).

After a short anterior course, the ramus inferior gives off a ventral branch. This branch (Fig.1, N.OB.IF) runs anteriorly in a ventromedial direction passing medial to the ciliary ganglion then to the rectus lateralis muscle and ventromedial to the rectus superior muscle. Shortly forwards, it becomes ventral to the main ramus inferior and ventromedial to the ciliary ganglion, the rectus lateralis, the rectus superior and the rectus inferior muscles. Thereafter, it shifts medially in an anterior direction being ventral to the rectus inferior muscle, ventrolateral to the rectus medialis muscle and dorsal to the levator arcus rimitiv muscle. This branch continues its course surrounded by the rectus medialis muscle dorsolaterally, the rectus inferior muscle ventrolaterally and the levator arcus rimitiv muscle ventrally. More forwards, this brach becomes dorsomedial to the rectus inferior and the rectus medialis muscles and medial to the eye. After a long anterior course, it becomes lateral to the levator arcus rimitiv muscle and dorsal to the rectus medialis muscle. Finally, it enters the obliquus inferior muscle from its dorsolateral edge and terminates between its fibres (Fig.1, N.OB.IF).

Shortly, anterior to the origin of the previous branch, the ramus inferior extends more forwards running medial to the ciliary ganglion, ventrolateral to the rectus superior muscle, medial to the rectus medialis muscle and dorsolateral to the rectus inferior muscle where it divides into two branches, one lateral and the other medial (Fig.1).

The lateral branch (Fig.1, N.RIF) extends anteriorly in a ventromedial direction passing lateral and then ventral to the medial branch and medial to the ciliary nerve. Thereafter, it continues running anteriorly being ventrolateral to the medial branch and lateral to the rectus inferior muscle. Finally, the lateral branch enters the latter muscle from its ventrolateral side where it achieves its final distribution.

The medial branch (Fig.1, N.RM) runs forwards in a dorsomedial direction extending medial and then dorsal to the lateral branch and ventromedial to the rectus superior muscle. Shortly anterior, it passes dorsomedial to both the ciliary nerve and the rectus inferior muscle and ventromedial to the rectus superior muscle. After that, this branch shifts dorsomedially passing ventral to the rectus superior muscle and dorsal to the rectus inferior muscle. Directly after that, it reaches the lateral side of the rectus medialis muscle where it enters and ends between its fibres.

Ciliary Ganglion

In *Gambusia affinis affinis*, the ciliary ganglion (Figs.1, 6 &7, G.CIL) is an oval shaped structure, consisting of a collection of ganglionic cells. It lies in the posterior part of the orbital region. The ganglion (Figs. 6 & 7, G.CIL) is surrounded by the rectus lateralis muscle laterally (M.RL), the ramus inferior of the nervus oculomotorius (R.IF) medially, the ramus superior of the nervus oculomotorius (R.SP) dorsally and the adductor hyomandibularis muscle (M.ADHY) ventrally. It measures about 40 mm in length. The light microscopic examination indicated that the latter ganglion consists of peripheral large neurons and central small ones (Fig. 7).

The ciliary ganglion is commonly described as possessing three roots; a motor (parasympathetic), a sensory and a sympathetic. The first root carries preganglionic parasympathetic (rimiti-motor) fibres which arise in the midbrain. These fibres, as it has long been known, constitute the tectal portion of the cranial outflow of the parasympathetic system. The preganglionic parasympathetic fibres are transmitted to the ciliary ganglion by way of the nervus oculomotorius, with or without a special root; the radix ciliaris brevis. They terminate in the ganglion in synaptic relationship with the postganglionic cell bodies. The sensory root of the ganglion consists of sensory components of the ramus profundus of the nervus trigeminus. These fibres enter the ganglion by means of a long branch; the radix ciliaris longa. The sympathetic root is composed of the postganglionic sympathetic fibres which originate in the the most anterior head (trigeminal or facial) sympathetic ganglion. Such fibres are carried to the ciliary ganglion by a fine branch; the sympathetic root. Both the sensory and postganglionic sympathetic fibres usually pass through the ganglion without interruption and become incorporated in the ciliary nerves arising from it.

In the present study, the ciliary ganglion and the ramus inferior of the nervus oculomotorius are in immediate connection; the radix ciliaris brevis is lacking (Figs.1&7). The microscopic investigation reveals that the preganglionic parasympathetic fibres leave the ramus inferior and directly enters the ganglion at the point of attachment between them. Such fibres constitute the parasympathetic (general motor) root of the ganglion.

In this study, the ciliary ganglion receives a long radix ciliaris longa (Figs. 1 & 7, RCL). This branch arises from the profundal ganglion of the nervus profundus and extends anteriorly in the ventromedial direction along the ventrolateral wall of the vena capitis lateralis and enters the ganglion from its dorsolateral corner (Fig. 7). The radix ciliaris longa receives the most anterior sympathetic fibres arising from the trigeminal sympathetic ganglion to carry them to the ciliary ganglion.

In this work, there is a single ciliary nerve (Figs.1 & 9, N.CIL) arising from the anterior end of the ciliary ganglion. This nerve extends forwards in a lateral direction, being ventral to the rectus superior muscle, medial to the ramus inferior of the nervus oculomotorius and then lateral to the rectus inferior muscle and medial to the eyeball. Shotly anterior, it shifts and becomes dorsal to the latter muscle, ventrolateral to both the rectus medialis muscle and the optic nerve and medial to the eyeball (Fig. 9, N.CIL). Finally, it enters the eyeball just posteroventral to the optic nerve.

Nervus Trochlearis

In *Gambusia affinis affinis*, the nervus trochlearis arises from the lateral side of the midbrain just anterior and dorsal to the origin of the nervus trigeminus, by a single small root (Figs.1 & 8, RO.IV). This root extends anteriorly within the cranial cavity in a ventrolateral direction passing ventral then lateral to the brain and dorsal to the trigeminal nerve (Fig. 2, N.IV). Shortly forwards, it becomes ventral to the ganglion of the anterodorsal lateral line nerve and medial to the membranous labyrinth (anterior semicircular canal). Thereafter, the nervus trochlearis continues forwards running ventrolateral to the brain and ventromedial to the auditory capsule (Fig.4, N.IV). On reaching the postorbital region, it stills intracranially extending medial to the supraorbital cartilage and lateral to the brain. After a considerable anterior course in the orbital region, it leaves the cranial cavity by penetrating the meninx rimitive through its own foramen (Fig.9, F.TR).

Extracranially, the nervus Trochlearis runs forwards dorsal to the eyeball, ventromedial to the supraorbital cartilage and lateral to the cranial wall. Thereafter, it continues its course dorsomedial to the rectus superior muscle and dorsolateral to the cranial wall. Then, it becomes dorsal and then medial to the latter muscle. On reaching the mid-way of the orbital region, it continues running in a dorsolateral direction being dorsal to the obliquus superior muscle and ventromedial to the supraorbital lateral line pit. More forwards, it continues its course passing dorsomedial to the obliquus superior muscle and ventromedial to the supraorbital cartilage. Finally, it enters and ends between the fibres of the latter muscle (Fig.1).

Nervus Abducens

In *Gambusia affinis affinis*, the nervus abducens originates from the ventrolateral corner of the medulla oblongata by a single fine root just medial to the origin of the anterior octaval root (Figs.1 & 10, RO.VI). Directly after its origin, it starts its intracranial forward course passing ventrolaterally being medial to the nervus octavus. Shortly forwards, this nerve continues passing medial to the lagena and dorsal to the lateral margin of the prootic bridge which forms the roof of the posterior myodome (posterior eye muscle chamber).

After a considerable anterior course, the nervus abducens leaves the cranial cavity by piercing the meninx rimitive through a foramen in the lateral margin of the prootic bridge (Fig. 3) passing ventral to the geniculate ganglion and dorsomedial to the truncus hyomandibularis then enters the posterior myodome (Fig. 4, PM), which lodges the rectus lateralis muscle. Within the myodome, it ramifies and enters the rectus lateralis muscle where it terminates (Fig. 4).

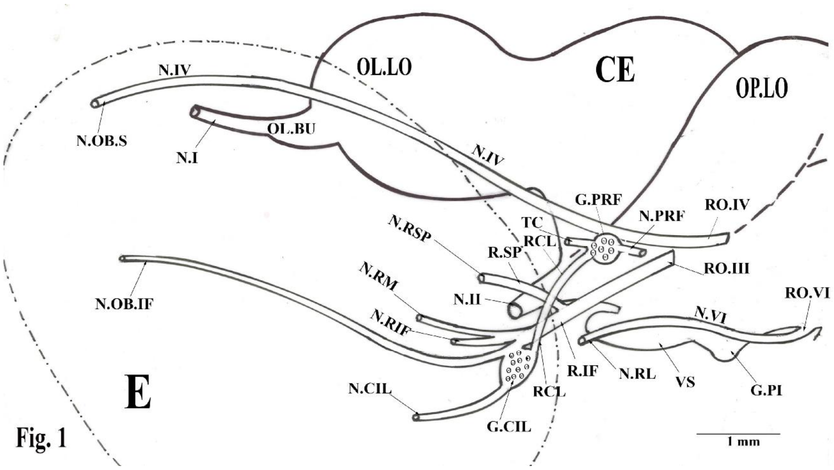
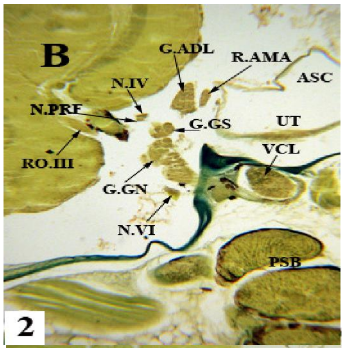


Fig. 1

Fig.1: Lateral view of a graphic reconstruction of the nervi oculomotorius, trochlearis, abducens and the ciliary ganglion of *Gambusia affinis affinis*.



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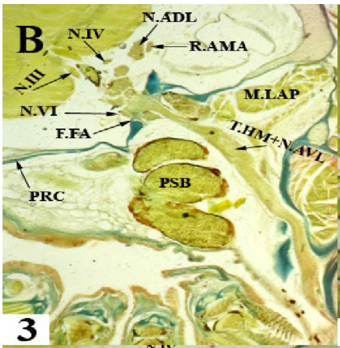

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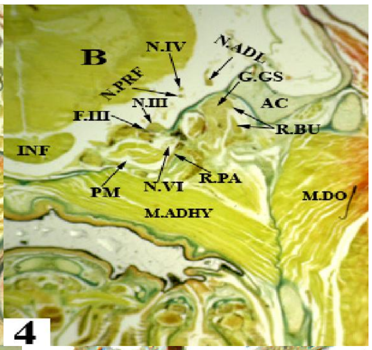

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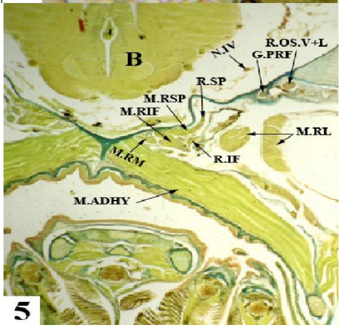

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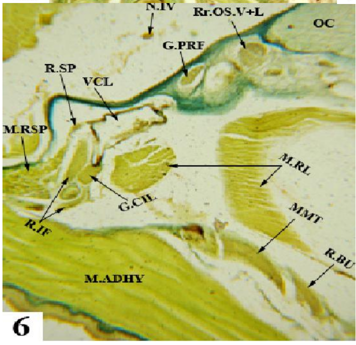

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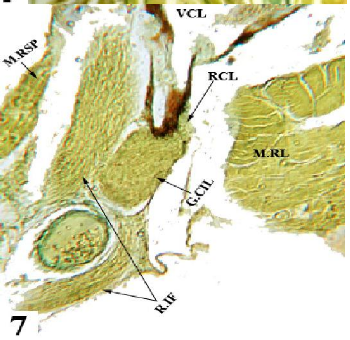

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Fig.2: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the otic region, showing the root of the nervus oculomotorius and the nervi profundus, trochlearis and abducens. It also demonstrates Gasserian ganglion, geniculate ganglion, ramus ampullaris anterior of the octavus nerve.

Fig.3: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the otic region, illustrating the nervi oculomotorius, anterior lateral line, trochlearis and abducens.

Fig.4: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the otic region, demonstrating the oculomotor foramen, nervi profundus and trochlearis, the nervus abducens within the posterior myodome.

Fig.5: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the postorbital region, showing the division of the nervus oculomotorius into rami superior and inferior, nervus trochlearis and profundal ganglion.

Fig.6: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the postorbital region, nervus trochlearis, profundal ganglion, illustrating the position of the ciliary ganglion.

Fig.7: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the postorbital region, demonstrating the structure of the ciliary ganglion and the radix ciliaris longa entering the ganglion.

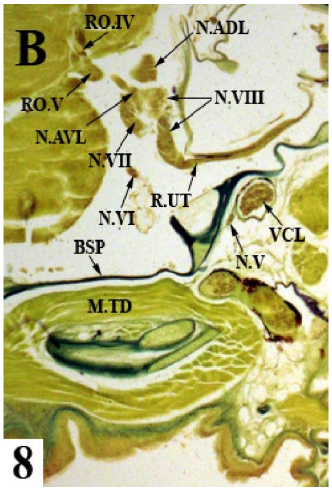

Fig.8: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the otic region, the root of the nervus trochlearis arising from the brain.

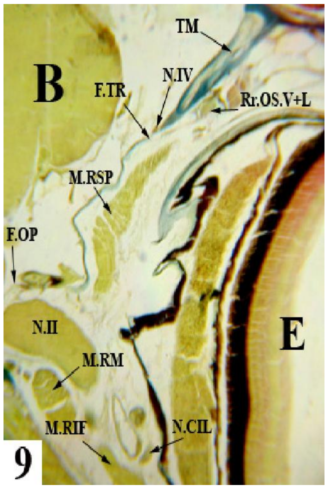

Fig.9: A photomicrograph of part of transverse section of *Gambusia affinis affinis* passing through the orbital region showing the trochlear foramen and the ciliary nerve.

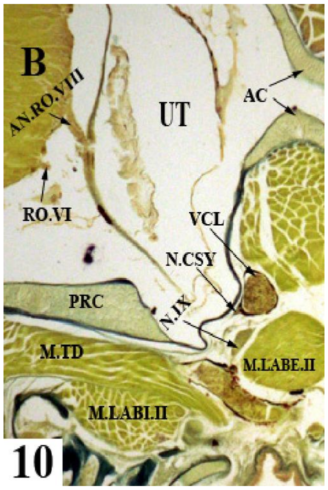

Fig.10:A photomicrograph of part of transvers section of *Gambusia affinis affinis* passing through the otic region, illustrating the origin of the root of the nervus abducens from the medulla oblongata.

LIST OF ABBREVIATIONS

AC: Auditory capsule; **AN.RO.VIII**: Anterior root of the nervus octavus; **B:** Brain; **BSP**: Basisphenoid bone; **CE**: Cerebral hemisphere; **E**: Eye; **F.FA**: Facial foramen; **F.III**: Oculomotor foramen; **F.OP**: Optic foramen; **F.TR**: Trochlear foramen; **G.ADL**: Anterodorsal lateral line ganglion; **G.CIL**: Ciliary ganglion; **G.GN**: Geniculate ganglion; **G.GS**: Gasserian ganglion; **G.PI**: Pituitary gland; **G.PRF**: Profundal ganglion; **INF**: Infundibulum; **MMT**: Maxillo-mandibular trunk; **M.ADHY**: Adductor hyomandibularis muscle; **M.AMM**: Adductor mandibularis medius muscle; **M.DO**: Dilator opercularis muscle; **M.LABE.II**: Second levator arcualis branchialis externus muscle; **M.LABI.II**: Second levator arcualis branchialis intrnus muscle; **M.LAP**: Levator arcus palatini muscle; **M.RIF**: Rectus inferior muscle; **M.RL**: Rectus lateralis muscle; **M.RM**: Rectus medialis muscle; **M.RSP**: Rectus superior muscle; **M.TD**: Transversus dorsalis muscle; **N.ADL**: Anterodorsal lateral line nerve; **N.AVL**: Anteroventral lateral line nerve; **N.CIL**: Ciliary nerve; **N.CSY**: Cranial sympathetic nerve; **N.I**: Nervus olfactorius; **N.II**: Nervus opticus; **N.III**: Nervus oculomotorius; **N.IV**: Nervus trochlearis; **N.IX**: Nervus glossopharyngeus; **N.OB.IF**: Nerve to the obliquus inferior muscle; **N.OB.S**: Nerve to the obliquus superior muscle; **N.PRF**: Nervus profundus; **N.RIF**: Nerve to the rectus inferior muscle; **N.RL**: Nerve to the rectus lateralis muscle; **N.RM**: Nerve to the rectus medialis muscle; **N.RSP**: Nerve to the rectus superior muscle; **N.V**: Nervus trigeminus; **N.VI**: Nervus abducens; **N.VIII**: Nervus octavus; **OL.BU**: Olfactory bulb; **OL.LO**: Olfactory lobe; **OP.LO**: Optic lobe; **PM**: Posterior myodome; **PRC**: Prootic cartilage; **PSB**: Pseudobranch; **RCL**: Radix ciliaris longa; **R.AMA**: Ramus ampullaris anterior; **R.BU**: Ramus buccalis; **R.IF**: Ramus inferior; **R.SP**: Ramus superior; **R.OSL**: Ramus ophthalmicus superficialis lateralis; **R.OS.V+L**: Ramus ophthalmicus superficialis trigeminus and lateralis; **R.PA**: Ramus palatinus; **R.SP**: Ramus superior; **R.UT**: Ramus utriculus; **RO.III**: Root of the nervus oculomotorius; **RO.IV**: Root of the nervus trochlearis; **RO.V**: Root of the nervus trigeminus; **RO.VI**: Root of the nervus abducens; **Rr.OS.V+L**: Rami ophthalmicus superficialis trigeminus and lateralis; **T.HM+N.AVL**: Truncus hyomandibularis and anteroventral lateral line nerve; **TC**: Truncus ciliaris; **TM**: Taenia marginalis; **UT**: Utriculus; **VCL**: Vena capitis lateralis; **VS**: Vascular sac.

4. Discussion

In the present study, the nervus oculomotorius shows no decussation near its origin in the brain. A complete decussation for the nervus oculomotorius within the brain was observed by Dakrory (2000) in *Ctenopharyngodon idellus*, Ali (2005) in *Tilapia zillii*, Hussein (2010) in *Mugil cephalus* and Taha (2010) in *Hypophthalmichthys molitrix*. The nervus oculomotorius gets its exit from the cranial cavity through its own foramen, the foramen oculomotorius. This condition was found also in many cartilaginous fishes (Chandy, 1955; Hamdy, 1959; El-Toubi and

Hamdy, 1959 &1968; Gohar and Mazhar, 1964; Hamdy and Khalil, 1970; Hamdy and Hassan, 1973; Khalil, 1978 & 1979a &b; Mazhar, 1979; Dakrory, 2000).

Among bony fishes, the nervus oculomotorius was found to issue from the cranial cavity through its own foramen as in *Ailia* (Srinivasachar, 1956), *Amphipnous cuchia* (Saxena, 1967), *Trichiurus lepturus* (Harrison, 1981), *Ctenopharyngodon idellus* (Dakrory, 2000) , *Tilapia zillii* (Ali, 2005) and *Hypophthalmichthys molitrix* (Taha, 2010). However, the nervus oculomotorius was found to leave the cranial cavity together with the nervi Opticus, trigeminus, abducens and facialis through a large sphenoid fissure in 29 mm *Arius jella* and 16 mm *Plotosus canius* (Srinivasachar, 1959). In *Clarias batrachus* (Dalela and Jain, 1968), the nervus oculomotorius was found to emerge from the cavum cranii together with the nervi trochlearis, trigeminus, abducens and facialis through the foramen prooticum. In *Polypterus senegalus*, the nervus oculomotorius leaves the cranium, together with the profundus nerve through a single foramen. This finding may be related to the absence of the true pila prootica (El-Toubi and Abdel-Aziz, 1955; Piotrowski and Northcutt, 1996). On the other hand, in *Gnathonemus petersii* (Szabo *et al*., 1987), the oculomotor nerve is divided within the cranial cavity into two branches, which enter the orbit separately, *i.e.,* there are two foramina for the nervus oculomotorius.

In the present work, the oculomotor foramen is located between the lateral edge of the prootic bone medially and the pleurosphenoid bone laterally. This result is similar to the finding of Ali (2005) in *Tilapia zilli*. Different localities for the oculomotor foramen were described in other fishes by some authors. This foramen was found in the lateral ethmoid bone in *Amphipnous cuchia* (Saxena, 1967), in the basisphenoid bone in *Trichiurus lepturus* (Harrison, 1981), in the orbitosphenoid bone in *Polypterus senegalus* (Piotrowski and Northcutt, 1996) or surrouned by the pleurosphenoid bone in *Ctenopharyngodon idellus* (Dakrory, 2000) and in *Hypophthalmichthys molitrix* (Taha, 2010). However, Ray (1950) described a special oculomotor foramen in the membranous cranial wall of the orbitotemporal region in *Lampanyctus leucopsarus*, while Srinivasachar (1956) described this foramen in the preoptic root of the orbital cartilage in *Ailia*.

In the jawless fishes, Johnels (1948) described an optic fenestra through which emerge the optic and the three eye muscle nerves from the cranial cavity in *Petromyzon*. However, Jollie (1968) described a separate oculomotor foramen in lampreys. The author added that this may confluent with a large optic foramen located anterior to it. On the other hand, the three eye muscle nerves along with their muscles are lacking in the hagfishes (Jollie, 1968; Northcutt, 1985; Wicht, 1996). Fernholm and Holmberg (1975) stated that the hagfishes have relatively small eyes, and there was tendency toward eye reduction. Parallel with these results, Wicht (1996) recorded that the external eye muscles as well as the accompanying nerves are entirely lacking in all species of hagfishes even in that retained relatively large and differentiated eyes as in *Eptatretidae*.

In Amphibia, the oculomotor nerve has its own foramen as described by many authors (Sokol, 1977 & 1981; Mostafa and Soliman, 1984; Shaheen, 1987). However, in *Rhyacotriton olympicus* (Srinivasachar, 1962), the optic and the oculomotor nerves pass together through a common foramen.

In the present investigation, the nervus oculomotorius is divided extracranially into two rami, the ramus superior and the ramus inferior. This case was agreed with what was generally found in most fishes such as *Ctenopharyngodon idellus* (Dakrory, 2000), *Tilapia zillii* (Ali, 2005) and *Hypophthalmichthys molitrix* (Taha, 2010). However, in the teleosts *Gnathonemus petersii* (Szabo *et al*., 1987) and *Alticus kirkii magnosi* (Ali and Dakrory, 2008) the nervus oculomotorius is divided intracranially into a posterior branch to the rectus superior muscle and an anterior branch to the other three muscles. In *Lampanyctus leucopsarus* (Ray, 1950), the division of the nervus oculomotorius into its two rami is in the oculomotor foramen.

The studied species showed no connection between the nervus oculomotorius and other cranial nerves. This observation was similar to that found in *Tilapia zillii* (Ali, 2005), *Alticus kirkii magnosi* (Ali and Dakrory, 2008), *Mugil cephalus* (Hussein, 2010) and *Hypophthalmichthys molitrix* (Taha, 2010). However, the connection between the nervus oculomotorius and the nervus trigeminus was recorded among bony fishes. In *Polypterus senegalus*, this nerve joins the profundus nerve (El Toubi and Abdel-Aziz, 1955). In the same species, however, two connections between these two nerves were found by Piotrowski and Northcutt (1996). In *Ctenopharyngodon idellus* (Dakrory, 2000) the nervus oculomotorius is connected to the trigeminal ganglion through a fine anastomosing branch. In *Gnathonemus petersii* (Szabo *et al*., 1987), the oculomotor nerve anastomoses with the ophthalmic branch of the trigemino-lateral line complex. Earlier, an anastomosis between the nervus oculomotorius and the nervus trochlearis was found in *Pleuronectes* (Cole and Johnstone, 1901) and between this nerve and the nervus abducens in *Cyclothone acclinidens* (Gierse,1904). However, Marathe (1955), Dakrory (2000), Ali (2005) and Taha (2010) revealed no connections between the nervus oculomotorius and both the nervi trochlearis and abducens in *Pseudorhombus arsius*, *Ctenopharyngodon idellus*, *Tilapia zillii* and *Hypophthalmichthys molitrix*, respectively.

An anastomosis between the nervus oculomotorius and other cranial nerves seems to be widely spread among Amphibia, Reptilia, Aves and Mammalia. With respect to amphibians, the nervus oculomotorius is connected with both Gasserian ganglion and the ramus ophthalmicus profundus as in *Bufo viridis* and *Bufo regularis* (Paterson, 1939; Soliman and Mostafa, 1984; Shaheen, 1987).

The ciliary ganglion of the fish *Gambusia affinis affinis* is found in the postorbital region of the head, this finding was also reported by Dakrory (2000) in both *Ctenopharyngodon idellus* and *Rhinobatus halavi* and in *Gambusia affinis affinis*, *Tilapia* and *Mugil cephalus* (Dakrory, 2003) , *Tilapia zillii* (Ali, 2005), *Alticus kirkii magnosi* (Ali and Dakrory, 2008) , *Mugil cephalus* (Hussein, 2010) and *Hypophthalmichthys molitrix* (Taha, 2010). Among bony fishes, a distinct ciliary ganglion was also described in the perciform *Pseudorhombus arsius* (Marathe, 1955), *polycentrus schomburgkii* (Freihofer, 1978), *Trichiurus lepturus* (Harrison, 1981) and in the cladistian, *Polypterus senegalus* (Piotrowski and Northcutt, 1996), in *Ctenopharyngodon idellus* (Dakrory, 2000) and in *Tilapia* and *Mugil* (Dakrory, 2003).

In cartilaginous fishes, the ciliary ganglion was observed by Young (1988) in dog fish *Mustelus* and in skates and rays. However, the ciliary ganglion was completely lacking in *Salmo* and *Cyclothone acclinidens* (Gierse, 1904), in *Dipnoi* (Jenkin, 1928) and in the ray fish *Dasyatis rafinesque* (Chandy, 1955). Again, Burr (1933) denied the presence of the ciliary complex in *Opistroproctus soleatus*, but he found a ganglion on the third cranial nerve.

In Amphibia, the ciliary ganglion seems to be absent or transitory. It was found to be absent in *Amblystoma punctatum* (Herrick, 1894), *Amphiuma means* (Norris, 1908) while it was only transitional and non-functional in *Amblystoma tigrinum* (Coghill, 1902; Kuntz, 1914). In *Rana bedriagie*, the ciliary ganglion is poorly developed (Dakrory, 2002). However, Mostafa and Soliman (1984) described a ciliary ganglion of two parts in *Bufo viridis*.

In the current study, the ciliary ganglion consists of two types of neurons, large neurons at the periphery and small ones at the central region. Such case was recorded in both the batoid *Rhinobatus halavi* and the cyprinid *Ctenopharyngodon idellus* (Dakrory, 2000), *Tilapia zilli* (Ali, 2005) and in *Hypophthalmichthys molitrix* (Taha, 2010). The same structure was also recorded in many reptiles by many authors such as Dakrory (2009) reported in *Uromastyx aegyptius* and *Sphenops sepsoides* and Omar (2009) in *Agama sinaita* and in birds (Oehme, 1968; Soliman *et al*., 1976). In mammalia, the ganglion is formed of one type of neurons (Stefani, 1972; Hegazy and Mostafa, 1990). On the other hand, the ganglion of the bony fishes *Mugil cephalus* (Dakrory, 2003 & Hussein, 2010) and *Alticus kirkii magnosi* (Ali and Dakrory, 2008) showed no regional differentiation, i.e. it consists of one type of neurons. However, in the birds studied by Soliman *et al*., (1976) and Abdel-Kader and Fathy (2002), the ciliary ganglion consists of two parts, the first is composed of small neurons and the second is composed of large ones.

In general, the ciliary ganglion has three roots; sensory, sympathetic and parasympathetic (motor) roots. The sensory root of the ganglion consists of sensory components of the ramus ophthalmicus profundus of the nervus trigeminus and these fibres enter the ganglion by the way of the radix ciliaris longa. The sympathetic root is formed of the postganglionic fibres that arise from the facial sympathetic ganglion and they are transmitted to the ciliary ganglion via the sympathetic root. The motor (parasympathetic) root of the ganglion is composed of the preganglionic fibres that originate in the brain and transmitted to the ciliary ganglion by the way of the nervus oculomotorius through the radix ciliaris brevis.

In the present study, the sensory root, the radix ciliaris longa, originates from the profundal ganglion of the nervus trigeminus. Also, it was reported that the radix ciliaris longa originates from the profundus ganglion in *Polypterus senegalus* (Piotrowski and Northcutt, 1996) and in *Mugil cephalus* (Dakrory, 2003). On the other hand, the radix ciliaris longa was found to arise from Gasserian ganglion in the batoid *Rhinobatus halavi* and the cyprinid *Ctenopharyngodon idellus* (Dakrory, 2000). It was found by some authors that it arises from the truncus ciliaris profundus of the nervus trigeminus as mentioned in *Lampanyctus leucopsarus* (Ray, 1950), *Tilapia zilli* (Ali, 2005), *Alticus kirkii magnosi* (Ali and Dakrory, 2008) and *Hypophthalmichthys molitrix* (Taha, 2010).

In the present work, there is no sympathetic connection between the ciliary ganglion and the anterior sympathetic head ganglion. Similar condition was found in *Pseudorhombus arsius* (Marathe, 1955), *Polypterus senegalus* (Piotrowski and Northcutt, 1996), *Alticus kirkii magnosi* (Ali and Dakrory, 2008) and in *Hypophthalmichthys molitrix* (Taha, 2010). Similarly, Cyclostomata lack such system (Walker, 1987). In Amphibia, this connection was not cited in the literature (Mostafa and Soliman, 1984; Shaheen, 1987; Dakrory, 2002). Also, the cartilaginous fishes lack the head sympathetic system (Chandy, 1955; Walker, 1987; Young, 1988; Dakrory, 2000).

Among bony fishes, the sympathetic root originates from the facial sympathetic ganglion. Such condition was reported in *Lampanyctus leucopsarus*

(Ray, 1950), *Trichiurus lepturus* (Harrison, 1981), *Ctenopharyngodon idellus* (Dakrory, 2000), *Mugil cephalus* (Dakrory, 2003) and in *Hypophthalmichthys molitrix* (Taha, 2010). However, in *Uranoscopus* (Young, 1931) and in *Polycentrus schomburgkii* (Freihofer, 1978), the sympathetic fibres pass from the trigeminal sympathetic ganglion and fuse with the ciliary nerve distal to the ciliary ganglion. On the other hand, such sympathetic root or connection was absent in the dipnoian *Lepidosiren paradoxa* (Jenkin, 1928), *Pseudorhombus arsius* (Marathe, 1955) and in *Polypterus senegalus* (Piotrowski and Northcutt, 1996). Also the cartilaginous fishes lack the head sympathetic system (Chandy, 1955; Walker, 1987; Young, 1988; Dakrory, 2000). Again cyclostomes lack such system (Walker, 1987). In Amphibia, there is no mention of this connection in the literature cited (Mostafa and Soliman, 1984; Shaheen, 1987; Dakrory, 2002).

In the present investigation, there is no radix ciliaris brevis and the motor component of the nervus oculomotorius is transmitted directly to the ganglion from the ramus inferior. A similar finding was reported among bony fishes by Dakrory (2000 &2003) in the cyprinid *Ctenopharyngodon idellus* and in *Mugil cephalus*, respectively, by Ali and Dakrory (2008) in *Alticus kirkii magnosi* and by Taha (2010) in *Hypophthalmichthys molitrix*. On the other hand, a well-developed motor root, the radix ciliaris brevis, was observed in *Lampanyctus leucopsarus* (Ray, 1950*), Polypterus senegalus* (Piotrowski and Northcutt, 1996) and in *Tilapia zillii* (Ali, 2005).

Among Chondrichthyes, Young (1988) and Dakrory (2000) reported that the motor root from the oculomotor nerve joins a sensory one from the trigeminal nerve then it enters the ganglion. A radix ciliaris brevis was found in some reptiles (Soliman and Hegazy, 1969; Abdel-Kader, 1990; Omar, 2009), in some birds (Soliman *et al*., 1976) and in some mammals (Godinho, 1972; Hegazy and Mostafa, 1990). From the above mentioned observation, it appears that the parasympathetic fibres (the motor root) of the nervus oculomotorius may or may not form a separate branch, radix ciliaris brevis, which enters the ganglion or it is found on the ramus inferior without any communicating branch.

In the present study, one ciliary nerve arises from the ciliary ganglion. The number of ciliary nerves is variable in vertebrates. The presence of one ciliary nerve appear to be a common character among bony fishes as in *Trichiurus lepturus* (Harrison, 1981), in *Polypterus senegalus* in (Piotrowski and Northcutt, 1996), in the cyprinid *Ctenopharyngodon idellus* (Dakrory, 2000), in *Mugil cephalus* (Dakrory, 2003), in *Alticus kirkii magnosi* (Ali and Dakrory, 2008) and in *Hypophthalmichthys molitrix* (Taha, 2010). On the other hand, there is one ciliary nerve arising from the ophthalmicus profundus nerve and not from the ciliary ganglion as in the ray *Dasyatis refinesque* (Chandy, 1955).

In the current study, the poeciliid fish *Gambusia affinis affinis* shows that in addition to the ciliary nerve, a truncus ciliaris profundus enters the eyeball through a foramen excavated in the dorsal side of the sclera just ventral to the obliquus superior muscle. This finding shows that the eye is accommodated by both the ciliary nerve and the truncus ciliaris. Therefore, this reflects the fact that the eye is well developed in the studied fish and this fish depends on vision during its feeding. So, it may be considered as a diurnal animal. A similar observation was found also by Young (1988), Ali (2005) in *Tilapia zillii* and Taha (2010) in *Hypophthalmichthys molitrix*. In *Polypterus senegalus*, Piotrowski and Northcutt (1996) described two ciliary nerves.

In cartilaginous fishes, Kent (1978) stated that the postganglionic fibres penetrate the sclera and pass to the sphincter pupillae and the ciliary muscle of the iris diaphragm. The author added that the bony fish lack the ciliary muscles but there is a special compound, Campanula Halleri, was found which draw the lens backwards for accommodation. Young (1988) concluded that the Campanula Halleri or retractor lentis muscle is innervated through the oculomotor nerve and the ciliary ganglion.

Among Amphibia, there are two ciliary nerves in *Bufo viridis* (Mostafa and Soliman, 1984) and *Rana bedriagie* (Dakrory, 2002). On the other hand, there is no ciliary ganglion and consequently, no ciliary nerve was present in some other amphibians (Norris, 1908; McKibben, 1913; Paterson, 1939; Shaheen, 1987).

In the present study, the nervus trochlearis emerges from the cranial cavity through a special foramen, the trochlear foramen that located in the pleurosphenoid bone. This is the case found in some fishes such as *Parasilurus asotus* (Atoda, 1936), *Lampanyctus leucopsarus* (Ray, 1950), *Polypterus senegalus* (El-Toubi and Abdel-Aziz, 1955; Piotrowski and Northcutt, 1996), *Amphipnous cuchia* (Saxena, 1967), *Trichiurus lepturus* (Harrison, 1981), in the cyprinid fish *Ctenopharyngodon idellus* (Dakrory, 2000), *Tilapia zillii* (Ali, 2005), *Alticus kirkii magnosi* (Ali and Dakrory, 2008) and *Hypophthalmichthys molitrix* (Taha, 2010). However, Srinivasachar (1959) showed that there is a large sphenoid fissure for the emergence of the nervi II-VII in the 29 mm larva of *Plotosus canis*. In *Clarias batrachus*, there is a common foramen for the exit of the nervi oculomotorius, trochlearis, abducens and the trigemino-facial complex (Dalela and Jain, 1968). In the Goldfish, *Carassius auratus*, the nervus trochlearis leaves the braincase together with the ramus ophthalmicus superficialis through an opening on the optic tectum

(Puzdrowski, 1987). Nakae and Sasaki (2006) reported that the trochlear nerve in *Mola mola* emerges from the cranium through the anterior part of the suture between the pterosphenoid and basisphenoid.

Among cartilaginous fishes, the nervus trochlearis leaves the cerebral cavity through its own foramen, the trochlear foramen (Chandy, 1955; El-Toubi and Hamdy, 1959 & 1968; Hamdy and Hassan, 1973; Mazhar, 1979; El- Satti, 1982; Dakrory, 2000). In the cyclostomates *Petromyzon*, the nervus trochlearis leaves the cranial cavity together with the optic, oculomotor and abducens nerves through the optic fenestra (Johnels, 1948). On the other hand, Jollie (1968) reported a special foramen for the trochlear nerve in lampreys.

In most amphibians, the trochlear nerve exits the cerebral cavity through a special foramen (Herrick, 1894; Norris, 1908; Stadtmuller, 1925; Aoyama, 1930; de Beer, 1937; Paterson, 1939; Sokol, 1977 & 1981; Mostafa and Soliman, 1984; Shaheen, 1987; Trueb and Hanken, 1992; Haas, 1995; Dakrory, 2002). In most cases, this foramen is found in the orbital cartilage. However, Van Eeden (1951) mentioned that the trochlear foramen, in *Ascaphus truei*, does not pierce the orbital cartilage at all; but the nervus trochlearis passes over its margin. This author added that *Ascaphus truei* shares this feature with some Urodela. Sokol (1977) reported that the trochlear foramen in the anuran *Pipa cadvalhoi* is very small and presumably lies above the oculomotor foramen as in other tadpoles. In this respect, the trochlear foramen *Amblystoma punctatum* (Herrick, 1894) and *Necturus* (McKibben, 1913) was found to be located in the parietal bone. Sheil (1999), dealing with *Pyxicephalus adspersus*, stated that the trochlear foramen is located ventral to the lamina perpendicular to the frontoparietal bone or pierces it. On the other hand, a large optic-prootic foramen, for the exit of the nervi II-VII was described by Trueb and Cannatella (1982) in *Rhinophrynus dorsalis* and *Pipa pipa*. Haas and Richard (1998) revealed that the nervi opticus and trochlearis leave the cranial cavity together through a large foramen opticum in Boophis.

In the present study, there is no decussation of the left and right trochlear nerves inside the brain. This finding was in agreement with that reported by Ali (2005) in *Tilapia zilli* and by Ali and Dakrory (2008) in *Alticus kirkii magnosi*. However, there a complete trochlear decussation of the left and right trochlear nerves inside the brain as reported in *Gnathonemus petersii* (Szabo *et al*., 1987), *Polypterus senegalus* (Piortrowski and Northcutt, 1996), in both the batoid *Rhinobatus halavi* and in the cyprinid *Ctenopharyngodon idellus* (Dakrory, 2000), in *Mugil cephalus* (Hussein, 2010) and in *Hypophthalmichthys molitrix* (Taha, 2010).

The present investigation shows no connection between the nervus trochlearis and the other cranial nerves. This observation was in agreement with the result recorded in *Rhinobatus halavi* and *Ctenopharyngodon idellus* (Dakrory, 2000), *Tilapia zillii* (Ali, 2005, *Alticus kirkii magnosi* (Ali and Dakrory, 2008) and *Hypophthalmichthys molitrix* (Taha, 2010). An anastomosis between the nervus trochlearis and the nervus trigeminus is widely found among fishes. Such anastomosis was mentioned with the mandibular branch of the trigeminal-lateral line complex in *Gnathonemus petersii* (Szabo *et al*., 1987) and with the profundus nerve in *Polypterus senegalus* (Piotrowski and Northcutt, 1996). The connection between the trochlear nerve and the trigemino-facial ganglion was previously observed by Atoda (1936) in *Parasilurus asotus*. A connection between the nervus trochlearis and the ramus lateralis accessorius was recorded by Herrick (1899) in *Menidia*.

Among amphibians, the nervus trochlearis was found to anastomose with the ramus ophthalmicus profundus of the nervus trigeminus in *Amblystoma punctatum* (Herrick, 1894), *Xenopus laevis* (Paterson, 1939) and in *Bufo regularis* (Shaheen, 1987). However, such a connection is not found in *Amblystoma tigrinum* (Coghill, 1902) and in *Bufo viridis* (Mostafa and Soliman, 1984).

Generally and as presented in the current study, the nervus trochlearis innervates the obliquus superior muscle; a finding which was reported also by many authors (Kassem *et al*., 1988; Bauchot *et al.*, 1989; Dakrory, 2000; Ali, 2005; Nakae and Sasaki, 2006; Taha, 2010).

It is clear from the detailed anatomical study of the serial sections of the head of the fish *Gambusia affinis affinis* that the nervus trochlearis carries special somatic motor fibres.

In this work, the nervus abducens of the studied poeciliid fish arises from the medulla oblongata by a single root. This is the same condition observed in *Argyropelecus hemigymnus* (Handrick, 1901), *Scomber scomber* and *Scorpaena scrofa* (Allis, 1903 & 1909), *Cyclothone acclinidens* (Gierse, 1904), *Tetrodon oblongus* (Bal, 1937) *Lampanyctus leucopsarus* (Ray, 1950), *Dasyatis rafinesque* (Chandy, 1955), *Polypterus senegalus* (El-Toubi and Abdel-Aziz, 1955), in *Nadus nadus* (Saxena, 1969), *Ctenopharyngodon idellus* (Dakrory, 2000), *Tilapia zillii* (Ali, 2005) and *Alticus kirkii magnosi* (Ali and Dakrory, 2008). On the other hand, the nervus abducens arises by two roots, as it was found by Stannius (1849) in *Cottis* and *Trigla*, Herrick (1899 & 1901) in *Menidia* and *Ameiurus melas*, respectively, Allis (1909) in both *Lepidotrigla* and adult *Scorpaena scrofa*, Pancratz (1930) in *Opsunus tau*, Atoda (1936) in *Parasilurus asotus*, Harrison (1981) in *Trichiurus lepturus* and by Bauchot *et al.*

(1989) in *Chaetodon trifasciatus*. In the fish *Tridentiger trigonocephalus*, Kassem *et al*. (1988) stated that the abducens nerve has only one root, but further down the nerve divides into two distinct fascicles, which innervate two distant regions of the lateral rectus muscle. In this respect, Harder (1975) concluded that a double root is considered to be standard for teleosts. However, multiple roots were described for the nervus abducens in *Amia calva*, *Palydon spathula*, *Scphirynchus platorhynchus* and *Lepidosteus platostomus* (Norris, 1925), in the dipnoan *Latimeria chalumnae* (Northcutt *et al*., 1978) and in *Polypterus senegalus* (Piotrowski and Northcutt, 1996).

Among the cartilaginous fishes, it has been found by some authors that the nervus abducens arises by a single root as in *Dasyatis rafinesque* (Chandy, 1955), in *Hydrolague* (Jollie, 1968) shark *Squalus acanthias* this nerve arises by two roots (Norris and Hughes, 1920; Jollie, 1968). In Amphibia, the nervus abducens arises by one root (Mostafa and Soliman, 1984; Shaheen, 1987; Dakrory, 2002).

The present study shows that the nervus abducens emerges from the cranial cavity through a foramen in the lateral margin of the prootic bridge. This case is in agreement with what was reported by Ali (2005) in *Tilapia zillii* and Ali and Dakrory (2008) in *Alticus kirkii magnosi*. This case is also found in agreement with that observed in the cartilaginous fishes such as *Chlamydoselachus anguineus* (Allis, 1923), *Rhinobatus halavi*, *Rhynchobatus djiddensis* and *Trygon kuhlii* (El-Toubi and Hamdy, 1959), *Rhinoptera bonus's* (Hamdy, 1960), *Aetamylus milvus* (Hamdy and Khalil, 1970), *Torpedo ocellata* (Hamdy and Hassan, 1973), *Trygon postinaca* (Khalil, 1979b), *Squatina oculata* and *Rhinoptera jayakari* (El-Satti, 1982) and *Rhinobatus halavi* (Dakrory, 2000). It was also found that the nervus abducens leaves the cranial cavity through a foramen excavated between the prootic bridge and the prootic cartilage in *Hypophthalmichthys molitrix* (Taha, 2010). However, among bony fishes, the exit of the nervus abducens from the cranium was observed through a special foramen as in *Trichiurus lepturus* (Harrison, 1981) and in *Ctenopharyngodon idellus* (Dakrory, 2000). On the other hand, El-Toubi and Abdel-Aziz (1955) and Piotrowski and Northcutt (1996), dealing with *Polypterus senegalus*, revealed that the nervus abducens emerges from the cranial cavity together with the nervus trigeminus through the trigeminal foramen. In *Clarias batrachus*, the nervus abducens issues from the cerebral cavity together with the trigeminofacial complex, through the foramen prooticum (Dalela and Jain, 1968). In addition, Saxena (1967) showed that the nervus abducens runs out of the cranial cavity together with the nervus opticus, through one foramen located in the lateral ethmoid bone in *Amphipnous cuchia*.

In jawless fishes, the nervus abducens emerges from the cerebral cavity together with the optic, oculomotor and trochlear nerves, through the optic fenestra (Johnels, 1948). On the other hand, Jollie (1968) reported that in lampreys the nervus abducens passes out the cranium together with the trochlear and trigeminal nerves through a large opening in the lateral side of the skull. However, Kent (1978) stated that lampreys seem to lack an abducens nerve or may be represented by small bundle emerging from the hind brain on the anterior surface of the trigeminal nerve.

Regarding the emergence of the nervus abducens from the cerebral cavity in Amphibia, it was found that this nerve passes with the nervus trigeminus, through the foramen prooticum (Sokol, 1977 & 1981; Mostafa and Soliman, 1984; Shaheen, 1987; Reiss, 1997; Dakrory, 2002). However, Haas (1995) showed that the nervus abducens in *Colostethus nubicola*, *Colostethus subpunctatus*, *Epipedobates tricolor* and *Phyllobates bicolor*, leaves the cranial cavity through a fissure prootica. On the other hand, Trueb and Cannatella (1982) described a single foramen "optic- prootic foramen" for the exit of the optic, oculomotor, trochlear, trigeminal, abducens and facial nerves in *Rhinophrynus dorsalis* and *Pipa pipa*.

In this study, the nervus abducens shows no connection with other cranial nerves. This is the case, which was mentioned in many fishes (Allis, 1903; Bal, 1937; Ray, 1950; El-Toubi and Abdel-Aziz, 1955; Chandy, 1955; Saxena, 1967 & 1969; Harrison, 1981; Dakrory, 2000; Ali, 2005; Ali and Dakrory, 2008). However, two connections between the nervus abducens and the profundus nerve were recorded by Piotrowski and Northcutt (1996) in *Polypterus senegalus*.

In Amphibia, the nervus abducens passes through the Gasserian ganglion without any interchange of fibres. It leaves this ganglion with the ramus ophthalmicus profundus with which it is merged (Herrick, 1894; Coghill, 1902; Norris, 1908; Wiedersheim, 1909; Paterson, 1939; Mostafa and Soliman, 1984; Shaheen, 1987).

Generally and in the present work, the nervus abducens, as in all vertebrates, innervates the rectus lateralis (externus) muscle. This condition was reported by many authors in some fishes (Bauchot *et al*., 1989; Dakrory, 2000; Ali, 2005; Nakae and Sasaki, 2006; Ali and Dakrory, 2008; Taha, 2010). In *Tridentiger trigonocephalus*, Kassem *et al*. (1988) stated that the rectus externus muscle consists of two kinds of fibres and is innervated by two distinct nerve bundles. However, in *Latimeria chalumnae* (Northcutt and Bemis, 1993) and in many tetrapoda, it innervates the rectus externus and the retractor oculi muscles. In Cyclostomata, Edgeworth (1935) stated that the nervus abducens innervates the rectus externus and the rectus externus inferior muscles. Fritzsch *et al*. (1990) found that two of the six ocular muscles are innervated by the nervus abducens in *Petromyzon marinus*. Pombal *et al*. (1994) confirmed this finding.

The rectus lateralis muscle is located within the posterior myodome (the eye muscle chamber). Some authors recorded the presence of this myodome in *Ctenopharyngodon idellus* (Dakrory, 2000) and *Tilapia zilli* (Ali, 2005).

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