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RESEARCH ARTICLE

Anatomical studies on the cranial nerves of fully formed embryonic stage of Gambusia affinis affinis (Baird & Girard, 1853). II. Nervus glossopharyngeus

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Abstract

The organization of the roots, ganglia and the peripheral distribution of the glossopharyngeal nerve in the fully formed embryos of *Gambusia affinis affinis* are examined in serial transverse sections. The analysis of the fibres carried by this nerve is studied. The results of this study demonstrated that the nervus glossopharyngeus arises by one root and leaves the cranial cavity through the jugular foramen. It has an extracranially petrosal ganglion. This nerve has two rami; ramus pretrematicus and ramus posttrematicus. There is no ramus pharyngeus. The ramus pretrematicus carries general viscerosensory fibres. The ramus posttrematicus carries both general viscerosensory fibres and special ones and also carries visceromotor fibres.

Introduction

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.

It is clear from the available literature on the cranial nerves of teleosts that there are few investigations were performed on the members of family Poecilidae. Generally in fishes, early studies were done by some authors on cranial nerves of bony fishes (Allis, 1909 & 1922; Herrick, 1900 & 1901). Recently, the cranial nerves of some teleosts were studied by some authors such as Freihofer (1978) on Polypterus schomburgkii, Harrison (1981) on Trichiurus lepturus, Northcutt and Bemis (1993) on Latimeria chalumnae, Piotrowski and Northcutt (1996) on Polypterus senegalus, Dakrory (2000) on Ctenopharyngodon idellus, Ali (2005) on Tilapia zillii, Nakae and Sasaki (2006) on Mola mola, Hussein (2010) on Mugil cephalus and Taha (2010) on Hypophthalmichthys molitrix. Other studies were performed on one cranial nerve or a group of cranial nerves in some other bony fishes. Kassem et al. (1988) and Bauchot et al. (1989) gave an account on the eye muscles nerves in Chaetodon trifasciatus and Tridentiger trigonocephalus, respectively. In addition, De Graaf (1990) studied the innervation of gills in Cyprinus carpio by dissection.

The most recent studies performed on bony fishes are presented by some other authors such as Dakrory (2003) who studied the ciliary ganglion and its anatomical relations in some bony fishes. Sneddon (2003) examined the trigeminal somatosensory innervation of the head of a teleost fish, *Oncorhynchus mykiss*. In addition, Kerem et al. (2005) described somatotopic organization of the trigeminal ganglion cells in a cichlid fish, *Oreochromis niloticus*. Meader (2005) gave an account on the innervation of the muscle of accommodation in the eye of the teleost fish, Holocentrus ascensionis. Ali and Dakrory (2008) studied the eye muscle nerves of Alticus kirkii magnosi.

It is evident from the the *aforementioned* historical review that there are numerous studies performed on the cranial nerves of bony fishes; however few studies were done on the cranial nerves of members belonging to family Poeciliidae. Therefore, the present study aimed to show the anatomy of the glossopharyngeal nerve of one species belongs to this family. Also, it is very important to make a full analysis for this nerve, its distribution and its relation with the other structures of the head.

MATERIALS 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 Grenscher borax carmine (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 sectioned 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 reconstruction for the glossopharyngeal nerve is made in a lateral view. Also, parts of certain sections were photomicrographed to demonstrate the relation of this nerve with the other cranial structures.

RESULTS

In *Gambusia affinis affinis*, the nervus glossopharyngeus (Figs. 1 & 2, RO.IX) originates from the dorsolateral side of the medulla oblongata by means of one root. After its origin from the medulla oblongata, the nervus glossopharyngeus runs posteriorly, within the cranial cavity. It passes (Fig. 2) medial and then ventromedial to the ramus ampullaris posterior (R.AM.PO) and the posterior lateral line nerve (N.PLL), dorsomedial to the membranous labyrinth (LG), dorsal to the lagenar ramus (R.LG) and lateral to the medulla oblongata (B). Shortly backwards, it (Fig. 3, N.IX) becomes ventrolateral to the root of the nervus vagus (RO.X), ventromedial to both the ramus ampullaris posterior (R.AM.PO) and the posterior lateral line nerve (N.PLL) and dorsal to the membranous labyrinth. It continues running posterolaterally together with the nervus vagus and the posterior lateral line nerve for a considerable distance. After this course, it shifts ventrally to become dorsal to the inner ear, ventromedial to the nervus vagus and ventral to the posterior lateral line nerve. Shortly after that, it continues passing ventral to both the vagus and the posterior lateral line nerves within the capsular cavity. Thereafter, the nervus glossopharyngeus leaves the cranial cavity together with the vagal nerve through the jugular foramen. This foramen is located in the anterior part of the exoccipital bone (Fig. 4, F.JU).

Immediately outside the cranial cavity, the nervus glossopharyngeus (Figs.1 & 4, N.IX) begins its anterior course passing medial to the nervus vagus (N.X), dorsomedial to the common ganglion of the third branchial vagal and visceral trunks (G.EPB.3+VS) and dorsal to the vena capitis lateralis (VCL). It continues anteromedially passing dorsomedial to the vena capitis lateralis and ventral to the exoccipital bone for a long distance. During this course, it anastomoses with a branch of the cranial sympathetic nerve (Figs.1 & 3). More forwards, it becomes dorsomedial, medial and then ventromedial to the vena capitis lateralis and dorsolateral to the first internal levator arcus branchialis muscle. Here, it separetes from the head sympathetic nerve. Directly after that, the glossopharyngeal nerve enters the petrosal (epibranchial) ganglion (Figs.1 & 5, G.PE). This ganglion (Fig. 5) is triangular in the transverse sections and lies ventromedial to the vena capitis lateralis (VCL), dorsomedial to the first branchial vagal trunk, dorsolateral to the second internal levator arcus branchialis muscle (M.LABI.II), ventral to the cranial sympathetic nerve (N.CSY) and dorsomedial to the second external levator arcus branchialis muscle (M.LABE.II).

The nervus glossopharyngeus arises from the anterior end of the petrosal ganglion as one trunk (Fig.1, N.IX). This trunk runs forwards passing dorsomedial to the second external levator arcus branchialis muscle, ventromedial to both the vena capitis lateralis and the cranial sympathetic nerve and ventrolateral to the cranial wall. Shortly forwards, the nervus glossopharyngeus (Fig.1, N.IX) gives off a medial branch to innervate the transversus dorsalis muscle (Fig.1, N.TD). More forwards, it gives off a lateral branch (Fig.1, N.LABE.I) to the first external levator arcus branchialis muscle. Thereafter, the nervus glossopharyngeus passes between the first internal and external levator arcuale branchiale muscles laterally and the circus cephalicus medially. Here, it gives off a motor branch for the first internal levator arcus branchialis muscle (Fig.1, N.LABI.I). Shortly after that, it becomes lateral to the circus cephalicus, dorsomedial and then dorsal to the first adductor arcus branchialis muscle, ventrolateral to the first external levator arcus branchialis muscle and ventromedial to the first internal levator arcus branchialis muscle. Here, the nervus glossopharyngeus turns posteriorly to run in a posterolateral direction. Directly after that, it gives off a fine motor nerve for the first adductor arcus branchialis muscle (Fig.1, N.ADAB.I) and numerous fine posterior branches to innervate the dorsal gill filaments of the first holobranch (Fig.1, Nn.GF). Here, it divides into two main rami; the ramus pretrematicus IX (Fig.1, R.PR.IX) and the ramus posttrematicus IX (Fig.1, R.PT.IX).

Ramus Pretrematicus IX

After its separation from the posttrematic ramus IX, the ramus pretrematicus IX (Fig.1, R.PR.IX) runs anteriorly in a ventral direction. It penetrates the fibers of the first adductor arcus branchialis muscle to become medial to the first epibrancial cartilage and lateral to the gill rackers. It (Fig. 6, R.PR.IX) runs forwards for a long distance dorsal to the first ceratobranchial cartilage (CB.I) and ventral to the gill rackers (GR) giving rise to several fine branches to the epithelium and the taste buds of the dorsal margin of the gill arch (Fig.1, Nn.TB+EPI). Thereafter, the ramus pretrematicus IX gives off several fine branches to the gill rackers of the first holobranch in this region (Fig.1, Nn.GR). More forwards, the ramus pretrematicus IX (Fig.1, R.PR.IX) continues running anteriorly in the same position for a long distance, giving off numerous fine branches to the taste buds (Fig.1, Nn.TB). Finally, it ends as many fine nerves in the gill rackers and taste buds of the first holobranch at the anterior end of this region.

Ramus Posttrematicus IX

After the separation of the ramus posttrematicus IX (Figs.1 & 6, R.PT.IX) from the pretrematic ramus IX, the former directly gives off numerous fine branches to the gill filaments (Fig.1, Nn.GF) of the first holobranch. Directly anterior to these branches, the main ramus posttrematicus IX extends ventrally passing dorsolateral to the ceratobranchial cartilage, dorsal to the first efferent branchial vessel and lateral to the first adductor arcus branchialis muscle. It penetrates the latter muscle and becomes medial to the gill filaments of the first holobranch, ventrolateral to the first adductor arcus branchialis muscle and lateral to the efferent branchial vessels. Here, it gives off a medial branch to innervate the first adductor arcus branchialis muscle (Fig.1, N.ADAB.I). Shortly anterior, it gives off a ventral branch which ramifies to innervate the gill filaments and their muscles at the apex of the holobranch (Fig.1, N.GF). Thereafter, the ramus posttrematicus IX (Fig. 7, R.PT.IX) runs anteriorly passing ventrolateral to the first ceratobranchial cartilage (CB.I) and lateral to the first efferent branchial vessel (EB.I). It runs for a long distance in this position giving off many branches to the muscles and epithelium of the gill filaments (Fig.1, Nn.GF).

More forwards, the ramus posttrematicus IX (Figs.1 & 7, R.PT.IX) extends ventrolateral and then ventral to the first ceratobranchial cartilage (CB.I) and dorsal to the first afferent branchial vessel (AB.I). Here, it gives off several branches to the gill filaments (Fig.1, Nn.GF). Thereafter, it continues forwards in the medial direction passing ventral to the ceratobranchial cartilage and dorsal to the first afferent branchial vessels till it becomes ventromedial to the latter cartilage. Here, it gives off many fine nerves to the gill filaments (Fig.1, Nn.GF) and their muscles. More forwards, it shifts more medially to enter the isthmus passing ventral to the hypobranchial bone and dorsal to the first obliquus ventralis muscle. Here, it gives off a fine branch for this muscle (Fig.1, N.OV.I). Finally, it runs anteromedially passing through the hypobranchial to extend dorsal to it and ventral to the epithelial lining giving rise to many fine nerves to the isthmus. It continues forwards till it enters the tongue where it ends in its epithelium (Fig.1).

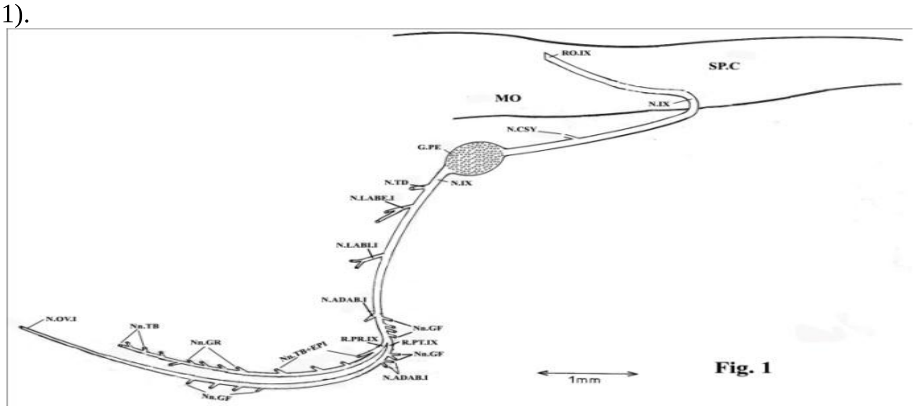
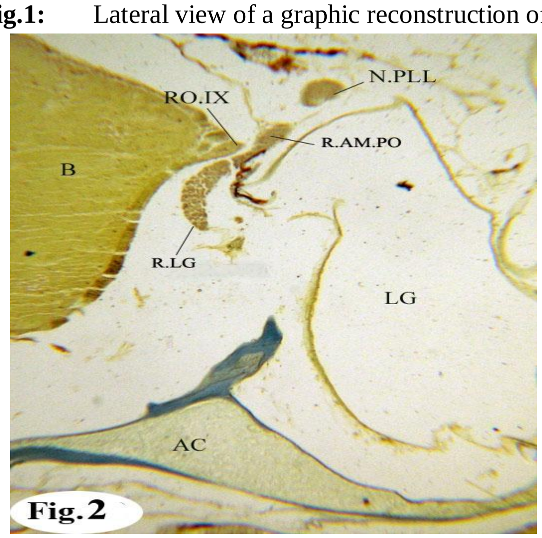


Fig.1: Lateral view of a graphic reconstruction of the glossopharyngeal nerve of *Gambusia affinis affinis*.



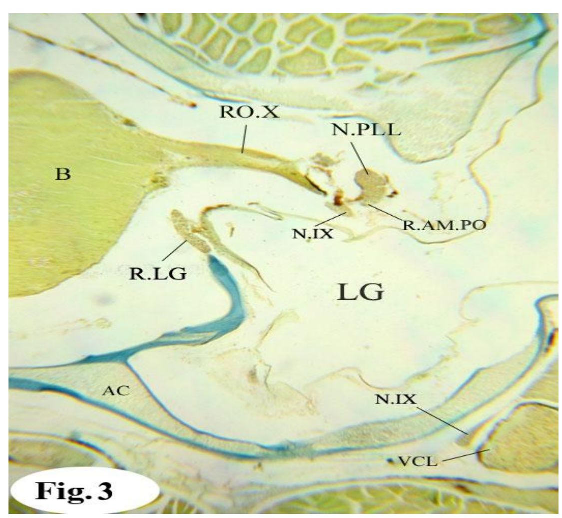
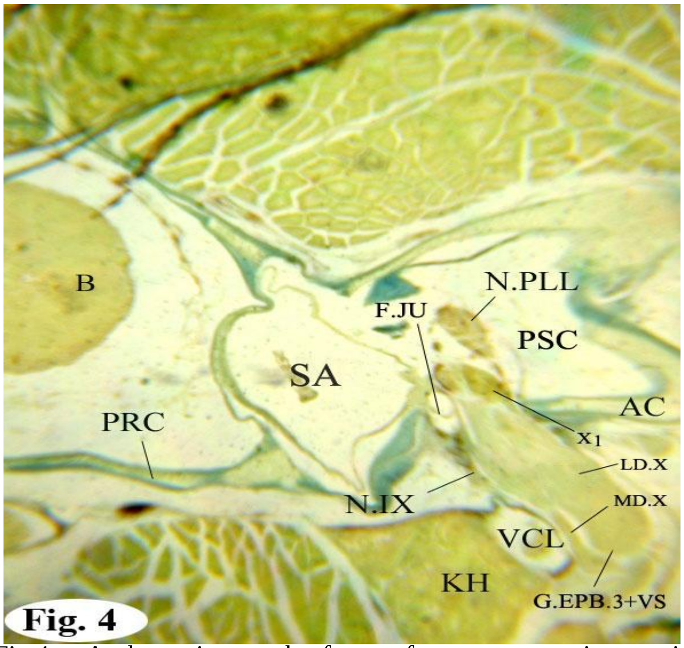


Fig.2: A photomicrograph of part of transverse section passing through the otic region of *Gambusia affinis affinis* demonstrating the root of the nervus glossopharyngeus, the lagenar ramus, the ramus ampullaris posterior and the posterior lateral line nerve.

Fig.3: A photomicrograph of part of transverse section passing through the otic region of *Gambusia affinis affinis* illustrating the course of nervus glossopharyngeus through otic capsule, the root of the nervus vagus, posterior lateral line nerve, the ramus ampullaris posterior and the lagenar ramus.



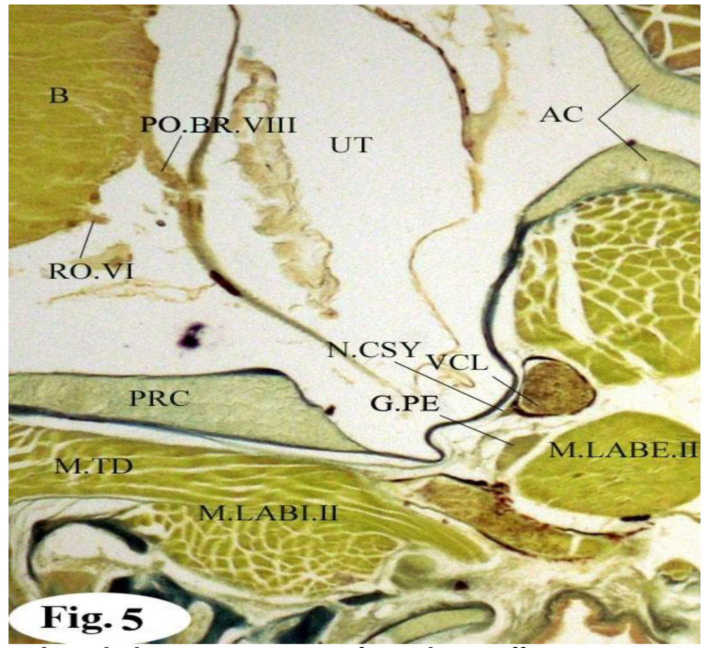
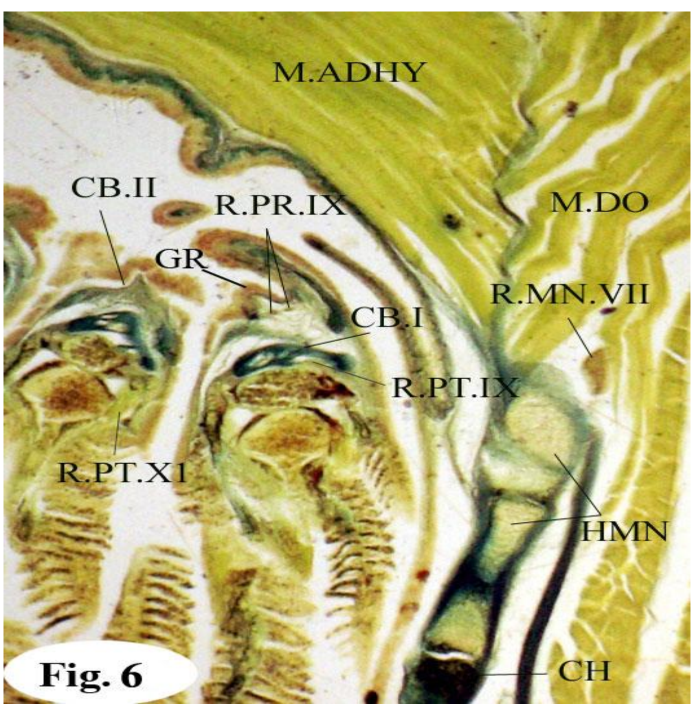


Fig.4: A photomicrograph of part of transverse section passing through the postotic region of *Gambusia affinis affinis* showing the exit of the nervus glossopharyngeus through the jugular foramen, the first branchial vagal trunk, the posterior lateral line nerve and the Common ganglion of the third branchial vagal and visceral trunks.

Fig.5: A photomicrograph of part of transverse section passing through the otic region of *Gambusia affinis affinis* demonstrating the petrosal ganglion, the posterior octaval branch, the root of the nervus abducens and the cranial sympathetic nerve.



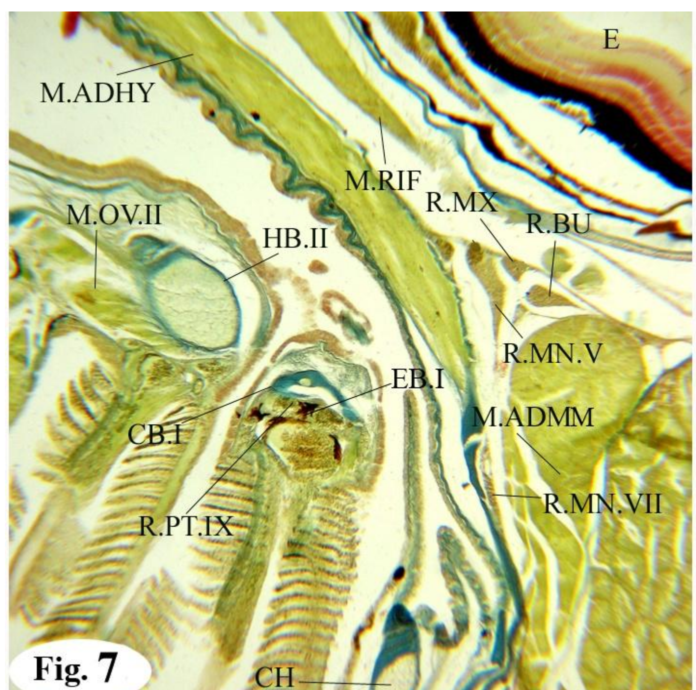


Fig.6: A photomicrograph of part of transverse section passing through the anterior otic region of *Gambusia affinis affinis* illustrating the rami pretrematicus and posttrematicus of the nervus glossopharyngeus, the ramus mandibularis facialis and the ramus posttrematicus of the first branchial vagal trunk.

Fig.7: A photomicrograph of part of transverse section passing through the orbital region of *Gambusia affinis affinis* showing the ramus posttrematicus of the nervus glossopharyngeus, the ramus maxillaris, the ramus mandibularis trigeminus, the ramus mandibularis facialis, and the ramus buccalis lateralis.

LIST OF ABBREVIATIONS

AC: Auditory capsule. **B**: Brain. **CB.I**: First ceratobranchial cartilage. **CB.II**: Second ceratobranchial cartilage. **CH**: Ceratohyal cartilage. **E**: Eye. **EB.I**: First efferent branchial vessel. **F.JU**: Jugular foramen. **G.EPB.3+VS**: Common ganglion of the third branchial vagal and visceral trunks. **G.PE**: Petrosal ganglion. **GR**: Gill rackers. **HB.II**: Second hypobranchial cartilage. **HMN**: Hyomandibular cartilage. **KH**: Head kidney. **LD.X**: Lateral division of the nervus vagus. **LG**: Lagena. **M.ADHY**: Adductor hyomandibularis muscle. **M.ADMM**: Adductor mandibularis medius muscle. **M.DO**: Dilator opercularis muscle. **M.LABE.II**: Second levator arcus branchialis externus muscle. **M.LABI.II**: Second levator arcus branchialis internus muscle. **M.OV.II**: Second obliquus ventralis muscle. **M.RIF**: Rectus inferior muscle. **M.TD**: Transversus dorsalis muscle. **MD.X**: Medial division of the nervus vagus. **MO**: Medulla oblongata. **N.ADAB.I**: Nerve to the first adductor arcus branchialis muscle. **N.CSY**: Cranial sympathetic nerve. **N.IX**: Nervus glossopharyngeus. **N.LABE.I**: Nerve to the first levator arcus branchialis externus muscle. **N.LABI.I**: Nerve to the first levator arcus branchialis internus muscle. **N.OV.I**: Nerve to the first obliquus ventralis muscle. **N.PLL**: Posterior lateral line nerve. **N.TD**: Nerve to the transversus dorsalis muscle. **Nn.GF**: Numerous fine branches to the gill filaments. **Nn.GR**: Numerous fine branches to the gill rackers. **Nn.TB**: Numerous fine branches to the taste buds **Nn.TB+EPI**: Numerous fine branches to the taste buds and epithelial tissues. **PO.BR.VIII**: Posterior branch of the nervus octavus. **PRC**: Prootic cartilage. **PSB**: Pseudobranch. **R.AM.PO**: Ramus ampullaris posterior. **R.BU**: Ramus buccalis lateralis. **R.LG**: Lagenar ramus. **R.MN.V**: Ramus mandibularis trigeminus. **R.MN.VII**: Ramus mandibularis facialis. **R.MX**: Ramus maxillaris. **R.PR.IX**: Ramus pretrematicus of the glossopharyngeal nerve. **R.PT.IX**: Ramus posttrematicus of the glossopharyngeal nerve. **R.PT.X_1**: Ramus posttrematicus of the first branchial vagal trunk. **RO.IX**: Root of the nervus glossopharyngeus. **RO.VI**: Root of the nervus abducens. **RO.X**: Root of the nervus vagus. **SA**: Sacculus. **SP.C**: Spinal cord. **UT**: Utriculus. **VCL**: Vena capitis lateralis. **X_1**: The first branchial vagal trunk.

DISCUSSION

In the present work, the nervus glossopharyngeus arises from the medulla oblongata via a single root. This case was described in most bony fishes. However, the nervus glossopharyngeus arises by two roots in Mastacembelus armatus (Maheshwari, 1965) and Amphipnous cuchia (Saxena, 1967). On the other hand, Norris (1925) recorded four or five groups of rootlets for the nervus glossopharyngeus in Scaphirynchus.

Among the cartilaginous fishes, a single root for the nervus glossopharyngeus was recorded in Dasyatis rafinesque (Chandy, 1955) and Pteroplatea altavela (Mazhar, 1979). However, in Rhinobatus halavi, Dakrory (2000) revealed that the nervus glossopharyngeus arises by means of three rootlets, which soon unite into one root.

In Agnatha, there is a single postotic nerve (nervus glossopharyngeus) which issues from the vagal lobe and passes to the pharynx and gills (Matsuda et al., 1991). This is the case found also in the lamprey Ichthyomyzon unicuspis (Wicht, 1996) and the hagfishes Eptatretus stoutii and Myxine glutinosa (Braun, 1998). On the other hand, separate glossopharyngeal and vagal nerves were mentioned by Jollie (1968) and Fritzsch and Northcutt (1993) in lampreys and by Kuratani et al., (1997) in embryos of Lampetra japonica.

Among Amphibia, the nervus glossopharyngeus arises separately from the medulla oblongata as a single trunk and enters the anterior part of a large ganglion shared by the nervi glossopharyngeus and vagus in Salamander salamander and Plethedon cinereus (Wake et al., 1983) and Bufo regularis (Shaheen, 1987). In Bufo viridis (Soliman and Mostafa, 1984), the nervi glossopharyngeus and vagus arise together by three roots, which enter a common ganglion.

In the species under investigation, the nervus glossopharyngeus exits from the cranium together with the vagal nerve through a foramen in the exoccipital bone; the jugular foramen. The same case was recorded by Nakae and Sasaki (2008) in Triacanthus biaculeatus, Kentrocapros aculeatus and Ostracion immaculatus. On the other hand, there is a separate foramen in the exoccipital bone for the exit of the nervus glossopharyngeus from the cranial cavity found in Lampanyctus leucopsarus (Ray, 1950), Mastacembelus armatus (Maheshwari, 1965), Cyprinus carpio (De Graaf, 1990), Gnathonemus petersii (Lazar et al., 1992), Polypterus senegalus (Piotrowski and Northcutt, 1996), Clarias gariepinus (Adriaens and Verraes, 1998), Ctenopharyngodon idellus (Dakrory, 2000), Tilapia zillii (Ali, 2005; Dakrory and Ali, 2006) and Hypophthalmichthys molitrix (Taha, 2010).

Nakae and Sasaki (2008) carried out studies on ten tetraodontiform families; they stated that the relation between the glossopharyngeal foramen and the elements of the cranium shows a wide range of variation. These authors showed that in Triacanthus biaculeatus, Kentrocapros aculeatus and Ostracion immaculatus, the nervus glossopharyngeus exits from the cranium together with the vagal nerve through a foramen in the exoccipital bone, as previously mentioned. While the nervus glossopharyngeus leaves the cranial cavity through a foramen in the pterotic bone in Sufflamen chrysopterum and Zeus faber. However, in Canthigaster rivulata and Antigonia capros, this nerve emerges from the cranium through a foramen in the posterior part of the prootic bone. In Diodon holocanthus, the glossopharyngeal nerve leaves the skull through an opening between the exoccipital and basioccipital bones. On the other hand, the nervus glossopharyngeus and the nervus vagus emerge through a foramen in the prootic in Mola mola. In Lophiomus setigerus, the nervus glossopharyngeus emerges from the cranium through a foramen rimmed by the prootic, exoccipital and basioccipital bones. In Malakichthys wakiyae and Siganus spinus, the glossopharyngeal nerve leaves cranium through a foramen in the exoccipital bone.

Among cartilaginous fishes, the nervus glossopharyngeus passes through a glossopharyngeal canal, which is communicated with the cavity of the auditory capsule. This canal was described by El-Toubi (1949) in Acanthias vulgaris and in other fishes by Hamdy (1960), El-Toubi and Hamdy (1959, 1968), Hamdy and Hassan (1973), El-Satti (1982) and by Dakrory (2000). Thus, this canal appears to be a common feature for the cartilaginous fishes.

Regarding amphibians, so far described, the nervi glossopharyngeal and vagus pass outside the cranial cavity through the jugular foramen as stated by many authors such as (Sokol, 1981; Soliman and Mostafa, 1984; Shaheen, 1987; Haas, 1995; Reiss, 1997; Hall and Larsen, 1998). Thus, the presence of a single foramen for the exit of the nervi glossopharyngeal and vagus appears to be a general rule in amphibians.

In the studied poeciliid fish, there is only one glossopharyngeal ganglion, the petrosal (epibranchial) ganglion for the glossopharyngeal nerve, which is located extracranially. Among bony fishes, the nervus glossopharyngeus has a single extracranial petrosal ganglion as in Lampanyctus leucopsarus (Ray, 1950), Trichiurus lepturus (Harrison, 1981), Cyprinus carpio (De Graaf, 1990), Ctenopharyngodon idellus (Dakrory, 2000), Tilapia zillii (Dakrory and Ali, 2006), Mugil cephalus (Hussein, 2010) and Hypophthalmichthys molitrix (Taha, 2010). On the other hand, a medial sensory intracranial ganglion in addition to the lateral extracranial petrosal one, were found for the nervus glossopharyngeus in Latimeria chalumnae (Northcutt and Bemis, 1993) and Polypterus senegalus (Piotrowski and Northcutt, 1996).

Among cartilaginous fishes, a single extracranially located petrosal ganglion was found in Squalus acanthias (Norris and Hughes, 1920) and Dasyatis rafinesque (Chandy, 1955). Among amphibians, Wake et al., (1983) mentioned that only one ganglion is present for the nervi glossopharyngeus and vagus in Salamandra salamandra and Plethodon cinereus. This was also the case found in Xenopus laevis (Paterson, 1939), Bufo viridis (Soliman and Mostafa, 1984). In this respect, Northcutt (1992) stated that, in Ambystoma trigrinum and other salamanders, the glossopharyngeal ganglion fuses with all the other sensory ganglia of the postotic cranial nerves, forming a postotic ganglionic complex. On the other hand, Shaheen (1987) stated that each of the glossopharyngeal and vagal nerve has its own separate ganglion.

The studied fish, Gambusia affinis affinis, has two rami arising from the nervus glossopharyngeus after its exit from the petrosal ganglion; the ramus pretrematicus and the ramus posttrematicus. This means that, the ramus pharyngeus is lacking. In Ctenopharyngodon idellus (Dakrory, 2000) and Hypophthalmichthys molitrix (Taha, 2010), there are two rami arising from the nervus glossopharyngeus after its exit from the petrosal ganglion; the ramus pharyngeus and the ramus posttrematicus. This means that, the ramus pretrematicus is lacking. On the other hand, the nervus glossopharyngeus has three rami; the ramus pharyngeus, ramus pretrematicus and the ramus posttrematicus as in Polycentrus schomburgkii (Freihofer, 1978), Trichiurus lepturus (Harrison, 1981), Cyprinus carpio (De Graaf, 1990), Polypterus senegalus (Piotrowski and Northcutt, 1996) and Tilapia zillii (Dakrory and Ali, 2006). Nakae and Sasaki (2006 & 2008) described that in Mola mola and Triacanthodes anomalus, the nervus glossopharyngeus divides into anterior (glossopharyngeal pharyngeal plus glossopharyngeal pretrematic) and posterior glossopharyngeal posttrematic. In Menidia, however, Herrick (1899) stated that the nervus glossopharyngeus shows considerable reduction in its peripheral branches; there is no ramus pharyngeus and the ramus pretrematicus is reduced to a tiny remnant. Still further reduction for the ramus pretrematicus was found by Gierse (1904) in Cyclothone acclinidens. Moreover, this nerve, in Gnathonemus petersii, is small both peripherally and centrally (Lazar et al., 1992). Mithel (1964) and Hussein (2010) reported that the ramus pharyngeal was lacking in Bagarius bagarius and Mugil cephalus, respectively.

Regarding cartilaginous fishes, three rami arise from the petrosal ganglion; the rami pharyngeus, pretrematicus and posttrematicus. This is the typical condition found in elasmobranches as reported by Norris and Hughes (1920) in Squalus acanthias and Mustelus californicus, (Chandy, 1955) in Dasyatis rafinesque and Dakrory (2000) in Rhinobatus halavi.

In the studied mosquito fish, there is no connection between the nervus glossopharyngeus and the nervus facialis. This case was mentioned by Dakrory and Ali (2006) in Tilapia zillii and by Hussein (2010) in Mugil cephalus. On the other hand, a Jacobson's anastomosis between the ramus pharyngeus of the nervus glossopharyngeus and the posterior palatine ramus of the nervus facialis was reported by Freihofer (1978) in Polycentrus schomburgkii, Dakrory (2000) in Ctenopharyngodon idellus and by Taha (2010) in Hypophthalmichthys molitrix. Also, there is a connection between the nervus glossopharyngeus and the nervus facialis in Amphipnous cuchia (Saxena, 1967) and Trichiurus lepturus (Harrison, 1981). In this respect, Piotrowski and Northcutt (1996) described a connection between the ramus pharyngeus of the nervus glossopharyngeus and the rostral pole of the facial ganglion in Polypterus senegalus.

Among amphibians, the ramus hyomandibularis facialis is communicated with the nervus glossopharyngeus in Bufo viridis (Soliman and Mostafa, 1984) and Bufo regularis (Shaheen, 1987). Norris (1908) described that in Amphiuma means, the nervus glossopharyngeus anastomoses with the ramus alveolaris (chorda tympani).

In the present work, the ramus posttrematicus is not divided into two parts; anterior and posterior. This condition was the same in Ctenopharyngodon idellus (Dakrory, 2000), Tilapia zillii (Dakrory and Ali, 2006) and in Hypophthalmichthys molitrix (Taha, 2010). On the other hand, this ramus is divided into pars anterior and pars posterior in all the ray-finned fishes (Norris, 1925), Latimeria chalumnae (Northcutt and Bemis, 1993), Polypterus senegalus (Piotrowski and Northcutt, 1996) and the shark, Squalus acanthias (Norris and Hughes, 1920).

In the present study, the pseudobranch is innervated by the ramus palatinus facialis. This met with that mentioned in Menidia (Herrick, 1899) and Hypophthalmichthys molitrix (Taha, 2010). On the other hand, the pseudobranch is innervated by branches arising from the ramus pharyngeus of the nervus glossopharyngeus as it was confirmed by Allis (1903), Freihofer (1978), Dakrory (2000) and (Ali, 2005). Moreover, the pseudobranch is innervated by a branch from the truncus hyomandibularis facialis in Lampanyctus leucopsarus (Ray, 1950) and Trichiurus lepturus (Harrison, 1981).

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