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Research Article

Gross Anatomy and Histological Features of *Polypterus bichir* (Cuvier, 1829) from the Lower River Niger at Agenebode in Edo State, Nigeria

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Abstract

Background: *Polypterus bichir* belonging to the family Polypteridae is widely distributed in Nile basin and West Africa. In Nigeria, it is highly valued as an indigenous ornamental fish, relish dish and of commercial importance. Apart from its importance as an exported fish source with value of commercial importance not much is known about this fish species, its hardy and rich protein source could perhaps make it as suitable identity in fish culture an increase the variety of affordable culture-able species in Nigeria hence the study of the anatomy and histology of its gastrointestinal tract.

Results: The anatomy is a composite one composing of oesophagus, a "Y" shaped stomach highly vascularised lungs, an anterior valvular intestine and a true intestine which ends in the cloaca. The histological results of the GIT show four conspicuous layers of outer circular muscularis, inner longitudinal layer, submucosa, mucosa from the outer to the inside. The gut revealed various mucus glands, longitudinal folds, with a prominent columnar epithelium. These features provide durable length for an extension of the gut. The mucus aids lubrication and movement of food materials, protection in the mucosal epithelium from injuries.

Conclusions: The GIT is a composite of organs and reveals that it well adapted for a hardy survival, purely a carnivore that could be managed under propagation and culture. The histology reveals a GIT formed by four conspicuous layers from the inside to the outside of mucosa, submucosa, and inner longitudinal layer of muscularis and outer circular of muscularis typical of higher vertebrates.

Keywords: *Polyterus bichir*; Canine Teeth; Valvular Intestine; Git; Oesophagus; Gastric Gland

Background

Fisheries is a dependable arm of agriculture that significantly contributes to the Gross Domestic Product of a Nation [1]. Its resources and products are also fundamental components of human feeding and employment [2,3]. *Polypterus bichir* belonging to the family Polypteridae is widely distributed in Nile basin and West Africa. It is native to Nigeria. *P. bichir* is an extant member of the most primitive of the ray finned fishes from the Devonian period [4-10]. Polypterus species is a commercial importance species in Nigeria, where it is eaten, exported and used as an ornamental fish. It is hardy and highly priced than other ornamental fish. Selling at $3 - $10 for 20 - 40/box [11]. Most Nigerian ornamentals are caught from the wild. Apart from its role in the development of a nation, it is a cheap source of highly nutritive protein that contains other essential nutrients required by the body and its import as medicinal purposes due to its replenishment of human body with vitamins [4-8]. *P. bichir* is rated as a fish with high food value, rich in minerals and micronutrients that are essential for healthy growth. Since most it's catch are from the wild, it is reasonable to note that its decline is not avoided over time hence fisheries science has to make available approaches to towards sustainable strategies of the important species. A decline in numerous fish species with *P. bichir* not excluded has been reported by [5-8], hence the need for management practices. Hence, A live fish breeding centre is thus recommended to solve the problems of environmental pollution and degradation, inadequacy of collection and management. In ad-

dition, there is inadequate knowledge about the biology, species variation and seasonal abundance of most ornamental fishes [12]. To successfully breed wild species in captivity, the knowledge of the biology; growth, nutrition and specifically the reproductive capacityand strategies has to be obtained. Knowledge on the biology of *Polypterus bichir* is scanty. A thick armor of shiny scales covering the whole of the body, with the specialized mineralized tissue ganoine makes it hardy amongst other valid attributes makes this species appropriate for propagation. Furthermore, it is reported that *P. senegalus* has a high percent of Saturated Fatty Acid (SFA) in its muscles giving it an advantage in curing processes. The fish fat is recommended as an important source of food, for maintaining human health and effective for the improvement of learning ability [9]. As such, with the aforementioned attributes of the Polypterus, further studies should be conducted on its biology to determine the anatomy of the mouth and gastrointestinal tract, the histology of its GIT to enable understanding of its food and feeding pattern, rate of digestion and absorption of nutrients, the nature and dynamics of its GIT. The information obtained from this study will avail researchers with efficient baseline information for the effective culture, propagation and management of sustainable fisheries to increase and improve its availability, abundance, attainable income maintain biodiversity, for fisher folks, fisheries and the economy of the nation. This research is therefore aimed at the study of the biology of *Polypterus bichir* in the Lower River Niger at Agenebode to determine the gross anatomy, physiology and histology of its mouth and Gastrointestinal tract.

Methods

Twenty samples of *Polypterus bichir* comprising of different sizes (length and weight) (21-61 cm ± 35.22 cm and 634-2015g ± 356.68g) respectively were obtained from catch landings from the Lower River Niger at Agenebode, Edo State and transported to the Laboratory Unit, department of Biological Sciences, Edo State University Uzairue. In the Lab, the samples were rinsed and wiped dry. The mouths and intestinal tracts were removed, the oesophagus, stomachs and intestines were gently slit open, their content rinsed off in gently flowing tap water, and thereafter fixed in 10% formaldehyde. Then the samples were dehydrated through a standard ethanol series to 100%, cleared in xylene and embedded in paraffin wax then sectioned with a rotatory microtome set at 5-6 pm, deparaffinized and stained with haemotoxylin and eosin. Prepared slides of the gastro-intestinal tract, were mounted and examined with the Electronic Olympus microscope (model Bino Cxi IS4381) to capture features of biological interest.

A digital camera (Model X650B) was used to take pictures of the mouth, jaws and pharyngeal teeth and GIT.

This study was self-funded hence submission and approval by the ethics committee of my institution is not applicable.

Results

The body of *Polypterus bichir* is cylindrical, elongated (taeniform) and covered with rhomboid scales from the back of the head to its tail region (Figure 1a). The body has a unique series of 14-16 dorsal spines called finlets. Each of these dorsal finlets has one spine with a double edged tip that is attached to soft rays with 4- 6 veins (Figure 1a). The body composes of a pair of pectoral fin. Each of these fins has a fleshy lobe that ends in 39-42 soft rays. The pectoral fin (39-42 rays) reaches the end of the first dorsal ray (Figure 2). *P. bichir* also has a pair of pelvic fins ending in 12 -14 rays (Figure 3), an anal fin with 12 -14 rays (Figure 4), and an abbreviated heterocercal caudal fin with 21- 26 articulated rays (Figure 5). It has 56 -60 scales on its lateral line that posses a black dot in its centre, there are 8 scales above and 14 scales below the lateral line (Figure 1a) (Formula for scale count = $56\frac{8}{14}$). The fin formular for *P. bichir* is thus written as D14-16$^{(2/4-6)}$: P39-40: V12-14: A12-14: C21-26(56). This bichir has two gular as shown in Figure 1a, which is often used as an amour for protection, two slit-likespiracles on top of the head and a pair of elongated nostrils for breathing air out of water (Figure 1, 2, 3, 4, 5 and 6).

Figure 1a: Body of *Polypterus* bichir x0.5 mag.

Figure 1b: The Rhumboid scale of P. bichir. s1; outer side of the scale, s2; inner side of the scale.

Figure 2: Head of *P. bichir*, X1.0 mag showing slits and elongated nostrils..

Figure 3: Dorsal fin of *P. bichir*, X1.0 mag. showing spine and rays.

Figure 4: Pectoral Fin X1.0 mag showing 39 rays.

Figure 5: Pelvic Fin X1.0 mag showing 12 rays.

Figure 6: Abbreviated heterocercal Caudal fin X1.0 mag showing 24 rays. The anal fin and tail region is used to sex the fish.

The mouth of *Polypterus bichir* is terminal, not retractable, snout is acuminate and devoid of scales as shown in figure 1a and figure 2. It opens upto7% of the total body length (Figure 7). In figure 8 and figure 9, one row of canine villiform teeth are arranged on the premaxillae, on the maxillae are a mixture of villiform and cadi form teeth. The vomer, palatine and parasphenoid of the upper jaw (on all bones forming the roof of the mouth) (Figure 9) are covered with multi serial molariform teeth. The lower jaw (Figure 8) has canine teeth well defined on the mandillae and dentary. After these rows of large teeth lie multiple rows of smaller teeth on the prearticular and coronoids. Teeth on the first outer row are

well defined and prominent compared to the second. There are no teeth on the tongue.

Figure 7: Gape mouth of *P. bichir* X0.5 mag.

Figure 8: The lower jaw of *P. bichir* X2 mag. Canine teeth well defined on the mandillae and dentary. Inside these rows of large teeth lie multiple rows of smaller teeth on the prearticular and coronoids.

Figure 9: The upper jaw of *P. bichir*. X2 mag. One row of canine villiform teeth are arranged on the premaxillae, on the maxillae are a mixture of villiform and cadiform teeth.

Four gills are present on the right and left side of the fish. These gills have thick and cartilaginous gill arches, the gill rackers are almost absent (4 stunted rackers) and numerous gill filaments (75) (Figure 10 and Figure 11).

Figure 10: Gills of *P.bichir*. X2.0 mag Comprising of four gills fused with pharygeal teeth and gills.

Figure 11: One gill of *Polypterus bichir*. X4.0 mag. Gill rackers reduced to nodes on the pharyngeal arch.

The Gastrointestinal Tract (GIT) of *Polypterus bichir is* a longitudinal organized organ whose components include the oesophagus, stomach, highly vascularised lungs, intestine and cloaca that were well secured by the peritoneal serosa (Figure 12). The oesophagus is long and distensible. The oesophagus leads to a long cylindrical, flat, tubular and slender "Y" shaped stomach with a posterior conical end.

Figure 12: The composite gastrointestinal tract of *Polypterus bichir*. X1.0 mag.

The short intestine forms a curvature before connecting to the spiral intestine (the pyloric cecae is absent in the bichir). The leads and pours into the intestine which is thick and muscularthat ends with a cloaca. The intestine can easily be distinguished as a complex arrangement with two intestinal loops, the first section of the intestine is thicker than the small intestine.

The paired lungs are situated in the ventral position (Figure 13), the lung is asymmetric, bi-lobed and arises from a slit in the ventral side of the pharynx, and the left lung is shorter than the right. Sheaths of connective tissue and blood vessels hold the various organs in place. The liver and pancreas are located on the right side of the stomach.

Figure 13: The detached GIT of *P. bichir* X2.0 mag showing organs. O, Oesophagus; S, stomach; LI, Valvular intestine; SI, small intestine; C, Cloaca; LL left lung; RL, right lung.

The result of the light microscope (LM) of the oesophagus of *P. bichir* was formed by four conspicuous layers of outer circular muscularis, inner longitudinal layer, submucosa, mucosa from the outer to the inside (Figure 14a). The mucosa showed large numbers of the esophageal length of the lumen of the oesophagus giving oval shaped appearance in all sections. These longitudinal–oval-folds were thick and elongated and had few gastric glands, the serosa is distinct. The stomach of *P. bichir* (Figure14c) showed dense regions of gastric gland revealing gastric cells. The mucosa of the stomach consists of surface and gastric epithelium. The surface epithelium is made up of a single layer of columnar epithelial cells and the gastric epithelium consists of gastric glands. The lamina propria, in the form of connective tissue network lies in between the gastric glands. The muscularis consists of the outer longitudinal and an inner thick circular muscle layer. The columnar epithelium was filled with lamina propria and mucus secreting cells. Figure 12a is an extension of the enlarged portion of the lamina propria.

Figure 14: LM of GIT of *P. bichir*. In (a) Lp-lamina propria; s-serosa; cm-circular muscle; lmf-longitudinal muscle fibre; gastric gland; (b) enlarged gg; (c) gp-gastric pits; ce-columnar epithelium; sm-submucosa; (d) enlarged lamina propria. X100mag.

Figure 15, shows LM of the intestine of *P. bichir*. The intestine is densely packed with short projections of the columnar epithelium and lamina propria. Reduced regions of submucosa and muscle fibres are prominent.

Figure 15: LM of intestine of *Polypterus bichir*. X100 mag. Sm-submucosa; ce-columnar epithelium; cm-mucus cells; cmf- circular muscle fibre.

Discussion

The cylindrical and elongated (taeniform) body of *Polypterus bichir*as shown in Figure 1a gives the fish an advantage to glide through its habitat which is mainly to live along the edges of flood-plains so as to remain concealed during the day and be able to forage at night. The rhomboid scales (Figure 1b)are serially arranged from the back of the head to its tail region serves for protection. The unique series of finlets, pectoral fin, pelvic fins, and the abbreviated heterocercal caudal fin (Figure 1a) are measures used for distinct taxonomy and identification of this fish species [12,13]. This fins have also been used to calculate the fin formular of this fish as given in the results as D14-16$^{(2/4-6)}$: P39-40: V12-14: A12-14: C21-26 (56). The gular (Figure 1a) on the head is often used as an amour for protection, two slit-like spiracles on top of the head and a pair of elongated nostrils are added breathing organs of air out of water. It is reported by [14] that Polypterus regenerates its pectoral fins with a remarkable accuracy which is a characteristic property restricted to urodele amphibians, hence relating a link between the amphibians and the Polypteridae. The shape of the tail is often used to identify *P. bichir*, the anal fin and caudal fins of males have a wider and deeper curve while the females is slimmer and pointed [15]. The terminal mouth of *Polypterus bichir* has the capacity to swallow prey as large as 7% of the total body length indication the distensible capacity of the mouth, throat and gut (Figure I). The arrangement and mixture of the types of teeth, pharyngeal teeth on the upper and lower jaws (Figure 2, Figure 8 and Figure 9) enables the fish to capture, seize, tear, crush, firmly grip and hold onto its prey and swallow its varieties of prey, an indication that it is carnivorous [16-21]. Figure 3 reveals the cartilagenous gill arch, and fleshy leaf-like filaments which is an indication that the bichir is a carnivore. The gill rackers (Figure 10, Figure 11) are replaced with few cartilaginous nodes, again an indication that the fish particularly inclined to take large sized food substances again indicating carnivorous feeding [17-22].

The composite gastrointestinal tract of *Polypterus bichir* is made up of different organs and structures which are packed together by connective tissues and wrapped up by fatas shown in figure 12.

The well-developed pair of lungs with ventral connection to oesophagus, showing a smooth inner surface (Figure 12). They are highly vascularised and totally covered by thick yellowish fat. The lungs are filled with air sacs. Predatory and carnivorous species often possess a short and distensible oesophagus which provides the opportunity to accommodate large sizes of live and whole prey (Figure 12). Rounded and elongated mucous secreting cells were recognized in the epithelium of the esophagus (Figure 14). The rounded cells were larger in size, concentrated centrally, and represented the majority of mucous secreting cells [20,23]. In Figure 13, a long 'Y" shaped stomach, and short intestine which could be distinguished into straight and longitudinal GIT was observed. The large stomach is distensible capable to accommodate large food materials. It is smooth and not separated into segments from external examinations. From histological examinations, Figure 14 revealed that the stomach was full of mucus and longitudinal ridges, few gastric glands and reduced gastric pits. Numerous longitudinal-oval folds were present in the stomach [18-20,22,24], suggested that the presence of longitudinal ridges makes it possible for contraction to be obtained in the musculature wall. The contraction of the circular muscle is thought to result in a reduction of the lumen of the digestive tract and assists with the grinding and mixing of food. The stomach is primarily to store food and slow down the passage of food into the intestine. There is a curved end at the introduction from the stomach to the intestine, this could be some sort of modification of a pyloric cecae, which in essence is to provide enzymes and digestive abilities for food. The absence of pyloric caeca can be attributed to the fact that all actinopterygians with straight stomachs do not possess pyloric caeca [20,24,26]. The stomach lacked gastric glands and microvilli making the function of the stomach specialized which are similar to the findings of [18-21,24,25].In this study, it was observed that the stomach muscularis possesses a circular layer that is thicker than the longitudinal layer which is agreeable with the findings of [17,18,33,35]. In Figure 15, showed the first section of the intestine which is the valvular intestine, it is 1/3 in length of the whole intestine, is thicker than the true intestine and terminal segment, this valvular intestine is made up of spiral valves (Figure 15). [36,37] stated that specializations like the pyloric cecae and spiral valves can increase the surface area in certain species therefore maximize the effective surface for absorption and enzymatic digestion while maintaining a relatively short intestinal casing and conserving space for other activities like reproduction as also reported by [34-38] for carnivorous species. The gut is designed to accommodate numerous longitudinal folds, abundant mucus glands, and a distinct columnar epithelium that provides a desired length or an extension of the gut. In addition, the presence of mucus is to aid lubrication for easy

movement of food materials along the gut in as much as protecting the mucosal epithelium from chemical and mechanical injuries arising from interactions with digestive tract contents or enzymes and the presence of absorptive cells for intake of valuable nutritive substances as also reported by [17,18,38-41]. Figure 15 also shows the second portion which is the true intestine is more visible short folds and a densely packed sub mucosa. The epithelium is filled with mucus cells, lamina propria, blood vessels and signs of microvilli were also noticed. In figure 16, the terminal region had few gastric glands and microvilli; thick longitudinal muscle layer and thick submucosa, the serosa was very prominent. Form the aforementioned it is evident that the intestine performs a specialized function of movements and absorption of substances, the mucus secreted into the lumen of the digestive tract is either acidic, basic, and neutral depending on the glycoproteins it contains [40-43].

Figure 16: LM of Rectum of *P. bichir*. s-serosa; sm-submucosa; lm-longitudianl muscle; cm-circular muscle; ce-columnar epithelium; gp-gastric pits; bc-blood capillary; gg-gastric gland. X100 mag.

Conclusion

The results obtained from this study show the anatomical organizations and histology of the mouth and gastrointestinal tract of *Polpterus bichir*. The GIT is an organisation of organs and reveals that it well adapted for a hardy survival, purely a carnivore. The GIT shows four conspicuous layers of outer circular muscularis, inner longitudinal layer, submucosa, mucosa from the outer to the inside. The gut revealed various mucus glands, longitudinal folds, with a prominent columnar epithelium typical of higher vertebrates. *P. bichir* is thus a fish species with maximal food value and very suitable for culture.

Highlights

- The GIT is a composite of organs and reveals that it well adapted for a hardy survival, purely a carnivore.
- The histology reveals a GIT formed by four conspicuous layers from the inside to the outside of mucosa, submucosa, and inner longitudinal layer of muscularis and outer circular of muscularis typical of higher vertebrates.
- The long 'Y" shaped stomach, short intestine and nature of the muscularis reveals strongly that *P. bichir* is purely carnivorous.

Bibliography

1. Federal Department of Fisheries - FDF. "Fishery Statistics of Nigeria". (fourth ed.), Federal Department of Fisheries (2007): 49.
2. Emygdio L C. Food and Agriculture Organization, Food and Agriculture Organization of the United Nations (2003).
3. Famoofo OO and Abdul WO. "Biometry, condition factors and length-weight relationships of sixteen fish species in Iwopin fresh-water ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria". *Heliyon* 6.1 (2020): 11.
4. Sikoki S K and Otobotekere A J T. "Fisheries". E.C. Alagoa (Ed.), The Land People of Bayelsa State Central Niger Delta, Port Harcourt (1999): 301-319.
5. Ross N., *et al*. "Small indigenous fish species in Bangladesh: contribution to vitamin A, calcium and iron intakes". *Journal of Nutrition* 133.11 (2003).
6. WHO. "Vitamins and Mineral Requirements in Human Nutrition". 2nd Edition. WHO FOA (2004): 362.
7. Ohen S B and Abang S O. "Economics of catfish farming in rivers state, Nigeria". *Academic Journal of Plant Sciences* 2 (2007): 56-59.
8. WHO. "Healthy diets" (2015).
9. Brian K H. "John Samuel Budgett (1872-1904): In Pursuit of Polypterus In Biology in history". *BioScience* 51.5 (2001): 399-407.
10. Froese R and Pauly. www.fishbase.com. The bichirs, Polypterus bichir (2020).
11. Mbawuike BC., *et al*. "Assessment of the mortality rate of some ornamental fish species in Nigeria export trade". *American Journal of Social and Management Sciences* 2.3 (2011): 325-328.

12. Agbugui M O and Oniye SJ. "Some morphometric parameters of Pomadasys jubelini in the New Calabar - Bonny River, Port-Harcourt, Nigeria". *Academia Arena* 5.8 (2013): 1-4.

13. Agbugui MO and Abhulimen EF. "Morphometric and Meristic Characteristics of Protopterus annectens (Owen, 1839) in River Niger at Agenebode, Edo State". *Journal of Fisheries and Aquatic Science* 13.2 (2018)76-81.

14. Areola FO. "Export potential of ornamental live fishes in Nigeria". In: 18th Annual Conference of the Fisheries Society of Nigeria (FISON) (2013): 589-596.

15. Rodrigo C., *et al*. "Full regeneration of the tribasal Polypterus fin". *Proceedings of the National Academy of Science* 109.10 (2012): 3838-3843.

16. Holden M J. "Significance of Sexual dimorphism of the Anal fin of Polypteridae". *Nature* 232 (1971): 135-136.

17. Agbugui MO., *et al*. "Gastrointestinal tract of Pomadasys jubelini (Curvier, 1860) in the New Calabar-Bonny River, Rivers State, Nigeria". *International Journal of Engineering and Scientific Research* 7.10 (2016) 1086-1105.

18. Agbugui MO and Oniye SJ. "The Mouth and Gastro-Intestinal Tract of the Lung Fish Protopterus annectens (Owen, 1839) in River Niger at Agenebode, Edo state, Nigeria". *Egyptian Journal of Aquatic Biology and Fisheries* 23.4 (2019): 181-188.

19. Agbugui MO., *et al*. "Gross Anatomy and Histological Features of Gymnarchus niloticus (Curvier, 1829) from the River Niger at Agenebode in Edo State, Nigeria". *International Journal of Zoology* 14.6 (2021): 43-55.

20. Agbugui MO., *et al*. "The biology of the African bony tongue Heterotis niloticus (Curvier, 1829) from the Lower River Niger at Agenebode in Edo State, Nigeria". *International Journal of Zoology* 14.6 (2021): 43-55.

21. Agbugui MO and Adeniyi AO. "The biology of the Spotted sucker (Curvier, 1829) from the Lower River Niger at Agenebode in Edo State, Nigeria". *International Journal of Fisheries and Aquatic Research* 6.2 (2021): 82-90.

22. Abumandour MMA and El-Bakary NER. "Morphological Descriptions of the Esophagus of the Sea Bream (Sparus aurata, Linneaus 1758)". *Russian Journal of Marine Biology* 44 (2018): 135-140.

23. Hickman P C. "Integrated Principles of Zoology". McGraw Hill, New York, 15th Edition (2011): 831.

24. Buddington R K and Diamond J M. "Pyloric ceca of fish: A "new" absorptive organ". *American Journal of Physiology-Gastrointestinal and Liver Physiology* 252 (1987): 65-76.

25. Takiue S and Akiyoshi H. "Light and Scanning Electron Microscope Examination of the Digestive Tract in Peppered Moray Eel, Gymnothorax pictus (Elopomorpha)". *The Anatomical Record* 296.3 (2013): 443-451.

26. Fänge R and Grove D. "Digestion". In: WS Hoar, DJ Randall, JR Brett, editors. Fish physiology: Bioenergetics and Growth. San Diego: Academic Press (1979): 161-260.

27. Anderson TA. "Histological and cytological structure of the gastrointestinal tract of the luderick, Girellatricuspidata (pisces, kyphosidae), in relation to diet". *Journal of Morphology* 190 (1986): 109- 119.

28. Caceci T., *et al*. "The stomach of Oreochromis niloticus has three regions". *Journal of Fish Biology* 50 (1997): 939-952.

29. Awaad AS., *et al*. "Comparative Histomorphological and Histochemical Studies on the Oesophagus of Nile Tilapia Oreochromis niloticus and African Catfish Clariasgariepinus". *Journal of Histology* (2014): 87041.

30. Olsson C. "Gut anatomy and morphology". *Encyclopedia of Fish Physiology* (2011): 1268-1275.

31. Alabssawy AH., *et al*. "Anatomical and histological adaptations of digestive tract in relation to food and feeding habits of lizardfish, Synodusvariegatus (Lacepède, 1803)". *The Egyptian Journal of Aquatic Research* 45.2 (2019)159-165.

32. Hussein A., *et al*. "Food and Feeding habits of some Nile River fish and their relationship to the availability of natural food resources". *Egyptian Journal of Aquatic Research* 45.3 (2019): 273-280.

33. Arratia G and Schultze HP. In Mesozoic fishes. (eds Arratia, G., Schultze, H.-P. and Wilson, M.) 87-120 (Dr. Friedrich Pfeil) 5 (2013).

34. Argyriou T., *et al*. "Exceptional preservation reveals gastrointestinal anatomy and evolution in early actinopterygian fishes". *Scientific Reports* (2016).

35. Domeneghini C., *et al*. "Histochemical analysis ofglycoconjugate secretion in the alimentary canal of Anguilla anguilla L". *Acta Histochemica* 106 (2005): 477-487.

36. Bakke AM., *et al*. "Feeding, digestion and absorption of nutrients". In: M Grosell,AP Farrell, CJ Braunaer, editors. Fish physiology: The multifunctional gut of fish. San Diego: Academic Press (2010): 57-75.

37. Braga RR., *et al*. "Feeding ecology of fishes: an overview of worldwide publications". *Reviews in Fish Biology and Fisheries* 22 (2012): 915-929.

38. Farrag M M., *et al*. "Marine biodiversity patterns off Alexandria area, southeastern Mediterranean Sea, Egypt". *Environmental Monitoring and Assessment* 191 (2019): 367.

39. Ramadan SE., *et al*. "Benthic communities in the Nile River, Egypt II-Mollusca". *Bulletin of the Institute of Oceanography and Fisheries* 26 (2000): 149-166.

40. Blazer V. "Histopathological assessment of gonadal tissue in wild fishes". *Fish Physiology and Biochemistry* 26 (2002): 85-101.

41. Sarava A., *et al*. "A histology-based fish health assessment of farmed seabass (Dicentrarchuslabrax L.)". *Aquaculture* 488 (2015): 375-381.

42. Azab AM., *et al*. "Anatomical and histochemical studies on the alimentary tract of two benthic marine fishes of different feeding habits. I-Esophagus and stomach". *Egyptian Journal of Aquatic Biology and Fisheries* 2.4 (1998): 425-440.

43. Atta KI. "Morphological, anatomical and histological studies on the olfactory organs and eyes of teleost fish: Anguilla anguilla in relation to its feeding habits". *The Journal of Basic and Applied Zoology* 66.3 (2013): 101-108.

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