



The mouth and gastrointestinal tract of the african lung fish *Protopterus annectens* (owen 1839) in River Niger at Agenebode, Edo State Nigeria

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ABSTRACT

The mouth of *P. annectens* is terminal, its jaws are modified to hold incisors -scissor-like teeth that can hold and tear deep into the flesh of prey. The mouth opens up to 10% of its total body length which allows the fish to seize its prey easily. The gastrointestinal (GIT) is straight, short and a composite comprising of many organs and tissues. The organs are wrapped in serosa. The morphology and histology of the GIT, (oesophagus to the cloaca) reveals the adaptation to the food and feeding habit of fish. The numerous mucosal folds in the intestine are a usual occurrence in carnivorous species. The ability of the intestine to distend and the presence of the numerous large folds allow fishes to accommodate a large quantity of food items as digestion takes place and nutrients are being ingested.

INTRODUCTION

The West African Lung fish are an important source of food supply and protein for man. These fish species have adapted successfully to the River Niger which consist mainly of fresh water. This successful adaptation has made them versatile in their mode of feeding. The kind of food ingested is dependent on the alimentary canal and fish processes which provide suitable modifications for maximum utilization of food taken (AnnaMercy and Pillabi, 1985). Research efforts are presently geared towards understanding the biology of numerous aquatic species in our water bodies; such studies will give an understanding of the food and feeding habits, nutrition and the ecology of different species. Studies have been carried out on the Gastro-intestinal Tract of *Pomadasys jubelini*, and teleost (Agbugui *et al.*, 2016 and Banan Khojesta, 2012).

The structures of the digestive tract of fish vary with different factors within species which include digestion, nutrient absorption and hormone secretion. It structures also varies due to its food and feeding habits. It is short in carnivorous species, about 20% of its body length; with distinct portions of mouth cavity, esophagus, stomach and rectum (Agbugui *et al.*, 2016) or the digestive tract is long (20 times the body length (Banan Khojesta, 2012). The knowledge of fish digestive system is becoming increasingly important for the understanding of fish anatomy, fish physiology, fish digestive system and the improvement of nutrition protocols.

This knowledge may help identify the differences in the anatomy and histology of internal organs of various species.

The identification of the mouth and Gastrointestinal tract of *P. annectens* in the Niger River at Agenebode, will reveal the best available knowledge on the mouth, morphology and histology of the fish.

MATERIALS AND METHODS

Ten specimens of the West African Lung fish, *Protopterus annectens* weighing 135g-600g were collected from the River Niger at Agenebode, Edo State, Nigeria. Samples were collected from catch landings at the water front. After collection, the samples were killed with a blow on the head and the ventral body wall was opened from the anal area. Further dissections were made to allow the exposure of the liver, pancreas and entire gut wall. Digital pictures of the mouth, jaws and the Gastro-Intestinal Tract (GIT) were taken with a Samsung Digital Camera (Model PL 210). The entire gut was identified, removed and tissue samples were stored in 10% formaldehyde. The samples were then dehydrated through a standard ethanol series to 100%, cleared in xylene and embedded in paraffin wax. 5-7 μ m serial sections were deparaffinized and stained with Haemotoxylene and Eosin. The sections were examined under a Nikon light microscope and photographs were taken with a Nikon photo micrographic attachment.

RESULTS

The mouth of *Protopterus annectens* is terminal and has no scales (Plate I). The mouth opens up to 10% of the total body length (Plate II). The jaws reveal scissors-like incisors teeth. There are a set of premaxillary teeth (teeth on the upper lip) on the upper jaw and a set of mandibular teeth on the lower jaw (Plate III, Plate IV, and Plate V). Four gills are present on the left and right side of the fish. The gills have thick and cartilagenous gill arches, with much reduced gill rakers (16) and numerous gill filaments (24 on Plate VI).



Plate I: Mouth of *Protopterus annectens*



Plate II: The gape mouth of *P. annectens*



Plate III. The gape mouth of *P. annectens* showing the incisors teeth



Plate IV. The upper jaw of *Protpterus annectens* (arrow indication premaxillary teeth)



Plate V: The lower jaw of *Protopterus annectens* (teeth are incisors scissors-like and fused together)

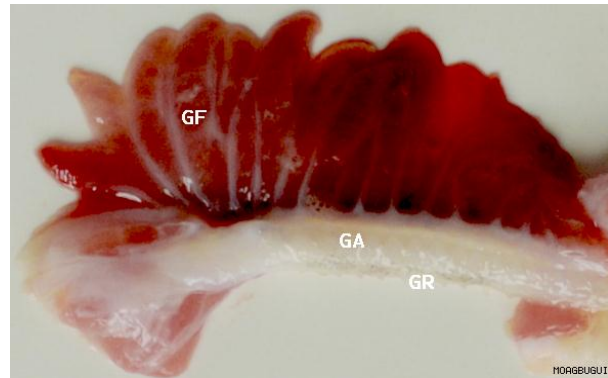
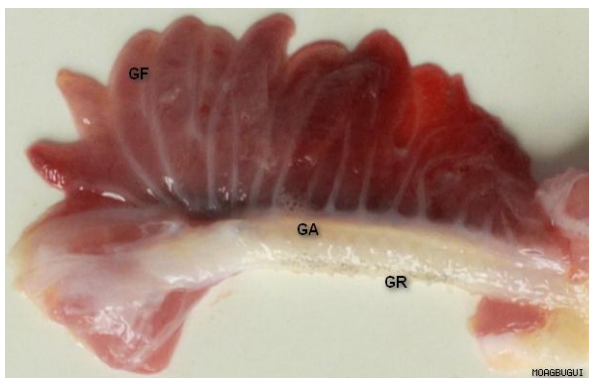


Plate VI: One gill of *Protopterus annectens* (GA, Gill arch; GR, Gill rakers; GF, Gill filament).

The gastrointestinal tract (GIT) of *Protopterus annectens* is a longitudinal organized organ whose components include the oesophagus, stomach, pyloric aperture, intestine and cloaca that were well enveloped by the peritoneal serosa (Plate VII). The oesophagus is short and distensible, a typical characteristic in predatory and carnivorous species. The oesophagus leads into a short, flat, tubular, somewhat straight stomach which pours into a tubular pyloric aperture. The pyloric aperture is without outgrowths or projections. The pyloric aperture leads to the intestine which is longitudinal and made up of seven folds. The intestine is not distinguished into small and large, it is a continuous longitudinal spiraling tube from the anterior part to the

posterior end. This spiraling effect progresses to the rectum and then ends at the cloaca. The inner intestine surface is very dark. The mucosal ridges are tenuous and disorganized. The lumen of the whole gut is filled with mucus and dark mesenteries.

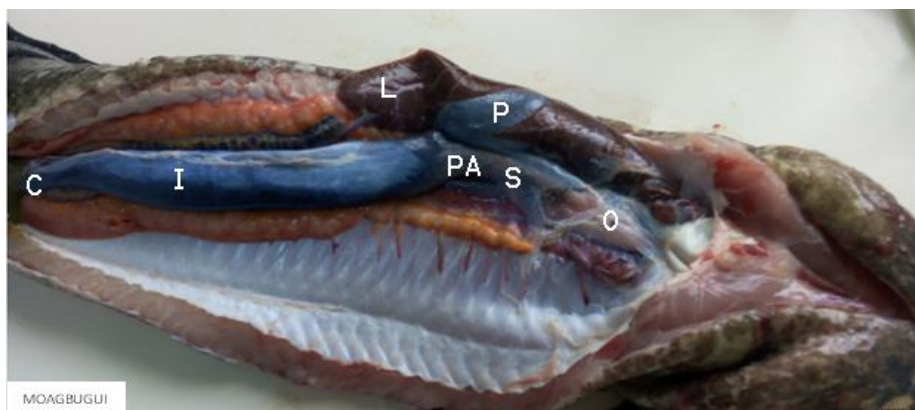


Plate VII. The Composite GIT of *P. annectens* (insitu) C: cloaca; I: Intestine; L: Lungs; PA: Pyloric caecum; P: Pancrease; S: stomach; O: Oesophagus

The intestine is a single, thick longitudinal tube which ends with a cloaca. The intestine is much larger at the anterior part than at the caudal end. The intestine had several spiral folds forming six coils all through the length of the intestine, the intestine is also 15% of the fishs' total body length. The liver and pancreas are located on the right side of the stomach. The pancreas runs caudally and dorsally and is tightly fitted to overlap a shallow area on the liver (Plate VIII). Plate IX shows the tightly fitted shallow area of the liver occupied by the pancreas. The two organs maintain a close relationship with the caudal end of the liver overlapping the cranial part of the pancreas. Both organs are attached to each other and to other organs of the GIT by sheaths of connective tissue and by serosa and blood vessels.



Plate VIII: The detached GIT of *P. annectens*. O, Oesophagus; S, stomach; I, intestine; C, Cloaca; P, Pancreas; L, liver. (16% of total body length)



Plate IX: The GIT of *P. annectens* showing the pyloric aperture, arrows revealing the shallow area occupied by the pancreas.

Histology of the gastrointestinal tract of *P. annectens*

The oesophagus

The oesophagus revealed no internal protrusions, no compact connective tissue, a few blood vessels, fibres and gland ducts; these merges with the muscularis mucosa to extend as part of the mucosal fold which is primarily large. Discrete boundaries between segments were not observed. The oesophagus was filled with mucus. (Plate X).

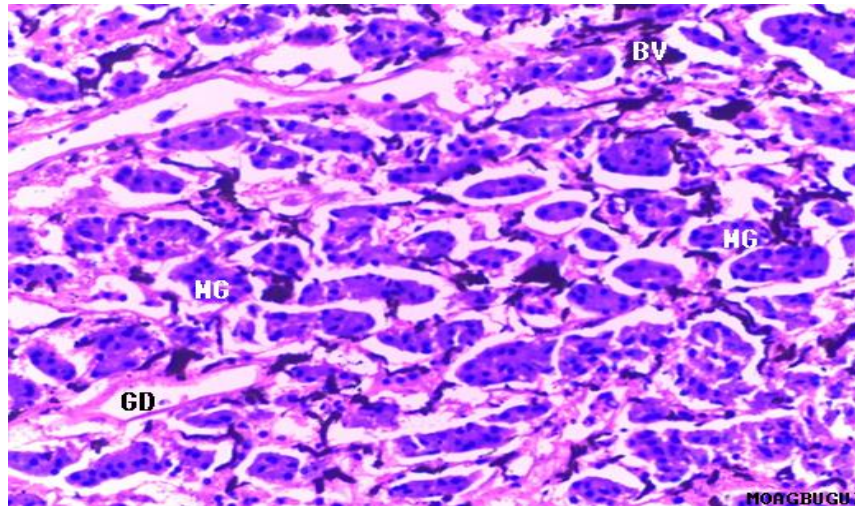


Plate X: The Oesophagus of *P. annectens* (x500) MG; Mucus Gland: GD; Gland duct: BV; Blood vessels

Stomach:

The stomach lacks regional specializations though the internal surface shows few but large longitudinal folds and pits. Goblet cells with uniform secretory cells and gastric ducts are also present (Plate X1).

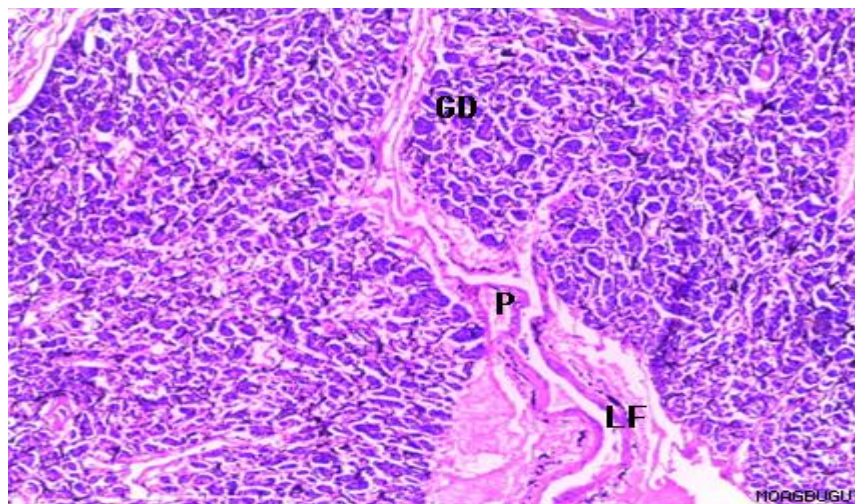


Plate XI: The Stomach of *P. annectens* (x500) GD; Gastric ducts: P; Pits: LF; longitudinal fold

Pyloric caecum:

The epithelial lining is made up of columnar absorptive cells with goblet cells for mucus secretion. The mucosa was elaborated into numerous basal columnar membranes which are closely packed and prominently visible. The pyloric aperture was guarded by a valve that consists of two thick lateral leaflets and a void (Plate XII).

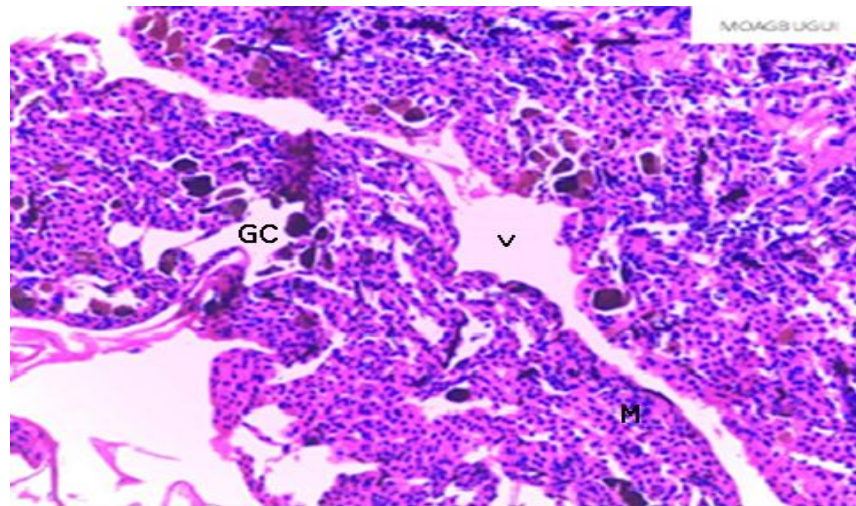


Plate XII: The Pyloric Caecum of *P. annectens* (x100) GC; Goblet Cells; V; Valve; M; Mucosa

The Intestine:

The intestine consists of very few and large chambers. This large chamber continues downward forming six coils and attached to the lower wall with the aid of serosa. The coils are cone shaped and piled one over another. The large spaces between the turns are also very conspicuous Plate XIII.

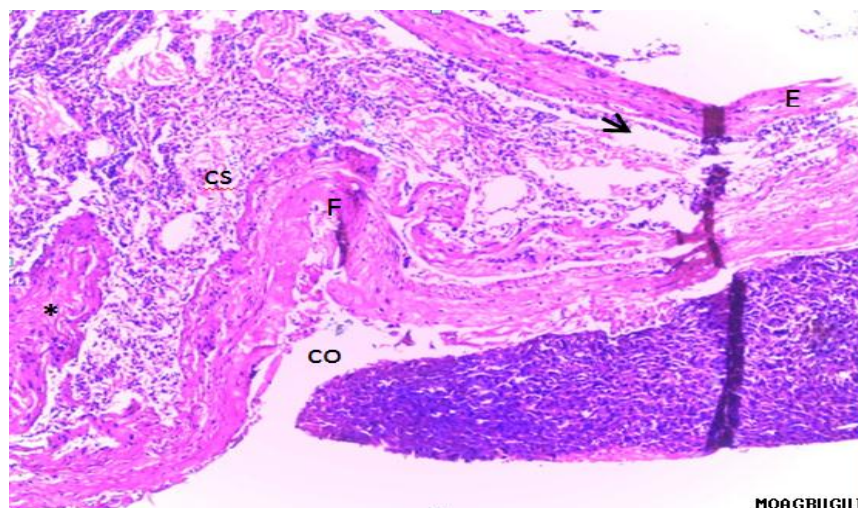


Plate XIII: The Intestine of *P. annectens*. (x100) *: Reticular tissue; E: Epithelial sheath; Co: Coil; F: folds; Arrow: First Coil leading to ridges, an Indication of overlapping of coils.

DISCUSSION

The terminal mouth of *P. annectens* opens up to 10% of its total body length, this allows the fish to adequately seize its prey. The incisors- scissor-like teeth also support the fish to firmly grip, seize and tear through the skin of prey before swallowing. The cartilagenous gill arch, and fleshy leaf-like filaments is an indication that the fish is a carnivore. The gill rakers are few, sparsely arranged and very short, again an indication that the fish does not particularly take in small sized food substances.

The gastrointestinal tract of *Protopterus annectens* is made up of different organs and structures thus making the GIT a composite. It is packed together by connective tissues and wrapped by the serosa.

A short, straight and longitudinal GIT was observed in *P. annectens* which was similar to the findings of Icardo *et al.*, 2010, which is known to be common feature in lungfishes (Parker, 1892; Rafn and Wingstrand, 1981), though it is thought to be a primitive characteristic similar to the lamprey (Kadong, 2006).

The short and distensible oesophagus is a characteristic typical in predatory and carnivorous species (Agbugui *et al.*, 2016). The stomach was full of large quantity of mucus and longitudinal ridges, gastric pits and glands were not present in the stomach. Holmgren and Nilson. (1999) suggested that the longitudinal ridges could be the reason for the contraction of the musculature wall. The stomach is primarily to store food and slow down the passage of food into the intestine. A double folded pyloric valve is noted to end the pyloric aperture. This double folded aperture is said to be similar to that of *Neoceratodus* (Rafn and Wingstrand 1981; Icardo *et al.*, 2010). The intestine makes up about 75% of the whole Gastro-Intestinal Tract (GIT). The spiral valve in the intestine was noted to have begun at the posterior end of the pyloric aperture, winds down in six coils progressively through the whole length of the intestine and ends at the cloaca. A different observation was made by Rafn and Wingstrand. (1981) where the spiraling coils in the intestine of the Australian lung fish *N. forsteri*, begins behind the glottis. On general notes, the spiraling feature of the intestine appears to be similar in all lungfishes, varying differences might be seen in the length of the intestine and the number of coils, again it is said that the higher the number of coils, the greater the more time needed for digestion. The spiraling feature of the intestine is said to be primitive and also observed in Sturgeons and in some Elasmobranchs. The spiraling feature aids food transit, facilitates digestion and absorption (FAO 2010). The reticular tissue forms part of the intestine mucosa and submucosa. The presence of connective tissue appears to hold all the components of the gastrointestinal tract together. The spaces and guts observed may be a reserve for holding fluid or other substances for absorption. The intestinal mucosa of *P. annectens* show oblique ridges, the ridges are seen mainly at the first and second chambers and the end abruptly, similar findings were made by Icardo *et al.*, 2010.

CONCLUSION

The results obtained from this study show the anatomical organizations and histology of the gastrointestinal tract of *P. annectens*. The GIT is a composite of organs and reveals that it purely of carnivorous origin and similar to other lungfishes.

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