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Gross morphometry of the heart of farmed African catfish (*Clarias gariepinus*) in Maiduguri, Nigeria

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Abstract
The study was designed to investigate the gross morphometric of heart of farmed African catfish (*Clarias gariepinus*) in Maiduguri, Nigeria. The total of twenty fish comprises of both male and female were used for this study, the average weight of fish were 980 g, average length of fish were 42 cm, average weight of heart were 1.3 gm and average length of heart were 2.6 cm. Grossly the heart were seen enclosed in a thin membranous sac, pericardium and lies cranio-dorsally to the pectoral region. It consist of sinus venosus, an atrium, ventricle and a thin walled structure known as bulbus arteriosus. The thin walled sinus venosus forms the caudo-dorsal part of the heart. The atrium is very well developed and forms the prominent chamber of the heart having irregular outline. The inner line of atrium is spongy due to criss cross formations of muscle fibres and forms a number of smaller pits very much pronounced to the left part. The muscular ventricle is laterally compressed and has a large ventral age, cranially to the ventricle is a small pear-shaped bulbus arteriosus with a small basal portion which continues to the gills capillaries. Therefore the present study shows the gross morphometric of the heart and its components of *C. gariepinus* in Maiduguri, Nigeria.

Keywords: African catfish, atrium, bulbus arteriosus, sinus venosus, ventricle, Maiduguri, Nigeria

1. Introduction
Clarias, or mudfish as they are appropriately named, have long bodies with dorsally flattened head enclosed by bony plates [1] they have large terminal mouths and four pairs of barbells which resembles cat whiskers hence the name; catfish[1]. The nostrils are far apart, with the anterior one tubular and the posterior ones equipped with a long tentacle, Both the dorsal and anal fins are without spines and are very long almost reaching the caudal fin which is a single rounded lobe [1]. The pectoral fin each has a spine, and the air-bladder is bi-lobed. The numerous small teeth of clarias are arranged in bands on the jaws and also on the roof of the mouth. The character of these bands of teeth is the most reliable means for determining the species in catfish [1]. Adult males can be distinguished from the females by the fact that they posses long, conical papilla, a projection from the vent containing the sexual opening, but this is not always exposed [2]. The colour varies considerably, but is usually blackish on the dorsum and white or slightly yellowish on the ventral side [2].
Fish have a simple circulatory system, which consists of a two-chambered heart, blood and blood vessels [3].Unlike mammals, they have a single circulatory pattern, Gollock et al reported that fish have a closed circulatory system with blood always contained in a circuit of blood vessels [4]. Fish have a single circulatory pattern, where-in the blood passes through the heart only once during each complete circuit. Oxygen-deprived blood from the body tissues comes to the heart, from where it is pumped to the gills [5]. Gaseous exchange happens within the gills and the oxygenated blood from the gills is circulated throughout the body. The heart of fish is usually somewhat asymmetrical slightly curved to the left which consist of a simple muscular structure that is located caudal to the gills [6]. It is enclosed by the pericardial membrane or pericardium. The heart consists of an atrium, ventricle, a thin walled structure known as sinus venosus and a tube called bulbus arteriosus [6]**.** Though it has four parts, the heart of a fish is considered two-chambered. The four parts of a fish heart, do not form a single organ as compared to the mammalian heart [7]. Usually they are found one behind another. The veins carry the deoxygenated blood into the sinus venosus**,** which is a like small collection chamber. The sinus venosus has pacemaker cells that are responsible for initiating contractions, so that the blood is moved into the thin-walled atrium, which has very few muscles [8].

The atrium generates weak contractions so as to push blood into the ventricle, The ventricle is a thick-walled structure with lots of cardiac muscles, It generates enough pressure to pump the blood throughout the body [9] . The ventricle pumps blood to the bulbus arteriosus, a small chamber with elastic components. The name is bulbus arteriosus in teleost, but the structure is known as conus arteriosus in other fish like elasmobranchs [10] . Conus arteriosus has many valves and muscles, whereas bulbus arteriosus has no valves. The main function of this structure is to reduce the pulse pressure generated by the ventricle, in order to avoid damage to the thin-walled gills [11]. The heart of teleost pumps blood throughout the body delivering oxygen and digested nutrients to the cells of various organs. It transports waste products from the cells to the kidneys and liver for elimination. This re-oxygenated blood then flows on to the rest of the body's tissues and organs removing carbon dioxide and replacing it with life-giving oxygen [12]. Blood is finally pumped back to the heart's atrium chamber where the process begins again. There is a paucity of information of the gross morphometry of the heart of African catfish within the study area and in Nigeria, hence the need to carry out the research which will provide baseline data upon which similar work can be build upon.

2. Methodology

2.1 Study area

The study was conducted in the Gross Laboratory of Department of Veterinary Anatomy, University of Maiduguri, Nigeria. Maiduguri is located between latitude 11º and 50º north and longitude 13˚ and 36º east. The annual rainfall average 320 mm, rainy season begins in June and last till October and dry season begins in November and last till May. The rainfall is monsoonal, generally been heaviest in August. The annual temperature average 35.4ºC, the climate of Maiduguri can be divided into six zones: Guinea zone, sunado-Guinea zone, sunado-sahelian zone, sahelo-sudanian, sudano-saharan zone and Saharan zone .

2.2 Sources of fish

Twenty adult of both males and females of wild African catfish (*Clarias gariepinus*) were used for this study. All fish were bought from fish retailers in Gamboru market in Maiduguri, Nigeria whose fish were from Lake Alau. The Lake is located 20 km south east of Maiduguri, Borno State and is situated at the semi-Arid north Eastern Zone of Nigeria (11˚40N to 11˚45N and 13˚10′ E to 13˚20′ E). It is believed to be a remnant of former Mega Chad. It receives an annual delivery of water from Ngada and Yedzeram rivers system, but sometimes these two rivers and their other tributaries dries up completely during dry season, Lake Alau retains water all year round . The fish were transported alive in a plastic trough to the Gross Laboratory of the Department of Veterinary Anatomy University of Maiduguri, Nigeria.

2.3 Experimental design

Each fish was euthanized using Tricaine (Metomidate Hydrochloride) anesthetic at the dose of 1600µl /litre of water [13] . After which an incision was made from the mouth through the operculum and the heart was exposed caudal to gill arches containing the gill rakers. The heart was photographed in situ using canon digital camera power shot (A470). Afterwards the heart was removed en mass using scalpel, scissors and tissue forceps and also photographed using the same camera.

3. Results

The average weight of fish were 980 g, average length of fish were 42 cm, average weight of heart were 1.3 gm and average length of heart were 2.6 cm. Grossly the heart were seen enclosed in a thin membranous sac, pericardium and lies cranio-dorsally to the pectoral region. It consist of sinus venosus, an atrium, ventricle and a thin walled structure known as bulbus arteriosus. The thin walled sinus venosus forms the caudo-dorsal part of the heart. The atrium is very well developed and forms the prominent chamber of the heart having irregular outline. The inner line of atrium is spongy due to criss cross formations of muscle fibres and forms a number of smaller pits very much pronounced to the left part. The muscular ventricle is laterally compressed and has a large ventral age, cranially to the ventricle is a small pear-shaped bulbus arteriosus with a small basal portion which continues as gills capillaries. The photographs of the fish, heart and the schematic representation of the components of the heart are presented in Figures 1 to 3.

Fig 1: Photograph of African catfish (*C. gariepinus*) placed on ventral recumbency showing its entire length

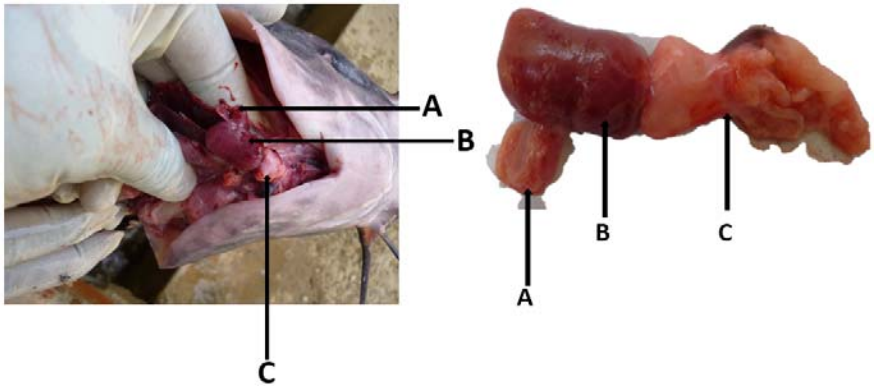

Fig 2: Gross picture of heart of C. gariepinus showing its components (A- conus venosus, B- Atrium, C- Ventricle) both in-situ and ex-situ.

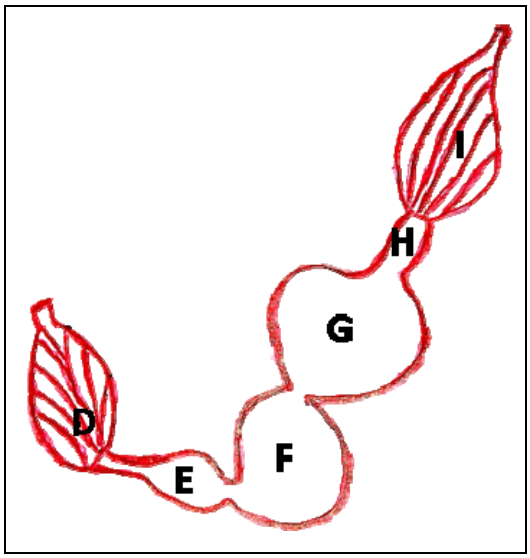

Fig 3: Schematic representation of heart of C. gariepinus showing all its components and its associated vessels (I-Body Capillaries, H – Conus Venosus, G- Atrium, F- Ventricle, E- Bulbus atriosus, D- Gill capillaries).

4. Discussion

The mean values of length and weight of *C. gariepinus* obtained in the present study which are often used as one of the factors for determining maturity of fish did not agrees with the previous work done by [14], but it agrees with the reports of Nwokoye et al and Ikpegbu et al who both reported similar findings [15, 16]. However, unlike other vertebrates that stops growth at a certain age due to heredity, fish does not really lose the capacity to grow [17] even though as the fish grows older, Instead growth rate slows down. This could possibly be a reason why there were notable differences in the weights and lengths of the fish examined in some previous works. The four components of the heart observed in the present study also agrees with that reported by [12, 18], Who reported that a typical teleost circulation is comprised of a single heart connected in series with the gills. Venous blood returns from the periphery and enters the sinus venosus, via the paired ducts before entering the atrium. The ventricle was observed to be compressed laterally in the present study, and according to [19], is the main pressure generating component of the heart, is filled by atrial contraction, but also by direct inflow of blood from the central veins during diastole. Both the atrio-ventricular and sino-atrial junctions are guarded by valves, whereas the connections between the sinus venosus and its tributaries are not [18]. The bulbus arteriosus in the present study was observed to be soft and elastic located between the ventricle and the gill capillaries. Similar work has also been reported that the ventricle pumps blood via the highly compliant bulbus arteriosus into the ventral aorta, which splits into four pairs of afferent branchial arteries that perfuse the gills where gas exchange takes place [19]. There are two major pathways in the gills. In the arterio-venous pathway, blood flows directly over to the central venous compartment and supplies the gill tissues with oxygen and nutrients, whereas oxygenated blood in the arterio-arterial pathway leaves the gills via four pairs of efferent branchial arteries [19]. The main portion of this blood enters the dorsal aorta, but some is also directed to the cephalic region via the carotid arteries. In unfed fish, 30-40 percent of cardiac output is typically diverted to the gut circulation (stomach, intestine and liver) via the coeliaco-mesenteric artery which in many species branches directly from the dorsal aorta but in fed fish the amount of the blood reduces because the vessels are relatively compressed [20, 21]. After having passed through the capillary beds, blood is returned to the heart via the venous circulation. Blood from the stomach and intestine is collected by the hepatic portal vein carrying blood to the liver, which in turn is drained by the hepatic veins directly into the sinus venosus [22]. The hepatic veins are typically short and differ in number among species. It has been suggested that active control of sphincters in these veins is a mechanism by which blood can be rapidly mobilized from the splanchnic circulation to the central venous circulation [23]. Paired caudal and cranial cardinal veins drain the caudal and cranial portions of the body, respectively [24] .Dorsal, lateral and ventral cutaneous veins primarily drain the skin, but also the buccal and opercular cavities [25, 26]. Valves are present in fish veins, but only at the junction of tributary vessels (ostial valves), and not along the length of the vessels (parietal valves) as in mammals

5. References

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