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Skeletal and Other Morphological Abnormalities in Cultured Nigerian African Catfish (*Clarias Gariepinus*, Burchell 1822)

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Abstract
Morphological abnormalities decrease the quality of cultured fish by affecting their aesthetic appeal, growth and survival. This study was designed to assess the different morphological abnormalities in African catfish raised from hatcheries on farms in Ibadan, Nigeria. Pre-tested structured questionnaires were administered to 58 consenting farmers/farms while samples of abnormal fish were collected and subjected to photography and radiography. Majority (91.4%) of the farmers had ever experienced morphological anomalies with the common ones identified being head, spinal and tail, representing 69.0%, 20.7% and 1.7%, respectively. Of the 58 farms visited, 40 (68.96%) had fish with deformities ranging from skeletal, tumours, fin and skin erosion. Consequently, 62.0% of the farmers claimed to have had difficulties selling deformed fishes, thus posing economic loss. Further research is required to identify the factors causing such deformities to enable aquaculture develop in a sustainable and profitable manner, especially among small and medium-scale fish farmers.

Keywords: Morphological abnormalities, *Clarias gariepinus*, Aquaculture, Fish hatchery

1. Introduction
Aquaculture is concerned with the propagation and rearing of aquatic organism under complete human control, involving the manipulation of at least one stage of an aquatic organisms' life before harvest in order to increase its production [1]. Aquaculture is usually threatened by the ever present susceptibility of cultivated animals to disease, instability in provision of water of suitable quality and rearing conditions different from the species- or developmental stage-specific ones [1, 2]. Several factors have been implicated in the appearance of deformations in fish, some have been linked to environmental disturbances and toxicants [3], parasites [4], nutritional deficiencies [5], genetic leaning [6], or traumatic injury [7]. Deformities have also been reported to be caused by non-inheritable congenital defects [8].
The quality of aquaculture-produced fish depends on organoleptic and morphological characteristics that are directly related to the quality of the fry and its diet [9]. In aquaculture, skeletal abnormalities portend serious economic problem, since they reduce the market value of produced fish by affecting aesthetic and survival [10]. Since manual sorting is required to discard deformed individuals, there is also a negative effect on growth and conversion rates as well as susceptibility to disease [10, 11].
Previous studies suggest that malformations are induced in early stages during the embryonic and larval periods of life, although the causes and mechanisms responsible are not well understood [10]. Several factors have however been proposed to explain skeletal deformities in hatchery reared fish larvae in because of the high frequencies of deformities, often associated with reduced growth and viability [12, 13]. However, the most probable cause seem to be the existence of unfavorable abiotic and rearing conditions [10, 14, 15] but nutritional deficiencies [16], have also been implicated. Aquaculture is still in its infancy in Nigeria, it is therefore essential to take stock of the progress made to ensure sustainable aquaculture development. Additionally, for continued aquaculture promotion and profitability, reduction of abnormalities in hatchery-reared fish is very important. This study was therefore aimed at identifying and describing the abnormalities occurring in hatchery-reared African catfish (*Clarias gariepinus*), the most commonly cultured species in Nigeria. Diagnostic imaging was used as a complementary technique to further evaluate specimens.

2. Materials and Methods

2.1 Questionnaire: Well-structured and pre-tested questionnaires were administered by interviewer to 58 consenting breeder and grow out fish farmers where fish are breed and stocked to table size to collect information on occurrence, types, frequency and impact of abnormalities, amongst others.

2.2 Sampling for photographic and radiographic assessment: When available, specimens of abnormal fish were collected for photographic and radiographic assessment and documentation of the different types of abnormalities. Fish were sampled during sorting and cropping periods in each of the farm. Ponds were drained and all fish cropped, counted, weighed and deformed fishes were separated. Photographs of abnormal fishes were taken with a digital camera (Nikon Coolpix® L30). Abnormalities adjudged to be skeletal were separated for radiography using GE AMX4 plus Model 2275938-9 Portable X-Ray Machine. Fishes were placed in lateral and/or dorso-ventral positions; the location, type and severity of deformities including lordosis, scoliosis and kyphosis were examined by observing the structure, size and position the vertebral column.

2.3 Statistical Analysis

Questionnaire data was computed and presented as frequencies and percentages.

3. Results

3.1 Questionnaire

Majority (91.4%) of the farmers had ever observed morphological abnormalities on their farms (Table 1) and 69.0% reported head abnormalities, 20.7%, body, and 1.7% tail, while 8.6% reported no abnormalities (Table 2). The farmers reported that a larger proportion (36.2%) of abnormalities were discovered in adult fish, 27.6% in post-fingerlings, 17.2% in juveniles, 10.3% in Post-juveniles and 8.6% fingerlings (Table 3).

The findings on frequency of occurrence of abnormalities showed that majority (41.4%) of the farmers claimed that abnormalities was rarely observed, 32.8% claimed that it occurred occasionally and 25.9% claimed that it occurred very often (Table 4). Table 5 revealed that majority (93.1%) of the farmers believed that morphological abnormalities retarded growth in fish, 1.7% did not, while 5.2% didn't know either way. Table 6 reveals rate of survival of affected fish to market size. Majority of the farmers (34.5%) said 75% of affected fishes usually survive to market size, Majority (46.6%) of the farmers sold off fish at 6 months, 22.4% at 5 months, 17.2% at 9 months and 5.2% at 4 months.

Table 1: showing frequency and percentage of morphological abnormalities on Fish

	Response	Frequency	Percentage
Have you ever noticed any morphological abnormalities on your catfish?	Yes	53	91.4
	No	5	8.6
	Total	**58**	**100.0**

Table 2: showing part of the body most implicated in morphological abnormalities

	Response	Frequency	Percentage
On which part of the fish's body is abnormality usually found?	Not affected	5	8.6
	Head	40	69.0
	Body	12	20.7
	Tail	1	1.7
	Total	**58**	**100.0**

Table 3: showing stages at which abnormalities are observed

	Response	Frequency	Percentage
At what stage do you notice the abnormalities?	Fingerlings	5	8.6
	Post fingerlings	16	27.6
	Juvenile	10	17.2
	Post juvenile	6	10.3
	Adult	21	36.2
	Total	**58**	**100.0**

Table 4: showing frequency of occurrence of abnormality in each batch of fish reared

	Response	Frequency	Percentage
How often do you notice abnormality in each batch of fish reared on your farm?	Very Often	15	25.9
	Occasionally	19	32.8
	Rarely	24	41.4
	Total	**58**	**100.0**

Table 5: showing effect of abnormality on growth fish

	Response	Frequency	Percentage
What effect does the abnormality have on growth of the fish?	Retards growth	54	93.1
	Does not retard growth	1	1.7
	I don't know	3	5.2
	Total	**58**	**100.0**

Table 6: showing rate of survival of affected fish to market size

	Response	Frequency	Percentage
Rate of Survival of affected fish to market size	100% of the fishes affected survive to market	6	10.3
	75% of the fishes affected survive to market	20	34.5
	50% of the fishes affected survive to market	15	25.9
	25% of the fishes affected survive to market	6	10.3
	0% of the fishes affected survive to market	6	10.3
	Not affected	5	8.6
	Total	**58**	**100.0**

3.2 Gross abnormalities

Out of the 58 farms visited; 40 (68.96%) had fish with different types of deformities. The deformities were externally apparent and were identified as spinal deformity (Figures 1-3), head deformity (Figures 4-8), tumours and fin deformities (Figures 10-11), and skin erosion (Figure 11).

Fig 1a: showing Dorso-ventral lordotic curvatures in *Clarias gariepinus*

Fig 1b: showing radiograph of the *Clarias gariepinus* with dorso-ventral lordotic curvature with two flexures

Fig 2a: showing spinal deformity (scoliosis) in *Clarias gariepinus*

Fig 2b: showing radiograph of the *Clarias gariepinus* with scoliosis

Fig 3a: showing mild scoliosis and kyphosis in *Clarias gariepinus*

Fig 3b: showing radiograph of the *Clarias gariepinus* with a Scoliosis and kyphosis

Fig 4: showing *Clarias gariepinus* with a protuberance on the parietal part of the head

Fig 5: showing *Clarias gariepinus* with a depression on the parietal part of the head

Fig 6a: showing *Clarias gariepinus* with skeletal deformity and calcification of the head

Fig 6b: showing radiograph of the *Clarias gariepinus* with skeletal deformity and calcification of the head

Fig 7: showing *Clarias gariepinus* with skeletal deformity leading to depression of the bone between the eyes

Fig 8: showing *Clarias gariepinus* with skeletal deformity of the head and abnormal head to body ratio

Fig 9: showing *Clarias gariepinus* with fin and skin discoloration, and growth on the ventral part of the operculum

Fig 10: *Clarias gariepinus* with abnormal growth (myofibroma)

Fig 11: *Clarias gariepinus* with darkening and ulceration of the skin

4. Discussion and Conclusion

Skeletal abnormalities are very vital to product quality, animal welfare and cost-efficient production of fish. In the wild, malformed animals rarely survive because of the force of natural selection but larvae with many morphological anomalies survive in hatcheries [17]. The morphological deformities in fish result from disruptions in the skeletal developmental process. In this study, morphological abnormalities were reported to retard growth in fish and although affected fishes usually survive to market size, 25.9% claim customers had very poor disposition to buying affected fish. They have been similarly reported to cause lowered growth, high mortalities, reduced market value, and are consequently a significant loss for the farmer [17].

Various types of skeletal anomalies have been previously described in different fish species [18]; these include scoliosis, lordosis, spondylolisthesis, mandibular deformities, semi-opened operculum, stump body, pug-head, double fins, fin fusion and cross bits [19, 20, 21]. Head deformities were the most common deformity observed in the present study (Figures 4-8) which was in accordance with reported head deformities in many species of freshwater and marine fish [5]. Olatunji-Akioye *et al.* [22] also reported similar abnormalities in adult catfish sourced from private fish farms in Ibadan, but they observed no spinal column involvement. The predominant type of spinal deformities observed was scoliosis (Figures 1-3) which varied in degree and the number of flexion of the vertebral column. The first effect of spinal deformity is buckling failure of the axial skeleton due to an increased compressive load. The second effect is extra bone deposition as an adaptive response of the vertebrae at the cellular level, caused by an increased strain in these vertebrae.

Radiography is faster and simpler to perform than standard histological methods for examining skeletal anatomy and provides considerable details without requiring the sacrifice of the animal. This was affirmed in this study as evidenced by the details of abnormalities obtained from the radiographs of observed abnormalities (Figures 1b, 2b, 3b and 6b), which is complementary to previous publication [22]. Yadegari *et al*, [23] also reported various patterns of skeletal deformities including lordosis, kyphosis, Scoliosis, fusion of vertebrae, mandibular joint deformity, two mouth fish and parrot-like head in cultured rainbow trouts in Iran.

Hatchery conditions associated with skeletal abnormalities include inappropriate hydrodynamics in the tank (particularly high speed currents), high or low temperature, light intensity and salinity [17]. Diseases, particularly of bacterial origin, have also been implicated in skeletal deformities in fish [24]. The skeletal system of some fish is so sensitive to pollutants that fish have been proposed as biological indicators of water purity or pollution [10]. Several individual cases of spinal deformities in catfish were attributed to vitamin C deficiencies [25]. The teratogenic effect of retinoic acid, a compound related to vitamin A, is now well documented in vertebrates [26]. High dietary retinoic acid levels resulted in higher incidence of bone deformities, such as vertebral curvature, central fusion and compression of vertebrate in Japanese flounder larvae [16]. According to Hiroaka and Okuda, [27], the red medaka (*Oryzias latipes*) developed spinal abnormalities in proportion to the concentrations of two heavy metals and two agricultural chemicals to which young fish were exposed.

In the current study, further study is required to determine the exact cause of the observed deformities; however, based on previous studies in other fish species; sub-optimal culture conditions, Inbreeding, nutritional deficiency, a genetic or congenital mutations or a combination of the aforementioned are likely to elicit the abnormalities.

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