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Macroscopic description and histopathological characterization of lesions observed on fish farmed within the Saint-Louis region of Senegal

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Abstract
Fish farming, one of the priority sectors in Senegal, is well established in the Saint-Louis region, which offers a high potential, with more than 50% of farms in activity and dispose of a well-supplied hydrographic network and support services (executive agencies and university).
However, this development is correlated with a variety of health problems observed in the most cultured fish in Senegal (tilapia and catfish). The objective of this study is to describe the clinical cases and lesions observed in tilapia (*Oreochromis niloticus*) and catfish (*Clarias gariepinus*), reared in fish farms in the Saint-Louis region. The study started with surveys followed by the description of clinical signs and macroscopic lesions observed on sick or freshly dead fish and then by bacteriological and histopathological examinations. Results from the investigations have highlighted, firstly, the risks of chemical or microbiological contamination related to the proximity of habitations to fish farms (environmental contamination), and secondly, the fluctuations of physico-chemical parameters and the degradation of water quality, feed quality and its storage conditions. The results showed that clinical cases are associated with lesions either localized on different parts of the body (fins, gills, eyes), or generalized to external and internal organs. Cases of malformations and swollen masses were also noted. Bacteriological analysis revealed the presence of *Aeromonas hydrophila*, in co-infection with *Vibrio* sp. Histology confirmed multiple necrotic, hemorrhagic and cystic lesions on skin and in other organs. The observed clinical cases are associated with the poor conditions of fish farming and of the local environment in the study area.

Keywords: Fish farms, tilapia, catfish, lesions, Saint-Louis, Senegal

1. Introduction

Senegal is a country with long tradition of fisheries disposing of a great potential in aquaculture having a dense hydrographic network. In Senegal, fish is the primary source of protein with at least 70% of total animal protein intake [1, 2]. In a context of rarefaction of captured fish due to overfishing, fish farming in Senegal is positioned to play an important role in reducing poverty and improving food security for communities. Fish farming in Senegal is practiced in intensive and semi-intensive systems which, as any intensive production activity, is facing various technical, institutional and sanitary constraints as well [3]. In terms of animal health, the development of this activity is limited by numerous diseases of which understanding is a requirement to limit their impact on the performance of fish farming in Senegal. Fish diseases are closely linked to the aquatic environment. Indeed, in addition to the stress due to the fluctuations of water physico-chemical parameters used for fish farming and involved in the appearance of non-infectious diseases, there is the presence, in the environment of the farms, of micro-organisms that can become pathogenic when the farming conditions deteriorate. Indeed, these micro-organisms can be found in the water or sediment of farming facilities (ponds or reservoirs), in the environment following the conduct of human activities (agricultural pollution, various waste). Thus, fish diseases can appear at any time within a farming facility, often resulting in serious losses [4].

The sanitary and disease management of a fish farm calls for the establishment of a disease surveillance program to detect early warning signs in order to make a proper diagnosis and effective management [5]. In identifying suspected diseases, careful examination of diseased fish combined with necropsy, histopathology and microbiological analysis is the best approach to achieve an accurate diagnosis followed by appropriate control measures. Indeed, in pathology in general and in fish in particular, histological examination is very useful for diagnosis since most common diseases have specific histological features [6]. The present study's aim is to perform a health surveillance and describe the clinical occurrences and lesions observed in the different species of tilapia and catfish cultured in fisheries in Saint-Louis region. Data collection methodology consisted of a follow-up at the active farms in the region and the administration of a questionnaire during field visits. Then, clinical examination was performed based on a general examination at the aquaculture farms surveyed (ponds, basins, floating cages or others) and then an individual examination of all fish that showed any clinical signs of disease. The general objective of the present study is to make a health follow-up and to describe the clinical cases and lesions observed in fish (tilapia and catfish), reared in fish farms in St. Louis region.

2. Material and Methods

2.1 Study area and Fish

This study covered 63 fish farms installed in different localities of the Saint-Louis region (Figure 1). St. Louis is an area where fish farming is growing rapidly with the presence of accompanying structures (two agencies involved in aquaculture and a university with a program in aquaculture). More than half of the Senegalese fish production is produced in this region through the fish farming stations of Maraye and Richard Toll, which produce most of the fingerlings that supply the majority of fish farmers in the northern aquaculture zone of Senegal (Saint Louis, Louga, and Matam regions). The observed fish sample consisted of 74 individuals showing signs of disease, including 45 tilapias belonging to the species *Orechromis niloticus* and 29 catfish of the species *Clarias gariepinus*. These two species are the main species reared in the area under study. These fish were in different stages of development (reproduction, larval stage, rearing, grow-out.

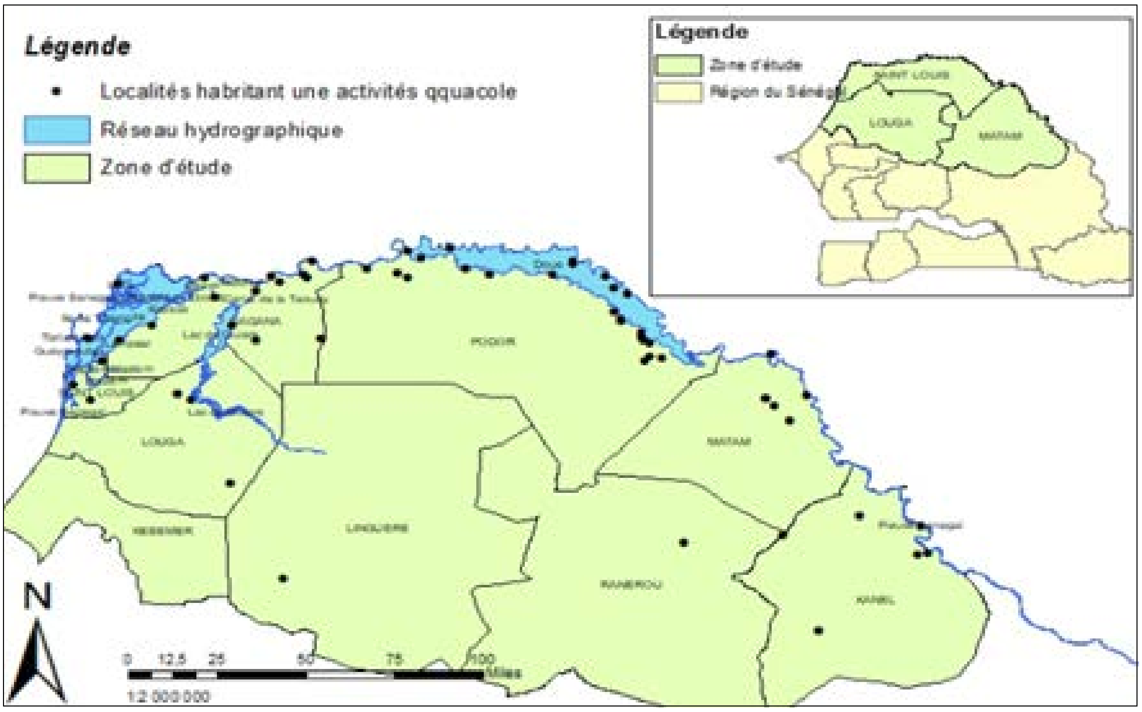

Fig 1: Area study with Fish farms localization in St. Louis region (**.**) [5]

2.2 Surveys

Data collection consisted of regular field visits to operating farms, where a questionnaire was administered to collect information related to geographical location of the farms, environmental assessment of the farm, assessment of water quality and physico-chemical parameters and evaluation of the feed quality and its storage conditions.

2.3 Health surveillance and anatomo-clinical description of disease occurrences

Clinical examination consisted of a general inspection of the aquaculture farms surveyed (ponds, tanks, floating cages) and fish that showed clinical signs of disease. First, data were collected through case history and commemorative records, then fish showing unusual behavior in the water column and/or the presence of visible lesions with the eye were examined. Macroscopic description of these lesions was performed on different parameters (size, shape, color, consistency) of the affected tissues and organs. The approach followed is the further observation with appreciation of the swimming and behavior of the fish, their positions in the water column, their way of swimming, their behavior in the presence of food in the water. After these different phases, a close examination was carried out on the fish in order to better define the existing lesions. Fish showing signs of disease are captured, humanely killed, and necropsied. Necropsy of diseased fish follows a protocol described by [6]. Briefly, the fish is placed on its right side with its belly toward the person performing the necropsy. Three incisions are then made: the first incision is made along the ventral midline from the anal orifice to the ventro-caudal edge of the gill cavity; the second incision continues on from the end of the first incision, in a dorsal direction, following the caudal border of the gill cavity, to the dorsal limit of the abdominal cavity; the third incision is curved, follows the dorsal end of the abdominal cavity, and joins the two ends of the first and second incisions. By removing the dissected slice of muscle and skin, the abdominal cavity is thus exposed. Organ position and any abnormalities found as well as parasites are noted. From the lesioned organs, samples were taken, some of them were used to make wet mount preparation for parasites microscopic examination as described by [7]. Others samples were fixed in 10% buffered formalin for histopathological examination at the Laboratory of Animal Histopathology and Cytology of the Interstate School of Veterinary Science and Medicine (EISMV) in Dakar using the standard histological method [8]. Samples for bacteriological analysis were also taken and sent to the Laboratoire National de l'Élevage et de Recherches Vétérinaires (LNERV) where standard procedure for isolation and identification of bacteria was applied [9, 10].

3. Results and Discussion

3.1 Influence of close proximity to housing on water quality and fish health

Surveys revealed that more than 50% of the farms surveyed in this area are close to residential areas. This proximity to the residents exposes the fish farms to different types of pollution, as washing and bathing activities are noted in 25% of the fish farms close to the houses (Figure 2). As a consequence, the populations often discharge wastewater into the river. 55% of the farms are close to or integrated with agricultural activities that use pesticides. These practices may affect fish health [11] and public health, particularly in terms of the suitability of fish from these farms. According to [6] and [12], many diseases can affect fish as a result of chemical water pollution, including environmental gill disease, brown blood disease and environmental hypoxia. Similarly, pollutants, under certain conditions, can be responsible for a variety of skin lesions in fish including cases of deep ulcers and barbel loss attributed to chronic irritation from chemical contamination of sediments in Canada [6]. These consequences would be contributing factors to the occurrence of the reported clinical cases (skin lesions, gill involvement) during this study. According to [13], man's activities have had profound, and usually negative, influences on freshwater fishes. Some negative effects are due to contaminants, while others are associated with changes in watershed hydrology, habitat modifications, and alteration of energy sources upon which the aquatic biota depends.

Fig 2: Floating cage system (red circle) near households

3.2 Fluctuations in water physicochemical parameters, degradation of water quality and consequences on fish health

Controlling physico-chemical parameters is an important part of the daily management of fish farming facilities. Indeed, the survey of physico-chemical parameters allows to know the quality of the water and to adjust these parameters to the needs of the species that are farmed. Results of this study revealed that the recording and analysis of physical and chemical parameters is not yet systematic at several farms in the St. Louis region (Figure 3). Yet, abrupt variations in physico-chemical water parameters are factors that promote stress in fish, but also the development of disease problems as stated by [6]. Indeed, when farmed fish are kept in optimal conditions, they grow well as noted by [15, 16].

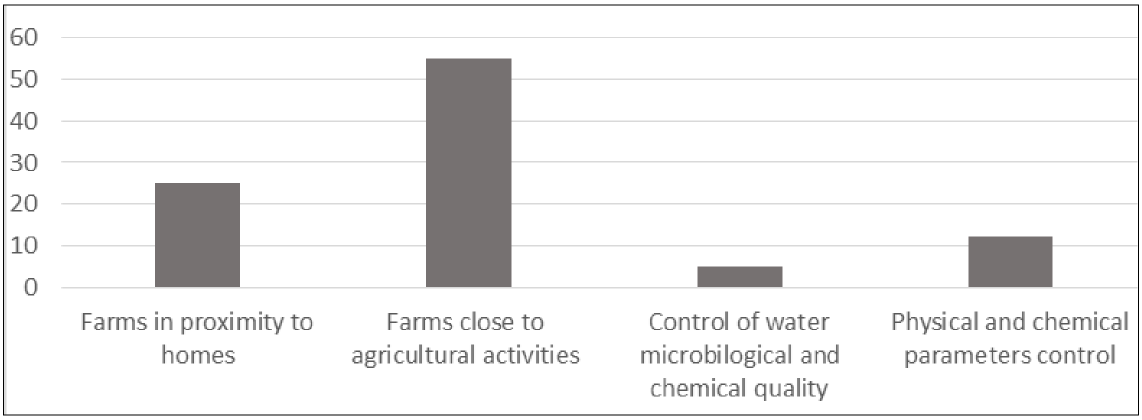

Fig 3: Location of fish farms in regards to habitations

Parameters such as pH, levels of various components (ammonia, nitrate, nitrite), temperature and dissolved oxygen are recorded in farms belonging to government agencies or university, especially at hatchery and larvae rearing sites. Figure 4 describes the variations of physico-chemical parameters in a larval rearing of *Clarias gariepinus* on a period of one month. It shows that pH varied from 3.25 to 7.75 (figure 4 A); ammonia (NH_3) between 0.2 and 0.75.6 mg/l (figure 4 B); nitrite (NO_2^-) between 0.125 and 0.625mg/l (figure 4 C) and nitrate (NO_3^-) 0.25 and 7.5 mg/l (figure 4 D).

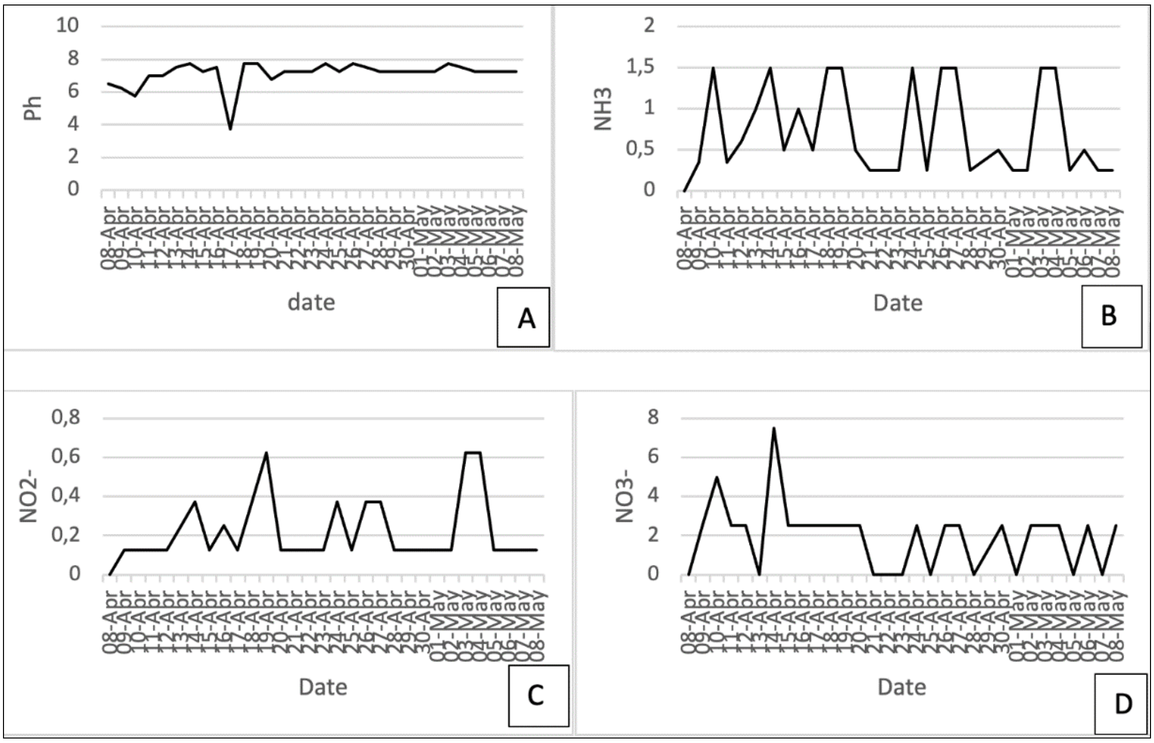

Fig 4: Physical and chemical parameters variation in a larval rearing facility

The lowest pH period (3.25) coincided with the highest ammonia concentration in the rearing facility, 1,5 mg/l and at the highest nitrite level (0,625 mg/l). During this period, very high mortalities, up to 100% loss of larvae, and the appearance of signs of suffering were noted in the fry. The observed clinical signs, among five-month-old fry, are: abnormal and erratic swimming, surfacing and clustering at the border of the tank, high mortality with agonizing individuals, pale discoloration all over the body, hemorrhagic abdominal lesions and whitish spots on the dorsal side of the body (Figure 5).

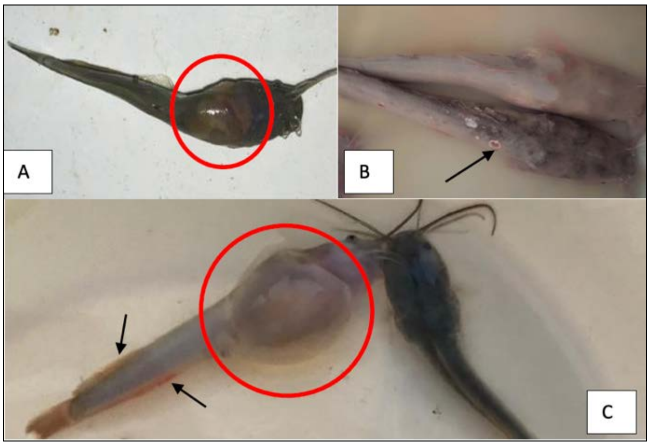

Fig 5: Catfish (*Clarias gariepinus*) fry showing signs of abdominal distension (circles A and B), discoloration (B), and focal hemorrhagic ulcerations (arrows B and C)

These clinical signs are associated with slow growth and very high mortalities ranging from 75 to 100%. These disease conditions are attributed to water quality deterioration with often low temperatures, high ammonia and nitrite levels, and low dissolved oxygen levels enhancing fungal infections [17, 18, 19]. Systemic infections are then observed producing mycelial masses in the intestine and viscera, causing peritonitis, extensive bleeding, necrosis, and external signs of bloat caused by intestinal obstruction (20). Temperature variations during this study was between 25 and 27 °C (figure 6). These values are adequate for larval and fry development. It should be noted that according to [21], sudden temperature variations can, under certain conditions, lead to trouble in fish farms.

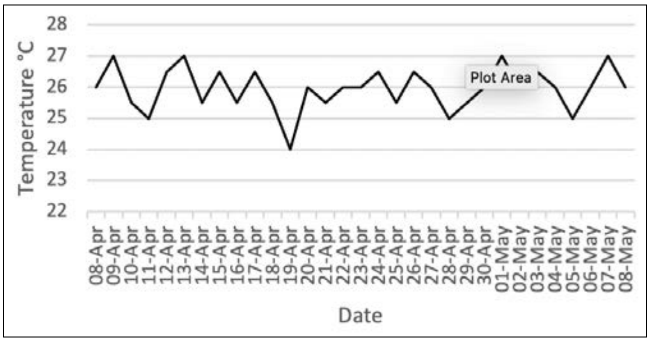

Fig 6: Temperature variation in a larval rearing facility in Saint-Louis region

The measured parameters (pH, ammonia, and nitrite) were found to be abnormal and may have caused health problems for larvae and fry during this study. These results are similar to those reported by [14, 15, 18]. Managing water quality, both physical and chemical, used in the operation of a fish farm is an important issue in fish farming [11].

Water quality deterioration also has consequences on adult fish health and growth. Indeed, management of certain fish farming facilities (ponds, tanks) is made complex by installations that do not always allow an adequate renewal of the water. Thus, it is common to observe fish mortality in ponds or reservoirs with deteriorated water quality. Figure 7 shows adult tilapia (A) and adult catfish (B) dead in water that has not been properly renewed. In such water, ammonia and nitrate levels are very high; oxygen levels, on the other side, are very low due to high biological oxygen demand. According to [22], stress due to poor rearing conditions is one of the factors favoring bacterial and fungal outbreaks and parasitic infestations. These outbreaks are frequent in the study area and constitute a real problem when there is deterioration in water quality as described by [11]. Indeed, a concentration of ammonia and nitrite can be explained by overfeeding or non-ingestion of the feed which can lead to its accumulation in the rearing environment and become a problem for the larvae. This problem will be exacerbated if the physical and chemical parameters are not controlled and adjusted to the species' requirements, or if the existing facilities do not allow for proper drainage.

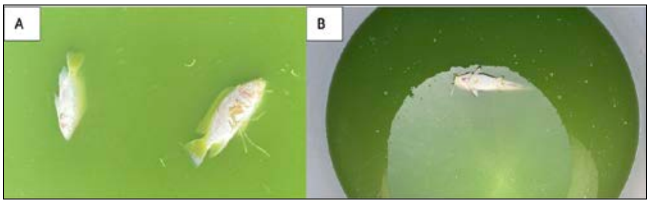

Fig 7: Death fish *Oreochromis niloticus* (A) and *Clarias gariepinus* (B) raised in poor water quality

3.3 Feed quality and storage, and their impact on fish health

The investigation revealed that almost half (48%) of the farms in the northern zone use local feed made on site, while 47% use both local and, sometimes, industrial feed and only 5% use exclusively industrial feed (Figure 8). The industrial feed is more suitable because of its well established and relatively well balanced composition.

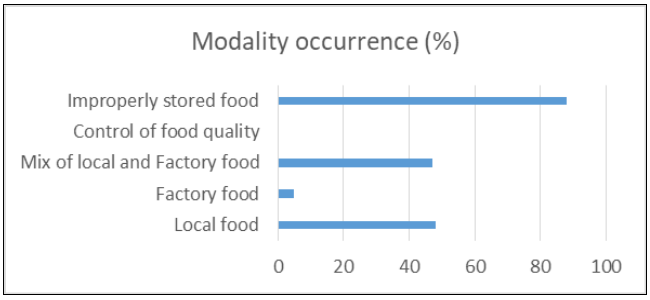

Fig 8: Feed varieties used in fish farms and their storage environment

Proper storage of the feed, which guarantees its stability and quality, is not always done in good conditions on the farms visited. Poor quality or deteriorated feed can lead to deficiencies in the animals receiving such feed. Among problems identified and related to nutritional imbalance, there are cases of growth retardation (fish of 5 months of age with an average weight of at most 20g against a minimum of 30g, figure 9). Affected fish present a clinical pattern with skin darkening, exophtalmia and opacification of the eye lens, mouth ulcers, surfacing, lethargy, irregular swimming, but with normal internal organs. Growth deficiency is often related to poor feeding due to the size of the pellets not adapted to the rearing stage. The associated clinical signs are retrobulbar vascular damage responsible of hemorrhages and blood accumulation in the eye cavity, which leads to the protrusion of the eye out of the globe (exophthalmia). According to [23, 24], bad storage conditions of feed deteriorate their quality; resulting in either deficiencies or intoxications. According to [25], foodborne injuries are very common in fish farming and can occur at any stage of development. The intensification of the farms and the intake of unbalanced artificial feed can lead to the appearance of disorders, especially malformations as described by [26].

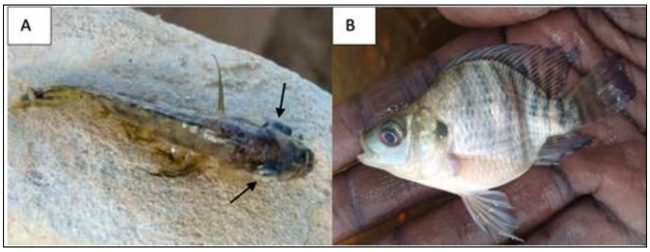

Fig 9: Tilapia (*Oreochromis niloticus*) fry showing growth deficiency combined with exophthalmos (A) and bone malformation (B)

3.4 Anatomo-clinical and histopathological aspects of disease cases recorded on fish farms in Saint-Louis region

3.4.1 Lesions located on body and fins

In general, the most frequent skin lesions observed are caused by injuries during handling. These skin lesions constitute gaps that expose affected fish to microbial over-infection. Affected fishes' primary sign is an abnormal swimming behavior in the water column, most often lateral. On close examination, inflammatory and hemorrhagic lesions are seen on the pectoral fins, absence of scales in some areas and superficial loss of epidermis or fins in other specimens (Figure 10).

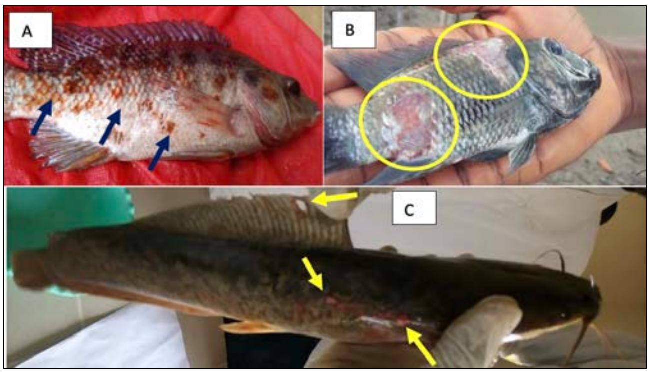

Fig 10: Tilapia (*Oreochromis niloticus*) showing hemorrhagic-type lesions (arrows) (A); with scale loss and deep ulcer (circled) (B), and catfish *Clarias gariepinus* with skin and fin injuries (arrows) (C)

Wet mount examination of a craping on injured skin revealed ciliated, motile protozoa belonging to *Trichodinadae*, genus *Trichodina* sp. and monogenic trematodes of genus *Gyrodactylus* sp (Figure 11).

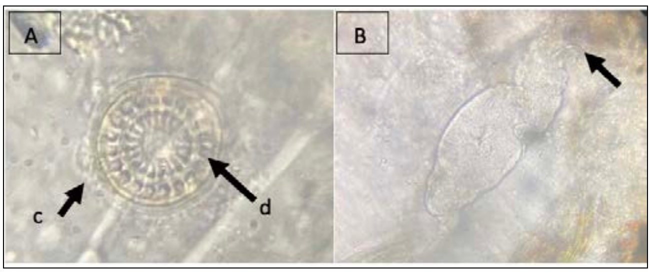

Fig 11: A wet mount of skin lesions (light microscope, x40). Showing *Trichodina* sp with cilia (c) and denticles (d) and *Gyrodactylus* sp in a tilapia (*Oreochromis niloticus*) with fixation organs (arrow, B)

Histological examination revealed hyperplastic and congested gill lamellae in some areas (Figure 12).

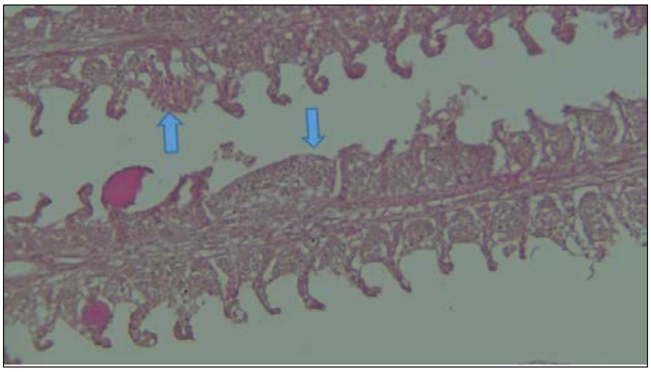

Fig 12: Histological appearance of hyperplastic, altered and fused gill lamellae.

*Trichodina*e, described by [27], are characterized by the presence of a band of ombicated cytoskeletal denticles, which are responsible for cell support and adhesion to fish surfaces. *Gyrodactylus* sp are tiny monogenic leech-like ectoparasites that live on the body surface of freshwater fish. These parasites are present in both tilapia and catfish. Their posterior extremities have an attachment organ called haptor, that they use to attack the host fish. *Trichodina* spp were found in the gills of both tilapia and catfish. Infested fish showed gill hyperplasia, pale gills, thickened and fused gill lamellae with heavy mucus secretion. This damage to the gills leads to respiratory difficulties and sometimes to skin irritation when the parasite is attached to the skin. These results confirm [28] who made a similar anatomical-clinical description on fish farms affected by Trichodinosis. According to [29], *Dactylogyrus* generally prefer gills as a location for feeding and attachment, as found primarily in freshwater fish, while Gyrodactylus attach to the skin of catfish using an attachment organ called a haptor. These results are similar to [30, 31]; they also corroborate work reported by [32, 33] who demonstrated that infested fish have thickened and congested, and sometimes deformed gills. Mastocytic/eosinophilic granule cells containing multiple eosinophilic granules were observed. However, we were unable to detect ring structures on the histological sections examined that reveal *Trichodina* spp. as described by [32]. Histological studies on tilapia gills, infected with *Trichodina* spp. and *Monogenea* spp. showed the presence of the parasites in the gills with secondary lamellar damage, fusion, vascular disturbances (congestion, hemorrhage) and mucus hypersecretion. Other remodeling is noted including epithelial hyperplasia and desquamation, fusion of secondary lamellae [34].

Among *Clarias gariepinus*, the observed skin lesions consisted of cutaneous ulcerations of the ventro-caudal region of the operculum, hemorrhages at the fins (caudal, anal, pelvic and pectoral) and at the urogenital orifice. The ulcerated areas are clearly delimited by hemorrhagic edges. However, when the abdomen is opened, the internal organs are normal, but the gills are slightly pale (Figure 13).

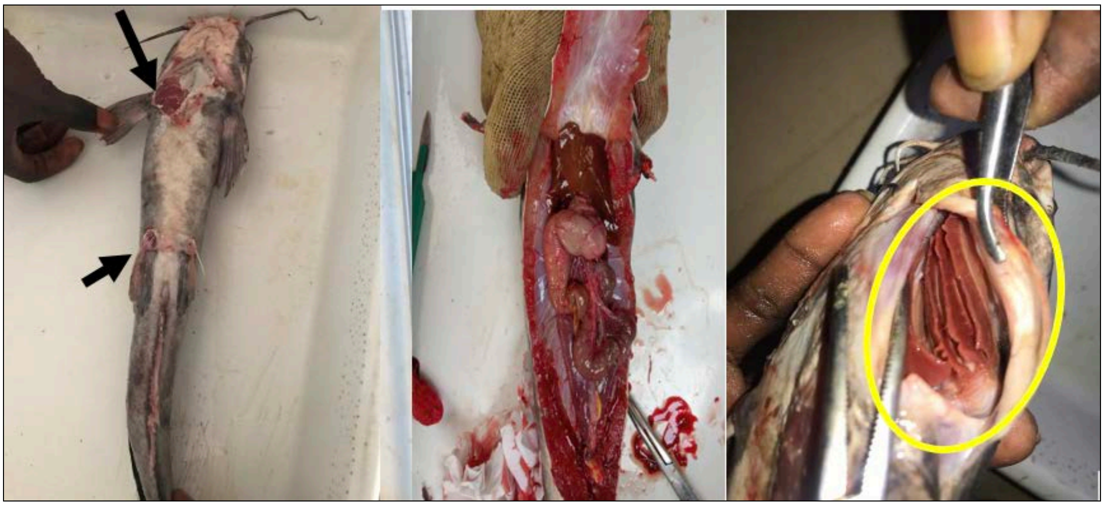

Fig 13: Cutaneous ulcers (arrows) with normal internal organs and pale gills (yellow circle) in *Clarias gariepinus*.

In fish farming, cutaneous lesions are dominated by chronic inflammatory lesions due to excessive handling during stripping [35]. Indeed, some of these lesions have been observed in broodstock that received hormone injections (ovaprim) during artificial reproduction, which injections led to bacterial superinfection.

During the larval and fry rearing stages, several sanitary problems are noted at farm sites. In fact, these stages of rearing are among the most critical phases of fish farming with mycotic diseases in both tilapia and catfish. Affected fish present a clinical picture similar to saproleniasis with a whitish mass with a cottony appearance and long filaments surrounded by hemorrhagic areas at the opercules and urogenital orifice. A wet mount craping from a cutaneous lesion shows coenocytic, long, and large nonseptate hyphae as described by [35] (Figure 14).

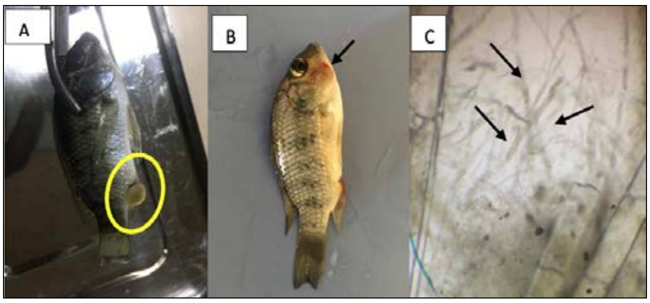

Fig 14: Tilapia (*Oreochromis niloticus*) fry affected by mycosis characteristic of saproleniosis with the presence of a cottony mass (A: yellow circle), surrounded by a hemorrhagic zone (B: arrow) and the presence of non-septate hyphae found by microscopic observation from a wet mount preparation (C: arrows)

This symptomatology is already described by [25] who demonstrated non-septate hyphae of *Saprolegnia* ssp with reproductive structures separated from somatic hyphae by a zoosporangium containing bifid zoospores. These diseases rarely affect healthy fish, infections are often associated with extreme temperatures and water quality deterioration, as discussed by [11]. Secondary infections due to bacteria are common. Affected individuals swim above the water column. According to [37], *Saprolegnia* is a common infection in Tilapia and catfish. *Saprolegnia* prefer temperatures between 15 and 30 °C [17, 19], conditions similar to those observed at fish farms in the St. Louis area. Indeed, fungi attack any existing injuries or lesions in the cutaneous barrier and can spread into healthy tissue. Any kind of stress to which the fish are subjected predisposes them to disease. Generally, saproligniasis is noticed when a white to gray or brown cotton-like material is present on the skin, fins, gills, eyes or on fish eggs. As the infection progresses, the fish usually become lethargic and less responsive to external stimuli [38]. However, fungal infections can spread rapidly and cover most of the body. Mass mortalities have occurred as a result of dermal mycoses due to *Saprolegnia* in pond-reared tilapia during periods of low temperatures in African countries [39]. Eggs are severely damaged by *Saprolegnia* sp when infected during artificial incubation. Invasion is enhanced by existing necrotic substances such as unfertilized and damaged eggs [40]. Systemic infections produce mycelial masses in gut and viscera, causing peritonitis, extensive hemorrhage, necrosis and adherence. In juvenile fish, external signs of bloat caused by intestinal obstruction may develop.

Cases of deep ulcerations, localized on the underside and chin, with loss of all barbels have been observed in a pond farm (Figure 15). The ulcerated areas are covered with necrotic tissue and surrounded by a hemorrhagic and inflammatory zone. These are traumatic wounds caused by the rough edges of the concrete tank in subjects, freshly caught from the natural environment, and introduced into this tank for acclimatization. The location of these ulcerations (chin, barbels, contact areas) in resting fish suggests chronic irritation by contact with the sides of the tank as reported by [6]. Often, these skin lesions undergo bacterial superinfection [14]; which worsens their evolution.

Fig 15: Ulcerative lesions on the chin (arrows) with loss of barbels in a catfish fry (yellow circle showing total absence of barbels)

3.4.2 Localized lesions in the opercules, gills and eyes

Abnormalities have been noted in various organs of adult tilapia reared on fish farms in this region. Among these abnormalities are those affecting the mandibles (Figure 16 A and B); affected individuals show compression of the ethmoidal region and the upper mandible. When the operculum is lifted (Figure 16 B), the gills are disorganized, dark red and hyperplastic with heavy mucus secretion, fusion of the gill filaments and then of the gill lamellae and laminae. Affected individuals swim on surface of the water column (surfacing).

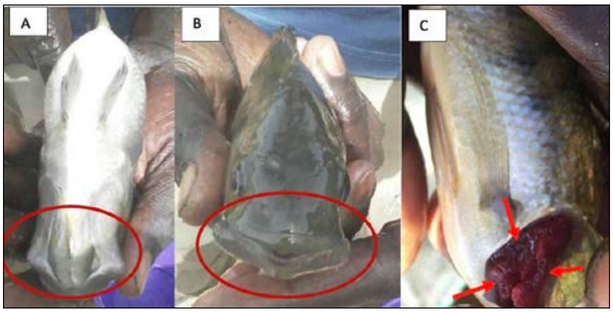

Fig 16: Compression of the ethmoidal region and upper mandible (circles in A and B and hyperplasia, disorganization and fusion of branchial filaments in Tilapia (arrows in C)

Other types of abnormalities have been recorded, notably in the opercules, with the presence of an opercular slit (figure17), the prominence of the gill rays, leading to the exposure of the gills which become dark red and hypertrophied. There is also a hypersecretion of mucus, fusion of the gill lamellae and filaments. Affected fish swim on the surface (surfacing), and show distension of the abdomen in some specimens. Mortalities of about 5% have been recorded at the site. These affections would be due to multifactorial causes, in particular the deficiencies in minerals and vitamins and the food which most often is unsuitable.

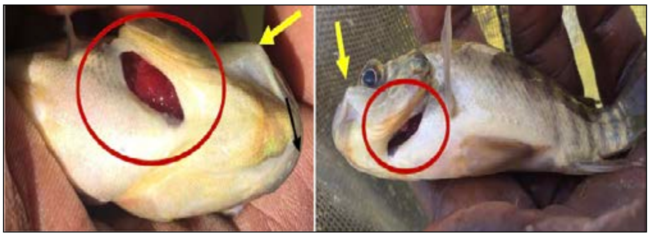

Fig 17: Tilapia fry with opercular malformations showing the presence of an opercular crack (circled areas) and prominent branchiostegal rays (arrows)

According to [26], deficient diet (in minerals and vitamins), due to too fresh water and inadequate feeding, poor in vitamins, or rearing methods affecting, in particular, the development of the spine, lead to scoliosis, lordosis or, sometimes, opercular, mandibular or maxillary deformity. In addition to the skeletal anomalies associated with feeding, there are a number of other anomalies of diverse origin (genetic, traumatic, temperature, rearing conduct.) [6, 25, 26, 41]. Generalized affection was manifested by exophthalmos, distension of the abdomen (Figure 18 A and B), hemorrhages in the pectoral fins of the gills, pallor of the gills (Figure 18 C), hypersecretion of mucus, fusion of the brachial lamellae associated with hypertrophy and necrotic areas. Opening of the abdominal cavity revealed a very pale liver with a gallbladder distended with fluid and the presence of clear abdominal fluid, and an empty digestive tract (Figure 18 D).

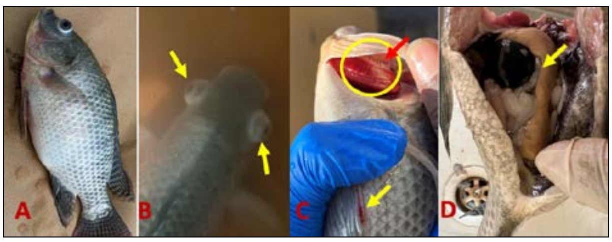

Fig 18: Tilapia (*Oreochromis niloticus*) with generalized lesions

A wet mount of skin scraping was examined and revealed monogenic parasites of the genus *Gyrodactylus* sp, family *Gyrodactylidae*, which are skin parasites, and gill tissue was examined and revealed monogenic parasites of the genus *Dactylogyrus* sp and *Gyrodactylus* sp (Figure 19), family *Dactylogyridae*, which are gill parasites. The genus *Dactylogyrus*, also known as the gill fluke, is a monogenic trematode that attaches to the gills or skin with two pairs of anchors [42]. In heavily infected fish, this parasite can also be found in the oral cavity, and sometimes on the fins and skin of freshwater fish. Other morphological characteristics of Dactylogyrus include the appearance of black eye-like spots called ocelli characteristic of the species. According to [43,44], these parasites, called small flukes, attach to the skin, gills, and fins using small hooks located in the caudal region and an attachment organ located close to the head. They feed on the epithelial cells and blood, which damages the skin and the gills of the fish. Indeed, the encrustation of trematodes in the gills of fishes leads to a reactive hyperplasia of the gills. In case of severe infestations, there is a hypersecretion of mucus at the level of the attachment zones of the parasites, giving a shiny and bluish aspect to the lesions. Hyperplastic epithelial lesions, ulcers, necrosis of the fin tips and respiratory difficulties are also noted. Our results corroborate those described by [45,46] in farmed fish particularly in tilapia and catfish.

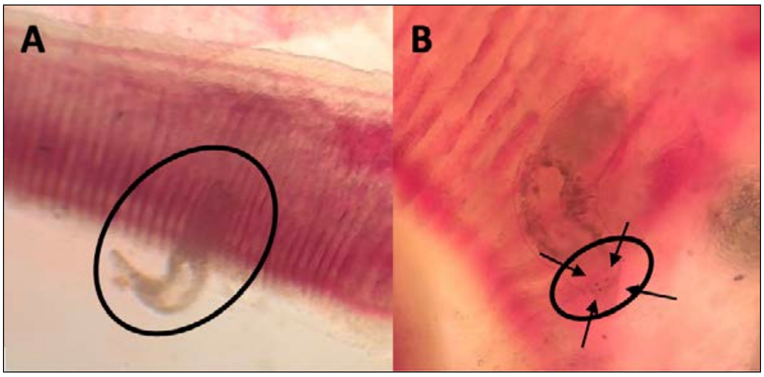

Fig 19: Wet mount showing *Dactylogyrus* sp embedded in gill of a tilapia (A and B), with four eye spots (arrows B)

Bacteriological investigations revealed the presence of *Aeromonas hydrophila*, in co-infection with *Vibrio* sp., which caused hemorrhagic septicemia in fish. According to [47], *Aeromonas hydrophila* is widespread in aquaculture and is probably the most common bacterial disease infecting wild and farmed tilapia. Furthermore, in fish farming, *Aeromonas hydrophila*, is an opportunistic pathogen in fish, as it is also in humans [48]. Clinically, infected tilapia typically exhibit inappetence, skin ulcers and hemorrhages, fin loss, and exophthalmos [48,49,50]. Other signs were also described such as ascites, hypertrophy (liver, kidneys, spleen) focal hemorrhagic necrotic lesions (liver, heart, skeletal and smooth muscles).

Histological examination revealed fin necrosis and hemorrhage (20A), hepatic steatosis (20B), and necrotic patches in the brain associated with emboli (20 C).

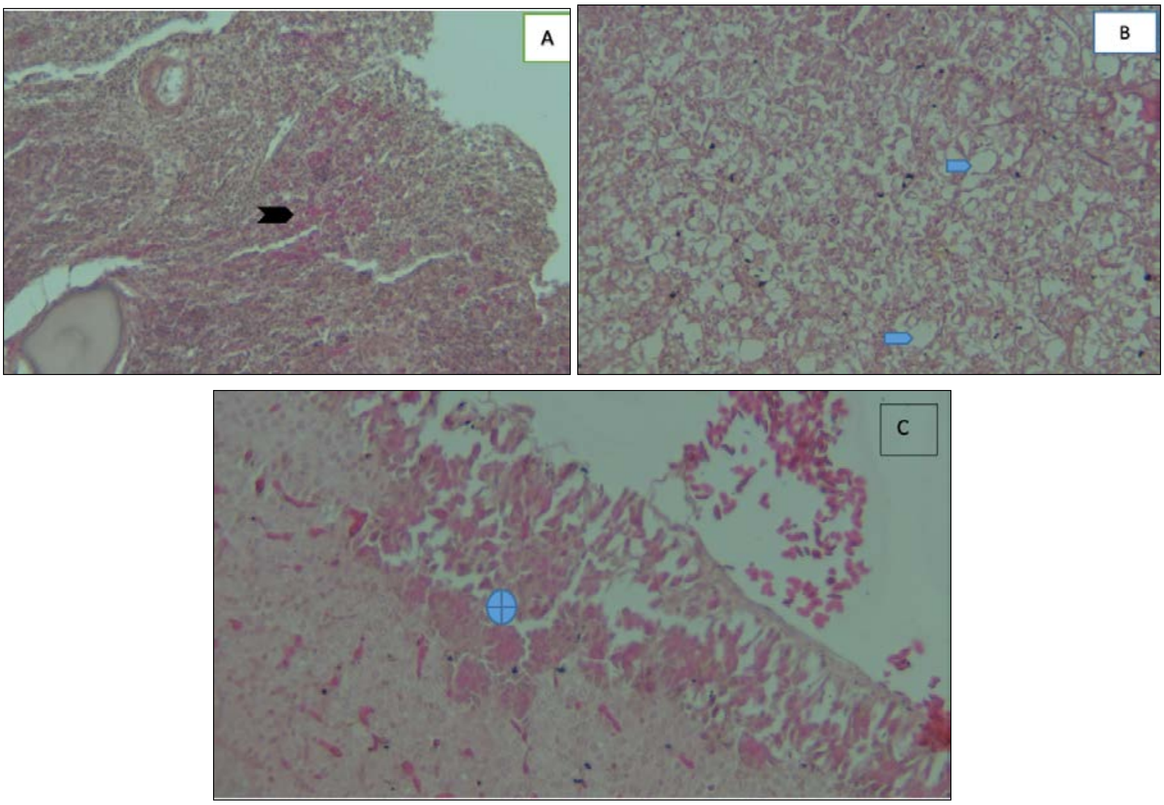

Fig 20: Histological aspects of fin remodeled by necrosis and hemorrhage

(A), liver with steatosis (B,), brain remodeled by patches of necrosis associated with emboli (C).
Hemorrhagic lesions and necrosis associated with emboli are compatible with bacterial sepsis. Some of these patterns of injury have been described by [51].
During this study, clinical cases with generalized lesions, encountered in catfish during the grow-out phase, were mainly deep ulcerations of the skin of the thoracic region with exposure of the underlying muscle tissue, hemorrhage at the caudal, anal, pelvic and pectoral fin levels (Figure 21). The necrotic zones are clearly delimited by hemorrhagic borders. Several individuals, at different farms, showed the same symptomatology, but to varying degrees. In some individuals, although they had the lesions described above, their internal organs were normal. In others, the abdominal cavity was very pale, gills were hyperplastic and very pale, liver and spleen were very dark to blackish, and gonads were discolored with a greenish appearance (Figure 21 B).

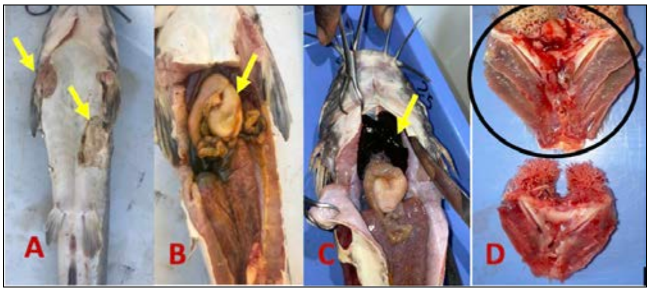

Fig 21: Cutaneous ulcers (arrows A) with discoloration of the internal organs (arrows B and C) and damage to the gills (circled D) on a *Clarias gariepinus*

In catfish, cases of septicemic enteritis, as described by [52], are frequently reported in *Clarias gariepinus* and *Clarias anguillaris* farms. Affected fish show lethargy, apathy, refusal to feed, skin darkening, and disoriented, spiral swimming. In the most advanced forms, there is the presence of raised skin patches progressing to superficial ulcers on the flanks and head, generalized hemorrhage (fin bottoms, around the mouth, on the throat, on the operculum, in the abdomen and intestines). There is also presence of exophthalmia, abdominal distension, ascites, pale gills, lesions on the liver and other internal organs (very dark liver, soft and pale spleen, petechiae on the kidney), and the anal orifice is swollen with leakage of feces (Figure 22).

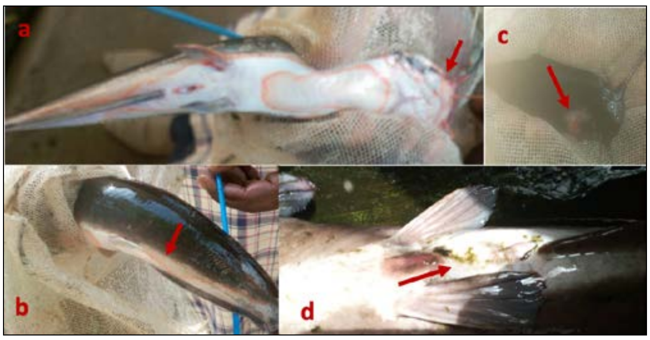

Fig 22: Catfish (*Clarias gariepinus*) with hemorrhages all over the body (barbels, anal orifice, base of fins) (a and b), a cranial ulcer (c) and a trail of feces (d) typical of catfish septicemic enteritis

3.4.4 Malformations and tumefaction masses
Various malformations, localized in different organs, were observed during this study. Indeed, a malformation of the oral cavity with loss of the jaw tips was noted in one tilapia (Figure 23A); similarly, scoliosis and lordosis, at different locations of the spine, were noted in a different tilapia (Figure 23B). Lordosis is a ventral deviation of the spine, as opposed to scoliosis which is a lateral deviation of the spine and xyphosis which is a dorsal deviation of the spine. Many factors can cause these malformations (nutritional, genetic, traumatic, environmental).

Fig 23: Deformation of the oral cavity with loss of the tips of the lower and upper lips (A), malformation of the spine showing scoliosis and lordosis (arrows) (B) in tilapia (*Oreochromis niloticus*)

In fish, deformities can be associated with various factors including chemical pollution which acts on bone metabolism and modifies their mineralization [53]. In fact, [54] have described various conditions including deformities, exophthalmos and tumors. The etiology of these types of pathologies is not well known, but incriminated causes have been the contamination of the sediment by toxic substances, intermittent stresses caused to fish by overflows, and pollution from urban activities [24].
Abnormal masses were noted in this study (Figure 24 A and B). It should be noted that fish, such as all animals, are prone to the appearance of spontaneous tumors [25].

Fig 24: External poly-lobed mass (A) and tumefaction (B) located at the urogenital orifice

4. Conclusion
The purpose of this study was to carry out a health survey in order to describe the clinical cases observed in the different species of tilapia and catfish, reared in fish farms located in the Saint Louis region. Results revealed environmental consequences, including variations in physico-chemical parameters and degradation of water quality, and inappropriate food storage conditions, due to the presence of the farms in the close surroundings of houses. In addition, results described various diseases in tilapia and catfish farmed in the surveyed farms. Considering the importance of these diseases, there is a need to combine clinical and laboratory diagnosis in order to refine their etiological diagnosis. Likewise, it is essential to reinforce good production practices (habitat, feed, water, biosecurity) within farms in order to reduce as much as possible the exposure of fish to pathogens and environmental risk factors, and thus improve their sanitary conditions.

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