



Aquatic Health in Sub-Saharan African Aquaculture

Perceptions and recommendations for evidence-based sector strengthening



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Acronyms

AAH	Aquatic Animal Health
EUS	Epizootic Ulcerative Syndrome
GCOA	Ghana Chamber of Aquaculture
ISKN	Infectious Spleen and Kidney Necrosis (Virus)
OIE	Organisation Internationale des Epizootics
TiLV	Tilapia Lake Virus
WOAH	World Organisation for Animal Health

Acknowledgement

We wish to thank all those working in African aquaculture who took the time to complete the online survey. Special acknowledgement also goes to: Dr Gillian Taylor, Venny Mwainge, and John Domozoro for their help in raising awareness of this survey to those working with and/or affected by fish/shrimp diseases across southern, east, and west Africa respectively. Our thanks also to the Food and Agriculture Organization of the United Nations for the financial support for the data collection survey.

Disclaimer

All data and information collected in this survey has been anonymised down to stakeholder group level. As such, all direct written responses from respondents to specific questions (in italics in the text) used in this report have been anonymised. The authors take no responsibility for these, but consider it is important for the sake of veracity, rigour and potential outcomes of this survey that they are included in this report.

Introduction and Rationale

In the last 10-15 years aquaculture has begun to commercialise and intensify across SS Africa, particularly in countries such as Nigeria, Ghana, Uganda, Kenya and Zambia. As an inevitable consequence of the intensification of any commercial livestock production system the risk and commercial implications of health management and diseases control becomes increasingly important (Chan *et al.*, 2021). There is already an evidence base from Egypt and Ghana clearly indicating the detrimental impacts and costs of fish diseases on the commercial aquaculture sector and the wider value chain. In Egypt, the so called “summer mortality syndrome” has affected commercial pond and hatchery tilapia aquaculture across the Nile delta, with consistent mortalities of up to 25% in grow out ponds. Since 2010, Egyptian fish farmers have been experiencing significant unexplained losses between March and September each year. Epidemiological surveys indicated that 37% of fish farms were affected in 2015 with an average mortality rate of 9.2% and an estimated loss of around US\$ 100 million (Fathi *et al.*, 2017). For Ghana, primarily in the cage and hatchery sectors on and around Lake Volta from 2016, large scale losses of tilapias are estimated to have cost the private sector over USD 100 million (Verner-Jeffries *et al.*, 2017, Leschen *et al.*, 2022). In the commercial shrimp farming sector, e.g., in Mozambique, specific viral pathogens have caused significant economic loss; in a localised sector where export of a healthy, internationally branded product is crucial (Responsible Aquaculture Foundation, 2013).

It is under these circumstances, as aquaculture expands and intensifies elsewhere across the African continent, that [ThinkAqua](#) and [Casammak](#) set out to collect up to date information on aquatic health systems in ten sub-Saharan African countries: South Africa, Malawi, Mozambique, Madagascar (southern Africa); Kenya, Tanzania, Zambia eastern Africa); and Ghana, Nigeria, Sierra Leone (western Africa). This was carried out through key informant interviews based on a checklist of questions across the subject area. A range of aquatic health experts (n=12) were engaged in each of the ten countries from all stakeholder groups (government, private sector, research, NGO). From this data short information briefs were produced for each country summarising key information and findings. These have been published on-line in March 2023 in order to increase the basic information available publicly on aquatic health and biosecurity (Leschen *et al.*, 2023).

Casammak and ThinkAqua subsequently conducted an open access online questionnaire survey across sub-Saharan Africa, where a number of the key findings from the original key informant discussions, and associated knowledge information gaps, were further examined. The online questionnaire survey was open to the four broad stakeholder groups, although the major focus of the survey was to better understand activities and needs from the private sector in order to better support the growing commercial sector across the continent.

Below we present the methodology, results and conclusions from this online survey along with some summary recommendations.

Methodology

The online questionnaire survey was divided up into four versions for the different stakeholder groups involved: Private sector, Government, Education Training Research, and NGOs. With each sharing a common initial section on contact details and demographics, then specific stakeholder sections. Some of the findings from the previous key informant data collection exercise informed specific areas and themes which were explored further with questions, both quantitative and qualitative, in the online questionnaire.

The resultant four stakeholder group questionnaires were entered into the JISC online questionnaire format (JISC online surveys 2022), which included software providing a level of built-in automated analyses of findings. These questionnaires were then piloted with 3 Africa-based aquatic health experts from the private, government and university sectors respectively. Modifications were made and the survey was publicised and disseminated out online in June 2022 through a series of African continental, regional, and national networks and organisations, including the SARNISSA African Aquaculture network, national fish farmers associations, WOA, African Aquaculture Magazine and World Aquaculture Society (WAS) African chapter. This covered the four stakeholder groups, but with a focus on private sector. A prize draw was publicised for two monocular National Geographic field microscopes in order to boost participant numbers. The online survey ran for six weeks, with regular reminders online. After six weeks the survey was closed and resultant data collated from the JISC software. Further analyses were carried out using Excel (Microsoft Excel 2018) and R studio (R studio IDE version 2022.02.0).

Results

The four-stakeholder sectors participation and completion of the online questionnaire survey is summarised in Table 1 below:

Table 1. Participants' stakeholder group information and demographics

	Stakeholder Sector Group participants				Total
	Private n=26	Government n=14	Education Research n=24	NGO n=5	n=69
Gender	25 male (96.8%) 1 female (3.2%)	10 male (71.4%) 4 female (28.6)	18 male (75%) 6 Female 6 (25%)	5 male (100%)	58 male (84%) 11 female (16%)
From..... Countries	Ghana 17 (65%) Kenya 4 (15%) RSA 1 (3.8%) Togo 1 (3.8%) Malawi 1 (3.8%) Rwanda 1 (3.8%) Cape Verde 1 (3.8%) n= 7	Zambia 2 (16.6%) Uganda 2 (16.6%) Malawi 1 Kenya 1 Ghana1 Angola 1 Algeria 1 Ethiopia 1 RSA 1 Nigeria 1 Eswatini 1 Guinee Bissau 1 (all 8.3%) n=12	Kenya 6 (25%) Nigeria 5 (21%) Ghana 3 (12.5%) Malawi 3 (12.5%) Tanzania 2 (8.3%) DRC 2 (8.3%) Namibia 1 Botswana 1 Ethiopia 1 (all 4.15%) n=9	Ghana 2 (40%) Zambia 1 Tanzania 1 Uganda 1 (all 20%) n=4	20 countries Most participants: Ghana 23 (33%) Kenya 11 (16%) Nigeria 6 (9%) Malawi 5 (7%) Zambia 3 Uganda 3 Tanzania 3 (all 4%) n=20
Education level	Postgrad 12 (46%) Undergrad 10 (38.5%) Vocational Dip / Cert 4 (15.4%) PhD 1 Dr Vet Medicine 1 Secondary Sch leaver 1 (all 3.8%)	Postgrad 7 (50%) Undergrad 4 (28.6%) PhD 2 (14.3%) Dr Veterinary Medicine 1 (7.1%)	PhD 13 (54.2%) Postgrad 9 (37.5%) Undergrad 2 (8.3%)	Postgrad 2 (40%) Undergrad 2 (40%) PhD 1 (20%)	PhD 17 (24.6%) Postgrad 30 (43%) Undergrad 18 (26%) Vet Dr 2 (2.8%) Vocational dip/ Cert 4 (5.8%) Sec Sch leaver 1 (1.4%)
Work sub sectors –	Fish farm producer 19 (73.1%)	Veterinary 4 (28.6%) Aquaculture 4 (28.6%)	Univ student 6 (25%)	Africa country NGO 3 (60%)	

(some multiple answers/ roles)	Hatchery producer 10 (38.5%) Consultant 10 (38.5%) Market wholesale / retail 5 (19.2%) Extension/Training 4 (15.4%) Veterinary and diagnostics 3 (11.5%) Feed Company 2 (7.6%) Agric/ Pharmaceuticals input dealers 2 (7.6%) Animal/fish welfare organisation 1 (3.8%)	Aquaculture & Fisheries 2 (14.3%) Specific fish diseases 2 (14.3%) Fisheries 1 (7.15%) Regulatory legal enforcement 1 (7.15%)	“Non Univ” research 5 (20.8%) Univ staff 5 (20.8%) Univ research 4 (16.7%) Voc College staff 1 Univ Technical staff 1 (both 4.2%)	International NGO 2 (40%)	
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Key points on respondents

There was a total of **69 individuals** who completed the online questionnaire, with the **private sector having the most respondents (26) (36.9%)**, of which 65% were from Ghana. This report focuses on their participation and responses. The education and research sector next with 34.7% respondents.

84% of all respondents were male, with the government (28.6%) and then Education/ Research (25%) sectors having the highest female representation; the private sector only had 1 female respondent (3.2%).

In terms of the countries overall, **Ghana was the highest represented (33.3%)** followed by Kenya (15.9%) and Nigeria (8.7%) respectively.

Whilst for the education status of respondents not surprisingly **the education and research sector respondents had the highest education levels** with 54.2% being PhDs, we had 2 Veterinary Doctors - one from government, the other from the private sector. Whilst the majority of private sector respondents were university educated BSc, MSc up to 1 PhD holder, there were 4 respondents (15.4%) who had either certificate or diploma qualifications from the vocational training sector, with one further (3.8%) secondary school leaver.

Fish farm producers made up the majority (73.1%) of the private sector respondents, whilst the government and university/research respondents were more balanced across their employment positions; **Research staff** both university and outside made up the majority of the education and research sector (41.6%), whilst university students were also well represented in this sector at 25%.

The following focuses on the key findings from the survey for the Private Sector respondents. Please note where we include text *in italics these are the direct anonymised responses from respondents to specific questions within the questionnaire*. All data and information collected within this survey has been anonymised down to stakeholder level.

Private Sector

How often in last five years are you working related to fish diseases?

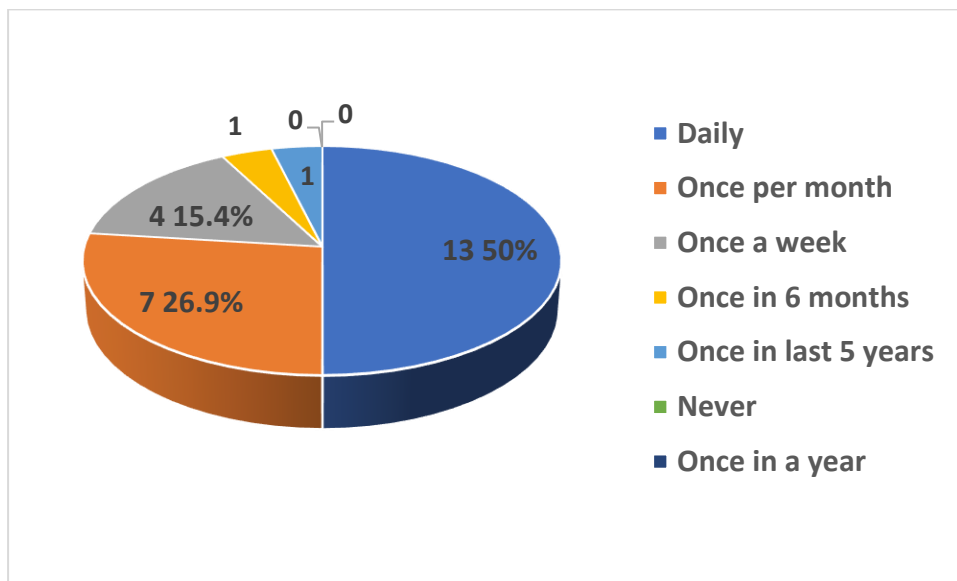


Figure 1. Private sector: Frequency working with fish disease related issues

1. Please explain briefly how specifically aquatic health/fish/shrimp diseases are included in your work over last five years?

- *In consultancy activities and contracts*
- *On-farm diagnosis, treatment, advising farmers with disease challenges. Work with farmers hands on husbandry/disease management training.*
- *General fish husbandry, monitor workers fish handling to reduce stress and injury leading to infections and disease. Disinfection of equipment for handling often overlooked by staff unless I insist.....*
- *Observe fish closely in cages before feeding for any abnormal symptoms or behaviour, if necessary, carry out treatment for particular cage with either vitastress or antibiotics- we also use herb treatments.*
- *Once per month having issues to treat recurrence of fish mortality due to bad water conditions*
- *Feed producer selling feeds – involved in farmers training on fish health, good farm practices, preventive methodologies.*
- *Use safe antibiotics to mix with fish feed and administer it daily.*
- *Treat fry with hot water once per month to remove disease parasites.*
- *In hatchery use potassium permanganate or salt for prophylactic treatment for parasites. Take interns through fish health/disease management trainings.*
- *In hatchery treat fish with potassium permanganate before transferring between tanks. Ensure 80% tank water drained and dirt siphoned every morning. Use salt solutions to clean tanks and equipment before use.*
- *Work for feed company visiting farmers almost every week. One time a farmer complained about disease and it's a parasite. Recommend salt bath for treatment.*
- *Work on growout cages, have knowledge on new disease cases, which include some information on fish diseases.*
- *In hatchery and nursery stage, use common salt and potassium permanganate for parasite removal, stress reduction and sore treatment.*
- *Work on farm where we use bitter leaf as preventive method for diseases.*

- As consultant my main obligation is to monitor fish to keep them healthy. Fish health key factor of production, must come first as human population grows, water quality declines causing fish health problems.
- As consultant, I develop, monitor and maintain biosecurity protocols for my clients, also as producer ensure on farm biosecurity and monitor ectoparasites also vaccinate my stock against bacterial infections now commonly present in Volta Lake and river.
- From my farm send fish samples showing clinical signs of some bacteria or parasite under microscope to identify and treat respectively with salt and potassium permanganate.
- Disinfect tilapia eggs using KMnO4/Salt, Preparation of footbaths using chlorine for disinfecting hatchery system and equipment.
- Carry out monthly trainings on farm to be able to identify diseases and how to mitigate
- As fish farm owner deal with issues relating to fish health and biosecurity every day.
- As extension consultant work daily to train farmers how to control parasitic and fungal fish related diseases.
- Working for pharmaceutical company..... train vaccinators and sample for diagnostics. Also assist with trials.

Knowledge of/use of fish disease diagnostic laboratories?

- a. Do you know if there is one (or more?) operational working fish/shrimp diseases diagnostic laboratory/laboratories in your country where you or anyone else can take samples to - to be analysed for fish/shrimp diseases which is both affordable and accessible?**

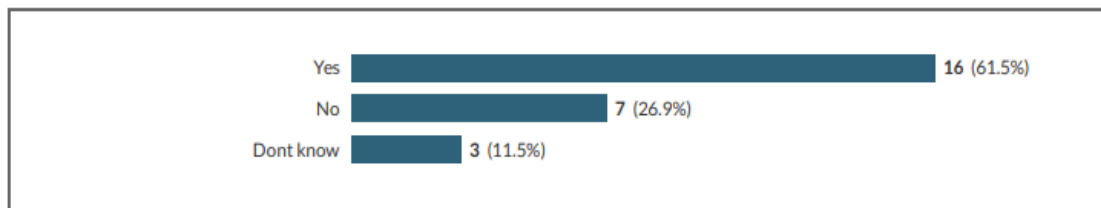


Figure 2. Respondents' knowledge of whether there is or not working diagnostic lab in their country

- b. If yes, please can you give details – e.g., its location and whether run by government, private, or university sector(s)? (n=18)**

- No such lab (X3 replies)
- University of Ghana Legon (X3 replies)
- La Veterinary services center and University of Ghana, Department of Marine and Aquaculture. CSIR
- Fisheries Commission veterinary lab., Accra.
- Aquaculture Development Center Akosombo Government institution
- Kumasi KNUST - Central Lab, run by university
- University of Ghana. Research team and government of Ghana, Fisheries Commission.
- Tema FDA, Government
- Central Veterinary Laboratories in Lilongwe city, Blantyre city (Malawi Government)
- Noguchi and University of Ghana Biological laboratory (X 2 replies)
- Government Veterinary Laboratory, in Kabete, outskirts of Nairobi
- Kenya Eldoret - University Kisumu - Government
- Kenya Marine Research Institute, is a government run Institution
- There are multiple laboratories in Ghana, but none equipped for diagnostics of all major tilapia diseases including viruses. Veterinary HQ and Legon university spring to mind, also others ie FDA

- c. If yes, please do you know which categories or types of pathogens and or testing this lab is able routinely and regularly able to detect? Including other services they offer? Please give multiple answers if necessary.....

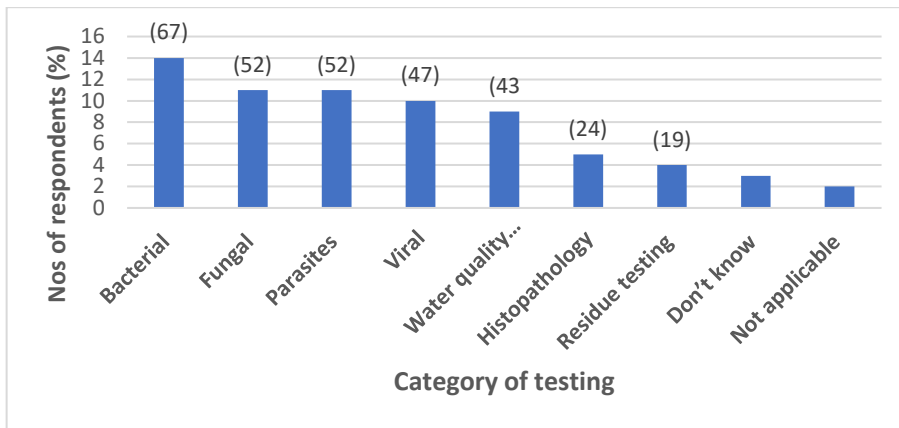


Figure 3. Respondents' knowledge/understanding on categories of testing carried out in their own country diagnostic laboratories.

- d. If you run or work on a fish/shrimp farm or hatchery – in the last 5 years, have you/the farm sent out samples to a laboratory or elsewhere to be analysed for disease(s)?

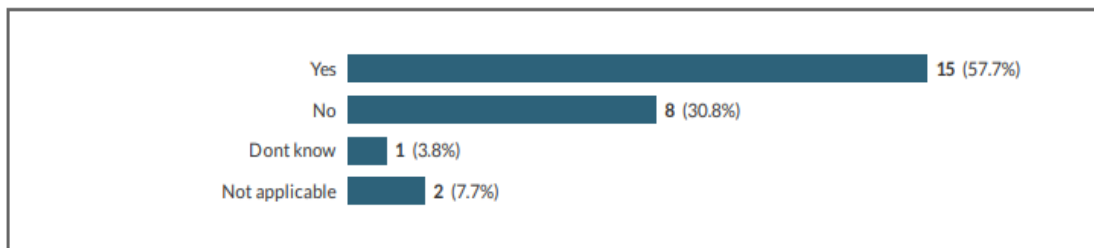


Figure 4. Fish farm/ hatchery respondents sending samples to laboratory in last 5 years

- e. If yes, can you state which laboratory you sent to? (Multiple answers accepted)

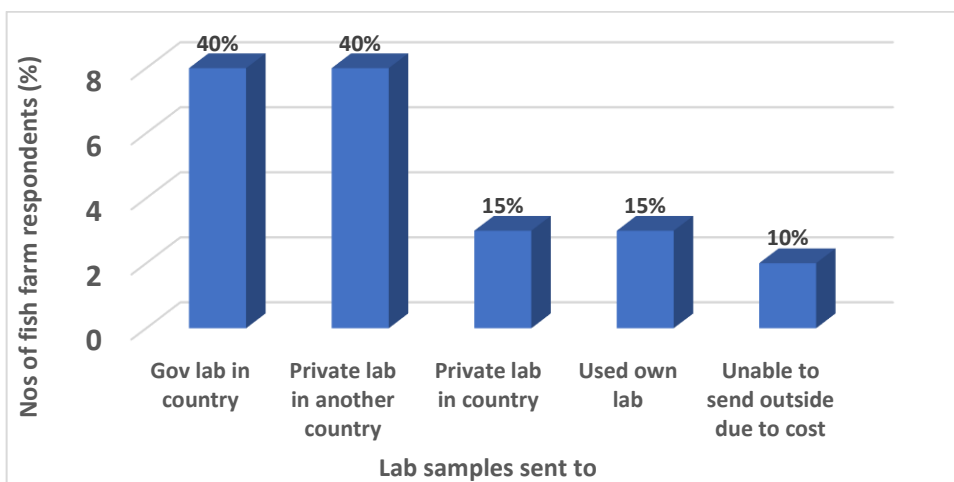


Figure 5. Type of laboratory used by fish farmers

Note that of those fish farmers who sent fish disease samples to a laboratory in last 5 years (14 out of 24) 58% used private sector labs either in country or outside as compared to 40% using governments in country labs (8 out of 24).

f. If yes, can you state how long it took to obtain the results back from this lab?

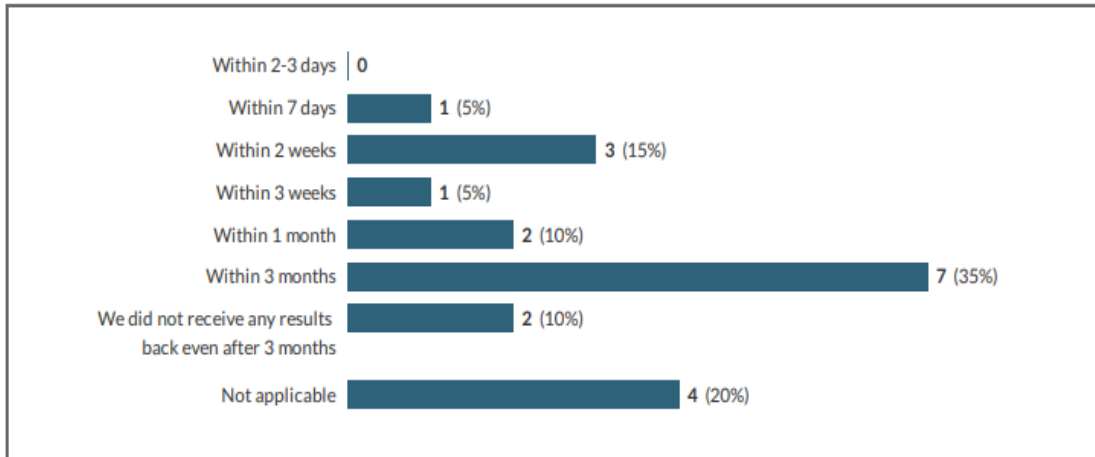


Figure 6. Length of time taken for fish farmers to receive sample results back

Noting that for 35% of fish farmers it took between 1-3 months to receive results back, whilst 10% did not receive any results back even after 3 months. Only 5% received results back within 7 days.

Fish Mortalities/Pathogens

When asked 19 (73%) of fish farmers said they had experienced significant mortalities on their farm(s)/hatcheries in the last 5 years, with 71% of these stating they knew the reasons why fish were dying.

When then asked what was the cause of their mortalities their responses are given below in Figure 7 noting multiple answers allowed:

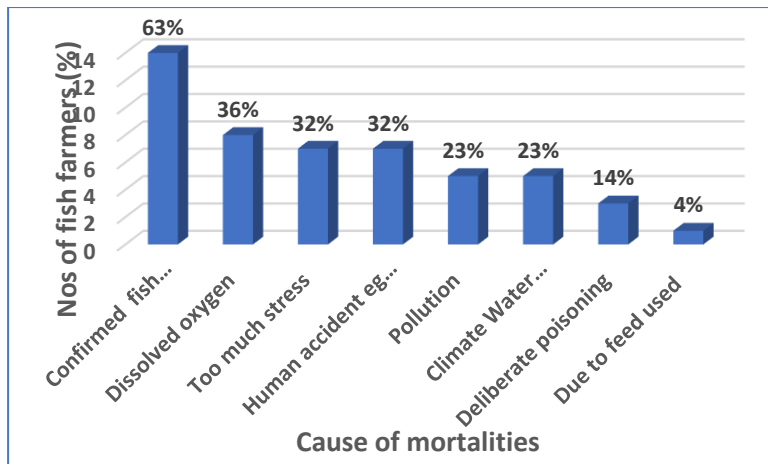


Figure 7. Causes of mortalities on farms in last five years according to fish farmers/hatcheries

Whilst 63% of fish farmers claimed that a known/confirmed fish pathogen killed their fish, interesting to see other environmental and human causes high on the list – dissolved oxygen, stress, bad handling, pollution and water temperature climate issues.

For those who stated mortalities were caused by a known fish pathogen when then asked to name one or more of these pathogens that had killed their fish, they gave the following responses:

- *Streptococcus agalactiae 1b, 1a, ISKNV*
- *Streptococcus ISKN*
- *ISKV*
- 1. *Streptococcus*. 2. *ISKNV*
- *Infectious Spleen and Kidney Necrosis Virus, Streptococcus*
- *Saprolegnia Fin rot*
- 1. *Fungus* 2. *Streptococcus*
- 1. *Streptococcus agalactiae* 2. *Infectious spleen and kidney necrosis virus (ISKNV)*
- *Infectious spleen and kidney necrotic virus streptococcus bacteria columnaris*
- 1. *Epizootic Ulcerative Syndrome* 2 *Bacterial infection*
- *White shrimp virus*
- *Tilapia Lake Virus Columnaris Dropsy*
- 1. *Streptococcus agalactiae 1b* 2. *Columnaris*
- *Parasitic infections, Gyrodactylus, anchor worms*
- 1: *Trichodina sp* 2: *Streptococcus sp*
- *Strep 1a, ISKNV, strep 1b*

When asked 71% of the respondents thought fish diseases were now a big problem for their farm/also within their country, with a further 9% saying they were a slight problem presently. Only 1 respondent (3.8%) saying fish diseases not a problem in his country now and he thought they would not be a problem in the next 5 years.

Private Sector support for fish disease

When asked: Can you give any specific examples of how people/companies/organisations from the private sector in your country provide help/support/services related to aquatic health / fish diseases

– 58% of respondents said yes, 42% no. Of those who responded in the affirmative, they (15) responded:

- *Ghana Chamber of Aquaculture provide trainings online. Vaccine company provide advice and vaccinations also technical advice*
- *Vaccine company collect samples from farms, send to their overseas labs for testing. Also sell vaccines and vaccinate fishes to mitigate mortality*
- *Putting in some biosecurity measures in place to guard against both external and internal biosecurity courses of fish health diseases*
- *WISHH is helping with Water Quality management and fish husbandry*
- *Vigorous training and awareness to farmers. Best practice, intervention and facts findings by the government Veterinary or fish health team*
- *Organise short seminar, workshops and training on water quality management concepts and fish health and disease management.*
- *1. By training a group of farmers about biosecurity. 2.By training farmers how to manage good farming practices*
- *Farmers share information on their fish health status farmers allow stakeholders to take samples on their farms relating to fish health*
- *Farmer-to-Farmer assistance and help from someone who is supposed to know more.*
- *Extension services to support farmers. Regular training and workshops for farmers*
- *1. Help in lab diagnosis 2. Materials for fish disease diagnosis 3. Host fish research interns*
- *Training farmers on water quality management*
- *Collaborate with government and state institutions to deal with such diseases especially when outbreaks and huge mortalities are recorded.*
- *Provision of predator nets, training on management and market access*
- *We offer free disease screening to as many farmers as we are able to reach in Ghana and beyond. We provide on job training of fish vaccination and technical support for products and trials with our customers.*

Information and Knowledge

When asked: Where do you look to find information about aquatic health / fish diseases in order to learn more and increase your knowledge? The top 5 ranked responses from private sector respondents were:

1. Internet – this was by far most popular choice
2. Books
3. From colleagues, fellow fish farmers, friends
4. Extension officers
5. Fish health specialists and veterinary companies mainly from outside country

When asked: Which information or knowledge about fish or shrimp diseases would you like to know more about but currently cannot find out? The following responses were given:

- *Vaccination of fish/tilapia across Africa*
- *None specifically*
- *How to reduce fish mortality on farms 10 - 20 %.*
- *Causes of high mortality.*
- *Management of fish health*
- *Cause of high mortality rate*
- *Strong and visible fish lab and professionals*

- Fish disease diagnostics.
- Preventive measures.
- Available treatments for most diseases also their dosages and withdrawal periods.
- How the various water quality parameters affect the introduction of some diseases. Causes of mass mortalities of fishes above 50grams when stocked
- The state of the ISKNV and how farmers need to tackle it
- Rotten gill
- Fish pharmacology Fish molecular research in Malawi
- practical knowledge on diagnosis of fish/shrimp diseases
- Fish viral infection and control Tilapia growth and feed requirement
- Fish Viral diseases. Diagnosis, identification
- Bacterial and Viral Where to get laboratory facilities
- How paraffin can be used to control insects in water
- NNV, TIPV

Those information gaps can be summarised as:

1. Diagnosis, identification, treatment of viral disease of tilapia.
2. Understanding of on-farm causes, diagnoses, and fish health management procedures; including measures for preventing/mitigating fish mortalities.
3. Pathogen detection, identification and treatments and vaccination.
4. Where to access effective diagnostic laboratories.

When asked if they were aware of any specific fish diseases or aquatic animal health issues in other African countries 58% of respondents said they were not.

Treatments

When asked: Have you personally done or been involved in any of the following treatments in the last 5 years: Multiple responses allowed:

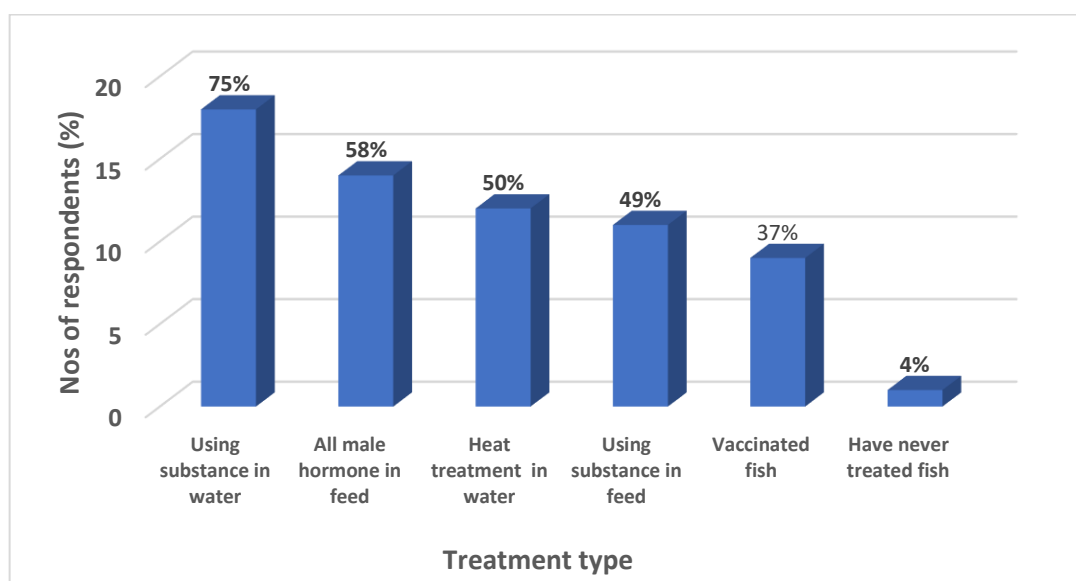


Figure 8. Different treatments carried out by private sector respondents

67% of those who said they had personally had been involved in treating fish did so because of a particular pathogen they knew was present. 37% also said they treated due to seeing clinical signs/marks on the fish and 29% because they also observed behavioural changes in the fish. Whilst 42% said they routinely treated fish (prophylactically) to prevent disease occurring.

The following were the list of specific treatments they had been involved in using/ administering in last 5 years:

- *NaCl, Formalin, Methylene Blue, Chloramine T, Benzalkonium Chloride, KMnO₄*
- *Streptococcus agalactiae 1b vaccine, KMnO₄, Formalin, SR hormone, Copper sulphate, Normal salt and Epsom salts, sodium bicarbonate*
- *Common crystal salt, potassium permanganate*
- *Herbs (neem leaves) and salt.*
- *Vaccines and Aquafior (X2 replies)*
- *None*
- *1. Salt treatment. 2. Tetracycline. 3. Vitamin C.*
- *Salt. Antibiotics 17alpha methyl testosterone*
- *Potassium Permanganate Hydrogen Peroxide Methylene blue Povidine iodine*
- *1. Ammoxycillin 2. Floxinor 3. Salt 4. Humivet 5. Neoxyvit*
- *Salt bath*
- *Oxytet*
- *Common salt Hydrogen peroxide Potassium permanganate Copper sulphate Aquavaccin Iridovaccin*
- *Permanganate de potassium*
- *Malachite green, formalin and lime*
- *Ethanol, stain*
- *Salt Oxytetracycline Icytovac MSD vaccine*
- *Salt, potassium permanganate, strep injection vaccine.*
- *NaCl, KMnO₄,*
- *Sodium Chloride*
- *Sex reversal hormones*
- *Tilavac Volta, tilavac s3, tilavac s1a, hydrogen peroxide, heat treatment method, various anaesthetics, various treatment trials*

31% of respondents said they were not aware of specific places/outlets where they could purchase fish health related chemicals/ pharmaceuticals/ vaccines. For the remaining 69% who said they were, they listed the following specific outlets /locations where they could purchase:

- *Local markets and aquatic shops*
- *Tema timber market*
- *Poultry vet shops*
- *Rannan at Prampram (Accra), fish feed company (x4 replies)*
- *Koudijs feed*
- *Ministry of Fisheries*
- *Any big pharmacy shops.*
- *Mallam, Accra - Wella Chemicals Limited*
- *Pharmacy and chemical shops in Akosombo and Atimpoku*
- *La veterinary service Labadi, greater Accra.*
- *Ziweto Enterprise and Agriculture Trading Centre in Lilongwe Malawi*
- *In Rwanda normally buy abroad no precise place*
- *Oak farms Frankatson Reiss and Co BVD limited*

- *Agrovets in Nairobi, countrywide (x2 replies)*
- *Aquarech company*
- *Aquavet solutions, Achimota, Accra*

Biosecurity

When asked: What do you personally understand the term “Biosecurity “related to your own farm and or aquaculture in your country or elsewhere to mean? We received the following:

- *The processes and activities which help to mitigate and or control the transmission of fish/shrimp pathogens between units on a farm site, between different farms, between different regions within a country, and between countries*
- *Securing all or most channels to which external pathogens can be introduced to my farm and vice versa*
- *What protective or preventive ways are you adopting or can adopt to ensure your farm is safe from introduction (external or internal) of any form of disease or infections into your farm that could affect your fish stocks.*
- *The prevention of disease-causing agents entering or leaving any place where they can pose a risk to farm animals, other animals, humans, or the safety and quality of a food product.*
- *Procedures or measures designed to protect the population against harmful biological or biochemical substances. "Biosecurity risks"*
- *Simply put, self and staff protection of doing things right by controlling what is within.*
- *Biosecurity: putting in place a disinfection point at the entrance of your farm or hatchery.*
- *The procedures you put in place to prevent diseases or disease pathogens from being transferred to fish or if pathogens are present, they get the needed environment to thrive.*
- *Measures put in place to prevent you, the farm workers or any visitor from spreading or transmitting pathogens on farm.*
- *Measures put in place to prevent disease outbreaks in farms.*
- *Measures used at preventing the spread of infectious diseases*
- *Preventing spread of infectious diseases from one place (farm) to another.*
- *To avert human health risks and economic losses, to prevent the introduction of infections*
- *Protection of farm organisms against disease from other organisms or human*
- *Measures to prevent and disease/pathogen entry into the farm and if present to prevent it from spreading*
- *Just use of biological organism with respect to the rules set*
- *Exercise enforced to prevent the spread of disease from human or external sources to fish, also prevent fish disease to spread to humans. Also involves prevention of spread of pathogens amongst fish*
- *Measures taken to control spread of biological disease-causing microorganisms.*
- *Measures put in place to safe guard the fish from infections, transmission and mortalities.*
- *Don't know*
- *Precautions taken to ward off infection and to control diseases in farming fish*
- *Procedures designed to protect the population against harmful biological or biochemical substances.*
- *Farming of fish/shrimps in an enclosed place free of poisonous chemicals e. g fish pond*
- *Biosecurity does not exist in Ghana, and most attempts are poorly informed and half hearted.*

Those who provided a definition of biosecurity above and who work on farm or hatchery were then asked to list the different examples of biosecurity they are aware of at their own place of work:

- *Foot dips, pond fencing, water and fish disinfection, restricted human access*

- *Disinfection of farm equipment prior and after being used to handle fish, treating incoming water flowing into the farm, ensuring quality fingerings purchased, visitors screened/ disinfection before entering farm etc*
- *Washing hands, boots etc before entering farm*
- *Nil none*
- *1. Saline solution. 2. Chlorine.*
- *Washing hands before and after handling live fish. Disinfecting hands and feet with salt water. Wearing of protective clothes/disposable gloves. Using alcohol in washing equipment.*
- *Foot bath, wear appropriate gears when harvesting in ponds, frequent hand wash with soap or change of gloves after handling diseased fish, scheduled disinfection of farm floors and tanks.*
- *1. Foot dip 2. Quarantining fish from other farms in isolated tanks for some days before introducing onto farm. 3. Isolating diseased fish in treatment tanks 4. Not allowing unauthorized visitations into farms or hatcheries. 5. Not moving equipment from tank to tank 7. Disinfecting any used equipment before and after usage. 8. Not sharing equipment among farms*
- *1. Visitors Restriction 2. Disinfections 3. Biosecurity awareness among staff*
- *Isolation, clean clothes to all guests, shower in/out and managing vehicles traffic.*
- *Foot dip handwash quarantine system medicate vehicle dip*
- *No other person from elsewhere in our facilities without disinfectant*
- *Ensuring farm not vulnerable to incoming diseases*
- *Using different fishing gears in ponds, Quarantine new fish prior to adding into ponds with other fish,*
- *Gene manipulation*
- *Sanitation Foot dip Safety and clean equipment Biosecurity work book and protocols Sterilized equipment*
- *Foot dip, cover nets, surgical gloves, nose masks.*
- *Car Bath, Foot baths, Equipment disinfection*
- *Foot dips, sanitizing, gloves when handling fish*
- *Procedures for handling incoming live fish, disposal of sick or dead fish and restricted access to farm.*
- *Disinfect all equipment after use. Never visit 2 farms in one day and if I do have to then carry change of clothes and shoes, my vehicle will be disinfected as well. Dissection is carried out in lab or in a sensible location away from tanks/ ponds cages etc.*

Training in aquatic animal health

77% of respondents said they had had some form of training in aquatic animal health/fish diseases in the last 5 years, whilst 38% said they had given fish diseases related training. When then asked what type of training and who was it run by? Received (Recd) or Given? They responded as below:

- *Given: Online fish health webinar given to members of Ghana Chamber of Aquaculture and others*
- *Recd: Disease management and treatment, water quality monitoring and remedies*
- *Recd and Given: Through work practices in the field and organised fish health conferences.*
- *Given: Auburn University*
- *Recd: By both local government authorities like ADEC also private sector, WISH, FISH VET, TILAVET*
- *Recd: Aquatic animal health and basic biosecurity measures. Dr. Peter Ziddah, Fisheries Commission, Accra.*
- *Recd and Given: ASA WISHH in Fish health and disease management. I trained interns from the university.*
- *Recd from feed company on fish health and good farm management.*
- *Recd : On biosecurity run by John Domozoro*
- *Recd: Controlling rising mortalities – looking at seasonal differences*
- *Recd: Workshop organized by WISHH and ASA for farmers on production and fish health management*

- *Recd: On job - General deceases of fish in a rearing cycle*
- *Recd : From Extension officers training. Community based training*
- *Recd and Given: Trained in Aquatic medicine course during my Veterinary Medicine program, been involved in training fish farmers on protozoan parasites and EUS disease*
- *Recd: Masters in aquaculture, aquatic health was module Freshwater fishery research center*
- *Recd: Trained in vaccination and selection of fish Also on biosecurity tips All at intermediary levels from trained veterinary doctors from Europe*
- *Recd: WISHH programs on Fish Health by Dr. Jeff Terhune (x2 replies)*
- *Recd and Given: MSc. Veterinary Pathology, Microbiology & Parasitology (Fish Science) UoN Ongoing Trained fellow colleagues on biosecurity*
- *Recd: Introduction to aquaculture, pest and diseases, value chain process and marketing – from govt fisheries officers*
- *Recd: Biosecurity on farm by fish farming consultants.*
- *Recd and Given: Ictyopharma training on tilapia diseases, my colleague-field training on sampling and clinical signs, me-training of farm staff and others in vaccination, anaesthetisation, heat treatment, dissection, record keeping.*

Import Export of live aquatic organisms

Only 27% of respondents said that they had (some) experience or knowledge about procedures for bringing in or sending out shipments of live fish/aquatic animals/plants at airports land borders seaports in their country in last 5 years. The remaining 73% had not. Of those who had they listed below their experience and or knowledge:

- *Need to obtain certificate/permit from the fisheries commission and Vet. service Dept.*
- *I know you need to secure a permit at the fisheries regulatory authority prior to sending or bringing in any fish sp into or out of the country either through airports, sea or land bothers.*
- *Permit approval by department in charge is a must*
- *Stuart Ornamental Fish Exporting company in Salima, Malawi. All fish are treated first for external parasites prior to packaging in oxygen filled bags and exported via Kamuzu International Airport*
- *A licence and certificate of origin coupled with documentation from the country of origin is scrutinised by the authorities before one is allowed to send fish to another country. Test are carried out on specific details and one must pass the test before the final entry is made.*
- *Health Certificate, Country of Origin - Nairobi*
- *I know it is (or at least was, as I'm not sure how the new African intercontinental free trade agreement applies to this....) illegal, there are currently no quarantine facilities for fish in the country, also it's foolish and immoral and happens regularly.*

From the 7 out of 26 (27%) of those who were able to answer this question it appears from the above that for at least 5 of these they are referring to their knowledge but not actually being involved in the process itself either as a private sector individual importing/exporting or government authority involved in regulating. 76% of respondents did not know any internet site or a place they could go to go to - to find out information and regulations for importing/exporting (live) fish/shrimp/aquatic plants into and from their own country.

The ones who did know gave the following specific sources they were aware of:

- *I stated No but in our global world today, YouTube have everything out there*
- *FAO*
- *Animal Health and Livestock Development department under Ministry of Agriculture, Malawi government both offices in Lilongwe or website and Fisheries department, ministry of agriculture, Malawi government in Lilongwe, Capital hills*

- www.mofad.gov.gh www.fishcom.gov.gh
- *OIE manual*
- *Farm Africa*
- *Ministry of Fisheries and Agriculture*

Of the seven who responded above only one was able to provide a specific govt website and two others Govt ministry locations / offices. Interesting to see the others quote international organisations like FAO OIE and Farm Africa.

Final comments /recommendations from private sector

At the end of the questionnaire the respondents were asked to include any comments recommendations or / issues they thought were missing from the questionnaire:

- *More efforts should be channelled in training more personnel in areas of fish health and disease management.*
- *Should be strict regulation governing the aquaculture sector. There are a lot of loose laws in the country.*
- *Train the trainers and build a training program*
- *Aquatic health fish and shrimp diseases are not given much priority in my country*
- *Viral diseases are difficult to diagnose*
- *In my country Fish diseases have not really been considered critical. Aquaculture is still a fairly infant industry. We need to pay attention to biosecurity and take a proactive rather than a reactive approach.*
- *Unfortunately, there are charlatans and ineffective products eroding trust as well. Unlicensed/poorly positioned farms. There are many hard-working farmers here, but no real support infrastructure for them to rely upon.*
- *Are there scholarships or detailed training programmes for people like us interested in fish health? If yes, how do we tap into those opportunities?*
- *1. Can this survey help build more labs to diagnose diseases in the aquaculture sector? 2. Can you also made available chemicals for treatment when anything is being diagnosed.*
- *We need more / current fish diseases in African aquaculture issues case studies to learn from.*
- *I want to know more about the use of antibiotics in fishtailing.*
- *Fish turns dark in colour and swim with faeces attached to vent. I want to know the treatment and cause*
- *How coordinated is my country's aquaculture and veterinary departments in dealing with aquatic animal diseases? Whose mandate is fish/shrimp disease treatment?*

These responses can be summarised into the following recommendations from private sector also ranked in terms of their frequency in the above:

1. Strengthen budgets given to AAH / fish diseases in country - in terms of resources, infrastructure, monitoring and regulations.
2. Produce far more information in easily accessible and understandable formats on aquatic health / fish diseases and associated biosecurity – viral pathogens of tilapias were particularly mentioned.
3. Better practical hands-on training in aquatic health and biosecurity at all levels – that is tailored and relevant for each country, production systems, species - not based on European and US examples.

4. At least one functional accessible, affordable aquatic health diagnostic laboratory in country with necessary experienced and trained staff, which can process and turn over samples in reasonable timeframe in order to be useful for commercial producers.

5. Available, accessible suppliers of chemicals, pharmaceuticals including vaccines for treating fish alongside clear, user friendly, country specific information and guidelines.

The key focus of the online questionnaire survey was the private sector. However, significant responses were also received from the Government, Education and Research, and NGO sectors, the outcomes of which are summarised below.

Summary findings from the Government, Education and Research, and NGO sectors

	Government n=14	Education Research n=24	NGO n=5	Total n=43
Gender	10 male (71%) 4 female (29%)	18 male (75%) 6 Female (25%)	5 male (100%)	33 male (77%) 10 female (23%)
From..... Countries	Zambia 2 (14%) Uganda 2 (14%) Malawi 1 Kenya 1 Ghana 1 Angola 1 Algeria 1 Ethiopia 1 RSA 1 Nigeria 1 Eswatini 1 Guinee Bissau 1 (all 7%) n=12	Kenya 6 (25%) Nigeria 5 (21%) Ghana 3 (12%) Malawi 3 (12%) Tanzania 2 (8%) DRC 2 (8.3%) Namibia 1 Botswana 1 Ethiopia 1 (all 4.15%) n=9	Ghana 2 (40%) Zambia 1 Tanzania 1 Uganda 1 (all 20%) n=4	16 countries Most participants: Kenya 7 (16%) Ghana 6 (14%) Nigeria 6 (14%) Malawi 4 (9%) Zambia 3 Uganda 3 Tanzania 3 (all 7%) n=20
Education level	Postgrad 7 (50%) Undergrad 4 (27%) PhD 2 (14%) Dr Veterinary Medicine 1 (7%)	PhD 13 (54%) Postgrad 9 (37%) Undergrad 2 (8%)	Postgrad 2 (40%) Undergrad 2 (40%) PhD 1 (20%)	PhD 16 (37%) Postgrad 18 (42%) Undergrad 8 (19%) Vet Dr 1 (2%)
Work sub sectors – (some multiple answers/roles)	Veterinary 4 (29%) Aquaculture 4 (29%) Aquaculture & Fisheries 2 (15%) Specific fish diseases 2 (15%) Fisheries 1 (7%) Regulatory legal enforcement 1 (7%)	Univ student 6 (25%) “Non Univ” research 5 (21%) Univ staff 5 (21%) Univ research 4 (17%) Voc College staff 1 Univ Technical staff 1 (both 4%)	Africa country NGO 3 (60%) International NGO 2 (40%)	

Key points on respondents

There was a total of **43 individuals** who completed the online questionnaire, for the 3 stakeholder groups with the **Education and Research group having the most respondents (24 56%)** followed by government (14 32%).

77% of respondents were male, with the government (29%) and then Education/ Research (25%) sectors having the highest female representation; the NGO sector although smaller numbers (n=5) had no female respondents.

In terms of the countries overall, **Kenya was the highest represented (16%)** followed by Nigeria and Ghana (both 14%) and Malawi (9%) respectively.

Whilst for the education status of respondents not surprisingly **the education and research sector respondents had the highest education levels** with 54% being PhDs, we had 1 Veterinary Doctor in the government sector.

Research staff both university and outside made up the majority of the education and research sector (41.6%), whilst university students were also well represented in this sector at 25%.

For the **NGO group** the respondents were only 5 individuals (12% of total), with notably no female respondents, with all being educated up to undergraduate level, and fairly equally divided between working for in-country NGO or international equivalents.

Key findings

Respondents in all 3 groups were involved in aquatic health at least once per month with significant percentages involved in some way in aquatic health on a weekly basis.

Respondents' knowledge of a working, accessible aquatic health/fish diseases diagnostic lab in country....

	% Respondents in each group		
	Govt	Education research	NGO
Yes, there is one	50	58	40
No don't know of one	43	37	40

Working Diagnostic laboratories named:

- **Kenya:** Dept of Veterinary Services supports Dept of Fisheries. Implementation of AQUATIC ANIMAL HEALTH ACT in its infancy led by 1. Dr Mwansa Nsonge 2. Dr Harris Phiri
- **Kenya** Marine and Fisheries Research Institute
- **Kenya:** Univ of Nairobi Lab
- **Ghana:** Fish Health Unit, Fisheries Commission, Ridge, Accra. X 2 replies
- **Uganda:** National Fisheries Laboratory, Government Analytical Lab., Directorate of Government Analytical Laboratory (DGAL- Kampala) and National Animal Disease Diagnostics and Epidemiology Center (NADDEC- Entebbe).
- **South Africa:** Aquatic Animal Health Unit within Directorate: Sustainable Aquaculture Management in the Department of Forestry, Fisheries and the Environment. Director: Mr. Asanda Njobeni based in Cape Town
- **South Africa:** Govt lab Onderstepoort
- **Zambia:** Univ of Zambia Veterinary Lab
- **Nigeria:** Aquatic Animal Health Branch, Animal Health & Clinical Services Division, Federal Dept of Veterinary & Pest Control Services., Federal Ministry of Agriculture & Rural Development, Garki Area 11, Abuja, Nigeria/ Dr G.A. Modupeola Ogunnoiki
- **Tanzania** Nyegezi fisheries laboratory at Mwanza

Categories of pathogens these laboratories are able routinely and regularly able to detect in country and services they offer.

- Respondents across the groups gave the lowest percentages for capacity to detect viral pathogens in these labs – Education and Research only 28% and NGOs 0%
- Whilst for parasitology and bacteriology the respondents across all groups gave much higher percentage - up to 80% for parasitology in the Education and Research group and 60% for bacteriology in the Government group.
- For provision of histopathology services in these labs – Govt respondents said 40% Education/Research only 28%.

In response to the question: Have you sent samples to a laboratory or elsewhere to be analysed for disease(s) in last 5 years?

- 57% of Government respondents said they sent out samples to a lab in the last 5 years, this being similar for Education/ Research from which 62% sent samples to a lab. Only 20% from NGO group did this.

The Pathogens

- 83% of Education/Research, 57% Government and 50% of NGO respondents respectively were able to name at least one fish or crustacea /shrimp disease or condition **causing significant mortalities** in either aquaculture or wild fisheries in their country in the last 5 years.
- These are listed below by group. (note the frequencies of each are mentioned).

Specific pathogens causing mortalities as named by respondent groups		
Govt	Education and Research	NGO
<i>Epizootic Ulcerative Syndrome (EUS) all in wild fish X5</i>	<i>Epizootic Ulcerative Syndrome (EUS) Aphanomyces invadans all in wild fish X3</i>	ISKN x2
<i>Edwardsiella tarda Edwardsiellosis X2</i>	<i>General parasites incl Ectoparasites protozoa, endoparasitic helminths, also Ich whitespot, fish louse, black grub X3</i>	EUS – wild fish
<i>Fungal infections in farmed fish</i>	<i>Saprolegniasis Surface Systematic fungi x3</i>	
<i>Tilapia virus</i>	<i>TiLV X2</i>	
<i>Infectious Spleen and Kidney Necrosis Virus ISKN</i>	<i>ISKN x2</i>	
<i>Streptococcosis</i>	<i>Streptococcus agalactiae streptococcosis x2</i>	
<i>Flavobacteria columnae – saddleback disease in farmed clarias</i>	<i>Citrobacter freundii infection in fish, jaundice in catfish</i>	
<i>Myxobacterial infection</i>	<i>Ligula intestinalis</i>	
	<i>Broken Head Disease</i>	
<i>Aeromonas sp</i>	<i>White Spot Syndrome Virus Acute Hepatopancreatic Necrosis Disease in shrimp X2</i>	
<i>Columnaris disease</i>	<i>Gram positive or negative bacterial infections</i>	
<i>Koi Herpes Virus</i>	<i>Infectious haematopoietic Necrosis IHN, Infectious pancreatic necrosis IPN – both viral, Aeromonas hydrophila Mycotoxicosis – all in rainbow trout</i>	
<i>Aeromonas hydrophilis Aeromonas Disease</i>		

Specific Examples of training and other services in AH offered within/by each sector in their country in last 5 years.

Support / services given on Aquatic health by respondent groups		
Govt	Education and Research	NGO
<i>Fisheries Dept Extension services supporting farmers & giving advice general X 8</i>	<i>Aquatic Health (AH) training, workshops and advice given to fish farmers X7</i>	<i>Wrote articles on AAH in international media</i>
<i>Formulating biosecurity protocols, enforcing strict fish movement monitoring. X2</i>	<i>Sometimes universities take samples for fish farmers for analyses X3</i>	<i>Online Aquatic animal health training programs set up by our NGO provides capacity building to farmers on on farm level disease detection</i>
<i>Vaccination Training workshops and seminars Disease Diagnosis and management</i>	<i>EUS policy perspective/recommendations written to guide Malawian govt</i>	<i>One NGO treated fish farmers stock to reduce mortalities after fungal outbreak</i>
<i>Annual health inspections on abalone farms South Africa</i>	<i>One Ghanaian univ now working through Norwegian funding to better develop its overall AH both within and outside university</i>	
<i>Process: Fisheries Dept Technical staff first point of call-in event of fish disease outbreaks. Firstly, assess water quality and recommend remedies before escalating to Veterinary dept experts at District level. Samples sometimes taken for analyses at specialised labs. For wild disease outbreaks Fisheries and Veterinary staff visit site, collect samples for lab analyses, press statements, share findings with outside once results processed. Communities often advised to refrain from consuming diseased fish.</i>	<i>In Botswana little occurring in univ sector in terms of AH and fish diseases There is OIE Focal point offering just parasite diagnosis to fish farmers</i>	
	<i>Disseminate out research findings to fish farmers via workshops and trainings</i>	

Sources of information on aquatic health, biosecurity and fish diseases

The internet was by far the most popular choice for respondents from all sectors, with written materials books manuals (if available) being a clear second. Government respondents also mentioned they searched for information from specific organisations CEFAS, WOAHA, one also saying short fish disease courses in China. The Education and Research sector mentioned key publications: 1. Fish Pathology R.J. Roberts; 2. Fish diseases - Diagnosis & treatment E. Noga; 3. Bacterial Fish Pathogens

by B. and D. Austin, also Journal of Fish Diseases. They also regularly searched on Researchgate, Google scholar (receiving notifications), OIE/FAO websites, aquaculture magazines etc. One Education and Research respondent mentioned recent online webinars on Aquatic Health and Biosecurity.

Awareness of Aquatic Health/Fish disease in another African country

All three sectors had relatively low awareness of aquatic health in any other African countries. For govt only 36%, 37% for Education and Research, and 40% for the NGO sector of respondents. For those that did, when asked which countries, Egypt, Ghana, Nigeria, South Africa, and Zambia were mentioned. Lake Victoria and recent detection of TiLV (Mugimba K.K. et al 2018) also mentioned along with strong concerns for aquaculture biosecurity of three neighbouring countries around the lake. EUS in Malawi in wild fish, and the use in Ghana of heat shock rather than chemotherapeutants also mentioned. One government respondent mentioned the detection of TiLV in Ghana (as far as authors aware TiLV not yet detected in Ghana).

Treatments

57%, 56%, and 50% of respondents from Government, Education and Research, and NGO sectors had personally been involved in treating fish / shrimp with chemicals / substances in water. Whilst this dropped significantly to only 14%, 28% and 30% respectively who had personally treated fish/shrimp using substances in their feed. This dropped even lower for experience in vaccination of fish: 14%, 5% and 20% for Government, Education and Research and NGO respondents respectively.

Government respondents gave relatively few examples they had personally used: salt X3, potassium permanganate, hydrogen peroxide, and one had used the Aquavac Irridov vaccine. Whilst the Education and Research sector said they had used many more: including: a number of antibiotics oxytetracycline, chloramphenicol, plant extracts, 17 MT for sex reversal, yeast, formalin, lime for pond disinfection. Several from Ghana had used heat shock treatment.

In terms of sources/outlets from which such chemicals could be sourced and purchased the Education and Research sector provided the most responses. All three sectors mentioned agro-vet, livestock, and agricultural suppliers/dealers, but also mentioned were farmers cooperatives, fish farming consultants and ornamental fish dealers. Two Education and Research respondents mentioned they bought from overseas suppliers in Asia.

Biosecurity Definitions and examples

Most of the 3 sectors respondents were able to give their own definitions of what the term "Biosecurity" meant to them. Most were along the lines of this below example given by a government respondent:

"Biosecurity in aquaculture is the ability to prevent microorganisms or potentially hazardous agent or organism from entering an aquaculture farm or premises..."

It is interesting to note similar for the private sector group, virtually all definitions given related to farm level or at most wide farm to farm transfer. There were no definitions including wider regional, national and international context.

Examples of biosecurity measures and activities they had personally seen in last 5 years can be summarised below:

Biosecurity measures and activities		
Government	Education and Research	NGO
<i>Foot dip and hand washes on entering farm sites and within different sections X 8</i>	<i>Foot dip and Hand-wash X11</i>	<i>Foot dips and hand washes X2</i>
<i>Site Fencing X4</i>	<i>Keeping all equipment sanitized after use Avoid using tools from other farms X3</i>	<i>Too numerous to list</i>
<i>Sterilising/quarantine facility/tanks in hatchery x2</i>	<i>Protective on farm clothing, special boots and covering clothes for visitors X3</i>	<i>Disinfecting equipment after use</i>
<i>UV treatment/ other filtration of water incl waste water x2</i>	<i>Restricting visitors X 2</i>	<i>Restricting visitors to the site</i>
<i>Anti-predator nets on ponds</i>	<i>Only one entrance and exit to farm site</i>	
<i>Signage outside at entrance to farm and within</i>	<i>Separation of production stages on farm site.</i>	
<i>Fallowing period of ponds/tanks</i>		
<i>Non mixing sharing of equipment from different parts of farm</i>		
<i>Annual audits of biosecurity systems on abalone export farms</i>		
<i>Footwear and farm clothes specifically for farm use</i>		

Government legislation: Aquatic health / fish shrimp diseases including control of live movements at international borders

Only 50% of the government respondents said they were aware of specific statutory legislation in their country related to aquatic health:

- *Fisheries Act No. 22 of 2011; regulates all fishing and aquaculture activities in Zambia Animal Health Act No. 27 of 2010; mandate over management of all Livestock diseases*
- *Ghana Aquatic Animal Health Policy, June 2016*
- *Fish Act Uganda bans importation of certain aquatic organisms, also requires quarantine measures for importation of live fish species.*
- *Animal Diseases Act Aquaculture Development Bill Ghana*
- *Fish Bans on movement of live fish within Ghana - special measures.*

Experience or knowledge on procedures for import/export of live fish at borders (airports land borders and /or seaports) in the last 5 years?

All three sectors appear to have low personal knowledge and experience in this area. Only 31, 29 and 25% of respondents from Government, Education and Research, and NGO respondents had personal experience or knowledge. Whilst 77, 59 and 60% respectively were unable to give an online website or other source/location for their country to go to to find out the regulations and procedures for live fish imports/exports.

Future recommendations/points made by the three sectors respondents:

Future Recommendations		
Government	Education and Research	NGO
<i>More budget allocated within government sector for specialised unit, staff and resources AH – Ghana good example. X2 Must have annual monitoring /sampling for each registered farm.</i>	<i>Governments should allocate more funding/investment in country for AH. X4</i>	<i>Fish health/ finfish aquaculture sector across Africa should learn from level of AH management, and biosecurity of much smaller African commercial shrimp sector.</i>
<i>Commercial development/ more research and information on molecular diagnostic kits</i>	<i>Students need more specialised on farm and also in lab AH training. X2</i>	<i>Fish/shrimp farmers should have biosecurity manuals on site</i>
<i>Improve relationship, responsibilities and coordination between Fisheries and Veterinary Depts – at moment not working.....</i>	<i>Lacking any national/ regional diagnostic labs for AH to help fish farmers X2</i>	<i>Ask simple question Does each African country have adequate number and quality of fish health experts to assist farmers. If not ... act on it .</i>
<i>Need to review collection and online open access dissemination out of data from AH monitoring, surveys, diagnostics including efficacy of vaccination programmes</i>	<i>Basic treatments/ chemicals should be made available for all fish farmers including guidelines to use them. X2</i>	
	<i>Train more/ at least some? specialised fish histopathologists</i>	
	<i>Question should be asked how many people are actually working on/ researching biosecurity in each country? No national guidelines !!</i>	
	<i>Training in AH not just about universities. Should be included/ developed more hands on in vocational training colleges.</i>	
	<i>Focus on technologically sustainable ways of addressing biosecurity with designs for optimality within/outside farms, also larger natural water bodies like Lake Victoria which is uniquely shared among states.</i>	
	<i>Fish/shrimp health should be far more closely linked to current environmental issues including large water bodies, intensification, cage stocking densities, carrying capacities, other water users.</i>	

Conclusions

Importance of Aquatic Health

It is perhaps first worth observing the demographics and types of individuals who took time (and had interest) in completing this SS African focussed open access online survey. Over all four stakeholder groups there were only 11 (16%) female respondents. With this dropping to just one (3.2%) for the private sector and none with the NGO respondents. There are obvious implications of this for the private sector; potentially missing the necessary skillsets and experience increasingly required across the private sector - including input and service sectors in aquatic animal health. The private sector had the largest number of respondents, whilst countrywide Ghana had the most respondents (33%) with 65% representation in the private sector group. With the survey being disseminated continent-wide through a range of different organisations, networks, fish farmers associations, specialist aquatic animal health organisations, the fact that Ghana has the most respondents may well be linked to it currently being the only SS African country where fish diseases have caused significant financial losses for its national aquaculture producers and associated value chain (Verner-Jeffries *et al.*, 2017, Dverdal *et al.*, 2018, and Ramirez-Paredes *et al.*, 2019). As a result, since 2017-18 the Ghanaian government has set up its own specialised Fish Health Unit. Ghanaian interest and involvement in this survey shows, especially for private sector producers, they already have a relatively good background and experiences in fish diseases and the many challenges emanating from them on a daily basis.

In Zambia Samui *et al.* (2007), and in Malawi Munthali (2021), have recorded isolations of the pathogen *Aphanomyces invadans* (the causative agent of Epizootic Ulcerative Syndrome, EUS), however both mortalities and economic loss have been localised in wild riverine catfish species. The threat of spread to fish farm species, with associated economic loss, appears not to have materialised in both countries. It should also be noted that in terms of wider risk and susceptibility to EUS for farmed and wild tilapine species, the literature shows tilapias to exhibit a degree of resistance to this pathogen (Afzali, 2015). In the last 2-3 years Zambia has been developing its own aquatic animal health research and infrastructure (including both a diagnostic lab and future potential vaccine development) through a USAID funded project.

For the other main aquaculture countries' respondents in this survey, Kenya, Nigeria, Uganda and Tanzania, are all countries where aquaculture is beginning to commercialise and intensify, but as yet not experiencing major issues with fish diseases. They can learn so much from what has happened in Ghana. Some of the comments and recommendations from respondents from the three Lake Victoria riparian countries indicate there are already major concerns in terms of aquatic health and biosecurity as commercial aquaculture sectors begin to grow and intensify. Large-scale mortalities of tilapia in cages have already been reported across national media in both the Kenya and Uganda (Alando, 2022).

In this report we include the words of a number of the respondents as we believe these are important in demonstrating where each of the stakeholder sectors are now as regards to aquatic animal health, what they are individually and commercially doing, and where they see the major challenges, bottlenecks and ways forward to either prevent or at least mitigate the effects of fish/shrimp diseases in their countries in the future. In certain countries the private sector is beginning to set up its own mechanisms and activities towards increasing awareness and self-regulation. From the survey section/questions directly asking how each respondent is involved in aquatic health, fish and shrimp diseases we can see on the production side primarily from Ghanaian responses, many are used to daily/weekly treating fish either in response to noted observational clinical signs or fish behaviour. Interesting to note in terms of daily management the dynamics between owners, managers and their staff in trying to maintain regular biosecurity and disinfection procedures on their farms and hatcheries. Also clear to see from service sector feed and pharmaceutical company employees and

consultants involved not just weekly in advising their fish farming clients but also for some providing sampling and diagnostic services for their customers.

In terms of its importance to the private sector, for 50% of respondents their work involves working with fish health fish diseases on a daily basis, with another 43% working on fish health related issues every 1-4 weeks. There was a range of respondents from across the value chain, feed, vaccine and pharmaceutical suppliers, diagnostics and veterinary, also consultants and extension and training. This illustrates, for a country like Ghana, how the associated fish health service sector is now expanding to fit the needs and demands of the industry. This should serve as an example for other countries; where governments need to invest in their own staff and resources, but also support commercial diversification in aquatic health expertise as the sectors grow.

Diagnostic laboratories samples mortalities

The issue of diagnostic laboratories in country was one of the repeated outcomes of this survey across all the stakeholder groups. In terms of in-country infrastructure and capacity in fish health although 61% of private sector respondents replied they were aware of a working, accessible, affordable fish diseases diagnostic laboratory in their country. When questioned further it can be seen in reality this still not the case, especially for labs which are able to detect and diagnose all relevant tilapia pathogens including viruses. This is further backed up by similar responses from the Government and the Education and Research sectors who were at around 50% who stated there was a working diagnostic lab in their country. For private sector 67% thought it could handle bacterial fish pathogens, 52% for parasites and fungi, and only 47.6% for viral pathogens. Again, similar percentages confirming this in the other three sectors' responses. One other clear finding was the relative lack/absence of histopathology services – only 24% of private sector respondents were aware of them being available in their laboratories. This is a significant finding and also gap in terms of wider resource allocation and expertise, especially with increasing rapid molecular based diagnostics, many of which are used without any reference or confirmation to histopathology. Nearly 58% of operating fish farmers sent samples to a lab in the last 5 years - with 35% of these waiting for between 1-3 months to get results back, some (10%) never received results. Whilst 58% of private sector respondents used private labs either in country or outside – only 40% stated they used government labs in country. This indicates presently the supply-demand gap for diagnostics and the need for a reliable, accessible service that can support and help the growing fish farming sector. Producers still have a significant level of uncertainty about which pathogen responsible is present and which treatment to use. This decision-making process for a commercial fish farmer made far more difficult without any operational, fit for purpose, affordable diagnostic laboratory where they can get results back within relatively quick sample turnaround time.

Treatments

The responses on treatments showed for a number of the private sector respondents personally having some/ good experience in treating fish either in water or using in feed. This not the case in the other 3 stakeholder groups with at the most 57% of government respondents saying they had personal experience of treating fish in water, this then declining to only 14% who had used in feed treatments and 14% who had been involved in vaccination of fish. Contrary to this vaccination was well represented through the Ghanaian private sector respondents showing they had used both a commercial *Streptococcus agalactiae* and an ISKN vaccine, the latter originating from Singapore. Heat treatment was also mentioned, which has been increasingly practiced at the hatchery and nursery

stages of tilapia farms in Ghana since 2018. One private sector response about treating regularly in cages from Ghana was important. To carry this out regularly and effectively in open water is a skilled procedure, much more complicated than in closed water units like tanks or ponds. This skillset is now present in some in the private sector something that is important to highlight and include in further hands-on trainings with others across all sectors. There were several alarming quotes about daily use and mixing of “safe” antibiotics and also a range of these listed. One Education and Research respondent quoted using an antibiotic banned for use in fish. Another in private sector seemingly still using malachite green on a regular basis. These words illustrate the challenges, in any country, of regulating the safe use of chemicals and drugs. Understanding other commercialised aquaculture country’s experiences that this can develop into far more serious problems, including Antimicrobial Resistance (AMR) without effective monitoring and regulation, which is already becoming an issue in Egyptian aquaculture (Ali *et al.*, 2022). This further highlights the need for government resources and budgets to be available to monitor and regulate this, and the need to budget for increases as the industry grows. Increasing Government/Ministry budget and resource allocation towards AH are repeated in the recommendations from both Government and the Education and Research respondents. The need to improve the working relationship, responsibilities, and coordination between Fisheries and Veterinary Depts in terms of aquatic health was raised by all four stakeholder sectors.

The Pathogens

The private sector showed good knowledge of the specific pathogens that were important on their farms – and with Infectious Spleen and Kidney Necrosis (ISKN) and the two *Streptococcus agalactiae* strains these were obviously emanating from the Ghanaian respondents. The Malawian and Zambian respondents (n=4) also mentioned EUS (Epizootic Ulcerative Syndrome) which is recorded as being detected mainly in wild riverine catfish species in both countries. Malawi, it can be said, with its low aquaculture production and still only one really large-scale commercial producer, has far more fundamental challenges within its smaller scale aquaculture producers i.e. feed and fingerlings. It should be noted though that Malawi is still one of the few SS African countries who ban the introduction of any non-indigenous live *Oreochromis niloticus* fish into its waters. Whether in agreement or not with this longstanding policy, one outcome from this, if the country is able and has the funds to regulate this effectively, is the undoubted reduction in risk in importing potentially serious tilapia pathogens into the country from either outside Africa or within the continent.

Information and Knowledge

The internet is where all sectors search for and get most information about aquatic animal health, which means there is a wide spectrum of the quality of information. Books are still important, as are contacts and networks with colleagues. Extension officers and fish health specialists, including from outside the country also important. In terms of peer reviewed papers, specialist journals and books, and setting up online notifications the Education and Research sector were ahead of the others.

In terms of what respondents would like more information on, it was clearly viral diseases of tilapia associated to their detection diagnosis, treatment and impacts, plus in general preventive measures to reduce risk of mortalities on their farms/hatcheries in the first place. Below this a better understanding of general diagnostics and detection and more specific details on treatments, methods, dosages, withdrawal periods etc. Again, fourth in this list was request for *proper working fish diagnostic laboratory* along with *professional experienced staff*. One government respondent also

interestingly mentioned developments in new molecular based diagnostic kits and their potential place in future within rapidly commercialising aquaculture sector.

Training

The survey showed the majority (77%) of private sector respondents had been on some form of training on fish health in the last five years, whilst four of these individuals had also been involved in giving training. Whilst the majority of the training quoted was from outside Africa [organisations such as WISHH (World Initiative for Soy in Human Health), Auburn University, Fish Vet Group, Tilavet, Ictyopharma etc.] there were some originating and organised by African private sector e.g. Ghana Chamber of Aquaculture, commercial feed companies and two private consultants. Government-run trainings were also mentioned through main Veterinary Dept fish health expert and wider extension officers. As for the efficacy and measurable beneficial impacts from these trainings this was not clear through the survey responses. However, it could clearly be seen training in this subject area was far more prevalent in Ghana than any of the other countries involved with already private sector involvement in organising and running specific trainings. Education and Research sector also mentioned the more recent use of webinars specifically on fish disease and biosecurity.

Biosecurity farm and wider international level import export procedures and regulations

In spite of the deliberately worded wider focus in the question on defining what biosecurity meant ... “on farm for the country or elsewhere”, it was interesting to note that most respondents across the four sectors saw biosecurity as just a farm-level issue – not wider provincial or national/ international concern. Again, comprehensive examples of biosecurity were primarily mentioned at farm site level. Interestingly no one in private sector mentioned specific biosecurity for cages in larger bodies of water where certain pathogens are already endemic, and where the bulk of tilapia production now happens (by volume); whilst this was alluded to by one of the government respondents in future recommendations. Some level of reality and veracity returning was noted in the response ... “*Biosecurity does not exist in Ghana ... half-hearted etc*”. This from a service sector pharmaceutical / vaccine provider perhaps more realistic as someone who weekly visits many farms, as to what is actually occurring on the ground or in the water.

Across all sectors there were very low percentages of respondents who claimed to have any knowledge or personal experience in importing/exporting live fish: Only 27% from private sector, and 31% from government in the last 5 years. Even fewer, 24% in private sector and 23% in government, claimed to know where to go to – an internet site online or a physical place i.e. Ministry – to get details for importing/exporting live fish from/to their country. When further questioned only one private sector and two govt respondents could give specific websites. The other respondents gave international organisations like FAO, OIE and even Farm Africa as sources for these country level regulations and information. In terms of risk of importation of potential financially important fish pathogens within stocks of live fish, these above findings for the private sector demonstrate a clear gap which positively without too much money and resources can be acted on at each country level. The evidence base from Ghana clearly shows what happens when this gap is not addressed and acted on.

Recommendations/Comments

Finally, there are a number of relevant and insightful comments from the respondents across all sectors at the end of the survey:

- Improving infrastructure, coordination and relationship between the government Veterinary and Fisheries and Aquaculture Ministries was mentioned by both private and government sector respondents. Certainly, an issue affecting many African countries – with, still for some, unclear mandates and responsibilities – and different resources, budgets, communication and operation. This is often confusing for the private sector.
- Better, more specialised in-country training/information on aquatic animal health and biosecurity including an emphasis on viral pathogens. Not just university-based, but more emphasis on hands on specialist trainings in vocational colleges to Certificate or Diploma level.
- Minimal importance and government resources allocated towards fish diseases for monitoring and regulatory provision, especially in countries not yet suffering from fish/shrimp disease issues. In some instances, this void is filled by investment from the private sector, in others the private sector is still playing catch up.
- The issue of a lack of diagnostic laboratories repeatedly surfaces across all sectors. Possibility of looking at Asian/WorldFish PPP Public Private Partnership model for an effective and self-sustaining income generating model, for example the one now operational in Bangladesh.
- Still relatively few (and often too general) regulations in the national legislature for aquatic animal health in their countries. As yet only two sub-Saharan African countries (with another in planning stage) have specialised designated Fish Health Units within ministry structures.
- For private sector operators, either producers or others across the value chain, the lack of diagnostic labs and under-developed national legislation leaves a number of inconsistencies, which lead to uncertainty, financial risk and difficulty in operating/expanding their businesses. This opens opportunities to circumvent and abuse the system.
- African fin fish aquaculture sector should understand better and learn from biosecurity and management operating procedures of commercial shrimp farming sector. Potential for far more communication and collaboration between the two.
- Focus on technologically sustainable ways of addressing biosecurity both within and outside farms, especially in larger natural water bodies like Lake Victoria - which is shared among states. Should be biosecurity guidelines/manual available for each country, specific to their needs and including guidance on the siting and day to day operation of cages.
- For each country, clear information available (online and in accessible physical locations) on step-by-step procedures, the forms to fill, and criteria to meet for import/export of live aquatic organisms.
- Utilise technology to support better health management. Review and improve collection and online dissemination of data from AH monitoring, surveys, diagnostics - including efficacy of

vaccination programmes - for the benefit of all across the sectors. Possible future use and inclusion of on-farm sensors and environmental “warning” tools.

- Better knowledge on access to and availability of legal chemical and other treatments, including clear guidelines on safe procedures and also lists of those banned.
- Need for more trained specialist histopathologists – resources and budget depending – at first at regional level.
- Students at all levels need for more hands-on lab and on-farm training/awareness in disease diagnosis, treatment and biosecurity procedures.

This is, to our knowledge, the first SS African aquaculture open access online survey looking to understand and document the views of the various private sector stakeholders whose work is regularly involved with and impacted by aquatic animal health. There have been a number of key findings from which there are associated focussed activities which can follow to address and or further support individuals/ organisations in the growing commercial private sector to prevent or significantly lower the impact and risks from aquatic animal health in future.

Appendix 1 - Copy of online questionnaire (Private Sector example)

Aquatic Health / Fish / Shrimp Diseases Online Questionnaire for Private Sector African Aquaculture May 2022

Introduction



This questionnaire is part of FAO's activities to understand and support the management of aquatic health* same again across Africa. The questionnaire is delivered through the organisation [ThinkAqua](#).

Its aim is to collect up to date information from across a range of African countries where aquaculture is now beginning to intensify and develop commercially. This information will be anonymised, analysed and shared online as a resource that can be consulted by all those working across the sector, the continent and internationally. This questionnaire is part of a series of activities, including key informant interviews, to understand the status and associated infrastructures for aquatic health across Africa.

We would be grateful if you can give a small proportion of your time to fill in the questionnaire – as you will see there is a general section, then specific sections for 2 and 3 for your particular stakeholder group. All information collected will be anonymised down to stakeholder group.

There will be a **prize draw** for all those who complete the online questionnaire for 2 X National Geographic monocular small field microscopes with smart phone adapter:



Before starting this questionnaire if you have any questions or require clarifications, please feel welcome to contact William Leschen williamleschen@gmail.com . We welcome completed questionnaires from all African countries....

Section 1 General Details

1. Name:
2. Country/Province Location: e.g., village town or city
3. Gender:
4. Level of education furthest completed:

Secondary School uncompleted Secondary School completed Vocational college Certificate

Vocational college Diploma University undergraduate University postgraduate Masters University PhD

Other please state

5. Email Address and Tel Nos incl International Country code (for the competition)
6. Please indicate your expertise or knowledge (as you consider it) related to aquatic health (for example, fish, or shrimp diseases)

Very good/comprehensive Good Average I know a little I know nothing

Section 2 Private Sector /Aquatic Health Fish / Shrimp Diseases Experience

Please now answer this section.

If you are also involved working in a lesser capacity in one of the other stakeholder groups eg Govt, Education, or NGO please feel welcome to also complete the different questionnaire for this group also by going back to home page of the survey.

2a Private sector

Note this includes any people working related to aquatic production, fish farmers, shrimp farmers, input and service suppliers e.g. feed and equipment and pharmaceutical companies, market chain wholesalers, retailers, private sector research, consultants, private veterinarian, private sector diagnostics. Any others working in private sector. Can also be outside Africa private sector company working in one or more African countries in aquatic health in last 5 years

2.1 Please indicate the specific sub-sector or sub-sectors you work in the private sector - *please tick maximum of 2:*

Feed company Equipment supplier Fish farm producer Fish hatchery Shrimp farm producer

Shrimp Hatchery Pharmaceutical Company Agricultural supplies/inputs Dealer Market Wholesaler

Market Retailer Private sector research company Private sector training and extension company

Consultant Veterinary Private sector diagnostics laboratory

Other *please state*

Private sector organisation from outside Africa – *please state Name of organisation, country and also which African country/ countries you have been working in in last 5 years*

2.2 How often do you have to work with any issues related to aquatic health, fish/ shrimp diseases, biosecurity etc or they affect you in your work on average over the last 5 years?

Daily Once a week Once a month Once every 6 months Once a year

Once in last 5 years Never

2.3 If daily, once a week or once a month - Please explain briefly how specifically aquatic health/fish/ shrimp diseases are included in your work –

e.g. In the hatchery I work in we treat the tilapia fingerlings once per week with salt to remove any parasites or I work for a feed company which once in 3 months carries out trainings with our customers (fish farmers) which includes some content on fish diseases and treatment.....

2.4 – Do you know if there is one (or more?) operational working fish / shrimp diseases diagnostic laboratory/ laboratories in your country where you or anyone else can take samples to - to be analysed for fish/ shrimp diseases which is both affordable and accessible?

Yes No Don't know

2.5 *If yes* please can you give details - eg location and whether run by govt? private? or university sector(s)

2.6 *If yes* please do you know which categories or types of pathogens and or testing this lab is able **routinely and regularly** able to detect? Including other services they offer? *Please give multiple answers if necessary*

Viral Bacterial Parasitic Fungal They also offer Histopathology? Water testing Food safety testing

Residue testing Other

or I don't know Not applicable

2.7 *If you run or work on a fish/ shrimp farm or hatchery – in the last 5 years have you/ the farm sent out samples to a laboratory or elsewhere to be analysed for disease(s)?*

Note – as stated previously - all information disclosed in this questionnaire is confidential – we will only present this data to a general fish/shrimp farm level – no farm business or individuals names will be revealed

Yes No Don't know Not applicable

2.8 *If yes* can you state which laboratory you sent to (*tick all that apply*):

Govt lab in country Private Sector lab in country (*state lab*) Govt lab in another country (*state country and lab*)

Private sector lab in another country (*state country and lab*) Sent to our own lab (*state country and lab*)

Other type of laboratory (*please state*) or

I/we wanted/needed to send samples to a lab but were unable to due to cost

I/we wanted to send to outside country lab but unable to do so due to import/ export regulations including bans for sending biological samples outside the country

I/we wanted/needed to send samples to a lab but were unable to due to other reason(s) (*please state reason*)

Not applicable for this question

2.9 *If yes* Can you state how long it took to obtain the results back from this lab?

Within 2-3 days Within 7 days Within 2 weeks Within 3 weeks Within one month

Within 3 months We did not receive any results back even after 3 months

Not applicable

Any other relevant comments on this you wish to make

2.10 *If applicable* has your farm/ business had any significant fish/ shrimp mortalities in the last five years?

Yes No Don't wish to reveal this information Don't know Not applicable

2.11 *If yes* – Did/do you know the reasons why the fish/shrimp were dying?

Yes No Not Applicable Other please *state*.....

2.12 *If yes to above please state the known cause / or causes of these mortalities – tick more than one if necessary*

Water quality Climate / weather / temperature Dissolved oxygen Pollution

Known/confirmed fish disease/pathogen Known/confirmed shrimp disease/ pathogen

Due to feed used Human accident (*eg treating or handling fish/shrimp*) Due to too much stress

Deliberate poisoning Other *please state*

2.13 **If confirmed** a fish or shrimp disease(s) Please name it /them and if more than one rank by importance/ financial loss

2.14 Can you select one or more of below:

Currently I do think fish/ shrimp diseases are **a big problem** for my farm/my work/my region/ my country

Currently I do think fish/ shrimp diseases are **a slight problem** for my farm/my work/my region/ my country

Currently I don't think fish/shrimp diseases are a problem for my farm/my work/my region/ my country

I do think fish/shrimp diseases will be a problem for my farm/my work/my region/ my country **in next 5 years**

I don't think fish/shrimp diseases will be a problem for my farm/my work/my region/ my country **in next 5 years**

I don't know

I have no opinion

NA

2.15 Can you give any specific examples of how people/ companies/ organisations from the private sector in your country provide help/support/ services related to aquatic health / fish diseases?

Yes *please state*

No

2.16 Where do you look to find information about aquatic health / fish diseases in order to learn more and increase your knowledge. Please state in order of importance. e.g. books library internet, extension officer, friends, company, other – *please state*

or I don't look for information on aquatic health fish/shrimp diseases

2.17 Which information or knowledge about fish or shrimp diseases **would you** like to know more about but currently cannot find out?

2. 18 Are you aware about anything to do with aquatic health/ fish diseases in another African country?

Yes No

2.19 *If yes* please describe briefly:

2.20 Treatments: Have **you personally** done or been involved in any of the following in the last 5 years:

Please select more than one if appropriate

Treated live fish or shrimp using a chemical or substance in the water? Yes No

Treated live fish or shrimp using a chemical or substance in their feed Yes No

Vaccinated live fish/shrimp Yes No

Used any sort of heat or electrical applications to treat fish/ shrimp? Yes No

Treated fish or shrimp by injection

Treated fish or shrimp in any other way - *please state*

Produced all male tilapia fingerlings using a hormone in their feed?

2.21 *If yes* to any of the above please state why you did this?

For a particular disease/pathogen I knew was present?

Because the fish / shrimp were dying

Because someone told me to do it

Because you saw a change in the fish/ shrimp's behaviour?

Because you saw external (clinical) signs on the fish / shrimp which you thought was caused by a disease?

As routine to prevent the fish or shrimp being affected by a disease?

For another reason, please *state* Not applicable

2.22 *If yes* also please state the names of chemical treatment(s) or vaccine(s) or other treatment(s) **you personally have used** in the last 5 years

2.23 Are you aware of a place or places – sales outlet, agricultural inputs dealer, feed company, other, where **you or anyone else** can purchase chemicals, disinfectants, pharmaceuticals, other to treat fish/ shrimp?

Yes No

2.24 *If yes* please name(s) and also give location(s)

2.25 Do **you/ your employer organisation** have or use any specific equipment related to aquatic health fish/ shrimp diseases *If yes please state what it is If no state No*

Examples could be: microscope, dissection kit, large or small lab at workplace, on farm diagnostic kit(s), footdip, software on phone related to aquatic health, oxygen meter, aerator(s), measuring cylinders, syringes, chemical store, special treatment tank(s), heat shock equipment, vaccination equipment, other ...?

2.26 What do you personally understand the term “Biosecurity “ related to your own farm and or aquaculture in your country or elsewhere to mean ? *Please write in one sentence*

If you don't know what it means, please state Don't know

2.27 *If you said yes to above and work at a facility or place that produces live fish or shrimp, please list the different examples of biosecurity you are aware of at the place(s) you work*

2.28 If you work but are not a fish/ shrimp producer but rather work in the input supply sector eg feed company, agricultural supplies dealer, chemical/pharmaceutical company, or related please state if your company supplies any products including equipment related to fish/ shrimp diseases, aquatic health -

If you do supply, please list products you sell If you don't supply related to aquatic health fish /shrimp diseases please state We don't supply

2.29 Have you ever had any training or given any training related to aquatic health fish/ shrimp diseases in the last 5 years? – *can give up to two answers*

Yes, had training No not had Training Yes have given training Don't know

2.30 *If yes please state what this was on, at what level, and who ran the training. If you ran the training state who you were training?*

2.31 Do you have any other important information, questions or other you wish to add related to aquatic health fish/ shrimp diseases that has not been included above if so, please add here

Now move to final section 3.0

3.0 Final Section Future importance of fish/shrimp diseases, borders and training.

3.1 In your opinion from your experience – now at the present day - are fish / shrimp diseases a significant issue financially / environmentally for fish/shrimp farmers / others in the country you work in?

Not important at all Slightly causing some issues Important Very important Critically importantly

Don't know Don't have opinion Please *state the country again also*

3.2 If you answered not important or slightly important or Don't know - What do you think about their importance in aquaculture in the country in the future?

They will never be a problem They might be problem in 5-10 years They are likely to be a problem in 2-5 years

They are likely to be problem in 1 year I don't know I have no opinion

3.3 Have **you personally** had any experience or know about the position and procedures for bringing in or sending out shipments of live fish at airports land borders and /or seaports in the country you work in in the last 5 years?

Yes No

3.4 *If yes please describe briefly your experience or knowledge - please state airport - or land border or seaport*

3.5 Are you aware of a site on the internet or a place you can go to - to find out the rules and regulations for importing / exporting (live) fish or shrimp into and from the country you work in?

Yes No

3.6 *If yes please describe briefly if you can giving website url and/ or place /location /organisation where you can get the information in a leaflet, booklet or verbally...*

3.7 In terms of training - at all levels - which parts/subjects of aquatic health fish/ shrimp diseases **do you think are taught well** in your country eg Biosecurity Treatments Diagnostics - *please state - If you think none are taught well or none are taught then state None or if you don't know just state Don't know*

3.8 In terms of training at all levels - which parts subjects of aquatic health/ fish / shrimp diseases **do you think are not taught well** in your country and should be taught in your country? *Please state*

3.9 Please feel welcome to add anything further about aquatic health fish shrimp diseases that hasn't be mentioned above but you wish to include particularly if related to the private sector

Thank you for taking the time to fill in this questionnaire - You will be entered in a prize draw for one of the two National Geographic microscopes - the 2 winners will be announced on the SARNISSA African Aquaculture Network Facebook site <https://www.facebook.com/sarnissafrica> within 2 weeks of this questionnaire closing.

As previously stated, the information collected from this questionnaire will be anonymised down to stakeholder group level. The results and findings will be collated, analysed and then made available in a user-friendly open access document which will be shared out across the SARNISSA African Aquaculture network and FAO.

If you have any further questions or clarifications after completing this questionnaire, please contact William Leschen williamleschen@gmail.com

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