

National Fish Health/Fish Diseases Case Study: Ghana October 2021:
An interactive survey-based case study of the current and past status of fish health/ fish diseases within Ghanaian aquaculture

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Disclaimer:

Please note the content and views expressed in this document come from a wide range of stakeholders as recorded by the authors as part of the case study survey face to face interviews in Ghana in late October 2021. Any other content is the sole responsibility of the authors.

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We wish to acknowledge and thank all those who work in Ghanaian aquaculture who gave their time and contributed to this case study. It is for you and all your other colleagues working across Ghanaian aquaculture. We also wish to acknowledge Msingi East Africa for funding this case study.

More specifically to thank Drs Duodu and Addo of University of Ghana, Legon, for their help, technical and logistic support for putting together the interviews survey and editing of this document. This case study was also carried out in conjunction with the shooting, editing and production of a video - freely available online at XXXXXX which summarises the main findings, outcomes and recommendations. We recommend you should watch this video in conjunction with reading this case study. I wish to thank Siaka and his company Ask Studios for his patience and expertise in the making of the video.

We also wish to make clear none of the viruses including Tilapia Lake virus TiLV and Infectious Spleen and Kidney Necrosis ISKN virus mentioned are in any way harmful for humans. They are purely pathogenic towards fish – in this case tilapia.



Figure 1: Ghanaian aquaculture commercialising & intensifying since early 2000s, primarily cage culture of tilapia in and below the Volta Lake

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Acronyms

ARDEC WRI	Aquaculture Research and Development Centre Water Research Institute
GCOA	Ghana Chamber of Aquaculture
HDPE	High Density Polyethylene
ISKN	Infectious Spleen and Kidney Necrosis virus
KNUST	Kwame Nkrumah University of Science and Technology Kumasi
MT	Metric Tonne
OIE	Office International des Epizooties
PBA	Pillbrook Aquatics
TiLV	Tilapia Lake Virus
UOG	University of Ghana

1.0 Objectives and Rationale

The objectives and rationale behind this case study go back to August 2020 when following initial discussions, it was conceived between the author and Msingi East Africa, due to its relevance to the commercialising and intensifying aquaculture sector in East Africa especially related to commercial cage culture in Lake Victoria and the risks from importation of live fish species into countries where aquaculture was developing. By that time there had been over the preceding 3-4 years significant and repeated (reported) mortalities of farmed tilapia in cages and adjacent hatcheries in Ghana on and around Lake Volta and the river below the dam. Some mortalities were also experienced in ponds nearby to the lake in both Eastern and Volta regions. Before going on to describe chains of events and what happened in Ghana up to the present day it is prudent to mention that these mortalities and loss of farmed tilapia stocks have caused very high, and for some Ghanaian fish farmers of all scales, severe financial losses which resulted in a number of them, still currently in late 2021, with no fish in their cages, not trading, and having to lay off large proportions of their workforce staff.

We will then go on to relate and summarise the key words and findings from the range of Ghanaian stakeholders (private, government, research and academia) we interviewed face to face on their experiences and recommendations following the significant fish health/fish disease challenges they have faced in the last 4-5 years.

We thank and congratulate the various people across all sectors of Ghanaian aquaculture we interviewed for being willing and so open to take part in such a survey, which they too understood would not just potentially benefit their own country, but also inform other up and coming African aquaculture countries on the importance of fish health/fish diseases as their respective aquaculture sectors grow and intensify.

2.0 Introduction to Ghanaian aquaculture 2000 - 2021

The early years

Ghana has been developing its aquaculture sector since the 1970 – 80s. In those times it was primarily through overseas donor funded projects working with the government Fisheries Department and a range of NGOs with a focus on poverty alleviation and development of small-scale rural pond aquaculture, often trying to replicate South Asian integrated fish farming models. This was mainly across inland southern Ghana (Ashanti, Central, Western Eastern, Brong Ahafo and Volta regions) working often with large numbers of low-income rural smallholder crop and livestock farmers, attempting to integrate their subsistence crop and livestock plots with small scale pond culture of tilapias and catfish. Whilst the jury may be out on the success and measurable impact of these programmes, FAO statistics show national aquaculture production during this period didn't increase much past 5-7,000MT per annum staying at this level for 20 years despite the considerable amount of funding.

Change towards cage culture – first pioneers...

However, as the 1990's progressed there began a change in focus and location as the first rudimentary attempts at commercial small scale cage culture of tilapias in the Volta Lake commenced. This by inquisitive, entrepreneurial individuals who had been watching cage culture of tilapias begin to grow commercially in large freshwater lakes and reservoirs in south and central America, and southern Asia, as well as the birth of a large commercial tilapia cage producer in Zimbabwe. These pioneers knew and understood that southern Ghana had competitive advantage over many other (African) countries due to its favourable climate, year-round 27–31-degree temperatures, rainy season, abundance of water and growing urban markets where demand for fresh fish was growing.

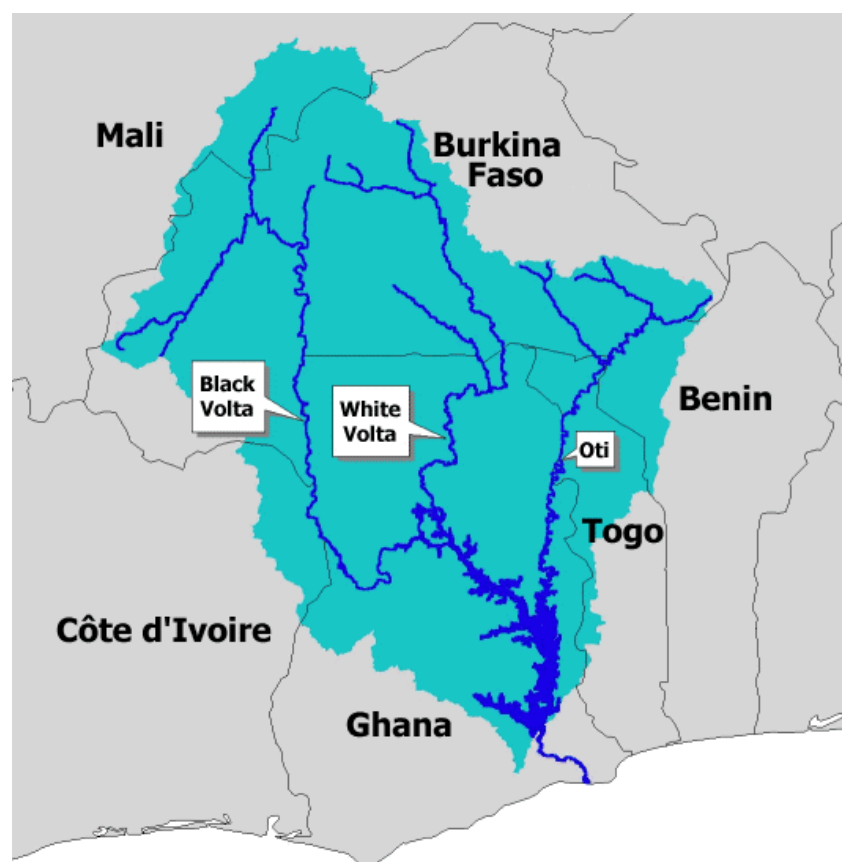


Figure 2 Ghana's Lake Volta showing extensive water catchment

These pioneers, both Ghanaian and foreigners, struggled at first to access the key inputs and resources needed for financially viable cage culture, including good quality commercial feeds, and fingerlings, with their cage designs based on locally welded metal frames with floats, and often poor-quality nets. Whilst it can be said they were “testing the water” these initial pilots were valuable learning exercises to move on to bigger things. By the end of the 90's the first pond hapa based commercial tilapia hatchery started through an outside investor – fed by an irrigation scheme below the Akosombo dam. It had a business model to supply the necessary

monosex tilapia fingerlings to stock and develop its newly developed nearby cage site on the Volta Lake, to produce 350-400g tilapia in 6-8 months to supply the urban Accra market 2.5 hours' drive away where demand and prices for fresh fish were both high and unmet.

Kickstarting the sector into an industry but with issues

There followed 3 further mid to larger scale cage hatchery model farms springing up on the shores of Lake Volta, one local, two overseas funded. By the early 2000's quality fish feed was still a big issue – with some commercial farms importing their feed from Brazil. However, a key game changer came in the mid-2000's when the first outside specialist fish feed mill was set up at Prampram near Tema around 2006. This had the effect of kickstarting the lake's cage grow out sector, as the larger farms could begin to scale up their production, whilst new mid to smaller producers could buy feed and begin to put their small cages into the lake.

At the time government monitoring, registration, permitting and regulation of this growing sector was limited primarily due to lacking infrastructure, manpower, budgets and resources, also sparse relevant legislation to regulate the expansion of cages in the lake and the river below the dam flowing down to the coast. In those early days the ministries also lacked specialist expertise in the sustainable and commercial development of cage culture in larger water bodies, carrying capacities, environmental modelling and fish diseases. At this time their staff had limited commercial experience and backgrounds.

Consequently, the number of cages grew both in the lake and river below, with sites often very close to each other and some in water depths of less than 3m. On the positive side the larger companies developed their hatchery capacities and expertise to produce millions of monosex tilapia fry, most of which were stocked into their own cages; however, a significant proportion were also available and sold to smaller farms thereby benefitting their businesses. By 2010 there were 5-6 larger producers around and below the lake each producing and selling over 1,000MT of tilapias per annum (largest two then 3-4000 MT) and employing between 50-450 staff across the value chain. Whilst the mid and smaller level cage farmers were proliferating producing between 1- 200 MT per annum and each employing in the range of 5 - 30 staff. For the first time, fresh farmed tilapias (also cooked in the canteens and restaurants) were commonly seen on sale on the streets of Accra, with the largest producer setting up a specialist sales hub on the outskirts of Accra near Tema, noting this was also close to the country's largest fish feed producer. This wholesale and retail sales hub sold in the main fresh iced whole gutted tilapia to a range of small and mid-sized buyers often female market traders who travelled from all over southern Ghana. Between 2012 – 2015 it was not uncommon for refrigerated trucks to bring 10-20MT of farmed tilapias to be sold daily at this hub. The largest company also for the first time in Ghana began to develop its online marketing and sales across the country, with regular and attractive posts on social networks and periurban home delivery by motorbike and small trucks.



Figure 3: Ghana's growing periurban demand and markets 2010-2015 drove its commercial aquaculture growth

During these years up to 2014-2015 cage culture of tilapias could be said to be booming with national annual production in 2015 around 45,000MT (FAO stat) – at that time at a value of USD 112.5 million. Strong demand and good market prices, saw sales radiating out to other southern/western Ghanaian cities like Kumasi, Takoradi and up to the north Sunyani and Tamale. Cage designs and construction had moved on with the larger producers beginning to use bigger volume HDPE cages originating from China and Turkey. They also began to use purposely designed support boats/barges and other equipment i.e., automatic graders and fish pumps, which further allowed them to scale up production and employ more people. In these years the Volta Lake cage producers were supplying 80-90% of the nation's farmed fish, with smaller scale pond culture in the hinterlands producing much smaller volumes – most still below 0.5MT per year and selling in kg rather than tonnes to local more artisanal markets.

Prior to 2015-16 there had been some reports of farmed fish mortalities in cages and ponds also in hatcheries, these mainly caused by environmental water quality issues leading to secondary fungal (*Saprolegnia*) or parasitic (ie *Trichodina sp*) diseases, the latter often found on the gills especially in hatcheries. Whilst these tended to be seasonal cage farmers enjoyed 70-80 % survival rates from fingerling stocking to harvest, and for them as well as the smaller scale pond farmers fish diseases were not an important issue.

2015-2016 A change coming

However, a change was about to happen.... Between 2015 - 2016 there were reported increased mortalities in cages on the lake especially in the 3–4-week period after stocking with 5-20g fingerlings. For some the losses were up to 50 %. Not for all but some noted these occurred following physical and environmental stress e.g., live fingerling transport pre cage

stocking and after heavy rains when localised water quality and temperature were affected around the cages. At the time it was difficult for the fish farmers particularly mid to smaller level to access any form of diagnostic and veterinary support to find out what was causing these mortalities – there was no operating diagnostic fish health laboratory in the country. Whilst the now 8-10 larger producers acted by getting fish samples to diagnostic laboratories overseas in UK, Thailand etc in order to try to find out the cause(s). They found two internationally well-known bacterial fish pathogens *Streptococcus agalactiae* and *Streptococcus iniae* were present with typical external clinical signs exophthalmia (bulging eyes) haemorrhagic lesions on flanks, dark coloration, raised scales and fluid filled extended abdomens. The detection was also backed up by clear histopathology with major tissue changes in internal organs i.e., spleen kidney and liver (V Jeffries et al 2017).

JOURNAL OF FISH DISEASES

SHORT COMMUNICATION

Streptococcus agalactiae Multilocus sequence type 261 is associated with mortalities in the emerging Ghanaian tilapia industry

D W Verner-Jeffreys ✉, T J Wallis, I Cano Cejas, D Ryder, D J Haydon, J F Domazoro, J Dontwi, T R Field, D Adjei-Boteng, G Wood, T Bean, S W Feist

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SHORT COMMUNICATION

WILEY 

Streptococcus agalactiae Multilocus sequence type 261 is

Figure 4: 2016 - 17 Mortalities on farms on and below the lake began to happen
Causing significant financial loss. First report of *Streptococcus sp* in Ghana (Courtesy of *Journal of Fish Diseases*)

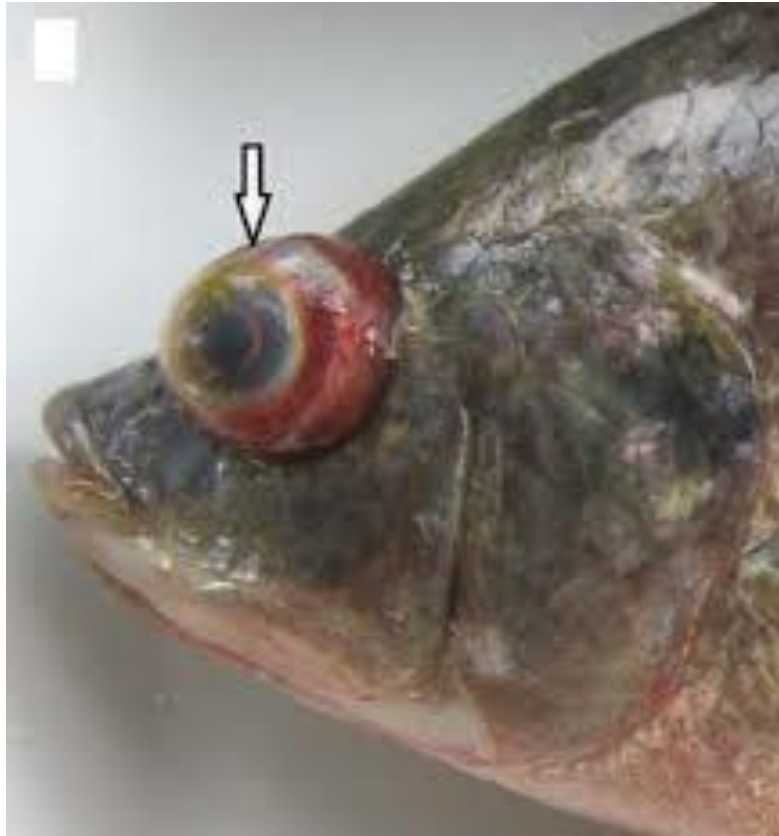


Figure 5 Exophthalmia (bulging eyes) in tilapia with Streptococcosis (*Li 2013*)

Limited veterinary and diagnostic services a government ban

Up to 2016 the government Fisheries and Veterinary Departments had limited diagnostic and fish health capacity with at the time just two full time veterinary officers with working remit for aquatic animal health across the whole country. At those times up to the present day there is still no fully functional fish health diagnostic laboratory in the country. By 2017-2018, whilst the causes of these mortalities were thought to be bacterial and a number of managerial measures were enacted by the farmers to mitigate and try to prevent the problems i.e., treatments, the beginnings of fish vaccination, use of antibiotics by some, herbal remedies, the mortalities continued. In July 2018 the ministry acted by bringing in a ban nationally on the outside introduction of live or dead tilapia and also of ornamental fish, as it was believed (but not definitively proven) the importation of live fish/fingerlings from outside sources – especially Asia - was introducing new and harmful fish pathogens into Ghana.

One farm fish mortalities in the media

In 2018 there was a large-scale mortality on a cage farm in the river below the lake with up to 40 MT tilapia dying. At the time this was widely reported in the media nationally and caused much consternation, not least because of inaccurate misleading reporting about the potential of a harmful virus causing these mortalities. Almost overnight these affected markets and sales of tilapias across the country, with women market traders being interviewed on news channels and radio talking about a virus which had badly affected their sales. The ministry closed down the farm, preventing any further movements of live or dead fish from it. It took

samples which were then sent to laboratories outside Ghana (UK and Norway) which came back with detection of two *Streptococcus* species - *S. agalactiae* and *S. iniae* associated with clear histopathology showing typical lesions in major organs spleen liver and kidney for these pathogens. The laboratories also tested for Tilapia Lake virus TiLV (by 2018 an increasingly reported pathogen in other commercial tilapia production around the world – Israel Ecuador Thailand China etc) **but did not detect it**. They also tested for, but did not find, any chemical or harmful residues in both the fish and water samples. The laboratories overall conclusions were that poor environmental water conditions at the time, poor water quality following heavy rains had increased stress on the fish to then create mass mortalities through these two bacterial pathogens.

2018 - 2019: Moving on to ISKNv – Infectious Spleen and Kidney Necrosis virus

Whilst this one farm's case was widely reported, elsewhere around the lake both larger and smaller cage producers and hatcheries continued to endure mid to high level mortalities particularly at the 15-30g stages when the fingerlings had been stocked into cages; for the following three to four weeks in most cages there would be a similar pattern of mortality, first 20-30 per day in each cage and then growing to hundreds lasting up to 4 weeks at which stage they could have lost 30-50 % of their original stocks. In most cases there were clear external clinical signs as already mentioned above.

In late 2018 into 2019 there appeared to be a change again with now hatcheries experiencing very high mortalities from swim up stages through to 1 – 5 g - for some up to 90 % losses. This was extremely worrying for them as they were unsure if it was the same *Streptococcus sp* pathogens or something else? Studies were carried out by overseas pharmaceutical and fish health specialists and the first identification of Infectious Spleen and Kidney Necrosis virus (ISKN) in Ghana was reported and published associated with large mortalities on a number of sites, both in the river below the dam but also in the lake above it (Ramirez Paredes 2019).

The effects of this virus along with co-infections of *Streptococcus agalactiae* were devastating across the region for cage farmers and hatchery owners. Firstly, supply and availability of fingerlings dropped considerably and those making it into the cages through stocking experienced further large-scale mortalities - some reporting up to 40 MT losses on their site over two-week periods and 90% mortality in their hatcheries (Domozoro 2021 *pers com*). This had the effect by mid-2019 of crippling the industry with production and sales of market fish declining rapidly. Many of the mid to smaller level cage producers went out of business, a number of others just left their cages empty, unable and for some frightened to stock them. Following this paper, the Fisheries and Veterinary Departments announced a ban on movement of any live fish from Volta and Eastern regions to elsewhere in the country. Whilst this ban was publicised nationally it is uncertain how effectively it could be implemented, and also how well it was actually kept to.

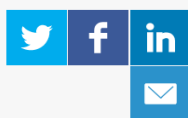
Virus linked to mass tilapia mortalities on Lake Volta

[DISEASE](#) [HEALTH](#)



by Efua Konyim Okai and Rob Fletcher
30 July 2019, at 6:00am

A new suspect has emerged in the search for the causes of the massive disease outbreak that has been affecting tilapia on Lake Volta in Ghana.



New research, led by a team of UK-based scientists working for [Ridgeway Biologicals](#), concludes that one of the causes of the mass mortalities on the lake is infectious spleen and kidney necrosis virus (ISKNV) – the first confirmed case of the virus in Africa. The report also warns international authorities and producers about the risk of spreading

Figure 6: First confirmed case(s) of Infectious Spleen Kidney Necrosis (ISKN) virus in Ghana July 2019 (Courtesy of The Fish Site)

In early 2020 the newly formed Fish Health Unit of the government Fisheries and Veterinary Services Departments also implemented a vaccination programme across Volta and Eastern regions in certain tilapia hatcheries and cage grow out facilities using a commercial ISKN vaccine originating in Singapore. The impact and effects of/ from this are not clear with no follow up data yet available on survival rates following in hatcheries and subsequent cages.

The position today.....

By late 2021 it is uncertain the impact and effect of the government ban on movements of live fish from Volta/Eastern regions to other parts of the country. It is also not clear but appears that the ban has been lifted. But as of now, (January 2022) there are no reports of any (large scale) mortalities on land-based pond/ tank-based farms or hatcheries 50 km plus away from the lake inland in Ghana. Since the original mortalities from *Streptococcus sp* in 2015-16, and then the crippling effects of the ISKN virus in 2018-19 it is undocumented how many cage and hatchery operators went out of business and how many jobs were lost. For those remaining Ghanaian cage farmers and hatchery owners in Volta and Eastern regions they have had to adapt to survive - or else they would also have gone out of business. This has involved many of them carefully reviewing their own farm management, biosecurity and operating procedures to identify how and where they can reduce stressing their fish leading to further mortalities. It has also involved them realising how their previous almost completely absent biosecurity measures both on and off farm had led to the spread of these pathogens in and around the lake, so as by 2020 – 2021 both the *Streptococcus sp* and ISKN virus could quite reasonably and scientifically said to be endemic in Lake Volta and its associated water catchments. The cage farmers have also tried a number of other measures

including vaccination and heat shock treatment both at the hatchery stage. A French company is now offering vaccination and diagnostic services across Ghana. The two main feed companies are also offering fish health services, advice and diagnostics for their customers.

The Universities

In terms of Ghanaian universities, prior to 2016 and the serious challenges with fish diseases, aquatic animal health was not well represented within their aquaculture or veterinary curricula or associated research. However, in the last years the University of Ghana (UOG) in collaboration with the Fisheries Commission and support of the Norwegian Veterinary Institute and WorldFish, is building local capacity in fish disease diagnostics through a funded project. Four newly recruited government veterinarians with working remit within the Fish Health Unit for aquatic animal health at national, regional and district offices (Accra, Koforidua, Akosombo and Kumasi) of the Fisheries Commission have received training in field sampling and laboratory fish disease diagnosis. The universities, UOG also Kwame Nkrumah University of Science and Technology Kumasi (KNUST) are also involved in capacity building through training of graduate students (MPhil and PhD) with expertise in fish and environmental health. The curricula and associated research within such programmes are now increasingly tailored to relevant issues affecting the aquaculture industry i.e., demand driven. Both universities also send their students out to a range of private sector farms including those around the lake for working internships, a number of these now also related to fish health issues.

And private sector representation and self-regulation.....

Positively, it should be also mentioned about the Ghana Chamber of Aquaculture <http://www.chamberofaquaculture.com/index.html> , a private sector organisation set up in 2017-18, not through (or subsidised by) any government or outside donor projects, but rather by professional people working across the Ghana aquaculture value chain with their own income generating business model. They provide environmental, business financial loan and legal support services, whilst in 2021 setting up the first pilot scheme for insurance coverage for their members. During the fish disease challenges of the last 3-4 years the Chamber has run a series of fish health related webinars bringing in outside experts from Asia and elsewhere with first-hand knowledge of the effect of these diseases to advise and support Ghanaian fish farmers across all areas. They also advise and produce content on farm and farm to farm biosecurity planning. Noting that the financial services and loan providers they now work with - will only offer loans under the conditions that the fish farmer has a strong business plan, an operating biosecurity plan, and is insured. The Chamber is an example - how private sector self-support and self-regulation, when carried out correctly, can be a constructive way forward for a sector intensifying and commercialising especially in terms of risk from aquatic animal health and financially sustainable standalone fish farming business development. The Chamber is also in regular contact with government, often lobbying up to ministerial level on specific issues for its members, including in the last 3-4 years the severe

crippling effects fish diseases have had on Ghanaian aquaculture and the implementation and effects of bans on imports of live fish into the country from outside.

The graphic features a background image of an aquaculture farm with rows of floating cages in a body of water. In the top right corner, there are logos for the International Aquatic Veterinary Biosecurity Consortium (IAVBC) and the Ghana Chamber of Aquaculture (GCOA). A dark blue circle on the right contains the text 'Part 2'. A light blue rounded rectangle in the center contains the title 'Biosecurity Principles in Aquaculture: Practical Disease Prevention, Control and Eradication at the farm'. Below the title, there are three portrait photos of the speakers and host, each with their name and affiliation. A Zoom logo is visible on the left side of the graphic.

International Aquatic Veterinary Biosecurity Consortium
www.iavbc.org

GCOA Chamber Of Aquaculture Ghana

Part 2

Biosecurity Principles in Aquaculture:
Practical Disease Prevention, Control and Eradication at the farm

zoom

Speaker A. David Scarfe
(Aquatic Veterinary Associates International, LLC)

Speaker Prof Dusan Palic
(Maximilians-University Munchen)

Host Dr. Collins Prah Doudu
(Lecturer, University of Ghana)

The block contains a calendar icon with a clock, followed by the date and time: '8th November, 2021 13:00 -15:00 GMT'. To the left of the text is a stylized graphic of a pencil and paper.

8th November, 2021
13:00 -15:00 GMT

Figure 7 Ghana Chamber of Aquaculture (GCOA) ran fish disease/fish health webinars for their members & wider fish farmers in Ghana & elsewhere (Courtesy of GCOA Facebook site)

3.0 The Ghana Fish Health Case Study Survey October 2021

3.1 Introduction

As mentioned above we now go on to describe the words, experiences and recommendations from the Ghana case study survey interviews. A summary video of these is also available online open access at XXXXX.

3.2 Methodology - what we did

An initial literature review (peer reviewed and other including online media) was carried out on fish health/fish disease issues in the development of the Ghanaian commercial aquaculture sector from 2000 – 2021, with particular emphasis on the importation of live fish into the country, the subsequent government ban, and then events which followed.

The authors (William Leschen, Dr Sam Duodu and Dr Sam Addo), then discussed and developed a Key Informants contact database of key persons across all stakeholder groups (private, government, research, and academia) which we wished to interview to gain their views, insights and experiences. Each of these individuals were contacted by email and/or telephone, firstly to clearly explain the objectives of the survey and then ask if suitable dates and times could be agreed for face-to-face interviews. Where possible we tried to arrange interviews at a location where the interviewees were comfortable, often their own workplaces. We also explained and asked for their permission to video their interviews towards making the summary video which would later put online open access.

From these initial contacts a week long schedule of visits was set up for 24-29th October 2021, with the interviews and visits being divided up into three locations: Volta and Eastern Regions, Greater Accra, then Ashanti Region. The first primarily with private sector producers and value chain around Lake Volta, the second with government sector in around Accra, and the third with both university research/academia and pond based private sector around Kumasi. A key informants check list/interview guide (Townley P. 1996) was put together with general themes to all but also including questions specific to each of the sectors. As with all key informant interviews, if the interviewee brought up a relevant theme or topic which was not on our checklist, the interviewer probed and allowed this to be developed further. As a result of initial interviews as we went along, we modified our key informants interview check list and themes to reflect and build on the information we had already gathered.

The interviews were recorded on video (with the prior permission of each key informant) along with footage from farms, hatcheries, input suppliers and university research facilities. Written notes were also recorded during the interviews. Once all the interviews were completed there followed a twofold process: Firstly, over 15 hours of video clips were edited down to produce a final 20-minute video in which we summarised the key findings and recommendations from the interviews. We also used the recorded interviews and notes taken to produce this 26-page, user friendly illustrated Case study summary document. When completed and agreed on by the authors and Msingi East Africa, the video and written case study document were publicised through the SARNISSA African Aquaculture and other networks and put-up open access online to a wider African and international audience.

3.3 Key Informants interviewed and their backgrounds.....

Within our initial selection and communications with key informants we were able to get over 90% reply and approval given for interviews from those we contacted. Two individuals, whilst replying to our requests, informed us they were unable to contribute specifically to the survey related to their companies or organisations for confidentiality reasons, however they supported the survey, and each said it was a positive move forward to inform and bring together the different stakeholder groups under what had been very challenging recent years.

Within 6 days at the end of October 2021 a total of 21 people were interviewed, the below Table 1 showing their locations and sectors in which they work:

Table 1: Breakdown of stakeholders interviewed including locations (n= 21)

3.4 Key findings from the survey

Region	Private		Government (n=5)	Research and Academia (n=3)
	Producers (n=10)	Other value chain incl Feed and Pharmaceuticals (n=3)		
Volta/Eastern (around lake)	5	3		
Greater Accra	1		4	
Ashanti/Eastern	4		1	3
Total	10	3	5	3
				21

3.4a: Onset of the disease problems, scale of the losses...

All of those interviewed from the private sector in Eastern and Volta Regions around Lake Volta i.e., cage and pond producers, hatcheries, feed suppliers and pharmaceutical companies were aware of the onset (starting in late 2015) and subsequent scale of mortalities and then financial losses across the industry. They were all also aware of the names of the key fish pathogens which had been identified from a range of the farm and hatchery sites on and around the lake. Certain of the producers at the time of the interviews (October 2021) had no fish in their cages and ponds and were still reeling from the losses they had borne previously. John Domozoro, a KNUST aquaculture graduate, and CEO of Pillbrook Aquatics (PBA):

“At our peak 2015 we produced 380 Metric Tonnes (MT) tilapia, (market value USD 836,000) from 16 X 6 metre diameter cages on the lake, employing 35 local people. In 2016-17 we suffered 70% mortalities from bacterial pathogens, first Streptococcus agalactiae 1b, then 1a in the following year. We lost ~15 MT in our cages over a 3-month period. Then December 2018 onwards we suffered worst losses of 40MT, this time from the ISKN virus and Streptococcus agalactiae confirmed by an overseas diagnostic laboratory. As of today (October 2021) all of our cages are empty, and we have only 5 remaining staff employed.”

Naga Murali, CEO of Fish and Feeds, an established hatchery and pond producer of both tilapia and shrimp located at Sogakope, reiterated before 2015 his site had experienced few aquatic animal health problems, mainly gill and ectoparasites i.e., *Trichodina sp.*, and secondary *Saprolegnia sp* infections. These were treatable and manageable and caused him no major issues. However, in 2015-16 the tilapia in his ponds (sharing pumped water from the river) were hit by *Streptococcus agalactiae* particularly in-between 30-100g sizes with up to 40% mortalities in his nursery ponds. Then in 2019 the ISKN virus was detected locally on a number of sites above and below the dam, with his losses in nursery ponds up to 50%. He noted a seasonal pattern of peak losses - September/October then again in March/April being the worst times. The story and experiences were similar from others we interviewed.

Prosper Gakpleazi, a cage and hatchery producer lost over 50% of his stock in cages in September 2019 and in his hapa based hatchery up to 90% loss of individual batches from swim up stages, this due to confirmed ISKN. Bright Agbo, 8 years manager at Lees Farms, a cage site below the dam at Atimpoku, said in the initial years of 2016-18 they experienced significant losses in cages of the mid-sized 30-100g fish due to *Streptococcus sp* however the onset of ISKN in 2019 was according to him far more severe, with losses up to 70% in both the fingerlings and also grow out cages.

Evans Danso of Flossel Farms, one of Ghana's largest tilapia producers, estimated:

"Ghana's national tilapia production dropped from 70,628 metric tonnes in 2018, to 45,760 metric tonnes in 2019 a 35% decline and overall loss of USD 55 million in just one year with large scale layoffs of staff and a number of cage enterprises and hatcheries around the lake going out of business, all as a result of the severe impacts from the diseases "

These findings were also backed up by other value chain actors we interviewed. Adolf MacCarthy, an agent for Raanan Feeds at Atimpoku, said his feed sales had experienced a steady decline from 2017 through to 2020, with him losing over 20 of his original customers who had gone out of business due to the troubles from diseases. He added he had only begun to notice an upturn in feed sales from his outlet in the last 6 months.

We also interviewed private sector mainly pond farmers in Ashanti and Eastern regions – away from the lake. They each expressed having had no major problems or losses from fish diseases up to the present day. Emmanuel Yeboah, an IT software specialist, established Total Solutions Fish Farms in 2014 at Konongo, Ashanti region with two earth pond/tank-based sites including hatchery growing tilapias and catfish:

"Whilst I personally have had no major losses to fish diseases or other causes, I'm aware of the cage farmers problems and losses due to diseases on the Volta Lake through the Ministry of Fisheries staff visiting me, but I'm not aware of the name or type of disease(s) that were involved. "

Mr Gyinaye Poku, a retired government Fisheries Officer, KNUST lecturer, and now with his own fish farm close to Bosumtui lake, Ashanti region, echoed the words of his Ashanti colleague, saying he had had few issues with fish diseases on his farm and hatchery over the last 10 years. But he was aware of issues on lake Volta and was concerned in more recent years as himself and a number of his Ashanti fish farming colleagues had been bringing in live fingerlings from hatcheries around the lake. He himself recently receiving brood tilapia (Volta strain) from the government ARDEC station at Akosombo. He went on to say he was not aware of any of his Ashanti region colleagues having any significant issues with fish diseases, but very much understood that intensification and commercialisation of any fish farming or livestock system will inevitably lead to fish disease problems.

3.4b Causes of the problems..... Importations of live fish from outside? Border agencies.. A working diagnostic laboratory ...?

We also visited and spoke to senior staff at the Department of Fisheries and government Veterinary Services in Accra including the recently set up Fish Health Unit who confirmed the above issues and timelines related to onset and severity of the fish disease problems.

Dr Peter Ziddah now retired, formerly of the government Veterinary Services and seconded to the Fisheries Commission confirmed it was likely that the onset of mortalities on/around the lake in 2015-16 -17 was due to two pathogenic strains of *Streptococcus agalactiae* (*1b* and then *1a*), and the subsequent detection of the ISKN virus in 2019 also causing severe mortalities, were both likely to have come from the illegal and unregulated importation of live tilapia for genetic improvement from outside Ghana, probably in his estimation Asia. He was unable to determine whether this was directly through air freight of live fish or through land transportation across borders from neighbouring countries, or a combination of both. But went on to say this was one of the reasons why in July 2018 the Ministry had imposed a ban of any live (or dead) fish importations of tilapia or ornamental fish coming into the country from outside.

The Director of Fisheries, Matthew Oyih, made the point that not just in Ghana but elsewhere around the world as the tilapia (or any other livestock production systems) sector intensifies, this had inevitably put environmental and other pressures including stress on farmed fish stocks as the sector year on year increased its production also its stocking densities and loadings of fish feeds into the lake. As a consequence of unregulated outside introductions of live tilapia into the lake and surrounding water catchments alongside intensification from 2015-16 onwards, this he said had resulted in significant fish health fish disease issues. He mentioned specifically that the ministry did not recommend the unregulated importation of live GIFT or other outside strains of *O. niloticus* into the country, not just for disease related issues, but also for the implications for biodiversity related to the country's existing indigenous strains of *Oreochromis niloticus* in Ghana's waterways including the lake. It should

be said that we heard some contrary views to the above. Naga Murali (Fish and Feeds) told us that the existing regulations didn't allow the importation of live fish into the country, however both the *Streptococcus sp* and then ISKN virus (2018-19) still managed to enter into Ghana, more specifically the Lake Volta water catchment, through illegal introductions of live fish from outside. He added that.... when you don't allow people to access faster growing, potentially more disease resistant strains of *niloticus* from outside they will end up finding their own ways of doing so without government permission and thereby compromising the national biosecurity and quarantine of the country. He went on to say:

"I would like to appeal to other African countries... please don't stop the growth of the industry by saying you want to secure the biosecurity of your own indigenous species... If you make the importation of new strains legal and implement with proper, well-designed, well-run quarantine in place, then the pathogens will not be smuggled into the country in the first place..... Human beings are more important than fish ..."

Whilst we did find these contrasting views Dr Mary Nkansah, the Acting Head of the Fish Health Unit explained:

"Aside from any bans If you are introducing an aquatic animal from outside of Ghana, you have to go through the official protocols. There are check lists..... When you are importing (or exporting) any live or dead aquatic animal..... we have to be in the know. We then look through the documentation to see whether it comes from a place that has any OIE (Office International des Epizooties) listed or other fish diseases of economic importance. We study all of these before we approve for any aquatic animal to be brought into the country..."

She went on to say that the Ministry acted further in 2019 by bringing out a ban on any movements of live fish from Volta and Eastern regions bordering the lake and river below the dam to other areas in Ghana away from the lake.

Dr Ziddah remembered back in 2015-16 at the onset of the disease problems, there were only two trained government specialist fish health persons who had the responsibility for running the whole country. Moving forward he went on to say that Ghana's border control and immigration needed to improve:

"The problem we have is we don't have very good border controls for the importation of live fish We need to better advise and equip our border control and immigration colleagues to insist on only allowing entry of live aquatic animals on the production and showing of the correct veterinary permits for importation of live fish into Ghana"

3.4c Biosecurity and diagnostic laboratory issues.....

Evans Omari of Friends and Family Fish Farm nr Nkawkaw, Eastern region some 60 km from the lake, built his farm and hatchery close to the source of a 12 month a year flowing spring with his site receiving all of its water by gravity with no other farms or other activities above him. He also had not suffered from any major disease problem and told us he is well aware of the issues on the lake and also treats the biosecurity status of his farm seriously. The site is fenced, with entry only by prior appointment, with foot dips on entry to the compound, they do not bring in any live (or dead) fish from outside the farm. He is now in the process of building a commercial monosex hatchery on site and is very aware of the importance of keeping this and his broodstock bio secure and disease free, as he realises the competitive advantage his fingerlings will have in future years.

On the subject of biosecurity at farm and intra farm levels, Sandy Chatham a fish vaccination expert working for a French pharmaceutical company in Ghana told us:

“Now there is a nationwide focus on trying to improve biosecurity within the industry with it being at grass roots level in the past.... In 2018 when I was first here biosecurity didn’t exist, a footbath or hand washing station was as good as it got Good to see recently the topic coming up more on online fora and webinars... I feel most people don’t understand the scope and importance of biosecurity in Ghana, particularly with transportation of live fish. There’s a lot of room for improvement....”

During our interviews the subject of a fish disease diagnostic laboratory came up a number of times. Mary Nkansah (Fish Health Unit) said they (the government) had 4 laboratories, of which only one was partially operating. She added there was an urgent need for these to be upgraded. Whilst from the private sector we heard concerns from several producers. John Domozoro (PBA) explained that when disease and mortalities were rampant on his site, he had to go to an outside diagnostics company to get his samples looked at. He said this was expensive, and not affordable for the average fish farmer – perhaps only for the top 1% of tilapia farming companies in the country. In the end he added for most fish farmers..... they are essentially trying to fish farm in the dark.....

This was echoed by Evans Danso (Flossel Farms):

“The cost of setting up and running a proper operational diagnostic lab in Ghana which can be accessed and affordable to the majority of Ghanaian fish farmers is just peanuts compared to how much the industry has lost to fish diseases in the last 4-5 years.... ”

Whilst Professor Daniel Adjei Boateng, at KNUST told us that it was high time in Ghana capacity is built in fish health – a critical mass of professionals with expertise in fish diseases alongside basic diagnostics at farm level. He added that the country urgently needed a

working operational diagnostic laboratory in the Akosombo aquaculture zone that can be deployed on farms where they report diseases and mortalities.

From Naga Murali's view:

“Without having a disease diagnostic centre aquaculture cannot advance as a commercial industry in Ghana..... “

3.4d By 2020 – present: The situation on the ground. Expanding the Fish Health Unit, treatments, vaccination, insurance and finance, research and information transfer

In 2019-2020 Dr Ziddah explained that the capacity of the Fish Health Unit was boosted with the arrival of 4 young fish health veterinarians who were designated to cover four key regions including the lake for all aquatic animal health issues. Alongside this in early 2020 the Fish Health Unit carried out (free) vaccinations on a number of hatchery and cage grow out sites around the lake and in southern Ghana. This was using an ISKN vaccine which originated from Singapore.



Figure 8: 2020: Ministry of Fisheries Government begin vaccination programme using ISKN vaccine from Singapore (courtesy of Modern Ghana media <https://www.modernghana.com/news/976725/ministry-of-fisheries-undertakes-immunisation-of.html>)

Whilst for the private sector those remaining were already reacting to what had been happening. Bright Agbo (Lee's farm) told us in the last 12 months they were vaccinating fingerlings (15-30g) prior to stocking in the cages using a *Streptococcus sp* vaccine. They also

were using heat shock treatment in the early fingerling stages 0.5-2g and finding this dual approach was reducing their subsequent losses in the cages to more manageable levels, from 70% down to 40% - 30% mortalities in recent months. Whilst other commercial farmers like Naga Murali (Fish and Feeds) were not vaccinating due to in his view the cost. He rather routinely was using a range of probiotics and oligosaccharides, up to 2.5MT per year (both in feed and pond water) particularly in the nursery stages. He said already this had reduced losses in his nursery ponds to below 20%. Naga has also set up a rudimentary on-farm laboratory where he can monitor routine parasitology and water quality. We also found some of the farmers we spoke to using antibiotics (oxytetracycline, fluorphenicol) mainly as prophylactic in feed treatments with 2-15 g fingerlings prior to their transfer from nursery ponds into cages. Whilst others were using plant/herbal extracts, neem being a common one. We spoke to KNUST post graduate PhD student Isaac Osei Kusi who was looking into the potential beneficial effects on the immune system of tilapia of 8 different in-feed plant extracts with a previous history of use in livestock medicine. He was challenging his treatment and control fish with *Streptococcus agalactiae* with his results being available on the publication of his thesis.

What's your biggest worry at work?

Like every farmer on the lake, the last few years have been more than challenging. First there was the ISKN virus outbreak, which caused mortalities of about 80 percent on most farms. I was able to limit my mortalities to under 60 percent through the use of a neem extract treatment which I developed myself. And when we started to recover from ISKN, Covid-19 broke out. We are now coming out of those challenges. But as a regular farmer on the lake I get anxious when there are very heavy rains, which affect the water levels on the cages and expose the fish to health challenges.



ISKN and Covid-19 have made business tough for Enoch and his fellow tilapia producers around Lake Volta, but prices for their fish have increased

Figure 9: Ghanaian fish farmers speak out about effects of ISKN on their business and coming out of the challenges (courtesy of the Fish Site)

We also spoke to the two leading feed producers/suppliers in Ghana who since the onset of the disease problems had been offering a range of related services to their customers. Jacques Magnee of Raanan feeds explained how they had been running a series of fish health trainings for their customers and also had brought in a specialist fish diseases veterinarian from France to provide information, advice and some diagnostics on the specific diseases. Whilst Anais Legendre of Cycle Farms (commercial fish feed manufacturer) explained they were working with Virbac, a French pharmaceutical company, to support their customers with fish health and biosecurity advice also a level of diagnostics. Sandy Chatham working for Virbac in Ghana since 2018 has also been involved in vaccination programmes (for *Streptococcus sp*) for fish farmers, and interestingly by late 2021 has built up a specialised Ghanaian team of mainly female vaccinators who now can safely vaccinate thousands of fish per hour. Each of the above are examples of private sector extension and services in fish disease and fish health which are now developing in Ghana.



Figure 10: Vaccination on commercial tilapia farm in Ghana 2018 (Courtesy of Adrian Astier)

Aside from farm level, the CEO of the Ghana Chamber of Aquaculture Jacob Adzika told us his organisation provided technical and also legal services for its members. In the last 2 years the Chamber had also run a series of Ghana based online webinars and seminars on fish health often bringing in outside experts to share their knowledge on biosecurity issues, the key fish pathogens, and importance of minimising stress on farms by looking far more carefully into day-to-day farm management operations. Jacob also informed us of how the Chamber were now getting involved in setting up insurance for their members:

“The Ghana Chamber of Aquaculture in partnership with Ghana Agricultural Insurance Group have in July 2021 begun piloting an aquaculture insurance scheme for fish farmers. This covers aquaculture production, biomass of stocks, and associated facilities, as well as other specified normally unforeseen risks. For some of our members who applied for loans from traditional banks, it is interesting to see the banks now demanding the loans are covered with such insurance policies.”

There were also requests from the private sector for relevant research and information on fish diseases and biosecurity to be made available to the industry in a far more user-friendly format that they could understand and potentially use for their benefit. John Domozoro (PBA and KNUST alumni):

“We are beginning to work on tailoring the outputs from research institutions in Ghana to be much more applicable to the farmer..... including the publications and papers they produce being much more user friendly.....”

Professor Dr Daniel Adjei Boateng from KNUST also recognised this saying that there was a dichotomy of their research being too academic and not in a language or form that can be appreciated and used by the industry. KNUST, he said, are now increasingly using social media and online webinars/seminars where this academic speak is broken down to a language simpler and easier to understand. Whilst he added it was now standard as part of their BSc MSc and even PhD programmes that the students spent time on working internships at some of the country’s top commercial farms.

Our interviews concluded by Saturday 30th October 2021.

4.0 Conclusions and Observations

By the nature of such a case study based on an interview survey of a range of stakeholders as described, in terms of conclusions, it is perhaps the different words, views and experiences of the individuals we spoke to which the reader should most draw their own conclusions from. And hence why we do not want to make this section our own long and comprehensive view and analysis of what we found. Through the methodology we used including key informant selection and then format of interviews we tried to bring out what had happened in Ghana from 2015 onwards in the recollections and views of different people, each involved in their own ways. Then leading on to how they saw the future and perhaps also the lessons learnt for Ghana and other countries in terms of aquatic animal health, development of commercial aquaculture, and the socio-economic and environmental consequences which came from it.

Some of the key issues to highlight would be:

To understand fully the situation in country before 2015-2016 and then very clearly why what happened then followed. It appears that what were reported as initial illegal and unmonitored introduction(s) of live fish (tilapia) into the country (2015-16) for reasons of genetic improvement (faster growing, larger final biomass), were the vehicle(s) for bringing in firstly *Streptococcus agalactiae a and b* then the ISKN virus probably as stated by the government veterinarian above from Asia. These then each and together caused, on at the time the thriving developing cage culture industry on and below lake Volta, to suffer financially crippling losses in both the hatchery and growout sectors, the scale of which is well documented in the words of those we interviewed who experienced it at first hand. However, it should be added that other factors were also in different ways also responsible or at least part of the reason why this happened. Our government veterinary interviewee highlighted the importance and also need to better resource and improve the country's border and customs infrastructure and staff, both at land and airport entry points including the insistence of correct veterinary documents and also operational quarantine facilities for any new introductions. This important area and capacity within a country is often not addressed or highlighted within aquaculture policy discussions and actions since it is a totally separate government department from Fisheries and Aquaculture and also Veterinary departments. In terms of resources and staffing levels it is good to see the government Fish Health Unit now has recruited 4 further young and developing fish health veterinarians beginning to provide a more regional coverage in fish health monitoring, regulation and support. This perhaps further emphasizes for both Ghana and other countries, that in order for government to effectively regulate and control fish diseases within an increasingly commercialising sector, this requires both staff coverage and expertise on the ground, across waters and within borders. The budgetary implications of this should be clearly understood.

Another relevant factor: Between 2010-2015 the commercial cage sector had been growing rapidly across and below the lake, and in the words of those we interviewed in the Ministries.... largely non permitted and non-regulated due to significant budgetary and manpower constraints they were experiencing at the time. The outcome of this, even pre 2015 and the onset of the first large scale mortalities on the lake, was cages being installed and then stocked all over the lake and river below with little thought for environmental

sustainability, carrying capacity of the water, and inevitably risk of disease transmission between sites and farms. This lack of a workable operational site and fish farm business registration system inevitably led to problems. It is hoped that lessons learnt for the future will not just recognise this, but also act on it. Without this cornerstone in place future development of a sustainable aquaculture sector in Ghana or anywhere else not just for fish health but also other issues will remain problematic.

Another key theme coming out of the interviews from all stakeholder groups was the lack of an operational fish diseases laboratory. As one of our private sector interviewees quite lucidly put it “It is like we are still fish farming in the dark.... “. Again, across the interviewees there were many views and even recommendations for the future, on how such a lab or labs should be set up, who should run them, location(s), different models etc. The consensus was that such a lab should be accessible and affordable to all levels of fish farmers, and also it was critically important that the staff involved firstly designing and then running it should be fully trained to provide the best service. As one other put it ... “We can’t have a sustainable developing aquaculture industry in Ghana without one.... “

The importance of and previous lack of biosecurity both at farm and intra-farm level was also repeatedly brought up. Whilst for some interviewed, they related in 2017-18 it was virtually non-existent on most sites on and around the lake. Also, it is pertinent to mention the differences operationally and in context, between biosecurity on a cage site in large body of water as lake Volta, compared to for a land-based hatchery site or pond based grow out site. Whilst there are some common factors, they are also some profound differences particularly when or if it is assumed that certain fish pathogens become endemic within a large lake or water body. As one private sector service provider noted he felt that the risks of live fish transportation between farms was largely underestimated and misunderstood. This was also echoed by two of the private sector pond-based farmers we spoke to in Ashanti region who expressed their concerns about the large proportion of tilapia fingerlings which were transported from hatcheries on lake Volta for pond fish farmers further afield. On a positive note, raising awareness of biosecurity and training on fish health issues has in recent years been taken on by a range in the private sector including feed companies and national fish farmers organisations thereby illustrating the growing importance of private sector extension across the country.

Finally, to mention that by October 2021, whilst the industry had suffered terrible losses, many had gone out of business, those remaining were now beginning to get back on their feet again with mortality rates in hatchery and grow out now beginning to decline. Different management and other strategies were being put in place by producers on and around the lake, and as one said to ... learn to live with the disease including vaccination, heat shock, private sector farm insurance linked to loans etc. There was also the recognition amongst universities and researchers they had an obligation and a role to make their fish health research more demand driven for the industry, as well far more understandable and in user friendly formats so that fish farmers could both put into use and also benefit from.

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