

# Cefas: preparing for, investigating and controlling Aquatic Animal Disease Emergencies

David W. Verner-Jeffreys

Moving Forward through Lessons Learned on Response Actions to Aquatic Animal Disease Emergencies  
16–18 December 2019, FAO Headquarters, Rome, Italy



Centre for Environment  
Fisheries & Aquaculture  
Science



Aquatic Animal Health



OIE Collaborating Centre for  
Emerging Aquatic Animal Diseases



Cefas

# Role/mandate & structures for dealing with MME

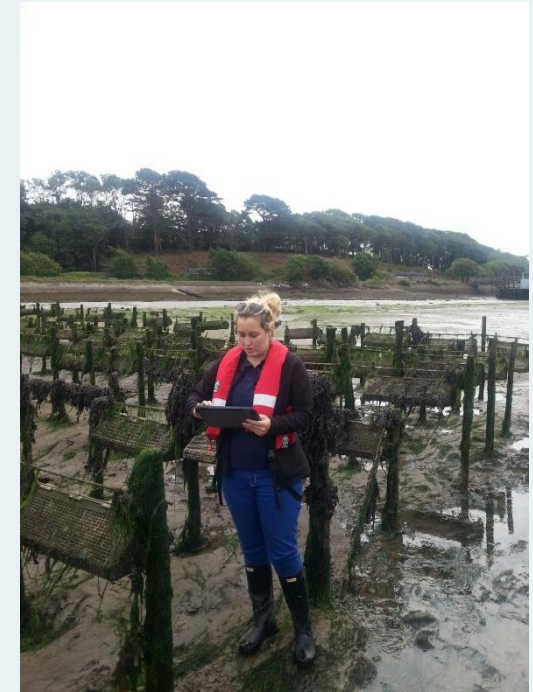
- Cefas: Centre for Environment Fisheries and Aquaculture Sciences. Executive Agency of UK's Department for Environment Food and Rural Affairs
- National: Cefas Weymouth laboratory: Fish Health Inspectorate (FHI)
- International: OIE Collaborating Centre for Emerging Aquatic Diseases





# Aquatic Animal Health: Official Services: Fish Health Inspectorates

- The Fish Health Inspectorates are the official service for the control of serious (listed) diseases of fish and shellfish in the UK.
- Listed diseases are generally untreatable, and are likely to have a significant economic impact on aquaculture, and/or wild fish populations.
- The Inspectorates are also responsible for the control of new and emerging diseases.
- The Cefas FHI covers England and Wales; Marine Scotland Science FHI covers Scotland and DAERA FHI covers Northern Ireland



# Main Aims

To prevent the introduction and spread of serious fish and shellfish disease through:



Risk based  
Surveillance

Compliance  
inspections  
and advice

Trade  
controls

Responding  
to disease  
outbreaks

Contingenc  
y  
(emergency)  
plans



# Disease controls

- Disease controls through statutory means
  - Movement controls on infected areas; cull and eradication; containment
- Contingency plans for serious disease outbreaks
  - Covers management of outbreak
  - Upscaling diagnostics if required
  - Disease controls and exit strategy
  - Communications across government and with stakeholders
- Multi-agency approach to assist FHI in application of control measures if required





**Cefas**

INTERNATIONAL  
CENTRES OF  
EXCELLENCE



International Centre of  
Excellence for Aquatic  
Animal Health

Incorporating a designation  
as an OIE Collaborating  
Centre and OIE Reference  
Laboratories



International Centre of  
Excellence for Seafood Safety  
Incorporating an application to  
the FAO as a Reference Centre  
for Bivalve Sanitation

**‘A world-leading national capability’**

Safe and sustainable seafood

Builds upon EURL statuses

New global designations pending

Cross-cutting :e.g. FAO Reference  
Centre for AMR (UK)\*

Global leadership in expanding sector

<https://cefas.cefas.co.uk/centres-of-excellence/>

**\*with APHA and VMD**



Centre for Environment  
Fisheries & Aquaculture  
Science



**Cefas**





# OIE Collaborating Centre for Emerging Aquatic Animal Disease

Centres of Excellence > Aquatic Animal Health > Designation > OIE Collaborating Centre for Emerging Aquatic Animal Disease

The emergence of disease in farmed and wild aquatic animals poses one of the most significant threats to sustainable food production and to the stability of natural systems. Rapid detection, characterization and reporting of the causative agents of disease provide a crucial first step in their control. For this reason, efficient and accurate reporting of emergent disease threats forms the central precept of this OIE Collaborating Centre. By working with our partners in aquatic animal health from across the globe, often in countries where aquaculture forms an increasingly critical component of food production and trade, we are focused on mitigating the yield-limiting effects of emergent diseases, improving the reporting of new threats and ultimately reducing their transboundary spread via trade and other pathways. In doing so, we aim to function as a global resource for research, diagnostics, standardization of techniques and dissemination of knowledge in the field of aquatic animal health.

International Database on Aquatic Animal Diseases



Prof Stephen W Feist

(Head of OIE Collaborating Centre:  
Emerging Aquatic Animal Diseases)

Contact Details:

[stephen.feist@cefasc.co.uk](mailto:stephen.feist@cefasc.co.uk)



# Sector leads

**Sampling and submission**

Centres of Excellence > Aquatic Animal Health > Designation > OIE Collaborating Centre for Emerging Aquatic Animal Disease > Sampling and submission

**Sample Submission**

If you would like to send samples to us, then please contact the relevant theme leads (below) who will request further details. Once the work has been discussed and agreed they will advise on the sampling protocols, permits and packaging requirements, prior to shipment.

Crustacean materials: [kelly.bate-man@cefascas.co.uk](mailto:kelly.bate-man@cefascas.co.uk)  
 Fish materials: [richard.paley@cefascas.co.uk](mailto:richard.paley@cefascas.co.uk)  
 Molluscan materials: [frederico.batista@cefascas.co.uk](mailto:frederico.batista@cefascas.co.uk)

**Sampling**

Sampling protocols are available upon request, please contact the relevant theme leads:

Crustacean materials: [kelly.bate-man@cefascas.co.uk](mailto:kelly.bate-man@cefascas.co.uk)  
 Fish materials: [richard.paley@cefascas.co.uk](mailto:richard.paley@cefascas.co.uk)  
 Molluscan materials: [frederico.batista@cefascas.co.uk](mailto:frederico.batista@cefascas.co.uk)

**Responsibility to Report to Competent Authority**

The OIE Collaborating Centre for Emerging Aquatic Animal Disease requires each sample submission to be reported to the relevant Competent Authority within the country of origin prior to shipment of materials. Should we find a notifiable disease within submitted samples we will request that this is reported to the OIE via the Competent Authority of the country of origin.

**Import Permits**

Samples may require an import permit from the Animal and Plant Health Authority (APHA); these must be applied for prior to shipment of any materials to the UK. Staff at the OIE Collaborating Centre for Emerging Aquatic Animal Disease will advise and assist with all applications.

**Nagoya Protocol**

The UK is a ratified party to the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization. In order to comply with this protocol the OIE Collaborating Centre for Emerging Aquatic Animal Disease requires that all sample submissions are reported to the relevant ABS Focal Point prior to shipment of materials. Should there be a requirement to provide a Material Transfer Agreement (MTA) or any other related documents please contact the relevant theme leads.

**Packaging and Shipment**

All samples must be packaged to comply with the transport of infectious substances, UN3271, Biological Substances, Category B. Further advice on packaging and shipment is available upon request, please contact the relevant theme leads.

Example of Packing and Marking for UN3271, Category B Infectious Substances (recreated from royalmail.com)

**Crustacean**

Centres of Excellence > Aquatic Animal Health > Designation > OIE Collaborating Centre for Emerging Aquatic Animal Disease > Crustacean

**Crustacean Health**

Dr Kelly Bate-Man is leading the work of the Crustacean Health Theme within the OIE Collaborating Centre for Emerging Aquatic Animal Disease and the International Centre of Excellence for Aquatic Animal Health at Cefas. She has over 20 years' experience in the diagnosis of disease in experimental, farmed and wild aquatic animals, with a particular interest in the identification and characterisation of novel and emerging pathogens of crustaceans. Kelly was the coordinator of the European Union Reference Laboratory (EURL) for Crustacean Diseases between 2008 and 2018, leading a network of laboratories across the European Union in maintenance and improvement of diagnostic testing for diseases listed in European legislation (e.g. White Spot Syndrome Virus). This was achieved through the organisation and assessment of proficiency testing and training programmes. Kelly has a special interest in the diagnosis and taxonomy of invertebrate viruses and is currently developing techniques to enhance the classification of these non-culturable viruses using pathology, transmission electron microscopy and next generation sequencing approaches. She is experienced in design and execution of field sampling programmes and in carrying out detailed experimental tank trials within the World class biosecure facilities at Cefas. In many cases, these trials have involved pathogens which are exotic to Europe and have been conducted on a wide range of host taxa. Kelly is a Trustee of the Society for Invertebrate Pathology and an Associate Editor for the society journal, the Journal of Invertebrate Pathology. She is an author on over 50 peer-reviewed publications in the field of aquatic animal health.

Contact Kelly for issues relating to crustacean health: [kelly.bate-man@cefascas.co.uk](mailto:kelly.bate-man@cefascas.co.uk)

**Fish**

Centres of Excellence > Aquatic Animal Health > Designation > OIE Collaborating Centre for Emerging Aquatic Animal Disease > Fish

**Fish Health**

Dr Richard Paley is leading the work of the Fish Health Theme within the OIE Collaborating Centre for Emerging Aquatic Animal Disease and the International Centre of Excellence for Aquatic Animal Health at Cefas. Richard is an experienced virologist and molecular biologist and is involved in all aspects of fish disease research and diagnostics - from the discovery and characterisation of new and emerging diseases through the development and implementation of diagnostic methods in an accredited environment, to research on pathogenesis of and resistance to viral diseases. He specialises in fish virology and works closely with government and industry on the diagnosis and control of viral infections in fish aquaculture. Since 2006 he has represented the UK as the national expert at the annual National Reference Laboratory meetings on fish diseases within the EU. He has been laboratory manager for UKAS and GLP/NDP accredited services. Richard leads a team of microbiologists in the Cefas Weymouth Laboratory and has managed or been a significant partner in numerous Government, UK RI and EU funded research projects and project manager or principle investigator for various commercial contracts developing aquatic animal health products including vaccines and selective breeding for disease resistance in fish and molluscs. Key to his work are the bio-secure tank facilities in the Weymouth lab which the team use for disease challenges in aquatic animals. Richard has over 20 peer reviewed publications on all aspects of fish disease.

Contact Richard for issues relating to fish health: [richard.paley@cefascas.co.uk](mailto:richard.paley@cefascas.co.uk)

**Mollusc**

Centres of Excellence > Aquatic Animal Health > Designation > OIE Collaborating Centre for Emerging Aquatic Animal Disease > Mollusc

**Molluscan Health**

Dr Frederico Batista is leading the work of the Molluscan Health Theme within the OIE Collaborating Centre for Emerging Aquatic Animal Disease and the International Centre of Excellence for Aquatic Animal Health at Cefas. He has over 15 years' experience in the diagnosis of molluscan diseases, with a particular interest in the identification and characterisation of novel and emerging pathogens of bivalves (e.g. oyster herpesvirus 1) using histopathology and molecular biology tools. Frederico has a special interest in viral diseases of mollusc and One Health approach. He was a member of the Portuguese National Reference Laboratory (NRL) for Molluscan Diseases between 2009 and 2014. More recently, he worked at the European Union Reference Laboratory for monitoring bacteriological and viral contamination of bivalve molluscs as well as in the UK NRL for foodborne viruses. Frederico has over 30 peer reviewed publications on aspects of diseases (e.g. marshalliosis, bonamiosis, perkinsiosis, vibriosis and viral infections), immunology, physiology and aquaculture of bivalve molluscs and other invertebrates.

Contact Frederico for issues relating to molluscan health: [frederico.batista@cefascas.co.uk](mailto:frederico.batista@cefascas.co.uk)



**Cefas**

International Database on Aquatic Animal Diseases

International Database on Aquatic Animal Diseases

This database is for those needing to access the OIE (World Organisation for Animal Health) published data on the occurrence of the OIE-listed aquatic animal diseases in all member countries and/or additional data in the published scientific literature.

The data is grouped in the following ways:

- OIE data
- non-OIE data
- all data.



<https://www.cefascas.co.uk/centres-of-excellence/aquatic-animal-health/designation/oie-collaborating-centre-for-emerging-aquatic-animal-disease/>



# Ghana Tilapia MME: Historical disease context

- Typically low production losses (<2% per month; 10-25% over grow-out cycle)
- Late 2015 rapid onset of increased mortality (40-70% over grow-out cycle)
- Associated with *Streptococcus agalactiae* MLST 261 (Verner-Jeffreys *et al.*, 2018)
- Autogenous vaccination introduced (Ridgeway Biologicals)
- Production sustained by use of antibiotics, autogenous vaccination and over production (Jansen *et al.*, 2018)
- Until...

Received: 19 April 2017 | Revised: 31 May 2017 | Accepted: 6 June 2017  
DOI: 10.1111/jfd.12681

SHORT COMMUNICATION

WILEY  Journal of Fish Diseases

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

D W Verner-Jeffreys<sup>1</sup> | T J Wallis<sup>2</sup> | I Cano Cejas<sup>1</sup> | D Ryder<sup>1</sup> | D J Haydon<sup>2</sup> | J F Domazoro<sup>3,4</sup> | J Dontwi<sup>5,6</sup> | T R Field<sup>2</sup> | D Adjei-Boteng<sup>4</sup> | G Wood<sup>1</sup> | T Bean<sup>1</sup> | S W Feist<sup>1</sup>

Report 17 - 2018

Investigation of tilapia mortality in Ghana



Veterinärinstitutet  
Vetinstutet  
Vetinstutet



# Fears over mass tilapia mortality incident

POST-HARVEST HEALTH

by Efuwa Konyim Okai  
23 October 2018, at 7:00am

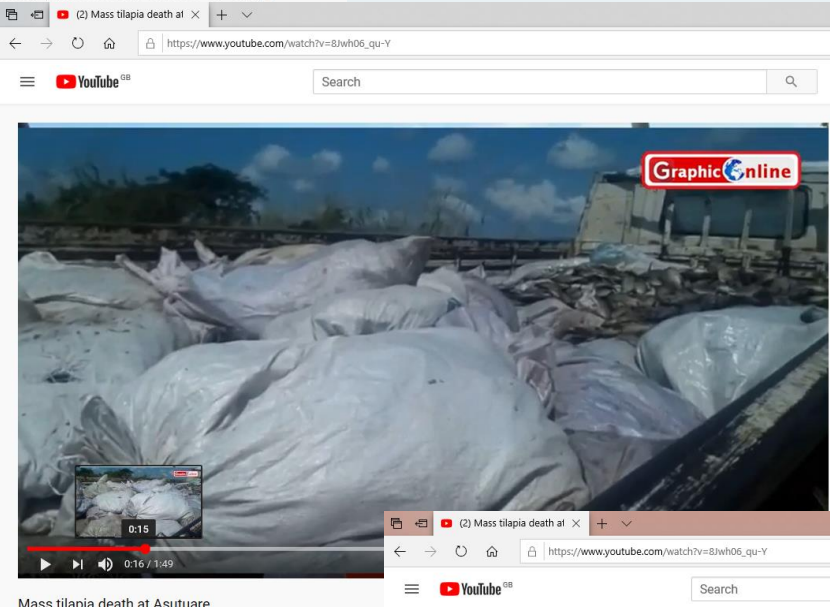
Tilapia farming was a hot topic in Ghana last week after photos and videos of large numbers of dead tilapia at the Asutsuare farm of a viral on social media.



Carl Fiati, a Director of Ghana's EPA received a report from Fujian which, they believed, was the result of factories in the Asutsuare Area amounted to 40 tonnes.

Acting on this report, the EPA placed a ban on products of Fujian, supervised the destruction of the dead fish and took samples of the fish and water. The Ministry of Fisheries and Aquaculture, the Aquaculture Research and Development Centre (ARDEC) also took samples. Apart from tests in local laboratories, some of the samples were taken to

## Sept/Oct 2018



# Asutsuare tilapia deaths not from poisoning — EPA

Date: Oct 22, 2018, 08:00 BY: Severious Kale-Dery & Domic Moses Awiah

Category: General News



Mr Carl Fiati, Director of Natural Resources, Environmental Protection Agency (EPA)

115 Shares [Share](#) [Tweet](#) [WhatsApp](#) [Email](#) [Print](#)

The Environmental Protection Agency (EPA) has ruled out the possibility that the fish kill at the Asutsuare in the Shai Osudoku District was due to poisoning.

In an interview in Accra last Saturday, the EPA, Mr Carl Fiati, said: "I can tell you that the allegation of poison is very remote."





# Epidemic

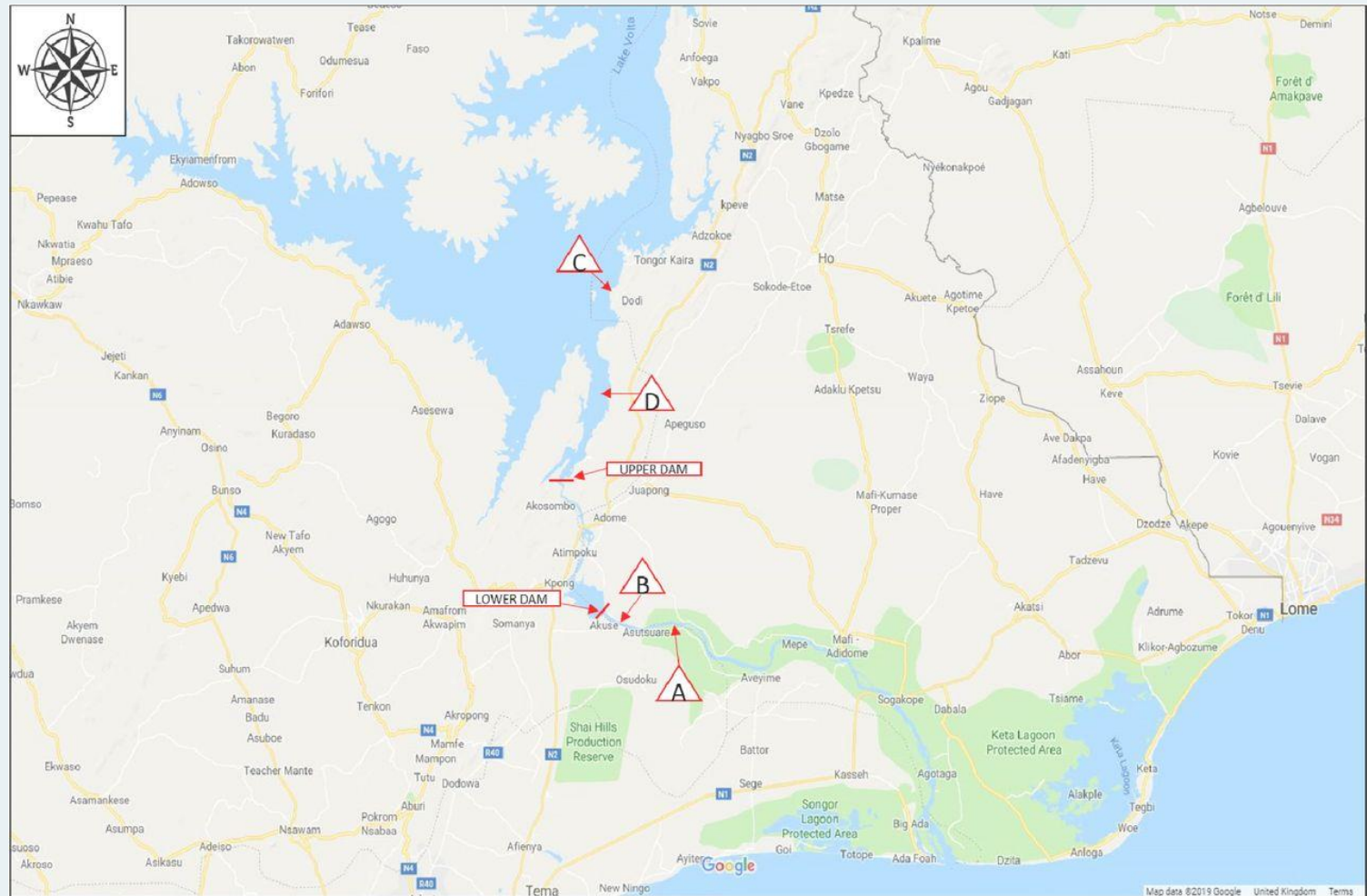
Sept - Nov 2018

Large scale acute mortality events (60-90%, 100 tonnes)

Grow out cages – vaccinated and unvaccinated

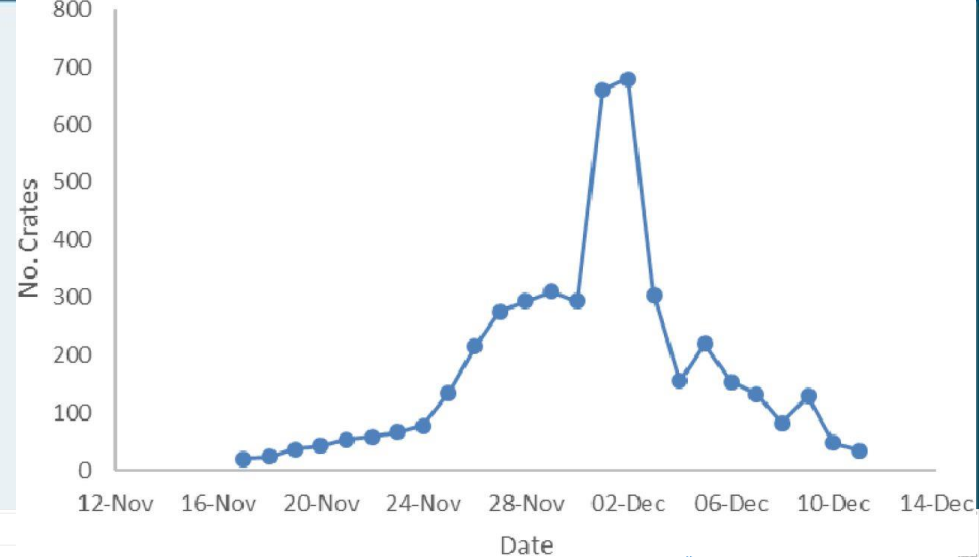
Feb 2019 - fry mortalities

March 2019 most farms in the Volta region experiencing increased mortalities not able to sustain by overproduction

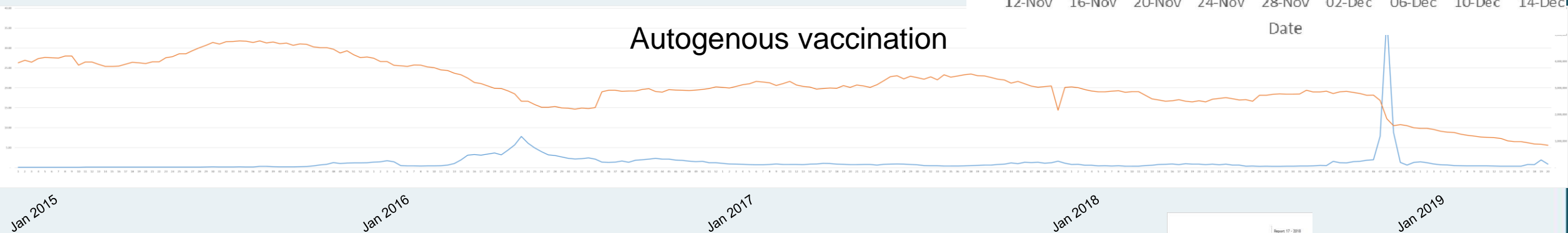




# Epidemic



## Autogenous vaccination



Received: 19 April 2017 | Revised: 21 May 2017 | Accepted: 6 June 2017  
DOI: 10.1111/jfd.12688

**SHORT COMMUNICATION** WILEY *Journal of Fish Diseases*

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

D W Verner-Jeffreys<sup>1</sup> | T J Wallis<sup>2</sup> | I Cano Cejas<sup>1</sup> | D Ryder<sup>1</sup> | D J Haydon<sup>2</sup> | J F Domazoro<sup>3,4</sup> | J Dontwi<sup>5,6</sup> | T R Field<sup>2</sup> | D Adjei-Boteng<sup>4</sup> | G Wood<sup>1</sup> | T Bean<sup>1</sup> | S W Feist<sup>1</sup>

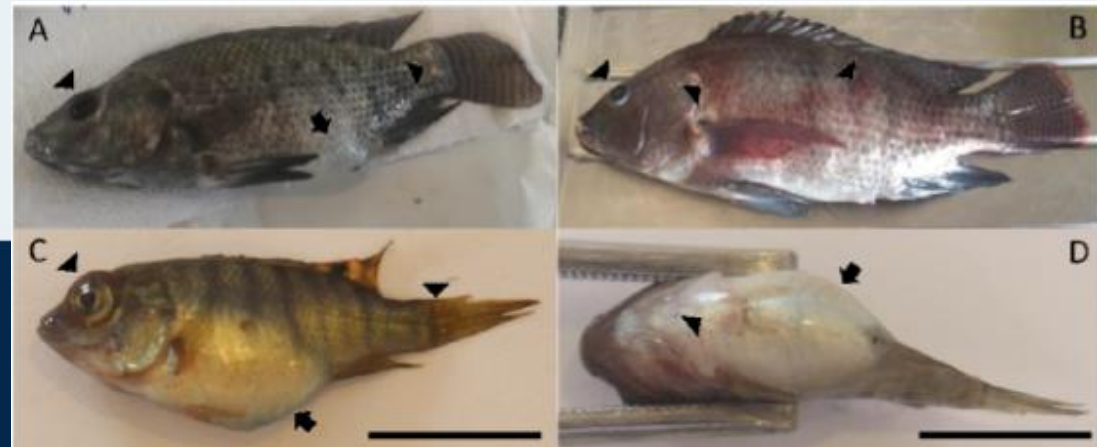
Report 17 - 2018

Investigation of tilapia mortality in Ghana

Wentworth Institute of Technology

# Gross clinical signs

- Abnormal swimming
- Anorexia, enophthalmia
- Skin haemorrhaging
- Abdominal distension
- Pale gills
- (Bloody) Ascites
- Enlarged and haemorrhagic organs – particularly liver and kidney



# Initial diagnostics

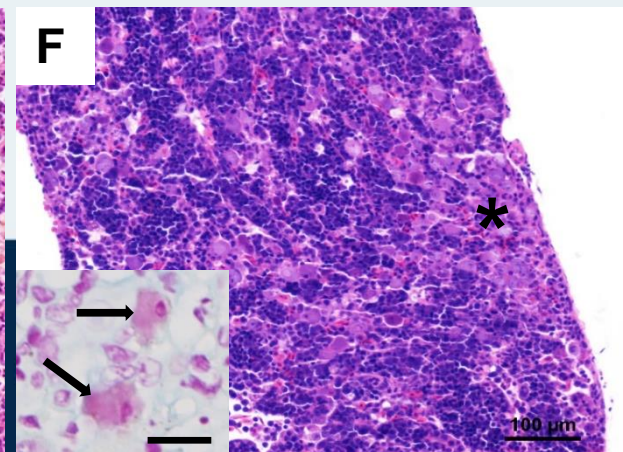
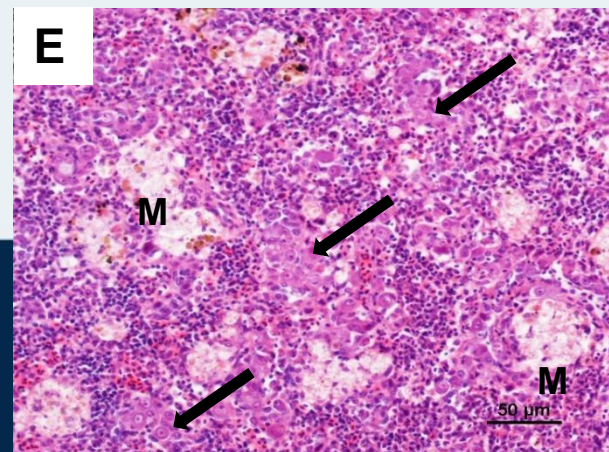
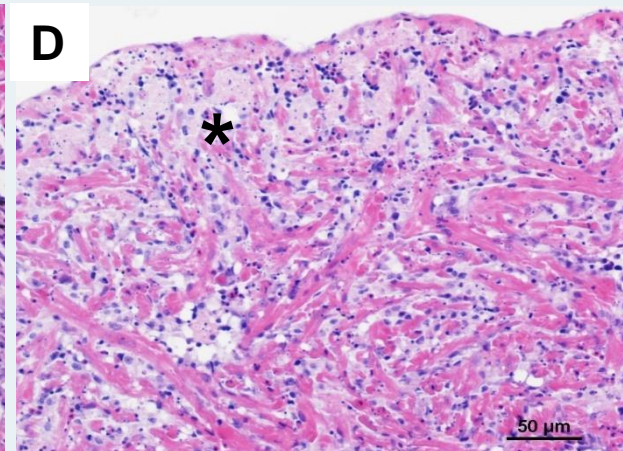
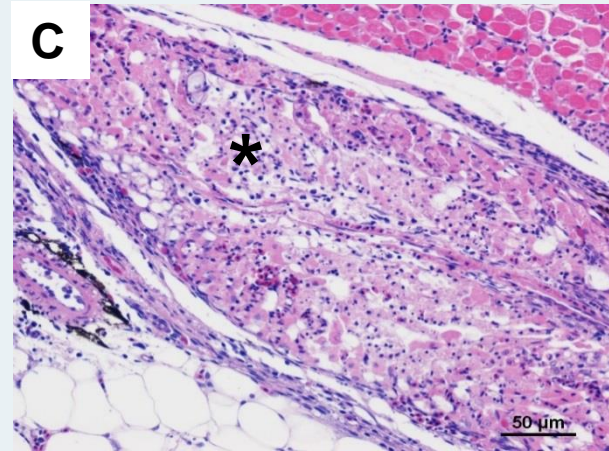
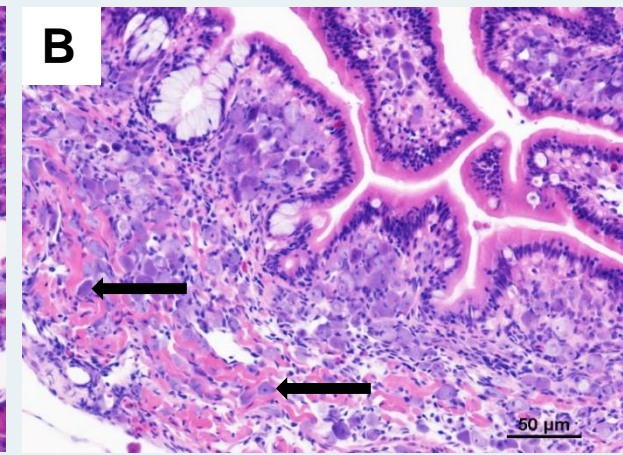
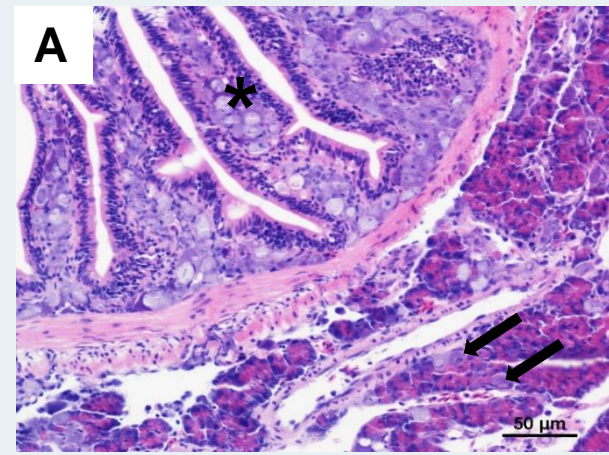
- Bacterial flora relatively normal – low level *Streptococcus* and *Aeromonas* positive, occasional bacteraemia
- Nodavirus and TiLV negative by qPCR



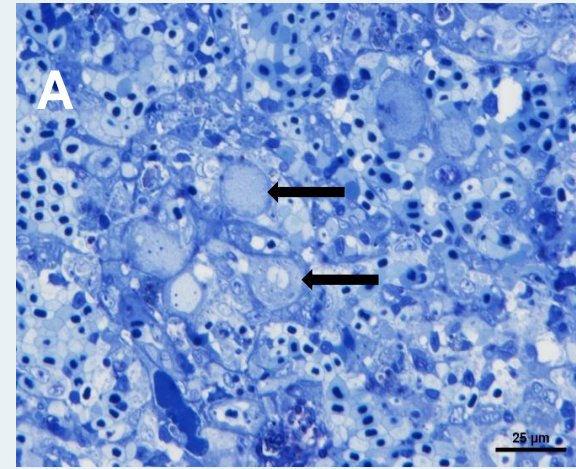
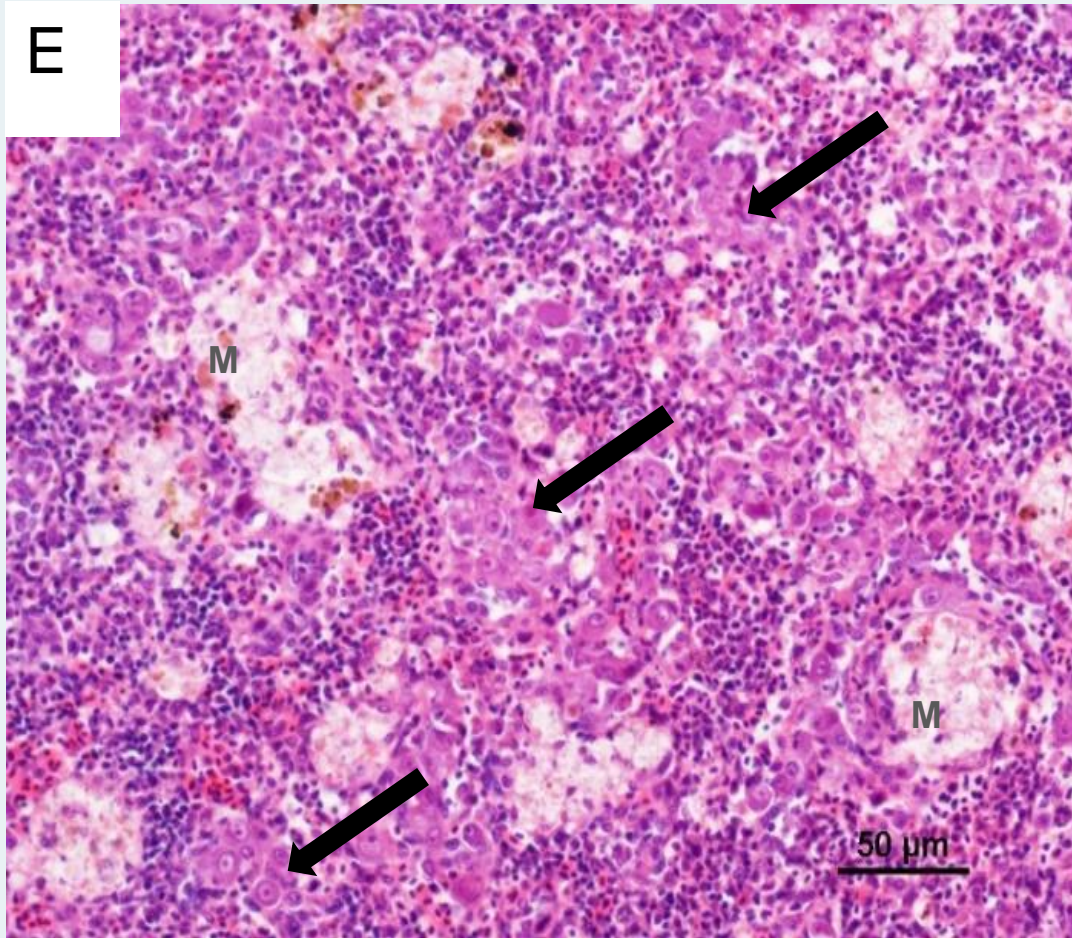


# Histopathology

- Mild tissue necrosis
- Eosinophilia
- Cytoplasmic and nuclear polymorphism

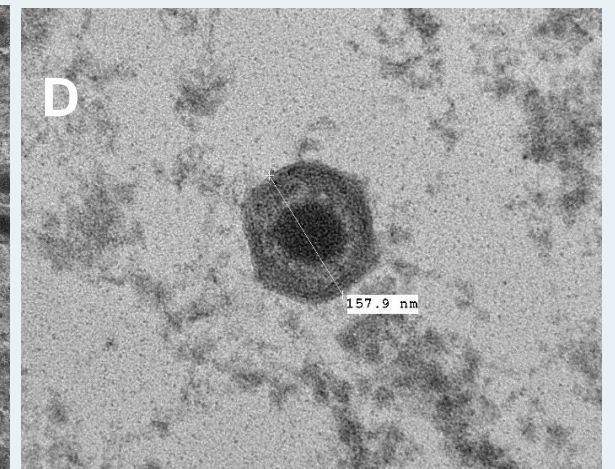
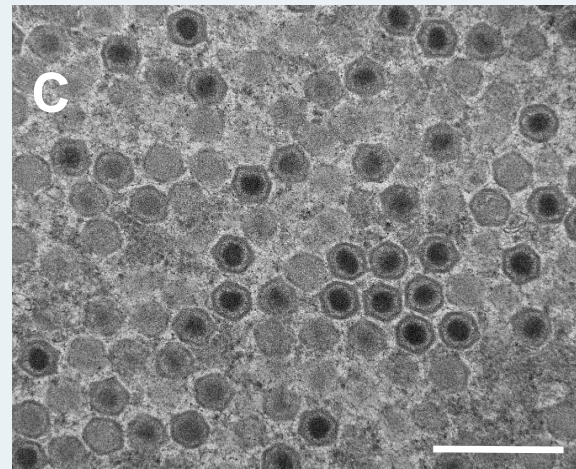
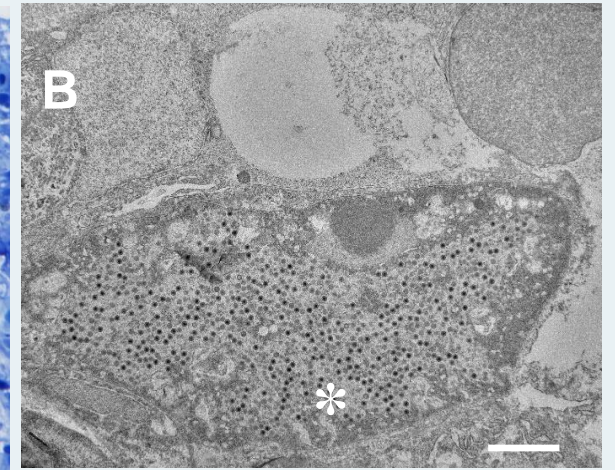
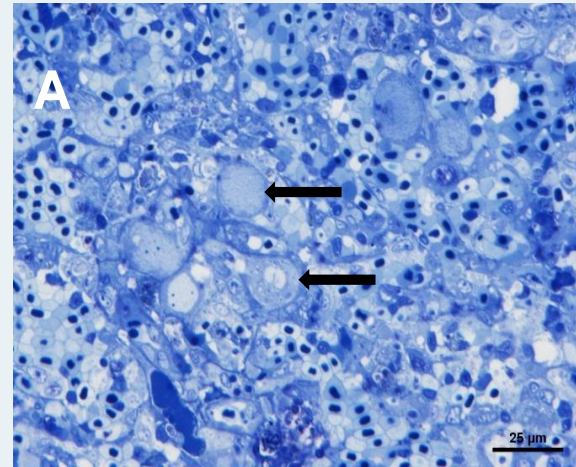
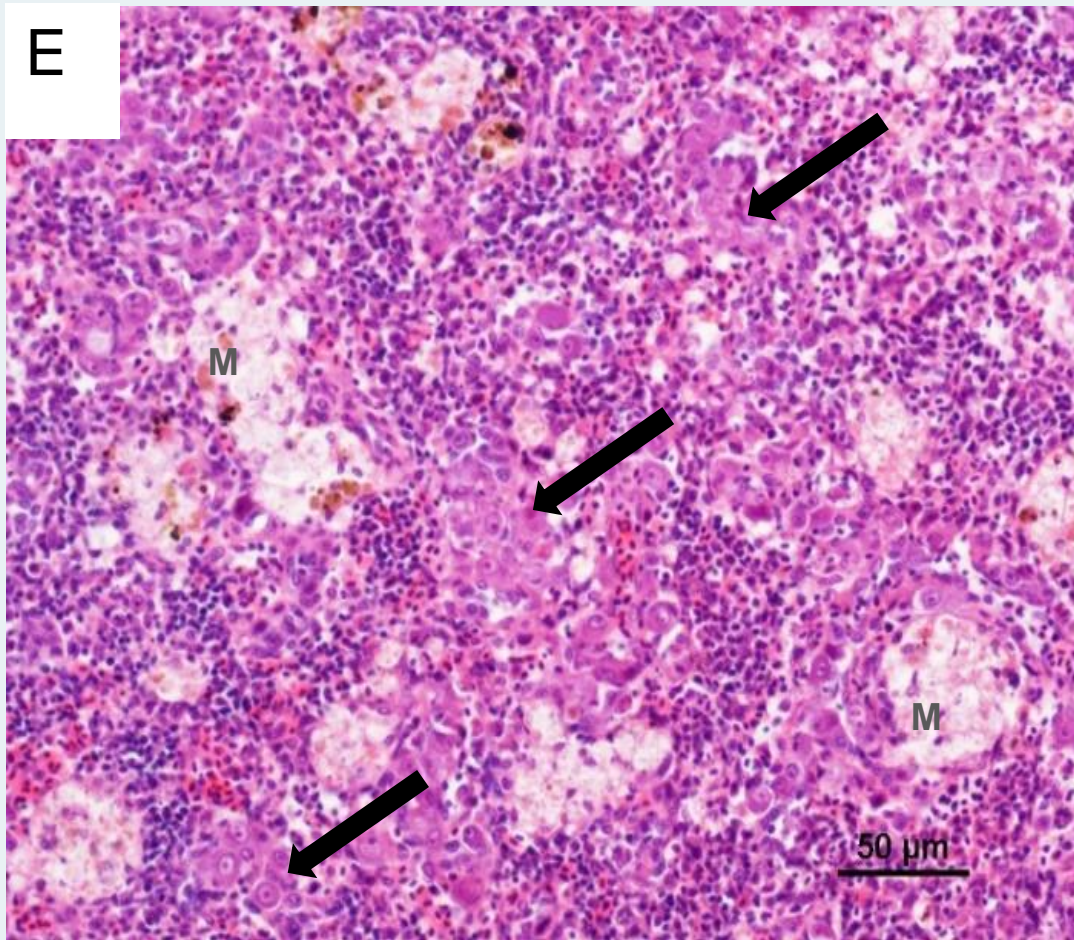






Haematopoietic cell cytoplasmic and nuclear pleomorphism  
Marginalisation of chromatin  
Typical of megalocytes in iridoviral infection (megalocytivirus)

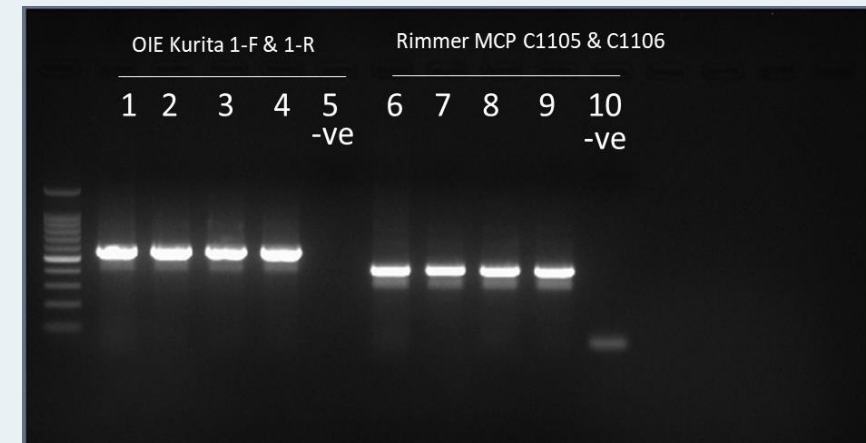


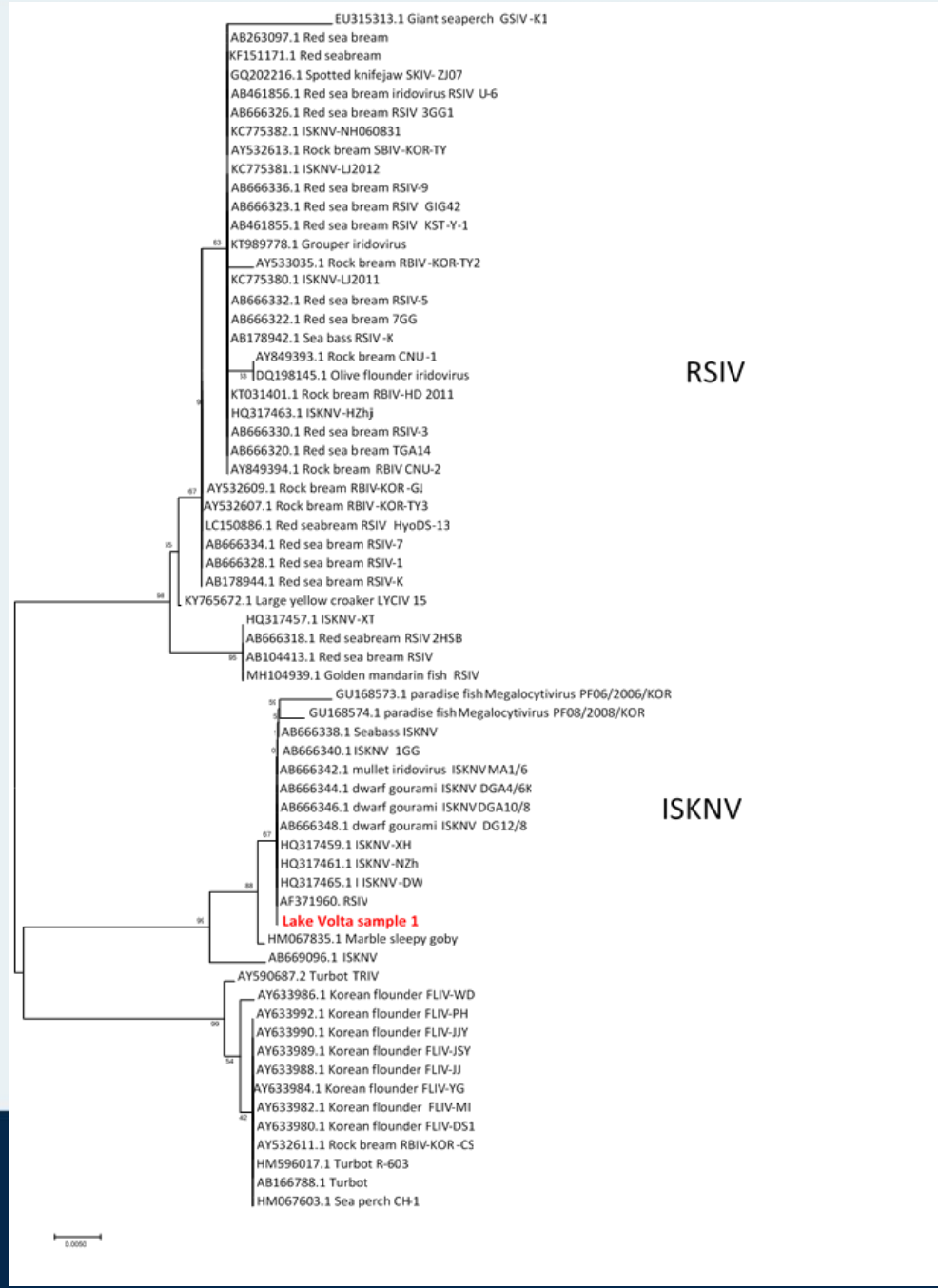




# Molecular testing

- Conventional PCR -
  - OIE recommended assay (Kurita et al., 1998)
  - MCP gene (Rimmer et al., 2012) for improved phylogeny





100% identity in the MCP gene

To several isolates of Infectious spleen and kidney necrosis virus (ISKNV) from various species from Asia

genus Megalocytivirus, family Iridoviridae (also inc. Ranavirus and Lymphocystivirus)

OIE listed – together with RSIV across a broad range of hosts.

# Context

- Retrospective analysis of previous survey samples  
ISKNV negative during 2016, 2017 and 2018.
- Indicating recent introduction and spread
- Not the first report of ISKNV in tilapia –  
Subramaniam *et al.*, 2016  
Suebsing *et al.*, 2016
- First record associated with mass mortalities in tilapia  
(currently not listed as susceptible)
- First record in Africa





# ISKNV in Tilapia – ongoing work

- Mortality ongoing – including all production stages
- Juvenile animals express very high viral titres
- Significant impact on production, business sustainability, price and availability of tilapia at market.
- OIE CCEAAD – currently working with the Ghanaian ministry to develop in country diagnostic capabilities, map the epidemic, investigate impact on other species, assist in developing control strategies.
- Prevention of national and transboundary spread
- Prevention/early detection of future incursions



# ISKNV in Tilapia – future control

- Vaccination – (autogenous or otherwise) – likely high chance of success
  - surviving animals are showing natural immunity
  - vaccine for RSIV in bream commercially available in Japan, several groups working on experimental vaccines for ISKNV in a variety of species but..
  - Off-line bio-secure hatcheries required
- Selective breeding
  - Possible strain differences
  - High fecundity – 3 generations/yr
- Alternative treatments – heatshock / natural immunity



# 5 minimum emergency disease preparedness response requirements

1. Detection systems: field & lab (rapid/ accurate/ predictive?)
  2. Effective Reporting systems (farm, national, international)
  3. Rapid decision making processes
  4. Control measures implementation plans
  5. Underpinning regulatory frameworks
- Response –ideally- to be led at a country level by dedicated and appropriately resourced Official Services





# The rise of the syndrome

*'A combination of (symptoms) and signs that together represent a disease process'*

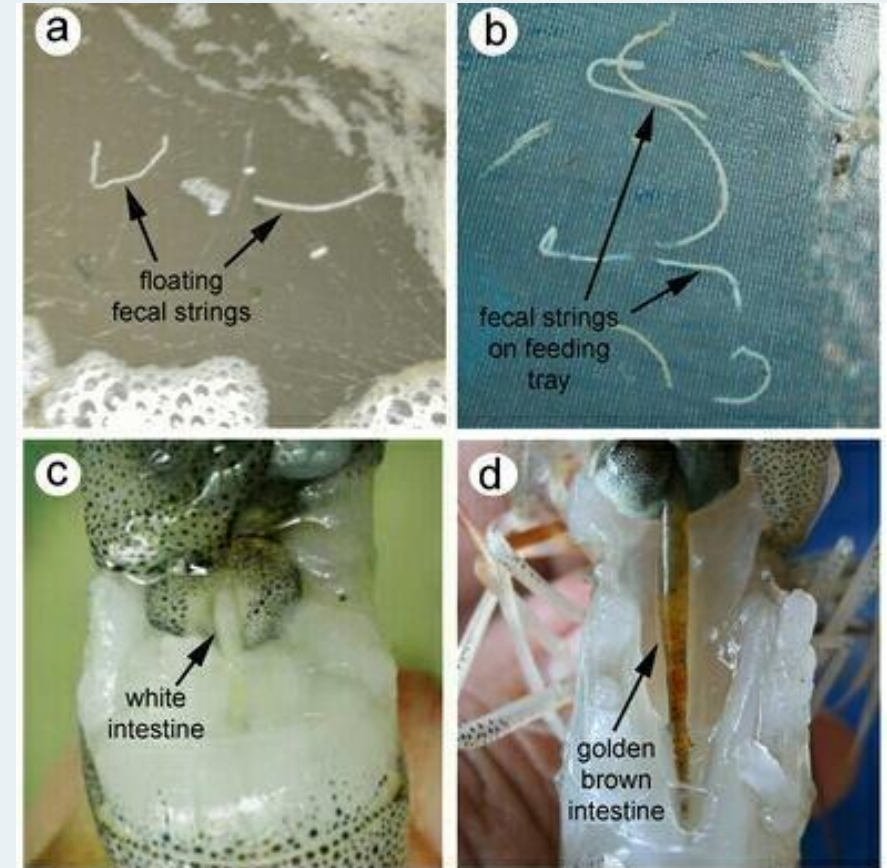
Multi-agent or even, non-infectious

Genetic, nutritional, environmental sub optima

May be driven by other 'pathogen exclusion' approaches

May be more difficult to control than specific agents

Challenges traditional management strategy



**PLOS** PATHOGENS

**Citation:** Stentiford GD, Sritunyaluksana K, Fiegel TW, Williams BAP, Withyachumnarnkul B, Itsathitphaisarn O, et al. (2017) New Paradigms to Help Solve the Global Aquaculture Disease Crisis. PLoS Pathog 13(2): e1006160. doi:10.1371/journal.ppat.1006160

**OPINION**

**New Paradigms to Help Solve the Global Aquaculture Disease Crisis**

Grant D. Stentiford<sup>1</sup>\*, Kallaya Sritunyaluksana<sup>2</sup>\*, Timothy W. Fiegel<sup>3</sup>\*, Bryony A. P. Williams<sup>4</sup>\*, Boonsim Withyachumnarnkul<sup>3</sup>\*, Orm Itsathitphaisarn<sup>3,5</sup>\*, David Bass<sup>1,6</sup>\*

# Decentralise diagnostics

But, centralise data

Provide a **decision tool** where needed and, a means of collecting surveillance data

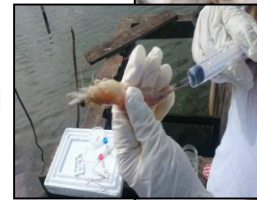
The farmer is the **keystone** in facilitating surveillance and disease management – a process traditionally reserved for national Competent Authorities

Innovate UK

Simple and quick



Pond-side testing



Remote locations



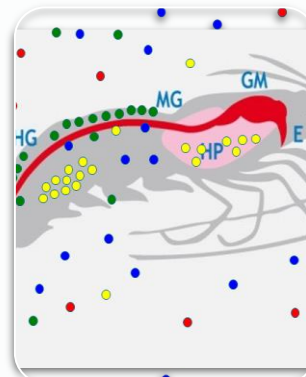
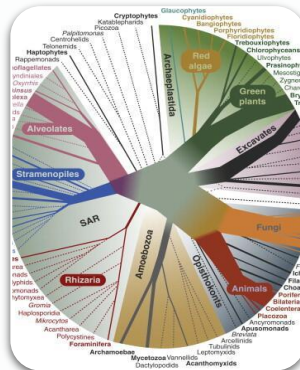
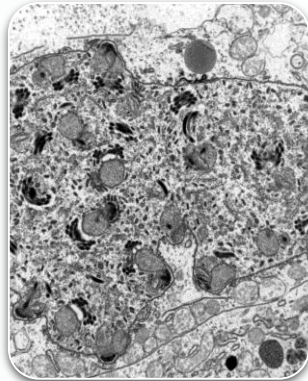
Smartphone app



Centralised data







### Improved Networking of AHPs

More efficient networking of a globally deficit resource

### Fast track diagnostics & surveillance

Pathogen genome data open access  
Translate genome data to diagnostics

### Decentralise diagnostics



Utilize farmer network  
Centralise the data for management

### Decipher background diversity

Pre-emergent threats better understood  
Refine diagnostics for listed taxa

### Single pathogen to pathobiome



Microbial consortia and disease outbreaks  
Microbiomes and immunity

### Embrace tech and parallel field thinking



Cutting edge approaches in medicine, agri-tech etc  
Remove silos

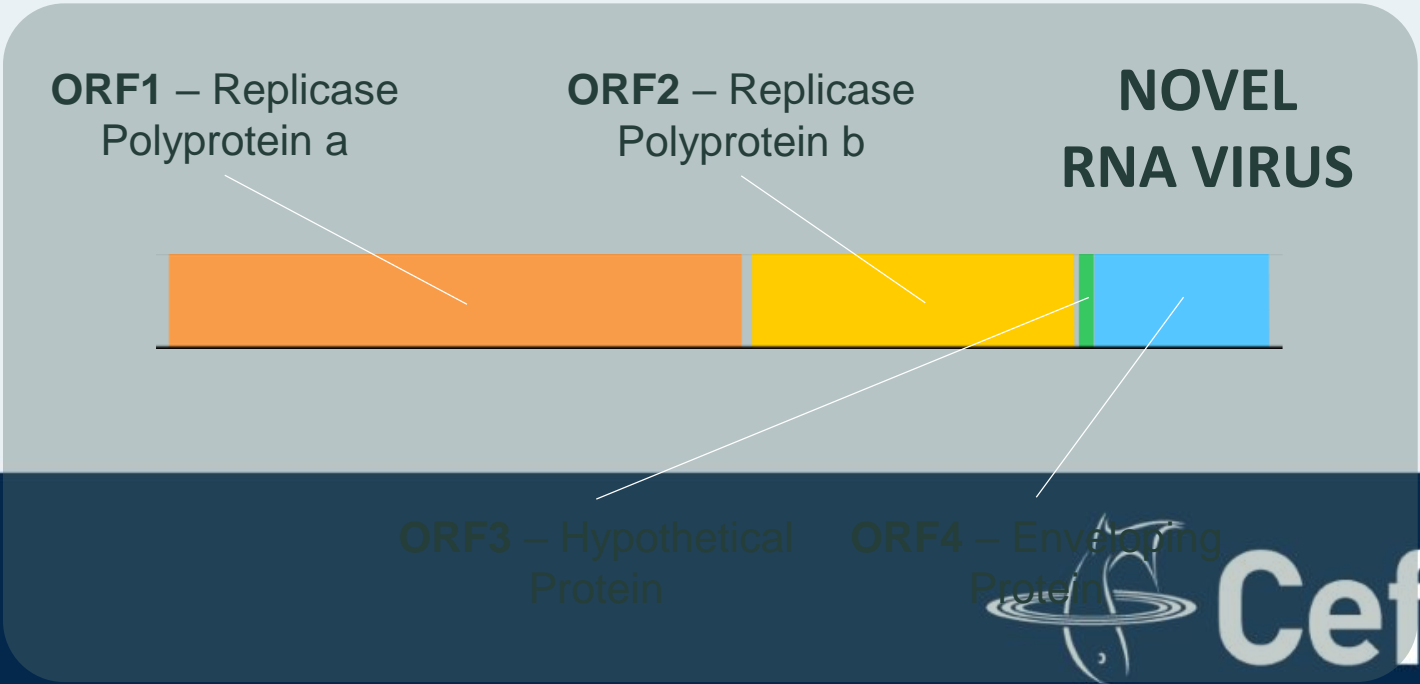
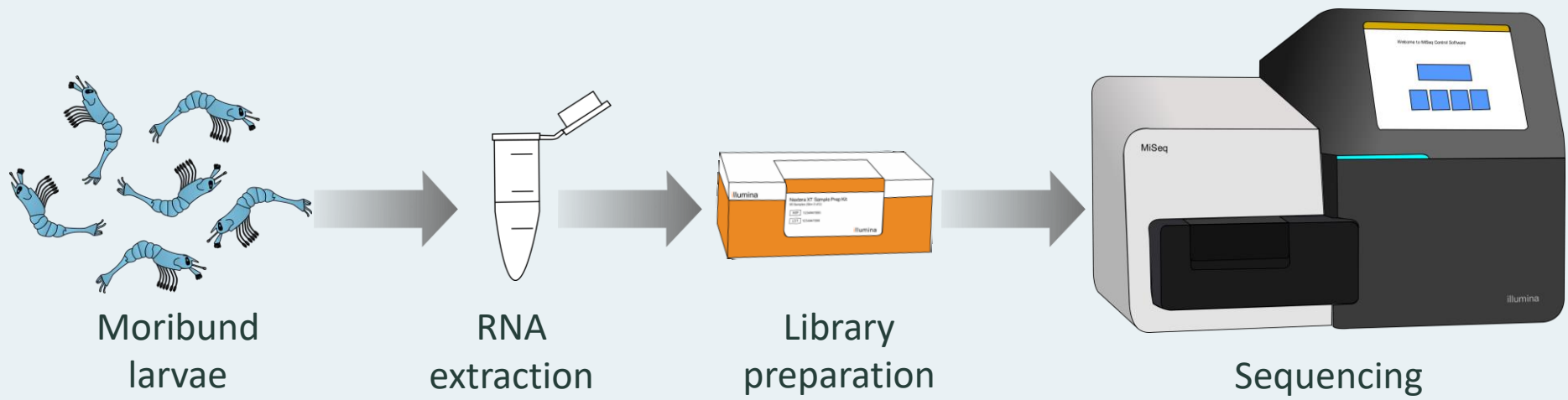
### Create resilient hosts



Open access host genome data  
Selective breeding, SNPs, edits..



Mass mortalities of *M. rosenbergii* larvae in the hatchery stage of culture in South Bangladesh





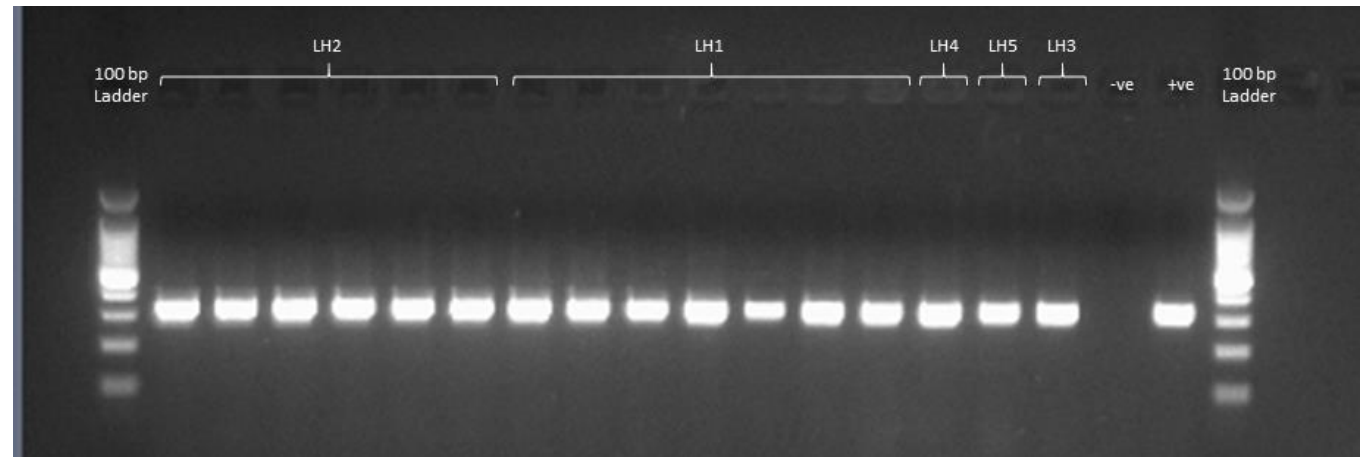


Mass mortalities of *M. rosenbergii* larvae in the hatchery stage of culture in South Bangladesh

Since 2011, *Macrobrachium rosenbergii* hatcheries have experienced mass mortalities of larvae resulting in an 80% decline in the number of hatcheries actively producing.

Discovery of a novel 29 kb single-stranded positive sense RNA virus associated with mass mortalities of *M. rosenbergii* larvae in hatcheries in Bangladesh.

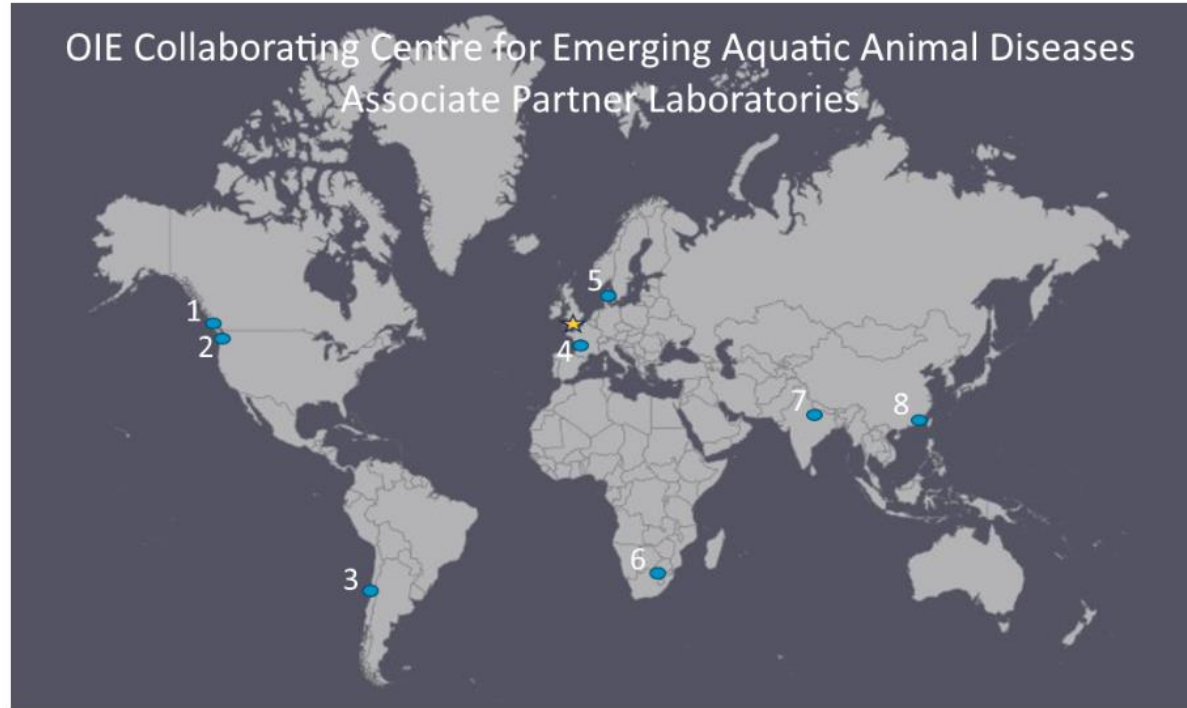
Specific PCR primers designed against the virus showed that it is widespread in hatchery culture: Five hatcheries experiencing mortalities were tested and all five were positive.



Further sampling planned for the 2020 production cycle to determine route of entry into the hatcheries and to sample for histopathology.



## OIE Collaborating Centre for Emerging Aquatic Animal Diseases Associate Partner Laboratories



### Lab 1

Dr Simon Jones  
Fisheries and Oceans  
Nanaimo, Canada

### Lab 2

Dr Gael Kurath  
U.S. Geological Survey –  
Western Fisheries Research  
Centre  
Seattle, USA

### Lab 3

Dr Fernando Mardones  
Universidad Nacional Andres  
Bello  
Santiago, Chile

### Lab 4

Dr Isabel Arzul  
European Union Reference  
Laboratory for Mollusc  
Diseases  
La Tremblade, France

### Lab 5

Prof Niels Olesen  
European Union Reference  
Laboratory for Fish and  
Crustacean Diseases  
Copenhagen, Denmark

### Lab 6

Dr Kevin Christison  
Department of Agriculture,  
Forestry and Fisheries  
Pretoria, South Africa

### Lab 7

Dr Neeraj Sood  
Indian Council of Agriculture  
Research – National Bureau of  
Fish Genetic Resources  
Utter Pradesh, India

### Lab 8

Prof Hong Lui  
The Key Laboratory of Aquatic  
Animal Disease  
Shenzhen, P.R. China

# Acknowledgements

- José Gustavo Ramírez-Paredes, William Hunt, Terry Field, David Haydon, Timothy Wallis - Ridgeway Biologicals
- Stephen Feist, Richard Paley, David Stone, Chantelle Hooper, David Bass- Cefas
- Peter Ziddah, Mary Nkasa – Fisheries Commission Ghana
- Dr Awuni & team, Livestock Veterinary Services, Ghana
- Samuel Duodu – University of Ghana
- Funding:
  - Ridgeway Biologicals
  - Defra FX001 - (OIE CC-EAAD)



The screenshot shows a bioRxiv preprint page for the paper "First detection of Infectious Spleen and kidney Necrosis Virus (ISKNV) associated with massive mortalities in farmed tilapia in Africa". The page includes the bioRxiv logo, a search bar, and navigation links. The abstract text describes the discovery of ISKNV in farmed tilapia in Ghana in late 2018, noting high mortality and specific histopathological findings.

HOME | AB

Search

New Results Comment on this paper

**First detection of Infectious Spleen and kidney Necrosis Virus (ISKNV) associated with massive mortalities in farmed tilapia in Africa**

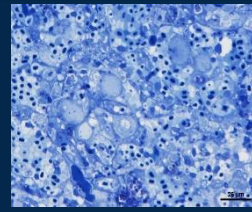
José Gustavo Ramírez-Paredes, Richard K. Paley, William Hunt, Stephen W. Feist, David M. Stone, Terry Field, David J. Haydon, Peter A. Ziddah, Samuel Duodu, Timothy S. Wallis, David W. Verner-Jeffreys  
doi: <https://doi.org/10.1101/680538>

This article is a preprint and has not been peer-reviewed [what does this mean?].

Abstract **Full Text** Info/History Metrics Preview PDF

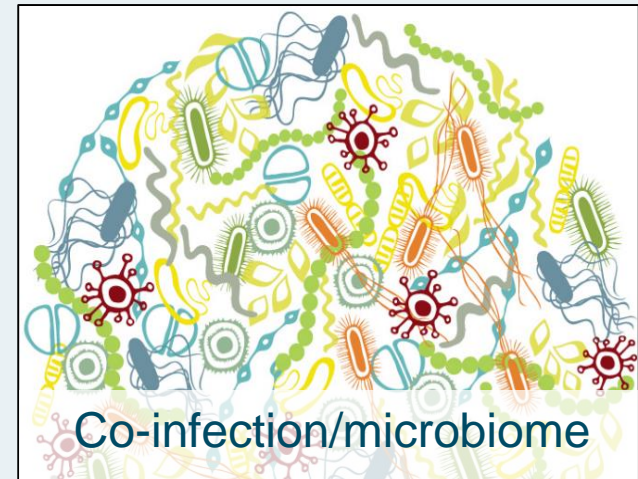
**Abstract**

In late 2018, unusual patterns of very high mortality (>50% production) were reported in intensive tilapia cage culture systems across Lake Volta in Ghana. Affected fish showed darkening, erratic swimming and abdominal distension with associated ascites. Histopathological observations of tissues taken from moribund fish at different farms revealed the presence of lesions indicative of viral infection. These included haematopoietic cell nuclear and cytoplasmic pleomorphism with marginalisation of chromatin and fine granulation. Transmission electron microscopy





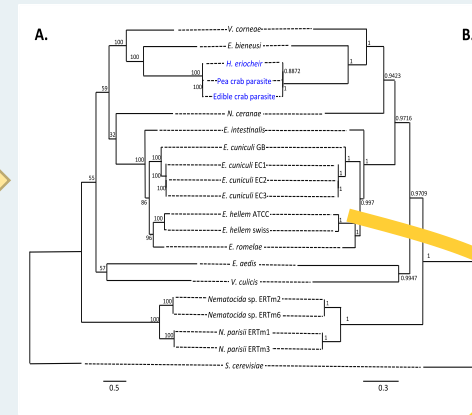
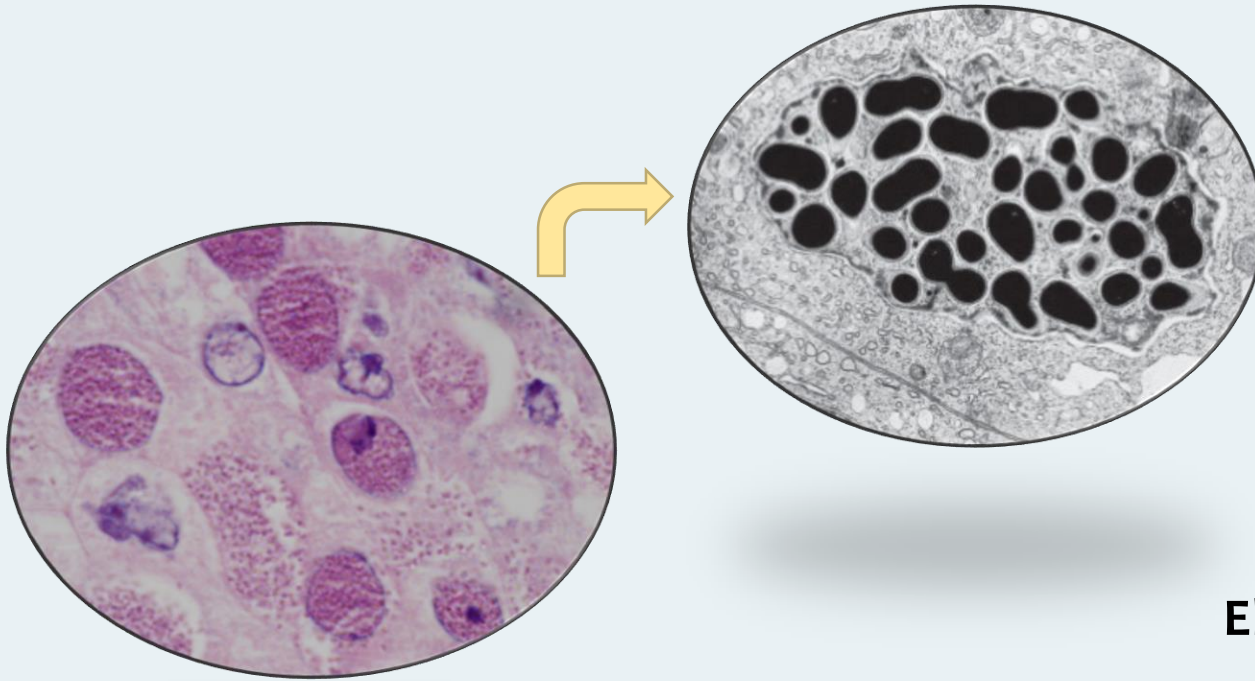
# Lessons learned: Broader thinking... the 'susceptibility window'



Etc....



# Lessons learned: the 'Exclusion' paradigm



Get writing  
Go to conference  
Have a beer

- Elevation agent to 'infamy' ✓
- 'Emergent', 'Listed' ✓
- Diagnostic target ✓
- Surveillance ✓
- Controlled ✓
- National/Global Focus ✓

Exclusion principle

frontiers  
in Plant Science

published: 25 October 2017  
doi: 10.3389/fpls.2017.01806

REVIEW

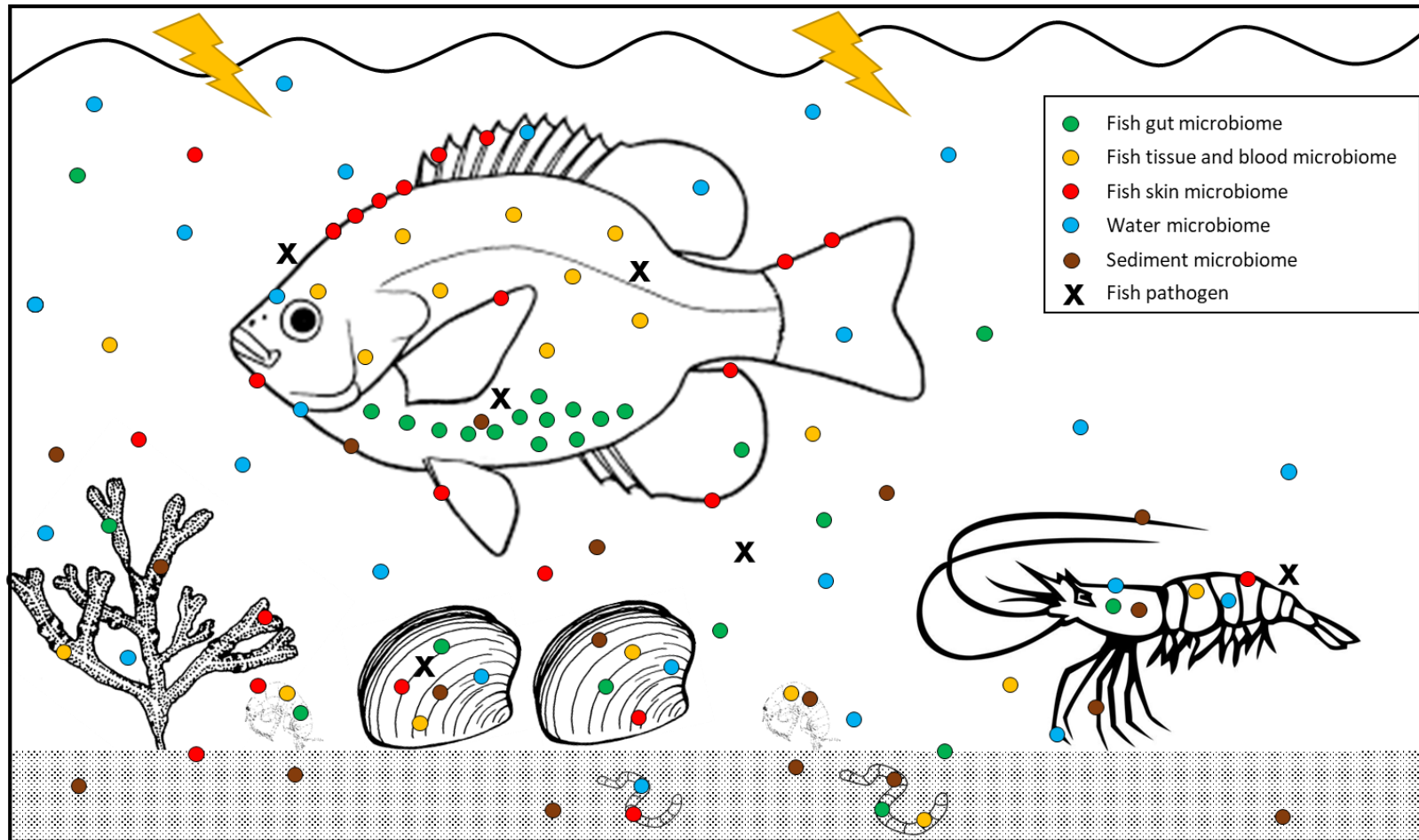
Check for updates

**Host-Multi-Pathogen Warfare:  
Pathogen Interactions in Co-infected  
Plants**

Araz S. Abdullah<sup>1\*</sup>, Caroline S. Moffat<sup>1</sup>, Francisco J. Lopez-Ruiz<sup>1</sup>, Mark R. Gibberd<sup>1</sup>,  
John Hamblin<sup>2</sup> and Ayalsew Zerihun<sup>1</sup>

# Decipher the 'pathobiome'

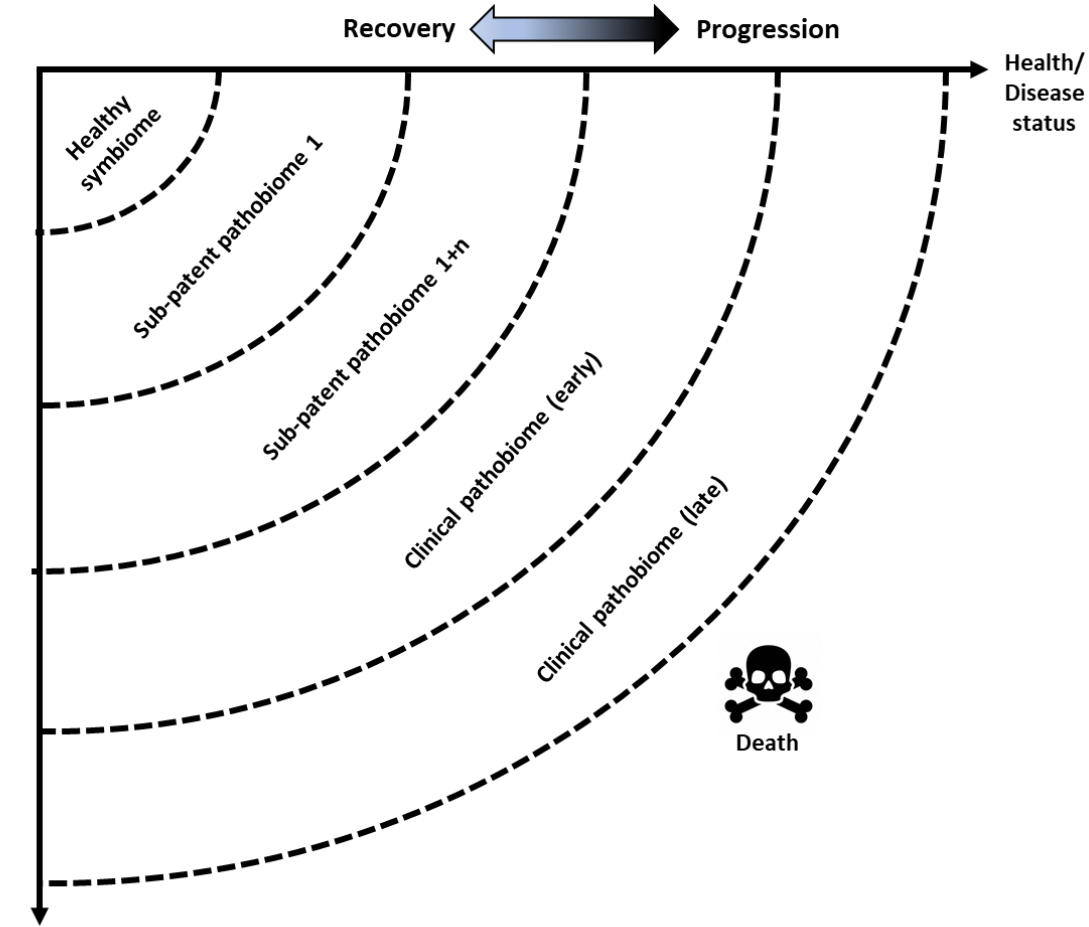
Bass et al. (2019). The pathobiome in animal and plant diseases. TREE (in review)



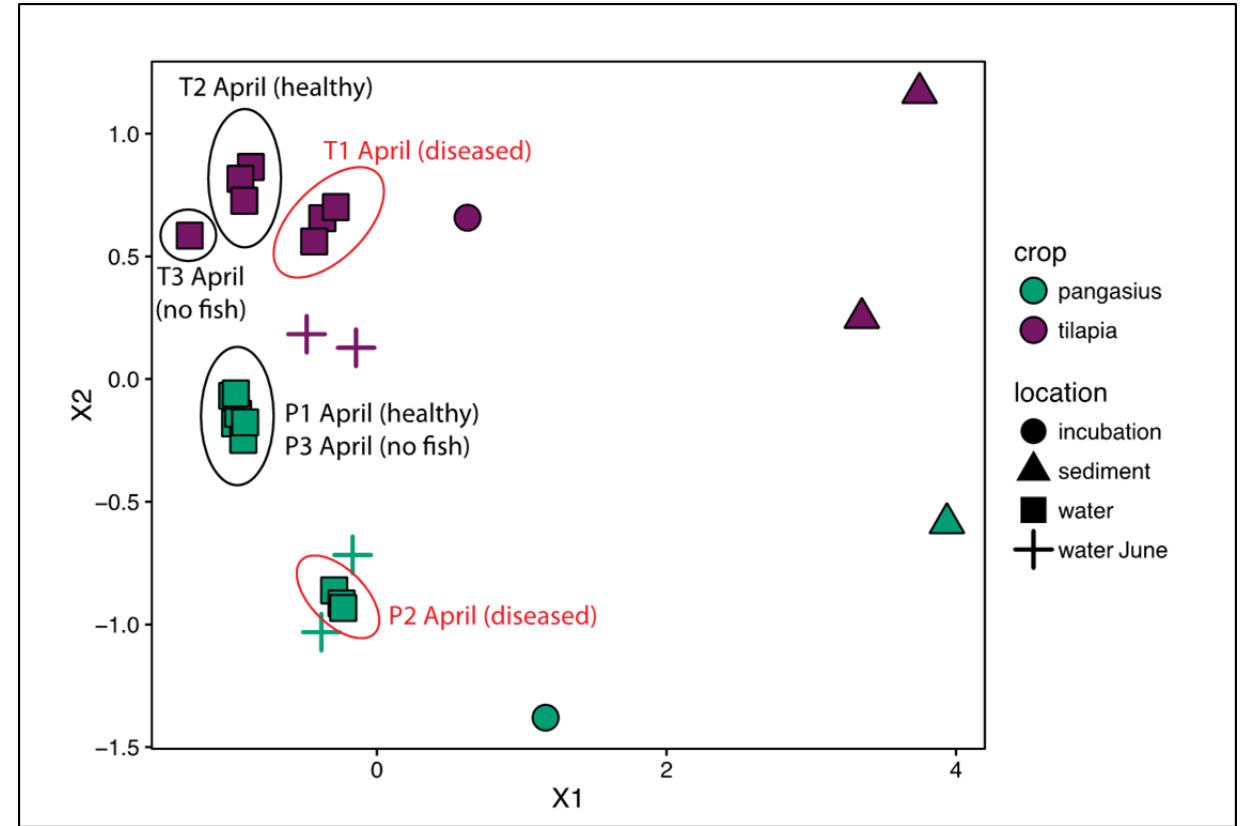
Manifestation of *disease* associated with *infection* by **pathogen X** may be driven by shifts in the environmental/host microbiome towards a '**pathobiome**' state.

Shift to pathobiome state may have significantly **preceded** (in time) replication of pathogen 'X'

# Decipher the 'pathobiome'



Time Bass et al. (2019). The pathobiome in animal and plant diseases. TREE (in review)





# Who we are in Weymouth...

- Scientific division within Cefas – former MAFF Fish Diseases Laboratory
- Employs approximately 150 staff, apprenticeships, industrial placement students, MSc and PhD students.
- Mixture of funders Defra, Food Standards Agency (FSA), Food Standards Scotland (FSS), EU, commercial contracts, university research collaborations.



# Fish and Shellfish Health at Weymouth

- *Fish Health Inspectorate – Competent Authority*
  - *Prevent introduction and minimise impact of serious diseases of fish and shellfish*
- *Investigation of emerging disease*
- *Biosecurity and economics*
- *Surveillance and diagnostics*
- *Use of new molecular techniques for pathogen characterisation and detection*
- *Non-native species*

