Diagnosis in a fish farmer's backpack

Dr Andrew C. Barnes[1], Suvra Das[1], Oleksandra Silayeva[1], Shaun Wilkinson[2], Fernando Cagua[3], Jerome Delamare-Debouteville[3]

[1]The University of Queensland, Australia; [2]Wilderlab, New Zealand; [3]WorldFish Center, Malaysia

ABSTRACT

Fish underpin future nutritional security, supplying high quality protein, iron, iodine and vitamin A that are critical to childhood development and deficient in many staple foods. In 2018, 54.1 million tonnes of fish were produced by farming, generating US$138.5 billion and directly employing 19.3 million people, mostly in developing nations. With expansion and intensification, disease losses are increasing and are a priority for the FAO sub-committee on aquaculture. In most developing countries, disease mitigation comprises over-stocking to compensate, and use of readily available antibiotics. Indeed 67 different antimicrobials are used in the 11 major producing countries, contributing to the global pool of antimicrobial resistance (AMR). Accurate identification of the causes and sources of infectious disease is essential for implementation of evidence-based treatment, biosecurity and prevention. Pathogen genomics can provide sufficiently detailed information but has, to date, been too expensive and time consuming. Lab-in-a-backpack uses nanopore sequencing technology and low-cost, low-waste sample preparation to generate whole pathogen genome sequence data from diagnostic samples on the farm without laboratory support. Our simplified safe workflow includes a cloud-based identification tool that returns near real-time information about the pathogen using any laptop or smartphone. This enables evidence-based treatment, epidemiological tracing, AMR surveillance and the production of simple low-cost locally produced 'autogenous' vaccines to protect the next crop. These big-data-informed but locally implemented solutions align well with FAO's recently proposed Progressive Management Pathway for Improving Aquaculture Biosecurity, and can deliver real advances in local economy, nutritional security, antimicrobial stewardship and animal welfare.

This talk is about disease diagnosis in a fish farmer's backpack. According to the United Nations, food and nutrition security is achieved if adequate food – in terms of quantity and quality – is accessible for, and utilised by, all individuals at all times to live a happy and healthy life. Fish is a particularly good source of high quality well-utilised protein and it also has high concentrations of iron, vitamin A, and iodine that are critical in childhood development and are deficient in many staple foods. As fisheries are mostly fished to capacity, the increasing demand for fish is being met by aquaculture, one of the fastest growing food production sectors. In 2018, 54.1 million tonnes of fin fish were produced by aquaculture, generating over US$138 billion and directly employing

This record has been prepared from a transcript of the video presentation.

19 million people in fin fish aquaculture production. The majority of these were in developing countries.

Disease is the major constraint to aquaculture growth and is a current focus of the FAO COFI Sub-Committee on Aquaculture. In most developing countries mitigation of disease includes stocking more fish to offset the losses, which makes the problem worse, and antibiotic treatments that lead to anti-microbial resistance. This underlines the importance of including aquaculture in a One Health approach to antibiotic stewardship.

Evidence-based disease control is central to reducing antibiotic use. We have all seen the power of genomic sequencing in outbreak management during the current COVID pandemic. Such high-resolution information identifies routes of transmission for biosecurity, informs appropriate treatment, and tells us which strains to include in vaccines. While genomic sequencing costs have fallen dramatically over the last decade, sample preparation is costly and involves toxic chemicals, and next generation sequencers are expensive and require large-scale infrastructure, and the masses of sequencing data need to be analysed to obtain actionable information. This puts the power of genomic sequencing beyond the reach of smallholder farmers in developing nations.

Lab-in-a-backpack

'Lab-in-a-backpack' creates a low-cost workflow for sample processing and genomic sequencing. It can be conducted anywhere, and it does not require expensive equipment or reagents, nor generate any toxic waste.

Our first innovation is a low-cost DNA purification workflow based on a safe household detergent available anywhere in the world. The samples have DNA tags or barcodes added, are pooled with samples collected during the same trip, and then loaded onto a MinION nanopore sequencer. These pocket-size devices are cheap to buy, simple to operate, and do not require lab facilities. Even here at The University of Queensland we do our nanopore sequencing in the office, not the lab. However, the data they generate are fuzzy. It is not possible to get actionable information directly from raw instrument reads.

Our next innovation – from our partners Wilderlab – adds cloud-based machine learning, trained on a custom fish-pathogen database developed by The University of Queensland and WorldFish. The alpha version of the app runs on an Android smartphone. The first few readings from the nanopore instrument are uploaded and return a detailed accurate diagnosis in a few seconds. A simple user interface then provides accurate information in near real-time via any laptop or smartphone, enabling the local fisheries officers to advise the farmers, and for simple custom vaccines to be manufactured using local fermentation capability. They can be used to vaccinate new stock on the farms that have the same bacterial strain types, thereby securing the output of the next crop, preventing spread between farms, and removing the need for antibiotics.

These big data-driven and locally-implemented solutions align with the FAO's recently proposed Progressive Management Pathway for Improving Aquaculture Biosecurity.

Lab-in-a-backpack can provide information that is accessible in real time and be employed directly in defining biosecurity risk, systems-implementation, preparedness and, of course, sustainable health management through vaccination. This will deliver real advances for local economies, nutrition security, human health, and animal welfare.

Thank you to our partners in the Inspire Challenge 2019 Prize, who have built a workflow to put the power of genomic diagnostics into a fish farmer's backpack*.

Dr Andy Barnes obtained his BSc (Hons) in Microbiology from Heriot-Watt University, Edinburgh, and his PhD from the Medical School, The University of Edinburgh. Andy worked for the Scottish Office Agriculture and Fisheries Department and at the Moredun Research Institute, Edinburgh, before joining a small Canadian biotech company, Aqua Health Ltd, specialising in vaccines for aquaculture in 1993. In 1999, Aqua Health was bought by Swiss pharmaceutical giant Novartis and Andy worked in their animal health division for 4 years before beginning an academic career at The University of Queensland. Currently in the School of Biological Sciences, Andy's research and teaching focus on animal health and welfare, including vaccines, diagnostics and healthy feeds for the aquaculture industry, with pure research on immunity and infectious diseases of aquatic animals ranging from reef-building corals, through prawns and oysters, to barramundi, tilapia, stingrays, kingfish, salmon and grouper.

* https://bigdata.cgiar.org/blog-post/meet-the-2019-inspire-challenge-finalists/