Charles Sturt University

Gulbali Institute
Agriculture Water Environment

Comprehensive genetic surveillance system for Australian biosecurity and public health

Australia faces ever-growing biosecurity challenges due to increased human activity, disrupted environments, and climate change – all of which facilitate the introduction and spread of invasive organisms and pathogens. Australia's extensive border and proximity to potential sources of animal and human pests and diseases (including major threats such as screw worm, foot-and-mouth, and African swine fever) are straining current capacities, as shown by recent cases of fire ants and varroa mites. Australia's unique vulnerability to these factors is clearly shown by the $25 billion spent annually managing existing invasive species.

The challenge

The existing biosecurity system focuses on safeguarding Australia's external border and relies mostly on passive surveillance and community science. This sub-optimal arrangement also assumes that introductions will be accidental, and not intentional acts such as smuggling or terrorism.

Proposed solutions

We propose using environmental DNA (eDNA) to develop a comprehensive, low cost, pathogen and biosecurity monitoring network across Australia. Utilising a series of methodological innovations from the field of ancient DNA, Gulbali Institute researchers have pioneered a uniquely simple, sensitive and powerful system that can simultaneously monitor all notifiable human and animal pathogens and invasive species.

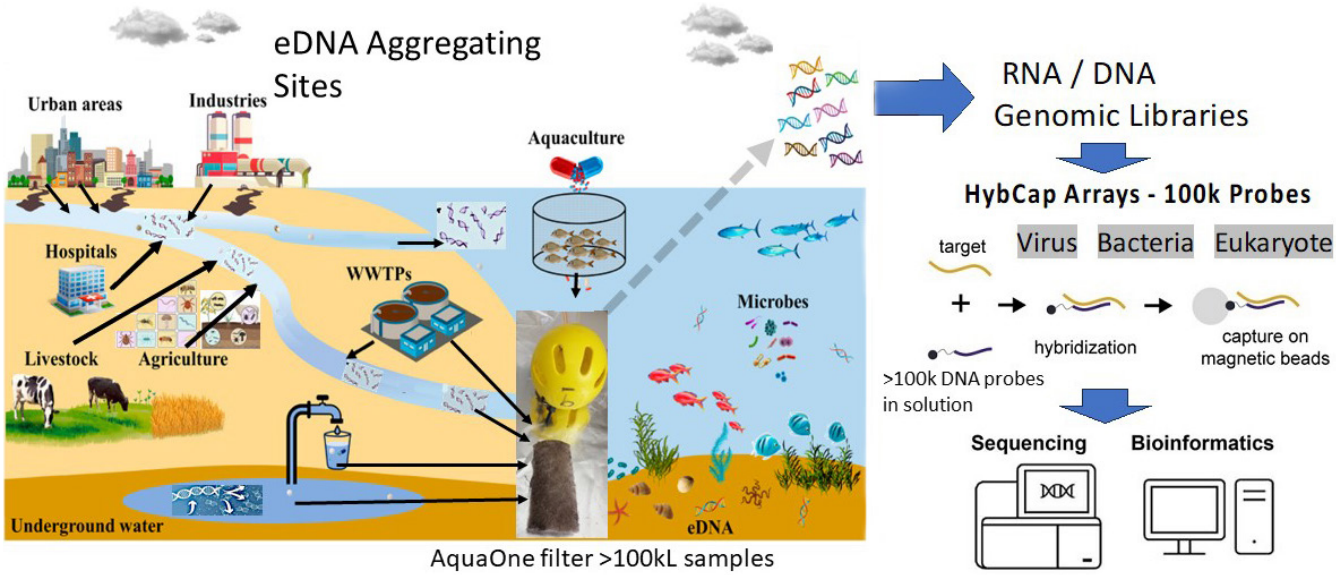
By monitoring eDNA from sites that naturally aggregate signals across landscapes or populations, such as rivers, water treatment systems and agricultural processing plants, our methods are capable of detecting trace levels of notifiable pathogens and invasives in a single analysis, revolutionising current biosecurity approaches.

The approach

We have developed the use of Hybridisation Capture Arrays (HybCap) – large cassettes of custom oligonucleotide probes – to capture and isolate a vast range of genetic targets within complex environmental mixtures, in a single inexpensive reaction. The key advantage of HybCap is that a single array can efficiently bind and isolate any taxonomic target – from viral to human, RNA or DNA – providing access to a full range of notifiable pathogens.

This flexibility allows a single HybCap array to target both pathogens and invasive species, providing a simple, inexpensive, combined surveillance tool. The low-cost analyses ($200/sample) will permit regular (e.g. weekly) surveillance across networks.

In contrast, current approaches remain heavily reliant on PCR metabarcoding (e.g. 16S, 18S genes), which is labour-intensive, has large inter-study variation, and can often have high false negative and positive rates.



Above: Environmental DNA is collected from natural aggregation sites using nylon filter pads (photo inset shows 24 hours of filtered river water), amplified with droplet PCR, and screened with HybCap Arrays to isolate viral, bacterial, animal and plant targets. (Image, Alan Cooper).

Benefits

This simple technology can be standardised across any laboratory to produce comparable data from different sites and studies, providing consistent information for efficient, integrated management and decision-making by Australian State and Federal agencies.

The power of the HybCap system is such that it could be implemented in multiple situations ranging from pathogen or biosecurity surveillance in the natural environment (e.g. using river eDNA to detect the presence of fire ant colonies upstream in NSW, or high risk ISEA arboviruses in the NT after tropical cyclones) – to routine epidemiological monitoring of urban and rural wastewater for pathogens like Avian influenza, meningitis, measles or polio.

Our platform would simplify water safety monitoring in rural distribution systems, outback communities or disaster areas, providing critical information for vulnerable groups, including diabetics and dialysis patients, the immunocompromised, young and elderly. As a result, a wide range of potential users exist, from the Aboriginal Health Network to outback landholders concerned about the impacts of agricultural dust in rainwater systems.

Our methodology is also ideal for international partnerships, and we will work with our Indonesian partners at the National Science Innovation Agency – BRIN to test the functionality and sensitivity of the HybCap on critical potential invasives (African swine fever, foot-and-mouth, lumpy skin, Nipah, and dengue).

The approach could easily be extended globally and would be a major asset for remedial work in disaster areas (e.g. for the Department of Foreign Affairs and Trade or the Department of Defence), and also for transport vessels with confined conditions (e.g. ships, aircraft) where airflow and wastewater systems could be routinely monitored.

Detection of invasive species

The new HybCap approaches allow all invasive species to be monitored at once, in a single reaction. River water in the Murray Darling Basin can be used to detect the presence of new risks such as fire ants in upstream tributaries, while at the same time monitoring for varroa mite and Avian Influenza.

Action

We are currently seeking financial support and partners to assist in the development of a nationwide biosecurity and pathogen monitoring network for Australia.

Find out more

Professor Cooper is a world expert at the detection of trace levels of genetic material, and has led global programs to analyse ancient humans, extinct species and past environments. The new Charles Sturt University eDNA lab is one of the most technically-advanced facilities in Australia.

Contact

Professor Alan Cooper
Gulbali Institute
Charles Sturt University
alacooper@csu.edu.au

1800 275 278 (free call within Australia)
+61 1800 275 278 (callers outside Australia)

research.csu.edu.au/gulbali

gulbali institute

gulbali institute

gulbali@csu.edu.au

Charles Sturt University