WildTech DNA

McMaster University

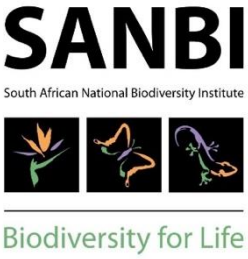
Wildlife DNA Detection Technology

Heralding a new era in conservation technology

In collaboration with

Natural Sciences and Engineering
Research Council of Canada

Conseil de recherches en sciences
naturelles et en génie du Canada



The urgent need for innovation

Part of the new era in conservation is in extending our capacity beyond the scientific world and enabling the participation of every day citizens. Sustainable conservation can only occur when we empower and involve the public, and new technology is making this possible….helping connect us, not just to each other, but to nature too…..

Finding effective ways to monitor species that are difficult to detect is of paramount importance to national and global conservation efforts and becoming increasingly more urgent. Conservationists need to analyse population dynamics, identify threats of local extinction, identify illegally trafficked wildlife products, and assess the effectiveness of mitigation actions. Detecting wildlife from the DNA profile of their remains has become a critical method in conservation to provide this information that would otherwise be difficult or impossible to obtain through other means. Currently, DNA retrieved from materials (e.g., feces, skin and bone) collected in the field need to be analysed using traditional methods in the lab or using expensive and complex portable DNA sequencers. Unfortunately, there are challenges with these methods that limit the widespread adoption of genetic species detection including:

1. they are time-consuming and require specialized expertise;
2. the samples' age and quality can impact the accuracy of the analysis; and
3. laboratory costs are too high for large-scale studies or for regions that do not have access to the latest costly equipment.
4. many countries have legal restrictions on the exportation of samples and are therefore limited in their capacity to contribute to wildlife monitoring without specialized laboratories in the country.

Such challenges prevent the inclusion of the largest proportion of the international conservation community, the public, and prevent many developing countries (often hotspots of biodiversity) from playing a significant role in conservation efforts due to socio-economic reasons.

Our approach

To develop a revolutionary & unique technology, - a portable, affordable, paper-based DNA testing device for the real-time identification and monitoring of elusive (or indeed all) wildlife.

We aim to solve two major scientific challenges that have been roadblocks to the engineering of low-cost, in-field DNA testing devices.

1. First, it is difficult to isolate target DNA from biological samples as the process requires multiple chemical, physical and thermal steps.
2. Second, it is difficult to detect a small amount of target DNA in a sample containing a large amount of background material.

We are in the process of developing a simple, paper-based hand-held device, much like a pregnancy test, which can perform three functions in one:

- capturing the DNA,
- producing copies of the DNA, and
- detecting the DNA through a colour change.

The unparalleled advantage of this anticipated technology will be its simplicity, high detection sensitivity and ultra-low cost (<US$1 per test); a game-changer for in-field DNA testing. The application for such a device is vast as it could be used by both experts and non-specialists for monitoring animals and plants across terrestrial and aquatic environments, both at the species and population level.

The technology can also be used by customs officers to rapidly identify the remains, such as skins and bones, of illegally trafficked species. It is the lack of ability to be able to distinguish between legal and illegal wildlife products, and do so quickly, that represents the biggest issue in the enforcement and prosecution of wildlife trafficking.

Further, applications in population identification/assessment for environmental impact studies point to use by government, corporations and research institutions to have easy and rapid access to data not previously possible to make effective and rapid decisions.

We believe extensions into forensic applications are further possibilities in the future as part of a portfolio of commercial applications that augment and stem from the conservation-led initiative.

Therefore, the major outcome of this project will be a highly effective tool that will aid global efforts in conservation, environmental protection and sustainable resource development.

Developing the technology for the world's big cats

The foremost objective is to design assays for each of the *Panthera* species including lion, tiger, jaguar, leopard and snow leopard – for both, fecal and illegal wildlife trade detection.

Why do we target the *Panthera* cats?

1. The *Panthera* species range from near-threatened to endangered according to the IUCN Red List and are all decreasing rapidly.

2. They are considered high priority species that drive the structure and function of biological communities in diverse ecosystems around the world. Because *Panthera* require large territories and plentiful prey populations to survive, conservation efforts aimed at preserving these species have the potential to produce significant biodiversity gains across multiple taxa.

3. The conservation monitoring of these species is extensive and scat samples are difficult to distinguish from other apex predators in the field.

4. They are an **i**conic, charismatic genera that are highly valued politically and feature prominently in the illegal wildlife trade. Many of the key countries where these products are trafficked do not have access or funding for detailed laboratory analyses of samples for prosecution.

5. Human-wildlife conflict with the big cat species is extensive. Expanding human populations and development have exacerbated competition for land and prey between people and big cats in *Panthera* range countries. In many cases these conflicts have resulted in a loss of livestock. *Panthera* cats are often falsely accused or misidentified and there is a need for innovative methods to enable communities to correctly identify predators responsible for livestock depredation so that appropriate mitigation actions can be applied. Samples taken to ID predators range from bite marks to scat samples. All of which have a high false identification rate.

6. Given the extensive global monitoring of these species and their prominence in major zoos, we have access to a plethora of samples including feces, skin, bone, hair and blood.
   For more details on available samples, see below.

7. We have extensive genomic data for all species.

Although the *Panthera* species will be the initial goal for the technology, we are keen to develop the detection device for other important cat species and subspecies including cheetah, lynx and puma (all of which we have samples for in our collection).

Our advantage: unparalleled experience in biosensor development and access to samples

The team at McMaster University include two Professors at the forefront of paper-based biosensor development for the early detection of human diseases and pathogens and their research lays the foundation for this project. Both stand at the interface between chemistry and biology and are world renown in their ability to create powerful molecular tools through the unusual functions of DNA and engineering paper surfaces for DNA capture.

The Senckenberg Institute and our partners the South African National Biodiversity Insititute have samples readily available for all *Panthera* species which include fecal, hair, skin, bone, tissue and blood samples. For some species we also have serum samples available, which will function as tests for low yield and quality DNA samples.

USP & advanced value

- Despite the existence of portable DNA detection machines on the market, these devices are expensive (over $1000 per unit), the error rates are high, particularly for mammalian DNA, and the flow cells need to be renewed regularly which adds substantially to the overall cost. Sample processing for these devices is also complicated and requires a level of expertise that precludes non-experts.
- Our technology is more portable (being the size of a pregnancy test), ultra-low cost (<US$1 per test), simple to use for non-experts and with a significantly lower error rate as we are not having to sequence the DNA. The technology is therefore a unique, cutting edge concept that is incomparable across the market.
- The goal is to develop a species monitoring device that is affordable and useable for non-experts, empowering communities and other stakeholders who are financially limited and do not have access to traditional laboratory methods, to be actively involved in conservation monitoring. With this goal in mind, we will ensure that all not-for-profit stakeholders have free licence to the technology.
- We conducted a pilot study over a year on the feasibility of the technology for snow leopard detection. In that time, we have proven the concept to be robust, specifically we've been able to:

    1. Prove we can extract DNA effectively on a paper platform (tested on bacterial DNA, scientific paper in preparation)
    2. Capture a piece of snow leopard DNA on paper,
    3. Produce many copies of that DNA
    4. Link the detection of snow leopard DNA to a simple colour change
    5. Prove the method is highly sensitive to low quantities of DNA (<1000 copies) with likelihood of improvement.

Our Team

The project team combines unique international and interdisciplinary collaboration between experts in biochemistry, materials science and conservation biology.

Dr. Natalie Schmitt is a postdoctoral fellow specializing in the development of novel genetic methods to assist in the monitoring and tracking of rare and elusive species and she will lead this project. She has worked with the Australian Antarctic Division and Panthera to develop new methods to track humpback whales, Antarctic blue whales and snow leopards (18 publications, ~155 citations). Dr. Schmitt has been instrumental in building collaborative networks not only within Canada but also internationally where there has been strong interest in the development of technology for the monitoring of ecologically important species and in tracking the illegal trade in wildlife products. She will over-see and coordinate all aspects of the project.

Dr. Carlos Filipe (McMaster University) is an expert in developing ultra-low-cost paper-based sensors, with a focus on environmental monitoring applications. He has ~90 publications (h-index: 30, ~6,600 citations) including a widely used textbook, and 14 granted patents. He has supervised ~100 HQP and his group now has 16 trainees. He will lead the design of the device and the integration of DNA capture and amplification-reporting.

Dr. Yingfu Li (McMaster University) is a leader in the area of functional nucleic acids and their applications as biosensing tools. He has published ~200 papers and book chapters (h-index: 57, ~13,000 citations), filed more than 20 patents and presented more than 150 invited talks to date. He has supervised ~150 HQP and currently runs a research group of ~20 trainees. He will be responsible for developing an RCA-based strategy to report the presence of specific genomic DNA and will work with Filipe on the capture of genomic DNA from complex samples.

Dr. Marco Musiani (University of Calgary) is a Professor in conservation biology at the University of Calgary, who specializes in wildlife management and molecular ecology, with a focus on field projects conducted in Alberta and BC. He has ~90 publications (h-index: 34, ~5,000 citations), including papers in Nature and Science, and edited two books on wolves and wildlife management. He has supervised over 40 HQP and currently runs a research group of 13 trainees. He will lead the field-testing component of the project for caribou and the development of species-specific markers.

Dr. Stefan Prost (Senckenberg Institute) has extensive experience in evolutionary and conservation genomics, and wildlife forensics. He is currently carrying out conservation genomics and wildlife forensics (illegal wildlife trade) projects for three big cat species, the cheetah, the jaguar and the snow leopard, in collaboration with national and international universities and NGOs, including IUCN, Panthera, WCS, the European Association for Zoos and Aquaria, and TRACE. He also has a decade of experience working with museum and heavily degraded DNA samples.To date, he has published 28 peer-reviewed research articles (h-index: 15, ~550 citations), 2 general newspaper articles and acquired about 580,000 Euros in grants.

Key in-kind partnerships

On top of our scientific team, we have also formed some strong partnerships with government and a big NGO to help with samples, expertise and ensuring the technology gets to where it is most needed for conservation. We are now looking for in-kind partnerships from any of the snow leopard range countries through GSLEP to assist in testing and optimizing the technology and helping us reach the people who need it most for the benefit of snow leopards.

South African National Biodiversity Institute (SANBI – South Africa)

South Africa is very active within the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and, as such, needs to comply with the convention. Of particular interest, is the rapid identification of bone and other parts of lion and other species. The South African government gives SANBI and the Barcode of Wildlife Project, South Africa their full support to help us develop the technology for the big cats by providing in-kind support. SANBI is the premiere biodiversity information clearinghouse in Africa. Partner – Michele Pfab (Scientific Coordinator).

"If successful, this technology will provide a powerful revolutionary tool for the real time detection of illegally trafficked wildlife products, thereby dramatically increasing the capabilities of customs and law enforcement entities to detect and respond to illicit trade."

Carmel Mbizvo, Acting Chief Executive Officer, SANBI

Wildlife Conservation Society (WCS – New York)

A global leader in big cat conservation with long term programs covering all of the important populations and spanning 33 countries and 3 continents. They will provide us with extensive in-kind support. Such a large and world-respected organization will be pivotal to ensuring the technology gets to where it is really needed in conservation. Partner – Luke Hunter (Executive Director – Big Cats Program).

"It is clear to us that the technology will be nothing short of revolutionary to big cat conservation. It will modernize and optimize conservation monitoring by enabling simple, real-time, inexpensive detection of cats from a variety of forensic samples including fecal matter, fresh tissue, skin and bone."

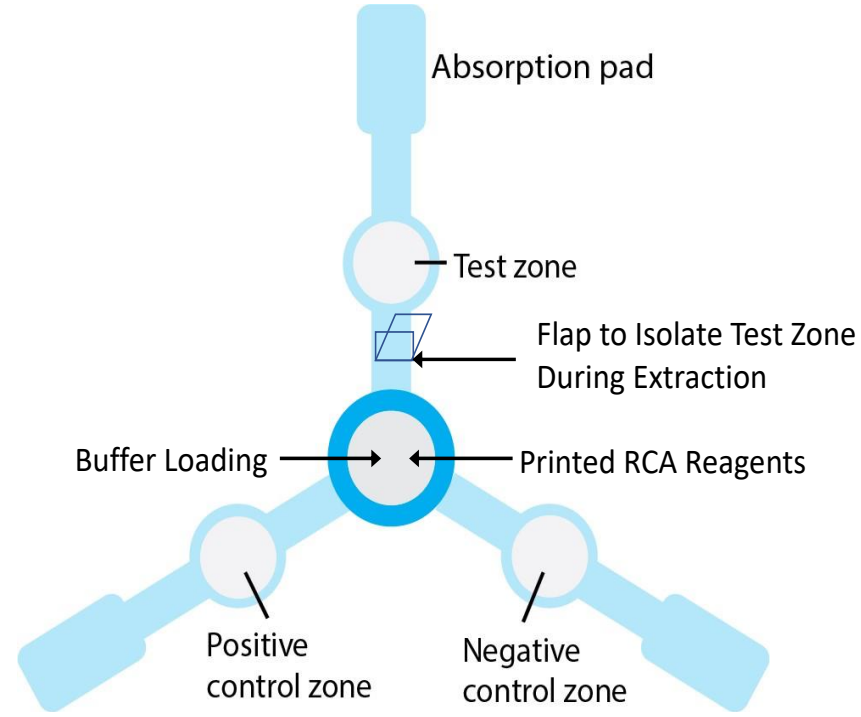
Luke Hunter, WCS

Future advances

Despite using the big cat species as our initial targets for the development of the technology, the technology can be applied to any species of interest, animal or plant, terrestrial or aquatic. The applications for such technology are also vast, with both commercial and non-commercial aspects, including:

- Environmental impact assessments used by industry.
- Monitoring of biodiversity by government, NGOs, tertiary institutes and citizen scientists.
- As a tool used by customs officers and rangers for the detection of illegal wildlife trade.
- Agricultural pest identification for farmers or greenhouse cultures.
- Detecting illegally caught fish species served in restaurants and sold in markets
- Ensuring meat authenticity and compliance with product labelling.

Product Details



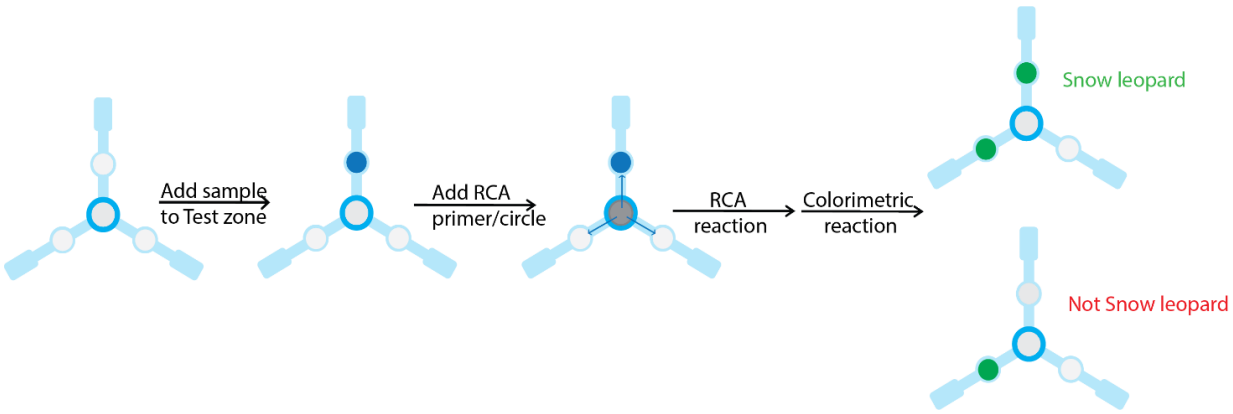


Figure. 1 Example of product design in detecting a snow leopard.

Testimonials

"The hand-held paper-based biosensor will completely democratize the ability to collect [species and population] information, dramatically expanding the capacity of stakeholders to make on-the-spot management decisions and extending their monitoring abilities…..We can also see this device as the beginning of a new paradigm in environmental monitoring by enabling participation by the general public – in essence, enabling crowd-based monitoring. With the ultra-low-cost of the device, communities, schools and individuals can directly participate in conservation efforts. One of the goals is to create a device that can be operated by a non-trained person and to design it in a way that can be easily produced. Such advancement in technology will enable us to learn much more about the impact of industrial operations and other anthropogenic effects on the environment, within our region of interest and beyond, and allow our industrial partners to make on-the-spot decisions on the impact of our operations locally."

Scott Grindal, Representative and Senior Environmental Coordinator

Canada's Oil Sands Innovation Alliance (COSIA)

"Current methods in genetic sampling and analysis have issues that prevent them from being utilized across [snow leopard] range countries including restrictions on exporting genetic material to other countries for analyses, slow and/or expensive processing to extract information about species of origin from genetic materials, and lack of capacity to conduct genetic analyses locally.

The proposed project's success could lead to substantial conservation benefits, especially to threatened and/or heavily trafficked species…..we see huge potential on developing it for species of interest in Central and South Asia."

Dr. Koustubh Sharma, International Coordinator

Global Snow Leopard Ecosystem Protection Program (GSLEP)

If you're interested in supporting this project or learning more, please contact me either on the email address below or through the contact form on the website.

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