Science & Society

EMBO reports

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How science is helping detectives to track down poaching and illegal trade in wildlife

Adam Gristwood

The migration of the European eel is one of the nature's most remarkable journeys. To spawn, the female eel swims downstream from freshwater lakes and rivers, 6,000 km across the Atlantic to the Sargasso Sea. Her body chemistry changes to cope with saltwater, her stomach shrinks to conserve energy, and her pupils widen so she can see better in the low light of the ocean. Once hatched, the eel larvae grow into tiny leaf-shaped creatures less than a centimetre long that are carried by ocean currents back across the Atlantic (Fig 1). The odds of making it back to Europe are thought to be less than one in five hundred. Due to pollution, overfishing and habitat destruction, they are now critically endangered. And soon, they could be made extinct entirely by a new threat: illegal poaching.

> *"Wildlife crime has exploded in the past 10–15 years, and is now the fourth largest crime area in terms of profit behind illegal drugs, counterfeiting and human trafficking"*

Thus, when 18 tonnes of eel meat was discovered in shipping containers in Vancouver harbour in May 2018 during Operation Thunderstorm—a major international wildlife crime sting led by Interpol—officials were taken aback by the sheer extent of an illegal, globalised trade that threatens wildlife not just in distant savannahs or jungles but on the doorstep of some of the world's richest nations. "Eels cannot be bred in captivity: we have found that they get poached in countries such as Portugal, Spain, Italy and France, are transported in hold luggage through major transport hubs including Heathrow and Frankfurt airports to Hong Kong," explained Sheldon Jordan, Director General, Wildlife Enforcement and Climate Change, Canada, who led Operation Thunderstorm for Interpol's Wildlife Crime Working Group. "From there, they are smuggled into mainland China, farmed, and later sold on as American eel, which is legal to trade and not endangered."

Illegal trade in wildlife

Operation Thunderstorm brought together police, customs and wildlife authorities from 92 countries, and was the second major global wildlife crime operation organised by Interpol in the past two years. Its main objective was to embolden countries to link up intelligence, identify criminal activity specific to their part of the world, and report back to Interpol and the World Customs Organization. The four-week initiative recovered 4,000 birds, 27,000 reptiles, 48 live primates, 14 big cats, 25 tonnes of wild meat from carcasses as diverse as bears, crocodiles, whales and zebras, tonnes of wood and much more besides (Fig 2). It also sparked leads for further investigations, in particular into globalised networks driving much of the world's illegal trade in wildlife, an enterprise that when factoring in animals and plants is estimated to be worth up to €125 billion annually [1].

"Wildlife crime has exploded in the past 10–15 years, and is now the fourth largest crime area in terms of profit behind illegal drugs, counterfeiting and human trafficking," Jordan said. "The whole system is very complex and interrelated, directly affecting hundreds of millions, if not billions of people. We tend to look at it as victimless crime, but in reality we are all victims of it. It's stealing from our economies, ecosystems and habitats. It undermines markets for legal wildlife trade, and contributes to the destruction of resources and the spread of disease. It's also believed to contribute to the financing of other criminal activities and to undermine global security. To put the whole issue into context, between 2007–2014, there was a 7,000% increase in rhino poaching. In a window of less than a decade Tanzania lost nearly two-thirds of its elephant population. Do the math. These species have 10–20 years before their populations crash if present trends continue."

> *"Being able to show the scale of their network, where they are operating and how the cartels link together is perhaps the most vital thing that we can do."*

At present, wildlife crime is estimated to grow three times faster than global GDP, and it has been described by Interpol and the UN as a threat to development, peace and security. The causes are diverse, including rising demand; high profits; low risks of capture; poor governance; political interference; lack of funding for police, prosecution and courts; and failures to develop conservation initiatives that truly benefit local communities. And it is apparent that in many regions around the world, the crisis is deepening [2].

What is less clear, however, is how to turn the tide. "One of the areas where we are increasingly putting our efforts as an

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DOI 10.15252/embr.201847452 | EMBO Reports (2019) 20: e47452 | Published online 14 December 2018

Figure 1. European eels are a critically endangered species. Credit: Ecofact.

enforcement community worldwide is in intelligence led policing," Jordan said. "We need to collect information, scope out what the issues are and who the high-risk people or commodities might be, so that we can make the interceptions that can give us the information to start going up the food chains of these organisations. A lot of wildlife crime opportunistic, but there is also a lot that is organised—you would not have rhinos literally being decimated if there were not coordinated efforts behind it."

Zooming in on criminal networks

One of the most charismatic victims of organised wildlife crime is the pangolin, an armadillo-like animal that has, over the past decade, become the world's most trafficked mammal (Fig 3). "As traditional markets start to dwindle, a common method of major traffickers is that they create a new market," explained Samuel Wasser, a conservation biologist at the University of Washington, USA. "That happened with pangolins. In the past, they were used only minimally for medicinal purposes, however some manipulative entrepreneurs started to put the word out that pangolin scales have huge medicinal value. Suddenly everyone was hunting them." Pangolins defend themselves from predators by rolling up into a ball. But this makes them easy prey for humans, who can simply pick them up and put them into a bag. More than a million have been seized in past 10 years, a figure that is thought to represent less than a tenth of the total numbers trafficked. "That's a hell of lot of pangolins," Wasser said. "How many are left? It's an urgent problem."

Wasser argues that given the huge challenge of unearthing trafficked wildlife from, say, the millions of shipping containers transiting around the world each year, it is crucial to tackle the problem at its source. Together with his graduate student HJ Kim, he has launched an initiative to map the genetic diversity of four pangolin species across their native range in Asia with the aim of mapping poaching hotspots. It is an approach that has already been used to combat trade in illegal ivory. More than 40 tonnes of illegal elephant ivory is seized every year, and Wasser has been trying to pull together evidence that could help to stop it (Fig 4). His work has two main objectives: to identify where the majority of this ivory is being taken, and to identify the shipments that individual criminals are responsible for. "We focus on large ivory seizures, a minimum of half a tonne," he said. "70% of all the world's illegal ivory is in such seizures, bearing the hallmarks of organised crime."

His group have pioneered methods to extract DNA from ivory and analyse microsatellite markers, similar to the techniques of forensics teams at human crime scenes. They take a small piece from the

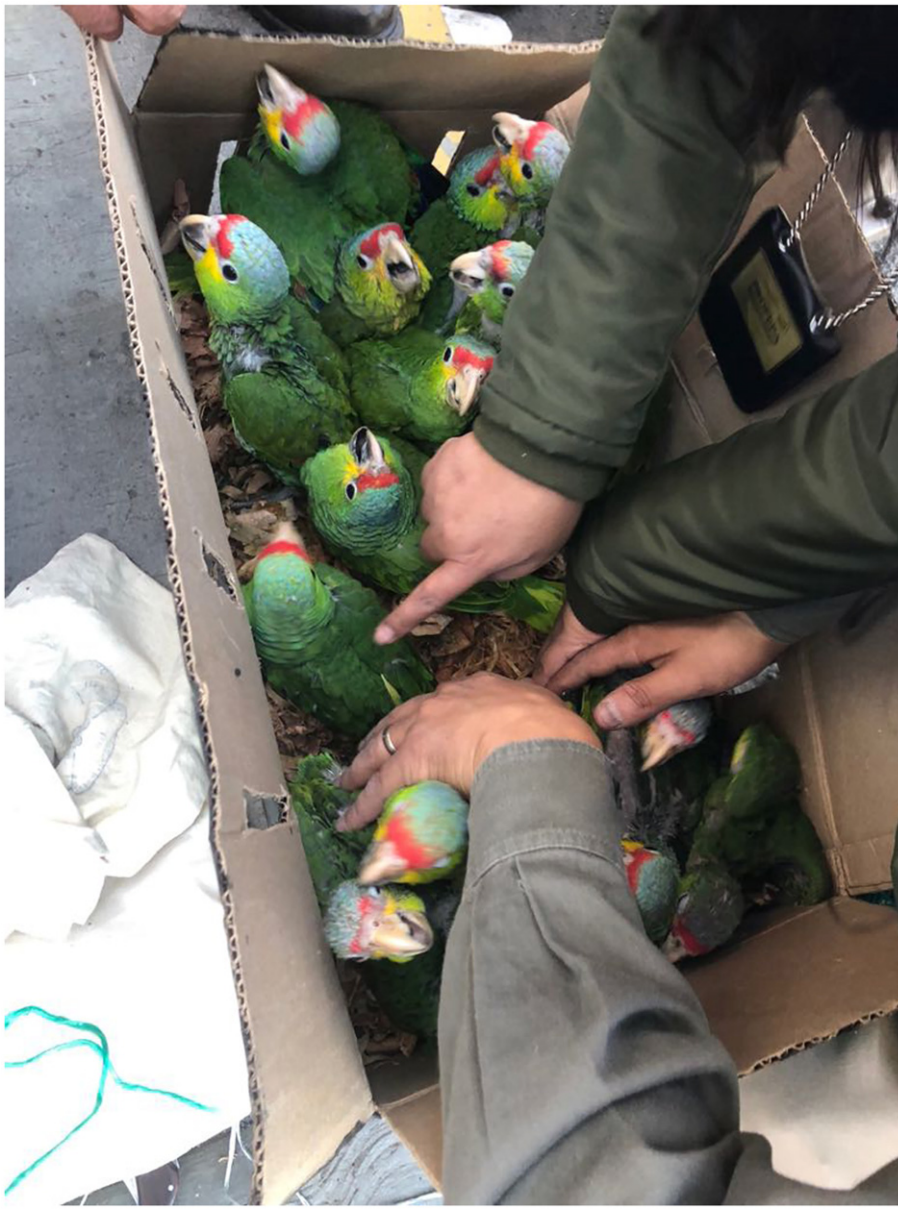

Figure 2. Agapornis parrots intercepted by authorities during Operation Thunderstorm. Credit: Interpol.

base of tusks recovered by seizures, pulverise it into a powder and extract the DNA. Over the past 15 years, the team have created a comprehensive geographic-specific reference map that enables them to trace ivory back to locations across Africa using something that shares ivory's genetic information: their dung. "We used DNA from dung to map elephant genetics across the entire continent of Africa," Wasser explained. "We now have a very good representation of the elephant genetics across the continent. When we take the genotypes of ivory from a seizure, we compare it to our map using a statistical algorithm and can identify where the main poaching hotspots occurred."

The work has shown that most of the ivory taken over the past decade originates from two main poaching hotspots: one that includes forests of Gabon and the Democratic Republic of Congo and another centred on savannahs of southern Tanzania and northern Mozambique. "We can take a tusk originating from anywhere in Africa and trace it to within 300 kilometres of where the elephant was killed, sometimes even the park," Wasser said. "It has given us a new understanding of how the ivory trade works. Organised groups of poachers appear to target the same sites over and over again, moving in and out where there is little chance of getting caught. But if you know that the ivory is coming from one area, you can act on this knowledge."

Their efforts come at a critical time for the African elephant. A comprehensive ban on the trade of ivory set out by the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES) came into force in 1990. Yet, when numbers recovered in some parts of Africa, policy decisions were made to allow one-off trades of government stockpiled ivory with countries such as Japan and China. Wasser believes that subsequent legal ambiguities have reinvigorated the ivory trade, with heightened consumer demand, permissive environments, lack of governmental capacity and toothless penalties fanning the growth of organised crime rings. Criminals also exploit a lack of consistency in laws between nations, with networks typically preparing merchandise and exporting ivory out of different countries to where it was poached. "There is a relatively small chance that ivory will be found once it is on a container ship: we need to stop the trade before it enters transit," he said.

Targeting the middlemen and consolidators

The poverty in many affected countries makes it easy to recruit the low-level poachers who typically operate over large areas, know those areas very well and often pay off park rangers to evade capture. Thus, instead of targeting poachers, Wasser's work has focussed on a pyramid of middlemen and consolidators that drives an interconnected trade. Information from seizures, combined with data from an aerial survey of tens of thousands of square miles of savannah, has enabled the researchers to track poaching hotspots across the continent [3].

More recently, through a stroke of good luck, they were able to link seizures to three of the largest wildlife trafficking cartels operating in Africa [4]. In order to reduce their sequencing burden when assessing seizures of hundreds of tusks, the team developed a

Figure 3. More than one million pangolins have been seized in the past decade. Credit: Wikipedia/David Brossard.

way to visually identify tusk pairs. This revealed that many tusks in large seizures are unpaired. Wasser's team used DNA to match tusks found in separate seizures, and learn more about how consolidators are moving ivory around the continent. This allowed them to identify the three biggest cartels operating out of cities in Uganda, Togo and Kenya. "We have found that coordinators can frequently be linked to multiple different seizures," Wasser said. "This makes it a major, transnational crime, subject to sentences that are much more severe than ivory trafficking in a lot of countries."

Very few ivory traffickers had ever been jailed for a considerable length of time, until 2016, when a Mombasa court convicted Feisal Mohamed Ali and sentenced him to two decades in prison. Ali was long suspected of being a major ivory consolidator, but was convicted on a single count of possessing illegal ivory. Campaigners celebrated, pointing out that the sentence sent a message to other traffickers that the net was closing around them [5]. Yet, in August 2018 his conviction was overturned, the case mirroring other cases where prosecutions have failed due to interrelated issues such as funding for courts and prosecutions, and corruption.

Notwithstanding, Wasser said it is crucial to remain focussed on strengthening the case against crime networks. "Often, the objective of investigations is on securing the convictions of individual criminals," he explained. "However, most cases don't go to prosecution and even when they do, they fail to look into the bigger picture. We know that the connectivity of these seizures is enormous. Being able to show the scale of their network, where they are operating and how the cartels link together is perhaps the most vital thing that we can do. Gathering intelligence on these crimes requires collaboration between governments. We need to understand the breadth and reach of these criminal networks and to use that to provide a roadmap for financial investigations into these crimes. Countries often work hard to solve these crimes in isolation, thwarting the ability of international investigators to bring down the largest criminal syndicates. It's losing sight of the forest for the trees."

Build intelligence

Building forensics capacity is widely regarded as an important goal when developed in a manner that facilitates collaboration between nations. Ken Goddard, head of the US Fish and Wildlife Service (FWS) Forensics Laboratory in Ashland, Oregon, said that a major challenge is to convince authorities of the seriousness of the crimes in the first place. "When prosecutors have

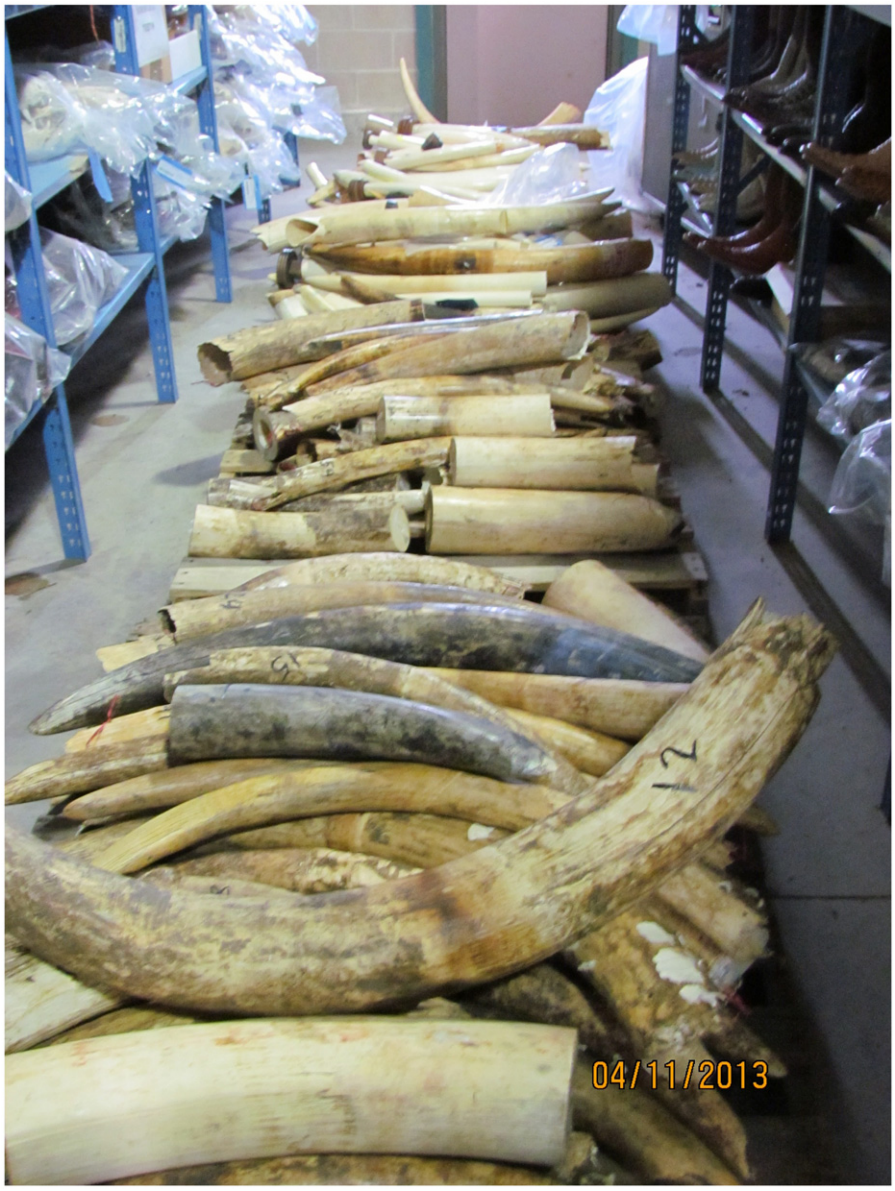

Figure 4. More than 40 tonnes of illegal elephant ivory is seized every year. Credit: USFWS.

murder cases to deal with, they might ask: do you really want us to work on an animal case instead?" he said. "The result is that there are very few people going after the bad guys."

There are currently more than 5,800 species of animal and over 30,000 species of plant protected by CITES, and the aim of forensics laboratories, Goddard explained, is to deliver evidence that can make cases as clear-cut as possible for investigators. "All police crime labs do two things, they analyse and compare evidence, and then, in a triangular fashion, they try to link suspect, victim and crime scene together with that evidence," he said. But for many wildlife crimes, there is another twist in the tale. "If you have a whole elephant, it is pretty obvious it is an elephant. But often we receive pieces, parts, products, maybe some skin that has lost species defining characteristics that told you what it was. You have to come up with new ways of identifying species to provide the evidence needed to testify in court."

Astonishingly, the FWS Forensics Laboratory is the world's only full-service crime laboratory dedicated to wildlife law enforcement, providing a service not only for the US government but also for all 182 nations party to CITES. Its services need to cover diverse areas such as chemistry, criminalistics, genetics, morphology and pathology. "We are sadly the only lab with all of these capabilities," Goddard said. "We would like not to be. We try to encourage other countries to develop similar labs, the idea being there will be more hands and brains to share technology and develop new protocols and procedures. In an ideal world, we would have labs in Africa, Asia, Europe, everywhere, to overcome language and distance barriers: when we are so far away, it can be a real problem engaging with investigators and the courts."

Since the 1980s, the laboratory has been building an archive that can be used by morphologists to identify flora and fauna and separate knowns and unknowns. It resembles a natural history museum—there are furs, feathers, bones, butterflies, boxes of beetles, whole carcasses, handbags bearing the hallmarks of caiman crocodiles (Fig 5). Some days team members will visit and analyse crime scenes in environments as diverse as coral reefs and Arctic tundra. There is only one constant: expect the unexpected. "Often what we are working with we have never seen before, and we have to come up with solutions on the fly," Goddard said.

When the laboratory was founded in the 1980s, Goddard explains that investigators were limited to "scalpels, cameras and forceps." Nowadays, they are able to lift fingerprints from objects submerged in saltwater; use mass spectrometry to identify the species and origin of types of wood; and use computed tomography to produce 3D images of animal carcasses that can be used to, say, trace the path of a bullet and fragments through a wolf torso. They have provided decisive evidence for prosecutions in crimes as diverse as caviar smuggling and ivory trafficking.

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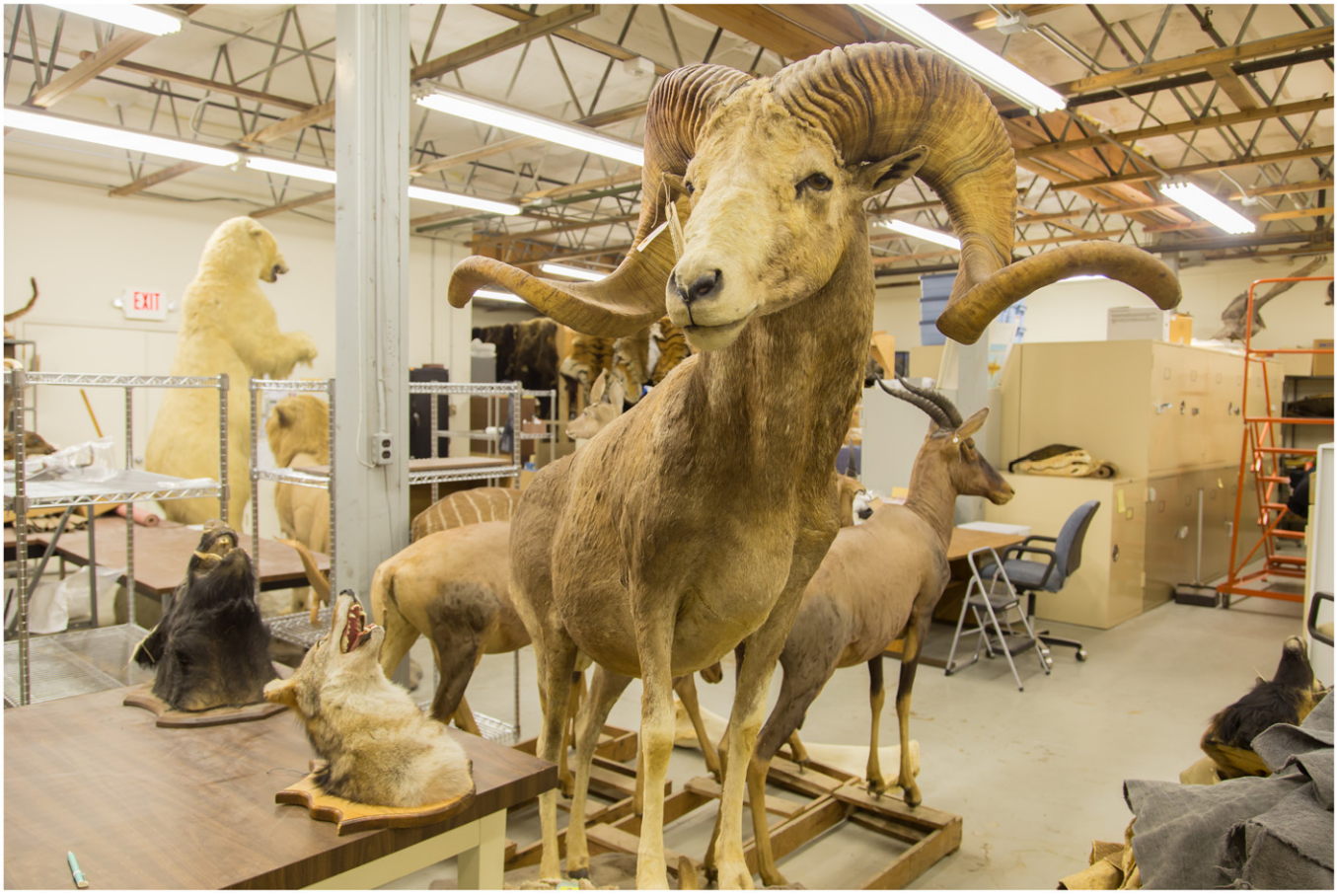

Figure 5. The US Fish and Wildlife Service Wildlife Forensics Laboratory is the world's only full-service crime laboratory dedicated to wildlife law enforcement. It hosts a huge collection of animals and plant species and parts. Credit: USFWS.

But a lack of resources remains a problem. "We have to turn away a lot of work that we do not have time to do," Goddard commented. "One way we try to increase our impact is by training wildlife rangers how to work kill sites as homicide crime scenes. The idea is that when these rangers come across a dead rhino or elephant, they are able to properly work the crime scene, gather the evidence in a way that best supports investigators. One of the frustrating parts is there are hundreds of possible cases out there and we are simply not able to do that amount of work."

Disentangling legal and illegal trade

The continued sight of exotic animals and parts illegally yet openly on sale in daily markets across Brazil inspired conservation geneticist Juliana Machado Ferreira to initiate a grassroots organisation to try to tackle the problem. Freeland Brasil, a spinoff of Asia-based Freeland, seeks to address illegal wildlife trafficking through public education, supporting law enforcement and influencing public policy. At first glance, her seemingly single-handed approach seems in sharp contrast to the sophisticated facilities of the FWS laboratory. But her goals are comparable. "It is not about chaining ourselves to gates: we want to help gather data and information and turn that into intelligence," she explained.

It is estimated that tens of millions of animals are illegally poached in Brazil every year, fuelling both international and domestic trade and decimating populations of all animal classes, with bird populations particularly affected. More than 400 bird species are targeted by the illegal pet trade, including some of the most striking creatures on the planet—yellow cardinals, golden parakeets, hyacinth macaws and many more. Some are poached alive, others killed for their feathers or meat. Freeland Brasil works with legislators, the executive and the judiciary with the goal of strengthening environmental legislation to put a stop to it. "It is a war zone in our congress right now," Ferreira said. "But we are non-partisan: we work on technical support for all parties, as well as on the development of a national strategy for wildlife trafficking. Through this, we hope to guide government agencies in putting money into areas such as training, and also rethink the ways that crimes are prosecuted."

One problem lies in a lack of coordination between Brazilian states. The situation is complicated further by the fact that many exotic species can be legally traded with a permit. "One of the biggest issues in Brazil is the legal market: the captive breeding of wild species is an entrance door for poached illegal wild animals,"

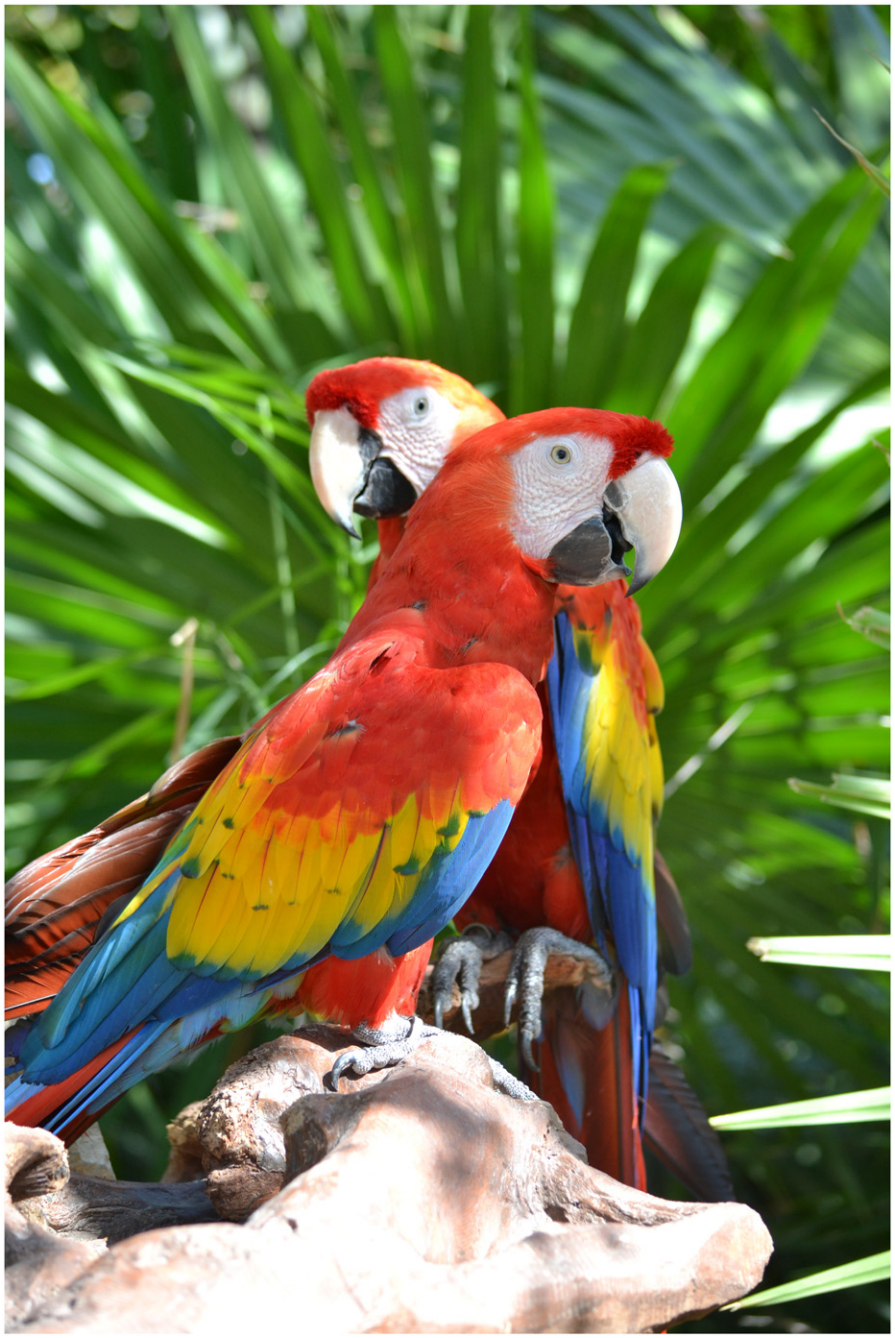

Figure 6. Numbers of scarlet macaws have plummeted in Central America due to poaching. Credit: Wikipedia/Noyolcont.

Ferreira said. "Anyone can fake papers, tags or microchips, it is so incredibly easy and profitable. Our aim is to work with inspection and law enforcement officers and use intelligence and data to investigate breeders that seem suspicious to us: for instance, someone who is selling many more chicks than breeding pairs might be able to produce."

Ferreira, who has worked with the FWS laboratory, initially wanted to create a similar facility in São Paulo. "I soon realised that the costs and logistics of doing that would be insane!" she said. "The government is cutting back on personnel – if they run the lab it is going to become junk in two years." Instead, she has focussed on the development of smaller initiatives, including education programmes, co-producing a book about scientific advances to combat wildlife trafficking, leading policy and political engagement, and developing an online platform that provides authorities with timely and relevant information relating to trafficked species.

However, funding is a major issue. The online platform is currently out of service, and while Ferreira has negotiated space for an independent forensics laboratory in São Paulo, it is not yet operational. "The idea is to perform tests and research directly requested by the government," she explained. "We must perform the basic research that is needed, when it is needed. The everyday lab costs are achievable, but the big problem is paying for the personnel we need. People working on this kind of analysis are highly skilled, but most grants do not allow me to pay employees. Right now, I have someone working for me in the USA speaking to foundations and private donors so that I might get just two years of salary for my staff. We have space, yet it still needs remodelling and equipment and, unfortunately, the lab remains empty. It is very frustrating, every time there is a change in government we seem to go backward again."

Ferreira pointed out there is also a need to address complex social issues. "A lot of the time people who trade illegally and keep protected species in their home do not have stable sources of income, education or healthcare," Ferreira explained. "It is a political issue because of the lack of state presence and legislators; it is a historical issue because the use of animals is an integral part of our history; it is a geographic issue because most of the people keeping animals brought the culture to cities; it is a biology issue because of the biodiversity and conservation aspects; and it is an animal welfare issue."

This is why public and policy education campaigns are so important, Ferreira added. "It is about the power and responsibility of consumers," she said. "It is about what kids can do as citizens concerning wildlife trafficking. It is about understanding the true meaning of healthy ecosystems and biodiversity, making the connection between the removal of birds from an area and the effect that that might have on seed dispersal, trees and even the entire ecosystem. It is hard but we can make a difference."

Think global, act local

Patricia Escalante, a geneticist at the National University of Mexico, argues that it would likely require a complete ban on trade in exotic birds to effectively address the problem of trafficking. "Not all species are endangered, but authorities have difficulties identifying them," Escalante said. "Several people in government are in favour of "sustainable use," but it is so difficult to regulate. It is better at this point to have a complete ban. The main problem is that often justice is simply not applied."

> *"More than 400 bird species are targeted by the illegal pet trade, including some of the most striking creatures on the planet…"*

Largely due to the illegal pet trade, the numbers of scarlet macaws in Central America has plummeted 95% since the 1970s (Fig 6). Some experts estimate that in less than a decade they will be gone completely unless radical action is taken. "The scarlet macaw has several remnant populations in Mexico," Escalante explained. "Unfortunately the government does not want to pay for lab tests, and sometimes releases birds without knowing if they are from the correct population."

Escalante's team undertake phylogenetic studies and combine these with genetic markers for bird populations. When a bird is confiscated, the idea is that by making a simple genetic test, authorities can establish quicker whether the bird is legal to trade. The team have developed low-cost laboratory kits that enable identifications when morphological clues are not visible. If the police department has a simple laboratory, they can carry out genetic tests within 24 hours. "Some government offices insist in allowing some trade in non-endangered parrot species," Escalante said. "We wanted to offer this tool so that they could regulate it."

Escalante also works on an initiative to reintroduce captive-bred scarlet macaws into the wild and now also aim to do the same with wild birds captured by authorities in seizures. She has led a project that has successfully reintegrated 150 scarlet macaws into the forests around Catemaco lake in Veracruz state. However, this comes with major challenges: animals need to be protected from further poaching; they must be in good health and display healthy reproductive behaviour; and then, there is the question of whether the population has adapted to specific local conditions. "We are using the species as a flagship for conservation," Escalante said. "We do a lot of work with local communities, to convince them of the value of taking care of these animals. People are very accustomed to having a pet parrot and do not realise that the populations are collapsing. The birds need a lot of retraining for their survival skills, but most of the ones we have worked with have survived."

> *"It can be overwhelming sometimes, but I do this out of conviction and for future generations."*

While this number is just a tiny fraction of the numbers of animals lost from trafficking, the project is raising public awareness of what is at stake. And Escalante argues that conservation projects offer hope that one day it will be possible to turn the tide on the wildlife trafficking crisis. "The most rewarding part is to hear their screams watching from the edge of the lake in the early morning or late evening," said Escalante. It is a sentiment bolstered by other successful conservation initiatives such as the reintroduction of golden lion tamarin monkeys in Brazil, the brown bear in parts of Europe and the recovery of the rhino population in Nepal [1].

These and other approaches such as tracking the movement of poachers and transit routes; methods to increase consumer awareness and decrease demand; promotion of safe whistleblowing; and measures that increase transparency in policy making and expose money laundering trails provide refreshing counterweights to the formidable challenges of tackling wildlife crime. "I hope that parrots and macaws will last long enough so that we can educate more people not to consume them at this cost, so that some of the perpetrators go to jail, and so that others are discouraged," added Escalante. "It is easy to get disheartened – I recently returned from a trip to the Guatemalan border and witnessed the trade in illegal wood first-hand: it was shocking. It can be overwhelming sometimes, but I do this out of conviction and for future generations."

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