Thanks to Africa's wild dogs and an American pioneer, the key to unlocking the science of scent — and saving many endangered species — is right under our noses

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ESSENCE OF THE MATTER

The rapier nose of Jean-Baptiste Grenouille, the fantastical anti-hero of Patrick Süskind's novel *Perfume*, could dissect 10,000 strands of odours. It was a remarkable feat, but this concept is pure make-believe for ordinary humans. Why? Because in reality, the science of scent remains a complete mystery to us.

For example, we still don't know exactly which compound attracts a dog to a bitch on heat, we cannot chemically comprehend why we kiss each other, and, despite all the false claims on the internet of musky, sexy sprays, no one has ever identified a human pheromone.

But right now, in a lab near Maun, Botswana, a team of scientists are working towards identifying volatile compounds in wild dog urine which may help solve some of these riddles. The camp, run by American Dr John "Tico" McNutt, is at the forefront of conservation of predators, and now the forefront of communication science. Its work centres around the behaviour of several packs of wild dogs — who use urine to mark territory — living in the Okavango delta. McNutt has been studying them for 20 years, alongside cheetahs, hyenas, leopards and lions, as part of the Botswana Predator Conservation Trust (BPCT), a project he runs with his wife, Lesley.

Wild dogs pay scant attention to the lines on maps and the makeshift wire fences that mark the edges of conservation areas in most of Africa, and once outside the protected areas they are vulnerable to shooting, poisoning, snaring and collisions. Numbers have dwindled to fewer than 6,000. But McNutt could be their saviour. No one has researched their behaviour more than him and his colleagues Dr Peter Apps and Dr Lesego Mmualefe. They are using gas chromatography and mass spectrometry to identify the compounds in the urine that make the dogs react in the way they do. The research, which is known as the BioBoundary Project, could revolutionise conservation in Africa.

In fact, the potential applications of the project reach far wider. They include enhanced breeding in zoo and domestic animals, disease diagnostics (the use of human body and breath odours in medical diagnostics is already being studied), population monitoring, repellents, baits and attractants.

But there is arguably no bigger problem in Africa than human-wildlife conflict. Wild animals trample and eat crops and humans kill them as a result. The BioBoundary Project could take the extraordinary step of helping farmers and rural communities all over the continent and conserve endangered predators at the same time.

The idea first came to McNutt in 1996 when there was a disease outbreak in his study area. Five out of ten packs died or disappeared. Though it was obviously devastating it gave McNutt an opportunity to record how the dogs re-colonised.

LEFT: One of the wild dogs being studied by Tico McNutt stalks through grass at Santawani reserve in the Okavango delta ABOVE RIGHT: Urine samples in the lab at Maun

He says: "What I observed was several months of the neighbouring packs that had somehow avoided the ravages of the disease behaving as if their absent neighbours were still there." There was no territorial expansion and the dogs showed respect for boundaries in the absence of living neighbours for more than six months. This showed the persistence of the chemicals. "I came to realize that they may not need neighbours at all, but only the chemical signals of neighbours to identify where territories start and end. This led me to reason that we might be able to manage the ranging behaviour of wild dogs using their own communication system."

McNutt realised this could be the key to the survival of wild dogs in their natural habitats. He says: "If we could identify (and synthesise) the chemical components that signal residence and territoriality to wild dogs, we could provide residents that have no neighbours (at the edges of wildlife areas, for example) with 'virtual neighbours' and in so doing, decrease the extent of conflict these endangered species encounter in areas where they can cause problems for farmers."

Apps adds: "If we can replicate territorial scent and use bioboundaries to stop established breeding packs from wandering out of protected areas then the African wild dog populations would be a lot more secure. And in principle it would work with wolves, spotted hyenas, lions — any animal that uses scent to create a boundary."

McNutt set up the BPCT in 1989 and, with Lesley's help, made it into one of the largest predator research projects in Africa. The BioBoundary project seemed fated to happen. McNutt and Apps met by chance at Maun airport and, after a long chat, realised that McNutt's ground-breaking biological field research into wild dogs and Apps' analytical chemistry (as well as a PhD in zoology) were a perfect match.

Their union has opened the door to understanding the semiochemistry (using substances to communicate) of wild dogs. But it has not been without difficulty. Biologists

and chemists view semiochemical problems from radically different perspectives, and another key stumbling block is the fact that humans do not use their olfactory systems like other creatures. As Apps says: "Smell has always been the Cinderella sense. One of the reasons why we don't understand chemical signalling in mammals is that our sense of smell is miserably inadequate compared with theirs. Nearly all mammals have noses that are at least a million times more sensitive than humans', with correspondingly more sophisticated neural processing of the olfactory inputs. Mammals live in a world of smells that humans have no concept of."

Dr Boris Schilling, an olfactory scientist at the fragrance company Givaudan, understands this well, and is impressed with the BioBoundary Project. "This is very interesting. The study is profiting from the high power of state-of-the-art analytical methods that allow them to identify minute amounts of chemical components in the urinary marks of wild dogs."

While the concept of the project is clear, the chemistry is certainly not. There are thousands of volatile organic compounds that could be involved in chemical communication, and these have to be separated and identified, and their biological roles deciphered. Historically the work has always been complex, lengthy, and painstaking. For example, the silk moth pheromone bombykol, the first pheromone to be identified, was only isolated in the 1950s after researchers spent two decades collecting just 6mg of it from about 500,000 moths. And even in 1996, it took Dr Bets Rasmussen, of Oregon, more than a decade of work to isolate a reproductive pheromone of the Indian elephant.

Identifying the African wild dog territorial compounds is as difficult as chemical analysis gets. Apps says: "The challenge that we face in identifying the signalling chemicals is that they are a tiny minority among hundreds or thousands of other organic chemicals that occur in wild dog urine and faeces, and each sample might contain as little as a billionth of a gram of the active compounds."

The first analytical step is to separate these hundreds of chemicals using gas chromatography, which is ideally suited to odours because it works on chemical vapours.

A chromatogram is to an odour what a sonogram is to a sound — it is the closest it is possible to get to a picture of a smell. Because the odours are such complex mixtures the chromatograms — graphs which display quantities of a substance's constituent chemicals — have hundreds of peaks, and the challenge is to work out which of the many chemicals are sending the territorial message.

By comparing urine chromatograms with those from faeces, and urine samples from different dogs, packs and places within a home range, Apps says: "We can eliminate the compounds that are just metabolic waste products, or which are not connected with territorial behaviour. In addition we know that any chemical that sends a territorial signal has to be persistent, and it has to be reasonably specific to wild dogs, so we can draw up a short list of the peaks on the chromatogram that match the requirements for a territorial signal."

But chromatography alone cannot identify the chemical compounds. The next step is to link the gas chromatograph to a mass spectrometer, which bombards the separated compounds with a beam of electrons. Apps says: "This fragments the molecules into patterns of fragments (the mass spectrum) that are characteristic of the molecular structure. By examining the mass spectrum or comparing it with the spectra from known compounds we can identify most of the molecules."

The compound that marks the dogs' territories could be known, or it could be completely new. Any compounds that are identified as potential territorial markers have to be tested on wild dogs in the field. The animals are wide ranging and scarce, and are not as complicit in being tested as, say, mice. After two years the team has identified more than 100 compounds from wild dog urine and faeces, and a handful of them are candidates for testing in the field. They may well be semiochemically irrelevant, or may already be very close to a workable prototype of an artificial territory marker.

Apps adds: "Once we have identified the compounds that are significant for territorial boundaries and measured how much of each is in the scent marks, we can reconstruct the scent marks using pure chemical compounds."

Semiochemistry is the next hugely important area that is waiting for a technical or conceptual breakthrough to trigger rapid progress — akin to the one PCR gave to genetics or MRI, CAT and PET scans gave to brain research. This might be the finding that launches another wave of progress. Similar techniques could help identify a human pheromone.

The identification of a territorial semiochemical in a natural population of large carnivores, and the first application of semiochemistry to conserve an endangered large carnivore, will be a huge breakthrough in the science of scent. "It could be the intervention that brings African wild dogs back from the brink of extinction," says Apps.

And when a wider range of the semiochemicals that influence mammal social behaviour and reproduction have been identified they could be used both to protect populations that are under threat and control pests like mice and rats. And as mentioned earlier, the scope of other potential applications is huge. Imagine if we could use a simple smell test to identify people at risk of Parkinson's disease, as has been proposed by German researchers. Or consider the health benefits of a cheap, concentrated mosquito repellent that is 100 per cent effective. Better still, ponder a perfume or aftershave so irresistible that ... well, you get the idea.

Sadly, in Western suburbia, we're not yet in a position to save money on a fence and keep the neighbours out by peeing round the garden. But you may soon be able to get a formulation to stop the neighbourhood mutts from messing on your lawn. In the developing world, such a product could have profound consequences. Charlie Mayhew, the chief executive of TUSK Trust, a conservation charity and backer of the BPCT, says: "To crack and mimic the chemical code of a predators' scent mark would bring far-reaching benefits for many rural communities right across Africa. Tico McNutt's BioBoundary Project is one of the most exciting research initiatives that I have witnessed in 20 years. Applying hard science as a means to help to alleviate the perennial problem of human-wildlife conflict, which blights so many communities and causes conservationists so much concern in their efforts to protect predators, is simply brilliant." Bioboundaries could be a lifeline in one of the biggest clashes of them all. ●

www.bpctrust.org

WEE FACTS

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Urine glows under ultraviolet light.
Porphyrins and certain chemicals in proteins react to the light.

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UV-sensitive predators, such as kestrels, are thought to use urine tracks to home in on voles and other small mammals.

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Feeding dogs ketchup can stop their urine damaging lawns.
The salt in ketchup makes dogs drink more, diluting the nitrogen in their urine that causes yellow patches. BEWARE: excess salt can be dangerous.

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Last year, astronauts on the International Space Station drank purified urine.
It reportedly tasted fine — but had a slight tang from the iodine in it.

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Compiled by Pia Fisher