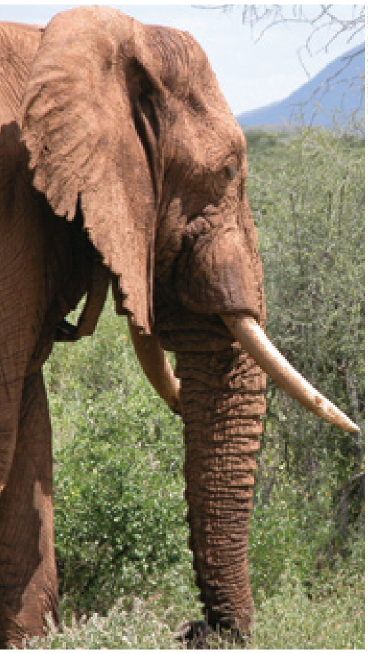


Fritz Vollrath has turned from spinning spiders to roving elephants to understand the decisions made by animals

Trunks, tracks and spiders' webs

In Roman times, elephants roamed widely over most of Africa and Asia, probably linking up somewhere around Mesopotamia. Indeed, not very much earlier, the elephant tribe consisted of hundreds of species ranging even further afield, covering most of Europe and America as well – with mammoths of up to five metres in the icy north and one-metre dwarf forms on Mediterranean (and Californian) islands. Everywhere, the large beasts shaped their environment by pushing over trees and denuding forests, thus creating open grasslands. Those halcyon days are long past, and all but two species are now extinct. Times have become rough for the survivors: over the past 100 years, the Asian *Elephas maximus* and the African *Loxodonta africana* have had to yield to human expansion and retreat into a few small pocket-size remnants of their natural ranges. But even these islands in the human ocean are now under threat, and with them, the future of the last elephants.

Even so, the African elephant remains a keystone species crucial to the natural function and transition of a variety of African ecosystems. For this reason it has become a focus of scientific study. The rocketing ivory market in the 1970s and '80s fuelled excessive poaching; populations everywhere were depleted so rapidly and effectively that global action was taken and the trade in ivory banned. This led to a general revitalisation, and today many local elephant populations are on the increase. To the tourist, this is a wonderful thing; to the resident farmer, much less so. Indeed, complaints about elephant 'troubles' are becoming everyday stories in the press. Much of this ill-will is the result of an expansion of farming communities into traditional elephant territory combined with the loss of cultural adaptations that once supported cohabitation. Unfair as it may be, calls are growing louder to renew 'sport'-hunting in order to 'make elephants pay' for their general protection. And even ivory trading is now back on the agenda, with obvious implications for poaching.

The result is that today's conservationists approach elephants with renewed urgency. Fortunately, since the 1960s many new research tools have emerged. Among those of particular interest are tracking devices that, like 'SatNav' systems in modern cars, use data exchange with satellites to pinpoint positions on the ground. With the help of clever electronics and tracking software, such 'tags' allow us to track animals with great accuracy, both in time and space, and over huge areas. Even better, the tags also work as mobile phones that can send and receive text messages, thus enabling scientists to 'talk' to one another nearby in the field station or far-off in the university laboratory – Oxford, for example.

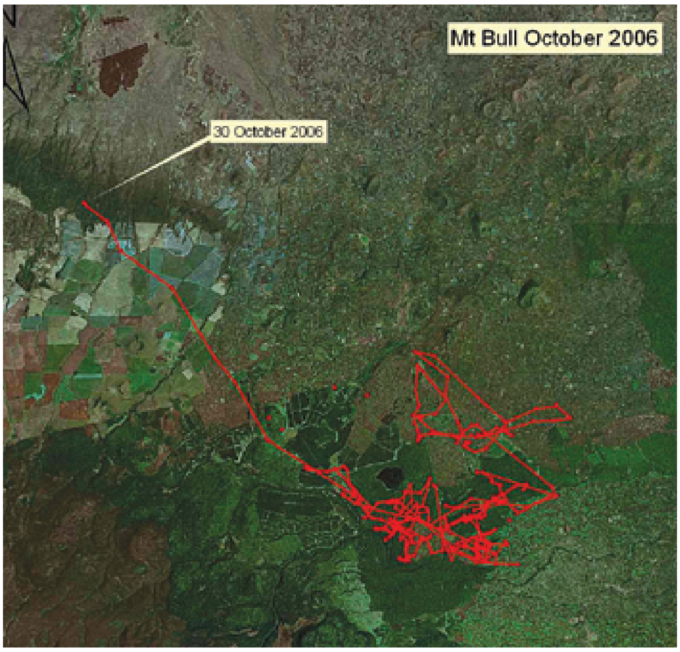
These new developments have put radio-tracking, as it is called, in the forefront of behavioural and ecological studies of wild animals. Gone are the days when a single position 'fix' of an animal took great effort, often making it necessary to circle for hours in a plane as Dr Iain Douglas-Hamilton had to do in the 1960s for his ground-breaking study of the Tanzanian Lake Manyara elephants. This DPhil study, supervised by Professor Niko Tinbergen, Nobel Laureate and founder of the Animal Behaviour Research Group at the Oxford Zoology Department, started Douglas-Hamilton on a series of detailed studies of elephant behaviour and ecology. Today, these studies combine the deployment of state-of-the-art collars with individual recognition by photo-file. Under the aegis of his UK conservation foundation 'Save the Elephants' (STE), the focus of research shifted to Samburu and Laikipia in Kenya, with other major elephant tracking projects in Gourma (Mali, southeast of Timbuktu) and Timbavati (next to the Krüger National Park in South Africa). In Kenya alone there are now more than 50 collared animals automatically adding hourly records of their position to a database

ABOVE: *Bull elephant*

OPPOSITE, TOP: *Studying the route a spider takes to build a web (left) can give insights into the elephant's track (right)*

RIGHT: *Radio collars fitted to elephants make it possible to track them night and day*

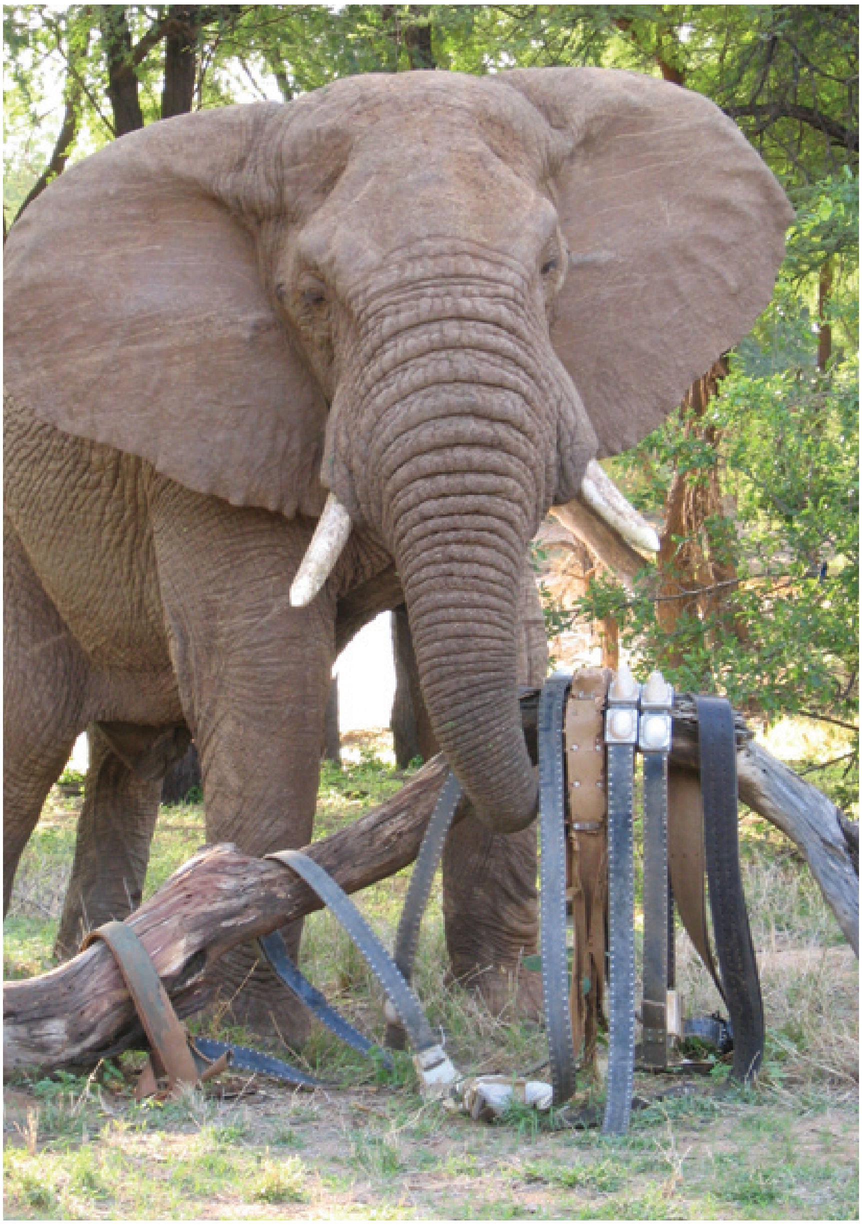
FRITZ VOLLRATH



SAVE THE ELEPHANTS

of over a million fixes. And nearly 1,000 elephants are individually known around STE's core research area of the Samburu National Reserve.

Why is tracking such a powerful tool? What kind of data does it give us, and what kind of insights can we gain from it? Tracks can tell fascinating stories, as Niko Tinbergen elegantly demonstrated in a 1967 Oxford University Press booklet of that title beautifully illustrated by Eric Ennion. But tracks can also be rather misleading: witness the wrong interpretation of footprints that led to Winnie the Pooh and Eeyore fleeing for their lives from the fearsome (albeit imaginary) Heffalumps. Moreover, tracks, if analysed incorrectly, will not represent the salient decisions underlying the behaviour. Take, for example, the spider's web. It is a superb record of the arachnid's decision rules (its behavioural algorithm). Each joint must be perfectly placed in the creation of the overall structure to turn it into the well-adapted fly-trap. Yet in order to make its filigree aerial net, the spider has to make many detours, since it is unable to jump between junctions. Thus the step-by-step track of the animal does not match the finished web. Hence, if we really want to understand web-building behaviour and web-ecology, then it is not the detailed track of the animal that we want to study but the discrete decisions made at each junction, when the threads are pulled taught and joined together. These are the salient features hidden underneath the animal's track; these are the essence of the web's architecture and the result of evolution's balance sheet, where construction costs are weighted against repayment measured in flies.



IAIN DOUGLAS-HAMILTON

Clearly, to gain insights into elephant behaviour and ecology we cannot blindly rely on the track alone. But what are the salient features of a track? Where (and based on what) is a decision made to effect a sharp turn in a path, for example to go for a drink in a faraway river, to find a delicious tree to strip or a nice juicy field of maize to devour? More generally, can tracks tell us whether elephants are able to distinguish between safe areas (such as a conservancy) and unsafe areas? Can they tell us when elephants navigate by knowledge learned from their mothers, and when they orient by local landmarks recalled from their remarkable memories? In short, can track analysis be a way to get inside the elephant's head and see things with its eye? There are many questions and, as yet, few answers. But first analyses are beginning to show patterns. Let us examine two specific examples.

The Samburu and Laikipia study areas of STE lay in Northern Kenya, in the Ewaso River ecosystem, which (from an elephant's perspective) is a patchwork of safe and unsafe areas. The quality of forage is unevenly distributed throughout the area, as is water, and elephants consequently move around this landscape with daily as well as seasonal migrations. Their tracks clearly show that they distinguish between dangerous and protected areas. Across dangerous terrain they streak at night and at top speed to reach a new safe area, where, having arrived, they meander about, slowly and relaxed. Indeed, before making a dash, an elephant might well patrol for days the perimeter of a conservancy. The trajectory of the tracks indicate that the animal knows very well where to go and how to get there, making a beeline for a gap in a fence that is many miles away.

Elephants' tracks clearly show that they distinguish between dangerous and protected areas

While tracks tell us of paths taken, a comprehensive survey also tells us of areas never visited. For example, over the past ten years, STE has accumulated hundreds of thousands of elephant positions criss-crossing its Samburu heartland. Those data show that there are some areas where elephants never go. Why not? One is the local town, Archer's Post – enough said. Others are villages or fenced tourist lodges. But some clearly are neither. A closer look shows that these are steep hills. Calorie calculations reveal that the forage available on the slopes would not be enough to fuel efficiently the huge energy costs required of the elephant to lug its four-plus tons uphill. In this analysis the absence of tracks, not their shape, has exposed an important phenomenon that affects an elephant's decisions: energetic cost-benefit considerations.

SHIVANI BHALLA, STE

Unrelated elephant cows tried to help the matriarch Eleanor as she lay dying

Finally, tracking also enables us to find an animal quickly, be it to collect samples or to observe behaviour at close range. Tracking a number of herds allowed a remarkable observation. Eleanor, the matriarch of a herd, was dying, perhaps as the result of a snake bite in her trunk. Other – unrelated – elephant cows not only tried to help her back up onto her feet, but came from considerable distances with their own herds for days after her death to visit the carcass. At first sight, it seemed as if they were paying their respects. In reality, they were probably visiting to assess mortal risks in the environment and to collect information about the changes in a familiar herd. After all, the death of a matriarch has crucial implications for the knowledge residing in a herd and thus on its collective behaviour. It will be fascinating to see how Eleanor's absence will affect the pattern of the tracks left behind by her old herd on the maps of the STE computers.

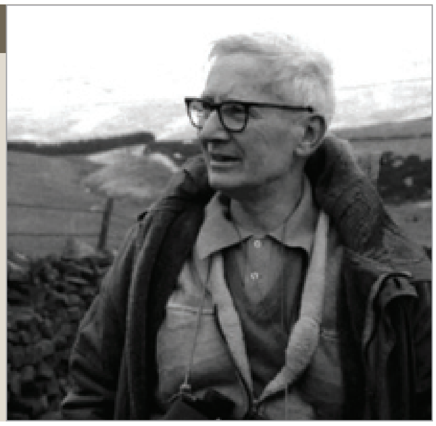
One day, we hope that tracks like these will allow us to infer an elephant's knowledge about all aspects of its environment. Is it far-fetched to assume that this kind of insight might make a difference and ensure that the last remaining members of a once powerful and still magnificent tribe may have a secure future?

Fritz Vollrath *is a professor in the Department of Zoology, and trustee of Save the Elephants.*

See **www.savetheelephants.com** for more on elephant tracking and conservation

Niko Tinbergen 1907–88

Niko Tinbergen, born 100 years ago this year, was Professor of Zoology at Oxford from 1949 until his retirement. He pioneered the science of ethology, the study of animals in the wild, for which he shared the Nobel prize in 1973 with Konrad Lorenz and Karl von Frisch. Tinbergen's students included Richard Dawkins, Marian Stamp Dawkins and Sir John Krebs, and Oxford's Department of Zoology continues to be a leading centre for the study of animal behaviour.



LARY SHAFFER