



# track & trace

## New technologies for studying bird movements

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**B**irds are among the most mobile organisms on earth, with many species literally moving from one side of the planet to the other twice a year. The mobility of birds means that documenting their movements is central to understanding their ecology. It is also critical for conserving them in ecosystems increasingly besieged by humans. The conservation of many long-distance migrants is severely hampered by a lack of knowledge of their habitat requirements and the threats that they face, not only on their breeding grounds and wintering ranges, but also along the routes they follow between these areas.

Our reliance on ringing to deduce birds' movements over local and global scales has largely become a thing of the past, as modern technology now offers a host of electronic and biochemical alternatives. These new

research tools are far more effective for studying long-distance avian movements, although there is no question that ringing still has a very significant role to play in 21st-century ornithology for investigating population dynamics and life histories.

### Listening from the ground

The most venerable of electronic technologies is traditional radio tracking, where a small radio tag is attached to a bird and then detected from a distance. The earliest known use of this technique was in the late 1950s. Traditional radio tracking remains a very powerful research tool, but it is subject to several limitations, one being that a researcher can accurately determine the direction of the tagged bird but often not the distance. This limitation can be overcome by having two observers tracking simultaneously. My own first encounter with radio tracking was in the early 1990s when I spent several weeks assisting with tracking vultures in the Kruger National Park. By simultaneously determining the bearing of a tagged vulture from each of two towers 80 kilometres apart – one south of Shingwedzi and the other north – simple triangulation provided an accurate location of the bird at any given time.

Radio tracking has been given a new lease of life with the advent of automated telemetry arrays. Within the past few years, a network of several hundred automated tracking stations known as the Motus Wildlife Tracking System has been built across Europe and the Americas, providing the basis for continuous tracking of tagged birds. A key feature of Motus is that all tags operate on the same frequency but are digitally coded to allow for the identification of individuals. As tagged birds move through areas covered by the Motus network, they are automatically detected and their



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movements are thereby monitored in real time.

Automated arrays such as Motus are providing remarkable insights into avian migration. A study of Savannah Sparrows migrating along the east coast of North America, for instance, revealed that the adults were much better than juveniles at picking suitable wind conditions at the start of their migratory flights. Adults departed only when favourable tailwinds were blowing, whereas inexperienced juveniles were far less selective. Consequently, juveniles were in the air about 40 per cent longer than adults, making migration a significantly more costly exercise for young birds.

A key limitation of ground-based receivers is that their range is often restricted by terrain, with hills and mountains blocking signals. One way to solve this problem is to have a large number of receivers – this is the approach taken with Motus. Another solution is to put receivers in the sky. The Smithsonian Conservation Biology Institute is currently working with Airbus and United Airlines to develop a system to

track tags that weigh less than one gram by using receivers installed on commercial airliners. This will provide comprehensive coverage along major air-traffic routes and allow for the automated tracking of even very small species.

Radio tags can provide information beyond simply a bird's location. Tags whose pulse rates change depending on whether a bird is moving or stationary reveal activity patterns as well as mortality, when there has been zero movement from the bird for an extended period. Physiological data can also be collected by telemetry. A few years ago my colleagues and I used temperature-sensitive tags to study Freckled Nightjars in winter in Namaqualand. The results showed that on moonless nights, when there was too little light for them to hunt flying insects, the nightjars reduced their temperature by as much as 30 degrees Celsius below their normal active temperatures.

Another physiological variable that can be monitored remotely is heart rate, although the development of this technology for small birds has lagged. Heart-rate >

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telemetry has the potential to revolutionise many aspects of ornithology as it enables researchers to determine exactly how much energy birds expend on a daily basis and reveals the cost of specific activities such as foraging, evading predators and breeding.

#### Watching from space

At present, radio tracking remains the only approach feasible for following most birds, for the simple reason that the tags used

can be tiny. The tags used by the Motus system, for instance, weigh as little as 0.2 grams and can be used on very small birds, bats and even large insects. The tracking of larger birds over long distances, on the other hand, has largely shifted to satellite-based systems. The smallest satellite tags available currently weigh five grams, making them feasible only for species heavier than 100 grams – the size of a Burchell's Starling or Lilac-breasted Roller. Satellite

tracking has the key advantage that birds can be traced anywhere on the planet, but the disadvantage of being expensive; tags typically cost about US\$3000 each and the subsequent cost of downloading data via satellite is often about the same again.

Satellite tracking has been instrumental in recent studies of both migratory and non-migratory African birds. A team of American and German researchers, for instance, used satellite tags to track Black-casqued and White-thighed hornbills in southern Cameroon's lowland rainforests. The study revealed major differences in movement patterns between the two species. Individual White-thighed Hornbills typically ranged over 20 000 hectares, an area nearly four times larger than the 5600 hectares used by Black-casqued. White-thighed also spent much more time in forests disturbed by human activities and were more likely to cross major roads; Black-casqued largely remained in pristine forests, and roads acted as important barriers to their movements. The picture that emerges from these satellite data is that Black-casqued is by far the more sensitive of the two species to deforestation and human activities and that the ecosystem service of

seed dispersal provided by this species is much more likely to be jeopardised.

Other recent research has focused on Common Cuckoos migrating between Europe and central Africa. A project coordinated by the British Trust for Ornithology has particularly caught the imagination of the birding world, because of a website ([www.bto.org/science/migration/tracking-studies/cuckoo-tracking](http://www.bto.org/science/migration/tracking-studies/cuckoo-tracking)) where members of the public can follow, in real time, the movements of individual cuckoos tagged in the UK and now sporting monikers like Boris, Peckham and Mr Conkers. Earlier data from cuckoos tagged in Scandinavia revealed that migrating individuals navigate in a giant clockwise loop, flying south across Libya and Sudan to wintering grounds in the Democratic Republic of the Congo, Angola and Congo-Brazzaville, before moving west to Mali and Niger and returning to their breeding grounds via Algeria and Italy. Similar studies are under way on other Palearctic migrants, including Amur Falcons and European Rollers.

An imminent and extremely significant development for the space-based tracking of small birds is the ICARUS initiative. Spearheaded

by Martin Wikelski of Germany's Max Planck Institute for Ornithology, ICARUS is a joint German-Russian project that will make possible the comparatively inexpensive tracking of small birds and other animals using hardware installed on the International Space Station (ISS). The ICARUS computer processor was transported to the ISS by a Russian rocket in late 2017 and the antenna is scheduled

#### MEMBERS OF THE PUBLIC CAN FOLLOW, IN REAL TIME, THE MOVEMENTS OF INDIVIDUAL CUCKOOS TAGGED IN THE UK AND NOW SPORTING MONIKERS LIKE BORIS, PECKHAM AND MR CONKERS

to go up during 2018. At the time of writing, Russian cosmonauts were training for a spacewalk to install the antenna on the ISS. The tags used by ICARUS (which provide several types of data in addition to an animal's location) currently weigh five grams, but a major goal of the initiative is to miniaturise the tags to the point where they can be used on even the smallest birds. Moreover, ICARUS tags cost

substantially less than current satellite tags and this system is set to make satellite-based tracking far more accessible to ornithologists with limited research budgets.

#### Using GPS

The advent of global positioning systems (GPS), where a receiver uses signals from orbiting satellites to precisely determine its position on earth's surface, created a new way to track birds. GPS receivers can be miniaturised to fit in tags small enough for many birds, logging latitude and longitude as a bird moves. Instead of transmitting saved locations continuously, tags either upload data via cellular networks or to receiving stations. A key advantage of these systems is that the tags can be made considerably smaller than satellite tags. Like satellite tags, their battery life can be greatly extended by adding a miniature solar panel that recharges the on-board battery whenever the bird is in the sun.

GPS tags that use cellular networks to transmit stored location data have been used to track the movements of, among others, Secretarybirds. As part of BirdLife South Africa's ongoing efforts to identify the reasons behind the recent decline in this species, >



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Secretarybirds including Spyrker and BLiNG have received backpack-mounted tags that provide unprecedented insights into the ecology of this species.

Other GPS tags transmit location data directly to a base station

whenever a bird comes within range of the station. Such systems are well suited for tracking the movements of species like large raptors that reliably return to a particular area. A base station installed in the vicinity of an active nest, for example, enables researchers to obtain detailed tracks of birds' movements, regardless of how far they range while hunting.

### Into the future

Several other electronic devices can also be used for studying bird movements. Geolocators are tiny devices that accurately record the time of sunrise and sunset as a bird migrates. After the geolocator is recovered, the downloaded data are used to calculate the approximate latitude and longitude for every day the device was on the bird. Geolocators have been

used successfully on migrants such as European Nightjars and Common Swifts, not to mention the Woodland Kingfishers that regularly returned to nest in Warwick and Michèle Tarboton's garden in Modimolle, Limpopo (see box, below).

Another key research tool is radar. Although birds have been tracked using radar almost since it was first invented during World War II, modern radar systems can provide extremely detailed information on flying birds. It is now even possible to distinguish similarly sized species based on their wingbeat frequencies, and portable vehicle-mounted radar systems can be deployed to remote areas to track migrants flying overhead.

Our ability to follow birds as they traverse the globe has expanded exponentially in recent decades and the future of this field is very bright indeed. The single greatest remaining challenge concerns tag size. In particular, the current five-gram lower size limit to satellite tags means that they still cannot be used on about two-thirds of the world's bird species. The ICARUS system holds great promise in this regard, with the development of very small tags having been one of the key objectives of this initiative since its inception. Given the rapid pace of technological advances, it is quite conceivable that within a decade or two even the tiniest birds will be able to be tracked from space as they criss-cross the world's continents and oceans. ♦



WARWICK TARBOTON

In an update to his article that appeared in *African Birdlife*, May/June 2014, Warwick Tarboton writes: 'Our colour-ringed pair of Woodland Kingfishers returned to our garden and bred again last year, he for the seventh year and she for the sixth. She (red ring) returned on 14 November and he (green ring) on 19 November. They teamed up straight away and this image of them was taken on 22 November. A few days after this, they began inspecting the nest box and she laid the first of her three-egg clutch in it on 1 December. Three chicks fledged and in due course left the nesting area, possibly to migrate.'

### References and further reading

<https://motus.org/>  
<https://icarusinitiative.org/>  
Chasar, A. et al. 2014. 'Spatial and temporal patterns of frugivorous hornbill movements in central Africa and their implications for rainforest conservation.' *Biotropica* 46(6): 763–770.