Satellite Tracking of Raptors – How PTTs Changed Our Lives

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The first author had already become preoccupied with raptors for two of his schoolboy years when, in 1964, he came across a small book about the Lesser Spotted Eagle *Aquila pomarina* (LSE). Two aspects of the biology of this species immediately fascinated him. First, the so-called 'Cain and Abel struggle', also known as cainism, whereby the eldest chick ("Cain") kills its younger sibling ("Abel"), and secondly, the species' lengthy migration routes to southern Africa, the longest of any raptor breeding in Germany.

He was interested not only in how and why cainism occurred, but also the question as to whether this phenomenon could be used to protect this endangered species, by using human intervention to prevent the death of the younger sibling, thereby doubling the reproductive rate of the breeding pair.

Photo by Bernd-U. Meyburg

First eyrie of LSEs where two nestlings fledged due to our human intervention, Slovakia, August 1968.

The LSE was once widely distributed in Germany but, over the 20th Century, its German breeding range had shrunk to a small region in the northeast of the then German Democratic Republic (GDR or East Germany) to the north of Berlin. Although the nearest breeding site was only some 50 km away from my flat, it proved impossible to visit. As a resident of West Berlin, all attempts to arrange observation and studies of these birds were unsuccessful. The Cold War was at its height and West Berlin, surrounded by a Warsaw Pact country, was seen as a particularly bitter enemy of the Eastern Bloc.

Nevertheless the senior author did not give up and he was able to begin eagle observations and experiments in 1968 in Czechoslovakia instead. He managed to make contact with local raptor specialists and get the necessary permits to visit. He soon made friends with Jan Švehlik from Kosice, and his room in his parent's flat was quickly converted into a laboratory which we equipped with an incubator so we could artificially hatch the second-laid eggs and hand-rear the chicks.

Our big day came at the beginning of August that year. Two second-hatched chicks, which had been hand-reared in captivity and ringed, were returned to their nests in the wild and they later fledged with their siblings. We observed them for as long and as well as we could after they flew from the nest, wondering whether both young eagles would continue to be cared for by their parents. This proved quickly and happily to be the case. The next question was whether both would be fit enough to survive the long migration to Africa and back. This was an open question as satellite telemetry (ST) was unheard of at that time, but I already had this dream.

1989 signalled political change and the end of the GDR, an important and decisive moment in my life. During the final months of the GDR regime there were no more political restrictions to LSE research. Telemetry studies, up until then unthinkable, were suddenly possible. At almost the same time an old dream, research into the migration of the LSE to southern Africa using telemetry, came closer to being realized. Satellite transmitters (PTTs) had now become more and more miniaturized and finally reached a size and weight which enabled them to be fitted to this medium-sized eagle. In 1992 the great moment came. We fitted the first nestling with a transmitter weighing 50g.

In 1994 we were able to fit transmitters to the first four adult eagles in Germany and Slovakia. In one case it was possible to document the eagle's complete migration to Zambia, its wintering there, and its spring migration back to its breeding territory in Germany. Luck played a big part here as the transmitters were still battery powered. This meant that they had to be programmed so as to be active only for several hours every few days in order to extend the battery life to almost a year. This complete documentation of the annual route of a European migrant was the first of its kind.

As the population of the LSE in Germany continues to decline and the expansion of the EU increases the threat to the populations beyond the former territory of the GDR, through Poland and into the Baltic States and Slovakia, our previous experience of thwarting cainism came to the fore again. In 2004 two young LSEs flew from an eyrie located to the north of Berlin in Brandenburg. One of them had been captive-reared in a conservation station, before being returned to its nest to fledge. As a result, more second-born eaglets were also captive-reared in 2005 and 2006 and put back in their eyries with their siblings just before the latter flew from the nest.

Our old question still remained unanswered though. Were these rescued birds fit enough to migrate to southern Africa and back? In 2007 we got at least part of our answer. Two of Europe's biggest nature conservation organizations started to support the project making it possible to satellite track young LSEs on a larger scale. At the same time we also began to import young Abels from Latvia since not enough nests were found early enough in Germany to rescue the second-hatched chicks.

Photo by Bernd-U. Meyburg

Two chicks of the LSE shortly after hatching. The smaller one would normally disappear within a few days due to cainism.

In 2007 six young eagles were fitted with PTTs in three nests, each eyrie containing a German and a Latvian fledgling. The second big question arose: Would the young birds from Latvia take the same route as the German ones to arrive at the Bosphorus to continue along the Mediterranean coast to Africa?

In late September the birds left Germany. The Abels migrated at least as well as the Cains. Two of the three Latvian Abels migrated exactly on the same route as the German eagles. One of them was tracked as far as Zambia. Its German nest companion, however, decided to winter in southern Sudan,

a great surprise, because the species was not known to spend the winter months north of the equator. In March and April 2008 the adult eagles we tracked have so far not triggered their return migration. Whether the one year old eagles stay in Africa or return to the breeding grounds is another question which we hope to solve. Considerably more second-hatched young eagles must be hand-reared every year in order to ensure that the population remains sustainable. In 2008 18 more young eagles besides 5 adults are planned to be fitted with PTTs.

Technical development

As for our raptor studies the development of the technical side of satellite telemetry can be divided into three phases: the period during which only battery-powered transmitters with Doppler locations were available, the period during which solar-powered transmitters with Doppler locations were used, and finally the period during which transmitters with GPS locations could be employed.

Taking a middle-sized species such as the Osprey, in 1992-1995 we used battery-powered PTTs with Doppler locations. The PTT's life expectancy was about one year, when programmed to transmit for several hours every few days. We obtained a maximum of 100-150 locations from these PTTs. From 1995-2003 we used solar-powered PTTs with Doppler fixes for medium-sized raptors with a PTT life expectancy of several years (one case of 9 years) providing thousands of Argos locations per annum when sufficient light is available. Since 2004 we have used solar-powered PTTs with built-in GPS devices providing fixes precise to within a few dozen metres. These PTTs also furnish data on flight speed, direction and altitude to allow analysis of behaviour in detail for Ospreys and other similar-sized raptor species.

Depending on the size of the birds other PTTs are available. We used our first GPS PTT on an adult Imperial Eagle in 2003. Since 2007 we have used 22g GPS PTTs for Black and Red Kites. Very soon we hope to track three Hobby Falcons *Falco subbuteo* with tiny 5g PTTs, however with Doppler fixes.

Some highlights

Based on the monitoring of 146 individuals of 14 different species which we fitted with transmitters between 1992 and 2007 (see www.Raptor-Research.de for more information) we report here on a few highlights of our own telemetry results.

Year-round movements

One of our main objectives was to obtain a complete picture of the movements of adults throughout the year: the exact amount of time spent in the breeding sites, on migration and wintering. This was achieved for the first time in 1994-1995 for an adult male LSE tracked from northern Germany to its winter quarters in Zambia using a battery-powered PTT with Doppler fixes. This was the first detailed recording of this type for a European bird migrating to Africa. This eagle spent seven and a half weeks for each of its migrations over a distance of almost 9000 km. It flew a daily average of 166 km and its autumn and spring routes proved to be nearly identical. Its winter quarters in Zambia covered an area of 25,000 kms. We have succeeded in documenting the movements of other eagle species for at least one whole year, such as Steppe Eagles *Aquila nipalensis*, Greater Spotted Eagles *Aquila clanga* (GSE), Osprey, Honey Buzzard *Pernis apivorus*, Black and Red Kites *Milvus migrans* and *M. milvus*.

Thanks to solar-powered PTTs it has later been possible to compare the routes and time spent on several consecutive years. Satellite tracking of a pair of Lesser Spotted Eagles nesting in Germany yielded 3,641 locations in all. Four autumn and two spring migrations were recorded in full between 1997 and 1999. The two males' transmitters provided us with fixes over a period of about 24 months and that of the female 19 months.

The male took up its winter quarters in Zambia 9,300 km from its nest and the female 11,300 km in Zimbabwe, South Africa and Mozambique. She spent almost half the year on migration (47.6%) and only 9% wintering.

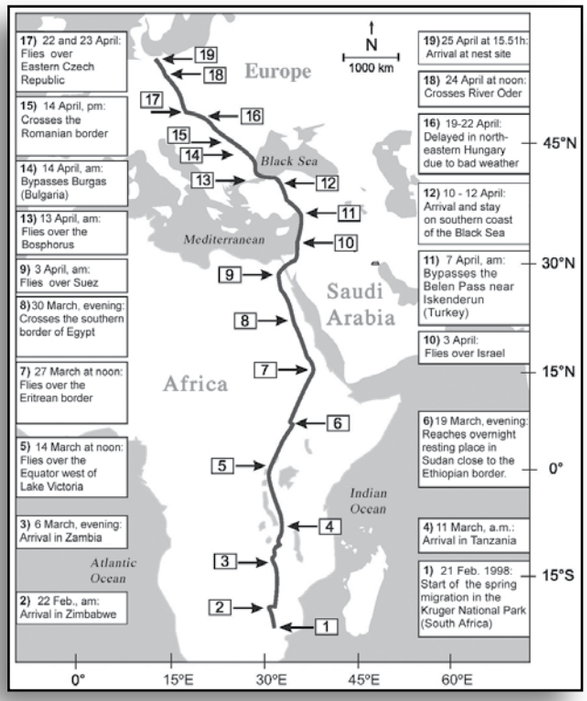

Fig. 1: The migration route of an adult Lesser Spotted Eagle female fitted with PTT 27999 from winter quarters in South Africa to breeding site in Germany with details of some of the passage points. Among the Doppler fixes were all night roosts along the 10,753 km long migration route which lasted 64 days.

The male devoted 35.1% of the year on migration and 21.1% wintering. The migrations lasted an average of 81 days (52-119 days), the autumn migrations being clearly longer (74-119 days) than those in spring (52-64 days). The speed of migration varied not only from year to year but also according to the regions crossed. The longest stages were recorded during the crossing of the Sahara desert (up to 521 km a day), with the highest speed reaching 66.8 km/hr.

The complete spring migration route of the female LSE from winter quarters to breeding site, including all overnight stops, was documented in detail for the first time in 1998 using a solar-powered PTT with Doppler fixes. The female left its winter quarters in the Kruger National Park, South Africa, on 21 February 1998 and 64 days later, on 25 April, arrived late at the breeding site in Germany. During 51 days it covered on average 211 km (min. 18, max. 406 km/day) (see Fig. 1 above). The arrival of the female at the breeding site was observed directly. This enabled, for the first time, proof of a temporary partner change. The female (fitted with a transmitter) from the previous year immediately ousted a new female that had already paired with the last year's male.

An adult female Black Kite furnished inverse results so far as the length of migration was concerned. This bird nesting in Thuringia in central Germany, fitted with a solar-powered PTT on 16 June 2002, has to date yielded several thousand Doppler fixes. Six winterings, mainly in southern Mauritania, and twelve migration routes have been thoroughly documented. Each year it has migrated far more rapidly in autumn - the fastest taking only 17 days (averaging 332 km per day) - than in spring.

Migration routes and wintering zones hitherto unknown

Wahlberg's Eagle *Aquila wahlbergi* is a species frequently met with in many parts of Africa, yet there have been very few returns of rings and its migratory behaviour remains virtually a mystery. In Central Africa it disappears after the breeding season to a destination unknown.

The first satellite tracking of a Wahlberg's Eagle, between February and November 1994, gave proof of transequatorial migration within Africa. This adult female, after nesting in north Namibia, was tracked by satellite for a total distance of 8,816 km. At the end of the breeding season it flew northwards, visiting northern Cameroon, northeastern Nigeria and western Chad. The distance between its breeding territory and its sojourn outside the breeding season was 3,520 km. The northward migration took one month and the return southward took two weeks longer.

Since 1995 13 GSEs from Poland have been tracked by satellite. They visited at least five countries where they had never, or hardly ever, been previously observed by ornithologists (Chad, Central African Republic, Tanzania, Zambia, Malawi). Two males wintered in Zambia, around 1,500 km beyond the most southern wintering zones hitherto known for this species (Kenya and Uganda). The first male wintered in Zambia in 1996-97 and again in 1997-98, giving us proof that it spent these two consecutive winters in exactly the same region. During its first winter it remained there for two and a half months (26 December to 9 March 1997) in the northeast of the South Luangwa National Park, where it provided 114 Doppler locations. The following winter it returned to exactly the same winter quarters, where it was located 22 times. It remained in an area of only 22.75 km^2 (6.5 x 3.5 km). A second male wintered in this same region and was accordingly included in the list of Zambian birds, probably the first time that a species has been accepted in this way without having in fact been observed.

Fidelity to wintering sites

Most birds of prey remain faithful to their nest sites and return there each year. Very little was known regarding this so far as wintering was concerned. For all the species tracked over a number of years we established that the adults generally returned to the same winter quarters. This was proved in particular for an adult female GSE tracked from 1999 on and still sending locations in April 2008 (see Tracker News Vol. 6, Issue 2, p. 4). It spent eight consecutive winters since we started to track it in the Göksu Delta in Turkey north of Cyprus where in two years it was possible both to observe and to photograph it. This bird obviously holds the world record for long-term tracking with a single PTT.

Whereas the majority of species have winter quarters relatively limited in area, the LSEs and Black Kites behave nomadically and often wander several thousands of kilometres during their winter in Southern and West Africa. We could however confirm that they too visit the same regions in most cases. Thus a female adult LSE born in 2000 always winters in northern Namibia and northwestern Botswana since 2004 when it was fitted with a GPS PTT (see Fig. 2).

One Black Kite spent several consecutive years in southern Mauritania and northern Mali but was also located one year in Senegal and even the Ivory Coast. A Red Kite, which also wintered in southern Spain for two years, spent the third winter in the north of Spain.

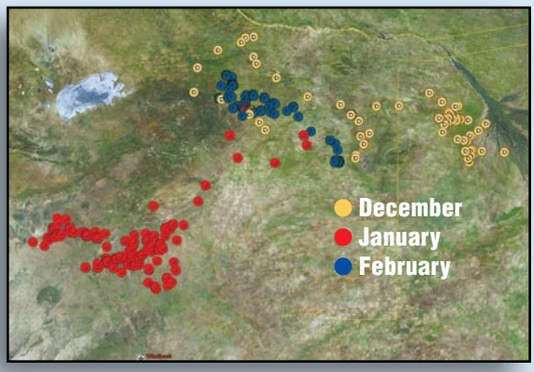

Fig. 2: Satellite photo with 963 GPS fixes of a female Lesser Spotted Eagle (with PTT 41861) during its wintering from 9 December 2004 – 20 February 2005 in an area 76,000 km² in Namibia and Botswana between the Okavango Delta (on the right in the photo), the Etoscha Pan (top left) and Windhoek (bottom left). It wintered in the same general area in all consecutive years.

The question of Steppe Eagles' migration routes between Asia and Africa answered

During the past 35 years raptor migrations to the Near East have been studied in detail by making counts at concentration points, and the migration of Steppe Eagles posed a few riddles. The greater number of migrating eagles at Eilat and Suez north of the Red Sea in spring than in autumn was a puzzling phenomenon. Indeed, one would have expected the opposite result in view of the increased mortality of young and immature birds as well as their longer-lasting stay in the wintering zones. Light was shed on this mystery thanks to satellite telemetry.

From 1993-1997 we fitted 16 Steppe Eagles in autumn in Arabia with PTTs, the last five transmitters fitted in 1996 and 1997 were solar powered. Seven of the birds flew to Africa via the Bab-el-Mandeb Straits in south Yemen, with others spending the winter on the Arabian peninsula.

Having wintered in Africa the spring migration of all these eagles led them to fly north of the Red Sea via Suez and Eilat, revealing the existence of a circular route around the Red Sea (see Fig. 3 & 4). The existence of this migration loop explains the differences noted by observers and answers the questions raised on this subject in the literature.

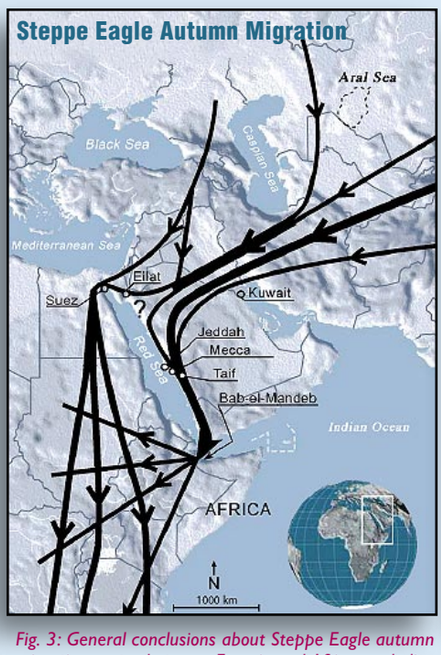

Fig. 3: General conclusions about Steppe Eagle autumn migration routes between Eurasia and Africa, excluding individuals wintering in Arabia. Conclusions are based on our data from 16 satellite-tracked Steppe Eagles and other studies.

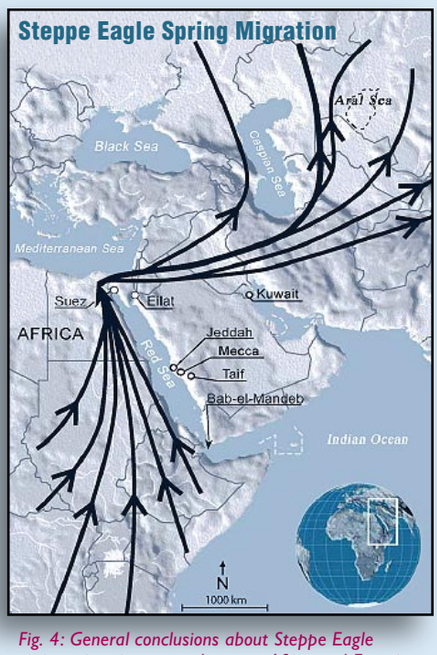

Fig. 4: General conclusions about Steppe Eagle spring migration routes between Africa and Eurasia, excluding individuals wintering in Arabia. Conclusions are based on our data from 16 satellite-tracked Steppe Eagles and other studies.

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Family break-up and emancipation of the young

It is relatively difficult to observe family ties after leaving the breeding site since the birds stray ever further from the nest towards the end of the emancipation of the young. Direct observation furnishes barely adequate information on the actual events. This is equally valid for wing-marking and VHF telemetry. In these cases it is very difficult to judge whether the parents and young leave together or separately. Only ST can provide such information with precision. Thus, with this in view, we tracked a family of GSEs.

Photo by Christiane Meyburg

Bernd Meyburg with Steppe Eagle

The two adults and their young were fitted with satellite transmitters in north-east Poland. Family ties broke up at the nest site with the departure of the female three or four days before the young bird. The male departed last on migration, a week after the female. The adults immediately set off towards the Bosphorus, whilst the young headed too far south, probably dying in Albania at the end of October after having flown 1,687 km.

Visits to neighbouring nests by Lesser Spotted Eagle

It has been generally accepted that nesting LSEs are strictly territorial and defend the area around their nests from intruders of the same species. It was thought that females looking after young remained, like the parents of other species, within a perimeter of only a few kilometers around the nest until autumn. ST studies and DNA analyses have proved to us that this commonly accepted hypothesis has been wrong. One female tracked by GPS transmitter on at least two occasions went over 50 km from the nest containing her young and also visited another active nest in the vicinity. It was equally proved that at least two "foreign" females visited her own nest, one with a nest 57 km away, and spent quite a while there. Visits to the pair by strange females was also confirmed by direct observation.

These flights during the period of rearing the young and at a considerable distance from the nest came as a great surprise and, as far as we know, have not so far been observed in other raptor species. It is even more astonishing considering that the birds paying these visits stayed quite a long time without the occupants raising any objection, for we saw no particular signs of aggression on their part.

Photo by Bernd-U. Meyburg

Portrait of the first Imperial Eagle (an adult male) tracked with a GPS PTT.

Breeding success can be influenced by migration

The date of the adults' arrival at the nest site often seems to determine the ability to breed of numerous species of migratory birds of prey. This is particularly evident when both partners arrive too late. An overdue return may inhibit egg-laying, as we have been able to observe in recent years with LSE populations. The most striking example of this was in 1997, during which most German pairs arrived abnormally late and only a third of them managed to breed. The same phenomenon took place in 2007 in Latvia where only 7% of the pairs laid.

It was generally but erroneously assumed that this delayed return from wintering was caused by bad weather conditions encountered during the spring migration, such as led in storks, for example, to catastrophic reduction in breeding success.

Thanks to ST we were able to prove for the first time in 1997 that not only was the return to Europe overdue but also the departure in autumn 1996 had been delayed.

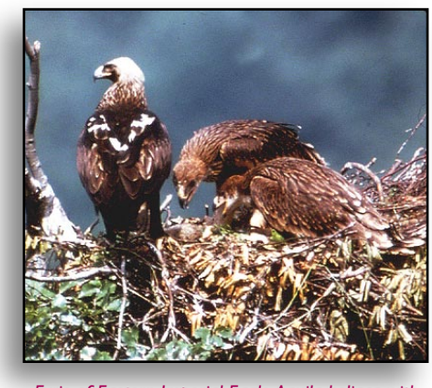

Photo by Bernd-U. Meyburg

Eyrie of Eastern Imperial Eagle Aquila heliaca with adult and two offspring. We tracked a relatively large number of adult and juv. Imperial Eagles in Saudi Arabia, Hungary and Slovakia.

In 1997 two of the eagles began their spring migrations on 14 and 16 March respectively, comparatively late according to the results from previous studies. The birds arrived two to three weeks late at their breeding sites. The eagle fitted with PTT 16865 crossed the Bosphorus on 17 April at a time when it would normally have reached its nest territory; it in fact arrived there on 4 May. On 12 April the bird with PTT 16867 was near Konya in Turkey, 430 km from the Bosphorus, whereas by this date many eagles have generally arrived north of Berlin.

This delay did not solely concern birds carrying transmitters; practically all eagles arrived with a similar delay in 1997, not only in Germany but also in Latvia. We presume that in many cases, as with the birds tracked by satellite, their departure on migration began too late the previous autumn and it was not the bad weather conditions during the spring migration which caused the nesting failure for many pairs in 1997.

GPS locations permit precise study of territory size and habitat use

Between 2004 and 2007 we were able to analyse territorial behaviour, home range sizes and habitat use by eight adult LSEs (six males and two females) fitted with GPS transmitters in Germany, several of which are still being tracked. The territory area of four males during one breeding season was a minimum of 32.78 km^2. The fifth male, which was tracked for two years, used territories of 93.78 km^2 in 2005 and 172.29 km^2 in 2006. The average size of these six territories was 72.29 km^2. The areas of activity of the two females differed greatly in size, although both bred successfully.

Now we can not only check our eagles' daily movements via the Internet during their migration period, we can also check on the location of birds who have returned to their breeding territories. Part of our current research is the evaluation of eagle habitat use by means of digital maps, air and satellite photographs, direct observation, etc. This means spending even more time on the computer and using increasingly complicated technology. Our eagle-watching techniques of the past, armed with binoculars and notebook, dodging the secret police in former East Germany, and the techniques we use today are worlds apart. Our eagle watching is no longer restricted by governmental regimes as we can now 'watch' our eagles migrate over many political boundaries around half of the world.