MONITORING RAPTORS BY MEANS OF SATELLITE TELEMETRY

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ABSTRACT. – Herein, we will outline the technical advances made in satellite transmitter technology for raptors since the mid-1990s, followed by brief accounts of the progress in our research, and the different trapping techniques we used. We also examine the intluences of weather on migration and discuss new insights into how migration and breeding success may influence one. Finally, we will discuss whether capture, fitting with a transmitter and the transmitter itself, have any negative influence on the bird.

Owing to their great mobility, birds of prey are extremely difficult to keep under observation over long periods of time. Therefore, in the past they have been almost exclusively studied at their nests so that in many species, breeding behavior and other questions concerning breeding biology have accordingly been analysed in depth, but observations away from the nest territory have remained more or less a matter of chance. Thus, for instance, for many species, very little is known about the post-fledging stage when the birds move ever further from the nest and become harder to observe.

With the introduction of VHF or conventional telemetry into omithology, it became possible to monitor small species with mini-transmitters over distances of up to several kilometres (reviewed in Kenward 2000, Kenward and Walls 1994, Walls and Kenward 1994). Thus, it became possible to find answers to such problems as determining hunting behavior, habitat utilization, territory size, etc., which had hitherto remained unclear, partly understood or else misinterpreted.

Many bird species spend only a small or relatively small part of the year in their breeding territories, leaving many unknowns about their length of stay, migration, behavior on wintering grounds, etc. For raptors, questions relating to migration are dependent on banding and observations at migration bottlenecks such as the Bosphorus, Straits of Gibraltar, etc., thus leaving many questions unanswered.

For example, the Lesser Spotted Eagle (LSE) (*Aquila pomarina*), the band recovery rate was only 2.5 %. During nearly 100 years of banding LSEs, only 41 recoveries out of 1649 individuals ringed were recorded in all countries where banding occurred (Danko et al. 1996). Several questions, such as how the LSE behaves during migration, how fast it flies, whether there is a distinction between adults and young, whether spring and autumn migration take place at different or similar speeds and follow the same or different routes, are just a few questions which needed clarification and to which earlier methods of research could provide no answers.

Researchers have long aimed to follow a migrating bird on its journey. In the United States, birds fitted with conventional transmitters had been followed from small planes (e.g., Cochran 1975). However, using this method, few facts could be ascertained, the cost was prohibitive and contact was often broken off prematurely. For such enterprises to be effective in Europe, the many political frontiers and ecological barriers were too forbidding.

With the introduction of satellite telemetry (ST) a little over ten years ago, the answers to a number of questions came within reach. Early on, this technique was applied particularly to albatrosses (*Diomedeinae*), cranes (*Gruinae*) and storks (*Ciconiinae*) and provided interesting information; to date there was little published material on raptors (e.g., Griesinger et al. 1992, Grubb et al. 1994, Brodeur et al. 1996, Kjellen et al. 1996).

Previously, we have published descriptions of ST technique and our initial investigations of raptor migration (Meyburg and Meyburg 1996, Meyburg et al. 1996 b, 1996 c, Meyburg and Meyburg 1998 a, 1998 b, in press). This paper will first outline the technical advances made since then, followed by brief accounts of the progress in our research, the different trapping techniques and addressing the ongoing question as to how far migration and breeding success may influence one another. Finally, we will discuss whether capture, fitting with a transmitter and the transmitter itself, have any negative influence on the bird.

NEW DEVELOPMENTS IN SATELLITE TELEMETRY TECHNIQUE

For us the most important development in recent years has been the introduction of small, 35 g and even 20 g satellite transmitters (PTTS) that are solar-powered. Hitherto, the only such transmitters available, weighing 65 g and 90 g, could be fitted on larger species such as the Imperial Eagle (*A. heliaca*) and Steppe Eagle (*A. nipalensis*). With these smaller PTTS, tracking of medium-sized species such as LSE, Osprey (*Pandion halietus*) and Egyptian Vulture (*Neophron percnopterus*) and even Honey Buzzards (*Pernis apivorus*) has became possible.

In contrast to smaller battery-powered PTTs already available, the problem of the limited life span and low capacity of the batteries was thereby eliminated. Solar- powered PTTs can, as became apparent in our work, transmit for several years. As of October 2001, we still maintain contact with birds equipped with transmitters as long as five years ago.

Unfortunately, these transmitters are still not entirely dependable. Transmitters may fade away prematurely or fail to function altogether. Whereas battery-powered transmitters are marketed by a number of firms in the USA, Japan and Germany, solar-powered models are obtainable from only two manufacturers.

Whilst battery-powered transmitters are available that weigh only 20 g, their life span is relatively short. They can be "stretched", in that the transmitter can be programmed to not be continuously active, but to send for only a fraction of that time, e.g., 8 h every 4 d. As well, the smaller the PTT, the fewer the locations that can be determined. From 30 g battery-powered transmitters, we have obtained between 50 and 100 locations during a period of up to one year.

We have accordingly not fitted birds with smaller battery-powered transmitters since the cost: productivity ratio was too disadvantageous. Almost all PTTs cost the same irrespective of their size and productivity.

Solar transmitters can deliver over 1000 locations/yr. Thus, not only can migration be recorded in detail, but other aspects such as daily activities during migration can also be recorded. We have been able to report on this in detail for the Short-toed Eagle (*Circaetus gallicus*)(Meyburg et al. 1998 a). For example, having extended power makes it possible to compare the routes taken and duration of a bird's migration in successive years. Thus, for the past few years we have used only solar PTTS, however, the cost of transferring data through the Argos satellite system for so many locations can be many times greater than the cost of the transmitter.

Introduction of a new type of transmitter is expected within a few months. This is the so-called GPS/PTT, i.e., a transmitter that can be located through the GPS (Global Positioning System). In contrast to the Argos system, precise locations can be obtained more frequently through GPS. Whereas the Argos data are as a rule adequate to document migration routes, the more efficient GPS will also make it possible to analyse home range size, habitat utilization, etc. Unfortunately, the first of these transmitters is expected to be relatively large (weight ca. 120 g); we intend to try one out soon on an Imperial Eagle.

Improvements to the Argos system are planned in the near future. The number of satellites is to be increased from the current two to three, and then later, four. The new satellites will have receiving equipment with improved sensitivity allowing for a greater number of locations that can be obtained.

INCORPORATION OF WEATHER DATA

Since larger raptors rely on thermals for soaring, they are clearly highly dependent on the weather. Data detailing how weather affects the speed of migration are still largely lacking and refer only to short sections of the migration route. By involving both a meteorologist and satellite photos, we have been able to adequately assess this dependence. For example, one adult Short-toed Eagle on autumn migration flew three times further on predominantly sunny days (311 km) than on overcast, rainy days (92 km) (Meyburg et al. 1998a).

METHODS OF CAPTURE

As would be expected, tracking of fledglings is very cost-intensive and relatively unrewarding due to the high mortality of young birds. Given this, we have concentrated on fitting transmitters to adults or, at any rate, immature individuals. Naturally, the first consideration when trapping is that the method should have no adverse influences on the bird. Unfortunately, at the beginning, we had no previous experience to guide us. In all, we have used six different methods of capture with varying degrees of success.

For eagle species breeding in Europe, a Dho-gaza near the nest site has proved to be the only successful method. This consists of a decoy bird, such as an Eagle Owl (*Bubo bubo*) perched on a stump, placed in front of a wide net. For LSEs, we usually set this net 200-500 m from the nest in a meadow or field. Watch is kept from a vehicle some distance away, so that the entangled eagle can be removed quickly. In only a few cases, has capture occurred 1 km away from the nest; the closer to the nest, the greater the chances of success. Only a small proportion of the adults reacted very strongly to the decoy with repeated glancing attacks that finally resulted in being caught in the net.

The rate of capture was dependent on the species of decoy, the stage in the breeding period and local circumstances. In Germany, LSEs react less violently to Eagle Owls, which were used almost exclusively in Slovakia. In Germany and Latvia, a live adult White-tailed Eagle (*Haliaeetus albicilla*) had a much stronger power of attraction and LSEs reacted to the eagle with typical alarm calls. To date, in spite of persistent efforts, recapture has only occurred in three individuals. In subsequent years, the birds were suspicious and seemed to remember the trap. For example, in Slovakia, a LSE was recaptured on two occasions; the third time, only six years after the previous capture. In most cases, males reacted more violently than females, so that to date we have only twice been able to equip both members of a pair.

Greater Spotted Eagles (GSEs, *A. clanga*) react feebly to decoys of various species outside the forest and cannot be trapped, so we set up the net only 50-80 m away from the nest within the forest itself. In this case, observation from a nearby blind in crucial. The observer maintains contact by radio with other helpers who can be summoned quickly to assist in the capture of the eagle. Only two adult females have so far failed to react; seven adults have been caught within a short time. In Poland, because it is a great threat to the young, Eagle Owls elicit a intense response from nesting GSEs. Both males and females seem to react with the same vigour; in one case both members of a pair were successfully caught. So far, however, it has not proved possible to catch the same bird twice except one male, which was trapped about an hour later.

Short-toed Eagles (STEs) have been trapped in the same way as LSEs. They react similarly to the Eagle Owl; more violently in areas where this owl actually occurs. Overall, however, the success rate has to date been low in comparison with other species. Many STEs often do not react to different decoy species. For example, one bird in Slovakia attacked the Eagle Owl, placed on a slope only 60 m from the nest in dense forest, and flew straight into the net. Unfortunately, it managed to free itself before it could be grabbed. On the following days it reacted to the owl with persistent alarm calls but made no second direct attack.

Ospreys can be caught far more easily than all the foregoing species by this method. When net and decoy are placed in the open, not far from the nest, around 90% of the adults of both sexes are trapped. A White-tailed Eagle used as a decoy is best for this purpose, however, a live or even stuffed Goshawk (*Accipiter gentilis*) can also lead to success. Oftentimes, both members of a pair are captured. Around 50% of the birds are also caught a second time, although a few Ospreys are wary in subsequent years and appear to remember the experience. One female was caught near the nest in three successive years.

Next to the Dho-gaza method, we also tried using Bal-chatris to trap LSEs in Germany and STEs in Israel. None of the birds reacted, however, LSEs that overwintered in Namibia, were caught by this method. Two Wahlberg's Eagles (*A. wahlbergi*) and one Steppe Eagle were also similarly trapped by Bal-chatris in southern Africa.

A large remote-controlled bow net baited with prey or carrion was ineffectual with LSEs in Germany and Egyptian Vultures in France. LSEs paid no attention to either the live prey or carrion whilst the vultures were too wary although the net was set up at a longstanding dump for offal. It is likely that insufficient time was allowed for them to acclimatize.

Further unsuccessful attempts were made with M. McGrady on LSEs in Latvia using a remote-controlled power snare placed around the nest cup (McGrady and Grant 1996). With the added help of a video camera, watch was kept from a blind near the nest. Devised and constructed by M. McGrady who had used it with considerable success on Golden Eagles in Scotland, in this endeavour, we found that LSEs were far more cautious than Golden Eagles and mistrusted the snare. Outside radio interference also affected the apparatus, and attempts were finally abandoned. Given a longer acclimatization, it should seem possible to catch LSEs in this manner.

In similar fashion, a snare was set by W. S. Clark at a waterhole in Israel to trap passing LSEs. However, the LSEs showed no interest in this drinking place perhaps they pass through the Near East as quickly as possible, without taking any food or liquid. This is also indicated by the ST data.

The most successful method of capture was a technique not yet described in the literature. First used to capture overwintering or passage Steppe and Imperial Eagles in Saudi Arabia, these birds often assemble at carcasses and end up with crops so full that they are barely able to fly. With the onset of dusk, thermals dissipate, greatly increasing the energy required to become airborne. In the flat and open landscape, heavily laden individuals can be singled out, followed, and outrun by vehicles. Within a few minutes they are generally so exhausted so that someone jumping out of one of the two or three surrounding vehicles can grab them. This works particularly well when birds are wet from previous rains.

Using this technique, over 100 Steppe Eagles and a number of Imperial Eagles have been trapped. Notably, one overwintering Imperial Eagle was captured at the same place in three successive years. To mitigate the effects of stress of this capture method, birds were kept captive overnight, given a thorough veterinary examinlation, and released the next moming. Eagles caught in this fashion could be tracked for up to over a year. If capture was to take just a few minutes, any stress was obviously slight and the birds suffered no ill effects. However, if capture does not occur within this short space of time, the attempt must be abandoned. The particular advantage of this method is, that individual birds can be singled out and caught, and the time spent doing so is minimized.

Results of trapping methods. – Up to and including 2001, we have succeeded in equipping 87 individuals of 12 species with PTTs (see Table 1). This paper will provide little more than a snapshot of the wide range of results from this research. Only a small portion has been previously published, the bulk of which still awaits analysis. Given that the study of migration and reproductive success are interdependent, wide-ranging results can be expected from the use of this technique. Thus, monitoring in the old sense, with first and foremost recording on census plots breeding pair density and the number of young raised, and monitoring away from the nest territory, particularly on migration and previously unforeseen.

We were first made aware of this by documenting the migration routes. Though presumed routes to wintering grounds are partially described in the literature, this discovery has led to great surprises. For example, general opinion has placed the wintering quarters of the GSE in northeast Africa, between Egypt and Eritrea; the GSE has never been observed south of the equator. All except one GSE we tracked, however, spent the winter far distant from the region described in the

Table 1. Details of the 87 raptors fitted with satellite transmitters between July 1992 and August 2001.

SPECIES	COUNTRY WHERE FITTED WITH TRANSMITTER (*N*)	AGE	PRESENT STATE OF PUBLICATION OF RESULTS (OCTOBER 2001)
Lesser Spotted Eagle *Aquila pomarina*	Germany (20), Latvia (3), Slovakia (2), Namibia (2), Poland (1)	4 Ns., 1 Im., 1 Su., 22 Ad.	Results from first 10 individuals tracked, published in Meyburg et al. 1993, 1995 a, 2000, 2001
Steppe Eagle *A. nipalensis*	Saudi Arabia (15), South Africa (1)	3 juv., 4 Im., 9 Ad.	Unpubl., in prep.
Osprey *Pandion haliaetus*	Germany (11)	1 Im., 10 Ad.	Unpubl., except for a brief section on two individuals in Schmidt and Meyburg 1998
Greater Spotted Eagle *A. clanga*	Poland (10), Saudi Arabia (1)	3 Ns., 8 Ad.	Only a small part published on wintering in Zambia in Meyburg et al. 1998 b
Imperial Eagle *A. heliaca*	Saudi Arabia (7), Hungary (1)	1 Ns., 1 Im., 6 Ad.	Only a small part published on fledgling in Hungary in Meyburg et al. 1995 d
Short-toed Eagle *Circaetus gallicus*	France (3)	1 Im., 2 Ad.	Published complete in Meyburg et al. 1996 a, 1998 a, 1999
Egyptian Vulture *Neophron percnopterus*	France (2), Bulgaria (1)	3 Ns.	Unpubl.
Honey Buzzard *Pernis apivorus*	Germany (3)	3 Ad.	Unpubl.
Wahlberg's Eagle *A. wahlbergi*	Namibia (1) and South Africa (1)	2 Ad.	Meyburg et al. 1995 b
White-tailed Sea Eagle *Haliaeetus albicilla*	Germany (1)	1 Ns.	Published in part in Meyburg et al. 1994
Steller's Sea Eagle *H. pelagicus*	Russia (1)	1 Ns.	Meyburg and Lobkov 1994
Peregrine Falcon *Falco peregrinus*	Saudi Arabia (1)	1 Ad.	Unpubl.

Ns. = nestling, Ad. = adult, Su, = subadult, Im. = immature

literature and also far more distant from their breeding territory. Most sensational were two adult male GSEs that spent the northern winter in Zambia approximately 1500 km south of the equator in South Luangwa National Park. One female migrated to Chad. In spite of intensive searches involving local omithologists and a personal visit to Zambia, the two birds were not observed in the field. In two consecutive years, the first of these birds wintering in Zambia was located in the same area over 100 times, and as such, this species was added to the national list. This is likely the first instance of a country adding a new species to its official list based on ST locations without its having actually been seen by any observer. The GSE also ranks as a new species for Malawi, Tanzania and probably Chad.

The longer this technique was used, the clearer it became that many other questions could be answered. Appendix 1 outlines such questions. Initial results have clarified many of these problems, a few of which are discussed below.

In each case where both members of a pair were radio-tagged, migration was accomplished separately and wintering grounds lay many thousand kilometres apart. This applied to GSE and LSE and to several pairs of Ospreys. Although it could have already been noticed without the aid of telemetry, in Germany, it was discovered that female Ospreys departed before the male. All equipped females left their young relatively soon after they departed the nest in early to mid-August, leaving further care to the male. Through this action, they would had already arrived in their winter quarters by the time their mates left breeding territories. In contrast, both LSE and GSE adults leave together at the same time with their young.

lt is generally thought that larger raptors mate seasonally or permanently and return each year to their nest site, where new pairing occurs only when one of the pair has died. This was made evident from the ST data in many cases, but led also to surprising deviations. For example, one female Osprey, settled in Brandenburg (Northem Germany) the year after it was radio-tagged 35 km distant to its original terriotry, while at the same time, the previous year's nest was occupied with a new female. Another example cites a male which had reared three young in the year he was radio-tagged (1996) retumed exceptionally late to its nesting area in the three consecutive years. In 1997 and 1998 its female bred with a new male and in 1999 the nest was unoccupied. In 2001, the second male was re-trapped at the nest. The ST data suggested that the first female died during the third outward migration. The 1996 male never did breed again. In 1997, this male was observed a few km distant from the nest. Why this bird always returned so late from its wintering grounds and played no part in the process of reproduction remains a mystery.

The timing of the adults' arrival in spring is critical for breeding success for many species and clearly depends not only on the weather conditions during spring migration but also on several other factors. The LSE provides a good example of this. In 1996, four adult LSEs were fitted with 35 g solar-powered PTTs of which one (PTT 16865) provided prolific data (694 locations up to the end of August 1997) in Germany. Two other transmitters (PTT 16866 and 16867) were located much less frequently, but still more often than battery-powered PTTs used in previous years. One (PTT 16863) delivered little data. Two of the others (PTT 16865 and 16867) are either today (October 2001) still active or have been active until March 2001.

Meteorological data were collected from various sources so that dependence during return migration on different weather conditions could be studied. In 1997, all four LSEs retumed to their nest sites. For the first time, the movements of three individuals in their wintering areas could be well documented. For two birds, the homeward journey through Africa could be traced allowing for a comparison with the outward journey.

The outward routes corresponded quite closely with LSEs tracked previously. Departure in autumn 1996 was however, delayed. One bird crossed the Bosphorus on 5 October while another not until 13 October. They passed through Israel on 15 and 22 October respectively, thus, with a delay of two to four weeks when compared to normal years. The ST data coincided with direct observations of LSEs in Israel.

Arrival in winter quarters followed on 13 November, 18 November and 23 December 1996, plainly later than LSEs tracked previously. All three birds covered long distances during their stay on their wintering grounds. One (with PTT 16867) spent the winter almost exclusively in Zambia, another (with PTT 16865) in South Africa (in Kruger National Park) and Zimbabwe, the third (with PTT 16866) in Zambia, Namibia (Caprivi Strip), Botswana, Zimbabwe and South Africa (Kruger National Park) and the fourth in the southern Congo.

Departure from winter quarters followed in two ascertainable cases between 14 and 16 March; again later than with previous studies. For the first time, it was possible to record precise daily distances flown since successive roosting places were frequently located. This revealed that daily distances flown were considerably larger than the highest known value of 290 km/day (Meyburg et al. 1995c). With one bird, the greatest day's distance covered was 537 km on 28 October 1996 through the Sudan.

As already expected owing to the late departure from their winter quarters, the LSEs, in spite of faster speed, arrived at their breeding grounds with a clear delay of two to three weeks. Thus, the eagle with PTT 16865 crossed the Bosphorus on 17 April 1997 at a time when it would have normally reached its nest site, which it did not reach until 4 May. On 12 April, a common date of arrival at breeding grounds north of Berlin, the eagle with PTT 16867 on its way from Kenya was in Turkey still 480 km from the Bosphorus.

This late arrival did not apply to only birds that were tracked. All other LSEs in Mecklenburg-Vorpommern (Northern Germany) arrived equally late (J. Matthes and G. Rohde, pers. comm.). This clearly led to only a few pairs (20-25%) managing to breed. From the viewpoint of reproduction, 1997 was not only a poor year in Germany but also, for example, in Latvia (U. Bergmanis, pers. comm.) and Poland. This was, however, only evident for all pairs under study. This highlights the necessity for other factors to be taken into consideration for successful long-term monitoring of a species. Since the few pairs which managed to breed mostly reared their young to fledging, it would appear that a high degree of reproductive success was attained; however, circumstances described above must be taken into account in long term monitoring as otherwise this leads to wholly false results and conclusions.

This late arrival in 1997 applied not only to LSEs, but also to other species such as GSE, Osprey and White Stork (*Ciconia ciconia*), resulting in a disaster year so far as reproduction was concerned. In the case of the White Stork, this could be attributed to poor springtime weather conditions in Turkey, while other factors must have been responsible for the LSEs. This likewise became evident for the GSE and Osprey.

RELATIONSHIPS BETWEEN MIGRATION AND REPRODUCTION

ST can provide answers to many questions that have hitherto defied research. Its application has revealed that in many species, the migration process and reproduction are mutually influenced.

By means of ST, for the first time, it has been possible to establish that bad weather from August to October following the previous breeding season was responsible for the delayed autumn departure in 1996 from Europe and the Near East. As well, it is not clear why birds again set out late from their wintering grounds. It is possible that these birds spend a specific length of time in their winter quarters in order, for example, to build up sufficient reserves of energy, so that late departure is consequential to late arrival. The unusually low rainfall in the wintering grounds of LSEs' in recent years attributed to the EI Nino phenomenon, particularly in Zambia and Zimbabwe, has led to a poor food supply.

The stay of LSEs in wintering areas coincides with the rainy season. lt has been suspected for a long time that in South Africa, LSEs follow the rain front (Steyn 1982). This appears to be confirmed by ST. For example, satellite photos have confirmed that in all places frequented by two overwintering LSEs tracked in Namibia, were places receiving the highest rainfall (Meyburg et al. 2001). The lower rainfall and accordingly reduced food base perhaps meant that the time needed for LSEs to acquire the aforementioned reserves of energy for the homeward journey had to be prolonged. This again could have meant that an early departure to the breeding grounds was made impossible by late arrival in winter quarters.

At any rate, as demonstrated for the period 1996/97, ST has indiacted a hitherto unsuspected interrelation between time of arrival in spring and breeding success. The phenomenon requires further analysis, and the authors would much like to receive data from other observers regarding spring arrival and breeding success in other species. ST clearly demonstrates the important role it has in the understanding of differential arrival times of long-distance migrants, and of the dynamics of migration and overwintering, which take up well over half the year.

Does fitting the transmitter have any negative influence? Every method of study has an important influence on the animal concerned. Whether the influence of ST's is considerable or insignificant is briefly considered. In our view, we have clearly established whether, and to what extent, breeding behavior is affected. The capture of breeding adults and fitting them with transmitters has in no case ever led to the birds visibly altering their behavior in any way. Immediately after release, they fly back to the nest or hunt for food. In no instance was breeding abandoned shortly after birds were fitted with transmitters. In several cases, we documented successful breeding of pairs where either one or both had been fitted with transmitters.

In fact, birds generally do not seem to be hampered in any way by the transmitter. A number of eagles were at the same time equipped with conventional transmitters and kept under close observation in the field. Most did not attempt to peck through the harness. Most of the LSEs and Ospreys returned the following year with their PTTs intact. One male Osprey, however, which was recaptured after several years had a transmitter without an antenna. No locations were received from this transmitter after a few months after the transmitter was fitted to the bird. However, some birds do have a tendency to remove their transmitters. This became apparent with a LSE and an Imperial Eagle. In both cases, the birds were recaptured about a year later and their rings were read. The PTTs were missing and there was no indication that they had ever carried them. Nonetheless, we believe that the negative effects of capture and fitting can be disregarded in view of the enormous gain in our knowledge of the biology of these species.

ACKNOWLEDGMENTS. – We thank the many colleagues who have helped us in particular for the fieldwork, in the different countries in which we have equipped birds of prey. We regret that it is not possible to mention them all by name because of lack of space.

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Appendix 1. Questions regarding birds of prey to which data from satellite tracking are expected to provide answers.

Migration behavior

+ On the routes followed by migrating species (distinctive routes taken by individuals in different years, possible differences between adults and young).
+ On navigation and orientation (difference between young and adult birds; conclusions from instinctive behavior and experience).
+ On the geographical aspects of wintering grounds.
+ On families breaking up or migrating together.
+ On problems of crossing ecological baniers (sea, mountains, deserts).
+ On the question as to what features serve as leading lines and landmarks during migration.
+ On bottlenecks. Do all individuals pass through them and at what time? Is an estimate of the total population of different species possible at these places through direct observation?
+ On the migration period:
  - Different for adults/immatures/juveniles?
  - Difference between males/females (different times of departure on autumn migration recorded between adult Ospreys).
+ Duration of the migration:
  - Difference between outward and homeward journeys.
  - Dependence on distance between breeding and wintering Grounds.
  - Difference for adult/immature/juvenile birds.
  - Difference from year to year.
+ Speed on migration:
  - Variation throughout migration.
  - ndividual differences.
  - Daily distances covered.
  - Actual average speeds.
  - Daily behavior on migration (time of starting in the morning and stopping in the evening, stopping for hunting etc.).
  - Dependence on weather.
  - Dependence on age (juv., immat., adult).
  - Dependence on participation/non participation in breeding.
  - Dependence on distance between wintering and breeding Grounds.

Resting places

+ Geographical Situation and number of resting places on migration route.
+ Ecological conditions at stopovers.
+ Time spent at stopovers.

Results on dispersion and dismigration

+ In species with little developed tendency to migrate.

Results on overwintering behavior
+ Geographical situation of wintering grounds.
+ Size and number of home ranges on wintering grounds.
+ Possible nomadism.
+ Fidelity to the same area in successive years.

Are migration and breeding success interdependent?
+ What accounts for later/earlier arrival in spring at the nest site (influence of weather during migration, later/earlier departure to wintering grounds).

Behavior in breeding area or summer quarters
+ Behavior of non-breeding adults (arrival, size of territory, possible nomadism).
+ Behavior of adults with breeding failure (fidelity to nest site after loss of brood?).
+ Behavior of immature birds (size of home range, nomadism?).

Fidelity to nest site and surrounding area
+ Annual return to nest site or change of nest site.
+ Fidelity of first breeders to area where they were bom (e.g. long or short-distance dispersion, example German Ospreys settling in France).

Pair continuity over a number of years
+ Attachment to old site?

Whereabouts of immature birds before reaching breeding condition
+ Retum to breeding area/remain on wintering grounds (e.g. LSE, Osprey, Egyptian Vulture)?
+ Size of home range, nomadism.

Loss on migration
+ Through human persecution (identification of areas of persecution).
+ Through navigational failure (e.g., flying of LASEs to the Pelleponnese/Greece),
+ Through other causes?
+ The fate of birds released to the wild (injured raptors after recuperation, reintroduction programmes, etc.).