J Raptor Res. 21(4):142–143

TELEMETRY TECHNIQUES FOR THE STUDY OF RAPTOR MIGRATION

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Radio telemetry makes it possible to observe migrant raptors in some detail over distance and time intervals. Such observations yield inferences stronger than those generated from fleeting glimpses of passing migrants or lines connecting banding and recovery sites.

Most studies that use telemetry are conducted in areas much smaller than those over which birds range during migration. Methods for such area-related studies are applicable to studies of migrants wherever migrants linger [see Holthuijzen and Oosterhuis (1985), or Hunt's summary herein]. Kenward's comments concerning planning, equipment, personnel, luck, etc., are applicable to serious studies that employ telemetry, including the study of raptor migration. I will restrict my discussion to the use of telemetry in the study of long-distance migrants.

One approach for studying migration is to observe one or a flock of individuals intensively. An airplane facilitates tracking because of its speed and freedom of movement (Gilmer et al. 1981; Mech 1983). Also, at higher altitudes reception is increased to 150 km or more for more powerful transmitters. Unfortunately, air tracking provides little opportunity for visual observation without risk of disturbing the subject. Furthermore, small-scale movements such as short hunting flights and signal variations that signify eating, hunting flight, roosting, climbing, descending, etc., are difficult or impossible to document from an airplane. If a rough plot of a bird's migratory route is all that is desired, a plane is a good choice; if care is taken to be in the air at the right time, anyone familiar with ground tracking can succeed immediately.

Where road networks permit and collection of behavioral data is important, by far the best tracking conveyance is a suitably equipped automobile. Frequent, and often hours-long, periods of visual observation of a migrant raptor as it perches, hunts, feeds, roosts or migrates provide welcome breaks in the monotony of electronic observation. By listening to the signal while watching the subject it is possible to learn to associate signal variations with particular activities. The easiest to associate are the steady signals from a perched or gliding raptor and cyclic signal fade of a raptor circling in an isolated thermal.

Automobile tracking requires constant route planning and replanning. River crossings and large metropolitan areas can be particularly frustrating. Planned temporary loss of contact is often required in detouring away from the migrant, for instance to cross a river at a bridge. Unplanned loss of contact occurs frequently when the bird comes down. Transmitter range for a soaring raptor is typically 50 km, but in a tree or on the ground range will drop to about 10 km and one km, respectively. Fortunately, search area for a nonflying raptor does not expand with time, and by keeping a running log of azimuth an observer always knows which way to go to close distance. However, routing mistakes, especially when winds aid a migrant, will result in trackers being left hopelessly behind and will require luck or the use of a (rental) airplane to reestablish contact.

An automobile and airplane form an ideal combination for tracking, complementing each other in their strengths and weaknesses. Cost of using both is considerably less than the summed cost of either alone (e.g., air time is not required to monitor a stopped or slowly moving migrant). Another advantage concerns what Kenward calls "lifespan of field workers"; by alternating duties between plane and automobile, observers can extend this lifespan that otherwise (in my experience of living in a vehicle) is about two wks.

A great variety of data may be collected while observing migrants. At the least, one is interested in food sources, daily rate and direction of travel, how the day is budgeted between hunting, perching and migrating, and how all these are affected by weather, habitat and topography or vary with age, sex and geographic region. Unfortunately, the migratory seasons provide time for observations of only a few individuals at most and many seasons may be necessary to acquire a data base that addresses such interests in a statistically sound way.

Small samples can, however, be revealing. For instance, a popular field guide (Robbins et al. 1983) comments that the Peregrine (*Falco peregrinus*) "rarely soars." The first Peregrine I tracked (for two full days in fall 1973) flew a total of 11.9 hr, 82%

of which was interthermal soaring (Cochran 1975). "Rarely" and 82% are quite incompatible yet it is likely that "rarely" was based on a large sample of observations. So, was this bird a freak? A later increase in sample size to 143 hr and 6 birds changed the outcome very little (84% soaring) (Cochran, unpub. data). One is sometimes left wondering which is better, a few high quality observations or a large sample of biased observations?

The slow rate of data acquisition inherent in studying individuals may be avoided in part by focusing on particular questions. For instance, having learned from the study of a few inland migrant Peregrine Falcons that individual migratory flight direction does not vary much from day to day, it is now reasonable to determine directional distribution of inland migrants by one- or partial-day tracks from a trapping area and to make inferences about sources and destinations. Several one-day tracks from a trapping site can be documented from one airplane in a single day; therefore, a large sample can be obtained in one season. Such a study would have little meaning at Assateague Island, MD, where individual Peregrines migrate south for several hundred km along the Atlantic coast before diverging on individual courses. Thus, the value of preliminary studies of individuals is to establish a suitable context within which question-oriented studies involving many birds can be pursued with confidence.

Radio tags may be used as *super bird bands* for the purpose of obtaining occasional or specific locations. For example many tags could be attached at various trapping sites during migration and later located during one or two air searches of winter or summer range. Careful preparations should be made for such studies; transmitters and attachments must be reliable for the required time. Air searches are most efficient when reception range is maximum. Therefore, and because range is very limited when birds are on the ground, a knowledge of time of day and kinds of weather favoring perched and soaring behavior is of great value in planning air searches. Cost effectiveness of such studies improves remarkably for large numbers of tags and can be enhanced by planning supplementary studies such as enroute tracking of a few birds, more intensive study of some individuals after relocation or gathering specific data on environs of the whole sample.

Fuller (1985) used a satellite to locate a Bald Eagle (*Haliaeetus leucocephalus*) over a six month period. The present limitation of satellite use, solely the result of having to use satellites designed for other missions, is that 100 g radio packages must be used, 10–100 times heavier than conventional transmitters for birds.

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