

Dispersal and migration

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Ringling of birds unveiled many aspects of avian migration and dispersal movements. However, there is even much more to be explored by the use of ringing and other marks. Dispersal is crucial in understanding the initial phase of migration in migrating birds as it is to understand patterns and processes of distribution and gene flow. So far, the analysis of migration was largely based on analysing spatial and temporal patterns of recoveries of ringed birds. However, there are considerable biases and pitfalls in using recoveries due to spatial and temporal variation in reporting probabilities.

Novel methods are required for future studies separating the confounding effects of spatial and temporal heterogeneity of recovery data and heterogeneity of the landscape as well. These novel approaches should aim a more intensive and novel use of the existing recovery data by taking advantage of, for instance, dynamic and multistate modeling, should elaborate schemes for future studies, and should also include other marks that allow a more rapid data collection, like telemetry, geolocation and global positioning systems, and chemical and molecular markers. The latter appear to be very useful in the delineating origin of birds and connectivity between breeding and non-breeding grounds.

Many studies of migration are purely descriptive. However, King and Brooks (King & Brooks, 2004) examine if movement patterns of dolphins change after the introduction of a gillnet ban. Bayesian methods are an interesting approach to this problem as they provide a meaningful measure of the probability that such a change occurred rather than simple yes/no response that is often the result of classical statistical methods. However, the key difficulty of a general implementation of Bayesian methods is the complexity of the modelling —there is no general userfriendly package that is easily accessible to most scientists.

Drake and Alisauskas (Drake & Alisauskas, 2004) examine the philopatric movement of geese using a classic multi-state design. Previous studies of philopatry often rely upon simple return rates —however, good mark-recapture studies do not need to assume equal detection probabilities in space and time. This is likely the most important contribution of multi-state modelling to the study of movement. As with many of these studies, the most pressing problem in the analysis is the explosion in the number of parameters and the need to choose parsimonious models to get good precision. Drake and Alisauska demonstrate that model choice still remains an art with a great deal of biological insight being very helpful in the task.

There is still plenty of scope for novel methods to study migration. Traditionally, there has been a clear cut distinction between birds being labelled as "migrant" or "resident" on the basis of field observations and qualitative interpretations of patterns of ring-recoveries. However, there are intermediate species where only part of the population migrates (partial migrants) or where different components of the population migrate to different extents (differential migrants). Siriwardena, Wernham and Baillie (Siriwardena et al., 2004) develop a novel method that produces a quantitative index of migratory tendency. The method uses distributions of ringing-to-recovery distances to classify individual species' patterns of movement relative to those of other species. The areas between species' cumulative distance distributions are used with multi-

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dimensional scaling to produce a similarity map among species. This map can be used to investigate the factors that affect the migratory strategies that species adopt, such as body size, territoriality and distribution, and in studies of their consequences for demographic parameters such as annual survival and the timing of breeding. The key assumption of the method is the similar recovery effort of species over space and time. It would be interesting to overlay maps of effort to try and remove any induced artefacts in the data.

Differences in timing or the route of migration has often been studied separately. Lokki and Saurola (Lokki & Saurola, 2004) develop an omnibus procedure to test if the migration timing and/or route differ among two populations of birds (e.g. males vs females). It uses a randomization test to calibrate the test statistic. However, it makes the key assumptions about equal recovery effort in time and space so that the method may be most applicable to comparison among species with similar migration timing and movement to keep differential sighting/recovery rates from affecting the result. Of course, it is in these cases where it is most difficult to separate the groups which will require substantial samples to have good performance.

Thorup and Rahbek (Thorup & Rahbek, 2004) provide a framework for accounting for unequal spatial recovery probability investigating the geometric influence of ocean and sea on observed migratory patterns. Taking the data set of Pied Flycatchers (*Ficedula hypoleuca*) ringed as nestlings in Scandinavia and recovered en route on their initial migration and using a model based on the clock-and-compass innate navigation hypothesis they are showing that geometric constraints explain quite a bit of the variation in ring-recoveries. The model also shows that ring recovery patterns do reflect the migratory patterns, and that they are suitable for an analysis of the concentration of the migratory route which is important for the general use of ringing data in studies of migration. This is important for the general use of ringing data in studies of migration and dispersal. The new approach has also implications for understanding the migratory orientation program.

The compiled papers highlight some novel ideas of how to analyse band recoveries to investigate migration routes and migration behaviour as well as dispersal patterns among birds and dolphins. Multistate modeling appears as a valuable tool as it enables to include various covariates and to analyse patterns of movement that change in time, are influenced by weather, or are different between age classes or sex.

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