BIRD-BANDING

A JOURNAL OF ORNITHOLOGICAL INVESTIGATION

VOL. XXII JULY, 1951 No. 3

THE ANALYSIS OF POPULATION BY BANDING

BY DAVID E. DAVIS

The use of bands to mark individual birds was developed a quarter of a century ago and now is an accepted technic of ornithological research. A vast storehouse of data has accumulated and been used for various purposes. Although the study of migration has naturally attracted most attention, other problems can be studied equally well. It is the purpose of this paper to discuss the utilization of banding data for the analysis of populations.

Numbered leg bands are obviously only one method of marking individuals. Many other methods are used, such as a variety of types of tags for fish and snakes and clipping toes from mammals and lizards. In addition, it is possible to mark a group of animals by feeding them dyes or injecting radioactive substances. This paper will discuss the utilization of information derived from marking animals for the analysis of populations. The number of animals in an area at a given time depends upon the amount of reproduction, mortality and movements. Marking can help to determine the relative importance of these three population forces.

Reproduction. The use of numbered or colored bands permits the determination of the number of eggs laid and young produced by an individual during the breeding season. A number of studies of marked birds (Nice, 1937; Sowls, 1950) show that the first clutch is larger than the second. Furthermore, such studies show how many clutches are laid by a female. In addition analysis of banding data shows what proportion of birds are laying (Kendeigh, 1941). The splendid study of penguins (Richdale, 1949) indicates the type of information that can be obtained. The analysis of such data will provide an estimate of the productivity of a population of, say, 100 birds. Such analysis has rarely been made in detail except for some game species, and offers a fertile field for study by bird-banders.

Mortality. The rate at which deaths cause a decline in a population can best be studied by the analysis of the history of marked birds. The simplest procedure is to determine how many die each year from the returns of dead birds of known age. Paynter (1947) constructed a life table for Herring Gulls and Farner (1949) described the death rate of Robins. Lack (1946; 1949) showed that the death rate of juvenile birds is higher than that of adults and that it is also higher for birds from large clutches than for birds from small. Baumgartner (1944) in a special type of study found that quail that were released when the population was low survived better than quail released when the population was high.

It is also possible to estimate mortality by analysis of the recaptured birds in a population. In brief, the method is as follows. A number of birds, say 100, are marked and released. The following year, some of these will be captured, some will not be captured even though alive, and some will have died or moved away. If the total population is known (see below for methods) it is possible to estimate the number of marked birds that were still alive and present in the following manner. Suppose that in the second year 70 birds are caught, of which 15 had been marked the previous year, and that the total population in the area is 200 birds. Then assume that the proportion of marked birds is the same in the 130 birds that were not caught as in the 70 birds that were caught. Since this proportion is 15/70, the number of marked birds in the total population is $\frac{15}{70}(200)=43$. Since 100 birds were marked the previous year, the probability of surviving for a year is $43/100=0.43$. The probability of dying is obviously 0.57. Analyses of this type have been made by Buss (1946) to determine the survival of pheasants. This method must be applied with caution because birds that move away are counted as "dead." Hence closed populations should be used or it should be clear that both deaths and emigrants are considered.

Movements. Although banding has been used to study the migration of birds, relatively little use has been made of colored bands to study local movements. For example, it is important to know something about the movements of unmated birds during the breeding season. Also, the local movements after the breeding season can be studied. The study by Odum (1942) shows the type of information that can be obtained. The young chickadees gather together in flocks while the adults are raising the later broods. In the Fall the flocks wander around over an area of several miles and settle for the winter in favorable habitats. In the spring, the birds disperse to suitable breeding areas. Studies of this type are a very worth while activity in the late summer when the breeding activity has waned. It would be especially interesting to determine the movements in winter of a flock of chickadees, nuthatches, and woodpeckers by observations of color-banded birds. Do the same birds associate day after day? How big an area does the flock cover?

Population Estimates. The three forces of reproduction, mortality, and movements combine to produce the population at a given time and place. The size of the population itself can be estimated by the use of marked individuals. This method has not been generally used by ornithologists principally because observational methods are relatively successful for active, diurnal species. But some worthwhile results can be obtained by persons not averse to a little arithmetic.

The recapture-ratio method was originally proposed for fish by Petersen in 1896 and was restated by Lincoln (1930). The method is based on the ratio of marked to unmarked individuals in a sample from a population in which a known number are marked. The method can be tried with a can of navy beans. Place an unknown number of beans in a can, remove a handful, mark them in some manner, return them, shake the can vigorously, and remove another handful. Call the unknown number in the can N, the number marked M, the number in the second handful n, of which m have been marked. It is apparent that $\frac{N}{M} = \frac{n}{m}$ or $N = \frac{nM}{m}$. This method is clearly applicable to birds. A number of birds (M) are banded in an unknown population (N). Then at a later date a number of birds (n) are captured of which m had been marked.

But like all mathematical methods, a number of assumptions are made. It is assumed that (1) the number of deaths, births and loss of marks is negligible, (2) the number of individuals moving into or out of the area is negligible, (3) there is no difference in catchability between marked and unmarked individuals, and (4) the marked individuals are randomly distributed throughout the population. In actual practice assumptions 1, 2, and 3 may be practically true if care in selection of time of year is exercised. The problem of deaths can be solved for studies conducted during long-time intervals by considering only individuals alive at the first marking period and assuming that the deaths are the same in the marked and the unmarked individuals. But the assumption (4) of random mixing unfortunately is often not true and the method may have serious error for this reason. Extreme care should be exercised on this point.

It should be noted that the ratio n/m is a sample from a population and hence is subject to sampling errors. Adams (1951) gives charts that permit an estimate of the confidence limits of the estimate.

Another method has been developed by Jackson (1939, 1948) for use on tsetse flies in Africa. After a number of individuals are marked they will comprise a smaller and smaller proportion of the individuals captured at subsequent times because of deaths and births. Suppose that we mark 100 birds and in each subsequent week, capture 100 birds. Suppose further, that in the first subsequent week 50 were recaptured; in the second, 35 were recaptured; in the third, 26 were recaptured, etc. By plotting these values against the week of capture, we can extrapolate to the value marked birds (63) which we would have caught if we had trapped again on the day we marked the birds. Then, utilizing the recapture-ratio method outlined above $N = \frac{100(100)}{63} = 159$ birds in the original population. Actually, the calculations are more complex than this simple example and the reader should use the original publication for analysis of results.

Still other methods are available for calculation of populations by results from banding. DeLury (1947) has developed a method for fisheries research based on the increased effort needed to catch a fish as the fishery is depleted. The method can be adapted to birds if, in the records, a marked bird is considered as dead or removed from the population. Thus, suppose that 100 birds are caught in 10 traps and banded the first day and 60 unbanded and 40 banded birds are caught in 10 traps the second day. Then the "Catch per unit effort" for an unmarked bird has decreased from 10 birds per trap the first day to 6 birds per trap the second day. The "catch per unit effort" will decline at a rate that depends upon the total catch and total effort. A plot of the catch per unit effort against the total catch gives the rate of decrease. These values can be used mathematically to calculate the original population but may be simply read from a graph. In the simplified example above, merely plot unbanded birds per trap (10 and 6) on the vertical axis and total unbanded catch (100 and 160) on the horizontal axis. Draw a line through these points and read the value at its intersection with the horizontal axis to give the total original population (250 in this case). For the actual details of the method the reader should consult DeLury (1947). An excellent discussion of methods is given by Ricker (1948). Modifications of this idea have been developed by Hayne (1949) and others.

These methods are obviously devised to overcome the fact that it is rarely possible to catch all birds in an area. Patently when all birds are marked, then the population is known. But such conditions rarely occur and hence estimates are necessary. These estimates usually involve the 4 assumptions listed above.

Banding data have seldom been used to estimate populations. Kendeigh's review (1944) covers this aspect in one paragraph and refers to only two publications. However, Borror (1948) analyzed records of White-throated Sparrows in an extensive study and called attention to the lack of utilization of banding records. His methods are variations of the methods described above and are given in detail in his publication. His results show for example, that White-throated Sparrows remain longer in the Fall than in the Spring, the numbers of birds in the waves during migration, and the number of birds present at any day of the migration.

The utilization of banding data as outlined above will permit an analysis of the extent of the three population forces and of the changes in populations. From these results, a further analysis may be made of the regulatory factors that govern the size of a population. The effects of environment, of predation, and of competition may be evaluated to give us some understanding of the factors that limit population.

To obtain the best results the species should be selected according to the problem in mind. Common species should always be selected because large amounts of data are necessary to prove an hypothesis. For example, to study reproduction performance a species must be easily caught in the nesting season. To study mortality the species must exist in relatively closed populations. Still another type of fruitful study is the comparison of a species in two different areas. Unlimited opportunities exist for the bird-bander to study populations.

REFERENCES

ADAMS, LOWELL, 1951, Confidence Limits for the Petersen or Lincoln Index Used in Animal Population Studies. *J. Wildlife Manag.*, 15(1): 13-19.

BAUMGARTNER, F. M., 1944, Dispersal and Survival of Game Farm Bobwhite Quail in North Central Oklahoma, *J. Wildlife Manag.*, 8(2): 112-118.

BUSS, I. O., 1946, *Wisconsin Pheasant Populations,* Wis. Cons. Dept.: 1-184.

BORROR, D. J., 1948, Analysis of Repeat Records of Banded White-throated Sparrows, *Ecol. Monog.*, 18(3): 411-430.

DELURY, D. B., 1947, On the Estimation of Biological Populations, *Biometrics*, 3(4): 145-167.

FARNER, DONALD S., 1949, Age Groups and Longevity in the American Robin: Comments, Further Discussion, and Certain Revisions, *Wils. Bull.*, 61(2): 68-81.

HAYNE, DON W., 1949, Two Methods for Estimating Populations of Mammals, *J. Mamm.*, 30(4): 399-411.

JACKSON, C. H. N., 1939, The Analysis of an Animal Population, *J. Anim. Ecol.*, 8(2): 238-246.

JACKSON, C. H. N., 1948, The Analysis of a Tsetse-fly Population III, *Ann. Eugenics*, 14(2): 91-108.

KENDEIGH, S. C., 1941, Territorial and Mating Behavior of the House Wren, *Ill. Biol. Monog.*, 18(3): 1-120.

KENDEIGH, S. CHARLES, 1944, Measurement of Bird Population, *Ecol. Monog.*, 14: 67-106.

LACK, DAVID, 1946, Do Juvenile Birds Survive Less Well Than Adults? *Brit. Birds*, 19: 258-264.

LACK, DAVID, 1949, The Apparent Survival-rate of Ringed Herons, *Brit. Birds*, 42(3): 74-79.

LINCOLN, F. C., 1930, Calculating Waterfowl Abundance on the Basis of Banding Returns, *U. S. Dept. Agr. Circ.*, 118: 1-4.

NICE, M. M., 1937, Studies in Life History of the Song Sparrow I, *Trans. Linn. Soc.*, N. Y., 4: 1-242.

ODUM, EUGENE P., 1942, Annual Cycle of the Black-Capped Chickadee, *Auk*, 59(4): 499-531.

PAYNTER, R. A., 1947, The Fate of Banded Kent Island Herring Gulls, *Bird-Banding*, 18(4): 156-170.

RICHDALE, L. E., 1949, *A Study of a group of Penguins of Known Age, no. 1*, Dunedin, New Zealand: 1-88.

RICKER, WILLIAM E., 1948, Methods of Estimating Vital Statistics of Fish Populations, *Indiana Univ. Pubs. Sci.*, Series no. 15: 1-101.

SOWLS, LYLE K., 1950, Techniques for Waterfowl-nesting Studies, *15th N. Am. Wildlife Cong.*, 473-489.

Johns Hopkins School of Hygiene and Public Health, Baltimore, Md.

A COLLAPSIBLE BIRD TRAP

BY ROBERT E. BAILEY

Many people trapping birds, whether for a nesting study, banding, or other purposes, are aware of the need for a trap which can be made in large quantities in a short time and which is fairly foolproof in operation. When faced with these problems in recent work with White-crowned Sparrows and other ground feeding birds, I devised a trap which was admirably suited to my purpose, the design and construction of which may be of interest to others.

The basic material used was ½-inch mesh hardware cloth, although ¾-inch mesh would be suitable for larger birds. The specifications given here apply to ½-inch mesh and the time required per trap when mass production methods are used is about 15 minutes. The sides, top, bottom, back end, and door were cut out by following the wires of the mesh, and it is important that only mesh in which the wires meet at right angles be used in order for the pieces to fit properly.