# PAPERS

## THE ROLE OF BANDING STUDIES IN EVALUATING THE ACCUMULATION AND CYCLING OF RADIONUCLIDES AND OTHER ENVIRONMENTAL CONTAMINANTS IN FREE-LIVING BIRDS

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With the recent advent of concern for man's environmental crisis has come a need to study the movement and ultimate fate of a number of contaminating materials which are now being introduced in ever-increasing quantities into natural ecosystems. Some of these contaminating materials include chlorinated hydrocarbons and other pesticides, heavy metals such as mercury and cadmium, various other industrial waste products and radioactive materials. Of all of these contaminants, radioactive materials offer particularly interesting possibilities for studies of the cycling processes by which such substances may move through natural systems and their inhabitants. This is because of the relative ease with which many of these radioactive substances may be detected and quantified in living subjects. This then opens the door to studies of free-living individuals which may be captured, have their body burdens of radioisotope contaminant determined, and then be marked for later identification and released. If this same individual can later be recaptured, its contaminant body burden may be determined once again, and when compared to the previous level, could indicate whether the contamination level had increased, decreased or remained constant during the period that the individual was free.

Of course, the success of such operations depends on whether or not the bird or other organism is recaptured by someone who possesses the proper expertise and detecting equipment to immediately determine the contamination level of the recaptured individual. There must also be a system of standardization, coordination and inter-communication so that both the person making the initial determination and the person making the recapture determination can exchange comparable data and results. These difficulties, while often insurmountable under many circumstances, can be easily overcome in cases where the same worker makes both the initial capture and determination, as well as the recapture. This is most easily done in the case of trap-prone passerines whose territory has been located or in the cases of repeated sampling of resident waterfowl populations which may stay in a given area for a certain number of months before leaving on their migratory journeys. The tendency of certain birds such as petrels, martins, swallows and



other passerines to return to the same breeding territory year after year also predisposes them to repetitive capture and contaminant determination by the same investigator.

Of the environmental contaminants mentioned earlier, most early work with banded birds has dealt with radionuclides, particularly gamma-emitting isotopes such as 137 Cesium. Such substances may be detected and quantified by restraining the bird in a small plastic tube, or, in the case of larger individuals such as birds of prey or waterfowl, wrapping the bird securely with an elastic bandage. The bird is then placed in the lead-lined chamber of a radio-emission detector where it must remain still for a period of between 20 and 50 minutes. After this counting period, the bird is banded and released, and subsequent counting determinations are made to determine the "background" radiation from cosmic rays and other sources that may have contributed the bird's apparent radioactivity. Finally, a standard or "phantom", containing a known amount of radioactive material and made to approximate the size, shape and body composition of bird, is counted. Comparisons of the counts from the bird and standard, both being corrected for "background" allows the calculation of the exact amount of isotope contained in the bird at the time it was counted. The same procedure is repeated for the recaptured bird, with appropriate changes being made in the size of the standard to correct for any possible changes in body weight which the bird might have undergone during its period of freedom. Because the living body tissues of birds are nearly 70% water by weight, aqueous solutions of the proper radioisotope are usually suitable materials for the construction of such standards. Laboratories which routinely make large numbers of such radioisotope determinations on living birds of many different sizes usually have on hand a number of different standards, usually made of aqueous isotope solutions in cyclindrical vials or bottles of varying size.

Such in situ contamination studies are of obvious importance for the determination and maintenance of overall environmental quality: if birds in a particular area are found to consistently increase their body burdens of some contaminant, it is a sure sign that there is some source of such a contaminant available to the birds in the area. In the case of birds whose migratory pathways are known (as determined perhaps through banding activities), increases in contamination levels over the years would suggest that certain contaminated areas are available to the birds along these routes. Several previous studies (Willard, 1960: Hanson and Jones, 1968) have utilized this concept of migratory birds

as cross-country integral monitors of the general level of environmental contamination, with the very mineral and elemental composition of the birds and such structures as their feathers, often being indicative not only of contamination sources, but the geographic area from which the bird came as well.

In the case of radionuclide contamination, birds frequenting waste disposal areas or the vicinity of nuclear power stations releasing radioactive contaminants to the environment would be expected to show increased levels of radioisotopic body burdens. Since most radioactive wastes are water soluble and eventually find their way into natural aquatic systems, studying the possible contamination levels of waterfowl and other aquatic birds in this regard may be particularly important. Furthermore, because the total bird community of a given area often includes numerous species of many different feeding habits, the monitoring of contamination levels of these birds would give a broad-spectrum view of possible contamination in many different food chains and pathways. If all of the bird species monitored in the vicinity of a given nuclear power station show non-significant levels of radioactive contamination, it is a pretty safe bet that no contamination of the environment is occurring as a result of plant operations at that site.

Another direct application of information obtained from a combination of banding and contaminant-monitoring studies of birds is the determination of the pathways and routes by which such birds may act to redistribute radionuclides or other dangerous materials from restricted waste-disposal areas. Such determinations are of particular importance when they involve species of game birds which may be shot and eaten by man as food. Such birds may therefore act as direct vectors of environmental contamination to the food chain of man. Even in situations where current contamination levels are negligible, the determination of the migratory patterns and movement habits of game birds containing even trace amounts of contaminants will provide the necessary predictive information which would allow an effective management and response to some large-scale accidental contamination in the area. For example, the determination of the migratory and movement patterns of waterfowl inhabiting cooling ponds and low-level waste disposal areas surrounding nuclear installations, would provide the information which would determine where, when and for how long the open season on waterfowl would have to be closed in the event of some kind of accident resulting in extraordinarily high waste contamination levels in the area. The obtaining of such information is not only



dependent upon banding studies in order to simply determine the movement and migratory patterns, from the waste disposal area, but banding work in conjunction with contaminant-determination studies, as described above, would also be needed in order to indicate how rapidly the birds would eliminate the contaminating material from their bodies once they leave the waste disposal area. This information, together with information concerning the speed and direction of movement, will predict those areas adjoining the waste disposal area where contamination levels of such game birds would render them unfit for human consumption.

In addition to the direct applications of integrated banding and contaminant-detection studies, such work may also occasionally provide direct means of verifying conclusions which otherwise had only been drawn on the basis of indirect evidence. For example, in a study reported in detail elsewhere (Brisbin, Geiger and Smith, in press), an attempt was made to determine the rate at which American coots (Fulica americana) accumulated radiocesium during their winter stay on a reservoir receiving reactor effluents. A sample of thirty coots was shot each month during the duration of their winter stay on the reservoir, and it was found that the radiocesium body burden of these sampled birds increased at an average rate of 2.69 + 0.249 (SE) pCi radiocesium/g live body weight/month ($r = 0.706$). Because of the method by which such data was collected, however, it would have been technically impossible to determine whether or not such an increase was due to a direct contamination of the birds residing in the area, or whether the increase was due to the continual arrival in the area of new birds which had become increasingly contaminated at some other site. Accordingly, banding studies were begun, and while such activities have not yet had the opportunity to produce a large number of recaptures in the area, the data obtained from the first such return capture of a Coot on the reservoir is indicative of the kind of information which can be obtained from such work.

USFWS Band No. 626-49703 was assigned to an immature male Coot which was live-trapped on the Savannah River Plant reservoir on 10 December, 1971. At this time, a whole-body count disclosed that the bird contained 5,783 pCi of radiocesium, or approximately 10.0 pCi/g live weight. This bird was maintained in captivity under non-contaminated conditions in order to determine the rate at which it eliminated the radioisotope from its body. On 22 December, 1971, when the bird's body burden had declined to 1,911 pCi (4.04 pCi/g), it was released on the reservoir again at the site of its

capture. On 26 March, 1972, after 94 days of freedom on the reservoir, this same bird was shot within 200 yards of the site of its release, during the collection of the routine March Coot sample. The bird's body burden at that time had increased to 5,943 pCi (9.54 pCi/g), representing an increase of 211.0% in the total body burden since the time of release, at a rate of 1.80 pCi radiocesium/g average body weight/month. Assuming the same statistical error distribution and confidence limits about this figure as those determined for the increase-rate calculated from the monthly shooting samples, it is not likely that these two independent means of determining contamination rate differed significantly. This banding work then suggested that the body burden increase shown by the monthly shooting samples was, indeed, due to an actual in situ contamination of the birds residing on the reservoir and not to an influx of birds contaminated elsewhere. It is interesting to note that the rate at which this bird was contaminated while living on the reservoir (1.80 pCi gained/g/month) was less than one-tenth of the rate at which it excreted the radioisotope during its 12-day period of captive confinement (18.43 pCi lost/g/month). This would suggest that once contaminated birds leave the area, they may excrete the majority of their body burden of radioisotope in a relatively short period of time, especially under conditions of sustained migratory flight which would place an extra drain on body energy reserves and thus make for a more rapid turnover rate of body tissue constituents.

In addition to the studies undertaken at the AEC Savannah River Plant, pioneering work in this area has also been undertaken at the Manomet Bird Banding Laboratory, Manomet, Massachusetts. Under the direction of Kathleen Anderson, this laboratory has successfully integrated a long-established program in bird banding with determination of radionuclide body burdens many species of birds netted in the vicinity of a recently-established nuclear power station. In that this Manomet study deals with determinations of the radionuclide body burdens of bird species representing many different feeding types and food chains, and also in that this study is based on being conducted in an area which has proved productive of multiple recaptures of numerous resident individuals in the past, this work fulfills most all of the criteria described above which are prerequisite to the collection of important data concerning the extent of environmental radionuclide contamination which may be produced by the power station.

As the number of nuclear power stations and other potentially contaminant-producing industrial activities expand throughout our



nation, the need for more such in situ environmental monitoring information increases. Unfortunately, few if any of even the most avid banders possess the equipment and expertise to do reliable contaminant monitoring at the location of their netting operations. However, it is possible that many such banders could lend some of their expertise in bird capture and identification to those groups of scientists possessing this ability, who might not be well-versed in banding techniques and procedures. Even in the absence of contaminant-monitoring equipment, the keeping of detailed and systematic records of numbers, species and the physical conditions of birds netted in the vicinity of potentially contaminant-producing sites could eventually prove of value in evaluating the environmental impacts of such areas.

For many years, the technique and art of bird banding has been pursued and developed by persons who possessed a genuine love for and appreciation of wild birds and the natural ecosystems in which they lived. It should be particularly satisfying to such individuals to now see this technique, which they had initially developed to learn more about the basic biology and natural history of birds, now also being applied to produce useful information which may be used, in turn, to prevent in some measure, the contamination and consequential destruction of such natural ecosystems by the unwise actions of man.

## SUMMARY

A combination of bird banding studies, along with simultaneous determinations of contamination levels of such substances as pesticides, heavy metals or radionuclides can provide much useful information of value not only in evaluating environmental impacts upon the birds themselves but also in detecting and determining the basic movements and cycling patterns of these contaminants through the environment in general, and thereby evaluating the possibility that such contaminants might eventually reach the food chain of man. Direct applications of such banding-contaminant detection studies include the possible detection of areas where contamination levels are consistently increasing in birds and other wildlife - thereby pinpointing areas of possible waste leakage or spills. Detection and/or prediction of possible contamination of game birds which might make them unfit to be eaten by man is also possible with this technique.

Another important aspect of such studies is the independent verification of data obtained by more indirect means to evaluate contaminant cycling. Examples are given of such banding-contaminant

determination studies which are currently being conducted in order to evaluate the cycling and movement patterns of radionuclide wastes in the environment surrounding nuclear installations. Although radionuclide studies have led the way in this field because of the relative ease with which they may be detected and quantified in living birds, the information and principles derived from such work are often of general applicability to probelms concerning other contaminants as well. Indeed, such studies are also proving to provide valuable basic information concerning the biology, ecology and natural history of many species of birds and the natural ecosystems which they inhabit.

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