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THE USE OF RADIOACTIVE TAGS IN MONITORING THE REPRODUCTIVE SUCCESS OF TERNS

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The accuracy of assessments of the breeding success of semi-nidifugous birds is often limited by the difficulty of regularly finding chicks. After about the first week of age the young of gulls and terns may wander long distances from their nests and in areas of heavy vegetation they can be very difficult to find. Some are quite easily located at habitual refuges which are marked by accumulations of food remains and feces, but the effort involved in finding all chicks in a monitored area may require intensive searches which disrupt the entire colony for undesirably long periods and which often destroy the vegetative cover in which the chicks take refuge. In order that the disturbance involved in monitoring breeding success might be reduced and to ensure that all chicks in a study area were accounted for, many investigators have used pens of wire mesh which enclose one or more nests (Kadlek and Drury 1968, Langham 1972, Nisbet and Drury 1972, Pearson 1968). Any chicks which are not removed by predators remain within such an enclosure, allowing breeding success to be determined with certainty and with minimal disturbance. But such enclosures are not effective in all circumstances; when put up in tern colonies on Sable Island, Nova Scotia, they were soon trampled by feral horses. This necessitated the development of an alternative method of ensuring that chicks from nests under study might be recovered easily and with little disturbance of the colony and of the breeding habitat.

STUDY AREA AND METHODS

Sable Island is a crescent-shaped sand bar about 160 km off the coast of Nova Scotia on which Herring and Great Black-backed gulls (*Larus argentatus* and *L. marinus*) and Common, Arctic, and Roseate terns (*Sterna hirundo, S. paradisaea,* and *S. dougallii*) breed. Lock (1973) showed that gulls breeding there were stressed in the breeding season by an insufficiency of food and that they preyed substantially on terns: 221 of 813 (27.2%) food fragments collected at Black-backed Gull nests were terns and tern eggs, although only 17 of the 713 (2.4%) fragments gathered at Herring Gull nests were tern remains. Investigations of tern reproductive success on Sable Island begun in 1983 showed that tern reproductive success was lower than in most studied colonies and that those birds breeding in heavy vegetation were usually the most successful. Because nest enclosures were not effective, monitoring of reproductive success required the presence of investigators in the colony for periods sufficiently prolonged, that in the circumstances of heavy gull predation pressure, the results obtained were considered unreliable.

There was an obvious need for a method of tagging substantial numbers of tern chicks in a manner which would allow them to be found quickly, without damage to the vegetation which provided their refuges, and at reasonable cost. Long range was not important. Experience had shown that the presence of chicks need only to be detected at a range of a meter or a little less by a detector passed over the vegetation in which they were concealed. The possibility of using modified metal detectors to detect metal leg bands or "optimal" targets attached to leg bands was explored but found to be not feasible. Small, very low-powered radio transmitters were a practical but not a cost-effective solution. The use of light-weight passive or unpowered transponders "illuminated" by a portable radio transceiver appeared to be practical, but such systems were not commercially available.

The only remaining possibility was the use of radioactive tags, a technique which has had wide use in small mammal studies (Linn 1978). The recent commercial availability of sensitive, hand-held scintillometers opened the possibility of finding chicks by detecting a low-activity radio-isotope tag attached to a leg band.

The most desirable attributes of any radio-isotope chosen for such a task are that it be a metal (for ease of handling) and that it have a relatively short half life. Tantalum 182 with a half life of 115 days was chosen. Two hundred pieces of tantalum wire 0.1 mm in diameter and approximately 1 cm long were irradiated to give an activity of 4 μ curies (148 kilobecquerells) each.

These sources emitted both β and γ radiation; the former more biologically damaging, but easily blocked by thin metal shielding; the latter less damaging, but less easily shielded. β radiation was effectively contained by rolling up the wire sources and enclosing them in aluminum capsules of 0.8 mm wall thickness. Thin-walled aluminum tubing is commonly available in 30 cm lengths in hobby shops in nesting diameters; i.e., 2.4 mm O.D. tubing with a 0.4 mm wall thickness exactly fits inside 3.2 mm O.D. tubing with 0.4 mm wall thickness. The Tantalum sources were sealed inside 0.5 mm lengths of nested 2.4 mm and 3.2 mm tubing which were carefully flattened with pliers to hold the source centrally in the tubing. This produced a 5 mm square, 2 mm thick which is easily attached to a metal or plastic leg band.

Although the specific activity of each source is very low and its half-life very short, it is desirable that tags should be removed from chicks before they fledge. To facilitate removal, tags were attached to the metal leg band by two thicknesses of 3.5 mm wide aluminum tape passing around the source and inside the band opposite the opening. This arrangement did not obscure the band number and allowed the tag to be easily pinched off the band. Such tape is sold in 50 mm widths and is normally used in car body repairs. Tagged bands were placed on chicks within two days of hatching and removed when the chick reached 21 days of age, Nisbet and Drury's (1972) Stage 5A.

The tags were detected with a hand-held scintillometer (E.D.A. In-

struments Model GRS 500 Differential Gamma Ray Spectrometer). This instrument has switchable energy-level windows and a choice of 1-s or 10-s sampling times. In this study the total count over a 1-s sampling time was used. The scintillometer was swung slowly, close over the top of vegetation in the search area and each second a scintillation count was displayed. But an instantaneous detection of an increase in γ ray flux was provided by an audio tone which increased in pitch as count rate increased. An adjustable threshold control allowed the instrument to be kept silent at prevailing background count level.

RESULTS

Initial experiments with the scintillometer and trial sources on Sable Island showed that variations in the background flux of γ rays varied slightly with time and from place to place. But over most of the Island during the daylight hours the background was around 90 counts/s. Random variations in the background count up to about 120 c.p.s. were frequent and if the audio threshold was set too low, responses to cosmic ray bursts confused the search. If the threshold was set to about 130 c.p.s. most of these bursts were eliminated yet sufficient sensitivity was retained to allow the detection of sources at a useful range. When searching for tagged chicks, the scintillometer was swung in an arc at an arm's length over the vegetation. A convenient scanning rate was found to be a swing through 180° in no less than 2 s. At this scanning rate the scintillometer responded reliably to a source at a distance which caused a γ ray flux approximately 50% greater than background. This response level allowed the detection of a 4 μ cu source at about 75 cm, 8 μ cu at 100 cm, 12 μ cu at 125 cm, and 16 μ cu at about 140 cm.

We planned to use the radioactive tags on all chicks hatched within discrete areas of the study colonies. Their use in this manner would be analogous to the employment of nest enclosures. However, the radioactive sources did not arrive until the peak of hatching had passed, so we had to tag late-hatching chicks in nests which were dispersed throughout the study colonies. The advantage of concentrated, as opposed to dispersed tagging, is that search time, and consequently colony disturbance, is reduced and since the area to be searched is smaller, the likelihood of missing chicks is reduced.

We put 181 tags on chicks of Common and Arctic terns in four colonies. In visits made at 3- or 4-day intervals, chicks were found more reliably and in a shorter time than in the previous year of the study. The method of mounting the tags on bands allowed easy detachment before chicks fledged, but 8 of the 181 tags (4.4%) were found in the colonies detached from the leg band.

DISCUSSION

In circumstances where use of nest enclosures is inconvenient or impractical, chicks can be monitored reliably by tagging them with low-activity radioactive sources. Chicks tagged in this manner will be found

as easily as chicks restrained within an enclosure, and assessments of chick survival so made will more accurately reflect survival in natural circumstances. Some chicks tagged in the course of this study were located as much as 75 m from their nests; enclosures do not allow this wandering in search of the best refuges, and where there are high gull predation pressures, enclosures may increase the vulnerability of chicks.

Searching for chicks is often quite destructive of the vegetative cover, particularly where birds nest in Beach Pea (*Lathyrus japonicus*). Tagged chicks were located with noticeably less damage to vegetation in the colony.

An unexpected advantage of the technique became apparent after the recovery of several dead chicks buried in the sand, chicks which would have otherwise not been recovered. These had been killed by horse trampling. In the previous year of the study some trampled chicks had been found on the surface, but the contribution of horse trampling to chick mortality would have been under-estimated had not the buried chicks been located by their tags.

After all terns had fledged, colonies were searched carefully for previously unlocated tags. None was found. However, searches with the scintillometer of a gull loafing area near one colony located 7 tagged bands and 2 detached tags, most of which were under vegetation or buried in sand and which would not have been found if bands were untagged. This suggests that the pattern of gull predation on tern colonies might be elucidated by careful searches with the scintillometer at gull nests and loafing spots around the study colony. It had previously been impossible to determine if those chicks which disappeared from a colony were victims of gull predation or whether they had simply wandered too far from the nest to be found in colony searches.

The use of tags in 1984 thus allowed us to partition chick mortality factors with confidence and accuracy. A major inaccuracy resulted from the 4.4% of tags which became separated from bands. We plan in future years to attach the shielded tags to flexible plastic leg bands which will be placed on the chick at the same time as the numbered aluminium band, but which may be easily removed from birds before fledging.

The use of radioactive isotopes in small mammal studies has been most recently reviewed by Linn (1978) and it is apparent that the activity level of tags used on Sable Island was far lower than those which have been used hitherto. Godfrey (1954, 1955) used 200 μ curie tags on voles and 80 μ curie tags on moles and reported no apparent ill effects. Punt and Nieuwenhoven (1957) used 250 μ curies on bats and Michaelsen (1966) used 200 μ curies and 5 m curies to tag shrews. The 5 m curie tags were not shielded to contain β radiation and at this level, 1250 $\times$ that used in the Sable study, some tissue damage was reported. Griffin (1952) details the calculations of exposure to radiation for tags of various strengths and half lifes and the exposure to which terns are subject if the Tantalum 182 tags are not removed is shown to be far below that which is likely to cause harm to the bird.

Radioactive tags seem not to have been previously used for the purposes of monitoring colonial bird reproductive success, presumably because of the unavailability of suitable sensitive and portable γ ray detectors. The 200 tags used in this experiment cost $700 and the scintillometer cost $3500. However, a cheaper detector without the γ ray spectrometric abilities of the GRS 500 would be quite adequate for detection of low level sources as described here. The abilities of this instrument to monitor γ ray emissions in three non-overlapping segments of the energy spectrum: 1.35–1.59 Mev, 1.65–1.87 Mev, and 2.45–2.79 Mev, allows its use to distinguish among three different γ ray sources. Since γ rays pass with only minimal absorption through non-metallic media, one could use such an instrument to monitor the presence or absence of burrowing organisms. In studies of hole-nesting birds, the male and female could be tagged with isotopes which emit in different parts of the γ ray spectrum and the chick could be tagged with a third. Monitoring the presence of these tags in the burrow could be accomplished with no disturbance simply by placing the scintillometer on the ground above the nest cavity and noting the presence or absence of emission in each of the separate parts of the γ ray spectrum. Suitable isotopes for such an endeavor could be selected from Bailey et al.'s (1973) list of isotopes which are considered useful for small mammal banding.

In any study tags should be removed before chicks fledge or before adults abandon the colony. Inevitably some birds will leave before tags are removed and in order that these birds should not be subjected to prolonged radiation exposure, the use of very short-half-life isotopes is imperative. Under no circumstances should one design an experiment which would result in the dispersal of long-half-life isotopes into the environment.

SUMMARY

The accuracy of investigations of the reproductive success of seminidifigous birds may be reduced by the difficulties of finding chicks in heavy vegetation. This problem is often overcome by the use of enclosures surrounding one or several nests, but where the use of enclosures is undesirable or impractical, it is suggested that chicks may be found reliably and with minimal disturbance with a scintillometer if each is tagged with a radio-isotope label. A short-half-life isotope, 182 Ta, was used and 4 μ curie tags were found to be detectable at a distance of 75 cm.

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