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EVALUATION AND IMPROVEMENT OF THE USE OF METAL DETECTORS FOR THE RECAPTURE OF MARKED GASTROPODS: RELIABILITY IN HABITATS OF VARYING STRUCTURE

In order to study and understand patterns of animal movement, in a range of habitats, researchers need a range of techniques for marking and recapturing individuals[1]. Detailed research is needed to develop and test such techniques so that they may be used with confidence[2, 3]. Lengthy pilot studies are often necessary to enable findings to be adjusted/interpreted correctly.

Techniques for tracking movements of intertidal animals over small distances have traditionally involved visual marks, such as painting the shell with enamel paint[4] or nail varnish[5] and attaching numbered plastic labels[6]. Marking is easy and the cost is negligible; but recapturing individuals marked in these ways requires labour intensive searches and is thought to have a high rate of failure, particularly in complex habitats.

Recently, underwater metal detectors have been used to recapture clams tagged with aluminium tags[7, 8] and gastropods tagged with small aluminium foil tags on complex coral reefs[3]. This technique has great potential utility, but had yet to be tested in other habitats. Such data are required to compare any differences in recapture success, so that comparisons are not affected by artefact of the technique. The performance of metal tags can be further improved by using solid pieces of metal, or folded metal sheets, that are less vulnerable to corrosion and can be stamped with a number, for the identification of individuals in the field.

In this note, I report improvement and evaluation of the use metal detectors[3] for use in mark-recapture studies of the intertidal gastropod *Littorina littorea* (L.). Tags were made from folded metal sheets stamped with a combination of number and letter. The reliability of the technique, tag loss and loss of detectability were tested on open rock, in rock-pools, among seaweed and among rocks and pebbles.

The study was carried out at two locations approximately 35 km apart on the east coast of Ireland; Bray Head, in Co. Wicklow (53°11′N, 6°04′W) and Rush, in north Co. Dublin (53°31′N, 6°04′W). Both locations are moderately exposed rocky shores. Small rough boulders, rocks and smooth stones constituted the general topography of shore in Bray Head. The topography of Rush consisted a network of bare bedrock, macroalgae, rock pools, mussel beds, stone, gravel and sand. I used a Pulse 8x underwater metal detector with a 7.5 in. detecting coil to locate tags fixed to the animals[3]. Aluminium metal sheets (weight per unit area 0.0486 $g.cm^{-2}$) were obtained in a range of colours from Creative Crafts, UK (http://www.creativecrafts.co.uk). Each tag was made from a 15 x 90 mm metal strip folded into a 15 x 15 mm square. Each tag was stamped with a combination of letter and number using a metal stamp. The tags were then attached to the shells using Milliput marine putty (Milliput™, The Milliput Company, UK). The smallest metal tag that could fit on a snail of size 8 mm, and still be reliably detected was of 0.3-0.4 g mass. The tags were detectable within a range of 7-8 cm and could be pinpointed to within 1-2 cm.

The reliability of the technique was defined as percentage of a known number of tagged *L. littorea* recaptured using a standard search pattern. To test reliability in a range of habitats, (open rock, rock pools, among seaweeds and among rocks and pebbles) 25 tagged *L. littorea* were spread in two transects of size 1 x 7 m in each habitat; the winkles were placed carefully in positions similar to those in which they had been found in previous research (on and under boulders, algal fronds and in rock pools). Immediately after releasing, a different researcher searched the area for tagged animals using the metal detector according to standard protocol. This involved walking at a steady pace and swinging the detector through overlapping arcs of 1 m wide. The detector was held as close to the substratum as possible[3]. Upon hearing the signal, the area beneath the coil was searched thoroughly for tagged snails. The total number of snails recaptured from each transect was recorded.

Loss of metal tags and loss of detectability were assessed in the field as part of a long-term experiment in which 25 tagged *L. littorea* were released at the centre of a 1 x 1 m plot in each habitat. Three replicates were carried out in each habitat. Searches were later carried out using the metal detector at different intervals of time: 1, 2, 3, 4, 5, 7, 10, 25, 36, 50, 60, 70, 80, 90, 101, 112, 123 and 131 days after release.

Reliability At Rush, 90-94% of the tagged *L. littorea* were recaptured immediately after release. Differences in recapture success were not significantly different between the different habitats ($F_{2,5} = 1.5$; $P = 0.35$). At Bray Head, only 82% of tagged snails were recaptured.

Tag loss and detectability During the four months field research involving metal-tagged *L. littorea*, 13% of tags were found detached from shells at Bray Head. At Rush, tag loss was 34% from animals released in rock-pools, 24% from animals released on open rock and 20% from animals released among seaweed. Tag loss occurred mainly during the first 25 days after release. On several instances, snails were recaptured from habitats other than the one into which they had been released. Eighty days after release, tags were detectable by the detector if held above 5 cm. Detectability of the tags reduced considerably after 80 days. After 123 days, the detector detected tags only if held 2 cm above each tag.

Metal tagging was effective in recapturing *L. littorea* from different habitats at Rush; 90-94% known number of tagged *L. littorea* were consistently recaptured immediately after release. Search for tagged *L. littorea* among seaweed was time consuming compared to other habitats, as snails lived cryptically among algal fronds. Recapture probabilities are likely to vary among sites, with low recapture from sites contaminated with metal debris. For example, Bray Head was contaminated heavily with metal debris and thus produced many false signals while using the metal detector. Therefore, the use of the metal detector was compromised which may have caused the lower recapture rate there. Using aluminium tags, Crowe et al. recaptured 86% of tagged *Trochus* [or trochids] from coral reefs immediately after release[3].

One day after tagging, Stewart and Creese recaptured only 16% of whelks tagged with aluminium discs and released at two intertidal sites[8]. After 10 days no whelks were found. In this study, I found an average 46% of *L. littorea* from different habitats after 10 days at Rush. Varying recapture of *Trochus* [or trochids] tagged using folded aluminium tags were reported in coral rubbles[13]. Less than 3% of the large *Trochus* [or trochids] released were recaptured in reefs at Australia, whereas 10% of *Trochus* [or trochids] were recaptured alive at Cunningham Point. None was recaptured from Sunday Island. They reported that, over 90% of those released could not be found at the sites after 3 months. The low recapture rate in this instance was attributed to loss of tag or predation. In contrast, I recaptured an average of 20% after 3 months.

Previous research on use of metal detectors was carried out in the tropics, mainly in soft sediment[8] and on coral reefs[3]. My study, on the other hand, showed the utility of metal detector in mark-recapture study in a temperate rocky shore. The metal detector detected tags until the end of four months, however, detectability reduced considerably after 80 days. Therefore, tag replacement is recommended at 80 days in long-term studies. Loss of detectability has been attributed to corrosion where tags were exposed to alternating combinations of salt water, air and sun[3]. Stewart and Creese[8] did not report loss of detectability of tags used in their study.

Individual marking has valuable applications for the shellfish restoration programs to monitor biological parameters like survival and growth[10, 8]. This can greatly improve the capacity for multiple observations and data recovery/analysis[11, 12]. Feasibility of reseeding is determined by the economic balance between the costs of producing hatchery-reared juveniles and the proportion that reach maturity after release[13]. Hence survival estimates are a key measure in assessing whether seeding is a viable tool for population enhancement.

Shellfish growth estimates are obtained, at the population level, using cohort analysis or through analysis of growth rings[13]. Individual tag recapture technique offers a more direct estimate of growth[14]. Recovering individually tagged animals greatly enhances the value of growth measurements of released animals.

Marking using numbered metal tags also provide dispersal distance data for individual snails. Such data are essential for modelling studies. Such data can be analysed for correlated random walk (CRW), an approach that can translate individual movement data into a measure of dispersal, or more importantly population redistribution[9]. Future research to explore population redistribution thus mainly depends on individual movement data, which are required to validate spatially explicit individual-based mathematical models[15, 16, 17].

There was greater tag loss in rock pools than in the other habitats at Rush. Predatory crabs were found in rock pools at Rush and may have contributed to increased tag loss in this habitat. Animals released in rock pools were wetted half an hour after attaching tags using Milliput, compared to animals released in other habitats, which were wetted by the tide only after 2-3 hours. This might have had contributed to lesser bonding of tags to the shell in rock pools, leading to tag loss. Stewart and Creese[8] reported a tag loss of only 10% in the field, but have not specified the time over which it occurred.

This study showed use of metal detectors for the recapture of marked intertidal gastropods. Improved tagging technique has allowed recapture and tracking of *L. littorea* in various habitats. The reliability and versatility of the technique has applications in the area of dispersal ecology and restoration monitoring of a variety of shellfish including *Trochus* [or trochids], giant clams, tropical and temperate abalone, terrestrial gastropods and scallops.

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