Corella, 1999, 23(1): 7–10

ASSESSMENT OF THREE METHODS USED TO ATTACH RADIO-TRANSMITTERS TO MIGRATORY WADERS IN NORTHERN NEW SOUTH WALES

D. A. ROHWEDER

School of Resource Science and Management, Southern Cross University, P.O. Box 157, Lismore, New South Wales 2480

Received: 21 September 1998

Thirty-two single-stage transmitters were attached to ten species of waders as part of a study on nocturnal habitat use. Three variations of a method used previously to attach transmitters to waders were compared. The aim of the comparison was to see if less disruptive variations of the standard attachment technique could provide similar retention times. The three variations were: 1) transmitter attached directly to the bird's lower back; 2) transmitter with gauze attached to a patch of trimmed feathers on the bird's lower back; and 3) transmitters were attached directly to a patch of trimmed feathers on the bird's lower back.

Retention time ranged from 11 to 55 days. The longest mean retention time was recorded for variation three (31 days), followed by variation two (30 days) and variation one (19 days). Despite the large difference between the averages there was no significant difference in retention time between the three variations. A significant difference in retention time was recorded between different weight classes. Birds weighing over 300 grams retained transmitters for a significantly longer period of time than birds weighing less than 150 grams. The results suggest that the capture and attachment of transmitters can have a short-term effect on bird behaviour.

INTRODUCTION

The use of radio-transmitters in the study of wader ecology has become a widely accepted method of obtaining data on habitat use (Dugan 1981; Wood 1986; Hill and Talent 1990; Warnock and Warnock 1993; Thibault and McNeil 1994; Warnock and Takekawa 1996). Dugan (1981) first used radio-telemetry on waders during his study of nocturnal habitat use by the Grey Plover *Pluvialis squatarola*. Since this early work, numerous researchers have employed telemetric techniques (Warnock and Warnock 1993). Apart from a brief study in the Hunter estuary (D. Geering, pers. comm.) and a study by Driscoll (1996) who used satellite transmitters to track the migration of the Eastern Curlew *Numenius madagascariensis,* there have been no detailed telemetric studies undertaken on waders in Australia.

As part of a study on habitat use it was necessary to attach radio-transmitters to waders and track their movements during the day and night. In the present study the major objective was to maximize the retention time of transmitters (i.e. the time the transmitter stays on the bird), while minimising the chance of detrimental impacts on the bird. The most widely used method of attaching transmitters to waders is to glue them to a patch of trimmed feathers on the bird's lower back using an epoxy resin (Warnock and Warnock 1993; Warnock and Takekawa 1996). Gluing transmitters is used as an alternative to harnesses, which can cause irritation and hamper movement (Sykes *et al.* 1990; Rappole and Tipton 1991).

Although gluing transmitters has proved to be a successful method, there is some concern that epoxy resin may irritate birds if it contacts the skin. In an attempt to reduce this risk three variations of the attachment technique described by Warnock and Warnock (1993) were compared. The work was undertaken in the Richmond River estuary, northern New South Wales (28°34'00"S, 153°52'30"E).

METHODS

During the study 32, single-stage transmitters (Titley Electronics) were attached. Single-stage transmitters were used because of their small size and cheaper cost. Transmitters ranged in weight from 2 to 6 grams. The smallest (2 gram) transmitters were used on the smaller species, such as Red-necked Stint *Calidris ruficollis*, Sanderling *C. alba*, Curlew Sandpiper *C. ferruginea* and Terek Sandpiper *Xenus cinereus*. The largest (6 gram) transmitters were used on large species such as Bar-tailed Godwit *Limosa lapponica*, Whimbrel *Numenius phaeopus*, and Pacific Golden Plover *Pluvialis fulva*. Battery life varied from 5 to 12 weeks depending on the size of the battery used. Transmitters were kidney-shaped and ranged in size from 12 mm long by 6 mm wide, to 20 mm long by 8 mm wide. The antennae ranged in size from 20 to 25 cm.

Birds were radio-tracked in January–February 1995 and 1996 and May–July 1995 and 1997. Ten species of migratory wader were involved in the study, these were: Pacific Golden Plover (3 individuals); Double-banded Plover *Charadrius bicinctus* (4); Sanderling (1); Red-necked Stint (2); Curlew Sandpiper (3); Grey-tailed Tattler *Heteroscelus brevipes* (5); Terek Sandpiper (5); Bar-tailed Godwit (5); Whimbrel (3); and Eastern Curlew (1).

Attachment method

Birds were caught at high-tide roosts and feeding grounds using standard mist netting procedures, although one Red-necked Stint was caught using a powerful spotlight and a butterfly net (Gerstenberg and Harris 1976) and a Sanderling was caught in a walk-in trap during a period of strong wind (more than 40

knots) and heavy rain. After capture, birds were weighed, sexed and aged (if possible). Age was determined using plumage characteristics described by Marchant and Higgins (1993) and Higgins and Davies (1996).

Selleys 'five minute araldite' was used to attach transmitters. Two advantages of using araldite were its availability and rapid hardening rate, which reduced the handling time of birds. The three attachment techniques were: 1) fine mesh (cotton) surgical gauze glued to the transmitter which was in turn glued directly to the bird's lower back (above the preen gland); 2) transmitters glued to an area of trimmed feathers on the bird's lower back (above the preen gland); and 3) transmitters with gauze were glued to an area of trimmed feathers on the bird's lower back (above the preen gland).

Depending on the technique being used a small patch of feathers on the lower back was trimmed leaving 1–2 mm of feather stub. Araldite was worked into the feather stubs using a small plastic spatula. Ethanol was used to clean oil or dirt from the feathers when transmitters were attached without trimming (variation one).

Prior to attachment, the bottom of each transmitter was roughened with sandpaper to improve contact with the glue. Birds were held until the glue had set, and were released near the point of capture. Handling time did not exceed 15 minutes. Transmitters were activated and tested immediately prior to attachment to ensure that a strong signal was received.

Information regarding the retention time of transmitters was obtained by counting the number of days from the time of attachment to either the time the signal was lost or the last time the bird was sighted with the transmitter. The wader population in the study area was counted at weekly intervals to monitor changes in bird numbers, and to search for bird's carrying transmitters with dead batteries. The counts revealed only small changes in wader numbers during the tracking periods. Signals were checked using a Regal 2000 telemetry receiver (Titley Electronics). The location of radio-tagged birds was determined at high and low tide at least three times per week.

Due to the mobile nature of migratory waders there are problems in determining the exact retention time of transmitters because it was not possible to always differentiate between a bird leaving the estuary and a transmitter falling off. Once transmitters fell into the water their signal was lost.

Although transmitters may be located if they fall off at high tide roosts no such observations were made during the study, suggesting that transmitters may have fallen off while in flight or at low tide feeding areas. Once a signal was located, the presence of the bird was confirmed by sight to ensure that the transmitter was still attached. By doing this the possibility of including days when a transmitter had fallen off was reduced.

RESULTS

Transmitter retention time

In order to evaluate the retention time of the three attachment variations the mean retention times were calculated (Table I). There was no significant difference in retention time between the three attachment variations (ANOVA — $P = 0.126$, DF 2, 28, $F = 2.23$), although trimming feathers resulted in a greater retention time than gluing transmitters directly on to feathers (Table 1). There was very little difference in the mean retention times between attaching gauze and trimming or simply gluing transmitters to trimmed feathers. Variations 2 and 3 displayed large ranges in retention times. Retention time varied by 34 days when using gauze and trimming, and 36 days when trimming with no gauze. A 12 day range was recorded when transmitters with gauze were attached directly to the feathers.

Differences in retention time were also apparent between different weight classes of bird (Table 2). The results show that birds weighing over 300 grams retained transmitters for a significantly longer time than birds weighing less than 150 grams (ANOVA — $P < 0.001$ DF 2, 28, $F = 11.0$).

The influence of bird size on retention time may have contributed to some of the variation recorded between the three attachment techniques (Table 1). The sample for trimming with no gauze and trimming with gauze were dominated by birds with a larger body weight. Smaller birds dominated the no trimming with gauze sample. The sampling bias provides further evidence to suggest that there is very little difference in retention time between the three attachment variations.

General observations

The results of radio-tracking suggest that the initial capture and attachment of transmitters can adversely affect the behaviour of some individuals. This was particularly evident for some Pacific Golden Plover, Terek Sandpiper and Curlew Sandpiper which were observed to move away from the lower estuary immediately after capture, returning 2–3 days later. One Terek Sandpiper and two Curlew Sandpipers appeared to stay at roosts for two days after capture.

Only one bird was not detected after capture; this was an Eastern Curlew, which may have left the estuary. In general, small birds displayed a more adverse reaction to capture and transmitter attachment than larger individuals.

TABLE 1

Comparison of retention time between the three variations of the method used to attach radio transmitters to waders.

Method of Attachment	*n*	Mean Retention time (days)	Range (Days)	SE
gauze, no trim	5	19	11–23	4.9
gauze and trim	15	29	15–49	2.8
no gauze and trim	11	31	19–55	3.3

TABLE 2

Comparison of transmitter retention time between three weight classes of wader. The three variations of the attachment method have been pooled for each weight class.

Species group	*Mean weight (g)*	*n*	Mean Retention time (days)	SE
godwit and whimbrel	367	8	40	3.1
golden plover and tattler	126	7	23	3.3
terek, small calidrids and plover	53	16	24	2.2

Most importantly, no mortality was detected as a result of the work.

Except for two Bar-tailed Godwits and one Whimbrel, which walked away, all individuals flew within 30 seconds of being released with transmitters attached. Some individuals shook themselves immediately after release, possibly in an attempt to remove transmitters. General observation of birds while roosting and feeding suggested that transmitters did not adversely affect movement and individuals were observed to behave in a manner similar to conspecifics. All individuals preened back feathers over transmitters leaving only the aerial visible. Aerials were preened into the tail feathers.

DISCUSSION

The results suggest that there was no significant difference between the three variations of the attachment technique, although the longest retention times were recorded when feathers were trimmed. Lower retention times may be expected when attaching transmitters directly to feathers as the increased drag on the end of feathers may cause them to fall out. This process may also be hastened when birds are moulting into breeding plumage. The results obtained for all three methods are likely to be influenced by the annual moult, and greater retention times may have been achieved if work was conducted in November and December, prior to moult. The failure to record a significant difference between the three variations is attributed to the large standard deviation, small sample size and low power of the analysis.

It is expected that a larger sample size would result in a significant difference. The results also show no difference in retention time between using gauze or not and trimming. This result is contrary to the findings of Whittingham (1996) who found that transmitters fell off after a few days if gauze was not used.

Retention time in the present study ranged from 11 to 55 days depending on the method of attachment. This is considerably less than the retention time achieved by Warnock and Warnock (1993), who had an average retention time of 49 days. The difference in retention time is likely to be related to the type of glue used. The large variation in retention times for each attachment method (shown by the standard deviations in Tables I and II) may be attributed to a number of factors. Some of these factors include: incorrect mixing of the glue, a failure to attain maximum bond strength, different moult stage, removal by the bird, or variation between species.

Araldite compares favourably to the results obtained for other readily available glues, such as, superglue (Sykes *et al.* 1990; Johnson *et al.* 1991; Warnock and Warnock 1993) or eyelash cement (O'Connor *et al.* 1987; Sykes *et al.* 1990), and the faster drying period of araldite and shorter handling time may be beneficial. For example, Warnock and Warnock (1993) found that 15 per cent of their birds were unable to fly with the transmitter, a result they attributed to time in captivity and bird weight. No such problems were encountered during the present study, a result attributed to brief handling times.

During their survey Warnock and Warnock (1993) targeted Dunlin *Calidris alpina* and Western Sandpiper *C. mauri*. Both of these species weigh less than 100 grams and would fall into the lower two weight classes used in the present study. Given the size of these birds, the retention times achieved by Warnock and Warnock (1993) appear significantly better than those achieved during the present survey.

The results show that by using small transmitters on large birds, retention time can be increased. This result may be attributed to the ratio between body weight and transmitter weight which was less for small birds. Although transmitters were 5 per cent of body weight for small birds they may have been only 1 per cent of body weight for larger individuals.

However, there is a trade-off between body weight and transmitter size and larger birds provide the opportunity to use heavier, multi-stage transmitters which can be detected at greater distances. During the present study, transmitters could be detected at distances of 0.5–2 kilometres depending on weather conditions the physical features of the site, and the size of the transmitter.

General observations indicate that the attachment of transmitters can have a detrimental effect on some species of wader. The failure of some individuals to fly immediately after release, the disappearance of others for up to three days, and the failure of some to leave roosts for similar periods, suggests that capture, handling and transmitter attachment can have a short term affect on bird behaviour. Warnock and Bishop (1998) also identified a 'capture effect' when attaching transmitters to migrant Western Sandpipers. They found that birds radio-tagged during migration remained at the tagging site for a longer period than birds radio-tagged earlier in the migration period. The effect recorded was attributed to a loss of body mass associated with capture.

The impact of capture and transmitter attachment may be detrimental to migratory waders when the high energy requirements of their annual cycle is considered. The results of the present study indicate that the timing of mist netting and radio-tracking activities immediately prior to migration should be avoided or at the very least due consideration must be given to the risk of effecting the ability of birds to migrate. Whether the behaviour observed during the study was a direct result of transmitter attachment or due to capture and handling is undetermined. Whittingham (1996) compared the behaviour of radio-tagged Eurasian Golden Plovers *Pluvialis apricaria* with control birds and found no difference in behaviour, although control birds spent more time roosting, while tagged birds foraged more. General observation of birds while roosting and feeding in the present study indicated that after the initial 'settling in' period birds with transmitters behaved in a manner comparable to conspecifics.

ACKNOWLEDGMENTS

Fieldwork was conducted under license No. A793 and the project was approved by the NSW NPWS and the

Southern Cross University Animal Care and Ethics Committee. Phil Straw, David Geering, Clive Minton and Bill Lane provided invaluable advice on mist-netting waders. Joe Wolfe, Simon Banks, Deanne Nelson, David Charley, Mick Howland, Trisha Rohweder, Bob Moffatt, and Ben Lewis assisted with the numerous hours of mist-netting, and Ben Lewis and Joe Wolfe helped with radio-tracking. Peter Baverstock, Mick Howland and Ross Goldingay provided comments on an earlier draft of the paper.

REFERENCES

Driscoll, P. (1996). Radio-tracking of waders: a general review and local work on Eastern Curlews in Moreton Bay, Queensland. *Southern Hemisphere Ornithol. Congress*. RAOU, Melbourne.

Dugan, P. J. (1981). The importance of nocturnal foraging in waders: a consequence of increased invertebrate prey activity. In 'Feeding and survival strategies of estuarine organisms'. (Eds N. Jones and W. Wolfe.) Pp. 251–260. (Plenum Press: New York.)

Gerstenberg, R. H. and Harris, S. W. (1976). Trapping and marking of waders at Humboldt Bay, California. *Bird Banding* **47:** 1–7.

Higgins, P. J. and Davies, S. J. J. F. (Eds) (1996). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 3, Snipe to Pigeons.' (Oxford University Press: Melbourne.)

Hill, L. A. and Talent, L. G. (1990). Effects of capture, handling, banding, and radio-marking on breeding Least Terns and Snowy Plovers. *J. Field Ornithol.* **61:** 310–319.

Johnson, G. D., Pebworth, J. L. and Krueger, H. O. (1991). Retention of transmitters attached to passerines using a glue-on technique. *J. Field Ornithol.* **62:** 486–491.

Marchant, S. and Higgins, P. J. (Eds) (1993). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 2, Raptors to Lapwings.' (Oxford University Press: Melbourne.)

O'Connor, P. J., Pyke, G. H. and Spencer, H. (1987). Radio-tracking honeyeater movements. *Emu* **87:** 249–252.

Rappole, J. H. and Tipton, A. R. (1991). New harness design for attachment of radio transmitters to small passerines. *J. Field Ornithol.* **62:** 335–337.

Sykes, P. W., Carpenter, J. W., Holzman, S. and Geissler, P. H. (1990). Evaluation of three miniature radio transmitter attachment methods for small passerines. *Wild. Soc. Bull.* **18:** 41–48.

Thibault, M. and McNeil, R. (1994). Day/Night variation in habitat use by Wilsons Plovers in northeastern Venezuela. *Wilson Bull.* **106:** 299–310.

Warnock, N. and Warnock, S. (1993). Attachment of radio-transmitters to sandpipers: review and methods. *Wader Study Group Bull.* **70:** 28–30.

Warnock, S. E. and Takekawa, J. Y. (1996). Wintering site fidelity and movement patterns of Western Sandpipers *Calidris mauri* in the San Fransisco Bay estuary. *Ibis* **138:** 160–167.

Warnock, N. And Bishop, M. A. (1998). Spring stopover ecology of migrant Western Sandpipers. *Condor* **100:** 456–467.

Whittingham, M. J. (1996). The use of radio telemetry to measure the feeding behaviour of breeding European Golden Plovers. *J. Field Ornithol.* **67:** 463–470.

Wood, A. G. (1986). Diurnal and nocturnal territoriality in the Grey Plover at Teesmouth, as revealed by radio telemetry. *J. Field Ornithol.* **57:** 213–221.