SHORT NOTE

A new technique for radio-tagging immature kiwi (*Apteryx* spp.)

Recent studies show that introduced mammalian predators are responsible for the decline of North Island Brown Kiwi *(Apteryx australis mantelli)* in mainland forests (McLennan *et al.* 1996). Young kiwi are especially vulnerable to mustelids (*Mustela* spp.) and cats (*Felis catus*) and in most years and places, recruitment rates are insufficient to compensate for adult losses.

The impacts of predator control on juvenile survival are now being studied in various parts of New Zealand, with the aim of developing strategies for the long-term preservation of kiwi in mainland forests. These studies depend heavily on radio-tracking to determine the fate of juveniles. However, young kiwi are particularly difficult to radio-tag for extended periods because they grow rapidly and their feathers dislodge easily. Furthermore, they spend considerable time in thick vegetation, which makes any harness system of attachment potentially lethal. Until this study, young kiwi were radio-tagged by attaching a transmitter to an area of shaved skin on their back, either with glue, or with a combination of sticking plaster and glue. This system accommodated growth but was extremely unreliable; most transmitters fell off within a few days of being attached. Here we describe a new method for radio-tagging young kiwi, and compare its performance to that of the 'back-mounted' method.

Kiwi chicks are exceptionally well developed when they hatch (Reid and Williams, 1975). They emerge from the egg as fully-feathered miniature adults, with adult-like feeding behaviour. Their bill and leg measurements are about one-third to one-half those of adults, but their mass and overall body size is much smaller (about 15% of an adult male). They usually begin to feed outside their nests within 2-5 days of hatching, and become fully independent juveniles at an age of just 3-5 weeks. They double their hatching weight (about 290 g) within 4-6 weeks of independence, then enter the adult weight range some 10-30 months later.

The transmitter packages currently used on adults (McLennan *et al.* 1987) are suitable for juveniles exceeding 1000 g, but are too heavy (20 g) and bulky (13 cm^3) to attach to kiwi less than seven months old. Young kiwi require small (<10 g) and 'streamlined' packages which do not entangle in vegetation. The transmitter packages also need to be attached in such a way that they accommodate growth, can be replaced easily when they near the end of their working life, and fall off before causing harm if the birds cannot be found in the event of transmitter failure. The package described here satisfied these requirements.

Design of the transmitter package for young kiwi

The transmitter package was designed to be strapped around the kiwi's leg, immediately above the 'knee' (tibiotarsus) joint, and to sit in place with the aerial

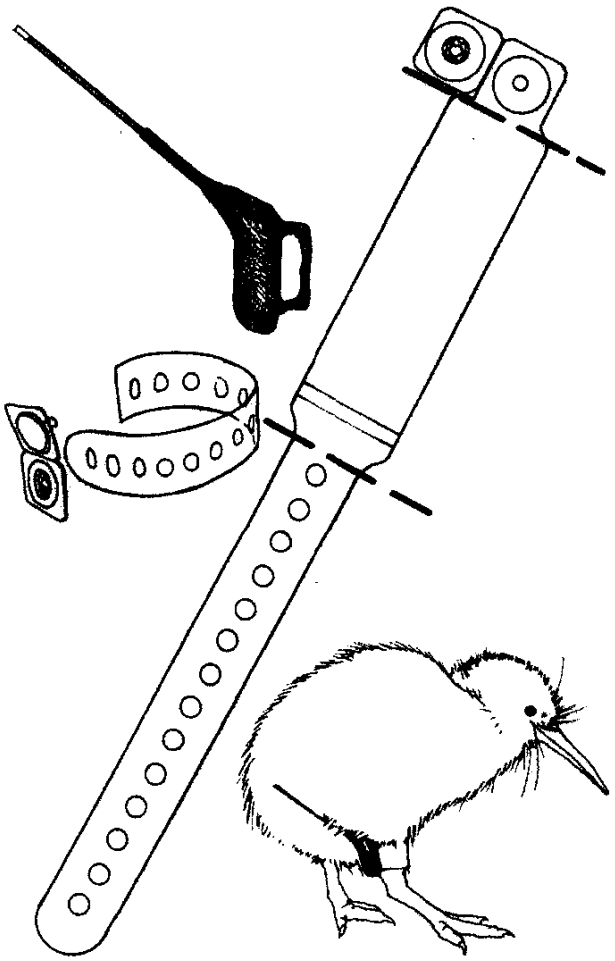

FIGURE 1- The new radio-tagging system for young kiwi showing the transmitter package (top left), the bracelet (middle diagonal), the two parts of the bracelet used to make the strap (middle left), and the transmitter in place (bottom right). The transmitter and bracelet are shown in actual size.

extending up and back at approximately 45°. The package contained: a single-stage transmitter with an external whip aerial and a line-of-sight range of about 1.5 km; a silver-oxide battery, sufficient to power the transmitter for about 90 days; and a magnetic reed switch, which enabled the transmitter to be switched off in storage. The complete package (Fig. 1) with its bracket and waterproof coating was light (4-5 g) and small (5 mm height x 18 mm length x 7 mm width + 40-55 mm whip aerial).

We attached the transmitter with a strap, made from parts cut from a hospital identification bracelet (children's model, manufactured by Precision Dynamics Corporation, San Fernando, California 91340, U.S.A.). These bracelets are made of clear plastic, strong enough to resist stretching, yet soft enough to prevent abrasion injuries (Fig. 1). We used the perforated end section of the bracelet as the strap, and fastened the ends together with the irreversible locking device supplied with the bracelet. The plastic degrades slowly in the field, and becomes so brittle after 2-6 weeks that it tears and releases the transmitter. We increased the life of the strap to about 10 weeks by strengthening it with one and half turns of PVC insulation

tape, wound on after the locking device was in place. The half-turn overlap ensured that the tape was firmly attached to itself, and would remain in place even if it peeled away from the plastic strap.

Tensioning the bracelet

The bracelet was tensioned carefully, so that the transmitter could rotate freely around the leg, but could not pass over the 'knee'. This is a clearly defined point, where small adjustments either way make the strap too tight or too loose. If necessary, we punched an extra hole to the bracelet to achieve the correct tension. When correctly fitted, the strap had sufficient looseness to accommodate up to 10 weeks of growth, about the time taken for the strap to degrade and fall off.

The entire process of attaching a leg-mounted transmitter took about 8 minutes, and could be performed by one person.

Comparative reliability of leg-mounted and back-mounted transmitters

From 1993 to 1996, we radio-tagged 15 chicks with back-mounted transmitters and 23 with leg-mounted transmitters. All chicks were tagged 3-25 days after hatching, and had not yet become independent. The two methods of attachment were compared sequentially, rather than as a paired trial, and involved successive broods from the same parents.

The back-mounted method of attachment proved to be largely unsatisfactory. All of the transmitters started to peel away from the skin after a few days, and so required frequent re-gluing to keep in place. This in turn meant that the juveniles had to be handled every 3-7 days, a task which became increasingly difficult as they became more agile and wary. Even so, 4 of the 15 back-mounted transmitters dropped off, on 2 occasions within 3 days of being re-glued. The signal from 3 of the remaining 11 transmitters was lost, probably because they stopped working; 7 transmitters were recovered after the chicks died or were killed by predators; and the last one was replaced after 6 weeks with a leg-mounted transmitter.

The leg-hold system was much more dependable. Only one of the straps failed prematurely, about half-way through its expected life. This happened after it lost its supporting strip of PVC tape. The remainder achieved their expected life of 10 weeks, or survived with no signs of failing up until the time the young kiwi were killed by predators. Juveniles which were still alive after 10 weeks were fitted with a new transmitter - a process which has been repeated whenever necessary. Five juveniles have now been re-tagged six times, and have worn a leg-mounted transmitter, without mishap or failure, for over a year.

Effect of back-mounted and leg-mounted transmitters on chick growth and behaviour

The growth rates of chicks with back-mounted transmitters did not differ significantly from those with leg-mounted transmitters in the first four weeks of

TABLE 1 - Comparative growth rates of North Island Brown Kiwi chicks with back-mounted or leg-mounted transmitters. Data are means ± one S.D. Bill length was measured along the upper mandible, from the curve of the cere to the tip. Differences between means were tested with Student's *t* test for independent samples.

Transmitter type	N	Body mass at tagging (g)	No. alive after 4 weeks	Growth rate ($g\ d^{-1}$)	Mean bill growth ($mm\ d^{-1}$)
Back-mount	12	287 ± 31	6	5.0 ± 1.2	0.18 ± 0.05
Leg-mount	14	322 ± 84	10	4.3 ± 2.2	0.15 ± 0.06
Significance, *P*		0.17		0.40	0.32

tagging (Table 1). Longer term comparisons were not possible because of inadequate sample size. Similarly, we could not assess whether survival rates were influenced by transmitter type because predator densities varied between years.

We seldom observed young kiwi when they were active at night, so were unable to directly determine whether the radio packages caused discomfort or behavioural changes. Apparently, however, chicks were not disturbed greatly by either the transmitter itself or the handling required to put it on, even though they struggled from time to time while the transmitter was being attached. They appeared to resume normal behaviour soon after being returned to their burrow. Radio-tagging did not influence fidelity to nest sites, even though we removed chicks from nests or captured them nearby to fit the transmitters. In all cases, the birds continued to use their nest until they reached fledging age. This suggested that the stress associated with radio-tagging was small, short-lived, and of little consequence.

Neither of the transmitter packages harmed the birds physically, though the leg-mounted transmitters occasionally caused mild chafing. This was never sufficient to break the skin, initiate infection, cause inflammation or swelling, and so was unlikely to cause discomfort or affect behaviour. On 2 occasions when we observed chicks with leg-mounted transmitters, the birds walked normally and did not attempt at any time to dislodge their transmitters.

All of the chicks with back-mounted transmitters tried to remove them from time to time, usually while they were preening. Some of the feathers that were glued onto the transmitter package or trapped beneath it may have tightened as the chick grew, and caused discomfort. Some birds managed to snap the whip aerial off the package, by repeatedly pulling it down then releasing it. Others pulled at the elastoplast base and caused it to fray along the edges. These observations suggest that the back-mounted transmitters were less comfortable than the leg-mounted ones - though seemingly the differences were not sufficient to affect growth rates.

In summary, the leg-mounted transmitters were better than the back-mounted ones, because they seldom fell off prematurely and appeared to cause less discomfort. The risk of damaging young kiwi, perhaps fatally, by encircling their tibia with a strap was avoided by using degradable materials with a predictable life. The technique

described here may well be useful for the young of other flightless birds, especially those with relatively slow growth rates.

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