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MARKING OF SOUTHERN ELEPHANT SEALS WITH PASSIVE INTEGRATED TRANSPONDERS

In the study of life histories, a longitudinal protocol has many advantages over a cross-sectional one: avoidance of sampling bias, estimates of survival and reproduction from lifetime individual records, full coverage of selection episodes, and the opportunity to relate life history strategies to phenotypic traits (Clutton-Brock 1988). A longitudinal protocol requires unequivocal recognition of individuals, to allow identification and tracking across years. In some species, natural marks permit reliable identification of individuals (Bateson 1977), but recognition is usually accomplished by artificial marking, in particular when a large number of individuals is involved. An important component of mark-recapture studies is reliability of marks, and mark-loss rate may affect estimation of survival and reproduction (Arnason and Mills 1981).

The most common long-term marking techniques for pinnipeds are plastic tags and branding (Erickson *et al.* 1993). While tags may last for many years, they are affected by a variable rate of tag loss, and their readability may be reduced by wear (Testa and Rothery 1992). Branding is not affected by the risk of mark loss (although readability of marks may degrade over time), but it not always produces usable marks (McMahon *et al.* 1999), and it may pose a significant problem when research is not the only activity in the study area, *i.e.,* when the area is also exploited for tourism and leisure activities, the aesthetic aspects of marks should be considered. From an ethical point of view, pain produced by brands is apparently greater than that produced by tags (Erickson *et al.* 1993).

In 1995 we started a long-term research project on southern elephant seals (*Mirounga leonina*) at Sea Lion Island, Falkland Islands (Galimberti and Boitani 1999). Every year from 1995 to 1998 we tagged the entire pup cohort (each year 505–543 pups survived until the end of the breeding season), with a plan to continue tagging in the future. We used Jumbo Rototags (Dalton Supplies Ltd; http://www.daluk.demon.co.uk/; info@dalton.co.uk) of different colors and with alphanumeric codes. We placed two tags in the interdigital web of the rear flippers of each individual, one tag in each flipper. The first tag was put in place just after birth and the second just after weaning. Tagging was deemed to be a very good method for marking elephant seals (Wilkinson and Bester 1997), and in our population tag-loss rate was low and showed a reduction in the latter seasons (this was most likely due to an improvement in our tagging capabilities). In 1997 and 1998 the likelihood of losing both tags, as calculated from a binomial model applied to double-tagged individuals, was 0.0031 for both males and females.

Notwithstanding that, the risk of tag loss may have a significant effect in the long term, in particular with pups and young individuals. Adults of both sexes return to land regularly and show strong philopatry (Nicholls 1970; SLI, unpublished data), and in small and localized populations, such as the one at Sea Lion Island, it is easy to replace lost or worn tags when each individual is marked with multiple tags from the beginning. However, young individuals have a less regular pattern of return to land, at least until maturity, making retagging more difficult. Since marking is an important component of our research plan, we employed an alternative marking method to estimate the likelihood of tag loss. We excluded branding to keep direct handling and pain-provoking procedures to a minimum. We were also concerned about the public reaction to branded seals in an area exposed to tourism. As an alternative, we implemented a marking system based on implanted passive integrated transponders (PITs), an increasingly common method for both domestic and wild animals (Fagerstone *et al.* 1987, Thomas *et al.* 1987, Schooley *et al.* 1993, Wright *et al.* 1998).

In 1997 we implanted Trovan PIT tag (model ID 100, Trovan Inc.; http://www.trovan.com/) transponders in 510 weanlings (= 93.2% of the full cohort of survivors). These small glass-encapsulated transponders (length 11.5 mm, diameter 2.15 mm, weight 0.1 g), operating at 128 KHz, are widely used in zoos and are endorsed by the Captive Breeding Specialist Group of the IUCN (Wright *et al.* 1998). We chose Trovan Inc. because they supplied a hand-held reader (model LID 500) that, although large (length 22 cm, width 17.5 cm, height 27 cm) and awkwardly shaped, had the greatest scanning distance (18–20 cm, depending on battery charge) of the models available on the market.

Most weanlings were implanted with one transponder, but some of them (3.7%) were implanted with two transponders, in order to verify the reportedly high reliability (due to the absence of batteries or mechanical parts). Transponders were implanted using an applicator fitted with a single-use needle (length 55 mm, diameter 2.6 mm). Each transponder was already loaded in the sterile needle and packaged in a blister. They were implanted at the base of one of the rear flippers (if possible on the left side, to simplify reading protocol). Initially, two people restrained the weanling by hand, one handled the applicator, and one read the transponder and recorded data. Ultimately, the transponder was placed by surprise; this procedure guaranteed a reduction in team size and was very effective in most cases. Implantation by restraining of the animals required 60–120 sec, while implantation by surprise was practically instantaneous, similar to placing a tag. An additional advantage of this second technique is that none of the operators actually touch the weanlings. Reaction to implantation was short. We verified the transponder code twice, when it was yet in the blister and just after implantation. Failure rate during implantation was less than 1% and was due mostly to the transponder falling out of the needle before actual implantation (dropped transponders were sometimes recovered on the ground but not re-used); this happened only when implantation conditions were not good (*e.g.*, awake individuals). Implantation of most transponders was carried out over a three-day period (18–20 November, at a rate of 102–192 transponders per day, one day devoted to each part of the study area). Transponders were then rechecked during the next four days (and 3–26 more PITs deployed), at the same time scanning weanlings to read already implanted transponders and to examine the implantation sites for external signs of tissue reaction. All transponders were readable and no tissue reaction was observed.

Implantation by surprise hinders preliminary disinfection of the implantation site, and this raises some concern about health of implanted weanlings. As a first check of the effect of PIT tagging on weanlings survival, we compared the proportion of returned weanlings (*i.e.*, weanlings that haul out at Sea Lion Island during the year after their birth) between the 1996 cohort (no PIT tagging) and the 1997 cohort. 9.25% of the 1996 cohort (n = 508 weanlings) was resighted *versus* 11.79% of the 1997 cohort (n = 543; Fisher's exact test: P = 0.1927). Our resighting effort covered just a part of the period in which yearlings may haul out (McMahon *et al.* 1999), but it was balanced between the two cohorts and, hence, we have no evidence of an adverse effect of PIT tagging on weanling survival.

In 1998 we verified the functionality of transponders in yearlings hauled out during late November for the molt. We tried to read the PIT tags in ideal conditions, *i.e.*, with the animal resting and unaware of our presence. In a sample of 45 individuals, 42 transponders were easily read one or more times, and on consecutive days. For two of the remaining individuals, transponders were not read the first time because reading conditions were not optimal but were read on subsequent attempts with the individual resting or sleeping. Only one individual did not return a transponder reading under optimal conditions and during multiple attempts. Overall, failure rate was very low (2.2%). In most cases, reading was easily accomplished, and with resting individuals the reading wand was within 5 cm of the body, which was well below the maximum operating distance of the reader. The major problem we had was failure of the batteries of the reader when not regularly recharged; this problem is attributed to an engineering fault and we have been informed that it should be rectified in the next generation of Trovan readers.

In 1997 in addition to weanlings, we marked a small sample of adult and large subadult males with transponders (32 were fitted with one PIT and 5 with two; in all, they represented 52.9% of the resident males), as well as a few adult breeding females. Implantation of PITs on males was easily accomplished without restraint. On the contrary, implantation and reading on females were much more difficult because of harem formation. Due to temporary failure of reader batteries, we were not able to carry out any systematic checking of transponders during the main part of the breeding season, hence we have no firm results on the effectiveness of PIT marking of adults. We were, however, able to successfully read PITs on some of the males at the end of the breeding season, and a transponder allowed identification of the only subadult male that lost all its plastic tags between 1997 and 1998.

The reliability of PITs in the long term remains unclear, but preliminary evidence reported in the literature (Wright *et al.* 1998) indicates that, if the transponder is properly placed, it should remain in that particular position without migration into deeper tissues. PIT tagging has many advantages, but it is expensive (6–12 times the cost of a plastic tag), marked individuals are not easily recognized at first encounter, and reading of the ID code requires an awkward battery-operated device. Hence, we consider PITs not as a replacement for plastic tags but as an effective back-up system, especially when lifetime identification is required. In this role, PITs are an effective way to mark elephant seals and probably seals in general.

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