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Surgical Implantation of Intra-abdominal Radiotransmitters in Marine Otters (*Lontra felina*) in Central Chile

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ABSTRACT: Six free-ranging marine otters (*Lontra felina*) were livetrapped on the central coast of Chile and implanted with specially designed radiotransmitters as part of a spatial ecology study. Marine otters frequent the rocky seashore, often squeezing their narrow bodies through cracks and crevices and grooming themselves on the rocks. They are also among the smallest of the otter species, weighing between 3.4 kg and 4.5 kg. For these reasons, the transmitter used was small, rectangular, and flat, measuring 3.5×3.2×1.0 cm. They were implanted using a ventral midline approach to minimize contact between the skin incision and sharp-edged rocks. Surgical incisions healed within 2 wk. The transmitters functioned well, but the duration varied from 62 days to 143 days instead of the 240 days predicted by the manufacturer. All six marine otters re-established in their home ranges, and survey results suggest they survived well beyond the life of the transmitters.

Key words: *Lontra felina*, marine otter, radiotransmitter, surgery, telemetry.

Marine otters (*Lontra felina*) live along South America's Pacific coast from Northern Peru to Cape Horn in Chile, including the Isla de los Estados in Argentina. The distribution of this endangered species is patchy throughout its range. The total population of free-living marine otters is unknown, but it is estimated to be a few thousand.

Relatively little is known about the reproductive biology, habitat use, and feeding ecology of marine otters. This information is essential for the development of an effective conservation plan for this species (Medina-Vogel et al., 2007). Marine otters are difficult to study by direct observation, however. Males and females exhibit no sexual dimorphism, and both spend up to 80% of each day on dry land—much of that time resting in their dens. Radiotelemetry has recently been used to study marine otter spatial ecology and habitat use in Chile (Medina-Vogel et al., 2007). Here, we report on methods used for these studies, including the use of a radiotransmitter designed specifically for marine otters.

When telemetry was first applied to study otters, a variety of transmitters and attachment methods were evaluated (Melquist and Hornocker, 1979; Garshelis and Siniff, 1983; Mitchell-Jones et al., 1984). Radios were attached using collars and harnesses, fixed to the rear ankle or foot, and they were implanted subcutaneously. Some otters removed their collars; others developed skin lesions and digit fractures; some died. These techniques have since been replaced by intra-abdominal placement of radiotransmitters in North American river otters (*Lontra canadensis*; Melquist and Hornocker, 1979; Hoover, 1984; Hernandez-Divers et al., 2001), as well as sea otters (*Enhydra lutris*; Williams and Siniff, 1983) and Eurasian otters (*Lutra lutra*; Fernandez-Moran et al., 2002).

Marine otters frequent the rocky seashore, often squeezing their bodies through cracks, crevices, and small cavities, and grooming themselves on the rocks. They are also among the smallest of the otter species, weighing between 3.4 kg and 4.5 kg. For these reasons, the transmitter used for this study was small, rectangular, and flat, measuring 3.5×3.2 ×1.0 cm and weighing 15.3 g, and it was equipped with an activity sensor (VHF 150–151 MHz, Sirtrack Ltd., Havelock North, New Zealand). Previously, a ma-

rine otter died after surgical implantation of a standard-sized cylindrical transmitter (10 cm in length×2 cm in diameter) weighing 40 g by using a ventral midline approach (Medina-Vogel, pers. comm.). In this case, the implanted animal died of peritonitis associated with a ruptured stomach, apparently caused by the large-sized transmitter pressing on the stomach contents, which included the sharp claws of crab. We chose a ventral midline approach for surgical implantation rather than a lateral approach through the paralumbar fossa as recommended by Hernandez-Divers et al. (2001) based on our observations of marine otter behavior. A ventral incision is exposed to more fecal and urine contamination, but it also minimizes the risk of trauma to the surgical wound in a species with a tendency to squeeze through narrow rocky spaces.

Between May and July 2004, six adult marine otters (three females and three males), with an average body mass of 3.7±0.3 kg, were livetrapped in the rocky seashore of Quintay (33°11′S, 71°43′W) on the central coast of Chile by using number 1.5 leghold traps (Victor Soft catch, Woodstream Corp., Lititz, Pennsylvania, USA) that were checked every 6 hr. An intramuscular injection of 5 mg/kg ketamine (100 mg/ml, Ketostop, Drag-pharma Invetec S.A., Santiago, Chile) combined with 50 μg/kg medetomidine (1 mg/ml, Domitor, Pfizer, Madrid, Spain) was administered for chemical immobilization (Soto-Azat et al., 2006) by hand-syringe with the otter restrained under a blanket. The otters were immediately removed from their leghold traps and transported to the field quarantine room at the Quintay Marine Research Center of the Universidad Andres Bello. Each otter was given a thorough physical examination that revealed moderate inflammation and minor cutaneous lacerations of the digits held by the trap in five individuals. One juvenile female otter suffered an open fracture of the second phalanx on the second digit of the left forelimb. This otter was treated with 25 mg/kg flucloxacilin administered four times a day orally for 14 days (500 mg, Flucloxacilina, Mintlab Co., Santiago, Chile), 1 mg/kg ketoprofen once a day orally for 5 days (10 mg, Naxpet, Drag-pharma Invetec S.A.), and flushes of povidone–iodine 3% solution applied using a 60-ml syringe from a short distance for 14 days. The other otters were also treated prophylactically with 2.5 mg/kg enrofloxacin (50 mg, Rostrum, Drag-pharma Invetec S.A.) administered orally two times a day for 10–14 days, and 0.5 mg/kg ketoprofen once daily orally for 3–5 days. No dental injuries were observed.

All otters were individually housed in wire mesh cages (90 cm in length×40 cm in width×48 cm in height) joined to a den made of polyvinyl chloride pipe (100 cm in length×40 cm in diameter). A 40-cm-diameter×15-cm-deep bowl was provided for drinking and swimming. Food was offered the same day of arrival and each day thereafter. The diet consisted of 900 g of fresh silverside (*Odontesthes regia*), flounder (*Paralichthys microps*), and local crabs (*Homalaspis plana*, *Cancer* spp., and *Mursia gaudichaudi*). All otters ate within the first 48 hr. Vitamins A, D, and E, 0.075 ml of a mixed preparation, were added to the diet once daily (Inveade, Drag-pharma Invetec S.A.) along with 2.5 ml of B vitamin complex two times a day (Hematon B12, Eximerk Ltda., Santiago, Chile). These supplements were given for 10 days to avoid common deficiencies observed in otters fed captive diets (Kollias, 1999). Finally, a single dose of 200 μg/kg ivermectin (10 mg/ml, Crack, Laboratorio Chile S.A., Santiago, Chile) was administered subcutaneously to prevent the acquisition of any parasitic infection. All otters were held in captivity for 2 wk before surgery to allow them to heal any injuries and acclimate to their surroundings. During this time, all otters behaved normally, grooming and scent-marking; each otter consumed an average of 617±93 g/day of

food. All otters gained weight, with an average increase of 217±301 g.

On the day of surgery, the otters were fasted for 6 hr. Anesthesia was induced using 5 mg/kg ketamine combined with 50 μg/kg medetomidine administered by hand syringe, with the otters restrained in a squeeze cage. The anesthetized animals were transported to a nearby operating theater. Isoflurane (2.7±0.8%) (Isoflurano USP 100%, Baxter, Guayama, Puerto Rico, USA) and oxygen (2 l/min) via face mask were administered for anesthetic maintenance. Physiologic and anesthetic parameters were monitored throughout anesthesia as described by Soto-Azat et al. (2006), and all otters remained physiologically stable throughout the procedure. A 6×4-cm area of the ventral midline cranial to the umbilicus was shaved first with electric clippers and then a scalpel blade, followed by a scrub of 0.5% chlorhexidine (Nolvasan, Fort Dodge Animal Health, Fort Dodge, Iowa, USA). A 4-cm craniocaudal incision was made in the center of the prepped area, the muscle layer was exposed by blunt dissection, and 3.5 cm of muscle and peritoneum were then transected through the linea alba. Before implantation, the transmitters were disinfected in 2% chlorhexidine for 40 min and then rinsed in abundant 0.9% NaCl sterile solution. The radiotransmitter was inserted in the abdominal cavity just cranial to the incision and placed horizontally over the ventral abdominal wall. Closure of the incision was made with the use of absorbable polyglycolic acid number 2/0 suture (Safil, Braun, Tuttlingen, Germany). The peritoneum and muscle were sutured together using an interrupted cruciate pattern; the subcutaneous tissue was apposed in a simple continuous pattern, and the skin was closed in a simple interrupted pattern. Once the surgical procedure was completed (57.5±4.5 min), the otter was given an intramuscular injection of 30,000 international units (IU)/kg penicillin G benzathine/penicillin G procaine solution (150,000 IU/ml, Bipencil L.A., Laboratorio Chile S.A.), 1 mg/kg ketoprofen, and 250 μg/kg atipamezole to antagonize the anesthesia (5 mg/ml, Antisedan, Pfizer) The animals were fully recovered from anesthesia (return to an ambulatory state) 16.6±5.7 min after the administration of the antagonist. No seizures or resedation were recorded. Their drinking/swimming bowls were removed for 5 days to keep the incisions dry (marine otters obtain fresh water from their food). Given the small size of the holding cages, some food detritus and fecal material did accumulate on the wire mesh; therefore, the surgical incisions were disinfected daily with abundant povidone–iodine 3% solution, applied as described previously.

At 10–17 days, when the surgical incision was judged completely healed, each otter was released in the same place it was trapped, and radiotracked at 10-min intervals. For the six otters, average tracking time until the transmitters ceased emitting signals was 100±30 days, with a total of 3,527 radiolocations. All implanted otters emitted a clear signal which could be picked up at a distance between 100 m and 1,200 m, depending on the animal's location, which ranged from close but inaccessible dens to the open sea. Including the postoperative period, the implanted transmitters lasted from 62 days to 143 days, considerably less than the 240 days predicted by the manufacturer.

Possible explanations for the early signal loss include battery failure, or the otters moved or died outside the range of the telemetry equipment. We have evidence that supports the batteries in our specially designed transmitters failed. We found no direct evidence of otter mortality or migration out of the study site while the transmitters functioned, and we saw no signs of illness or abnormal behavior on the last day the transmitters functioned for each of the six otters. We tracked every otter for at least 45 days after surgery, long after the surgical incision had healed, and all otters seemed to behave normally.

We were able to pick up signals from otters even when they moved into deep, inaccessible dens. Had the otters died in their dens—sick or injured marine otters are known to retreat to their dens to die—we would have detected an abnormally prolonged inactive signal while the transmitters functioned; all otters survived to the day their signals suddenly ceased. Finally, our telemetry results showed that all animals rapidly became re-established in their home ranges, and there was no evidence that they migrated outside of the study area. Marine otters rarely cross long sandy beaches, and both were present north and south of the study site (Medina-Vogel et al., 2007; Medina-Vogel et al., 2008).

We suggest evaluating a slightly larger transmitter with greater battery capacity for future radiotracking studies in marine otters if collection of data for a longer period is intended. We recommend the ventral midline approach for intra-abdominal radiotransmitter placement in marine otters for its ease and reduced risk of incision trauma associated with normal grooming behavior. In this study, daily povidone–iodine flushes and prophylactic oral antibiotics succeeded in preventing serious contamination or surgical wound infection.

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