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Note

The icing of external recorders during the polar winter

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Abstract: Recorders and transmitters are commonly attached to suitable polar species of vertebrates. When using these devices, power and memory are two of the most limiting factors in successful experiments. To conserve power and memory the units are often programmed to record or transmit at designated times. A commonly used sensor is operational only when the animal is in sea water. For this procedure to function properly, exposed electrodes close a circuit when the attached device is wet. Using satellite transmitters that were programmed to transmit only after they were dry for a prescribed time, we noted an uncommon number of failures in transmission. On later controlled experiments using captive emperor penguins, *Aptenodytes forsterii*, we found that mock transmitters formed a glaze of ice over their surface while the birds were diving freely into an ice hole cut in two meter thick sea ice. We concluded that the icing caused the sensor to fail in detecting when the birds had re-entered the water. Icing could be an important factor in successful use of attached recorders and transmitters on polar animals, especially in winter.

key words: PTT, satellite tracking, icing

Introduction

It has become a common procedure to deploy transmitters and recorders of various sorts on marine birds and mammals in polar regions (see these proceedings). Often the devices are programmed to operate at intermittent times during the deployment period, and/or they may have an external antenna for transmission of data or position. To conserve battery power the time of operation is frequently determined by sensing when the recorder is in or out of seawater. To do this, a conductivity sensor is installed that detects when it is immersed in seawater. We used such a system that had only limited success during January to April of 2000. We suspected a problem with the programmed detection of when it was in or out of seawater, which we had elected to use to try and extend the battery life so that we would get transmission receptions throughout the winter.

In order to determine what might have been the problem we tested mock devices of similar size, shape, and material attached to captive emperor penguins, *Aptenodytes forsterii*, diving at will from an isolated dive hole during October and November of 2000 (Ponganis *et al*., 2000).

Methods

In January and February of 2000 (the austral summer) seven satellite transmitters were deployed on emperor penguins, while transiting through the eastern Ross Sea on board the RVIB Nathaniel B. Palmer. Six of the transmitters had salt water switches (SWS), and were programmed to stop transmitting anytime the sensor was submerged in seawater. Five of the transmitters also had an extended surface program that stopped transmissions if they had been dry for three hours. In this latter case, once they were wetted for 30 s they would resume transmitting during the dry intervals of the wet and dry diving cycle. The sixth transmitter with a SWS was not programmed to stop transmitting after it was dry for three hours. The seventh transmitter had no SWS and transmitted continuously. These last two transmitters were also duty cycled to transmit for 12 h and to shutdown for 12 h. All Platform Terminal Transmitters (PTT) were attached in the standard manner of gluing the transmitter to the feathers with Loctite 401, and reinforcing the attachment with stainless steel cable ties. A cable tie gun was used to set the tension on the cable before cutting it flush with the locking collar.

In the spring of 2000 four mock transmitters that duplicated all characteristics of the PTT's excepting the electronics were attached in a similar manner as to those in the previous austral summer. The mock devices were left attached for three weeks during October and November. At this time the minimum daily temperatures ranged from –20°C to –10°C. There were frequent storms with strong winds. During the storms the birds were usually kept out of the water by covering the dive hole that had been established at the study site. At other times the birds were free to dive at will. The birds were willing to dive during storms, but the investigators were unwilling to spend lengthy periods out in the blizzards shoveling snow and ice out of the dive hole to keep it clear and enable the birds to come and go from the water safely.

Results

Five of the seven PTT's ceased transmitting from 16 to 83 days after release of the birds. These terminations occurred much sooner than the expected time of transmission cessation,

Table 1. Summary of data obtained on release locations of each bird. All latitudes are south and longitudes are west. All times are local. Configuration of the transmitters with SWS ran continuously except when wet. When dry they shut down for 3 h after leaving the water and did not restart until wet. Running continuously they were calculated to last 84 days. 18901 and 18902 had a 12 h on/12 h off duty cycle and no haul out shutdown. They were calculated to run for 168 days (from Kooyman *et al*., 2004).

Bird ID	Release location	Start (Date)	End (Date)	Days
6256; SWS	75.2; 145.53	28 January	14 March	45
6286; SWS	74.63; 156.46	5 February	21 February	16
6287; SWS	74.97; 157.04	6 February	1 March	24
16260; SWS	73.88; 157.93	4 February	4 April	60
18901; SWS	73.97; 147.63	29 January	9 June	132
18902	73.88; 157.93	4 February	16 June	133
18903; SWS	73.97; 147.63	29 January	23 April	83

Fig. 1. Captive emperor penguins held on sea ice in a corral at McMurdo Sound, Antarctica. The bird in the foreground has six objects that have accumulated ice while the penguin was diving in and out of a hole in two meter thick sea ice. The largest object coated with ice is the mock PTT. The other smaller objects are velcro patches and pieces of tape.

Fig. 2. Profile of an emperor penguin swimming underwater. There are two patches of accumulated ice. The largest is the mock transmitter without the antenna. Note the smooth contour of the ice from the front to that at the rear of the ice.

and were much shorter than those from the two transmitters that either had no salt water switch (SWS) or no haul-out sensing system for stopping transmissions (Table 1). Number 18902, which had a 12/12 h duty cycle, but no SWS ran for 133 days. Number 18901, which had the same duty cycle, but also a SWS to save power while the bird was diving, ran for 132 days. Number 18903 with a SWS and haul-out program ran for 83 days, but in the last month only two transmissions were received.

The semi-captive birds that had mock devices attached dived daily at an isolated ice hole in McMurdo Sound, Antarctica for three weeks. All mock recorders accumulated ice within a day after attachment during voluntary diving activity. This coating of ice became substantial after a few days (Fig. 1). Although the layer became thick, it also became molded into a streamlined shape caused by the water flowing over the mock device. The mock instrument and its coating of ice did not cause the birds to stop diving and feeding under the ice (Fig. 2).

Discussion

Except for two birds, 18901 and 18902, the premature loss of reception from the PTT's is a mystery. There is always the possibility that some birds died or were killed. Dying birds are most likely to do so on the ice. In that case for those with SWS and haul out timers the PTT's would have ceased transmitting and not started up again. It does not seem likely that four adult birds would have died or been killed over the course of the month of February and March, when it is realized that the annual survivorship of adult emperor penguins is greater than 90% (Jouventin, 1975). The two birds with no haul out program give some clues to what may have happened. For four months their PTT's gave a continuous stream of reliable locations of class 1 to 3 quality (Kooyman *et al*., 2004). 1) First, these two birds provide good evidence that none of the attachments failed. Also, similar attachments used on the captive birds diving from a hole during the three week experiment in McMurdo Sound from October to December 2000 showed no signs of loosening. 2) The PTT's of 18901 and 18902 lasted to within a day of each other demonstrating the consistency of the battery life. 3) This consistency suggests that the SWS failed on 18901 so that no power was being saved while it was underwater. 4) 18901 had no haulout program so the failure of the SWS would not have caused it to shutdown permanently as it would with a failed SWS programmed for a haul-out pause. 5) Therefore, we conclude that the four other PTT's failed because the SWS malfunctioned and did not detect when they re-entered the water shortly after the last transmission was received.

The bird experiment at the Penguin Ranch in McMurdo Sound provides the evidence for the cause of failure in the SWS. Figure 1 shows the susceptibility of the transmitters to become iced over. If this happened to the PPT's with haulout programs during the tracking experiment then the ice covered SWS would fail to switch on the transmission cycle after the bird returned to the water. Consequently, the PTT's would remain off for the rest of the winter. By spring, the thaw might have caused the ice to melt off the transmitters if they were still attached. Most likely they had fallen off. Perhaps the ice accretion would have become so great that the extra drag would induce the PTT to pull away. Also, the increased size of the transmitters, because of the attached ice, would probably become so irritable to the birds that they may have been successful in removing the PTT's.

Conclusion

We conclude from the fact that local seawater is at or near freezing that icing may be a significant factor in the failure of biologging devices used in the winter. We assume that the following events occurred that caused our PTT's to fail. After a period out of water a PTT will probably reach a temperature of –10 to –30°C. There will be no solar radiation during the winter to warm the transmitters. Instead they will get increasingly colder because of the low ambient temperature. When the PTT enters the water again, more ice will form on the very cold transmitter. Each time they leave the water any droplets or thin film of water still attached to the ice coated PTT will freeze as it cools to ambient air temperature. Similarly we have seen drops of water freeze to the feathers of emperor penguins as they leap out of the water on exceptionally cold days. The frozen droplets cling to the feathers until they do their ritual feather shake and ice and water droplets are flung away. Finally, the use of SWS's and other types of sensors for monitoring of physical variables during the winter may fail without some kind of de-icing measures. In emperor penguins, such a de-icing measure for birds that are traveling in a group will be their habit of huddling in the extreme cold (Kirkwood and Robertson, 1999).

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