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AN EFFECT OF INSTRUMENT ATTACHMENT ON FORAGING TRIP DURATION IN CHINSTRAP PENGUINS[1]

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Key words: Penguin; seabird; recorder; behavior; foraging; radio transmitter.

The behavior of seabirds away from the breeding colony is poorly understood. Recently, however, technologies have become available that promise to greatly expand our knowledge of the activity of birds at sea. Specifically, recent technological developments have led to studies of seabird diving (see Kooyman 1989), nest attendance (Wanless et al. 1985), foraging range and dive durations (Trivelpiece et al. 1986, Wanless et al. 1988a, Bengtson and Eberhardt 1989), and swimming velocity (Wilson and Bain 1984). These studies have relied upon electronic devices attached to the animal in some manner. Although essential in helping researchers to understand the activities of seabirds away from the nest, attached devices have the potential to alter the behavior of the animal under study either through the effects of increased drag or through the discomfort of instrument package attachment.

This problem has recently been recognized by a number of investigators: (1) Wilson et al. (1986) found that velocity meters attached to African Penguins (*Spheniscus demersus*) decreased swimming velocity (inversely related to the device's cross sectional area), and potentially decreased net foraging trip energy gain. (2) Wanless et al. (1988b) found that Common Murres (*Uria aalge*) fitted with radio transmitters with external antennas spent less time in the colony, were absent for long periods, and delivered fewer prey to their young. (3) Wilson et al. (1989) found that the handling and trimming of tail feathers of Adelie Penguins (*Pygoscelis adeliae*) increased the duration of a single foraging trip, and the attachment of devices increased nest desertion and foraging trip duration (after 19 days of attachment). They also speculated that the diving depths of penguins may be affected by recorder attachment, with mean maximum depths decreasing with increasing device cross-sectional area. (4) Wilson and Bain (1984) found that African Penguins peck at devices when researchers are out of the sight of the birds, while Adelie Penguins may spend a considerable amount of time trying to remove a device (Wilson et al. 1990).

Thus, studies of the effects of instruments on seabird behavior and performance are essential in interpreting results obtained by using them. The purpose of this study was to examine the potential effects of attaching radio transmitters and time-depth recorders (TDRs) on the foraging trip durations of Chinstrap Penguins breeding on Seal Island, South Shetland Islands, Antarctica.

METHODS AND RESULTS

Three groups of Chinstrap Penguins in a colony of 975 nests were selected for this study; individual nests were identified visually by relative location using Polaroid photographs (reference to trade name does not imply endorsement by the National Marine Fisheries Service, NOAA). Due to a lack of sexual dimorphism in Chinstrap Penguins, the sex of the birds in these groups was not determined.

No-instrument (control) group. Thirty-one nests where one member of each pair was marked 27 days prior to the start of the experiment. Birds were marked by squirting their breasts with a spot of nyanzol-D dye (a black waterproof dye) while the bird was brooding its chick. The birds remained on their nests during the approximately 15 sec it took to mark them.

Radio transmitter group. Fourteen nests where each member of the pair was equipped with a radio transmitter and marked with either picric acid dye (a yellow waterproof dye) or nyanzol-D dye for individual identification. The radios were attached to the middle of the back and secured with a plastic cable tie and about 15 g of Devcon 5-min epoxy worked into the feathers. The attachment process took approximately 15 min. The transmitters (Advanced Telemetry Systems, Model 4) were attached to the birds 14 days prior to the start of observations, weighed 25 g, had a frontal cross sectional area of 3.5 cm^2, and an external 28.5 cm whip antenna.

Time-depth recorder group. Eight nests where one member of each pair was equipped with a time-depth recorder (Wildlife Computers, Mark 4) and marked with picric dye. The recorders weighed 107 g, measured 36 mm in width × 22 mm in height × 110 mm in length (giving a frontal cross-sectional area of 7.9 cm^2), and were tapered anteriorly to reduce drag. They were attached to the feathers of the middle of the back using about 20 g of Devcon 5-min epoxy and three plastic cable ties. This process took about 15 min. The TDRs were attached to the birds four days prior to the start of observations.

Observations of nest attendance were made throughout a 48-hr period beginning at 13:00 on 15 January 1990. Nests in all three groups were checked visually

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TABLE 1. Comparison of foraging trip durations of Chinstrap Penguins with and without various instruments attached.

Group	*n* (birds)	*n* (trips)	Mean trip duration (hr)	Standard deviation
No instruments (control)	31[1]	158	9.3	6.0
Radio transmitter	14	43	14.4	9.2
Time-depth recorder	8	32	11.2	7.2

[1] Three of the control nests were disturbed by a storm on the second day of observations. Trips completed by mates in these nests after the storm were not included in analyses.

every half hour, and the individual in attendance was identified and recorded. It was also noted if both members of a pair were present. The average number of chicks per nest for each group was 1.65, 1.43, and 1.87 chicks per nest in the control, radio transmitter, and TDR groups, respectively. At approximately 03:00 on 17 January, a strong storm moved into the Seal Island area, bringing with it exceptionally high surf which disrupted nests below the study area, leading some chicks to move up into the study area. Three of the control nests were disturbed by the storm. Foraging trips completed by the occupants of these nests after the storm were not included in analyses. No other nests were disturbed by the storm.

The number of trips and the mean duration of those trips are shown in Table 1. A one-way analysis of variance (ANOVA) indicated that the foraging trip durations for the three groups were significantly different ($F = 7.4$, df = 2, $P < 0.05$). A multiple comparison (Gabriel 1978) revealed that the trip durations of the radio transmitter group were significantly longer than those of the control group ($F = 16.9$, df = 1, $P < 0.05$), while the TDR group's durations were not significantly different from either group ($F = 1.8$, df = 1, $P = 0.183$).

DISCUSSION

The radio transmitter's frontal cross sectional area (3.5 cm^2) was about 2.3% of the penguins' frontal cross sectional area, while the TDR's frontal cross-sectional area (7.9 cm^2) was about 5.3% of the penguins' frontal cross sectional area (150 cm^2, pers. obs., D. Croll). Hydrodynamic drag is directly proportional to frontal area (Vogel 1981), thus the transmitters and TDRs increased swimming drag by 2.3 and 5.3%, respectively. Wilson et al. (1986) found that traveling speed (y) of African Penguins was related to the device's cross-sectional area (x) as described by the equation $y = 2.14 - 0.063x$. The cross-sectional area of an African Penguin (140.4 cm^2) is similar to that of a Chinstrap Penguin (150 cm^2). Based on the results of this equation, the radio transmitters may have decreased traveling speed by 7%, while the TDRs may have led to a 15% decrease in traveling speed. These potential decreases probably explain why the birds with attached devices had longer average trip durations: more time was needed to search an adequate area to obtain sufficient prey to satisfy the needs of the adult and to return with a food load for the chick(s).

It is not immediately clear, however, why the birds carrying TDRs, which had a much larger frontal area, did not make significantly longer trips. Wilson et al. (1989) found that while attached packages increased the foraging trip durations of Adelie Penguins, this effect was not observed until the packages had been on the birds for at least 19 days. In our study, the radio transmitters had already been on the birds for 14 days at the start of the study, while the TDRs had only been attached for four days. It may be that the chronic presence of a device is equally or more important than differences in instrument size in disrupting normal behavior. Another possible explanation may lie in the presence of the antenna on the transmitter package. Wanless et al. (1988b) found that Common Murres carrying transmitters with an external antenna spent less time at the colony, were absent for longer periods, and had reduced rates of prey delivery, while birds carrying transmitters with internal antennae behaved similarly to birds without instruments.

The nests of birds with attached radio transmitters contained, on average, fewer chicks than the control and TDR groups. Although this may have led to differences in nest attendance patterns between these groups, one would perhaps expect that pairs which were providing for only one chick would need to bring less food to the nest, and thus would have shorter, rather than longer, foraging trip durations.

As the use of attached devices such as radio transmitters, dive recorders, velocity meters, and satellite transmitters increases, it is important for researchers to recognize and evaluate the potential effects of such instruments in creating bias in the measurements being taken. It may be beneficial to place devices posteriorly, behind the point of greatest diameter of the animal as this would place the device past the point where laminar flow has changed to turbulent flow. Such placement would prevent the attached device from prematurely tripping the flow of the boundary fluid layer. Streamlining devices by rounding or faring the edges in a downstream direction will reduce the width of the device's wake and thus its drag (Vogel 1981). Handling times, attachment techniques, enhanced streamlining, and the effects of package configuration on behavior are all important factors to consider in selecting experimental protocols and equipment. Package design could benefit greatly from flume studies on the effects of attached instruments on the energetic cost of locomotion. Information gathered through direct visual observation without disturbance will undoubtedly provide the least biased data, in spite of the fact that such observations require long hours of monotonous vigil. In many situations, however, the desired data can only be obtained through the use of attached instruments.

When this is the case, it is important to gather comparative control information in order to evaluate the extent of the behavioral perturbation. Given the results of the present study, and those of others, it is probably wisest to minimize package size, attempt to streamline the package as much as possible, minimize protuberances such as antennae, and to limit the duration of package deployment on individuals.

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ORPHANED MALLARD BROOD TRAVELS ALONE FROM NEST TO WATER[1]

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Key words: Mallard; Anas platyrhynchos; *brood; drought; travel; mortality.*

Waterfowl young often travel long distances from the nest site to water when accompanied by a parent; the timing of the trip can range from a few hours to days after hatching (Sowls 1955, Bjärvall 1968; Dzubin and Gollop 1972; Ball 1973; Duncan 1983; Afton and Paulus, in press). Little is known, however, of what happens to waterfowl broods or individual young stranded far from water by the death of a parent or after becoming separated or abandoned.

We documented the response of a Mallard (*Anas platyrhynchos*) brood orphaned at a nest in south-central North Dakota in July 1988 while studying daily survival rates and causes of mortality among Mallard ducklings in prairie pothole habitat. On 16 April 1988, an adult hen Mallard was captured in a decoy hen trap (Sharp and Lokemoen 1987), banded, and fitted with a radio transmitter. The transmitter weighed approximately 23 g and was attached with a back harness as described by Dwyer (1972). She later nested in tall, dense cattail (*Typha* spp.) vegetation in a 44-ha dry semipermanent wetland basin (Fig. 1). The last egg of her seven-egg clutch was laid on 5 June; pipping began

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