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Note

Balance: a neglected factor when attaching external devices to penguins

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Abstract: We observed that external attachments on penguins reduced their balance, which may be of as great concern to the individuals as the effect of increased drag. Little penguin *Eudyptula minor* swimming activity was observed in captivity at the Penguin Parade®, Phillip Island, Australia. Initially, time-depth recorders (TDRs) were attached centrally to the lower back of the penguins, the point for attachment widely suggested in the literature. In the water, the penguins showed strong signs of imbalance. They tilted from side to side trying to maintain stability, avoided diving and did not move around the pool. When the TDRs were moved forward, closer to the penguins' centre of gravity, the penguins started diving, swimming and preening as they had before having the TDRs attached. These observations suggest that the lower back area may not be the best attachment position for little penguins and that balance could be an important factor to consider when using back-mounted devices.

key words: little penguins, balance, external devices, diving, centre of gravity

Introduction

Many studies of penguin foraging ecology rely on data collected from back-mounted devices, such as time-depth recorders and satellite transmitters (*e.g.* Dann *et al.*, 1995). However, these devices may affect the performance of the penguins (Ropert-Coudert *et al.*, 2000). Drag is the main mechanical cost to diving birds (Lovvorn *et al.*, 2001) and its effect increases greatly when external devices are attached to their backs (Culik *et al.*, 1994). The energy expenditure of penguins is significantly higher when carrying even small devices, less than 6.8% of the animal's frontal surface area (Wilson *et al.*, 1986), even though the foraging trip duration and weight changes of the penguins may remain the same as for control groups (Gales *et al.*, 1990; Ropert-Coudert *et al.*, 2000). Thus, minimising the size is considered to be a crucial design feature for back-mounted devices on penguins (Culik *et al.*, 1994).

In addition to size, the position of the device on a penguin also has an important influence on the amount of drag it creates (Culik *et al.*, 1994). Culik *et al.* (1994) suggested that for Adélie penguins *Pygoscelis adeliae* the device should be placed behind the line of maximal girth, to minimise the cross-sectional area of the penguin with the device attached. Indeed, most studies using external devices have followed Culik *et al.* (1994) by placing them on the lower backs of penguins (*e.g.* Bethge *et al.*, 1997). The distal placement of a package, however, is likely to alter the centre of balance of the birds. In this study, we assessed the effect of the placement position of time-depth recorders (TDRs) on the balance of little penguins *Eudyptula minor*.

Methods

Observations were made on four captive penguins in an enclosed pool (6.7×2.7×1.3 m deep) at the Penguin Parade®, Phillip Island, Australia. The selected penguins were fully rehabilitated birds, that were within one week of their release into the wild. Each penguin had been in captivity for 20 to 30 days. They had been handled twice daily for feeding, and were released into the saltwater/ chlorinated pool to exercise and preen freely for one to three hours each day.

Prior to attachments, the penguins were released into the pool for 30 min. They dived and preened freely. Following this acclimatisation on period, a time-depth recorder (TDR, Lotek.com) was attached to each penguin's back feathers using PVC tesa tape (Wilson and Wilson, 1989). The TDRs weighed 17 g in air (1.8 g in seawater), were 18 mm diameter with a 'drop-nose' shape on the leading end and were 57 mm long. The frontal surface area was equivalent to 4.9% of the cross-sectional area of a little penguin (Lovvorn *et al.*, 2001).

Initially, the TDRs were attached to the lower backs of the penguins. After 30 min of observations in the pool, the penguins were recaptured and the TDRs were reattached to the penguins' mid-backs, with the front of the TDRs in line with the leading edge of the flippers (Fig. 1). The penguins were observed for a further 30 min.

To determine the centre of gravity of the penguins we attached a line to various positions on the back of a penguin that had died recently and had been frozen into a natural swimming position. The line was adjusted until the penguin's body lay in a balanced, horizontal position.

Results

Prior to attachment of the TDRs, all four penguins behaved normally within the confines of the pool, swimming, diving and preening. When TDRs were attached to their lower backs and the birds were released in the pool, all four penguins appeared to have lost their balance. They tilted from side to side trying to maintain stability. They did not dive or attempt to

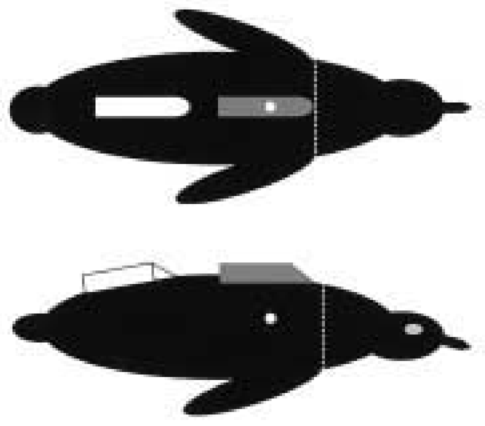

Fig. 1. Attachment locations for devices on the backs of little penguins. The white unit is in the currently preferred position to minimise drag (Bannasch *et al.,* 1994; Culik *et al.,* 1994). The grey unit is in a position where the little penguins displayed better balance and coincided with the birds' centre of gravity (white spot). In the 'improved balance' position, the nose of the TDR is aligned with the point where the leading edge of the flipper joins the penguin's body.

preen. This behaviour continued for the full 30 min with the penguins showing no sign of adapting to bearing the instruments.

When released into the pool with the TDRs moved forward to the mid-body, the penguins started diving, swimming and preening, seemingly unaware of the TDRs. The penguins' swimming and diving behaviour did not appear to differ from their behaviour prior to the TDR attachment. The centre of the TDR in this forward position coincided with the penguins' centre of gravity (Fig. 1).

Discussion

Our study aimed to optimise placement of TDRs on the backs of little penguins as the first step in a foraging ecology study of little penguins, and we did not attempt to quantify the observed effects on balance. Our observations of the effects of external attachments on balance are preliminary but we feel the need to report them promptly as they could have immediate implications for researchers who attach devices to small aquatic animals like little penguins.

Little penguins showed strong signs of imbalance in the swimming pool when fitted with TDRs on the lower back, the position suggested to minimise drag (Culik *et al.*, 1994). The penguins were unstable, avoided diving and did not move around the swimming pool. They did not attempt to preen, possibly because turning on their sides to preen could have caused them to topple. The penguins regained their normal balance and activity when the TDRs were moved forward to the mid-back, which coincided with the penguin's centre of gravity.

The instantaneous change in behaviour when the instrument was moved from a distal to a more proximal position (in relation to the centre of gravity) indicated that the penguins' balance had improved rather than the penguins getting used to bearing a device. We conclude that balance is an important factor to consider when fitting little penguins with external devices. Positioning devices close to the centre of gravity may allow the penguins to retain balance.

Penguins fitted with external attachments expend more energy than do unencumbered penguins (Culik *et al.*, 1994). Part of the extra expenditure could be due to exertion to retain balance rather than to drag (see Culik *et al.*, 1994). We recommend that future studies to consider both drag and balance when attaching devices to small aquatic animals and interpreting results. The optimum attachment site may be a compromise between reducing drag and allowing the animal to maintain its balance. Our study reports unquantified observations on penguins held in captivity. Further investigations of the effects of external devices on balance of marine vertebrates are warranted.

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