THE ROYAL SOCIETY biology letters

Penguin-mounted cameras glimpse underwater group behaviour

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Recd 25.12.03; *Accptd* 04.02.04; *Published online* 24.03.04

Marine birds and mammals spend most of their lives in the open ocean far from human observation, which makes obtaining information about their foraging behaviour difficult. Here, we show, by use of a miniaturized digital camera system, the first direct evidence (to our knowledge) of underwater group behaviour in free-ranging penguins. Penguins swim closely accompanied by other bird(s) during 24% of their possible foraging dives. This finding confirms that such miniaturized camera technology has broad applicability for advancing our knowledge about the previously unknown social interactions of marine animals at depth.

Keywords: diving behaviour; group behaviour; camera technology

1. INTRODUCTION

Information on the foraging behaviour of marine birds and mammals is often difficult to obtain as these species spend most of their lives in the open ocean far from human observation. Data-recording devices that can be attached to animals have been developed during the past decade and represent a major technological advance that has led to an increased understanding of foraging behaviour of marine predators (Le Maho 1994; Boyd *et al.* 2004). Recently, developments in animal-borne image and data recorders have begun to provide 'organism-eye' views of the foraging environment of diving animals (Davis *et al.* 1999; Ponganis *et al.* 2000; Hooker *et al.* 2002; Watanabe *et al.* 2003). Measuring the social interaction of animals at sea is one previously difficult subject that can now be tackled by the use of such data-recording technologies (Boyd *et al.* 2004; but see Sato *et al.* 2003). To help address this, we have developed a small camera system that can be attached to penguins and used to examine their group behaviour while foraging and moving freely at sea.

2. MATERIAL AND METHODS

In December 2002 and January 2003 at Signy Island, South Atlantic, Antarctica, we deployed a camera system on the backs of five Adélie (*Pygoscelis adeliae*) and five chinstrap penguins (*P. antarctica*), instrumenting each animal for a single foraging trip lasting 1–3 days during the chick-rearing period. The camera contains a depth sensor, is 21 mm in diameter, 138 mm in length, weighs 73 g in air and is manufactured by Little Leonardo Co. Ltd, Tokyo, Japan. The camera collected depth data every second and image data every 15 s over a 5 h period. In five cases, the camera was set to record pictures only at depths of greater than 2 m; on the other five deployments, the camera recorded data continuously both underwater and at the sea surface.

3. RESULTS

A total of 11 162 pictures (7387 pictures obtained underwater) from 2140 dives (of depths greater than 2 m) were obtained from the 10 penguins. These images showed that penguins swim underwater with at least one other bird during $15.1 \pm 10.6\%$ of their dives ($n = 10$ birds; figure 1). The number of birds in view was 1.8 on average ($n = 261$ dives) and 11 at the maximum. The proportion of dives with another bird(s) in view was even higher for dives that were deeper than 20 m (possible foraging dives (Ropert-Coudert *et al.* 2001)), with $24.1 \pm 10.9\%$ of dives (216 out of 862 dives) showing evidence of another bird. The images showed that accompanying penguins swim in the same direction (defined by the posture of the bird in the picture) in 81.6% of the 266 pictures examined. Birds were closely associated with each other, with the estimated distance to the other penguin(s) being less than 2 m in 44.4% of the 266 pictures. Although we obtained 104 pictures showing other penguins during the bottom phase of their dives, none suggested coordinated feeding by groups of birds.

4. DISCUSSION

A great deal is known about the behaviour of penguins on land, but very little is known about their behaviour away from their breeding colonies (Williams 1995). Previous studies on the group behaviour of penguins at sea have been based on observations at the sea surface (summarized in Wilson & Wilson 1990) or through the fortuitous recording of identical diving behaviour of two northern rockhopper penguins (*Eudyptes chrysocome moseleyi*; Tremblay & Cherel 1999). Although these studies have provided useful information, the information from our camera is invaluable in remote situations where it is impossible to make visual observations. The present study provides new insights into the group dynamics of penguins foraging underwater. The pictures are derived from an automatic system that does not suffer from any of the potential observer biases associated with diver-held cameras. Given that the camera took pictures only in front of the instrumented birds, our results suggest that penguins swim in a group for at least half of their dives while actively foraging. Our pictures indicate that penguins swim in the same direction in close visual contact with other birds at depth. However, we found no evidence of coordinated behaviour, suggesting that the primary reason for swimming in groups may be related to factors other than foraging: e.g. predator avoidance. Further tracking of marine predators using such miniaturized camera technology should provide more data about the social nature of foraging in the three-dimensional underwater environment.

Acknowledgements

We thank all of the members of British Antarctic Survey Signy Island Research Station 2002/2003 for their logistic support. This work was supported by Grant-in-Aid from the Japan Society for the Promotion of Science (JSPS) (14405027 and 15255003) and the JSPS Postdoctoral Fellowships Research Abroad (A.T.).

DOI 10.1098/rsbl.2004.0182

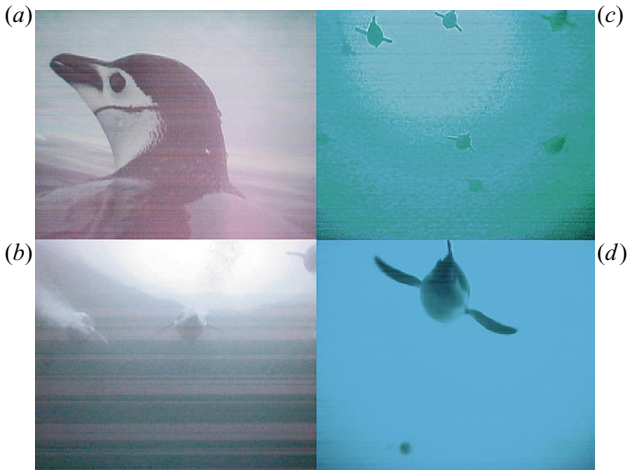

Figure 1. Digital pictures obtained from miniature cameras attached to the backs of penguins. (*a*) A self portrait of an instrumented bird obtained from the camera attached to its back. (*b*,*c*,*d*) Birds swimming in a synchronous fashion in front of a bird carrying a camera, at depths of 13 m, 50 m and 107 m, respectively (estimated distance 2 m, 4–10 m, and 1 m). Birds in the pictures stretch out their flippers in most cases. Air bubbles sometimes stream out from the feathers of swimming birds (*b*).

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