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SHORT COMMUNICATION

Night diving by some emperor penguins during the winter breeding period at Cape Washington

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ABSTRACT

All through the bird literature and feature films, there is much ado about dedicated emperor penguin males fasting for 115 days while they do all the incubation of the single egg. Sometimes, they may not fast for so long. Based on a winter visit to Cape Washington, we obtained evidence that some birds may feed before the egg is laid, and if they do, and some are males, then their fast is much less than 115 days. The consequence of a shorter fast for the male is a better chance of completing the 65 day incubation fast and success in fledging the chick. For those in northern colonies that may migrate south, there will be closer access to open water, but there will be the need to dive in the dark.

KEY WORDS: *Aptenodytes forsteri*, Winter, Cape Washington

INTRODUCTION

After the discovery of an emperor penguin (*Aptenodytes forsteri*, Gray 1844) colony at Cape Crozier (77.5°S, 169.4°E) in 1902, the first description of their breeding behaviour was reported (Wilson, 1907). Forty-five years later, more information was published about emperor penguin breeding at Emperor Island (67.9°S, 68.7° W), Dion Islets (Stonehouse, 1952). There was uncertainty about their breeding activity from these reports, and it seemed that multiple birds might participate in incubation of the single egg and raising of the chick. In 1956, Prévost, based within 100 m of the recently discovered Pointe Géologie (66.7°S, 140.0°E) colony, made detailed studies of penguin breeding behaviour. His study (Prévost, 1961) showed that the male begins to fast upon arrival at the colony, at about 36 kg, and the extra fat store has to see him through the egg-laying period as well as his incubation duties until the egg hatches. This amounts to a total of 115 days of fasting. By the end of the incubation period, the male has lost 45–50% of his body mass (Prévost, 1961). Parts of the 115 day fast were repeatedly studied in detail at the Pointe Géologie colony (Ancel et al., 1997; Le Maho et al., 1977). The journey from the colony to the edge of the ice at the beginning of the sea (i.e. to open water or pack-ice) ranges from about 50 to 100 km. The distance is too far for the breeding birds to commute to and from the ice edge for foraging in the pattern normal for other penguin species during pairing and incubation. According to current doctrine, male emperor penguins at all colonies fast until hatching, when they are relieved by their mate. The female assumes parental duties while the male leaves for 3 weeks to trek across the sea ice to open water, feed and replenish some of the weight lost during his long fast. The male returns to the colony to relieve the female for another 3 weeks. By this time, the sea ice is retracting closer to the continent and both the female and male each make about 10 shorter journeys to sea to replenish their food stores and bring food to the chick before it fledges (Kirkwood and Robertson, 1997).

Here, we present evidence obtained from satellite tracking data that indicate movement at sea in the dark of emperor penguins after egg laying. Our results were not the same as tracks obtained from two post-laying females travelling from the Auster colony to open water, 80 km northeast (Kirkwood and Robertson, 1997). The two females travelled for 6 days across the fast ice before reaching open water or pack-ice.

MATERIALS AND METHODS

With the basic behaviour of emperor penguins in mind, we spent the winter days of 28 and 29 May 1998 at the Cape Washington (74.6°S, 165.4°E) emperor colony. This Ross Sea colony is much further south than the colonies mentioned in the Introduction, which are located at about 66–70°S.

We came to the ice edge of the Cape Washington colony on 28 May 1998. To our knowledge, this was the first visit in winter, by ship, to a colony further than 70°S. Depending on the year and environmental conditions, Cape Washington is the second largest emperor penguin colony in the world (Kooyman and Ponganis, 2016).

After the bow of the ship was docked at the fast ice edge, some of us disembarked. As we trekked the ∼4 km in the moonless dark to the colony, we noted many fresh tracks leading to and from the colony, and saw two groups of 6 and 30 birds returning from the polynya, an area of open water surrounded by sea ice. Also, from the ship, one of the party observed a group of 30 emperor penguins swim by. Later, members of the team returning from the sea ice to the ship saw about 45 birds pass close to the ship in the water. About 30 penguins were seen negotiating the rafted ice near the ice edge. On close approach to the ship five more were seen. However, we had one additional method of observation. During our visit to Cape Washington, we captured, weighed and attached Argos satellite tags with salt-water switches to four birds (Sirtrack Kiwi101), before release (Antarctic Conservation Act Permit no. 99-001). By this means, we could tell when the birds entered the water, and how far they travelled from the colony. The tracks were filtered using a state space model (SSM; Jonsen et al., 2005). The location of the birds after the first water and details of their travels (i.e. distance travelled) were determined from the SSM-filtered data.

RESULTS AND DISCUSSION

The Cape Washington colony, 10 times larger and 7° further south than Pointe Géologie, is not ice bound despite its more southerly location. Instead, the ice edge is routinely within 5 km of the colony.

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Table 1. Fasting time and body mass loss before departure to sea of all birds tagged on 28 May 1998

Bird ID	Departure date	Total no. of days	Start mass (kg)	Departure mass (kg)	Last day and month of transmission	Distance from colony (km)
6255	6 June	9	25.5	24.3	31/08	282
6256	8 June	11	25.2	23.7	11/08	210
6286	8 June	11	25.9	24.4	25/07	56
6297	20 June	23	28.6	25.4	27/08	102

Assumptions: mass loss occurred at a rate of 137 g day^{-1} for free ranging birds able to huddle during the winter incubation (Ancel et al., 1997). Start body mass was obtained when the birds were weighed during attachment of the satellite-linked time–depth recorders. End body mass was calculated from the mass loss rate and the number of days until departure from the colony. Daylight and civil twilight times were determined from the Astronomical Applications Department, US Naval Observatory. Locations and distances travelled from the colony were calculated from the state/space model (Jonsen et al., 2005).

Based on our observations from our visit on 28 May 1998 at the Cape Washington colony, many, if not most, of the females had not yet laid eggs. Many of the birds were moving about as pairs, and there was much trumpeting by both males and females. The observations are limited, as they usually are for winter studies of emperor penguins.

The body masses of the four captured birds ranged between 25.2 and 28.6 kg. Table 1 summarizes the movement of the satellite transmitter-tagged birds. They remained in the colony from 9 to 23 days. All departed in June may have been females after laying, or non-breeding males and females. Assuming the birds did not feed after tagging and lost mass at 137 g day^{-1} (Ancel et al., 1997), they would have had a body mass ranging from 23.7 to 25.4 kg. Compared with birds nurturing a chick and foraging from Coulman Island (73.3°S, 169.6°E, 190 km north of Cape Washington) in early November, the average mass of five birds was 26.6 kg (Kooyman and Kooyman, 1995). The transmissions ceased from late July to late August. During the winter darkness, the birds travelled extensively from the Cape (Fig. 1). Bird 6286 travelled the least and was only 56 km from the colony on its last transmission on 25 July. Bird 6286 spent all of its time diving in darkness. The other three birds, 6255, 6256 and 6287, also departed in the June darkness. Their tracks lasted from 11 to 31 August, by which time there were 4–9 h of daylight, depending on their latitude. Although penguins may have an aversion to diving in the dark, they will do so if necessary (Ainley and Ballard, 2012). Our observations indicate that they will dive in the dark in numbers during the autumn and winter when high-latitude colonies are near the ice edge. It is assumed that all transmissions ceased because of battery depletion.

The importance of understanding emperor penguin behaviour in colonies located near an ice edge lies in the potential for expanded breeding success in birds with greater foraging opportunity. This possibility is transformative in our knowledge of this species. If the birds can successfully hunt in the dark, it makes sense that they would feed during the prenuptial and pre-laying period. A shortened fast, from 120 to ∼70 days, provides greater assurance that males could successfully endure the entire incubation period without abandoning the egg. Moreover, a female that has recently fed is in better condition for laying, and there is no vigorous effort after laying for the short walk to an ice edge. She also has the challenge of travelling and hunting to forage initially in the dark, moonlight and/or civil twilight. To her advantage, the open water beyond the edge

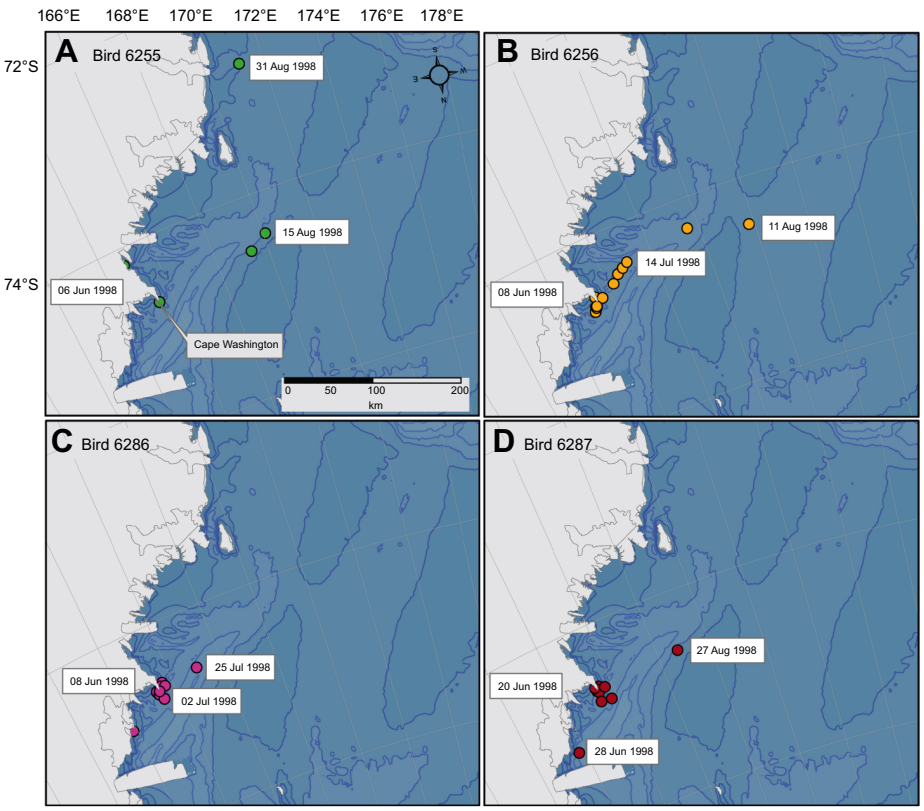

Fig. 1. Movement of the four tagged birds from the departure date to the last transmission. Each bird is represented by a different panel, A–D; bird identifier number is in the upper left-hand corner in each case. Locations were calculated from the state/space model (Jonsen et al., 2005). All birds were tagged at Cape Washington as labelled in A. Date labels in A–D are similar: the date of departure is the earliest date label; the last date label is the date of the last transmission. Compass direction is shown in the upper right-hand corner of A, and the scale bar is given in the lower right-hand corner. Hydrographic contours are in the blue section of A–D. There are no depth labels. Location points are indicated by colour-filled circles. Green is 6255, yellow 6256, pink 6286 and red 6287.

of Cape Washington may form a polynya that in winter extends much further north. If so, the watery path route to the north would enable females to travel faster by swimming, to a zone of longer duration, higher light levels, and possibly richer foraging than exists near the colony. Based on the extensive tracks in the area, the birds seemed in no hurry to travel north.

The number and concentration of emperor penguin colonies in the high latitudes of the Ross Sea are some of the greatest in the Antarctic (Fretwell et al., 2012). The possibility of birds feeding in the winter may help to explain the robustness of some of these colonies compared with those found at lower latitudes along Antarctica's continental shores. In the face of continued warming in the Antarctic, the success of these higher latitude colonies may be vital. As sea ice loss around the northern perimeter of the continent proceeds, the situation may not be so dire for the sea ice dependence of this species (Jenouvrier et al., 2014) as northern birds may shift towards the south. At present, such an emigration may already be occurring as indicated by the sharp rise in the adult population of emperor penguins at Cape Colbeck from 1994 to 2012 (Kooyman and Ponganis, 2016). At nearly 78°S, this is one of the most southerly and presently one of the largest of all emperor penguin colonies.

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Competing interests
The authors declare no competing or financial interests.

Author contributions
Conceptualization: G.L.K.; Methodology: G.L.K., R.P.v.D.; Software: L.A.H.; Formal analysis: L.A.H.; Investigation: G.L.K., R.P.v.D.; Resources: G.L.K.; Data curation: G.L.K.; Writing - original draft: G.L.K.; Writing - review & editing: G.L.K., R.P.v.D., L.A.H.; Project administration: G.L.K.; Funding acquisition: G.L.K.

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