

A new high-latitude record for the macaroni penguin (*Eudyptes chrysolophus*) at Avian Island, Antarctica

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Abstract On 20 and 22 January 2007, we observed macaroni penguins (*Eudyptes chrysolophus*) on Avian Island, Antarctica, approximately 1° south of the Antarctic Circle along the Western Antarctic Peninsula (WAP) near Adelaide Island, a new high-latitude observational record for the species within this region of the continent. Additionally, we report several extra-limital sightings of macaroni penguins over the last decade at relatively lower latitudes along the WAP near Anvers Island, including observations of breeding attempts. Although vagrancy cannot be ruled out as a possible causal factor in our observations, we hypothesize that a climate-induced shift in the species' bio-geographic range may be in progress. In this context, our observations are similar to the well-documented range shifts and eventual establishment of breeding populations by other sub-Antarctic penguin species along the WAP, over the last three decades, in response to regional climate warming. We highlight that the few observations reported here do not provide conclusive evidence for any putative causal mechanism explaining the presence of macaroni penguins at locations outside their natural geographic range. However, our

observations are important for developing a better understanding of the natural history of the species along the WAP.

Keywords Bio-geographic range shift · Climate warming · *Eudyptes chrysolophus* · Western Antarctic Peninsula · Vagrancy

Introduction

The macaroni penguin (*Eudyptes chrysolophus*) is circumpolar and sub-Antarctic in its breeding distribution (Parmelee 1992; Williams 1995). Breeding populations in the core of the species range occur on islands near the Antarctic convergence in the southwest Atlantic and south Indian sectors of the Southern Ocean such as South Georgia, Crozet, Kerguelen, Heard, Macdonald, and Marion Islands (Williams 1995). The most southerly known breeding colonies occur on the South Shetland Islands (~62°10'S, 58°30'W) (Fig. 1) (Parmelee 1992), located northwest of the Western Antarctic Peninsula (WAP), where small numbers of breeding individuals have been observed at Elephant, Gibbs, Nelson, Livingston, and Deception Islands (Volkman et al. 1982; Parmelee 1992).

Parmelee (1992) reviewed observations of macaroni penguins within the Palmer Archipelago, near Anvers Island (64°46'S, 64°03'W) (Fig. 1), located approximately 350 kilometers (km) south of the South Shetland Islands along the WAP, noting an early sighting of an individual occurring on Humble Island (64°45'S, 64°04'W) in January 1956. Beyond this date, the species has been observed only occasionally in this region (Bernstein and Tirrell 1981; Parmelee 1992), including a nesting attempt in 1988 also on Humble Island (Heimark and Heimark 1988). Here, we

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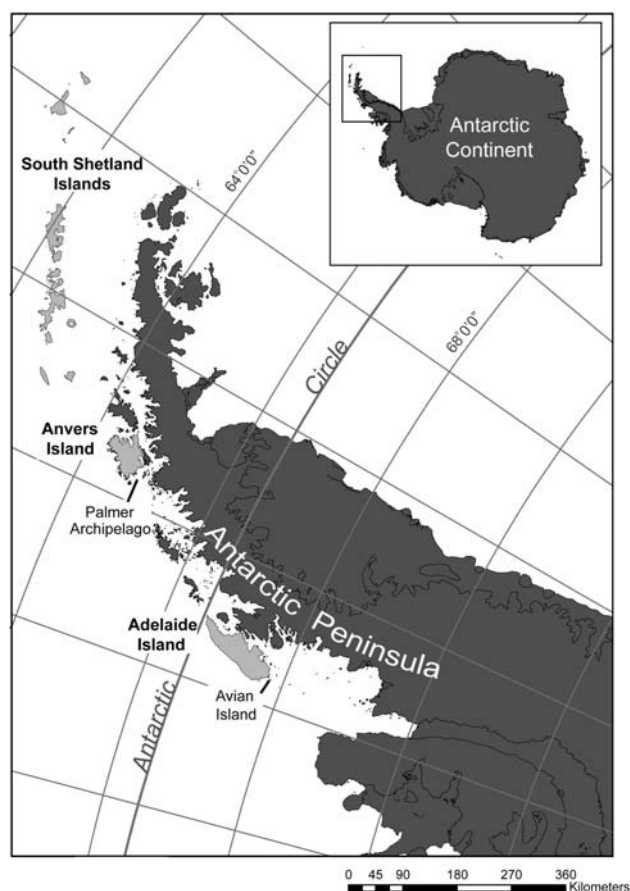


Fig. 1 The Western Antarctic Peninsula (WAP). *Boxed area in the upper right corner outlines the location of the WAP relative to other areas of the Antarctic continent.* Along the WAP, the South Shetland, Anvers, and Avian Islands are noted. Map by ESE

report on observations of macaroni penguins at Avian Island ($67^{\circ}46'S$, $68^{\circ}53'W$) (Fig. 1) located approximately 400 km south of the Palmer Archipelago along the WAP and 1° south of the Antarctic Circle, near Adelaide Island, during January 2007, a new high-latitude record for the species within this region of Antarctica. We also report more frequent extra-limital sightings of macaroni penguins over the last decade at relatively lower latitudes along the WAP within the Palmer Archipelago near Anvers Island (Fig. 1), including observations of breeding attempts.

Observations

On 20 January 2007, at an annual field research camp occupied as part of a long-term study on the breeding ecology of Adélie penguins (*Pygoscelis adeliae*) nesting at Avian Island (Fig. 1), we observed a macaroni penguin loafing on the beach where Adélie penguins typically return from foraging (Table 1; Fig. 2a). In addition, on 22

January 2007, we observed possibly two macaroni penguins at Avian Island as these sightings occurred within hours of each other, but at different beach areas (KBG and ESE, Pers. Obs.). Although the individual(s) reported here was not breeding or displaying any nest-attending behavior, these observations represent, to our knowledge, a first record of the macaroni penguin occurring in a geographically polar location along the WAP region of Antarctica.

Over the last decade, extra-limital macaroni penguins also have been observed with increasing frequency, including breeding attempts, along the Palmer Archipelago near Anvers Island (Fig. 1). In December 2000, an adult was observed incubating one egg within a nesting colony of Adélie penguins on Cormorant Island ($64^{\circ}48'S$, $63^{\circ}58'W$) (Table 1; Fig. 2b). A chick subsequently hatched from this same nest in January 2001; however, the parent later abandoned the chick at approximately 1 week of age (WRF, Pers. Obs.). On Dream Island ($64^{\circ}43'S$, $64^{\circ}13'W$) in January 2004, again, an adult macaroni penguin was observed incubating an egg within a nesting colony of Adélie penguins (Table 1). Although this egg was lost approximately 1 week later, the parent was observed occupying the failed nest until early February 2004 (WRF, Pers. Obs.). In both cases, single adults (i.e., not paired) attended only one egg, presumably the B-egg. Non-breeding adults also were observed loafing among breeding Adélie penguins on Dream Island in January 2003 (Fig. 2c) and December 2004 (Table 1), and on Torgersen Island ($64^{\circ}46'S$, $64^{\circ}04'W$) in December 2008 (Table 1; Fig. 2d) (DLP-F, BCP, and KBG, Pers. Obs.).

Discussion

Extra-limital observations of penguins are well known (Woehler 1992). Causal explanations for these occurrences generally focus on navigational errors due to severe storms or anomalous ocean currents acting independently, or in concert, with other factors such as young age or poor health. For some penguin species, it is even plausible that these individuals are escapees from captivity or were captured and released at different locations (van Buren and Boersma 2007); however, such scenarios are unlikely in Antarctica. Our high-latitude observations of a macaroni penguin(s) on Avian Island, and further observations of non-breeding individuals along the Palmer Archipelago, may have been the result of vagrancy as Parmelee (1992) considered the species to be uncommon south of its sub-Antarctic breeding range. Under this hypothesis, the most parsimonious explanation is that the individuals we observed were birds preparing to molt. Immature macaroni penguins, and occasionally failed breeders, are known to arrive at colonies to molt between January and February,

Table 1 Summary of described observations of macaroni penguins (*Eudyptes chrysolophus*) along the Western Antarctic Peninsula

Date	Location	Behavior
December 2008	Torgersen Island (64°46'S, 64°04'W)	Loafing adult
January 2007	Avian Island (67°46'S, 68°53'W)	Loafing adult
December 2004	Dream Island (64°43'S, 64°13'W)	Loafing adult
January 2004	Dream Island (64°43'S, 64°13'W)	Incubating adult
January 2003	Dream Island (64°43'S, 64°13'W)	Loafing adult
December 2000	Cormorant Island (64°48'S, 63°58'W)	Incubating adult

Fig. 2 Macaroni penguins (*Eudyptes chrysolophus*) observed at **a** Avian Island during January 2007, **b** Cormorant Island during December 2000, **c** Dream Island during January 2003, and **d** Torgersen Island during December 2008. Photos by KBG and DLP-F

whereas breeding adults return to molt by mid-March (Williams 1995). Therefore, the timing of our observations is temporally coherent with the molt process by immature and failed breeders. However, plumage quality of all birds reported here suggested that the molt process had not been initiated at the time of our observations.

Alternatively, we hypothesize that a bio-geographic range shift in response to regional climate warming may be in progress for this species. In addition to our documented breeding attempts by macaroni penguins along the Palmer Archipelago, including the production of at least one chick, all individuals involved in our sightings exhibited the typically large body size and developed head plumes of mature birds of at least 3–4 years of age (Williams 1995) (Fig. 2). As described below, this pattern of occurrence of mature individuals, coupled with repeated, but unsuccessful breeding attempts, closely resembles the well-documented climate-induced shifts in bio-geographic range now occurring among other sub-Antarctic penguins breeding within the WAP region of Antarctica.

Community composition of breeding *Pygoscelis* penguins along the Palmer Archipelago has shifted over the past 30 years coincident with regional climate warming (Vaughan et al. 2003; Ducklow et al. 2007; see Forcada and Trathan 2009 for review), a common biotic response predicted by theory on climate change (Parmesan 2006). Here, breeding populations of the true Antarctic, sea-ice obligate Adélie penguin have decreased by over 65% since the mid-1970s, and their range has contracted. Conversely, sub-Antarctic, sea-ice intolerant chinstrap (*P. Antarctica*) and gentoo (*P. papua*) penguin populations have increased, and their ranges have expanded with nesting colonies established in 1976 and 1994, respectively (Ducklow et al. 2007), representing unique events within the context of paleoecological data on penguin occupation of the region over the last 700 years (Emslie et al. 1998). Similar to the macaroni penguins previously discussed, breeding populations of chinstrap and gentoo penguins along the Palmer Archipelago were initiated by small numbers of individuals with persistent but early breeding failures. Once

established, these breeding populations were characterized by the increased presence of non-breeding prospectors looking to establish mates and breeding territories (WRF, Pers. Obs.). Of note, declines in numbers of chinstrap and gentoo penguins have been documented at some breeding colonies along the northern WAP (Woehler et al. 2001; Forcada et al. 2006; Sander et al. 2007; Forcada and Trathan 2009). In parallel, numbers of breeding macaroni penguins also have declined throughout the species sub-Antarctic range (Woehler et al. 2001; Crawford et al. 2003), including nesting colonies closer to the WAP such as those at South Georgia (Trathan et al. 1998; Forcada and Trathan 2009).

We cannot distinguish any causal mechanism for the presence of macaroni penguins at uncommonly high latitudes at Avian Island, or along the Palmer Archipelago, over the last decade based on our observations. However, we hypothesize that these extra-limital observations are either related to simple vagrancy or much more complex relationships between ocean-climate, population-demographic processes, and bio-geographic range dynamics. Nonetheless, our observations establish a current baseline for the occurrence of macaroni penguins at relatively higher latitudes along the WAP, now including geographically polar locations, which may prove particularly important should the effects of regional climate warming magnify and continue to influence top predator populations throughout the WAP region of Antarctica (e.g., Ducklow et al. 2007; Trathan et al. 2007; Siniff et al. 2008; Forcada and Trathan 2009).

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