

Population changes of Adélie and emperor penguins along the Prince Olav Coast and on the Riiser-Larsen Peninsula

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Abstract: The trends of penguin populations are thought to be reliable indicators of ecosystem changes in the Southern Ocean. There are seven Adélie penguin colonies and one emperor penguin colony along the Prince Olav Coast and one emperor penguin colony on the Riiser-Larsen Peninsula. We compiled and analyzed the available data collected by airborne and ground census between 1971 and 2000 in order to determine the breeding status of penguins in this area. Adélie penguin populations increased at two colonies; no apparent trends were observed at other colonies. Emperor penguin populations were high in the mid-1990s and suddenly decreased in 2000. Populations need to be carefully monitored in the coming years.

key words: Adélie penguin, emperor penguin, population, East Antarctica

Introduction

The trends of penguin populations are thought to be reliable indicators of environmental changes occurring in the Southern Ocean. Adélie penguins are decreasing in the Antarctic Peninsula area and increasing in East Antarctica and the Ross Sea area (Woelher *et al.*, 2001; Croxall *et al.*, 2002). The only long-term data set available for emperor penguin, breeding in Adélie Land, shows that the population there was stable from the 1950s to the mid-1970s, followed by a rapid decline in the late 1970s, and has stabilized since (Barbraud and Weimerskirch, 2001). The increase of air temperature and decrease of sea ice are thought to be the main causes for these population changes (Barbraud and Weimerskirch, 2001; Wilson *et al.*, 2001; Croxall *et al.*, 2002).

There are seven Adélie penguin colonies and one emperor penguin colony along the Prince Olav Coast, Enderby Land and one emperor penguin colony on the Riiser-Larsen Peninsula (Hoshiai and Chujo, 1976; Hoshiai and Matsuda, 1979; Hoshiai *et al.*, 1984; Ishikawa *et al.*, 1988). These colonies were discovered during the Japanese Antarctic Research Expeditions (JARE) and have been monitored occasionally by airborne and ground census since 1971. We compiled and analyzed the data collected between 1971 and 2000 in order to determine the breeding status and population trends of penguins in this area.

Materials and methods

Breeding colonies of Adélie penguins along the Prince Olav Coast, Enderby Land were observed occasionally between November and January from 1971 to the present by JARE. Penguins were counted three times from aerial photographs or directly on the ground. Average values were used for the analysis. In the Lützow-Holm Bay area penguins started to arrive at the colonies around mid-October. Numbers peaked in mid-November before decreasing through late November and finally stabilizing in early December (Watanuki and Naito, 1992). Numbers of breeding pairs (NP) were estimated from the numbers of individuals (NI) for each period using the following equations (Watanuki and Naito, 1992):

$$10\text{--}14 \text{ November: } NP = NI/2,$$

$$22\text{--}28 \text{ November: } NP = -3.34 + 0.77 \times NI,$$

$$5\text{--}14 \text{ December: } NP = NI.$$

Population trends were tested by regression analysis using StatView (SAS Institute Inc., U.S.A.).

There were one emperor penguin colony at Umebosi Rock on the Prince Olav Coast and one on the Riiser-Larsen Peninsula. Numbers of individuals were counted between August (chick-brooding) and December (crèche) from aerial and ground photographs. Until September, crèches had not formed and adults and chicks could be distinguished on photos. In October, the crèches formed, the number of adults in the colony decreased and it became difficult to distinguish adults and chicks on photos. Thus, we compared the numbers of adults counted between 22 August and 28 September.

Results

There were seven breeding colonies of Adélie penguins in the ice-free areas along the Prince Olav Coast (Fig. 1, Table 1) that ranged in size between 80 and 600 pairs during 1971–2000 (Fig. 2, Appendix). At Cape Hinode and Akarui Point, the populations of Adélie penguins increased since the 1970's at annual rates of 7.1% ($P < 0.01$) and 2.0% ($P < 0.05$), respectively, though no significant trends was observed at other colonies. At Cape Omega and Byôbu Rock, breeding populations tended to increase during the 1990's.

Both breeding colonies of emperor penguins on the Riiser-Larsen Peninsula and at Umebosi Rock were on the fast sea-ice at the foot of a cliff of the ice shelf. Population size fluctuated between 4000 and 9000 pairs on the Riiser-Larsen Peninsula and between 200 and 600 pairs at Umebosi Rock during 1984–2000 (Table 1, Fig. 3, Appendix). Populations of both colonies during the mid-1990s were twice to three times greater than those during the 1980s, but they suddenly decreased to half of the 1990s populations in 2000.

Discussion

Adélie penguins are found around the entire Antarctic continent and their population changes have been monitored in many places. The trends of Adélie penguin

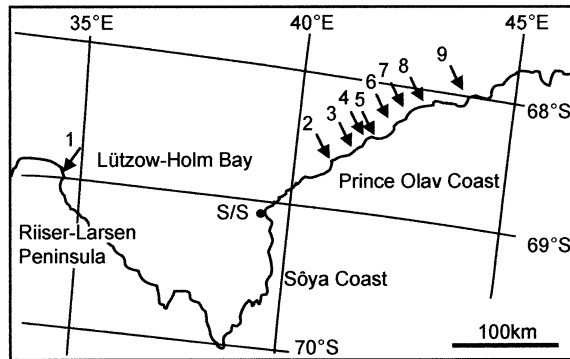


Fig. 1. Map of the study area. Arrows show the breeding colonies of Adélie and emperor penguins (see Table 1).

Table 1. Breeding locations of Adélie and emperor penguins along the Prince Olav Coast and on the Riiser-Larsen Peninsula. The numbers correspond to the arrows in Fig. 1.

Species	Location	No.
Adélie penguin	Cape Omega (68°34.9'S, 42°01.4'E)	2
	Akarui Point (68°27.5'S, 41°25.5'E)	3
	Tenmondai Rock (68°24.1'S, 41°45.2'E)	4
	Byôbu Rock (68°22.5'S, 42°01.9'E)	5
	Niban Rock (68°15.7'S, 42°29.6'E)	6
	Cape Hinode (68°08.6'S, 42°39.8'E)	7
	Cape Ryûgû (67°58.0'S, 43°56.4'E)	9
Emperor penguin	Riiser-Larsen Pen. (68°48.3'S, 34°23.7'E)	1
	Umebosi Rock (68°02.8'S, 43°04.9'E)	8

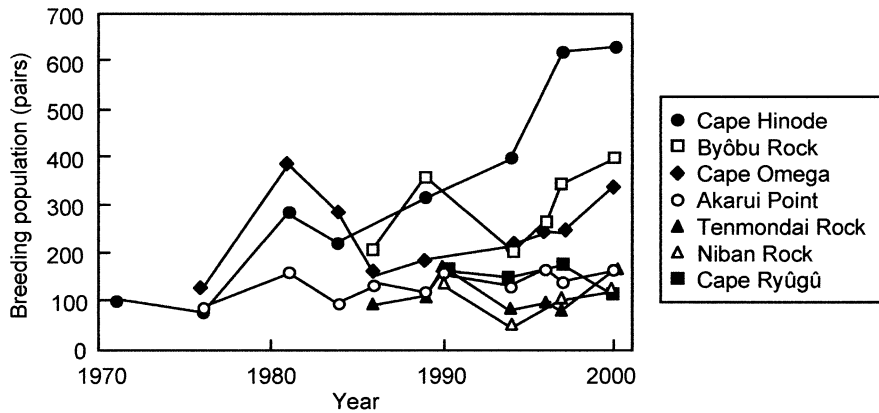


Fig. 2. Population changes of Adélie penguins at breeding colonies along the Prince Olav Coast.

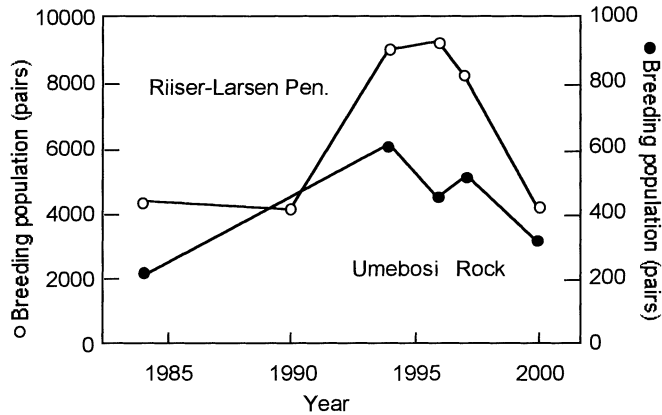


Fig. 3. Population changes of emperor penguins on the Riiser-Larsen Peninsula and at Umebosi Rock.

populations are closely related to sea-ice characteristics, which can be affected by climate changes (Fraser *et al.*, 1992; Smith *et al.*, 1999; Wilson *et al.*, 2001). Although information on climate change and population trends in East Antarctica is limited, Adélie penguin populations have been reported to increase there since the 1960s (Woelher *et al.*, 2001). The long-term population increases in East Antarctica may also be related to global-scale environmental changes, for example in the Ross Sea area (Taylor *et al.*, 1990; Wilson *et al.*, 2001). A similar trend has been observed for the populations of the Sôya Coast area in Lützw-Holm Bay (Kato *et al.*, 2002). The Sôya Coast is located inside of the bay and sea ice often remains even during the summer, while the Prince Olav Coast, east of Lützw-Holm Bay, faces the ocean and most of the sea ice present in front of the colonies disappears during the summer. Therefore, environmental conditions in the foraging areas of penguins from these two locations are expected to differ. Nevertheless, the long-term population trends were similar in these two areas. Over the last 40 years, sea-ice extent has fluctuated substantially, especially in winter, but no significant tendency, toward either an increase or a decrease, was evident between 1971 and 2001 in this area (Kato *et al.*, 2002).

Emperor penguins breed on fast sea ice during the Antarctic winter and their population data are very limited (Barbraud and Weimerskirch, 2001) because of the inaccessibility of the breeding colonies during winter. Although population data in our study colonies were limited, populations increased from the 1980's to the mid-1990s and suddenly decreased in 2000. As penguins are long-lived seabirds, actual population size does not change much on an annual basis. A sudden decrease might reflect a decrease in the attendance rate at the breeding colony. However, populations will need to be carefully monitored in coming years.

Because of the strong link between Antarctic penguin populations and the annual extent of sea-ice, environmental changes in forthcoming years, especially global warming issues, should be carefully considered. This is especially true in our study area (including the Riiser-Larsen Peninsula, Lützw-Holm Bay and the Prince Olav Coast)

where sea-ice condition varies considerably on a limited spatial scale. Moreover, environmental data are continuously available from the JARE monitoring program.

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Appendix. Date of censuses for Adélie and emperor penguins.

Year	Adélie penguin							Emperor penguin	
	Cape Omega	Akarui Point	Tenmondai Rock	Byôbu Rock	Niban Rock	Cape Hinode	Cape Ryûgû	Riiser-Larsen	Umebosi Rock
1971	-	-	-	-	-	1*	-	-	-
1976	3*	2*	-	-	-	2*	-	-	-
1981	24 Nov.	24 Nov.	-	-	-	24 Nov.	-	-	-
1984	14 Nov.	14 Nov.	-	-	-	14 Nov.	-	25 Sep.	28 Sep.
1986	24 Nov.	24 Nov.	24 Nov.	24 Nov.	-	-	-	-	-
1989	14 Dec.	14 Dec.	14 Dec.	14 Dec.	-	14 Dec.	-	-	-
1990	-	23 Nov.	23 Nov.	-	23 Nov.	-	23 Nov.	14 Sep.*	-
1994	12 Nov.	12 Nov.	12 Nov.	12 Nov.	12 Nov.	12 Nov.	12 Nov.	17 Sep.	22 Aug.
1996	5 Dec.	5 Dec.	5 Dec.	5 Dec.	-	-	-	31 Aug.	11 Sep.
1997	22 Nov.	10 Nov.	10 Nov.	10 Nov.	10 Nov.	10 Nov.	10 Nov.	9 Sep.	9 Sep.
2000	5 Dec.	5 Dec.	5 Dec.	5 Dec.	28 Nov.	28 Nov.	28 Nov.	12 Sep.	13 Sep.

* Ground census

References: 1 Aoyanagi (1973); 2 Hoshiai and Matsuda (1979); 3 Hoshiai *et al.* (1981)