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First documented observation of stone incubating behavior in chinstrap penguins

Jin-Woo JUNG[1*], Yeong-Deok HAN[1] andHosung CHUNG[2]

[1] *Research Center for Endangered Species, National Institute of Ecology, Yeongyang-gun, Gyeongsangbuk-do, 36531, Republic of Korea*

[2] *Division of Life Sciences, Korea Polar Research Institute, Yeonsu-gu, Incheon, 21990 Republic of Korea*

corresponding author: *jwjung@nie.re.kr*

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Abstract: Many ground-nesting birds are known to incubate non-egg objects; however, instances of incubation occurring without the bird's own eggs are rare. In the Antarctic region of King George Island, we observed a breeding chinstrap penguin *Pygoscelis antarcticus* incubating a stone instead of an egg. To our knowledge, this is the first documented instance of foreign object incubation in the family Spheniscidae. During the 2011–2012 to 2014–2015 breeding seasons, three nests exhibiting stone incubation were observed. Penguins at these nests displayed nest-defending behaviors against intruders, with individuals alternating incubation duties, resembling behaviors seen in pairs incubating eggs. All stone-incubating nests were located at the periphery of subcolonies and were established later than egg-incubating nests. Our findings suggest that this behavior is associated with the young and inexperienced bird hypothesis.

Keywords: Antarctic, South Shetlands, avian breeding behavior, foreign object incubation, Spheniscidae, inexperienced bird hypothesis.

Introduction

Exotic eggs and non-egg objects (pseudo-eggs) are frequently found in the nests of ground-nesting birds, particularly among species in the orders Pelecaniformes, Anseriformes, and Charadriiformes (Sugden 1947; Knight and Erickson 1977; Coulter 1980; Conover 1985; Hobson 1989; Mellink 2002). However, instances of birds incubating exclusively non-egg objects, without their own eggs, are rare (Langlois *et al.* 2012). Commonly reported non-egg objects include stones (Knight and Erickson 1977; Coulter 1980; Conover 1985; Mellink 2002; DeStefano *et al.* 2013), but materials such as driftwood (Witteveen *et al.* 2015), glass bottles (Guay *et al.* 2006), guano (Mellink 2002), large shells (Witteveen *et al.* 2015), mammalian bones (Langlois *et al.* 2012), and pine cones (Knight and Erickson 1977) have also been noted. In this study, we present observations of stone-incubating behavior in chinstrap penguins *Pygoscelis antarcticus* (Forster, 1781), which, to our knowledge, represents the first documented case of foreign object incubation in Spheniscidae.

Methods

This study was conducted at Narebski Point (62°14.3′S, 58°46.5′W) on the Barton Peninsula, King George Island, in the South Shetland Islands, Antarctica. Approximately 3 000 chinstrap penguins breed in this area annually from October to February during the austral summer. These penguins typically lay two eggs, with both sexes alternating between incubation and foraging duties. The research was carried out over four breeding seasons, from the 2011–2012 season to the 2014–2015 season. During this period, over 300 nests were randomly examined each week from December to February to identify the breeding stages of penguins. When a stone-incubating nest was detected, it was marked with a steel peg and monitored daily to confirm whether the penguins were indeed incubating stones.

Stone incubation was confirmed based on the following criteria: (*i*) the birds incubated with the stone positioned on top of both legs, (*ii*) they exhibited strong nest-defending behavior, (*iii*) the stone was warm to the touch, and (*iv*) both the male and female alternated incubation duties. The sex of each penguin in a pair was not determined by genetic or morphological methods, but they were inferred to be a male–female pair based on their alternating incubation behavior at the same nest. However, in younger individuals, pair-bond stability may be lower, suggesting that the observed pair could have been a combination of immature individuals rather than a true breeding pair. The possibility of same-sex pseudo-pairs also cannot be ruled out.

A ruler was used to measure the major and minor axes of the incubated stones to compare their size with that of eggs. Egg size was measured at 269 randomly selected nests during the 2014–2015 breeding season. The location of each nest was recorded as either at the periphery or within the sub-colony, and the distance to the nearest neighboring nest was randomly measured for 438 nests.

To test whether penguins could distinguish between eggs and stones, round-shaped stones (major and minor axes: 6–8 cm), similar in size to an egg, were placed in the nests of six pairs of chinstrap penguins. These pairs were selected because they were guarding their nests after either egg failure or predation by skuas. The selected nests were monitored daily to record the presence or absence of stone incubation. Pairs exhibiting nest-defending behavior shortly after losing their eggs were chosen for the experiment.

Results

Over four breeding seasons, we discovered three stone-incubating chinstrap penguin nests without eggs: one in 2012–2013 and two in 2014–2015 (Table 1). Two of the incubated stones were round-shaped (Fig. 1A and C), while one was pointed (Fig. 1B). The major axis of the incubated stones ranged from 70 to 115 mm (Table 1), which was relatively larger than the average major axis of chinstrap penguin eggs (67.8 ± 2.9 mm). However, this difference was not statistically significant (Welch's t-test: t (2.001) = –1.504, p = 0.271). Since the clutch size of chinstrap penguins is typically two, we compared the double length of the minor axis of the eggs with the major axis of the stones, and no significant difference was found (Welch's t-test: t (2.001) = 1.175, p = 0.361)

The observed stone-incubating nests were attended alternately by males and females for more than four days (Table 1). Individuals incubated the stones in turns, displaying nest-defending behavior similar to that of penguins incubating real eggs. Adults incubating stones showed aggressive behavior toward approaching intruders (including researchers) and exhibited typical egg-rolling behavior at intervals. Regular tactile checks confirmed that the stones retained warmth, indicating continuous incubation. During incubation, the stones were consistently placed on both legs, similar to the positioning of real eggs. These behaviors suggest that chinstrap penguins treated the stones as if they were eggs.

Among the three nests, the earliest discovery date was December 13, while the other two were discovered on December 28 and 29, respectively. The average hatching date of chinstrap penguins in this region is around December 25 (pers. obs.), indicating that these nests would have been established in mid-November to initiate incubation. All stone-incubating nests were observed during the later stages of incubation or the hatching period. All three stone-incubating nests were located at the periphery of the sub-colony, more than two meters away from the nearest neighboring nest (Table 1). This distance was greater than the average distance between chinstrap penguin nests (78.6 ± 12.1 cm), suggesting that these nests were established later than others.

Discussion

We observed chinstrap penguins incubating only stones, without any eggs. Such behavior has not been previously documented in penguins. Chinstrap penguins typically maintain a fixed clutch size of two eggs, and since both parents alternate incubation throughout the day, the possibility of eggs being transferred to other nests is very low.

Additionally, no evidence of interspecific or intraspecific brood parasitism, which could result in eggs being transferred to other nests, has been observed in this species. Although it is possible that an egg was present before the penguins began incubating the stones, it is uncommon for birds to continue incubating stones for more than four

Table 1. Summary of stone incubation observations, stone/egg dimensions, and nest location for chinstrap penguin nests.

Category	Observation / sample	Initial observation date	Final observation date	Stone incubating period	Position in colony	Distance to nearest neighbor's nest	Stone size / egg size (mm)	
							length	width
Stone incubating nests	Nest-1	29.12.2012	2.01.2013	4 days	periphery	> 2 m	80	60
	Nest-2	13.12.2014	20.12.2014	7 days	periphery	> 2 m	115	75
	Nest-3	28.12.2014	7.01.2015	10 days	periphery	> 3 m	70	50
Breeding nests	Eggs (N=269)						67.8±2.9	52.2±2.5
	Nests (N=438)					78.6±12.1 cm		

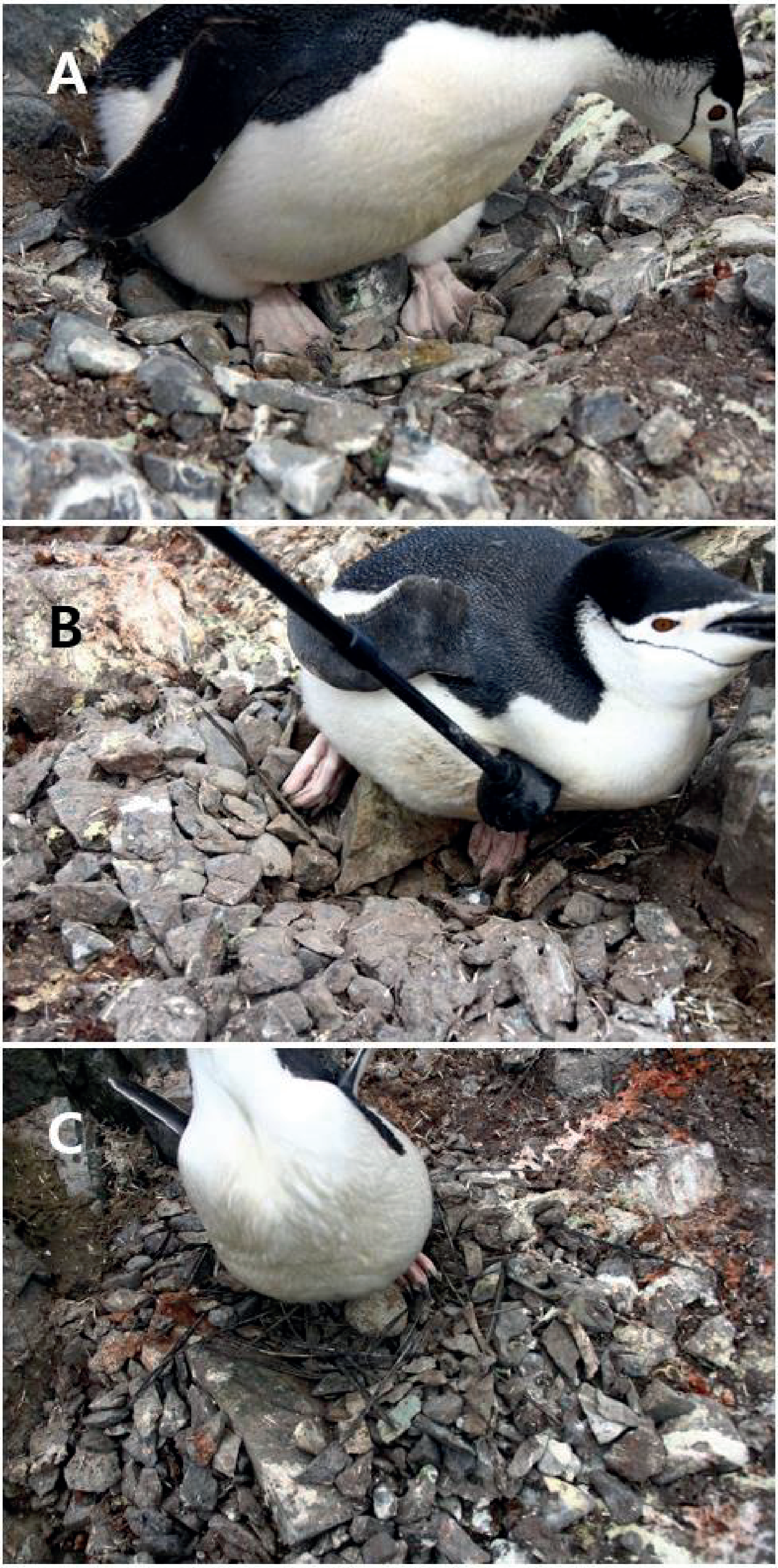

Fig. 1. Images of three stone-incubating nests of chinstrap penguins discovered: **A** – December 29, 2012, **B** – December 13, 2014, **C** – December 28, 2014.

days. Given the size of the stones (7–11.5 cm in major axis), which are too large to be carried by mouth, it is likely that the stones were dragged to the nests by the penguins or accidentally fell into the nests.

There are three main hypotheses that explain the incubation of non-egg objects in birds. First, the mistaken-food hypothesis, commonly observed in skuas, is excluded in chinstrap penguins because they do not prey on other birds' eggs and are unable to carry eggs with their bills. Second, the mistaken-egg hypothesis proposes that birds may treat exotic eggs or non-egg objects as their own if the object resembles an egg (Conover 1985). For this hypothesis to be supported, birds must continue incubation even when only the non-egg object remains. Although we did not conduct a direct experiment to test this, our observations showed that chinstrap penguins incubated stones for over four days, defended their nests against intruders, and displayed behaviors identical to those incubating real eggs. However, according to this hypothesis, birds should initially have their own eggs and cases of mixed egg and stone incubation should occur more frequently. During the study, no such cases were observed, and nests incubating both eggs and stones were not found. Furthermore, in our stone provision experiment, four out of six pairs did not incubate the provided stone, and those that did abandoned the nest when approached by researchers, unlike pairs incubating real eggs. This suggests that while some penguins may treat stones as eggs, they can generally distinguish between them.

Lastly, the young and inexperienced bird hypothesis appears to best explain the observed phenomenon (Crawford 1974; Hobson 1989). All stone-incubating nests were located at the periphery of the sub-colony. Similar behavior has been reported in double-crested cormorants *Phalacrocorax auritus* (Lesson, 1831), where stone-incubating nests were also found exclusively at the edges of sub-colonies (Hobson 1989). Peripheral nests in colonial seabirds are typically chosen by younger or inexperienced breeders (Siegel-Causey and Hunt 1986; Kharitonov and Siegel-Causey 1988). Barbosa *et al.* (1997) similarly noted that chinstrap penguin nests at the colony's edges have later hatching dates than central nests, indicating delayed breeding initiation. Ferrer *et al.* (2014) reported that peripheral nests of chinstrap penguins have lower fecundity than inner nests, and that the inner nests are occupied earlier. This suggests that more experienced individuals recognize the advantages of inner nest sites, whereas less experienced individuals face greater difficulty securing breeding opportunities when competition for nesting sites intensifies. In our study, the three stone-incubating nests were independent and located over 2 m from the nearest neighboring nest, substantially farther than the average inter-nest distance of 78.6 ± 12.1 cm. These findings suggest that the stone-incubating nests were established later in the breeding season by younger or less experienced individuals, likely resulting in lower breeding success.

Chinstrap penguins have a lifespan of approximately 16–20 years (Trivelpiece, unpublished data, after Borboroglu and Boersma 2013) and typically begin breeding at 3–4 years of age (Trivelpiece *et al.* 1990, after Borboroglu and Boersma 2013). Breeding under Antarctic conditions requires substantial parental investment, and experience plays a critical role in reproductive success. The observation of only three stone-incubating cases over four years, despite the large breeding population, highlights the rarity of this behavior.

Interestingly, stone-incubating nests were observed only in 2012–2013 and 2014–2015, when relatively heavy snowfall accumulated during the incubation period (based on the authors' field observations). This may suggest that the limited availability of suitable nesting sites created unfavorable conditions for younger and less experienced individuals. However, due to the small number of observed cases, this study does not support a definitive conclusion, and further research is needed.

These findings emphasize the complex interplay between environmental conditions and individual experience in determining breeding participation in chinstrap penguins. Younger and less experienced individuals may engage in such behaviors as a preparatory step, potentially allowing them to participate more effectively in breeding when ready.

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