ASPECTS OF THE BREEDING BIOLOGY OF THE GENTOO PENGUIN *PYGOSCELIS PAPUA* AT VOLUNTEER BEACH, FALKLAND ISLANDS, 2001/02

HELEN M. OTLEY,[1] ANDREA P. CLAUSEN,[1] DARREN J. CHRISTIE[1] & KLEMENS PÜTZ[2]

[1]*Falklands Conservation, PO Box 26, Stanley, Falkland Islands FIQQ 1ZZ, UK*
(heleno@southcom.com.au)
[2]*Antarctic Research Trust, PO Box 685, Stanley, Falkland Islands FIQQ 1ZZ, UK*

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SUMMARY

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The breeding biology of 14 pairs of Gentoo Penguins *Pygoscelis papua* was studied at Volunteer Beach, Falkland Islands during 2001/02. Breeding commenced in October and the mean hatch date for the first-laid egg was 6 December ± four days. The brood period lasted 27 days, and chicks fledged from the first week of February onward. The sexes shared incubation and brood duties equally. Mean minimum and maximum foraging trip lengths were 2.0–3.0 days and 0.7–1.8 days during the incubation and brood periods respectively. Timing of breeding and breeding success at Volunteer Beach were similar to those reported at other colonies in the South Atlantic Ocean/Antarctic Peninsula region. In contrast, the comparatively long foraging trips during incubation and brooding were similar to those reported for Gentoo Penguins breeding in the southern Indian Ocean.

Keywords: Gentoo Penguin, *Pygoscelis papua,* Falkland Islands, breeding biology

INTRODUCTION

The Gentoo Penguin *Pygoscelis papua* has one of the most extensive latitudinal ranges of any penguin species, breeding from the Crozet Islands (46°S) in the southern Indian Ocean to Petermann Island (65°S) on the Antarctic Peninsula (Woehler 1993). Despite the range of climatic conditions and marine systems, all studied colonies across the bird's range showed several similar breeding parameters (Williams 1995). Those parameters included asynchronous laying of two eggs, equal sharing of chick-rearing, and foraging trips of fewer than four days during the incubation and brooding periods.

However, significant differences have been identified in the timing of breeding and the foraging strategies of birds in colonies in the southern Indian and Pacific Oceans as compared with those in the South Atlantic Ocean/Antarctic Peninsula region (Trivelpiece *et al.* 1987, Bost & Jouventin 1990, Williams 1990, Williams & Rothery 1990, Bost & Jouventin 1991, Robinson & Hindell 1996, Quintana & Cirelli 2000). Birds in the southern Indian Ocean, such as at Marion, Crozet and Kerguelen Islands, commence breeding during the austral winter, with failed breeders often re-laying during spring, when birds in South Atlantic and Antarctic Peninsula colonies are first producing eggs (Bost & Clobert 1992). Higher breeding success has been reported in colonies in the South Atlantic Ocean/Antarctic Peninsula region as compared with colonies in the southern Indian Ocean (Williams 1990, Quintana & Cirelli 2000).

A 10-year record of breeding success in a number of colonies in the Falkland Islands suggests that breeding success there is similar to that observed in South Georgia (Pütz *et al.* 2001, Clausen & Pütz 2002). However, breeding biology beyond annual monitoring of breeding success has not been studied in the Falkland Islands, despite the islands' holding the largest population of the northern nominate subspecies (Williams 1995).

The present study describes the timing of the incubation, brood and fledge periods, and foraging trip lengths of the Gentoo Penguin in the Falkland Islands.

METHODS

The study was conducted at Volunteer Beach on the eastern coast of East Falkland Island (51°29xx'S, 57°50xx'W), which receives 1000 visitors each summer (HMO, pers. obs.). The 1000–breeding pair colony has been subject to the legal collection of eggs by people for many decades, with *c.* 150 eggs removed in late October 2001 (G. Smith pers. comm.).

Observations began during early egg incubation (the first week of November) when 14 pairs were identified by the presence of one bird on a nest and a second bird demonstrating nest building or breeding displays. The study commenced after early breeders had laid eggs. To reduce disturbance, only pairs breeding on the edge of the colony were selected. Although breeding success in *Pygoscelis* penguins is apparently not affected by nest location (Giese 1996, Barbosa *et al.* 1997, Quintana & Cirelli 2000), the 14 pairs selected were likely to have begun breeding up to one week later than the more centrally located pairs (HMO, pers. obs.).

We used a pole to capture the non-incubating partner at each nest by the ankle; the bird was then marked with a length of adhesive tape wrapped around the base of a flipper. Upper bill length (versus lower bill length, as cited in Williams 1990) and bill depth were measured to the nearest 0.1 mm; body mass was measured to the nearest 0.1 kg. It was not known if the marked bird had recently undertaken a long incubation shift before capture. In mid-January,

the unmarked partners in eight of the 14 selected pairs were captured and measured. Six partners could not be captured without causing disturbance to the colony. In the eight pairs in which both birds were measured, the partner with the larger bill was assigned as the male (Williams 1990). In the remaining six pairs in which the unmarked bird was not captured, birds with a bill length greater than 57 mm were assigned as male.

Between 31 October 2001 and 11 January 2002, after which all study chicks had entered a crèche, nests were checked daily at dawn (04h15–06h15) and dusk (19h00–21h30) for the presence of marked and unmarked birds, eggs and chicks. The interval between checks varied between eight hours and 16 hours, depending on the times of sunrise and sunset. Because exact times of changeovers were not recorded, the minimum (assuming that the change had occurred just before the check) and maximum (assuming that the change had occurred just after the previous check) durations for each trip were calculated.

Because study pairs were already incubating eggs when observations commenced, the incubation period was recorded for two late-breeding pairs whose eggs were laid after observations had commenced. Nests were approached using recommended methods (Giese 1998), and a bamboo pole was used to lift the incubating bird slightly so as to assess the number of eggs or chicks (or both). Just before crèche formation, we measured bill length and depth and body mass of three chicks from double-chick study pairs and three chicks from single-chick study pairs aged 22–31 days. Counts (average of three varying less than 10%) of incubating pairs and chicks were made every five days between 2 November 2001 and 29 March 2002.

If not otherwise stated, all values are given as mean ± standard deviation (SD). The Student *t*-test was used after checks for normality and variance.

TABLE 1
Statistical differences between mean bill length and depth of 12 male and 10 female adult Gentoo Penguins and the body mass of seven male and six female adult birds during early incubation. Also a comparison of bill dimensions and body mass of three chicks from single-chick clutches and three chicks from double-chick clutches aged 22 to 31 days as compared with the mean adult dimensions at Volunteer Beach

	Mean ± SD (n)				
	Male	Female	Significance	Chick	Percent of mean adult size
Bill length (mm)	60.5±2.3 (12)	54.1±1.9 (10)	$t_{11} = 4.84$, $P < 0.001$	33.7±3.2 (6)	62
Bill depth (mm)	24.8±4.0 (12)	23.2±2.6 (10)	$t_{11} = 0.29$, P=0.778	16.6±1.6 (6)	72
Body mass (kg)	7.0±0.7 (7)	6.6±0.6 (9)	$t_{12} = 1.87$, P=0.086	3.2±0.7 (6)	48

SD = standard deviation.

TABLE 2
Timing of breeding activities and foraging trip lengths undertaken by 14 incubating Gentoo Penguin pairs observed over a period of up to 39 days. Mean minimum and mean maximum values are ± standard error

Pair	Capture date	Clutch lay date[a]	Incubation observed (%)	Male			Female			Comparison of male and female	Eggs (*n*)	Hatching date	
				Trips (*n*)	Mean min (h)	Mean max (h)	Trips (*n*)	Mean min (h)	Mean max (h)			Chick 1	Chick 2
1	1 Nov	24 Oct	72	6	36	56	7	31	55	t_{11}=0.81, NS	2	29 Nov	30 Nov
2	8 Nov	28 Oct	67	6	37	58	8	55	77	t_{12}=1.69, NS	2	3 Dec	4 Dec
3	2 Nov	1 Nov	97	5	86	112	6	69	92	t_{9}=0.48, NS	2	10 Dec	12 Dec
4	1 Nov	27 Oct	95	6	44	66	5	59	80	t_{9}=0.33, NS	2	2 Dec	7 Dec
5	1 Nov	28 Oct	90	6	52	76	8	55	74	t_{12}=2.79, P=0.02	2	3 Dec	6 Dec
6	1 Nov	28 Oct	90	5	63	86	7	35	59	t_{10}=0.57, NS	2	3 Dec	6 Dec
7	1 Nov	29 Oct	87	6	36	52	5	73	97	t_{9}=2.09, NS	2	4 Dec	Not hatch
8	1 Nov	30 Oct	92	8	52	72	7	42	60	t_{13}=1.70, NS	2	6 Dec	7 Dec
9	3 Nov	1 Nov	92	7	38	58	5	59	82	t_{10}=1.16, NS	2	8 Dec	Not hatch
10	2 Nov	1 Nov	97	8	33	51	7	47	64	t_{13}=0.79, NS	2	8 Dec	9 Dec
11	6 Nov	3 Nov	79	5	68	96	8	43	73	t_{11}=0.83, NS	1	8 Dec	—
12	1 Nov	1 Nov	100	8	32	55	7	34	55	t_{13}=1.46, NS	2	9 Dec	10 Dec
13	1 Nov	1 Nov	95	8	35	56	5	48	76	t_{13}=1.34, NS	2	11 Dec	Broken
14	9 Nov	8 Nov	95	7	41	61	9	43	69	t_{14}=0.09, NS	1	15 Dec	—
		30 Oct ± 4			47 ± 4	68 ± 5		50 ± 3	72 ± 3		26	6 Dec ± 4	6 Dec ± 4

[a] Laying date of first egg extrapolated from an incubation length of 37 d recorded in two additional nests.
NS = nonsignificant.

RESULTS

Study pairs

Bill lengths for the assigned males and females were significantly different, but bill depths were not (Table 1). Body mass in early incubation was not significantly different between male and female birds; the birds weighed between 6.0 kg and 7.0 kg (Table 1).

Egg period

Twelve of the study nests and the two nests for which egg laying and hatching dates were both recorded contained two eggs. The two other study nests each contained a single egg. The single eggs were not noticeably smaller than the eggs in two-egg clutches.

In the two nests for which egg laying and hatching dates were both recorded, the incubation periods for the first egg were 36.5 days and 37.0 days. Using a period of 37 days, the extrapolated laying dates for the first egg in the study pairs fell between 24 October and 8 November, with a mean laying date of 30 October (Table 2).

During the egg period, males and females undertook foraging trips of a minimum duration of 8–190 hours and a maximum duration of 8–240 hours. In all but one pair, no significant difference between male and female maximum foraging trip lengths was observed (Table 2). The mean ± standard error (SE) minimum and maximum male foraging trip lengths were 47 ± 4 hours (2.0 days) and 68 ± 5 hours (2.8 days) respectively, compared with the mean ± SE female minimum and maximum foraging trip lengths of 50 ± 3 hours (2.1 days) and 72 ± 3 h (3.0 days; Table 2).

The mean date for the first hatching of an egg in 14 nests was 6 December ± four days, with the first egg in a study pair hatching on 29 November, and the last on 15 December (Table 2). Hatching success was 89%; one egg broke in the week before the hatching of the other egg, and one egg in each of two clutches failed to hatch. No nests were abandoned, and no eggs were preyed upon.

Brood period

During the brood period, the female of one pair did not return, and the male abandoned the two chicks after nine days. In the remaining 13 pairs, males and females undertook foraging trips of a minimum duration of 8–72 hours and of a maximum duration of 8–97 hours. In all but one pair, no significant difference between male and female maximum foraging trip length (Table 3) was observed. The mean minimum and maximum male foraging trip length was 18 ± 3 hours (0.8 day) and 42 ± 6 hours (1.8 days) respectively, as compared with the mean female minimum and maximum foraging trip length of 17 ± 2 hours (0.7 day) and 38 ± 3 h (1.6 days) respectively (Table 3).

The 15 chicks that survived the brooding period were brooded for between 21 days and 29 days (mean: 26 ± 2 days; Table 3). The brood period for eight chicks in four clutches in which both chicks survived to the end of the brood period was not significantly longer as compared with seven chicks in nests where only one chick survived (*t*-test: $t_{13} = 0.33$; $P = 0.75$).

Fifteen of 23 study chicks (1.1 chicks/pair) survived to the end of the brood period. Failure because of abandonment occurred in one nest after a brooding shift of nine days at the nest. Both chicks in two nests and one of the two chicks in two nests died for unknown reasons during the first 15 days after hatching. Mean body mass of two chicks from single-chick nests, one chick in a nest in which the other chick died 10 days after hatching, and three chicks from two-chick nests aged 22–31 days old was 3.2 kg. Bill dimensions were less than 72% of mean adult size at Volunteer Beach (Table 1).

Colony breeding success

In mid December, 1103 ± 22 breeding pairs were present at Volunteer Beach. The 1371 ± 16 chicks present in the colony in early January began to depart to sea in the last week of the month (Fig. 1). By the third week of March, no chicks were present.

TABLE 3
Foraging trip length undertaken by 14 Gentoo Penguin pairs, and chick survival during brooding. Mean minimum and mean maximum values are ± standard error

Pair	Trips (*n*)	Male		Female			Comparison of male and female (*t*-test)	Brood length (d)	Age at death (d)
		Mean min length (h)	Mean max length (h)	Trips (*n*)	Mean min length (h)	Mean max length (h)			
1[a]								—	9, 10
2	8	21	40	7	14	32	t_{13}=0.89, NS	—	8, 12
3	3	14	33	3	40	64	t_{4}=2.27, NS	—	3, 6
4	7	21	42	7	11	34	t_{12}=1.03, NS	29	15
5	5	47	113	5	15	37	t_{8}=1.12, NS	25, 28	
6	9	15	33	9	13	26	t_{16}=1.18, NS	26, 28	
7	9	20	41	10	12	32	t_{17}=1.80, NS	28	
8	8	23	45	8	14	31	t_{14}=1.61, NS	26, 27	
9	9	12	31	11	13	35	t_{18}=0.77, NS	25	
10	9	10	33	10	16	41	t_{17}=1.23, NS	26, 27	
11	8	18	40	10	19	42	t_{16}=0.23, NS	27	
12	9	13	30	12	15	36	t_{19}=1.54, NS	26	10
13	9	14	32	9	26	47	t_{16}=2.45, P=0.026	28	
14	9	11	31	7	16	34	t_{14}=0.48, NS	21	
		18±3	42±6		17±2	38±3		26±2	

[a] Female did not return after chicks hatched. Male waited nine days before abandoning the chicks.

Overall breeding production, based on the number of chicks just before fledging, was 1.3 chicks/pair.

DISCUSSION

Across its geographic range, the Gentoo Penguin exhibits variation in timing of breeding, foraging trip lengths during incubation and brood periods, and individual and colony-wide breeding success, with birds within the same oceanic system sharing similar patterns. Gentoo Penguins breeding on Marion, Crozet and Kerguelen in the southern Indian Ocean commence breeding during winter months and forage for mean periods of three days during incubation and 1.3 days during brooding (Table 4).

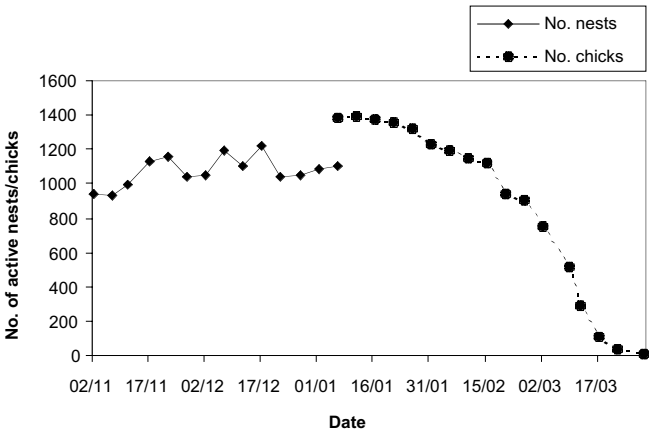

Fig. 1. Total numbers of breeding pairs and chicks at Volunteer Beach at five-day intervals, indicated by the number of active nests with eggs and chicks during November–December and the number of chicks in January–March, 2001/02.

Breeding success of Gentoo Penguins in the southern Indian Ocean is low, at fewer than 0.5 chicks/pair, which leads to replacement clutches being laid in spring months (Table 4). In contrast, at South Georgia, South Atlantic Ocean, the South Shetland Islands and the Antarctic Peninsula, and at Macquarie Island in the southern Pacific Ocean, breeding is initiated only in spring months. Gentoo Penguins in colonies at those localities undertake shorter foraging trips during both incubation and brooding, with a mean length of fewer than 1.4 days during incubation and 0.5 days during brooding. On average, pairs can successfully raise between 0.9 and 1.2 chicks each year (Table 4).

At Volunteer Beach, the mean hatching date for the first egg in 14 nests was early December, similar to other studied colonies in the South Atlantic Ocean/Antarctic Peninsula region. The overall breeding success of 1.3 chicks/pair reported in the present study was higher than the 10-year mean at Volunteer Beach of 0.86 chicks/pair (Pütz *et al.* 2001), a level that was somewhat lower than the levels recorded elsewhere in the South Atlantic Ocean/Antarctic Peninsula region (Table 4). Minimum–maximum foraging trip lengths at Volunteer Beach during incubation and brooding (2.0–3.0 days and 0.7–1.8 days respectively) were longer than the typical trips undertaken by Gentoo Penguins elsewhere in the South Atlantic Ocean/Antarctic Peninsula region and more similar to the trip lengths reported for birds in the southern Indian Ocean (Table 4).

Long foraging trips are usually associated with low breeding success at colonies in the southern Indian Ocean (Bost & Jouventin 1990), but this case does not appear to have held at Volunteer Beach during 2001/02. For example, the mean mass of six chicks in this study at the end of the brood period (3.2 kg) was higher than the annual means (1.6–2.7 kg) over three seasons at nearby South Georgia (Williams 1995). Adult body condition is one factor that

TABLE 4
Comparison of the timing of breeding, mean foraging length, breeding success and body mass of male and female Gentoo Penguins in the southern Indian, Pacific and South Atlantic Oceans and the Antarctic Peninsula region

Ocean	Locality	Latitude	Length of study	Sample size	Breeding initiated	Mean foraging length (d)		Mean breeding success (chicks/pair)	Mean body mass (kg)	
						Incubation	Brood		Male	Female
Indian	Crozet[1]	46°	4 seasons	455	June	2.8	1.2	0.48	6.7[a]	
	Marion[1]	46°	1 season	—	June			0.43		
	Kerguelen[1]	49°	1 season	—	June	3.1	1.4	0.60	5.4[a]	
Pacific	Macquarie[2]	54°	1 season	15	October		0.5	0.98	5.7[a]	
South Atlantic	Falklands[3]	51°	1 season	14	October	2.0–3.0	0.7–1.8	0.87	7.0	6.6
Antarctic	South Georgia[4]	54°	3 seasons	30–200	October	1.4	0.5	0.90	5.9	5.1
	South Shetlands[5]	61°	2 seasons	885	October	0.5	0.5	1.17		
	Antarctic Peninsula[6]	64°	1 season	26	October			1.12	5.8	5.0

[a] Body mass of unsexed birds from Williams (1995).
Sources: 1. Bost & Jouventin 1990; 2. Robertson 1986, Robinson & Hindell 1996; 3. Clausen & Pütz 2002, this study; 4. Williams 1995, Croxall *et al.* 1999; 5. Trivelpiece *et al.* 1987; 6. Renner *et al.* 1998, Quintana & Cirelli 2000.

contributes to the ability to withstand long periods fasting onshore during incubation and brooding (Bost & Jouventin 1991). The mean incubation mass of nine males and seven females at Volunteer Beach was almost 1 kg heavier than the mean incubation mass of both sexes at colonies in South Georgia and the Antarctic Peninsula and also when compared to unsexed adults at various stages of breeding at Crozet, Kerguelen and Macquarie Islands (Table 4).

Hatching success in colonies across the range of the Gentoo Penguin is usually around 60%–70%, because of abandonment resulting primarily from delayed relief (Williams 1980, Trivelpiece *et al.* 1987, Bost & Jouventin 1990, 1991, Williams 1995). Despite comparatively long incubation shifts at Volunteer Beach, no nests were abandoned, resulting in a high hatching success. The ability to withstand extended fasting periods was also shown by one study bird at Volunteer Beach that abandoned brooded chicks only after nine days. Birds at Crozet abandoned chicks after as little as five days (Bost & Jouventin 1991).

Our results indicate that the breeding biology of Gentoo Penguins at the Falkland Islands represents a mixture of the patterns displayed by birds from the South Atlantic Ocean/Antarctic Peninsula region and the southern Indian Ocean. Without at-sea data such as diet, foraging distance and prey availability—in combination with the unknown impacts of egg collecting and tourism at Volunteer Beach—it is difficult to interpret more fully the breeding patterns exhibited.

Two of the study pairs laid only one normal-sized egg, but that egg is unlikely to have been a replacement egg—replacement eggs are often smaller (Bost and Clobert 1992). Study clutches were not thought to be complete replacement clutches after egg collection because intervals of up to 25 days usually occur between failure and re-laying (Bost and Clobert 1992). Given the species' plastic breeding phenology (Williams 1990), a multi-annual study with larger sample sizes is required to fully understand the breeding biology and foraging ecology of the Gentoo Penguin in the Falkland Islands.

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