SOME ASPECTS OF THE BREEDING BIOLOGY OF THE DIVING PETRELS *PELECANOIDES GEORGICUS* AND *P. URINATRIX EXSUL* AT BIRD ISLAND, SOUTH GEORGIA

DANIEL D. ROBY *and* ROBERT E. RICKLEFS

Department of Biology, University of Pennsylvania, Philadelphia, Pennsylvania 19104, USA

ABSTRACT. Aspects of the reproductive biology of the diving petrels *Pelecanoides georgicus* and *P. urinatrix exsul* were studied at Bird Island, South Georgia, during January and February 1982. Average mass of *P. georgicus* adults near the end of the incubation period was 122.6 g ($n = 49$, S.E. = 1.20) and average wing length was 118.3 mm ($n = 49$, S.E. = 0.47). Incubating adults lost 4% of their mass each day. The length of *P. georgicus* eggs increased in direct proportion to width. Average fresh mass of *P. u. exsul* eggs was estimated to be 22.2 g. The estimated median hatching date for *P. u. exsul* (24 December) was 28 days earlier than the median hatching date for *P. georgicus* (22 January). The length of the incubation spell in *P. georgicus* was normally two or three days while the length of the brooding spell was usually one day. Length of the brooding period averaged 6.7 days for *P. georgicus* and was estimated to be 11–12 days for *P. u. exsul*.

The diving petrels (*Pelecanoididae*) are a distinctive, monogeneric family of small petrels (*Procellariiformes*) which are highly convergent upon the small auks (*Charadriiformes*: *Alcidae*) of the Northern Hemisphere (Murphy and Harper, 1921; Storer, 1960; Kuroda, 1967; Warham, 1977). In spite of their abundance as breeders on islands of the southern oceans, their breeding biology has been studied only by Richdale (1943, 1945, 1965) and Thoresen (1969) at New Zealand and by Payne and Prince (1979) at South Georgia. Several aspects of breeding biology are poorly known and there are few comparative data available to assess the degree of variation within and between populations. This note reports some aspects of the breeding biology of the common diving petrel *Pelecanoides urinatrix exsul* and the South Georgia diving petrel *P. georgicus* at South Georgia, during 1982.

METHODS

Work was conducted on Bird Island (54°00′ S, 38°02′ W), located at the western end of South Georgia, during January and February 1982. Nest burrows of *P. u. exsul* were located on Goldcrest Point in the northwestern part of Bird Island (Hunter and others, 1982), on steep, north-facing slopes covered by tussock grass *Poa flabellata* about 50–70 m a.s.l. Nests were interspersed with those of dove prions *Pachyptila desolata* and white-chinned petrels *Procellaria aequinoctialis*. Nest burrows of *P. georgicus* were located at about 110 m a.s.l. on a fine scree slope facing SSW at an angle of 10–20°. The slope was located above the north-central coast of the island just to the west of Gazella Peak in breeding area H (Croxall and Hunter, 1982). Payne and Prince (1979) describe in detail the nesting habitats and burrows of the two species of diving petrel.

Nests of *P. u. exsul* that could be reached easily were marked with flags and visited periodically in the course of other studies. Entrances of burrows of *P. georgicus* were partially excavated and enlarged for easy access, then covered with boards to protect the nests from skuas, and checked daily. Initially, we banded, weighed, and measured adults of *P. georgicus*, but we soon stopped handling adults when it

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became evident that many nests were being abandoned. *P. u. exsul* adults were not handled at their nests.

We used numbered monel bands. The two members of a pair were banded on different legs to enable identification without removing adults from the burrow. Masses were measured to the nearest 1 g with Pesola spring scales (300 g capacity). The straightened wing cord (bend of wrist to tip of longest primary) was measured to the nearest 1 mm with a flexible plastic ruler. Birds were held in the left hand and the wrist of the wing, held parallel to the body, was abutted against the left index finger at the end of the ruler. The end of the wing was held against the ruler with the right thumb and middle finger while the right index finger straightened the wing. Measurements taken in this fashion were repeatable to within 1 mm and did not differ from measurements on the same bird by P. A. Prince using a metal ruler with a right angle stop at the end. We measured the lengths and breadths of eggs to the nearest 0.1 mm with vernier calipers, and weighed eggs brought into the laboratory to the nearest 0.1 g on a triple beam balance.

Results

Measurements of adults

Masses and measurements of adult *P. georgicus* were obtained between 13 January and 17 January, near the end of the incubation period, from 49 adults removed from their burrows during the day, usually mid afternoon (Table I). The average mass, 122.6 g ± 1.20 g S.E., exceeded the value of 117.0 g ± 4.79 g S.E. obtained by Payne and Prince (1979) from five birds on 15 January 1974. Our measurements of wing length (118.3 mm ± 0.47 mm S.E.) were, however, quite similar to Payne and Prince's value of 118.2 mm ± 0.45 mm S.E. obtained on 50 individuals taken from nests throughout the breeding season.

The typical incubation spell of *P. georgicus* is two or three days (see below), and adults must lose mass during this period. We did not reweigh individuals during their incubation spells, but several birds were known to have been banded on the first day of their spell, and others on their last, normally the second or third day (see below). The average mass of the first group (125.3 g ± 1.8 g S.E., $n = 15$) was about 6 g greater than that of the second group (119.6 ± 2.3 g S.E., $n = 8$), which we estimate to have been incubating an average of 1.2 days. This suggests that incubating birds lose approximately 4% of their initial mass each 24 hours, which is similar to the value of 3.4% predicted by Croxall's (1982) equation based upon the regression of mass loss to initial mass in incubating adults of other species of petrels.

Mass and wing length were uncorrelated both in the sample as a whole ($r = 0.10$, $P > 0.05$, $n = 48$) and among individuals banded on the first day of their incubation

Table I. Measurements of adult *P. georgicus*.

	Mass (*g*)	*Wing length* (*mm*)
Sample size	49	57
Mean	122.6	118.28
Standard deviation	8.36	3.514
Standard error of mean	1.20	0.465
Coefficient of variation	6.82	2.97
Range	105–146	111–124

spell ($r = 0.24$, $P > 0.05$, $n = 15$). In addition, there was no correlation between mates either in the length of the wing ($r = 0.36$, $P > 0.05$, $n = 15$) or mass ($r = 0.22$, $P > 0.05$, $n = 13$), indicating an absence of assortative mating based on these characters.

Eggs

Our study on Bird Island commenced after most eggs of *P. u. exsul* had hatched. We obtained information on a few eggs that had been abandoned or were addled. The average dimensions of 8 eggs (Table II) were similar to those of 37 eggs measured by Payne and Prince (1979). These values exclude one egg, taken from under an adult, measuring 31.3 mm × 25.3 mm and having perhaps half the volume of an average egg. There was no development in this unusually small egg although the yolk appeared normally formed. For two unincubated eggs without air cells, evidently abandoned soon after laying, the ratios of the mass to the length times the square of the breadth were 0.554 and 0.550. From these values and the average egg measurements of Payne and Prince (1979), we estimate the average mass of fresh eggs to be 22.2 g.

The average dimensions of 51 eggs of *P. georgicus* (Table II) were similar to those obtained from 32 eggs by Payne and Price (1979). Coefficients of variation ((SD/mean) × 100) were of the order of 4–5% for egg length and the breadth of *P. u. exsul* eggs. The breadths of *P. georgicus* eggs (CV = 2.8% in Payne and Prince (1979) and 3.2% in this study) were significantly less variable than the lengths of the eggs ($F(31, 31) = 2.25$, $P < 0.025$) and the breadths of *P. u. exsul* eggs ($F(36, 32) = 3.6$, $P < 0.001$) (*F*-statistic calculated as the square of the ratio of CVs).

Table II. Measurements of eggs.

	n	$\bar{x}$	*SD*	*SE*	*CV*	*Range*
P. u. exsul[1]						
Length (L, mm)	8	39.9	1.5	0.5	3.9	38.1–43.0
Breadth (B, mm)	8	30.8	1.5	0.5	4.7	28.0–32.8
L/B	8	1.30	0.11	0.04	8.4	1.19–1.54
$LB^2/1000$ (cm^3)	8	37.7	2.87	1.0	7.6	33.7–42.1
P. georgicus						
Length (L, mm)	51	38.4	1.8	0.3	4.7	35.4–43.3
Breadth (B, mm)	51	30.9	1.0	0.1	3.2	28.8–33.5
L/B	51	1.24	0.05	0.01	3.7	1.17–1.36
$LB^2/1000$ (cm^3)	51	36.8	3.74	0.5	10.2	29.4–46.7

[1] Excluding one egg 31.3 × 25.3 mm.

In *P. georgicus*, lengths and breadths of eggs were positively correlated ($r = 0.62$, $P < 0.0001$). The slope of the relationship between length and breadth was 0.35 mm mm^{-1} ± 0.06 S.E. When plotted on logarithmic coordinates, the correlation between length and breadth was $r = 0.62$ ($P < 0.0001$). The slope of the relationship (0.88 ± 0.16 S.E.) did not differ from 1.0, therefore indicating that length increases in direct proportion to breadth.

Incubation spells

Our information on the length of incubation spells pertains only to *P. georgicus* and was obtained close to the end of the incubation period. We were able to determine the length of incubation spell in 16 cases in which our daily visits revealed

the nights during which adults exchanged at the beginning and end of the spell. Eleven of these were of 2 d, four were of 3 d and one was of 1 d. In many other cases we knew the night of changeover only at the beginning or end of the spell, hence the observed length was a minimum. Ten of these were of 1 d, 17 of 2 d and eight of 3 d. Two records of 4 d occurred in nests where one of the parents had disappeared. Apparently, the incubation spell is flexible and may be determined by the period the other adult remains away from the nest. For *P. georgicus* the normal incubation spell appears to be 2 or 3 d, with the first being about twice as frequent as the second. Richdale (1965) observed in *P. u. chathamensis* in New Zealand that incubating birds exchanged nightly without exception (18 nest nights at three nests).

Brooding spells

Observed lengths of brooding spells were 14 of 1 d and two of 2 d. One of the latter included the last day of the brooding period. Daily records for four nests starting on 15 January were as follows (R = band on right leg, L = band on left leg, A = undetermined adult, H = chick alone): nest 13 (hatched 15–16 January), RLRLAARL-A; nest 26 (hatched 14–15 January), LRLALRHH. . .; nest 29 (hatched 15–16 January), LRLRLRRHH. . .; nest 32 (hatched 14–15 January), LRLRLRHH. . . These observations suggest that the usual length of the brooding spell in *P. georgicus* is 1 d, as it is in *P. u. chathamensis* (Richdale, 1965).

Length of the brooding period

We observed the hatching dates of few *P. u. exsul* chicks and therefore had to estimate age from the relationship between wing length and age presented by Payne and Prince (1979). Where we knew the true age of a chick, this generally corresponded closely to age estimated from wing length. Table III summarizes the wing lengths and estimated ages of chicks separated according to whether they were brooded by adults or not during our nest checks. In nine instances for chicks less than 11 d old (day of hatching = 0), all were brooded. Few were brooded after 12 d, and about half (four out of nine) of chicks 11–12 days old were unattended. These observations indicate that the brooding period is about 11–12 days in *P. u. exsul*. Richdale (1965) found that chicks of *P. u. chathamensis* were first left unguarded at between six and 13 days of age, with an average of 9.8 days for 18 nests, although many chicks are sometimes guarded again at some later time. Thorensen (1969) stated that the length of the brooding period in *P. u. urinatrix* in New Zealand is 10–15 days but gave no details.

Table III. Wing lengths and estimated ages of *P. urinatrix* chicks attended and unattended by adults.

Wing length (mm)	*Estimated age (days)*	*Number of instances*	
		Attended	*Unattended*
14–16	0–2	4	0
17–19	4–7	2	0
20–22	8–10	3	0
23–25	11–12	5	4
26–28	13–14	2	7
29–31	15–16	1	8
32–34	17	1	7
35–37	18	0	3
38–40	19	1	4

Table IV. Length of the brooding period in *P. georgicus*.

	Age of chick (days)							
	0–4	*5*	*6*	*7*	*8*	*9*	*10*	*11*
Sample size	30	30	27	27	26	26	23	22
Percent of chicks brooded	100	93	67	33	23	15	4	0
Percent of chicks not brooded for first time	0	7	34	30	18	4	0	0
Percent of parents not brooding for first time ($n = 51$)	0	4	20	24	24	12	10	8

Brooding periods of *P. georgicus* at Bird Island were determined by daily observations of nests (Table IV). Two-thirds of the chicks were unbrooded on day 7 of the nestling period (day of hatching = 0). In 11 of 25 nests, chicks were attended after their first day alone. With two exceptions, these instances followed only one day without brooding, suggesting that one of the adults attended the chick 3 d longer than the other. On the assumption of daily exchanges at the nest during the brooding period, we were able to tabulate the age of the chick at which each individual parent no longer brooded, also presented in Table IV. The average age at which chicks were unbrooded for the first time was 6.7 days. It appears that the brooding period of *P. georgicus* is about 5 days shorter than that of *P. u. exsul* on Bird Island.

Date of hatching

Estimated and observed hatching dates of *P. u. exsul* and observed hatching dates of *P. georgicus* are portrayed in Figure 1. For *P. u. exsul*, the range of dates for 68 nests was 8 December to 27 January, with the bulk of hatching occurring prior to January 1. The median date was 24 December. Hatching dates at 18 nests observed by Payne and Prince (1979) ranged between 14 December and 31 December, with an average of 18.4 December. In our sample only about one-quarter of all nests had hatched by 18 December, indicating a somewhat later season than that observed by Payne and Prince. Richdale (1965) noted a spread of mean hatching dates over 6 seasons between 25.7 November (1940–41) and 9.4 December (1944–45) in *P. u. chathamensis*. The fact that eggs in four nests hatched more than one month after the beginning of the hatching period and more than two weeks after 90% of the eggs had hatched, suggests the possibility that *P. u. exsul* may be able to relay if an egg is lost early in the incubation period.

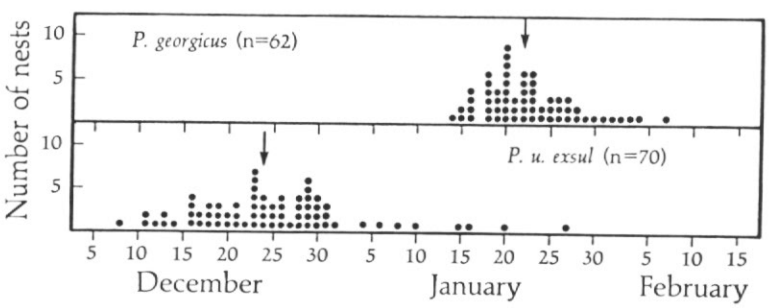

Fig. 1. Observed and estimated hatching dates of *P. u. exsul* and *P. georgicus* during the 1981–82 breeding season. Median dates are indicated by arrows.

Eggs of *P. georgicus* hatched between 14 January and 7 February, with a median date of 22 January ($n = 62$). Payne and Prince (1979) reported a range of 4–30 January for 20 nests, with an average of 28.5 January (?).

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