

THE DISTRIBUTION AND ABUNDANCE OF BURROWING SEABIRDS  
(PROCELLARIIFORMES) AT BIRD ISLAND, SOUTH GEORGIA:  
II. SOUTH GEORGIA DIVING PETREL *Pelecanoides georgicus*

By J. P. CROXALL and I. HUNTER

**ABSTRACT.** A census of the breeding population of the South Georgia diving petrel at Bird Island, South Georgia, was made in January 1980. As all breeding areas are in open scree or moss habitats, all 6 325 burrows could be counted directly. A sample of 228 burrows (177 in scree, 51 in moss) was investigated in detail. In scree, 9% of burrows were incomplete, 61% had eggs or chicks and an original breeding population of c. 4 900 pairs was calculated. Only 14% of burrows were in moss; 18% of these were incomplete, only 29% had eggs or chicks and an original breeding population of c. 500 pairs was estimated. The total South Georgia breeding population might be about two million pairs.

THE South Georgia diving petrel *Pelecanoides georgicus* (Fig. 1a) breeds at most sub-Antarctic islands (see Payne and Prince, 1979) and also off Stewart Island, New Zealand (Imber and Nilsson, 1980). Throughout its range it breeds in fine scree or open stony or sandy ground with little or no vegetation cover. This makes it potentially easy to census more accurately than other species of burrowing petrels.

As part of research investigating the distribution and abundance of burrowing petrels at Bird Island (Hunter and others, 1982), this paper reports an attempt to census the breeding population of *P. georgicus*. Breeding is confined to fine screes and their moss-covered fringes on south-facing slopes between 150 and 250 m a.s.l. (Fig. 1b). Except for a few dove prions *Pachyptila desolata* in moss at the edges of screes, no other species breeds in such sites.

#### METHODS

All burrows could be counted directly, and their contents were examined as described by Hunter and others (1982).

The scree banks on Bird Island are easily delimited discrete areas in which burrows could be counted and sampled separately. In each of 16 areas all burrow entrances were counted, and in 15 areas a small, randomly-selected, sample of burrows was investigated in detail. The status of the burrow was recorded in one of the following categories:

- 1 Burrow incomplete, lacking chamber.
- 2 Burrow complete with chamber—(a) empty, (b) egg present, (c) chick present.

The results from this sample were used to estimate the number of complete and occupied burrows in each area as a whole.

Burrows in pure scree and in the areas around their edges with extensive growth of moss (and sometimes other plants) were counted and sampled separately. The boundaries of both types of habitat were marked on large-scale maps, and the area of each habitat later determined planimetrically. The main angle of slope and principal aspect of each area was also recorded.

The survey was undertaken between 24 and 29 January 1980, well after the latest egg-laying date recorded at Bird Island (31 December; Payne and Prince, 1979), ensuring that any incomplete burrows were certainly not going to be used that season. The dates were close to the mean hatching date of 28.5 January  $\pm$  11 days (Payne and Prince, 1979), and thus avoided disturbing birds during early incubation when they are especially sensitive to interference.

#### RESULTS

The location of *P. georgicus* breeding areas on Bird Island is shown in Fig. 2. The average slope of these colonies ranged from 0° (flat) to 46°, with a mean value of 22°. Burrow aspects were between east and north-west and burrow dimensions resembled those illustrated by Derenne and Mougin (1976).



a



b

Fig. 1a. Adult *P. georgicus* removed from burrow.  
b. Typical breeding habitat of *P. georgicus* on Bird Island.

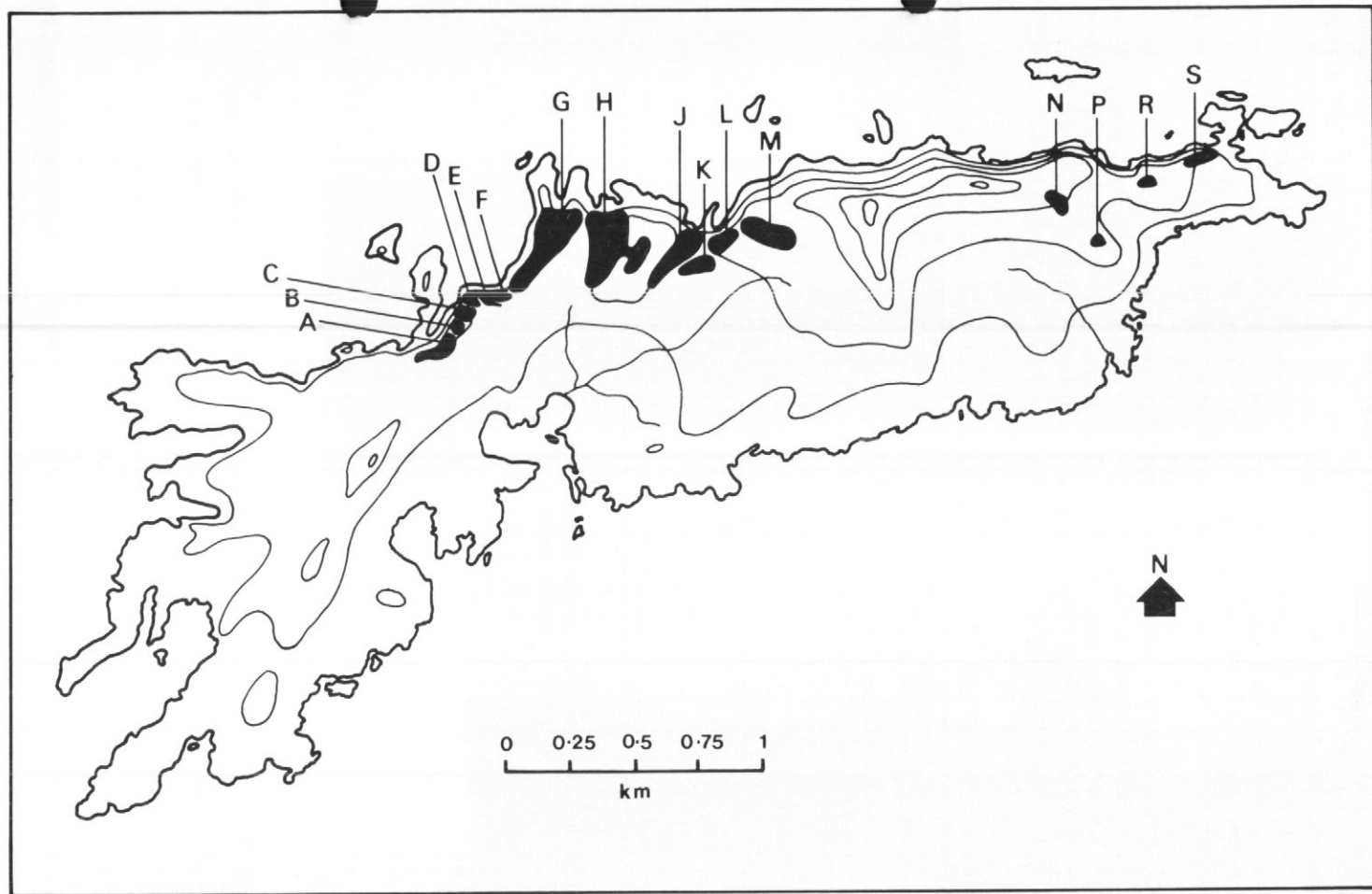


Fig. 2. Breeding distribution of *P. georgicus* at Bird Island. Contour interval 200 feet.

The results of the survey of scree habitats (Table I) and moss habitats (Table II) include details of the status of all 228 burrows examined. Only one chamber was associated with a single entrance and thus each entrance represented the breeding site of a single pair. Variation between areas, even within each habitat type, was substantial (Table III) so the number of occupied burrows was estimated for each area separately. A second estimate was obtained by combining all data and then estimating the overall level of burrow occupancy. The two estimates are closely similar, the former being 5% greater than the latter for scree habitats and 6% less for moss habitats.

Of 5408 burrows in pure scree habitats about 9% were estimated to be incompletely excavated. Of complete burrows an estimated 70% were occupied by birds for breeding. There were only 917 burrows in the mossy areas bordering scree, and nearly 18% of these were inadequately excavated. Of the remainder, only an estimated 35% were occupied by breeding birds, and this is a significantly lower ( $\chi^2$  test,  $P < 0.01$ ) than the 70% occupancy in scree habitats.

TABLE I. NUMBER AND STATUS OF BURROWS OF *P. georgicus* IN EACH BREEDING AREA IN SCREE

Burrow status	Breeding area															Total
	A	B	C	D	F	G	H	J	K	L	M	N	P	R	S	
Number of entrances	102	117	420	511	354	677	837	852	304	452	540	106	28	56	52	5408
Number of burrows examined	6	4	17	14	13	20	26	11	11	18	17	8	4	3	5	177
Number incompletely excavated	0	0	1	4	1	3	4	0	0	1	2	0	0	0	0	16
Number empty	5	3	8	1	5	4	6	2	2	4	5	3	2	1	2	53
Number with egg	0	1	6	8	6	12	14	9	9	13	10	2	0	1	1	92
Number with chick	1	0	2	1	1	1	2	0	0	0	0	3	2	1	2	16
Total number occupied	1	1	8	9	7	13	16	9	9	13	10	5	2	2	3	108
Estimated number occupied in area	17	29	198	329	191	440	515	697	249	326	318	66	14	37	31	3457

TABLE II. NUMBER AND STATUS OF BURROWS OF *P. georgicus* IN EACH BREEDING AREA IN MOSS

Burrow status	Breeding area							Total
	D	E	G	H	K	L	M	
Number of entrances	56	57	249	103	217	86	149	917
Number of burrows examined	11	0	9	9	22	0	0	51
Number incompletely excavated	4	0	2	3	0	0	0	9
Number empty	3	0	5	4	15	0	0	27
Number with egg	4	0	2	1	7	0	0	14
Number with chick	0	0	0	1	0	0	0	1
Total number occupied	4	0	2	2	7	0	0	15
Estimated number occupied in area	20	17	55	23	69	25	44	253

TABLE III. PROPORTION OF COMPLETE AND OCCUPIED BURROWS OF *P. georgicus* IN SCREE AND MOSS HABITATS AT BIRD ISLAND

Habitat	No. of samples	Status	Burrow numbers		
			Mean	S.D.	Range
Scree	177	% Complete	94.0	8.5	71.4-100
		% Occupied	57.8	18.0	16.7- 81.8
Moss	51	% Complete	77.0	16.5	63.6-100
		% Occupied	28.2	7.1	22.2- 31.8

## DISCUSSION

The total breeding population of *P. georgicus* at Bird Island, cannot exceed 6 325 pairs, the total number of burrow entrances, or be less than 3 570 pairs (Table IV), the number of burrows used for breeding at the time of the survey. However, the original breeding population will have been greater than the minimum by the number of birds that failed between egg-laying and the date of the survey.

TABLE IV. NUMBER AND STATUS OF BURROWS OF *P. georgicus* IN SCREE AND MOSS HABITATS ON BIRD ISLAND

Habitat	Total number	Burrows						
		Complete		Occupied		Maximum failed		
		No.	%	No.	% of complete	% of total	No.	% of complete
Scree <sup>1</sup>	5 408	4 919	91.0	3 300	67.1	61.0	1 619	32.9
Scree <sup>2</sup>	5 408	4 890	90.4	3 457	70.7	63.9	1 433	29.3
Moss <sup>1</sup>	917	755	82.3	270	35.7	29.4	485	64.3
Moss <sup>2</sup>	917			253		27.6		

1. Combining data from all areas
2. Treating each area separately before combining data

If our estimates of the number of complete burrows suitable for breeding are realistic and we assume that all these were originally occupied by breeding birds, then in scree habitats about 29–33% of birds had failed by the census date (Table IV). This is a reasonable figure (see Mougín, 1975), and we may conclude that the original breeding population in this habitat was c. 4 900 pairs.

A similar calculation for moss habitats, however, indicates that about 64% of birds would have had to fail during incubation (Table IV). Moss is clearly not the preferred habitat of *P. georgicus* at Bird Island. Only 14% of entrances are located there and, compared with scree, twice as many burrows are incompletely excavated. It is not impossible that mossy areas are mainly used by inexperienced birds, which might sustain appreciably greater egg losses. The original breeding population in this habitat was probably about 500 pairs and therefore the total island breeding population is about 5 400 pairs.

It is not clear why the mossy fringes of scree should be less suitable for breeding than pure scree, where burrows are likely to collapse during the winter and need re-excavation. Burrows in moss are more stable as a consequence of the better support given by the presence of plant fibre and humus. Such burrows are, however, much more easily waterlogged, and the freer drainage in fine scree may be an important feature influencing the selection of breeding habitat by *P. georgicus*.

There is plenty of scree habitat still available for *P. georgicus* at Bird Island, as suitable screes cover about 200 000 m<sup>2</sup>. If the 5 400 burrows were evenly distributed, this would represent 0.026 burrows m<sup>-2</sup>, whereas in favoured areas the density actually reached 2–3 burrows m<sup>-2</sup> and averaged about 0.25 burrows m<sup>-2</sup>. This is close to the values from 0.08 to 0.26 burrows m<sup>-2</sup> recorded by Derenne and Mougín (1976) at Ile aux Cochons, Iles Crozet. Using these values, and an estimate of 1 500 hectares available habitat, they assessed the population of the island as about two million pairs. It is possible, however, that the burrow densities used were only for areas where burrows occur and not averaged over all available habitat. If so, the population would be of the order of 200 000 pairs.

Although only a small number of colonies have been specifically reported from the South Georgia mainland, the species is widespread there in suitable habitat (Prince and Payne, 1979). We can very roughly estimate the extent of such habitat as follows. The island is 4 144 km<sup>2</sup> in area, 52% of this is covered with ice and half the remainder is rock (Smith, 1960). On Bird Island fine scree, suitable for *P. georgicus*, forms 9.2% of the remaining habitats (Hunter and others,

1982). If a similar relationship prevails on the mainland, the area covered by fine scree there would be about 80 km<sup>2</sup>. With a mean density of 0.026 burrows m<sup>-2</sup> such an area would contain a breeding population of about two million pairs.

## ACKNOWLEDGEMENTS

We wish to thank M. P. Harris for helpful comments on the manuscript.

*MS received 26 January 1982; accepted in revised form 24 February 1982*

## REFERENCES

- DERENNE, P. and J-L. MOUGIN. 1976. Les procellariiformes à nidification hypogée de l'île aux Cochons (Archipel Crozet, 46°06'S, 50°14'E). *Comité National Français des Recherches Antarctiques*, **40**, 149-75.
- HUNTER, I., CROXALL, J. P. and P. A. PRINCE. 1982. The distribution and abundance of burrowing seabirds (Procellariiformes) at Bird Island, South Georgia: I. Introduction and methods. *British Antarctic Survey Bulletin*, No. 56 49-67.
- IMBER, M. J. and R. J. NILSSON. 1980. South Georgia diving petrels breeding on Codfish Island. *Notornis*, **27**, 325-30.
- MOUGIN, J-L. 1975. Ecologie comparée des Procellariidae Antarctiques et Subantarctiques. *Comité National Français des Recherches Antarctiques*, **36**, 1-195.
- PAYNE, M. R. and P. A. PRINCE. 1979. Identification and breeding biology of the diving petrels *Pelecanoides georgicus* and *P. urinatrix exsul* at South Georgia. *New Zealand Journal of Zoology*, **6**, 299-318.
- PRINCE, P. A. and M. R. PAYNE. 1979. Current status of birds at South Georgia. *British Antarctic Survey Bulletin*, No. 48, 103-18.
- SMITH, J. 1960. Glacier problems in South Georgia. *Journal of Glaciology*, **3**, 707-14.