

# MORPHOLOGY OF PRIONS *PACHYPTILA* AND DIVING PETRELS *PELECANOIDES*

## AT HEARD ISLAND

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### SUMMARY

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Morphological data were collected from 40 Antarctic Prions *Pachyptila desolata* and 25 Fulmar Prions *P. crassirostris*, 40 South Georgian Diving Petrels *Pelecanoides georgicus* and 25 Common Diving Petrels *P. urinatrix* caught at sub-Antarctic Heard Island. Antarctic Prions at Heard Island were similar morphologically to those at Signy Island, but there was considerable overlap between populations. Fulmar Prions are believed to be sexually dimorphic, consistent with populations at other breeding localities. Common Diving Petrels may also be sexually dimorphic but South Georgian Diving Petrels are not. The sole criterion that reliably separated the two species of diving petrel was the colouration of the tarsus.

### INTRODUCTION

Morphological data collected from breeding birds at their breeding colonies are fundamental to determining the taxonomic status of individual populations, and assessing the degree of geographic variation present between breeding populations. The taxonomy of prions *Pachyptila* spp. is confused (Murphy 1936, Harper 1980), due partly to the use of beach-washed material of unknown origin, and partly to the small collections available in museums. The lack of statistically valid samples of morphological data from breeding adults at colonies, other than at a subset of known breeding localities (Tickell 1962, Brothers 1984, Jouventin *et al.* 1985), has hindered the taxonomic clarification of these morphologically similar birds. Some authors accept only three species (Cox 1979); others recognize at least four (Bretagnolle *et al.* 1990), or six (Harper 1980). The status of

subspecies is even more confused (Cox 1979, Harper 1980). The taxonomy of diving petrels *Pelecanoides* spp. is less confused. At present, four species are recognized; three are monotypic and the fourth species may have between one and four subspecies (Bourne 1968, Payne & Prince 1979, Norman & Brown 1987).

In this study, standard morphological data were collected from two species of prion (Antarctic *P. desolata* and Fulmar *P. crassirostris*) and two species of diving petrel (Common *P. urinatrix* and South Georgian *P. georgicus*) at Heard Island. These are the only species of burrowing petrel that breed at Heard Island (Downes *et al.* 1959), and few morphological data have been collected previously from these species at this locality. The Heard Island data provide reference material to compare with similar data collected at other breeding sites.

## METHODS

Breeding adults of three species (Antarctic Prion and both species of diving petrel) were captured as they returned to breeding burrows at various localities around the northwest of Heard Island (53 05S, 73 30E). Antarctic Prions and Common Diving Petrels were captured on the northeast slopes of Mt Aubert de la Rue, to the southwest of Atlas Cove, between 18 November 1987 and 21 February 1988. South Georgian Diving Petrels were captured on the Nullabor Plain approximately 500 m to the east of the Australian National Antarctic Research Expeditions' (ANARE) station at Atlas Cove between 5 and 11 November 1987. Fulmar Prions were captured within the ANARE station on the evening of 20 February 1988, when a high number of birds landed around the station buildings during a thick fog, having been attracted to the lights of the station. Spotlights were used to immobilize birds on the ground, and were also used to bring birds down from the air by locating them in the intersection of two beams.

The morphological data (and their abbreviations) collected were: bill width at base (BWB), bill width at unguis (BWU), bill depth at base (BDB), bill depth anterior to nares (BDN), bill depth at unguis (BDU), bill length from base (=culmen length, BLB), total head length (THL), tarsus excluding tibia (Tars1), tarsus including tibia, (Tars2), middle claw (M Claw), wing length (Wing L) and tail length (Tail L). In addition, moult stages of primaries and tail feathers were determined. Descriptions of these measurements can be found in Cox (1979) and Brothers (1984).

Masses were measured to the nearest 1 g; wing and tail lengths to the nearest 1 mm; all other measurements were taken to the nearest 0.1 mm. BDU was not measured on diving petrels because the measure was not repeatable. The mass, claw, wing and tail data were excluded from the cluster analyses (see below), because mass varies on a daily basis, claw lengths decrease during the season due to abrasion caused by burrowing, and moult and

abrasion alter wing and tail feather lengths. Birds were banded with monel bands prior to release to avoid duplication in measurements. No birds were collected, and therefore the sex of individuals was not determined directly.

The morphological data were subjected to hierarchical cluster analyses to describe the similarities between individuals and between breeding localities. The euclidean distances between data generated dendrograms based on the unweighted pairs group averaging linkage, UPGMA (Field *et al.* 1982, Pielou 1984). All analyses were made using applications in the BIostat package (Pimentel & Smith 1985).

## RESULTS

The morphological data collected are presented in Table 1. Since sex was not determined, the data were pooled for analyses and presentation.

### Antarctic Prion

The morphological data collected in this study did not show bimodality that would suggest sexual dimorphism, in agreement with Tickell (1962) who showed that morphological data from male and female Antarctic Prions at Signy Island were not significantly different. The cluster analysis (excluding wing, tail and claw data) also failed to separate the 40 birds measured into two dimorphic groups, and in fact divided the data into five clusters. The differences in measurements between clusters were not significant, except for THL, indicating that this measurement may exhibit some sexual dimorphism. There was considerable overlap in all other measurements obtained, and the differences between clusters did not show any consistent differences or trends, except THL. These findings suggest that Heard Island Antarctic Prions are similar to those at Signy Island, in that they are also not sexually dimorphic in their morphology.

Two Antarctic Prions were moulting their

TABLE 1

MORPHOLOGICAL DATA (IN G AND MM) FROM PRIONS AND DIVING PETRELS AT HEARD ISLAND.  
THE ABBREVIATIONS USED ARE DESCRIBED IN THE TEXT

Mass	BWB	BWU	BDB	BDN	BDU	BLB	THL	Tars1	Tars2	MClaw	Wing L	Tail L	
Antarctic Prion, n = 40													
Mean	158.7	14.74	3.25	13.37	9.74	8.14	28.60	64.20	33.29	36.81	7.92	192.7	93.1
SD	15.16	0.67	0.43	0.70	0.51	0.34	0.90	1.54	1.37	1.16	0.69	4.68	4.82
Min	130	13.3	2.5	12.2	8.4	7.4	27.0	60.4	29.7	34.1	6.2	182	77
Max	193	16.4	4.2	14.9	10.7	8.8	30.1	66.8	36.1	39.4	9.1	204	103
Fulmar Prion, n = 25													
Mean	125.8	10.18	4.65	9.77	7.08	7.04	22.08	55.19	33.26	36.02	7.55	174.0	87.3
SD	10.07	0.61	0.27	0.42	0.45	0.35	0.84	2.23	1.08	1.30	0.74	6.69	4.53
Min	102	9.1	3.9	9.0	6.3	6.3	20.8	49.4	31.0	33.1	6.0	156	76
Max	144	11.4	5.0	10.8	8.1	7.6	23.5	59.6	35.2	38.0	9.3	184	97
Common Diving Petrel, n = 25													
Mean	153.9	8.87	3.05	9.45	7.08	16.23	50.89	25.83	29.14	6.94	123.4	39.0	
SD	10.26	0.52	0.29	0.56	0.39	0.82	1.70	1.17	1.24	0.83	3.91	1.78	
Min	136	7.9	2.1	8.4	6.4	14.3	47.8	22.5	25.2	4.6	115	35	
Max	168	10.0	3.5	10.7	8.0	18.2	53.8	28.3	31.4	8.2	131	41	
South Georgian Diving Petrel, n = 40													
Mean	117.9	8.53	2.76	8.37	6.26	15.09	48.92	23.60	26.25	8.60	115.1	37.4	
SD	7.34	0.37	0.22	0.54	0.40	0.91	1.24	1.26	1.18	0.72	3.73	1.81	
Min	104	7.6	2.1	7.4	5.3	13.1	46.6	20.7	23.9	7.2	108	34	
Max	130	9.2	3.1	9.7	7.2	17.4	51.6	27.0	29.1	10.3	124	41	

primaries, one handled in mid-December, and the other in early February; all others had unworn primaries. All birds had 12 tail feathers, and no birds were observed moulting any of their tail feathers. Tickell (1962) reported no moult in either primary or tail feathers while the birds were ashore, and Harper (1972) recorded new plumages on Antarctic Prions in mid-September, and tail moults in early March.

Three previous data sets have been published from Heard Island Antarctic Prions. Falla (1937) showed that female wing and tail lengths were longer than those of males, but this could be a reflection of moult stage and abrasion. The tarsal, BLB and BWB data showed no sexual dimorphism. Tickell (1962) presented combined data from live and dead birds. The other data set, reported in Harper (1980), was also not comparable with the present study, because the data were collected from museum material that had shrunk between one and 13% through drying.

A comparison with data collected at other breeding localities (Table 2) shows that Heard Island Antarctic Prions are most similar to the île de l'Est, îles Crozet population in their morphologies (Fig. 1a). Antarctic Prions from Macquarie Island

and îles Crozet were similar, but the Signy Island population was morphologically distinct to the other four populations.

#### Fulmar Prion

There have been no previously published data collected from live Heard Island Fulmar Prions. Falla (1937) presented data from recently-killed birds ( $n=5$ ); the absence of internal organs prevented them from being sexed.

The cluster analysis separated the data into three clusters of nine, 14 and two individuals. The cluster of 14 birds was larger in eight of nine measurements (BWB, BDB, BDU, BLB, THL and both Tarsus measures), but smaller in BWU, than the cluster of nine birds. Of these measurements, only BLB ( $t=2.219$ ,  $P=0.038$ ), THL ( $t=6.639$ ,  $P<0.001$ ), Tars1 and Tars2 ( $t=2.602$ ,  $P=0.017$  and  $t=4.173$ ,  $P<0.001$ , respectively) were significantly different between the two clusters. Fulmar Prions have been shown to be sexually dimorphic, with males larger than females (Harper 1980), and therefore these two clusters (of 14 and nine) have been assumed to be female and male birds respectively (Table 3). Based on this assumption, male Fulmar Prions at Heard Island may have

TABLE 2  
MORPHOLOGICAL DATA (MEANS, IN MM) FROM ANTARCTIC PRIONS AT FIVE BREEDING LOCALITIES

Locality	BWB	BLB	Tars1	Wing L	Tail L	Source
Heard Island	14.7	28.6	33.3	192.7	93.1	This study
Macquarie Island	14.4	27.4	33.3	189.1	84.4	Brothers (1984)
îles Crozet	14.4	27.6	30.5	190	95	Mougin (1975)
île de l'Est, îles Crozet	13.9	27.7	34.2	185	-	Jouventin <i>et al.</i> (1985)
Signy Island	14.7	27.9	32.3	192.5	101.5	Tickell (1962)

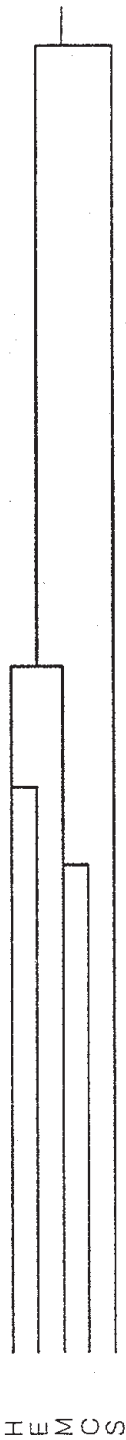


Figure 1a

Dendrogram based on morphological data (BWB, BLB and Tars1) of Antarctic Prions from Heard Island (H), île de l'Est, îles Crozet (E), Macquarie Island (M), îles Crozet (C) and Signy Island (S) (Table 2).

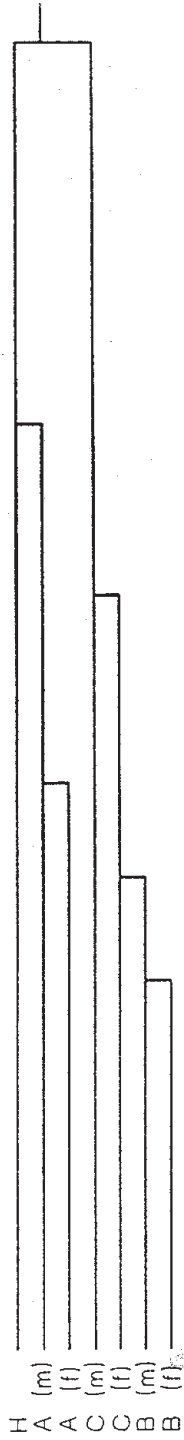


Figure 1b

Dendrogram based on morphological data (BWB, BWU and Tars1) of Fulmar Prions from Heard Island (H), the Auckland Islands (A), the Chatham Islands (C) and the Bounty Islands (B). Sex-specific data are used for all localities except Heard Island (Table 4).

TABLE 3

## MORPHOLOGICAL DATA (IN MM) FROM PRESUMED MALE AND FEMALE FULMAR PRIONS AT HEARD ISLAND

Sex	Statistic	BWB	BWU	BDB	BDN	BDU	BLB	THL	Tars1	Tars2
Female (n=9)	mean	10.09	4.72	9.64	6.96	6.93	21.58	53.51	32.51	34.86
	SD	0.62	0.20	0.47	0.53	0.36	0.64	1.18	0.99	1.33
	min	9.1	4.4	9.0	6.3	6.3	20.8	52.0	31.0	33.1
	max	10.9	4.9	10.5	8.1	7.5	22.6	55.2	33.9	36.7
Male (n=14)	mean	10.17	4.59	9.81	7.08	7.04	22.29	56.37	33.55	36.57
	SD	0.56	0.31	0.41	0.35	0.33	0.82	0.89	0.90	0.63
	min	9.3	3.9	9.2	6.6	6.6	20.9	54.4	31.9	35.1
	max	11.3	5.0	10.8	7.6	7.6	23.2	57.5	35.2	37.5

significantly longer bills, tarses and heads than females. In the absence of confirmation of sex, pooled data have been used for comparison with other breeding localities. The third cluster of two birds had measurements that were larger than any other birds for BWB, and large tarsal measures.

All Fulmar Prions handled had new primaries; and only one bird was found to be moulting any of its tail feathers: one bird had a worn outermost tail feather.

Morphological data from other breeding localities (Table 4), suggest that Heard Island Fulmar Prions are most similar to those at the Auckland Islands, based on bill morphology. The similarities then decreased with birds from the Chatham and Auckland Islands (Fig. 1b). However, there is considerable overlap between the populations at Heard Island and those in the New Zealand region (Table 4).

#### Common Diving Petrel

Cluster analysis divided the Heard Island data into four groups. Two of these clusters (of three and one individuals) had measurements that suggested

an error may have taken place in measurement or transcription. However, the other two clusters (of 14 and seven), were significantly different in THL ( $t=6.432$ ,  $P<0.001$ ), BWB ( $t=4.507$ ,  $P<0.001$ ), and to a lesser degree, Tars1 ( $t=2.167$ ,  $P=0.043$ ). These may indicate small, but significant, differences between males and females. Payne & Prince (1979) found no significant differences between measurements of male and female Common Diving Petrels at Bird Island, including BWB, but to date THL data have only been collected by Norman & Brown (1987), who found that beach-washed birds exhibited sexual dimorphism. Pooled data have been used for comparison with other breeding localities (Table 5 & Fig. 2).

No Common Diving Petrels were in primary moult, but one bird on 18 November 1987 was found to be moulting six of its 12 tail feathers.

When the data from this study are compared to those collected from birds at other breeding localities, Heard Island Common Diving Petrels are more similar to those breeding at Îles Kerguelen, Îles Crozet, Marion Island and South Georgia than those at Macquarie Island or Gough Island (Fig. 2).

TABLE 4

## MORPHOLOGICAL DATA (MEANS, IN MM) FROM FULMAR PRIONS AT FOUR BREEDING LOCALITIES

Locality	BWB	BWU	BLB	Wing L	Tail L	Source
Heard Island	10.2	4.7	22.1	174.0	87.3	This study
Chatham Islands						
males	12.7	5.5	23.5	192.9	97.7	Harper (1980)
females	12.2	5.3	22.5	192.6	97.7	Harper (1980)
Bounty Islands						
males	11.4	5.0	22.9	185.8	88.9	Harper (1980)
females	11.4	4.9	22.2	184.8	90.7	Harper (1980)
Auckland Islands						
males	10.7	5.1	20.8	180.0	91.2	Harper (1980)
females	10.2	4.8	19.8	179.5	91.3	Harper (1980)

It was not possible to generate a dendrogram based on morphological data because there were insufficient data available when wing and tail lengths were excluded. The only previous data

from Heard Island, that for two birds, were presented by Falla (1937).

TABLE 5

## MORPHOLOGICAL DATA (MEANS, IN MM) FROM COMMON DIVING PETRELS AT SEVEN BREEDING LOCALITIES

Locality	BLB	Tars 1	Wing L	Tail L	Source
Heard Island	16.2	25.8	123.4	39.0	This study
îles Kerguelen	16.2	25.4	123.0	40.4	Payne & Prince (1979)
îles Kerguelen	16.3	26.2	121	39.1	Bourne (1968)
îles Crozet & Marion Island	16.1	26.3	119	38.5	Bourne (1968)
îles Crozet	16.4	26.8	122	-	Jouventin <i>et al.</i> (1985)
Macquarie Island	16.9	25.5	125.0	40.0	Brothers (1984)
South Georgia	16.0	25.8	120	38.9	Bourne (1968)
South Georgia	16.3	26.8	124.1	40.2	Payne & Prince (1979)
Gough Island	15.7	21.2	117	38.9	Bourne (1968)
Auckland Islands	16.0	27.5	122.5	41.0	Bourne (1968)

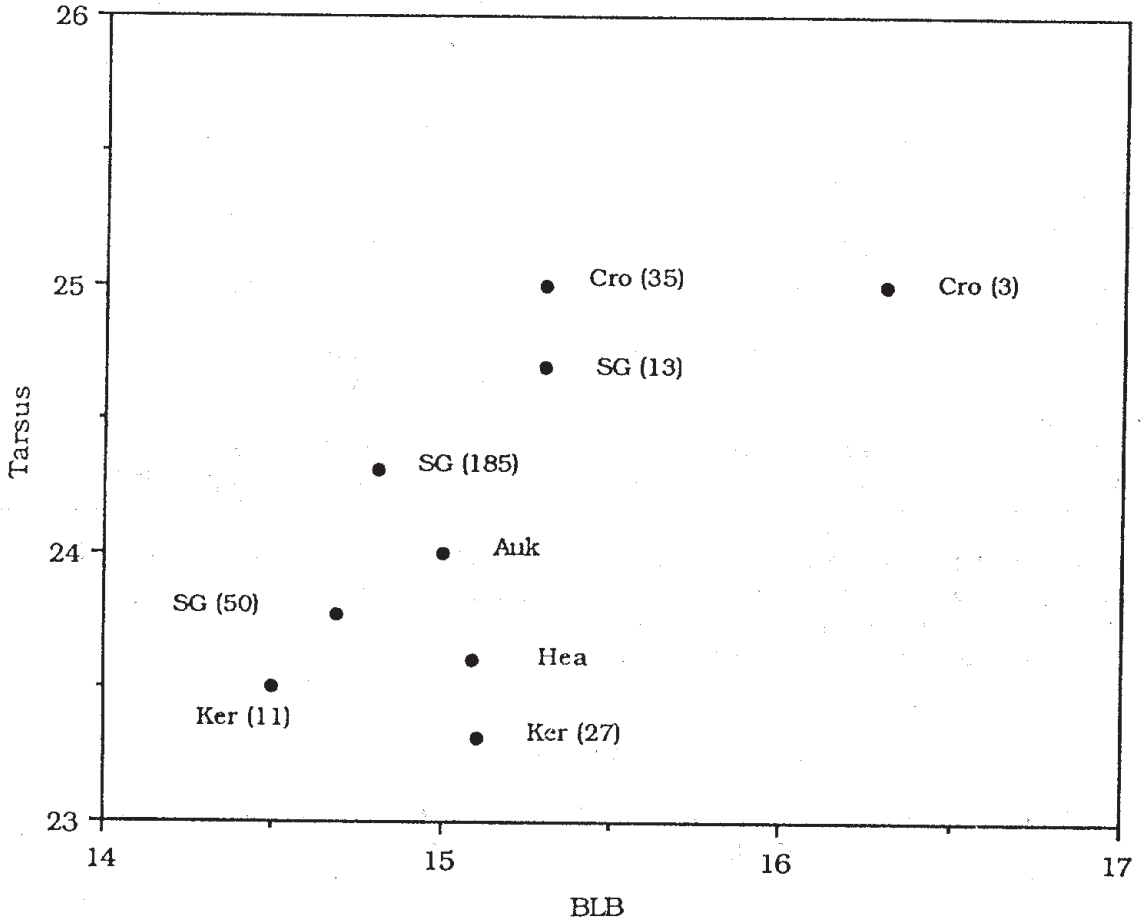


Figure 2

Plot of BLB and Tarsus (Tars1) data of Common Diving Petrels from Heard Island (Hea), îles Kerguelen (Ker), pooled îles Crozet and Marion Island (Cro/Mar), îles Crozet (Cro), Macquarie Island (Mac), South Georgia (SG), Gough Island (Gou) and the Auckland Islands (Auk). Numbers represent sample sizes (Table 5).



### South Georgian Diving Petrel

The cluster analysis divided the 40 birds into three clusters of 11, 24 and five. Differences between these two large clusters were significant only for Tars1 ( $t=6.648$ ,  $P<0.001$ ), and Tars2 ( $t=3.504$ ,  $P=0.001$ ), as there was considerable overlap in bill measurements. The third cluster consisted of five birds whose BLB, THL or Tars2 measurements were larger than those in the other two clusters.

No South Georgian Diving Petrels were in primary moult. Three of five birds that were found with 14 tail feathers were in tail moult. Two birds were found with 10 tail feathers and all other birds ( $n=33$ ) were found with 12. Over one third ( $n=12$ ) of these birds showed some moult of tail feathers, involving only one or two feathers. These birds were all completing a tail moult prior to the breeding season, as they were arriving at the breeding grounds in early November with new tail feathers.

It was not possible to generate a dendrogram based on morphological data because there were insufficient data available when wing and tail lengths were excluded. However, based on the

available morphological data (Table 6), South Georgian Diving Petrels at Heard Island are more similar to those at îles Kerguelen, and less so to those at South Georgia, the Auckland Islands and îles Crozet (Fig. 3). The only previous data from Heard Island, that for two birds, were presented by Falla (1937).

### DISCUSSION

Whether the differences between the clusters of individuals are characteristic of sexual differences must be examined with some caution, because the sex of individuals were not determined for any of the species examined in this study. It is unlikely that for Antarctic Prions, previously reported not to be sexually dimorphic, the Heard Island population would exhibit sexual dimorphism. Until confirmatory evidence is obtained, it is best assumed for this species that the clustering of individuals was an artefact of the analysis, perhaps reflecting the relatively small sample size and the high degree of accuracy of the analyses. Conversely, it may be that the analysis has picked up some of the subtle characteristics of the bill morphologies referred to by early workers, in describing the bill shapes and differences between populations

TABLE 6

MORPHOLOGICAL DATA (MEANS, IN MM) FROM SOUTH GEORGIAN DIVING PETRELS AT FIVE BREEDING LOCALITIES

Locality	BLB	Tars1	Wing L	Tail L	Source
Heard Island	15.1	23.6	115.1	37.4	This study
South Georgia	15.3	24.7	116	39.1	Bourne (1968)
South Georgia	14.7	23.8	118.2	39.7	Payne & Prince (1979)
South Georgia	14.8	24.3	113.2	37.9	Payne & Prince (1979)
îles Crozet	16.3	25.0	120	40.7	Bourne (1968)
îles Crozet	15.3	25.0	119	-	Jouventin <i>et al.</i> (1985)
îles Kerguelen	14.5	23.5	117	39.2	Bourne (1968)
îles Kerguelen	15.1	23.3	119.0	41.1	Payne & Prince (1979)
Auckland Islands	15	24	110	36	Bourne (1968)

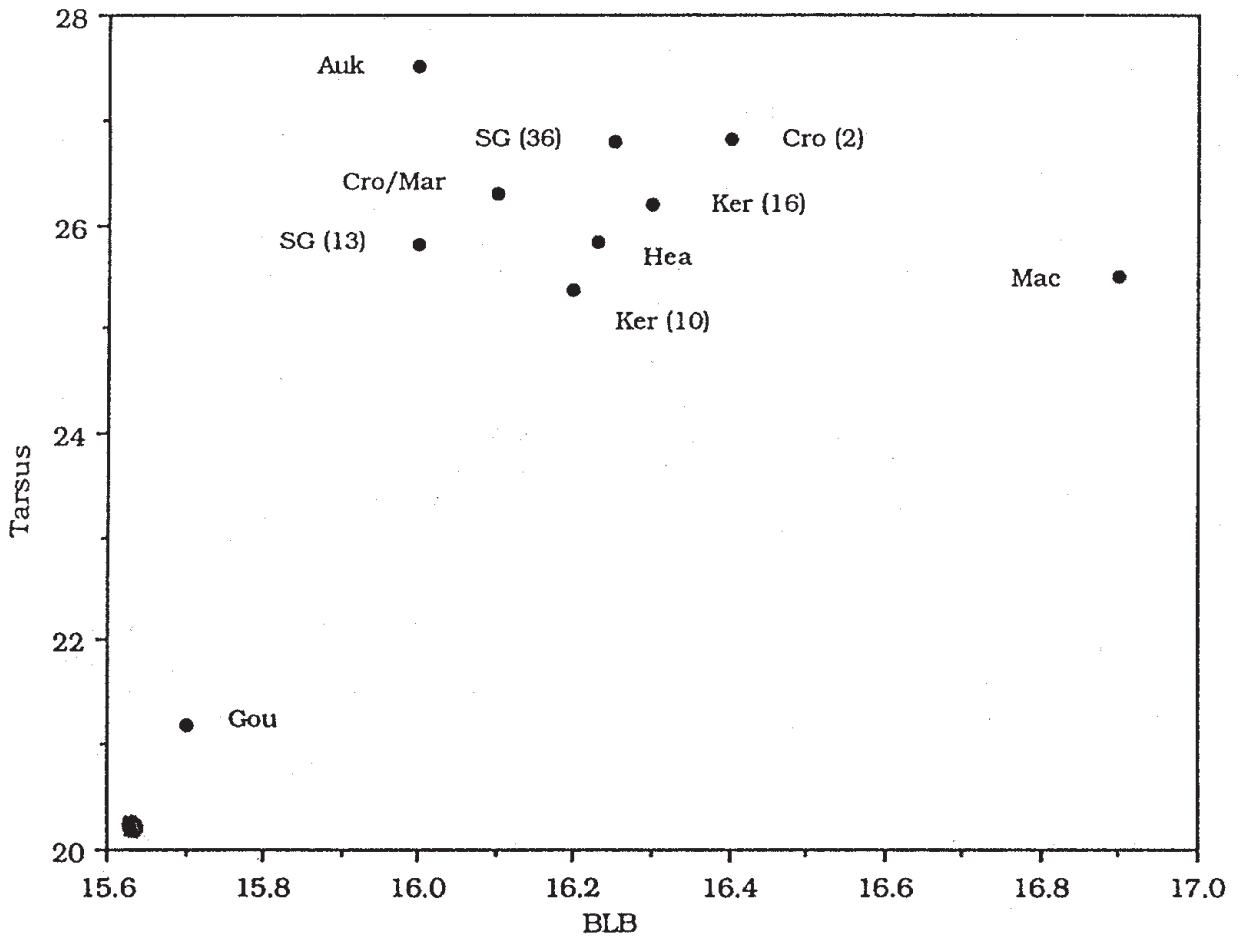


Figure 3

Plot of BLB and Tarsus (Tars 1) data of South Georgian Diving Petrels from Heard Island (Hea), îles Kerguelen (Ker), îles Crozet (Cro), South Georgia (SG) and the Auckland Islands (Auk). Numbers represent sample sizes (Table 6).

(Murphy 1936, Tickell 1962).

Some general comments on taxonomies can be made from the data collected in this study, since for three species they enable comparison of the Heard Island populations with those on other islands for the first time.

Tickell (1962) proposed three subspecies of Antarctic Prion, based on small differences in the bill, with the nominate *desolata* at îles Kerguelen, *banksi* at Heard, South Georgia and the South Orkney Islands and *alter* at Macquarie and the Auckland Islands. Harper (1972, 1980) was reluctant to follow Tickell's taxonomy, and argued for a single species based on the similarities between breeding locations, that exhibited geographic variation. The high degree of overlap in data from different breeding localities that differ only at the extremes of the range, lend support for Harper's opinion. Bretagnolle *et al.* (1990) also demonstrated the geographic variation between populations of Antarctic Prions in the southern Indian Ocean, and proposed two subspecies of *desolata*; one breeding on warmer sub-Antarctic islands, the other on colder sub-Antarctic islands.

Harper (1980) speculated that Fulmar Prions at Heard Island (nominally *eatoni*), would be consistent with Auckland Islands' *eatoni*, which were smaller than Fulmar Prions at other New Zealand region islands (Table 4), but did so in the absence of any data from the Heard Island population. He further reported that Fulmar Prions were sexually dimorphic in bill structure, with males in the two New Zealand populations having a wider unguis, on the average, than females. He also noted that the differences between the sexes were as significant as those between the two populations. Based on the cluster analysis of the Heard Island data, it is believed that this population is also sexually dimorphic, and that the unguis is also wider in males than in females, consistent with other data from this population (Table 3).

The previous absence of Common Diving Petrel data from Heard Island has prevented the population from being identified to subspecies, although Bourne (1968) suggested that the Heard Island population might belong to the *exsul* group, found at other sub-Antarctic islands. The data collected in this study show that the Heard Island population is morphologically similar to other Indian Ocean populations, including those at warmer water breeding locations, a finding consistent with the proposal of Norman & Brown (1987). Similarly, the possible sexual dimorphism suggested by the cluster analysis is also in agreement with their findings.

Payne & Prince (1979) found that there was no overlap in BDN measurements from Common and South Georgian Diving Petrels at South Georgia, and proposed that this measurement was a useful criterion for separating adults of the two species. However, this was not the case for the Heard Island data, where there was considerable overlap in BDN data between the two species, due to both species at Heard Island being larger in BDN measurements than those at South Georgia, and with a greater range in measurements.

The shape of the lower mandible has also been identified as a criterion for separating these two species (converging rami in South Georgian and parallel in Common Diving Petrels: Serventy *et al.* 1971, Payne & Prince 1979). However, Jouventin *et al.* (1985) found that this criterion was not reliable, as was the situation on Heard Island, where the rami were found to be both converging and parallel in South Georgian Diving Petrels. The other criterion that has been identified, that of a continuous narrow black line on the posterior of the tarsus in South Georgian, and a discontinuous line in Common Diving Petrels (Payne & Prince 1979), was found to be the sole criterion for separating the two species at Heard Island. A similar situation was reported by Jouventin *et al.* (1985) for these two species at îles Crozet.

It is clear from the results of this study that the

future collection of biometric data, and in particular, THL data may provide useful data on sexual dimorphism in species and populations of prions and diving petrels presently not believed to exhibit such a characteristic.

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