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PRELIMINARY INVESTIGATIONS INTO THE MORPHOLOGY OF THE CRESTED TERN *Sterna bergii* IN SOUTH-EAST TASMANIA

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Hierarchical cluster analysis of morphological data (total head length, exposed culmen and tarsus) from 56 Crested Terns *Sterna bergii* from south-east Tasmania enabled the identification of an individual's sex. Both total head length and exposed culmen can be used to differentiate the sexes as there is no overlap present. Tarsal lengths, due to a large degree of overlap, are of limited use. Comparison with unpublished morphological data from Western Australia indicates that a geographic variation exists between populations in Australia. Future studies should collect morphological data in order to describe the extent of this variation.

INTRODUCTION

The Crested Tern, *Sterna bergii* Lichtenstein, has been recorded breeding throughout the coastal regions of Australia (Serventy *et al.* 1971; Blakers *et al.* 1984). Previous studies on the species have focused on breeding biology (Dunlop 1985a; Hulsman 1977 and Langham and Hulsman 1986), moult (Dunlop 1985b) and behaviour (Dunlop 1987). Davies and Carrick (1962) investigated chick recognition by incubating parents. Carrick *et al.* (1957) and Carrick (1959) in early studies described movements of banded individuals.

The only published morphological data were presented by Serventy *et al.* (1971) for 12 individuals, and Pringle (1987) who presented ranges for morphological parameters, mostly from Serventy *et al.* (1971). Neither gave a source locality for the data. Hence there are no data available on any sexual or geographic variation that may be present in the various breeding populations around Australia. Such data are fundamental to determining the taxonomic status of a population throughout its range, concomitant to any ecological studies that are undertaken.

This paper presents the results of an analysis of morphological data collected from a breeding population in south-east Tasmania. These results provide a basis for comparisons in future studies in other parts of Australia.

METHODS

All data were collected between 11 January and 29 November 1987 from breeding adults on Spectacle Island (42°52′S, 147°36′E), Lachlan Island (42°39′S, 147°59′E) and Curlew Island (43°26′S, 147°10′E) in south-east Tasmania. Adults were captured using walk-in traps made of large mesh (c. 20 mm) chicken wire set over nests with eggs.

Standard measurements (total head length, exposed culmen and tarsus) were collected from 56 birds concurrent with banding operations. Body weights were collected but not analysed due to daily individual variation. Similarly, wing and tail lengths were obtained but not analysed due to variation from moult and abrasion. Cloacae were not examined during the data collection.

The data were subjected to a hierarchical cluster analysis examining euclidian distances between the data points in 3-dimensional space. Full mathematical treatments can be found in Pielou (1984) and Field *et al.* (1982). The analysis constructed a dendrogram based on unweighted-pairs group averaging linkage, describing the similarities between the individual's morphological data, and divided the data into clusters, from which univariate statistics were generated. No verification of the sex of individuals was made as this would involve the sacrifice of a significant proportion of the small breeding population of Crested Terns in south-east Tasmania.

Unpublished exposed culmen data (n = 29) collected at Fremantle, Western Australia, were kindly made available by J. N. Dunlop. These data were not subjected to the cluster analysis.

RESULTS

The dendrogram produced by the cluster analysis is presented in Figure 1. The analysis clearly separated the data into three clusters of 30, 23 and three individuals. Based on an examination of the raw morphological data, we propose that the birds in cluster 1 were females (n = 30) and those in cluster 2 were males (n = 23). This proposal was based on the fact that the species is known to be sexually dimorphic, with males larger than females (J. N. Dunlop, pers. comm.), based on dissections and copulatory observations. The small cluster of three represents individuals with data values for one or more of the three measurements well outside the range of values demonstrated by the individuals in the other clusters, and it was clear that an error in either data collection or transcription had been made. The data from these three individuals were excluded from all further analyses.

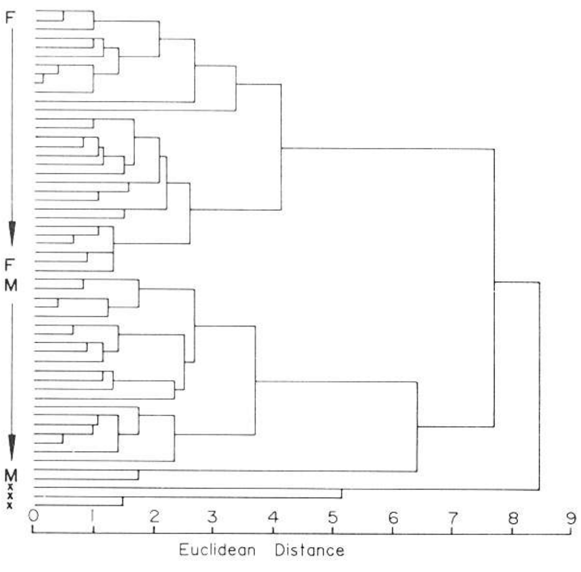

Figure 1. *Dendrogram produced by hierarchical cluster analysis of morphological data (total head length, exposed culmen and tarsus) from 56 Crested Terns in south-east Tasmania.*

TABLE 1

Range, mean, standard deviation and median for body measurements collected from male (n = 23) and female (n = 30) Crested Terns from south-east Tasmania. All measurements in mm.

	Minimum	Maximum	Mean	SD	Median
Male					
Total Head Length	113.6	120.9	116.21	1.90	115.6
Exposed Culmen	59.2	65.3	61.50	1.59	61.4
Tarsus	32.6	37.9	35.40	1.27	35.4
Female					
Total Head Length	107.5	113.4	110.49	1.91	110.3
Exposed Culmen	54.2	58.9	56.81	1.23	56.8
Tarsus	32.5	36.6	34.52	0.97	34.7

Based on the clustering, minima, maxima, means, standard deviations and medians for total head length, exposed culmen and tarsus of the 23 males and 30 females were calculated (Table 1). Either total head length or exposed culmen would apparently sex all individual Crested Terns in south-east Tasmania as there is no overlap between the sexes for either of these measurements (Table 1). The large overlap between the tarsal data precludes this measurement as a sexing guide, except at the extremes of the observed range in the data.

DISCUSSION

Despite the lack of verification of the presumed sex of individuals, we are confident that the results of the analyses are representative of the sexual dimorphism in the breeding population of Crested Terns in south-east Tasmania. Once sexing criteria have been established for breeding populations, the full range of sex-specific ecological studies becomes possible.

The pooled mean for length of exposed culmen obtained in this study (58.8 mm) is significantly different from the mean exposed culmen length of 66.2 mm obtained from breeding adults at Fremantle (t_{80} = 10.10, $p < 0.001$), but is not significantly different from that reported by Serventy *et al.* (1971) of 59.1 mm. Based on these data, it is clear that geographic variation exists in the morphology of Crested Terns around Australia.

TABLE 2

Previously collected morphological data from Crested Terns in Australia. All measurements in mm.

	Minimum	Maximum	Mean	n	Reference
Tail Length	151	176	163	12	Serventy *et al.* 1971; Pringle 1987
Exposed Culmen	52.0	65.5	59.1	12	Serventy *et al.* 1971; Pringle 1987
	60.3	72.7	66.2	29	J. N. Dunlop, unpubl. data
Tarsus	25	29	27	12	Serventy *et al.* 1971; Pringle 1987

The large difference between the mean tarsal length of 27 mm reported by Serventy *et al.* (1971) and that obtained in this study (pooled mean 34.8 mm) can be explained by the inclusion of the tibia in the tarsus measurement of this study (method "TZ" of the ABBBS). It is critical that all measurements collected are identical in methodology in order to determine the extent of geographic variation.

The extent of Crested Tern movements around Australia is not fully understood. Carrick *et al.* (1957) described northward and southward dispersion from breeding localities in New South Wales based on band recoveries and three resightings of bands in Tasmania, one from New South Wales and two from Victoria. Resightings of breeding adults banded in Western Australia were confined to within 32 km of the original banding site. No westward movements to Western Australia have been reported (Carrick *et al.* 1957; M. D. Murray, pers. comm.). A limit of 320 km has been suggested for the intermingling of individuals between colonies, although acknowledging more data were needed from longer time-scale studies (Carrick *et al.* 1957). More recent recoveries from Western Australia are of birds banded as chicks up to 500 km from their natal colony (J. N. Dunlop, pers. comm.). Serventy *et al.* (1971) and Blakers *et al.* (1984) described eastward movements of 1 850 km from breeding localities in South Australia to New South Wales and Queensland and also noted the continued absence of westward movements of individuals, based on band recoveries. Local movements between breeding localities in south-east Tasmania and more distant movements between mainland and Tasmanian breeding localities have been observed (Shorebird Study Group and WCW, unpubl. data).

Liddy (1968) postulated that two breeding populations of Crested Terns had bred sympatrically on islands off the north-east of Tasmania, based on a sudden large influx (c. 1 100 to 1 200 pairs) to these breeding sites. No evidence was presented to support the suggested source of these birds (stated as coastal New South Wales or eastern Victoria). This pattern of seasonal movement into a breeding area agrees with previously published data (Carrick *et al.* 1957; Carrick 1959), and more recent observations (WCW) of colonies shifting breeding locations between seasons and even within a season.

Such observations indicate a wide-scale movement of birds between natal and breeding colonies with a concomitant gene flow between populations. In the absence of any recorded westward movements of birds to Western Australia, the known dispersion of birds between colonies in south-east Australia and the morphological data presented here, it is reasonable to propose that there are morphological differences between breeding populations of Crested Terns around Australia.

Only three means of determining the sex of individuals are available: that of using museum skins, dissection of freshly killed birds and behavioural observations. Museum skins are known to shrink and warp, and are thus limited in their use for field work. The verification of sex by dissection is impractical in this case as it would involve a sample of at least 30 pairs to be statistically viable, and this was not feasible for the relatively small breeding population in south-east Tasmania (approximately 500 pairs). The third method of sexing individuals is that of behavioural observations at the nest site, for example, copulatory behaviour. This method requires ready access to the breeding colony (typically on offshore islands) and individually recognizable birds, i.e., a large proportion of the population needs to be colour-banded. This method is preferable, particularly when dealing with small populations.

The data presented here have clearly demonstrated differences in the morphologies of Crested Terns breeding in south-east Tasmania and Western Australia. Morphological data from other breeding localities covering the whole range around Australia are now required to enable the full extent of geographical variation present in this species to be appraised.

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REFERENCES

Blakers, M., Davies, S. J. J. F. and Reilly, P. N. (1984). 'The Atlas of Australian Birds'. (Melbourne University Press: Melbourne).

Carrick, R. (1959). The contribution of banding to Australian bird ecology. In 'Biogeography and Ecology in Australia'. (Eds A. Keast, R. L. Crocker and C. S. Christian) pp. 369–382. (W. Junk: The Hague.)

Carrick, R., Wheeler, W. R. and Murray, M. D. (1957). Seasonal dispersal and mortality in the Silver Gull *Larus novaehollandiae* Stephens, and Crested Tern *Sterna bergii* Lichtenstein, in Australia. *CSIRO Wildl. Res.* **2:** 116–144.

Dunlop, J. N. (1985a). Reproductive periodicity in a population of Crested Terns, *Sterna bergii* Lichtenstein, in South-Western Australia. *Aust. Wildl. Res.* **12:** 95–102.

Dunlop, J. N. (1985b). The relationship between moult and the reproductive cycle in a population of Crested Terns, *Sterna bergii* Lichtenstein. *Aust. Wildl. Res.* **12:** 487–494.

Dunlop, J. N. (1987). Social behaviour and colony formation in a population of Crested Terns, *Sterna bergii*, in South-Western Australia. *Aust. Wildl. Res.* **14:** 529–540.

Field, J. G., Clarke, K. R. and Warwick, R. M. (1982). A practical strategy for analysing multispecies distribution patterns. *Mar. Ecol. Prog. Ser.* **8:** 37–52.

Hulsman, K. (1977). Breeding success and mortality of terns at One Tree Island, Great Barrier Reef. *Emu* **77:** 49–60.

Langham, N. P. and Hulsman, K. (1986). The breeding biology of the Crested Tern *Sterna bergii*. *Emu* **86:** 23–32.

Liddy, J. (1968). Probability of two populations of Crested Terns breeding together in Tasmania. *Aust. Bird Band.* **6:** 78–80.

Pielou, E. C. (1984). 'The interpretation of ecological data: A primer on classification and ordination'. (Wiley Interscience: New York.)

Pringle, J. D. (1987). 'The Shorebirds of Australia'. (Angus and Robertson: North Ryde.)

Serventy, D. L., Serventy, V. and Warham, J. (1971). 'The Handbook of Australian Seabirds'. (A. H. and A. W. Reed: Sydney.)