A Statistical Method for Identification of Albatross (*Phoebastria*) Species

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Abstract

Species-level identification of albatross bone recovered from coastal archaeological sites can be problematic. With the exception of a few diagnostic features, the osteology of the three albatross species which visit California is remarkably similar. Furthermore, there are relatively few complete comparative specimens of one of these species, the nearly extinct Short-tailed Albatross (*Phoebastria albatrus*), in California biological or museum collections. However, the three albatross species differ markedly in size. This paper presents statistically established size ranges, based on measurements of museum-curated comparative specimens, for distinguishing between the species of albatross found in Pacific coast archaeological sites. As a test application, a sample of archaeological albatross bone is identified using this method.

Introduction

As a result of nearly total historic extirpation, comparative specimens of *Phoebastria albatrus*, the Short-tailed Albatross, are scarce. There are, however, numerous specimens of the smaller, more abundant species which visits our coast, *P. nigripes*, the Black-footed Albatross, as well as of *P. immutabilis*, the Laysan Albatross, which is less frequently found in California. Because of the overall rarity of the Short-tailed Albatross, many museum specimens of this species are partial or consist of degraded, fragmentary archaeological remains.

While identifying a large collection of albatross bone recovered in 1994 from the Eel Point Site on San Clemente Island (CA-SCLI-43) (Porcasi 1999), the paucity of comparative specimens of the Short-tailed Albatross became apparent and hampered definitive differentiation of that species from the Black-footed Albatross. Only a few fragments retaining diagnostic features could be unequivocally identified. The remaining albatross bones were identified only to the genus *Phoebastria* (formerly named *Diomedea*). However, the large size of the Eel Point albatross bone suggested that much of it might be Short-tailed Albatross and prompted the research reported here.

Background

Of the three local species of albatross, the Short-tailed Albatross is the largest. It can attain a body length of 94 cm (about 37 in.) and has a wingspan of about 229 cm (7.5 ft) (Palmer 1962:74; Peterson 1990:74). The Black-footed Albatross rarely exceeds a length of 80 cm (31.5 in), with a wingspan of 213 cm or about 7 ft; and the Laysan Albatross rarely exceeds a length of 80 cm (31.5 in) with a wingspan of 198 cm or about 6.5 ft (Palmer 1962:119, 126;

Peterson 1990:74). In short, the Black-footed Albatross is approximately 7 per cent smaller than the Short-tailed Albatross and the Laysan Albatross is approximately 13 per cent smaller than the Short-tailed Albatross.

With the knowledge that the Short-tailed Albatross is observably larger than the other albatrosses, a method for identifying these species based on statistically significant differences between size ranges of major skeletal elements can be developed. While size is not a conventional technique for identifying archaeological bones, it can suggest the most likely species within an osteologically similar genus when species differ significantly in size.

Method

Statistical methodology is simple: (1) measure as large a sample as possible of known species, (2) calculate the ranges of the measured elements, and (3) determine if the ranges are significantly different. Archaeological samples can then be provisionally identified by their placement within these ranges.

The statistical control sample of identified species used in this research consisted of 51 albatross tarsometatarsals and 50 carpometacarpals measured at several California and national museums and biological collections. The tarsometatarsal is a lower (distal) leg element and the carpometacarpal is a distal wing element (Fig. 1). Both are robust bones from relatively fleshless portions of the bird. They are frequently recovered archaeologically, perhaps because they are discarded into middens in a more intact condition than fleshier, more preferred limb bones such as humerus (proximal wing) or thigh (femur) or tibiatarsus ("drumstick"). All sample bones were complete elements from adult birds as determined by total ossification of the elements.

The greatest lengths (GL) of the tarsometatarsals and carpometacarpals were measured using metric calipers per Cohen and Serjeantson (1996) and von den Driesch (1976). Ranges for the three species were calculated and two statistical tests applied to determine if the size ranges of the three species were significantly different. These tests were Analysis of Variance (ANOVA) and the Newman-Keuls Multiple Comparison Test, both of which are efficient means of statistically comparing the averages between several samples to determine if they come from different groups or if the observed differences can be attributed to random variations within a single group. The measurements of the museum-curated elements also were statistically compared with those of the archaeological sample. Finally, measured elements from the archaeological sample were identified by placement within the provisional size ranges.

The archaeological sample consisted of 8 complete adult tarsometatarsals and 3 complete adult carpometacarpals from the 1994 Eel Point project along with 3 tarsometatarsals and 2 carpometacarpals collected from the Thousand Springs site on San Nicolas Island (CA-SNI-

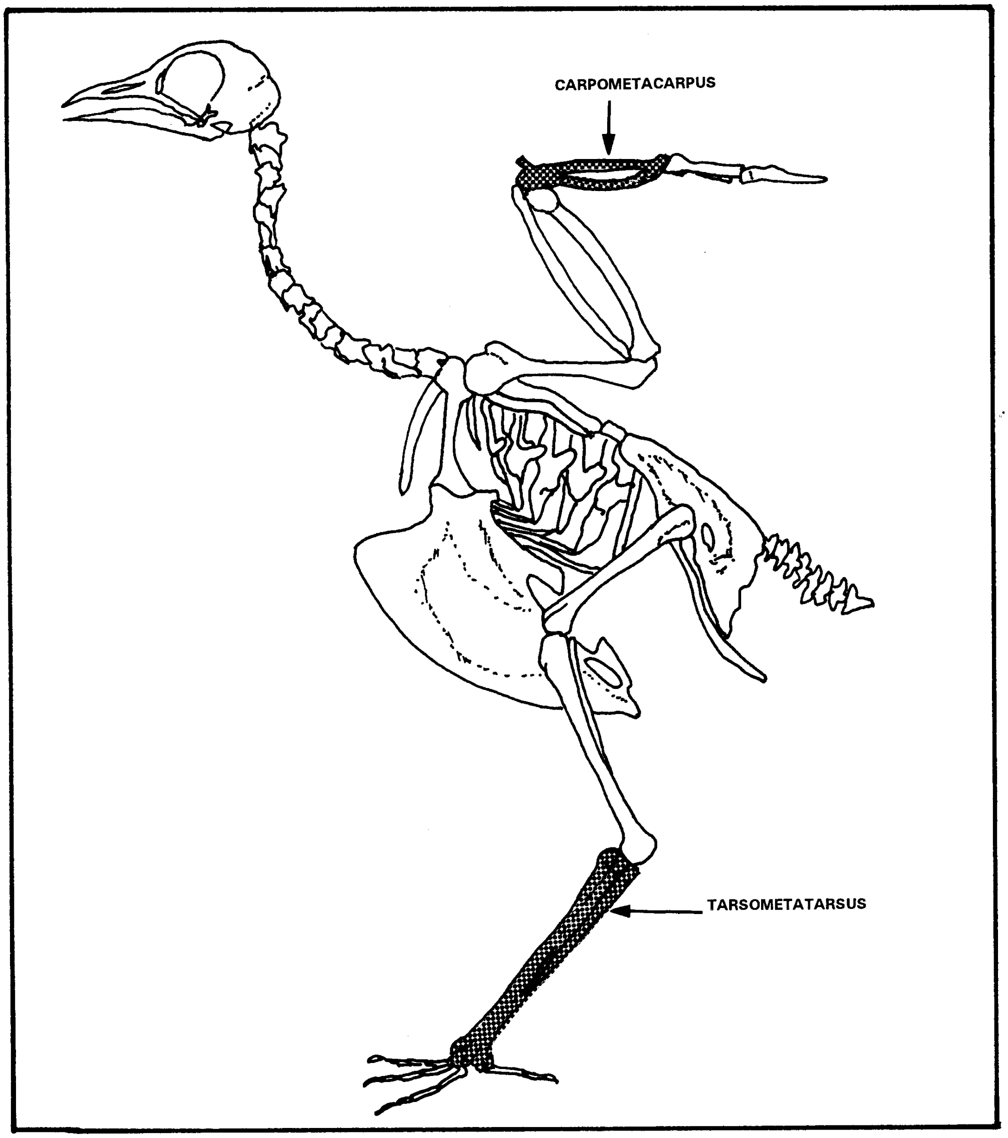

Fig. 1: Diagram of general avian osteology.

11) (Bleitz-Sanburg 1987). Measurements of the San Nicolas Island bone and their identification as Short-tailed Albatross are based on comparison with a specimen from the National Museum of Natural History (Smithsonian Institution) and were provided by D. Bleitz (personal communication 1996).

Results

Table 1 presents the statistical comparison of measured archaeological specimens and museum-curated tarsometatarsals, and Table 2 presents the statistical comparison of measured archaeological specimens and museum-curated carpometacarpals. Size ranges derived from these tables are summarized below:

Tarsometatarsals

Short-tailed Albatross: 97.7 ± 2.93 mm
Black-footed Albatross: 94.11 ± 2.64 mm
Laysan Albatross: 89.39 ± 4.09 mm. (In addition, Gilbert et al. [1981:212] present a length of 90 mm for the Laysan Albatross tarsometatarsal).

Carpometacarpals

Short-tailed Albatross: 112.32 ± 3.51 mm
Black-footed Albatross: 105.51 ± 4.18 mm
Laysan Albatross: 101.15 ± 3.82 mm

Statistical tests demonstrated that the size ranges of the three albatross species which visit California are significantly different (Figs. 2 and 3). On the basis of these data, length of these elements can be used to identify albatross bone to species, with the caveat that the identifications are statistically determined. It is also important to keep in mind that: (1) both the statistical control and archaeological samples were small, and (2) the curated specimens may not represent entirely unbiased populations. Furthermore, superficial observation of the archaeological sample relative to the curated specimens suggests that prehistoric birds may have been somewhat larger than more recent birds.

The eleven archaeologically recovered tarsometatarsals averaged 99.24 mm, exceeding the mean in Table 1 for museum-curated Short-tailed Albatross and clustering at the top of the Short-tailed Albatross range established above. The five archaeological carpometacarpals averaged 111.13 mm, greatly exceeding the means for Black-footed and Laysan Albatross, but measuring slightly less than the mean of the museum-curated Short-tailed Albatross (112.32 mm), much of which is actually curated archaeological material from the Channel Islands. However, the island albatross carpometacarpals greatly exceed measurements presented by both Yesner (1976) and Gilbert et al. (1981) for this element. Yesner (1976:270) presented carpometacarpal length of a single Short-tailed Albatross specimen as 104.23 mm (10.4 cm) and of four specimens of Laysan Albatross as 85.3 mm. Gilbert et al. (1981:126) present a carpometacarpal length of 103 mm for the Laysan Albatross (1981:126).

Table 1: Statistical comparison of tarsometatarsal length.

	Archaeological Specimens	Museum-Curated Specimens		
	Short-tailed Albatross (2 island sites)	Short-tailed Albatross	Black-footed Albatross	Laysan Albatross
Number	11	18	11	22
Mean (mm)	99.24	97.7	94.1	89.39
Standard deviation (mm)	3.45	2.93	2.64	4.09
Range (mm)	10.42	9.85	7.7	11.15

An ANOVA and Newman-Keuls Multiple Comparisons Test showed that the means of the Black-footed Albatross and Laysan Albatross were significantly different from the means of both the archaeological specimens identified as Short-tailed Albatross and the museum-curated Short-tailed Albatross treated separately ($p < .001$). These tests also showed that the means of the Black-footed Albatross and Laysan Albatross were significantly different from each other (Fig. 2).

Table 2: Statistical comparison of carpometacarpal length.

	Archaeological Specimens	Museum-Curated Specimens		
	Short-tailed Albatross (2 island sites)	Short-tailed Albatross	Black-footed Albatross	Laysan Albatross
Number	5	21	7	22
Mean (mm)	111.13	112.32	105.51	101.15
Standard deviation (mm)	3.75	3.51	4.18	3.82
Range (mm)	10.4	13.2	10.4	11.95

An ANOVA and Newman-Keuls Multiple Comparisons Test showed that the means of the Black-footed Albatross and Laysan Albatross were significantly different from the means of both the archaeological specimens identified as Short-tailed Albatross and the museum-curated Short-tailed Albatross treated separately ($p < .001$). In addition, the means of the Black-footed Albatross and Laysan Albatross were significantly different from each other (Fig. 3).

In these statistical tests,

Group 1 = Archaeological albatross tarsometatarsals
Group 2 = Museum Short-tailed Albatross
Group 3 = Museum Black-footed Albatross
Group 4 = Museum Laysan Albatross

Group Means and Standard Deviations:

1:	mean = 99.24182	s.d. = 3.450629	n = 11
2:	mean = 97.73055	s.d. = 2.930336	n = 18
3;	mean = 94.10909	s.d. = 2.639191	n = 11
4:	mean = 89.38863	s.d. = 4.094455	n = 22

Analysis of Variance Table

Source	S.S.	DF	MS	F	Appx. p
Total	1697.75	61			
Treatment	1011.00	3	337.00	28.46	<.001
Error	686.75	58	11.84		

Newman-Keuls Multiple Comparisons Test

Compare		P	Q	Critical q (.05)
Mean (1) - Mean (4) =	9.8532	4	10.966	3.742
Mean (1) - Mean (3) =	5.1327	3	4.947	3.403
Mean (1) - Mean (2) =	1.5113	2	1.623	2.832
Mean (2) - Mean (4) =	8.3419	3	10.787	3.403
Mean (2) - Mean (3) =	3.6215	2	3.889	2.832
Mean (3) - Mean (4) =	4.7205	2	5.254	2.832

The graph below represents the results of the Newman-Keuls multiple comparison test. At the .05 significance level, the means of any two groups falling within the same length increment are not significantly different and the means of groups not falling within the same length increment are significantly different. The “+” signs indicate locations of the means.

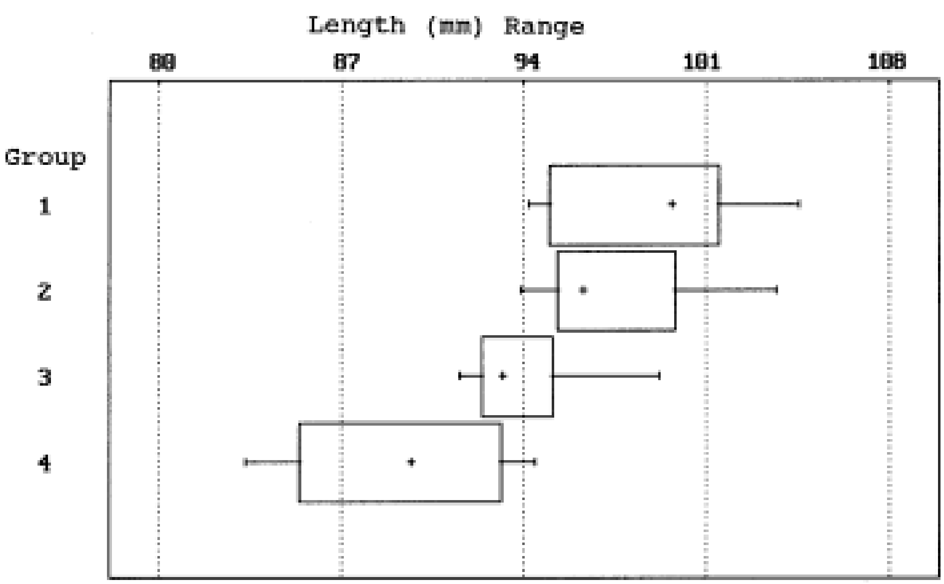

Fig. 2. Summary and graphical representation of ANOVA and Newman-Keuls Multiple Comparisons Test of means of Albatross tarsometatarsals.

In these statistical tests,

Group 1 = Archaeological albatross carpometacarpals
Group 2 = Museum Short-tailed Albatross
Group 3 = Museum Black-footed Albatross
Group 4 = Museum Laysan Albatross

Group Means and Standard Deviations:

1:	mean = 111.128	s.d. = 3.754908	n = 5
2:	mean = 112.3162	s.d. = 3.508264	n = 21
3;	mean = 105.5071	s.d. = 4.180068	n = 7
4:	mean = 101.1477	s.d. = 3.816778	n = 22

Analysis of Variance Table

Source	S.S.	DF	MS	F	Appx. p
Total	2160.25	54			
Treatment	1446.94	3	482.31	34.48	<.001
Error	713.32	51	13.99		

Newman-Keuls Multiple Comparisons Test

Compare		P	Q	Critical q (.05)
Mean (1) - Mean (4) =	11.1684	4	13.843	3.761
Mean (1) - Mean (3) =	6.8090	3	5.900	3.418
Mean (1) - Mean (2) =	1.1882	2	0.903	2.842
Mean (2) - Mean (4) =	9.9803	3	7.618	3.418
Mean (2) - Mean (3) =	5.6209	2	3.630	2.842
Mean (3) - Mean (4) =	4.3594	2	3.799	2.842

The graph below represents the results of the Newman-Keuls multiple comparison test. At the .05 significance level, the means of any two groups falling within the same length increment are not significantly different and the means of groups not falling within the same length increment are significantly different. The “+” signs indicate locations of the means.

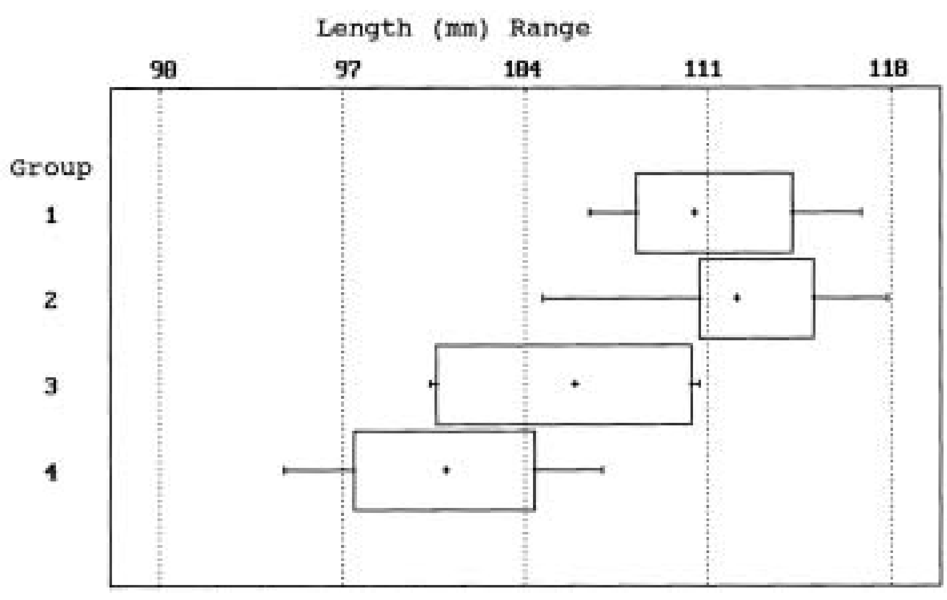

Fig. 3. Summary and graphical representation of ANOVA and Newman-Keuls Multiple Comparisons Test of means of Albatross carpometacarpals.

Conclusions

1. The variance of the size ranges and the strength of the statistical tests argues that albatross tarsometatarsals and carpometacarpals lacking species-level diagnostic features may be conditionally identified based on concordance with these size ranges, providing the identification is qualified as being statistical rather than based on osteological features.

2. Much of the Eel Point archaeological bone was identified as Short-tailed Albatross based on its placement within that size range (Porcasi 1999).

3. There is some small-sample evidence from these two island sites that prehistoric birds may have been larger than more recent specimens. This is consistent with the observation that overall body size of heavily exploited species appears to reduce over time as fewer individuals are allowed to attain full maturity.

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