Notornis , 2001, Vol. 49: 19-28
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The New Zealand musk duck (*Biziura delautouri* Forbes, 1892)

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Abstract The occurrence of musk ducks (*Biziura*) as fossils in New Zealand is reviewed and updated. Twenty-four bones from at least 7 individuals, and 67 elements from a single skeleton are known. Morphological differences between the fossils and the extant Australian *B. lobata* support continued distinction of the New Zealand form as the separate species *B. delautouri*.

Worthy, T. H. 2002. The New Zealand musk duck (*Biziura delautouri* Forbes, 1892). *Notornis 49(1)*: 19-28.

Keywords *Biziura delautouri*; New Zealand musk duck; morphology

INTRODUCTION

The presence of a species of *Biziura* in New Zealand was first revealed by Henry Ogg Forbes in a paper communicated by Mr J. T. Meeson to the Philosophical Institute of Canterbury on 1 October 1891. This paper (reported in *The Press* [Christchurch], October 2 1891: 5), gave notice of several new taxa. One of these was *Biziura* that Forbes reported was represented by a single tarsometatarsus similar to that of *B. lobata*, the musk duck of Australia. Forbes dispatched texts of this address to *Nature* and the *Transactions and proceedings of the New Zealand Institute*. The article in *Nature* was published first (Forbes 1892, March). In this, a right tarsometatarsus (now BMNH A1504) was designated as the type, and a valid, though succinct and not very illuminating description given for *Biziura delautouri*: '..a *Biziura* somewhat larger than *Biziura lobata*, the musk duck of Australia, an interesting species.' The bone was associated with large numbers of moa bones in the Enfield site near Oamaru, South Island, New Zealand and was named after Dr. H. de Lautour of Oamaru who helped acquire specimens from the site. The paper sent to the *Transactions* (Forbes 1892: May) referred to this taxon as *Biziura lautouri*, but with no further elaboration save again that the species was named "in compliment to Dr. H. de Lautour, of Oamaru".

Lambrecht (1933) wrongly considered that Forbes (1892: May) had been published in 1891, and regarded *Biziura lautouri* to be a *nomen nudum* and overlooked the valid earlier description of *B. delautouri*. Dawson (1958), having found the type in the British Museum (Natural History) and overlooking Forbes (1892, March), re-established the species as *Biziura lautouri*, and noted having found similar tarsometatarsi at Marfells Beach, Lake Grassmere. Howard (1964: 319-320) summarised the above history and established *Biziura delautouri* as the valid name with *Biziura lautouri* as a junior synonym.

Description of further elements of this rare species had to wait until Scarlett (1969) described a fossil right humerus (CM Av11160) from Marfells Beach. This was slightly larger than that of the modern Av7116 (Fig. 1), a male that Forbes had access to (Scarlett 1969). As Forbes's description stated only that *B. delautouri* was larger than *B. lobata*, we can infer that the type bone should be larger than the corresponding element in Av7116, which it is. Scarlett (1969) also described and attributed to the smaller female, a right tibiotarsus from Poukawa Swamp in the North Island that was broken both proximally and distally. He figured (Plate XXI), but did not refer to in the text, a right humerus of an appropriately small size also from Poukawa Swamp. Also, he clearly considered these bones to be indistinguishable from *Biziura lobata*, and the size differences to be insignificant in this strongly sexually dimorphic species.

Harrison & Walker (1970) also overlooked Forbes's (1892, March) description of *B. delautouri* when they re-examined the type [as *B. lautouri*] and concluded that the size difference, at 2.7% larger than the largest of 4 adult male tarsometatarsi measured from skins, was too slight to warrant separation of the fossil from *B. lobata*. Their comparisons were limited by having for reference only 2 female skeletons and 1 tarsometatarsus of a male (length 54.6 mm; BM 1900.6.24.1) extracted from 1 of the

Received 1 December 2000; accepted 19 May 2001

skins. Harrison & Walker (1970) noted that the larger humerus described by Scarlett (1969) was also 2-3% larger than in *B. lobata*.

Olson (1977) recorded 2 tarsometatarsi [both now catalogued as MNZ S23231] from Lake Grassmere collected by E. Dawson in 1951 among uncatalogued bones from that site in the (then) National Museum of New Zealand. Olson noted that the larger tarsometatarsus from Lake Grassmere (56.7 mm) and the type of *B. delautouri* (57.2 mm) were both longer than those in his series of 5 males of *B. lobata* (50.8-52.6 mm). The smaller Lake Grassmere tarsometatarsus at 47.2 mm was smaller than in the series of 5 males but longer than in the 3 females of *B. lobata* (39.5 - 44.0 mm) available to him. Olson also noted that the intercotylar knob was smaller and more pointed, and the shapes of the cotylae and the conformation of the hypotarsal canals were different in the Lake Grassmere specimens compared with those of *B. lobata*. As a result, he advocated the retention of the name *B. delautouri* for the New Zealand specimens.

Millener (1981) listed 2 individuals of *B. delautouri* from Far North dunes sites, and bones of 3 individuals from Poukawa Swamp, Hawke's Bay. These specimens have not been described. Horn (1983) noted that *Biziura* sp. had been recorded previously from three sites in New Zealand (Enfield, Grassmere, Poukawa - site N141/1, GR [V22] 28296 61525). He recorded 3 more unspecified bones from a second Poukawa site, N141/12 (GR [V22] 28283 61523), which probably represented 2 of the 3 individuals that Millener (1981) listed.

Here, all available fossil material is re-examined and compared with corresponding material of modern *Biziura lobata*, with the result that *Biziura delautouri* may be sustained as a distinct species.

METHODS

All the listed fossil material was studied with special reference to CM Av7116, and with additional measurements taken from AM S720 and NMNH 553598 (modern specimens of *B. lobata*) by THW. Anatomical terminology follows that advocated by Baumel *et al.* (1993) with English translations used preferentially after the first mention. Measurements were made with TESA® dial callipers to 0.01 mm and rounded to 0.1 mm.

Abbreviations AM, Australian Museum, Sydney, Australia; **ANSS**, Australian National Wildlife Collection, CSIRO, Australia; **AU**, Geology Department, University of Auckland, Auckland, New Zealand; **BMNH**, Natural History Museum, London, United Kingdom; **CM**, Canterbury Museum, Christchurch, NZ; **MNZ**, Museum of New Zealand Te Papa Tongarewa, Wellington, NZ; **NM**, Museum Victoria (was National Museum of Victoria), Melbourne, Australia; **NMNH**, Division of Birds, Museum of Natural History, Smithsonian Institution, Washington, D.C. USA.

In skeletal descriptions, left (L) and right (R) sides are identified. Element names are abbreviated as: cmc, carpometacarpus; cor, coracoid; fem, femur; fib, fibula; hum, humerus, rad, radius; scap, scapula; tmt, tarsometatarsus; tt, tibiotarsus.

Specimens used in comparison

MODERN *BIZIURA LOBATA* CM Av7116 plus MNZ S23232, parts of same male skeleton, Australia, H.O. Forbes collection. MNZ S23232 is the 'missing' left tarsometatarsus of CM Av7116 because it is a recent specimen rather than a fossil and both have Forbes' handwriting on them. AM S720, probable male, skeleton, Australia. NMNH 553598 (ex NM B8662), female, skeleton, Australia. NM W5353 Victoria, no data, received 19 May 1960; NM B6808 Victoria, zoo specimen (ex Mildura), received 10 May 1954.

FOSSIL MATERIAL Ninety-one fossil bones attributed to *Biziura* are listed in Table 1 from 5 sites (Fig. 1). The 67 specimens from dunes at Waikuku Beach, just south of North Cape, need explanation. In the Auckland University Geology Department collection there are 2 lots of *Biziura*, both from Waikuku Beach. One collection was made by J. Grant-Mackie, and the other by P. R. Millener. As the elements in each are not duplicated and are of appropriate size to represent a single individual, I consider that all 67 bones are from the same bird.

AU4677 - (Fossil Record Number N02/53), Waikuku Beach, southern part. Collected by P. R. Millener: L fem, R tt, L fib, L tmt, 16 phalanges, L hum, L ulna, R rad, L cmc, L cor, L scap, L side furcula, LR phalanx 1 of major manus digit, phalanx 2 of R major manus digit, phalanx 1 of R alular, axis vertebra, 9 cervical vertebrae, 4 thoracic vertebrae, 1 caudal vertebra, 1 pygostyle, fragments of sternum, 6 ribs, R quadrate, L pterygoid, 7 fragments of the mandible, fragments of cranium including occipital region and inter-orbital region (parts 58/1)

AU13802 - (FRN N02/51), Waikuku Beach, general collection, Collected by J. Grant-Mackie: R fem, L tt, R tmt, R scap, R cor, R hum, R ulna, L rad, R cmc. (9/1)

The only major element missing is the pelvis, which perhaps was not recognised as being from an anatid and could be stored elsewhere in the collection.

COMPARATIVE OSTEOLOGY

In the following section I draw attention only to those features that distinguish the 2 taxa.

Skull

The fragments of the cranium present in AU4677 did not differ in shape from comparable parts of CM Av7116, and the only difference detected in MNZ

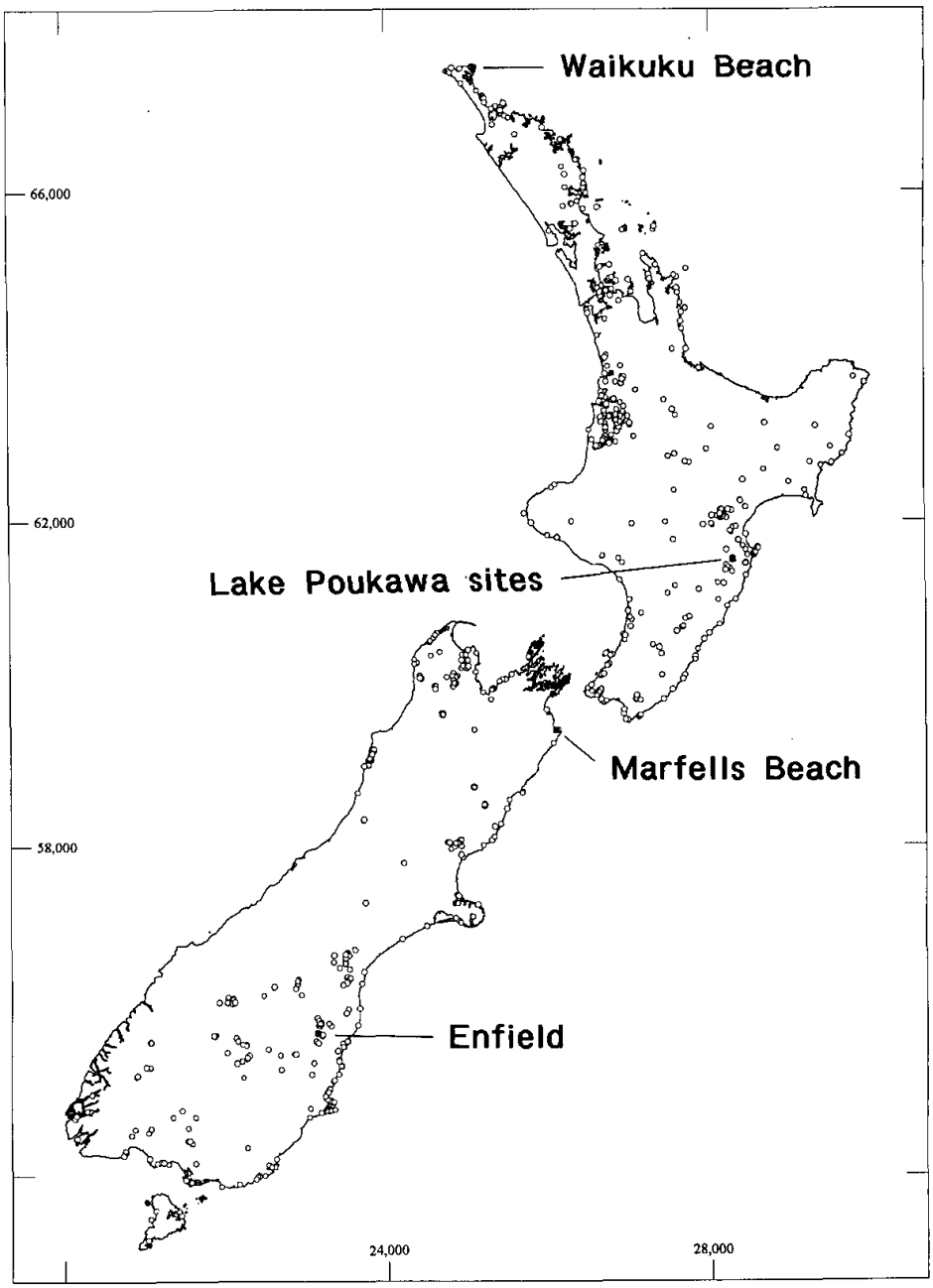

Fig. 1 Map of New Zealand showing distribution of fossil and archaeological sites for which avifaunas are known (hollow circles) and the 4 localities from which *Biziura* is known. The NZMS 260 map grid is indicated on the border.

S22160 from Poukawa was that the post-orbital width was relatively narrower in comparison to the inter-orbital width than in CM Av7116 (Table 1).

Pterygoid

The left pterygoid of AU 4677/13802 is larger (length between the quadrate and the palatine articulations 14.2 as against 11.9 mm) and differs in shape from CM Av7116. In CM Av7116, the ventral surface of the pterygoid has a deep groove formed by a flange arising on the posterior surface between the articular surfaces with the palatine and the rostro-pterygoid articulation. The flange is prominent along the posterior margin until it reaches the quadrate articulation. In AU 4677/13802, this flange is low and reaches only to the mid-point, and the resulting groove is considerably shallower than it is in CM Av7116.

Quadrate

The right quadrate of AU 4677/13802 is larger (height 17.4 cf. 15.5 mm) but is otherwise similar in shape to that of CM Av7116.

Humerus (Fig. 2)

The lengths of the deltoid and bicipital crests are relatively shorter (cf. total bone length) in the fossils than in the modern specimen (Table 2) indicating a relatively larger proximal end in the recent specimen.

Ulna (Fig. 2)

The area above the *tuberculum lig. collateralis ventralis* on the fossil AU 4677/13802 is not as deeply excavated below the ventral cotyla as it is in Av7116.

Table 1 Fossil *Biziura* specimens from New Zealand. L, length; PW, proximal width; SW, shaft width; DW, distal width; ±, estimated. Measurements by THW, except BMNH A1504, from Olson (1977).

Locality	Cat No	Element	L	PW	SW	DW
Enfield	BMNH A1504	R tmt	57.2	16.8	5.3	15.0
Marfells Beach	MNZ S23231	R tmt	56.6	15.1	7.9	14.3
Marfells Beach	MNZ S23231	L tmt	47.7	12.6	6.7	12.1
Marfells Beach	CM Av11160	R hum	122.6	25.0	7.7	15.8
Marfells Beach	CM Av11001	R fem	57.5±	16.0	5.9	16.5±
Marfells Beach	CM Av33636	L cmc	55.3	13.3		6.1
Marfells Beach	MNZ S36339	R fem	58.6	14.4	5.5	15.6
Marfells Beach	MNZ S36339	L fem	58.7	14.3	5.5	15.6
Marfells Beach	MNZ S36339	R ulna	101.7	10.9	5.9	9.3
Marfells Beach	MNZ S36339	L fem	49±	-	4.3	11.1
Poukawa - N141/1	CM Av34501	R hum	102.2	19.5	6.3	12.2
Poukawa - N141/12	MNZ S22161	R hum	97.8	18.4	5.2	10.4
Poukawa - N141/12	MNZ S22162	R hum (worn)			5.5	
Poukawa - N141/12	MNZ S17140	L fem			5.3	14.1
Poukawa - N141/12	MNZ S17550	R fem	56±		5.4	
Poukawa - N141/12	MNZ S18375	R fem	>66	16.7	6.5	
Poukawa - N141/12	MNZ S21576	sL fem			5.9	
Poukawa - N141/1	CM Av34501	worn R tt	99.5±			
Poukawa - N141/12	MNZ S19526	dR tt			6.7	13.2
Poukawa - N141/12	MNZ S21577	sL tt			6.8	
Poukawa - N141/12	MNZ S21707	sR tt			6.8	
Poukawa - N141/12	MNZ S20025	part L ramus				
Poukawa - N141/12	MNZ S22160	Cranium				
Far North, Waikuku	AU4677/13802	67/1				

Cranium	MNZ S22160	AU4677	CM Av7116
Length [A]			59.2
Interorbital W	8.8	9.8	8.1
Post-orbital W	31.6	-	36.0
Temporal fossa W	29.1	-	-
Squamosal W	-	-	33.1

A, Length from maxillo-nasal junction to posterior extent of occipital ridge.

Pelvis MNZ S36339, Marfells Beach	mm
Width at anti-trochanters	26.1
Length from the anterior margin of the acetabular foramen to the anterior end of the synsacrum	32.5

Coracoid (Fig. 3)

In AU 4677/13802, the ventral sternal facet was shorter relative to the width of the sternal end of the coracoid than in the recent specimen (41% cf. 52% in CM Av7116).

Pelvis

A pelvis from Marfells Beach, MNZ S36339, is the first example of this element known for *Biziura delautouri*. It differs from the pelvis in CM Av7116 mainly by being larger. While incomplete (broken ischia and pubes, and eroded lateral margins of the *ala postacetabularis ilii*), the pelvis differs markedly from that of *Anas* and most other anatids in that the *ala preacetabularis ilii* are fused in the midline, the *tuberculum preacetabulare* is prominent, it is narrow posteriorly with no *foramina intertransversaria*, and the *crista spinosa synsacri* is a prominent ridge along the midline posterior of the acetabulum.

Femora (Fig. 4)

The ventral surface of the femur has a distinct groove, possibly for the insertion of *M. ischiofemoralis*, which leads from the area between the femoral ball and the lateral surface. The groove is sharply delineated proximally in CM Av11001 and AU 4677/13802 but not in the modern CM Av7116. The *fossa poplitea* is deeper in the fossils than in CM Av7116.

Tibiotarsi (Fig. 4)

The *crista patellaris* is evenly convex caudally in the recent CM Av7116 in contrast to the condition in

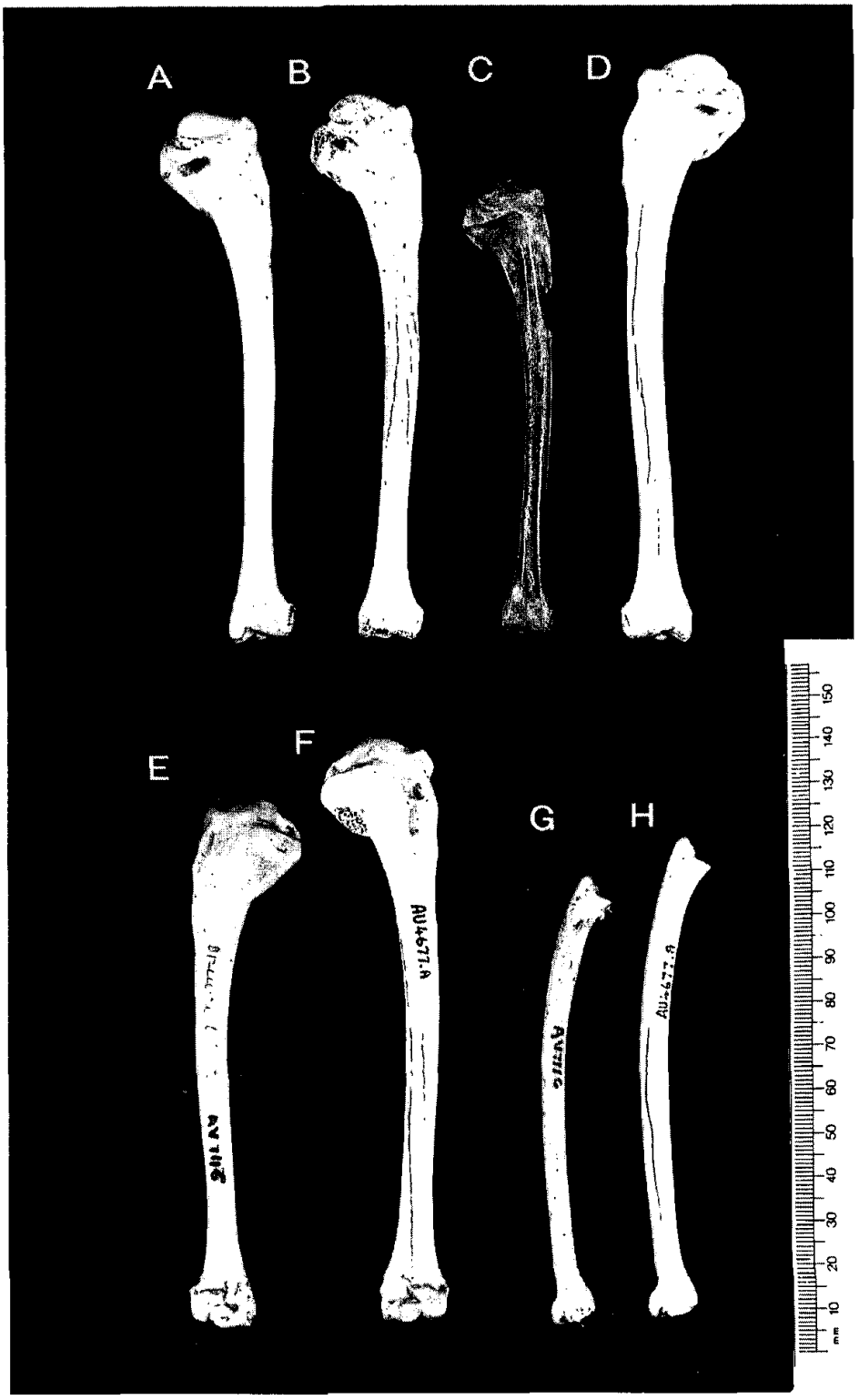

Fig. 2(A-H) Humeri of *Biziura* in caudal view (A-C, right side, D, left side) and in cranial view (E, F); left ulnae in ventral aspect (G, H). A, E, G, *B. lobata*, CM Av7116; remainder are *B. delautouri*, B, CM Av11160; C, CM Av34501; D, F, H, AU4677.

AU 4677/13802 where it is bounded by tuberosities on the rear of the *crista cnemialis cranialis* and on the *c. c. lateralis*, and is concave centrally.

On both fossils AU 4677/13802 and CM Av34510, the *impressio lig. collateralis medialis* is much deeper than in the recent CM Av7116, and undercuts the *facies artic. medialis* as a deep pocket, which is not present in CM Av7116. The angle formed by the *facies cranialis* and the *facies medialis* at the midpoint of the fibular crest is near 90° in AU 4677/13802 and CM Av34501, but is acute in CM Av7116.

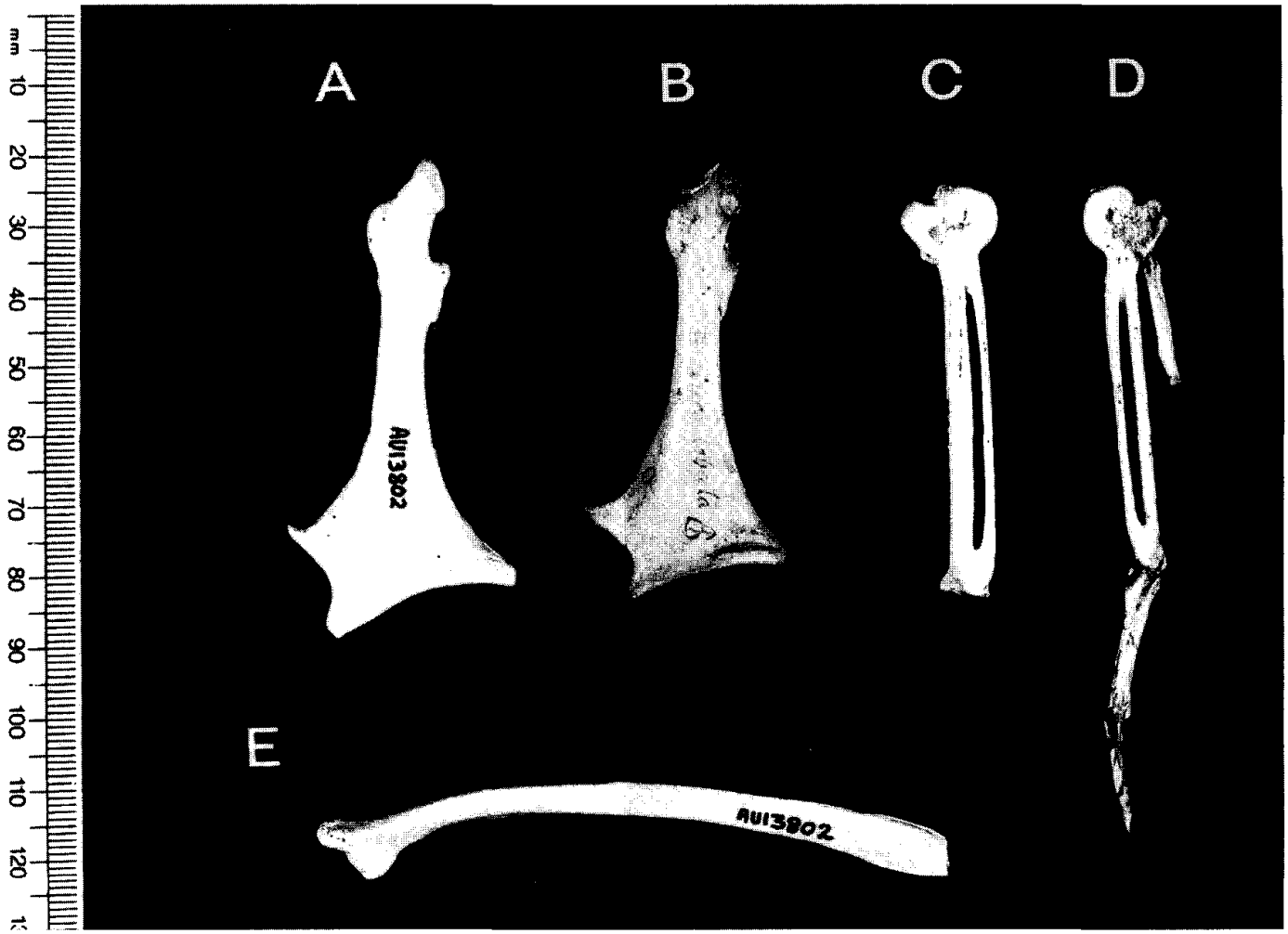

Fig. 3 (A-E) Right coracoids (A, B), carpometacarpi (C, D) and right scapula (E) of *Biziura lobata* CM Av7116 (B, D) and *B. delautouri* from Waikuku Beach AU13802 (A, C, E).

Tarsometatarsi (Fig. 4)

No significant differences between the fossils and recent specimens in the shape and extent of the intercotylar eminence were found, but the morphology of the hypotarsal canals differed as Olson (1977) stated. In the modern CM Av7116, all canals have a similar proximal depth, but in the fossils (AU 4677/13802 and MNZ S23231), the canal between hypotarsal ridges 2 and 3 is smaller and raised markedly above a line joining the outer and inner canals. In the modern specimen, hypotarsal ridge 3 is distinct from ridge 2 distally and terminates midway between the lateral foramen and the canal between ridges 1 and 2. In the fossils, ridge 3 converges distally on ridge 2 and the combined ridge terminates midway between the lateral foramen and the canal between ridges 1 and 2. Another possible difference is the medial profile of the hypotarsal ridge 1: the modern CM Av7116 and the BM specimen (Harrison & Walker 1970, Plate 1) have the ridge hooked distally, but the fossil (MNZ S23231) has no distal hook. The area is worn in other fossils.

Table 2 Measurements (mm) for fossil humeri of *Biziura* from New Zealand in comparison to a modern specimen (Av7116). DC, length of deltoid crest; BC, length of bicipital crest; TL, total length of humerus.

	DC	BC	TL	DC/TL	BC/TL
CM Av11160, fossil	33.0	24.7	122.6	0.269	0.201
CM Av34501, fossil	25.5	18.4	102.2	0.249	0.180
AU4677, fossil	30.3	26.2	131.9	0.229	0.199
CM Av7116, modern	33.3	27.4	120.0	0.277	0.228

MEASUREMENTS

The fossil *Biziura* bones from New Zealand vary widely in size as expected because the living *B. lobata* is markedly sexually dimorphic (Marchant & Higgins 1990; McCracken et al. 2000). The Waikuku specimen is the largest from New Zealand (Table 4), and the only one that allows the relative size of different bones to be examined. That the New Zealand bird might differ from *Biziura lobata* is indicated by the variation in percentage difference in size of each element from the corresponding ele-

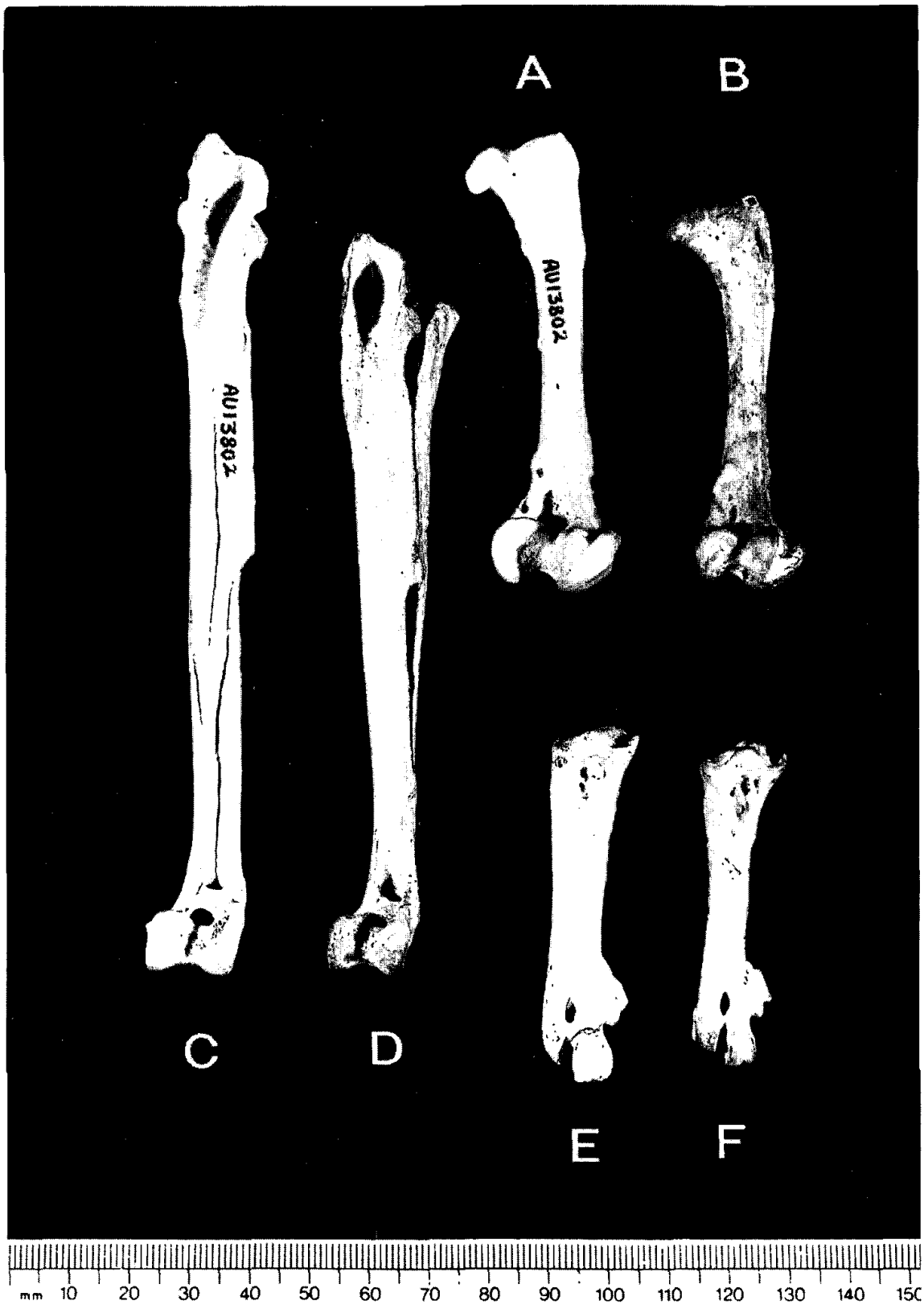

Fig. 4 (A-F) Leg bones of *Biziura delautouri* from Waikuku Beach AU13802 (A, C, E) compared to. *B. lobata* CM Av7116 (B, D, F). A, B – right femora; C, D – left tibiotarsi; E, F – right tarsometatarsi.

ment in CM Av7116 (% difference, Table 4). The legs are relatively larger than the wings. The percentage difference in normalised lengths (element length divided by femur length) between the 3 modern *B. lobata* skeletons (Table 3) and the corresponding values for the Waikuku specimen for each element are given in Fig. 5. The modern *B. lobata* have normalised humeri and ulnae lengths some 9-13% greater than the Waikuku specimen, whereas the tibiotarsus and tarsometatarsus display relatively smaller differences. Hence the Waikuku specimen, apart from being larger overall, has relatively

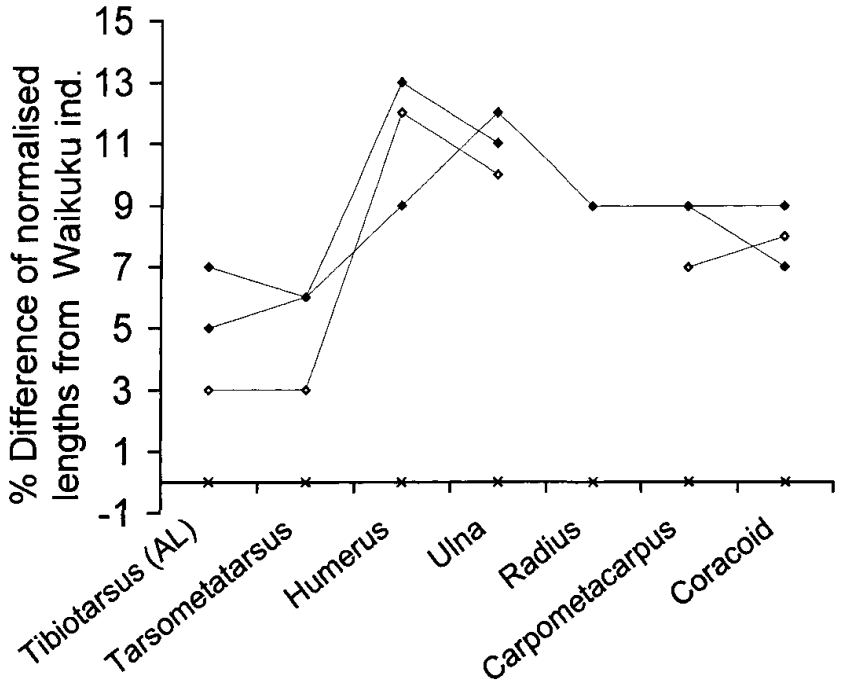

Fig. 5 Ratios of element lengths of 3 modern *B. lobata* plotted against those for the Waikuku fossil. Element lengths for individuals (Tables 3, 4) were normalised by dividing them by femur length and the percentage differences from the Waikuku specimen plotted, i.e. the Waikuku specimen is the basis of the comparison, with a 0 value for each element. Articular length of tibiotarsus (distal end to proximal articular surface) was used, because the cnemial crest could be expected to have undue individual variation associated with age or allometric factors. Filled diamond, specimens CM Av 7116 and AMS720; open diamond, NMNH 553598; crosses, Waikuku Beach fossil individual.

Table 3 Measurements (mm) of modern *Biziura lobata* bones. Measurements for BM 1900.6.24.1 from Harrison & Walker (1970); Museum Victoria (NM) specimens from Scarlett (1969); other 3 by THW. Dimensions: L, length (tibiotarsi length given as both total length – TL – and length from proximal articular surface –art. L; P, proximal width; S, shaft width (latero-medial width – anconal aspect; if 2 measurements are given, 2nd is dorsoventral width –palmar aspect; tibiotarsal, femoral, and tarsometatarsal shaft widths minimum values, other shaft widths at mid length; D, distal width. In addition to these measurements, Olson (1977) gave the following ranges for length of tarsometatarsi: 5 males: 50.8-52.6 mm; 3 females: 39.5-44.0 mm.

	Dimension	AM S720	CM Av7116	NMNH 553598	BM 1900.6.24.1	NM W5353	NM B6808
Sex		?M	M	F	M	F	F
Humerus	L	117.1	120.0	96.6		97.0	97.0
	P	23.7	24.5	19.3		21.0	19.0
	S	7.1	7.0 x 5.7	5.4		5.5	5.5
	D	14.4	16.1	12.0		11.5	10.0
Ulna	L	96.7	102.2	80.0			
	P	10.0	10.2	8.1			
	S	5.4	5.2 x 5.5	4.2			
	D	8.6	9.1	7.2			
Carpometacarpus	L	55.3	57.6	44.5			
	P	12.4	12.6	10.1			
Femur	L	61.1	64.3	50.8			
	P	16.3	16.6	13.4			
	S	6.1	6.4	5.0			
	D	17.5	18.2	15.2			
Tibiotarsus	TL	117.1	119.4	94.3			
	art. L	107.0	111.0	86.7			
	P	13.7	13.9	11.4			
	S	6.67	7.2 x 5.1	5.4			
	D	13.7	13.2	11.4			
Tarsometatarsus	L	51.2	53.6	41.2	54.6		
	P	14.3	14.2	12.1	17.2		
	S	7.3	7.1	5.8	5.0		
	D	12.9	13.5	10.7	14.6		
Coracoid	L	56.7	58.3	46.8			
	D	23.4	23.5	-			

Table 4 Measurements (mm) for bones of the *Biziura* specimen from Waikuku Beach and modern male, CM Av7116. Lengths are maxima, except for coracoids where medial length is given, and tibiotarsi, where lengths between articular surfaces is in parentheses. Other measurements are also maxima, except ulna shaft width given here in cranial view, and the shaft widths of femora, which are in caudal view first then lateral view. Width of the distal ulna is the maximum width across the dorsal condyle. Dim: L, length; P, proximal width; S, shaft width; D, distal width. % Diff. is the percentage difference in length of the Waikuku specimen and the recent male. A, cracked; B, arthritic proximal end.

		Dimension					
Element	Side	L	P	S	D	Length Av7116	% Diff.
Femur	L	74.4	18.9	6.6	21.1	64.2	16.0
	R	74.0	19.0	6.9*9.0	20.8	64.0	15.6
Tibiotarsus	L	134.9 (125.0)	15.5	8.5 [A]	15.2	119.7	12.8
	R	134.8 (124.8)	15.3	7.8	15.1	119.6	12.7
Tarsometatarsus	L	-	-	8.4	-	-	-
	R	58.0	14.5	8.3	14.4	53.6	8.3
Humerus	L	131.9	26.4	8.3 [A]	16.4	120.1	9.9
	R	131.7	24.4	7.7	16.6	-	-
Ulna	L	108.8	11.1	7.0	9.8	102.2	6.4
	R	109.3	11.2	6.0	9.9	101.6[B]	-
Radius	L	105.5	-	-	7.3	97.3	8.4
	R	105.9	-	-	6.9	97.4	8.8
Carpometacarpus	L	60.5	14.3	4.66	8.8	57.4	5.5
	R	60.3	14.2	4.74	8.5	57.6	4.7
Coracoid	L	62.3			28.3	-	-
	R	62.0			28.1	58.3	6.3

very large femora and large tibiotarsi and tarsometatarsi, or conversely, that modern *B. lobata* has relatively longer wing elements. If the Waikuku specimen is representative of the population formerly living in New Zealand, it appears that the New Zealand birds may have been becoming more sedentary, with bigger legs and relatively shorter wings than their Australian counterparts. However, the New Zealand birds were still able fliers.

The larger bones, for example, the tarsometatarsi longer than c. 56 mm (BMNH A1504, MNZ S23231), or the femora longer than c. 56 mm (CM Av11001, MNZ S36339 [the larger left and right bones], MNZ S18375), are larger than those of any modern males for which I have data. Therefore, male *Biziura delautouri* were probably larger than male *B. lobata*, which are c. 66 cm long and a weigh about 2.4 kg (Marchant & Higgins 1990). The smaller, presumably female, fossil bones are likewise larger than those of modern females, which are c. 55 cm long and weigh about 1.55 kg (Tables 1, 3).

DISCUSSION

The fossil record of *Biziura* is sparse in New Zealand. However, fossils have been found from the northern tip of North Island to North Otago, and where multiple bones have been found, they include both males and females. As the form is distinct from *B. lobata*, it must be assumed that the fossils represent a breeding population. Fossils are likely to be rare because fossil sites that sample the habitat preferred by musk ducks, as seen in Australia, are rare in New Zealand. In Australia, *B. lobata* is almost entirely aquatic, favouring deep water, stable, large, permanent swamps, lakes or estuaries (Marchant & Higgins 1990). The two main fossil sites in which *B. delautouri* has been found, Lake Poukawa and Marfells Beach adjacent to Lake Grassmere, suggest that New Zealand birds had similar requirements to their Australian counterparts.

The morphological differences in size, different relative proportions of skeletal elements, and variation in the shape of bones in comparison to *Biziura lobata*, confirm that the New Zealand musk duck was a distinct species, as originally described by Forbes (1892: March), and provisionally upheld by Olson (1977). It is therefore retained as a member of the New Zealand fauna.

ACKNOWLEDGEMENTS

I thank Rory O'Brien for providing information on Museum Victoria specimens, and the following people for allowing access to specimens in their care: Storrs Olson, Division of Birds, National Museum of Natural History, Smithsonian Institution; Walter Boles, Australian Museum; Geoff Tunnicliffe, Canterbury Museum, Alan Tennyson, Museum of New Zealand Te Papa Tongarewa; Neville Hudson and Jack Grant-Mackie, Geology Department, Auckland University. I thank Jim Palmer for the photography, and Storrs Olson and Richard Holdaway for comments that improved the text.

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