A SHELDUCK (ANATIDAE: TADORNA) FROM THE PLIOCENE OF SOUTH AUSTRALIA

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Summary

A complete fossil humerus referable to a shelduck (Anatidae: Tadorna sp.) is reported from an uncertain locality in the ‘Bookmark cliffs’ on the River Murray, a few kilometres upstream from Berri and Lyrup southwest of Renmark, in the Riverland region of South Australia. The fossil was embedded in a piece of pale grey, clean coarse sandstone having a siliceous cement. This is interpreted as being Parilla Sand, of late Pliocene age, which outcrops along the Murray River from Renmark to Loxton.

Keywords. Pliocene fossil, Shelduck, Anatidae, Tadorna, Australia.

Running Head. A Pliocene Shelduck

Introduction

The Tertiary fossil record of Australian avifaunas is relatively rich with faunas derived from early Oligocene and younger deposits as reviewed by Vickers-Rich (1991). The giant mihirung birds (Aves: Dromornithidae) once considered to be ratites are basal neornithines related to anseriforms and are well-known and widespread members of the Tertiary avifaunas (e.g. Murray & Vickers-Rich 2004). Other prominent and described components of the avifaunas from lacustrine and fluvial deposits are flamingos and palaelodids (Miller 1963; Rich et al. 1987; Baird & Vickers-Rich 1998) and pelicans (Vickers-Rich & van Tets 1981), ratites (Boles 1991) and megapodes (Boles & Ivison 1999), particularly in the South Australian deposits.

In contrast to the above groups, while waterfowl (Aves: Anseriformes) have been reported from various Australian Tertiary fossil faunas (e.g., Rich & van Tets 1982; Tedford & Wells 1990; Vickers-Rich 1991; Tedford et al. 1992; Boles & Mackness 1994; Boles 1997), they are very poorly known. None of the anseriform fossils from the late Oligocene – Miocene lacustrine deposits of the Lake Eyre and Tarkarooloo basins of northern South Australia (Vickers-Rich 1991) have been described. Anseriform fossils are relatively common in Pliocene-Pleistocene deposits (Tedford & Wells 1990; Tedford et al. 1992; Boles & Mackness 1994), but all nine extinct taxa named by de Vis from the Pliocene-Pleistocene have been referred to modern species by Olson (1977). Boles & Mackness (1994) noted the existence of several anatid taxa in Pliocene sediments of the Allingham Formation, Queensland, including a potentially undescribed Nettapus species. However, as yet, no extant anatids have been described from Australia, and no extant waterfowl taxa are known from pre-Pliocene deposits from Australia (Vickers-Rich 1991). This is despite taxa such as Anseranas (Anseranatidae), the dendrocygnines Dendrocygna spp, the anserines Cereopsis and Cnemiornis, and Stictonetta, all being primitive members of the Recent fauna (Livezey 1986, 1989, 1996, 1997; Kear 2005; Worthy et al. 1997) and therefore presumed to have a long history in the region.

The discovery of a fossil anatid humerus without data, but of likely pre-Pleistocene age, in the South Australian Museum collections is thus significant and precipitated this report. When prepared out of the matrix it was found to differ little from a modern taxon, but comparison of the matrix with other specimens of known provenance suggests it is of Pliocene age.
Abbreviations

Institutions: ANWC, Australian National Wildlife Collection, CSIRO, Canberra, Australia; BMNH, The Natural History Museum, London, United Kingdom; MNZ, Museum of New Zealand Te Papa Tongarewa, Wellington, New Zealand (formerly National Museum of New Zealand, Dominion Museum, and Colonial Museum); MV, Museum Victoria, Melbourne, Victoria, Australia; SAM, South Australia Museum, Adelaide, South Australia.

Materials and Methods

The fossil was mechanically prepared from the matrix by THW. Comparisons were then made with recent skeletons of a wide range of waterfowl taxa in the Bird Department, SAM. Additional taxa were examined from the collections of ANWC, MV, and MNZ. Measurements were made with Tesa® dial callipers and rounded to 0.1 mm. Anatomical nomenclature of specific bone landmarks follows Baumel & Witmer (1993) with English translations, or names following Howard (1929), thereafter.

Comparative tadornine material used in this study

*Tadorna tadornoides* (Jardine & Selby, 1828), Australian shelduck: Females, SAM B. 39572, 39872, 39873, 39874, 39875, 39877, 39878, 39879, 39886, 39887, 39889, 39890, 39894, 39897, 39902 (probable female), 46462. Males, SAM B.37048, 39567, 39568, 39575, 39578, 39579, 39580, 39584, 39585, 39591, 39592, 39593, 39595, 39899, 39901, 46554 (probable male). The two specimens referred to as ‘probable’ male or female were so allocated by their size, which was well within the range of the referred sex. *Tadorna variegata* (Gmelin, 1789), paradise shelduck: MNZ 25139, 25669, 26563, 26562, 16472, 16471, 15146, 16473, 24559, 16501, 16590. *Tadorna ferruginea* (Pallas, 1764), ruddy shelduck: SAM B.38602. *Tadorna tadorna* (Linnaeus, 1758), common shelduck: MNZ 12280; MV B25679; ANWC 22408, male. *Tadorna radjah* (Lesson, 1828), Radjah shelduck: MNZ 26206, 26207; ANWC 22411, male. *Alopochen aegyptiaca* (Linnaeus, 1766), Egyptian sheldgoose: ANWC 22239, male; BMNH 1930.3.24.217, unsexed; MNZ 24283; MV B25678. *Chloephaga picta* (Gmelin, 1789), upland sheldgoose: BMNH 1860.11.4.15. *Chloephaga poliocephala* (Sclater, 1857), ashy-headed sheldgoose: MV B13714, female. *Chloephaga hybridia* (Molina, 1782), kelp sheldgoose: MV B13227, male.

Results

Description of SAM P.19783 (Fig. 1)

SAM P.19783 is a right humerus that was slightly weathered before burial but is complete except for surface layers of bone in a few places, notably over the head, the *tuberculum ventrale* (ventral tubercle), the prominence on the *ectepicondylus dorsalis* (dorsal ectepicondyle), and the loss of the edge of the *crista deltopectoralis* (deltoid crest). While not all sediment was removed from the ventral pneumotricipital fossa, sufficient amounts were taken to indicate that the fossa was pneumatic and extended deeply under the *crus dorsale fossae*.

**Measurements:** Table 1 presents measurements for SAM P.19783 with comparative data from several other *Tadorna* species, which shows that it is smaller than *T. tadornoides*, *T. variegata*, and *T. ferruginea* and similar in size to *T. tadorna*.

**Locality:** The specimen SAM P.19783 was a humerus exposed in cranial view in a block of silicified sandstone. The only recorded datum associated with it was that it derived from the ‘Old Collections’. The sediment is distinctive coarse sand whose interstitial spaces are only partly infilled with silica, creating a cohesive, non-friable matrix. There are two other fossil specimens in South Australian Museum, still embedded in a very similar hard matrix. One is a battered left femur (SAM P.42169) broken both proximally and distally, tentatively identified as a sthenurine.
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kangaroo on the basis of its size and slightly curved shaft, collected by a Mr A. Owen in 1934. The other specimen is the shattered and incomplete right tibia of a macropodid (SAM P.18651), on which is pencilled “Bookmark Cliffs Murray River”. An associated printed cardboard display label states “Tibia of a KANGAROO in calcareous sandstone. Bookmark Cliff, River Murray. From a sandstone quarry at a depth of about 5 feet. PRESENTED BY MR. P. GODET.”. An associated note written in pencil on a piece of cardboard states “This specimen was kept by the late Prof. Stirling in his room in the old museum building, but no label could be found referring to any data concerning the specimen. [signed] F.R. Zietz, 23-vi-1920”. Therefore it is likely that the fossil bird bone described here was collected some years prior to 1920 (Stirling retired at the end of 1912, to an honorary position and died in 1919). The similar lithology and hence probable origin of the two macropodid specimens was apparently first noted by the then Honorary Mammalogist H. H. Finlayson in 1944.

Figure 1. Humeri of Tadorna species in caudal views (A-C) and cranial view (D, E). The Pliocene fossil SAM P.19783 (A, B, D) and Tadorna tadornoides SAM B.39873. Abbreviations: bc, bicipital crest; bf, brachial fossa; cd, dorsal condyle; ci, capital incision; csr, capital; shaft ridge; cv, ventral condyle; dc, deltoid crest; dpf, dorsal pneumatic fossa; dt, dorsal tubercle; h, humeral head; vpf, ventral pneumatic fossa; vt, ventral tubercle. Scale bar = 50 mm.

Bookmark Cliffs is the local name for cliffs near Bookpurnong on the Murray River just north of the town of Berri, southwest of Renmark (Baker et al. 2001). The area on the north side of the river due north of Lyrup is labelled ‘Bookmark’ on some old maps. ‘Bookmark’ was an old name for ‘Calperum’ station, a large property that once extended all the way to the Victorian border, and is now preserved in the name ‘Bookmark Biosphere Reserve’. The ‘RENMARK’ geological map, (S.A. Geological Atlas Series Sheet SI 54-10, 1:250,000, 1971 edition), has two sandstone quarries marked on the south (left) side of the Murray River near Lyrup. The quarry nearest the river is at
map grid 367767 on the RENMARK map. A few kilometres down river, just north of Loxton North and also on the south bank, there are quarries marked near ‘Bookpurnong’ at 362757 and 363754 on the RENMARK map, and the river stretch immediately downstream (west) of Bookpurnong Cliffs is called Bookmark Bend (Baker et al. 2001).

All these quarries were most likely for mining the Parilla Sand, which are shown on the RENMARK geological map as outcropping on the cliffs along the Murray River from Renmark to Loxton. The RENMARK geological map describes the Parilla Sand as “Fluvialite light grey, pale brown and pale yellow fine to medium grained clayey quartz sand with thin beds of olive sandy clay near the top. Upper sandy beds have been silicified in some places.” One of these quarries is therefore likely to be the source of the macropod fossil SAM P.18651, which is embedded in sandstone matching the description of the silicified part of the Parilla Sand. Based on similarity of matrix, it is likely that anatid humerus described below (SAM P.19783) is also derived from the Parilla Sand in this region of the Murray River.

**STRATIGRAPHY/AGE:** Probably Parilla Sand, which is of fluviatile origin and dated as Upper Pliocene in age (Firman 1966; Gill 1973; Morand et al. 2003; Rogers et al. 1995).

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**Systematic Palaeontology**

**Family ANATIDAE Leach:** Swans, Geese, Ducks

**Subfamily TADORINAE Reichenbach:** Shelducks

Tadorninae Reichenbach, 1849-1850; Avium Systema Naturale, p. X – tribus, i.e. subfamily; type *Tadorna* Fleming.

We refer SAM P.19783 to Tadorninae because it has the following unique combination of characters identified in part by Woolfenden (1961) and by Worthy et al. (2007), whose landmarks are shown in Figure 1: (1), is similar in size and proportions to tadornines; (2), has a capital shaft ridge extending to the ventral side of the *tuberculum dorsale* (dorsal tubercle); (3), has a shallow, relatively narrow, dorsal part to the *fossa pneumotricipitalis* (pneumotricipital fossa) that does not undercut the head; (4), has a concave dorsal surface to the deltid crest, which is elongate with 37% of length extending distal of the *crista bicipitalis* (bicipital crest); (5), has a dorsal tubercle elevated above the shaft; (6), has a *capital incisura* that in anconal or palmar view forms a shallow notch in proximal profile (rather than a deep notch or none); (7), has a pneumatic ventral pneumotricipital fossa that is wider than long; (8), has a proximally directed ventral tubercle; and (9), lacks a prominent *tuberculum supracondylare dorsale* (ectepicondylar prominence) distally.

Within Anseriforms, character (2) is here considered derived in Tadorninae, with the plesiomorphic condition of the capital ridge directed towards the head in Anhimidae and Anseranatidae, the sister taxa of Anatidae, and only in *Dendrocygna* and *Thalassornis* within Anatidae. Character (3) is also derived in Tadorninae, with the plesiomorphic condition (absence of a flattened dorsal pneumotricipital fossa) in Anhimidae, Anseranatidae, *Dendrocygna*, and *Thalassornis*. Characters (1) elongate shape, (4), and (5), are retained plesiomorphic features of Anseriformes. The shallow depth of the notch formed by the *capital incisura* in the profile of the proximal end (Characters 6) is derived relative to Anhimidae and Anseranatidae, where no notch is formed. Within Anatidae, presence of a shallow notch is more derived than in all Anserines, most *Dendrocygna* species, and *Alopochen* and *Chloephaga* (no notch), but less derived than *Thalassornis*, *Oxyura*, *Biziura* and all Anatines, which have a marked notch. Character (7) is considered a retained plesiomorphic character as seen in Anhimidae, Anseranatidae, and *Dendrocygna*, however, the size of the fossa is much enlarged compared with these taxa. The derived condition of a closed or non-pneumatic fossa occurs in *Thalassornis*, *Biziura*, *Oxyura*, *Aythya*, *Malacorhynchus*, *Mionetta*. Character (8) is also a retained plesiomorphic character with the derived condition (ventral tubercle overlapping the fossa) occurring in all diving taxa.
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The fossil is smaller than the humerus of *Anseranas* and those of all anserines, including *Cereopsis* and *Cygnus. Anseranas*, *Cereopsis* and *Dendrocygna* species also differ markedly from the fossil by having a stronger capital shaft ridge that is directed more ventrally towards the head, a much narrower dorsal pneumotricipital fossa, a more proximally-located epicondylus ventralis, and a more accentuated ectepicondylar prominence. The fossil is of similar length to some humeri of *Biziura lobata*, but this taxon differs markedly with a closed ventral pneumotricipital fossa, as have all oxyurines. The fossil is larger and more elongate than the humerus of *Stictonetta*, and of any anatine including *Chenonetta* and all *Anas* species.

Genus Tadorna Lorenz von Oken

*Tadorna* Lorenz von Oken, 1817, Isis von Oken 1: 1183 – type (by tautonymy) *Anas tadorna* Linnaeus.

SAM P.19783 is identified as *Tadorna* among modern tadornines as it shares with *Tadorna variegata*, *T. tadornoides*, *T. radjah*, and *T. tadorna* a highly pneumatic ventral pneumotricipital fossa, a capital shaft ridge that reaches the base of the dorsal tubercle, and a relatively shallow brachial fossa that is not especially deepened distomedially and that is separated from the medial margin by a relatively narrow rounded ridge. The three tadornines in the Australasian region were separated generically by Livezey (1997), with the two larger taxa, *T. tadornoides* and *T. variegata*, placed in the unbanded shelduck subgenus *Casarca* Bonaparte, 1838 and *T. radjah* left in *Tadorna*. We leave all in *Tadorna* following Dickinson (2003) and Kear (2005).

In Australia, there are two extant tadornine species. The tropical *Tadorna radjah* is a small species, and its humeri (e.g. ANWC 22408) are smaller than the fossil and differ markedly from the fossil and those of other extant *Tadorna* as follows. Its humerus has a less elevated dorsal tubercle, a much broader dorsal pneumotricipital fossa and much narrower opening to the ventral pneumotricipital fossa. The wider dorsal pneumotricipital fossa in *T. radjah* is deeper than that in *T. tadornoides*, which results in *T. radjah* having a better-defined capital shaft ridge. The relative prominence of the capital shaft ridge is therefore similar in *T. radjah* and in the fossil. The more widespread shelduck *T. tadornoides* is a larger sexually dimorphic species (Table 1). An outlier to the size range, the female SAM B.39881 with a humerus length of 100.8 mm, appears to be an aberrant specimen, but illustrates the possibility of specimens outside the normal range. Apart from its smaller size, the fossil differs from humeri of *T. tadornoides* by having a slightly deeper dorsal pneumotricipital fossa resulting in a better-defined capital shaft ridge. The deeper fossa results in the dorsal end of the *incisura capitalis* (capital groove) being higher (more caudal) than the fossa, rather than coplanar with it. The ventral tubercle appears less robust, but this may be due to erosion of its caudal surface. The humeri of New Zealand *T. variegata* are on average of larger size than *T. tadornoides* (Table 1) but are similar to the fossil with a deeper dorsal pneumotricipital fossa and better defined capital shaft ridge than in *T. tadornoides*. The humerus of *Tadorna ferruginea* (Europe) has a relatively slender shaft, a shallower brachial depression and relatively short deltoid crest, but has a similar deeper dorsal pneumotricipital fossa and better developed capital shaft ridge than those for *T. tadornoides*. Humeri of *Tadorna tadorna* (Europe) have very similar proportions to the fossil but have a distinctly shorter deltoid crest.

Shelducks are known from the Australasian fossil record by *Miotadorna* from the New Zealand Early-Middle Miocene (Worthy *et al*. 2007). Compared with SAM P.19783, humeri of *Miotadorna* have a much less pneumatic ventral pneumotricipital fossa with pneumatic bone extending from the interior to below the *crus dorsale fossae*; a capital shaft ridge that is sharper proximally and that is separated from the dorsal tubercle by a deep distally-flaring groove; a relatively small brachial depression that is deepest in the ventro-distal portion (not flat and shallow), and which is separated from the ventral margin by a convex surface wider than the facet for the attachment of the anterior articular ligament (separation of the brachial fossa from the ventral facies is much narrower in SAM P.19783).
Table 1. Measurement data for various species of *Tadorna* in mm compared with SAM P.19783. Data for *T. tadornoides* and *T. variegata* are given as mean, standard deviation, and range. Specimens (see Methods), except for *T. radjah* (ANWC 22411), and for *T. tadorna* (ANWC 22408). Abbreviations: TL, total length; PW, proximal width from tuberculum dorsale to tuberculum ventrale with calliper held parallel to shaft; SW, mid-shaft width in caudal view; DW, distal width in cranial/palmar view; d.c. is dorsal condyle; t.v., tuberculum ventrale; and v.p.f. is ventral pneumotricipital fossa.

| Taxon          | TL     | PW | Depth caput | Depth t.v. | Width caput | Length deltoid crest | SW  | DW  | Depth d.c. | Width v.p.f. |
|----------------|--------|----|-------------|------------|-------------|----------------------|-----|-----|------------|--------------|
| *T. radjah*    | 98.8   | 22.9 | 8.6         | 10.9       | 16.5        | 23.6                 | 7.4 | 16.0| 9.5        | 9.0          |
| *T. tadorna*   | 108.5  | 24.9 | 8.2         | 12.1       | 17.1        | 29.2                 | 7.7 | 16.7| 9.8        | 10.5         |
| *T. ferruginea*| 112.4  | 22.9 | 8.6         | 11.4       | 18.1        | 29.1                 | 7.5 | 16.9| 9.8        | 10.8         |
| *T. tadornoides* females (n=16) | 115.8, 2.77 | 25.0, 0.47 | 8.6, 0.26 | 12.2, 0.46 | 18.6, 0.55 | 31.4, 0.71 | 8.3, 0.36 | 17.6, 0.38 | 10.4, 0.26 | 11.3, 0.40 |
| *T. tadornoides* males (n=16) | 126.6, 2.13 | 26.9, 0.71 | 9.5, 0.29 | 13.6, 0.77 | 19.8, 0.61 | 33.8, 0.94 | 8.9, 0.33 | 19.0, 0.51 | 11.1, 0.35 | 12.6, 0.43 |
| *T. variegata* (5F,6M) | 126.4, 6.32 | 25.4, 1.28 | 19.5, 1.05 | 18.1-20.8 | 8.6, 0.42 | 18.3, 1.03 | 16.8-19.5 |
| SAM P.19783    | 105.4  | 22.4 | 8.2         | 10.2       | 17.1        | 26.2                 | 7.8 | 16.4| 9.1        | 10.0         |
Humeri of other tadornines were even less similar to the fossil. That of the African *Alopochen aegyptiacus* has a highly pneumatic ventral pneumotricipital fossa as in other modern tadornines, but differs from *Tadorna* by a more marked concavity of the dorsal surface of the deltoid crest, a usually weaker capital shaft ridge, and a relatively small, centrally placed brachial depression that is separated from the ventral facies by a broad rounded surface wider than the facet for the attachment of the anterior articular ligament. Humeri of the South American sheldgeese (*Chloephaga* spp.) have a very weak to non-existent capital shaft ridge, with the shaft slightly compressed adjacent to the angle of the deltoid crest, but are well-rounded from there proximally, and have a very deeply concave dorsal surface to the deltoid crest, and so differ markedly from those of *Tadorna* and *Alopochen*. As *Chloephaga* is confined to South America and *Alopochen* to Africa, Madagascar, and the Mascarenes, both to the exclusion of other tadornines, neither genus is likely in Australia.

The fossil SAM P.19783 is clearly a *Tadorna* species and the differences between it and *T. tadornoides* (smaller size and a slightly deeper dorsal pneumotricipital fossa and associated slightly better defined capital shaft ridge) are minimal and could easily reflect temporal and geographic variation within a species. We therefore refrain from naming this fossil as a distinct taxon and refer it to *Tadorna cf. T. tadornoides*.

**Discussion**

The fossil SAM P.19783, referred here to *Tadorna cf. T. tadornoides*, is the first fossil member of Anatidae: Tadorninae from the Australian Tertiary to be described. It reveals the presence of the *Tadorna* lineage in Australia at least three to two million years ago, which is expected given the presence of tadornines in New Zealand 19-16 million years ago (Worthy et al. 2007). The presence of a modern species of waterfowl in the upper Pliocene is not unexpected given that all Pleistocene waterfowl fossils so far reported from Australia are referable to modern taxa (Olson 1977). The fossil is slightly smaller than the smallest examples of modern *Tadorna tadornoides* and is not qualitatively distinct from that species. Given the similarity of the New Zealand *Tadorna variegata* to *T. tadornoides*, which on humeri alone, only separate on mean size, it remains a possibility that SAM P.19783, at three to two million years old, represents an ancestral form of one or both of these species. Resolution of this issue awaits more complete material.

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