A new emu (Dromaiinae) from the Late Oligocene Etadunna Formation

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Abstract. A new emu (Emuarius guljaruba, sp. nov.) is described from the Late Oligocene Etadunna Formation (Ngama Local Fauna), based on a complete tarsometatarsus. While exhibiting evidence of cursorial abilities advanced over those of cassowaries (Casuarius), this taxon was not as cursorially adapted as the living Emu (Dromaius novaehollandiae). This taxon is provisionally referred to the genus Emuarius, although a definite generic assignment cannot be made.

Introduction

Emus (Dromaius) are one of the most characteristic elements of the modern Australian avifauna. There is only a single living species, D. novaehollandiae, although the Tasmanian population (possibly specifically distinct) and two dwarf species, D. baudinianus (Kangaroo Island) and D. ater (King Island), have gone extinct within the past 200 years. There have been several nominal fossil species erected, primarily by C. W. De Vis towards the end of the 19th century (De Vis 1888, 1892). The fossil record of emus was reviewed by Patterson and Rich (1987) who reduced D. patricius De Vis, 1888, D. gracilipes De Vis, 1892 and the putative kiwi Metapteryx bifrons De Vis, 1892 to the synonymy of the living D. novaehollandiae. The only previously described palaeospecies they accepted was D. ocyphus, described by Miller (1963) from a tarsometatarsus from the Pliocene-aged Mampuwardu Sands at Lake Palankarina, South Australia (Palankarina Local Fauna).

In addition, Patterson and Rich (1987) described a new species, D. gidju, from the Lake Ngapakaldi Leaf Locality, South Australia (Wipajiri Formation; Kutjamarpu Local Fauna), considered to be early Miocene. This was based on an associated distal tibiotarsus, proximal tarsometatarsus and shaft, and complete pes. Boles (1992) reported a femur from the type locality of D. gidju. He considered that this belonged to the same species, but noted that, while the lower limb was very emu-like, the femur retained characteristics of the cassowaries (Casuarius). The dichotomy between the Casuariinae and Dromaiinae represents the acquisition in the latter of a more cursorially modified lower hindlimb (tibiotarsus and tarsometatarsus), as evidenced by the relative elongation of both bones and other associated characters. Within the Dromaiinae, Boles (1992) recognised a second dichotomy between taxa that had acquired modifications of the upper hindlimb (femur) and those that had not, represented by the genera Dromaius and Emuarius, respectively.

Emuarius has the advanced lower limb but retained the primitive character states of the upper limb; that is, it is a combination of the cassowary-like femur and the derived emu-like tibiotarsus and tarsometatarsus.

Specimens referred to Emuarius gidju have subsequently been found in the Late Oligocene–early Late Miocene of Riversleigh, Queensland (Boles 1992, 1997). Two specimens from the Late Miocene deposits at Alcoota, Northern Territory, were first mentioned by Patterson and Rich (1987) as Dromaius indeterminate, and cannot be distinguished from Emuarius from other sites; they are now considered to belong to E. gidju (Vickers-Rich and Rich 1993; personal observation). This gives a known temporal range for this species of Late Oligocene to Late Miocene.

Described herein is a new emu based on a complete tarsometatarsus, mentioned initially (‘an emu leg bone’) by Pledge (1984) among taxa comprising the Ngama Local Fauna recovered from Mammalon Hill.

Geology and Geography

Mammalon Hill is located near the north end of the western side of Lake Palankarina, South Australia (28°41′S, 138°24′E). Fossils at this site have been recovered from the Etadunna Formation. On the basis of the mammalian component of the fauna, five faunal divisions of this Formation can be recognised (A–E, from the bottom to the top, respectively). Faunal Zone D, from which the emu fossil was recovered, crops out at Mammalon Hill. It lies between Zones C and E, with a range of marsupials intermediate in their state of evolution between those in these zones. Pledge (1984) recognised the Ngama Local Fauna for the fossils from Zone D, as typified at Mammalon Hill. On the basis of ektopodontid and pseudocherid possums (Marsupialia), the age of this site is considered to be between the Etadunna Formation Faunal Zones A–C and the Kutjamarpu Local Fauna (Rich et al. 1991). A depauperate pollen flora immediately below the site was interpreted as mid-Miocene (Truswell and Harris 1982); subsequently, magnetostratigraphic data placed the age of the Etadunna Formation at 24–26 million years ago (Woodburne et al. 1993). Avian families represented in the Ngama Local Fauna include Anatidae, Accipitridae, Rallidae, Burhinidae, Palaelodidae, Phoenicopteridae and Columbidae; most have yet to be studied, but are consistent with the depositional environment being...
primarily lacustrine, with limited fluvial situations. For further information on the geology, age and vertebrate taxa recovered from the Ngama Local Fauna, see Stirton et al. (1961), Pledge (1984), Rich et al. (1991), Woodburne et al. (1993) and references therein.

Methods
Measurements were made with digital calipers and rounded to the nearest 0.1 mm. Osteological nomenclature follows Baumel and Witmer (1993), including the use of ‘dorsal’ and ‘plantar’ to designate the ‘front’ and ‘back’ of the tarsometatarsus, respectively.

Systematic palaeontology
The Mammalon Hill specimen (P23977) is held in the palaeontological collection of the South Australian Museum (SAM), as are the holotypes of E. gidju and D. ocypus. The specimen described here consists of a left tarsometatarsus, nearly complete other than minor loss of material somewhat distal to the midpoint where the reconstructed proximal and distal portions connect and on the plantar side of the cotyla medialis. There is slight abrasion to the dorsal surfaces of trochlea metatarsi II and III, and trochlea metatarsi II has been reconstructed; otherwise there is little crushing or distortion.

The tarsometatarsus is known for all species of Dromaius and for Emuarius gidju, thus permitting direct comparisons with this specimen. Examination of the Mammalon Hill Emu shows that it warrants recognition as a new species. Because Emuarius and Dromaius are separated by character states of the femur, in the absence of this element it is not possible to definitively refer the new specimen to either genus. Rather than make the assumption that the Mammalon Hill Emu possessed a derived femoral morphology, this taxon is provisionally allocated to Emuarius, although in the following discussion, comparisons are made with species of both genera. (Although D. ocypus is, like E. guljaruba, known only from the tarsometatarsus, its possession of an advanced stage of reduction of trochlea metatarsi II allows it to be placed in Dromaius.)

**Emuarius guljaruba,** sp. nov.

*Holotype*
SAM P23977, a complete left tarsometatarsus with minor damage (Fig. 1).

*Type locality*
Mammalon Hill, the north end of the west side of Lake Palankarinna, South Australia (28°41′S, 138°24′E).

*Formation, age and fauna*
Etadunna Formation (Late Oligocene); Ngama Local Fauna (= Etadunna Formation Faunal Zone D).

*Diagnosis*
This species is separated from Dromaius and Emuarius gidju by the following suite of characters: the distal end is propor-

![Fig. 1. Tarsometatarsi of fossil and Recent dromaiines, dorsal view. (A) Emuarius gidju (proximal end, holotype: SAM P26779, Leaf Locality, Kutjamarpu Local Fauna; distal end, AM F78587, Gag Site, Riversleigh); (B) Emuarius guljaruba (holotype: SAM P23977, Mammalon Hill, Ngama Local Fauna); (C) Dromaius ocypus (holotype: SAM P13444, Lawson Quarry, Palankarinna Local Fauna); (D) Dromaius novachollandiae (Recent). Bar equals 50 mm. Distal tarsometatarsus in (A) added to photograph digitally.](image-url)
tionally narrow relative to the proximal end, the shaft is slightly compressed anteroposteriorly but markedly compressed mediolaterally on its distal half, and the trochlea metatarsi II is not reduced relative to the other trochleae.

Description

The reconstructed length of the tarsometatarsus is about equal to that of the holotype of *Dromaius ocypus* and approaches the predicted length for *Emuarius gidju* (Boles 1997) (Table 1). Morphologically, the proximal end is similar to that of both *Emuarius* and other species of *Dromaius*, but in size it is considerably larger than *E. gidju*, approaching *D. ocypus*. The eminentia intercotylaris is low and broad. The sulcus extensorius is moderately deep and rather broad, although it is not as deep distally as in *D. ocypus*. While the shaft does not have the pronounced degree of anteroposterior compression that characterises *E. gidju*, it is somewhat more compressed than in *D. novaehollandiae*, particularly on the distal half of the medial side, where it is more rounded on the plantar surface, rather than as a raised, flattened platform as in *D. novaehollandiae*. Otherwise, *E. guljaruba* resembles *D. ocypus* and *D. novaehollandiae* in the structure of its plantar surface. The distal end of the shaft is mediolaterally compressed, particularly relative to the proximal end. The lateral borders of the shaft converge to about the midpoint, then are roughly parallel distally, until the divergence of the distal end. In contrast to the proximal end, the distal end is much smaller than in either *D. ocypus* or *D. novaehollandiae*, but is similar to that of *E. gidju*. This specimen, although about the same length as the holotype of *D. ocypus* (SAM P13444), has a relatively and absolutely much smaller trochlea metatarsi III, particularly in width, a shorter trochlea metatarsi IV, a longer trochlea metatarsi II and a less splayed plantar surface. The distal end of the shaft is mediolaterally compressed, rather than as a raised, flattened platform as in *D. ocypus*.

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Table 1. Tarsometatarsal measurements for *Emuarius guljaruba* compared with those of *Emuarius gidju* and species of *Dromaius*

<table>
<thead>
<tr>
<th></th>
<th><em>Emuarius gidju</em></th>
<th><em>Emuarius guljaruba</em></th>
<th><em>Dromaius ocypus</em></th>
<th><em>Dromaius novaehollandiae</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>est. 340</td>
<td>c. 335</td>
<td>362</td>
<td>322–422</td>
</tr>
<tr>
<td>Proximal width</td>
<td>36.8–37.9</td>
<td>44.3</td>
<td>48.1</td>
<td>47.2–54.0</td>
</tr>
<tr>
<td>Depth, cotyla medialis</td>
<td>19.1–22.9</td>
<td>26.6</td>
<td>&gt;25.3</td>
<td>25.4–27.6</td>
</tr>
<tr>
<td>Depth, cotyla lateralis</td>
<td>&gt;16.8–18.5</td>
<td>–</td>
<td>c. 26.3</td>
<td>19.9–23.7</td>
</tr>
<tr>
<td>Depth, dorsal side of area intercotylaris across hypotarsus</td>
<td>27.2–29.5</td>
<td>37.9</td>
<td>&gt;35.6</td>
<td>36.0–41.3</td>
</tr>
<tr>
<td>Minimum shaft width</td>
<td>–</td>
<td>19.8</td>
<td>–</td>
<td>11.6–17.3</td>
</tr>
<tr>
<td>Distal width</td>
<td>44.1–c. 47.4</td>
<td>c. 46.9</td>
<td>53.3</td>
<td>47.4–54.6</td>
</tr>
<tr>
<td>Width, trochlea metatarsi II</td>
<td>&gt;9.5–10.5</td>
<td>12.6</td>
<td>11.8</td>
<td>9.0–11.1</td>
</tr>
<tr>
<td>Depth, trochlea metatarsi II</td>
<td>&gt;10.5–15.5</td>
<td>&gt;15.1</td>
<td>18.1</td>
<td>13.0–17.6</td>
</tr>
<tr>
<td>Width, trochlea metatarsi III</td>
<td>17.6–21.7</td>
<td>20.6</td>
<td>27.8</td>
<td>21.9–28.9</td>
</tr>
<tr>
<td>Depth, trochlea metatarsi III</td>
<td>19.3–21.7</td>
<td>20.6</td>
<td>26.1</td>
<td>19.0–24.3</td>
</tr>
<tr>
<td>Width, trochlea metatarsi IV</td>
<td>&gt;12.2–14.5</td>
<td>&gt;15.4</td>
<td>15.0</td>
<td>12.2–14.9</td>
</tr>
<tr>
<td>Depth, trochlea metatarsi IV</td>
<td>13.4–c. 15.5</td>
<td>&gt;&gt;13.4</td>
<td>18.0</td>
<td>14.3–17.2</td>
</tr>
</tbody>
</table>
cassowaries, and, although probably close to the mutual ancestor of these groups, could not itself have been that ancestor. The Late Oligocene occurrence of *Emuarius guljaruba* adds support to this conclusion. Boles (1992) noted that the conclusion of Sibley and Ahlquist (1990), based DNA–DNA hybridisation data, of a cassowary–emu division at 20–25 million years ago, was too recent to account for *Emuarius*. The recently proposed divergence date of 35–38 million years ago by Cooper *et al.* (2001) is more reasonable.

Boles (1992, 1997) remarked upon the proportions of the hindlimb elements of *Emuarius gidju* relative to those of the more primitive cassowaries and their implications about this bird’s mode of locomotion. Some characters of the hindlimb of *E. gidju* are more similar to either *Casuarius* or *Dromaius*, while others are intermediate in structure between living members of these genera. Notably, *E. gidju* exhibited three morphological correlates with advanced cursoriality relative to the condition in *Casuarius*: overall lengthening of the lower hindlimb elements, lengthening of the tarsometatarsus relative to the tibiotarsus, and a reduction in the relative size of digit II. For these reasons, Boles (1992, 1997) considered that this taxon appeared to mark in the Casuariidae a stage in the transition from a generalised cursor to more specialised cursorial locomotion. From this, he suggested that the increased cursoriality may have been related to the occurrence of more open habitat in addition to the rainforest usually considered to have been present.

*Emuarius guljaruba* has the same modifications of the tarsometatarsus that led Boles (1992, 1997) to infer developing cursoriality in *Emuarius* relative to *Casuarius*. In comparison to *D. ocypus* and *D. novaehollandiae*, the trochlea metatarsi II of *E. guljaruba* does not exhibit marked reduction (similar to *E. gidju*, but more so than in *Casuarius*), indicating that specialisation for open-country locomotion was still at a much lower stage of development. Nonetheless, the longer, more slender tarsometatarsus of *E. guljaruba* compared with *Casuarius* is suggestive of an animal capable of more rapid locomotion, and thus the presence of more open habitat, although this is not the only explanation for the lengthened lower limb element (see Boles 1997). Obviously there is still much to be learnt about the early stages of emu evolution.

Acknowledgments

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References


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