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A pygmy cassowary (*Casuarius lydekkeri*) from late Pleistocene bog deposits at Pureni, Papua New Guinea

P.V. Rich,[1] Michael Plane,[2] & Natalie Schroeder[3]

Bones of a tiny cassowary from late Pleistocene bog deposits in the Southern Highlands of New Guinea are indistinguishable from bones of *Casuarius lydekkeri* of unknown provenance. The relationship of these fossils to another small fossil cassowary from Pliocene sediments in the Bulolo area of New Guinea is unknown. All the fossil cassowary material is distinct from corresponding bones of extant cassowaries. Until more material is found it will be impossible to determine the relationship between the extinct and extant forms.

Introduction

Although the present-day bird fauna of New Guinea is one of the richest in the world, its palaeo-history is almost unknown. Fossilised phalanges of a small cassowary have been collected from Pliocene sediments near Awe in eastern New Guinea (Plane, 1967), but no other extinct forms are known. A few extant taxa have been reported from archaeological sites, but these offer no real insight into the origins or evolutionary patterns of New Guinea birds.

A small cassowary has been known for some time from the late Pleistocene swamp deposits at Pureni, Southern Highlands Province, Papua New Guinea. It appears to represent a pygmy cassowary that is conspecific with the type and only specimen of *Casuarius lydekkeri*, whose provenance is unknown (Miller, 1962). The New Guinea fossils are associated with another extinct form, a diprotodontid marsupial, *Hulitherium tomasetti*, recently described by Flannery & Plane (1986). A murid rodent and *Phalanger carmelitae* also occur at the site.

Abbreviations cited in this paper are: AM, the Australian Museum, Sydney; CPC, Commonwealth Palaeontological Collections, Bureau of Mineral Resources, Canberra; TPVR, Monash University, Earth Sciences Department, Clayton, (Melbourne).

Geographic and geological setting

Pureni lies in the montane centre of western Papua, immediately south of the border with New Guinea (Figs. 1 & 3) at about 5°50′S, 142°50′E. Its district, the Tari-Koroba district, encompasses approximately 850 km^2 and lies between 1150 and 2744 m above sea level, with a local relief spanning some 600 m (P. Williams, personal communication). The area is drained by the River Tagari, which flows close to the Pureni fossil site, and eventually empties into the Gulf of Papua. To the west and east of Pureni are the Doma Peaks (3962 m) and Mount Sisa (2450 m), both volcanic in origin, which dominate the skyline and have influenced the geomorphology of the area considerably (P. Williams, MS.).

The geology of the Pureni site (Figs. 1 & 2) has been discussed by Williams & others (1972) and Flannery & Plane (1986). In summary, the late Quaternary swamp deposits, dated at 38000 years before present by ^{14}C analysis, overlie a thick sequence of late Oligocene to Pliocene marine limestones, siltstones, and calcareous sandstones (Williams & others, 1972). Lavas intruded these sediments in the middle Pleistocene and dammed as well as partially filled the valley of the Tagari River. A determination on these lavas carried out by McDougall (Williams & others, 1972) gave an age of approximately 850 000 years B.P. (Flannery & Plane, 1986). Vulcanism thought to have come from Mount Rentoul and Mount Sisa continued after this, and local legends suggest that these centres may not be extinct. Swamp deposition was concurrent with the volcanic activity, not only at Pureni, but also at Tarifuga and Mogorofuga, to the northwest, and Wabafuga, to the west. Sediments in all these organically rich sites include peat and clay, interbedded with ash.

The sediments at Pureni and in the surrounding Haibuga Basin have been mapped in detail (Williams & others, 1972), and good pollen collections have been obtained from sediments containing the vertebrates (Williams & others 1972). The swamp sediments in which the fossil cassowary bones were buried indicate a bog with bog forest on site, before which the area had been covered with open water. Regionally this change in conditions marked a transition from a cool, mixed forest with nearby subalpine grassland to a milder beech (*Nothofagus*) — dominated forest with mixed forest and subalpine grassland farther away, and finally to a relatively warm oak (*Lithocarpus*) and oak-beech forest. At all times during this change, mean annual temperatures were colder than at present.

Systematic palaeontology

Casuariidae Brisson, 1760

Casuarius Brisson, 1760

Preacetabular part of *synsacrum* elongate and narrow, not noticeably shorter than postacetabular part: synsacrum lacks prominent dorsal extension of dorsal margin anterior to acetabulum that is characteristic of *Dromaius*. *Femur* without pneumatic foramina proximally and posteriorly; in anterior view, internal and external condyles of nearly equal proximal extension; in medial view border of internal condyle angular, triangular in shape, not smoothly rounded; in distal view, condyles of nearly equal depth, external not noticeably deeper than internal; shaft elongate, slender and nearly parallel-sided; in side view shaft curved, decidedly concave posteriorly, not straight. *Tibiotarsus* with cranial crests not as mediolaterally compressed as in *Dromaius*; in proximal view, area between articular surfaces and cranial crests not flattened but tilting distolaterally; in lateral view, external condyle rounded, not distally flattened. *Tarsometatarsus*, in anterior view, with intercotylar prominence arched dorsally, not flat; medial border of internal cotyla rounded and tilting sharply laterally posterior to its anteroposterior midpoint, not tending to flatten as in *Dromaius*; hypotarsus somewhat recurved medially, not straight; distally trochlea II and IV very nearly

[1]Earth Sciences and Zoology Departments, Monash University, Clayton, Victoria 3168 and Museum of Victoria, Melbourne, Victoria 3000
[2]Division of Continental Geology, Bureau of Mineral Resources, GPO Box 378, Canberra, ACT 2601
[3]Earth Sciences Department, Monash University, Clayton, Victoria 3168

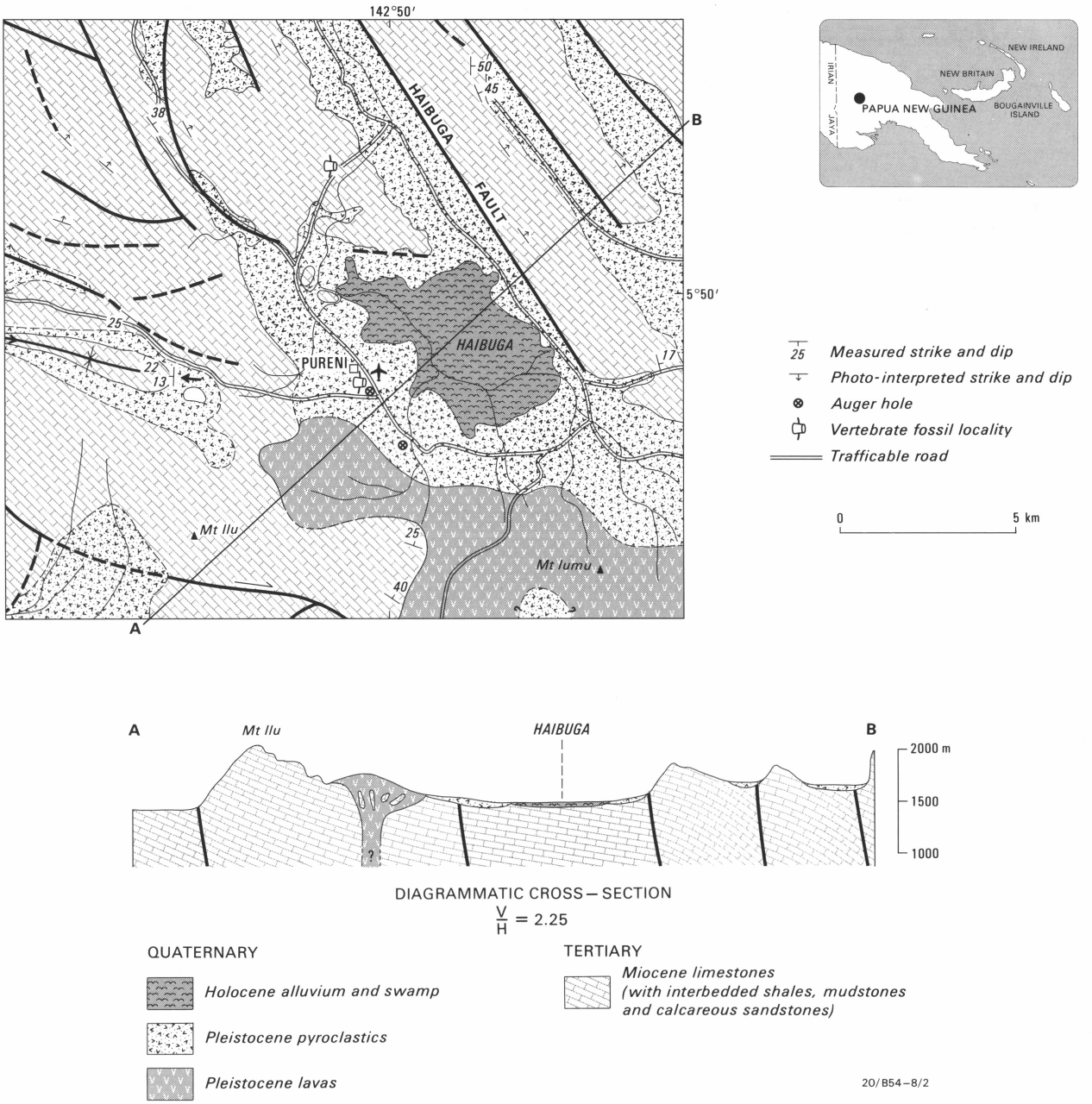

Figure 1. Geology of Pureni area, Papua New Guinea.

equal in size, not as in *Dromaius* where II decidedly smaller than IV; in distal view, trochlea II decidedly deeper than wide.

Casuarius lydekkeri Rothschild, 1911

Holotype. AM F50094, right distal tibiotarsus.

Type locality. Unknown. Originally reported as Wellington Valley, NSW, but later inspection by Drs J. Mahoney and L. Dawson (personal communication) casts some doubt on provenance because of the type of preservation.

Age. Unknown; age of Wellington Caves deposits is Quaternary.

Referred material. Partial skeleton: CPC26605a, synsacrum and partial pelvis; CPC26605b, 26605c, right and left femora; CPC26605d, distal tibiotarsus; CPC26605e, proximal tibiotarsus; CPC26605f, CPC26605g, right and left proximal tarsometatarsi; CPC26605h, left distal tarsometatarsi.

Locality of referred material. Bank on southwestern side of Pureni Mission airstrip, Wabag 1:250 000 sheet area 5°50′S., 149°49′E., Southern Highlands Province, Papua New Guinea (Flannery & Plane, 1986) (Fig.1).

Age of referred material. Late Pleistocene; ^{14}C date on a log in sediments containing the cassowary remains was 38 600 ± 2500 years B.P. (sample ANU-231 reported by Williams & others, 1972).

Specific diagnosis. Smaller than any of the extant cassowaries (*C. bennetti, C. casuarius, C. unappendiculatus*); pelvis shallower than any species of *Casuarius*, even more so than *C. bennetti*, the smallest of the extant forms; synsacrum does

not expand much anteriorly, with lateral borders nearly parallel, unlike in other cassowaries; pelvis proportionally narrower across acetabular area than in other cassowaries; femur more gracile than in any of the living cassowaries, and although about the same length as in *C. bennetti*, decidedly narrower; tibiotarsus, with condyles (in distal view) that may be proportionally deeper than in extant cassowaries; tarsometatarsus, in proximal view, with medial margin smoothly rounded, lacking tendency to be flattened and with internal-most point near anterior margin; lateral margin, likewise, smoothly rounded, not flattened as in *C. bennetti* or notched posteriorly as in *C. casuarius* and *C. unappendiculatus*; depression on posterior half of intercotylar area deep, not shallow; in side view, hypotarsus not rising sharply proximally, nor protruding far proximally; in posterior view, proximal end only slightly splayed, not broadly splayed as in extant forms; trochleae II and IV shallower relative to width than in *C. bennetti* or *C. unappendiculatus*, more resembling their condition in *C. casuarius*; in anterior view, muscle depression at base of trochlea IV deep, not shallow; distal foramen present, contrasting with a tendency to lose it in *C. bennetti* and *C. unappendiculatus*.

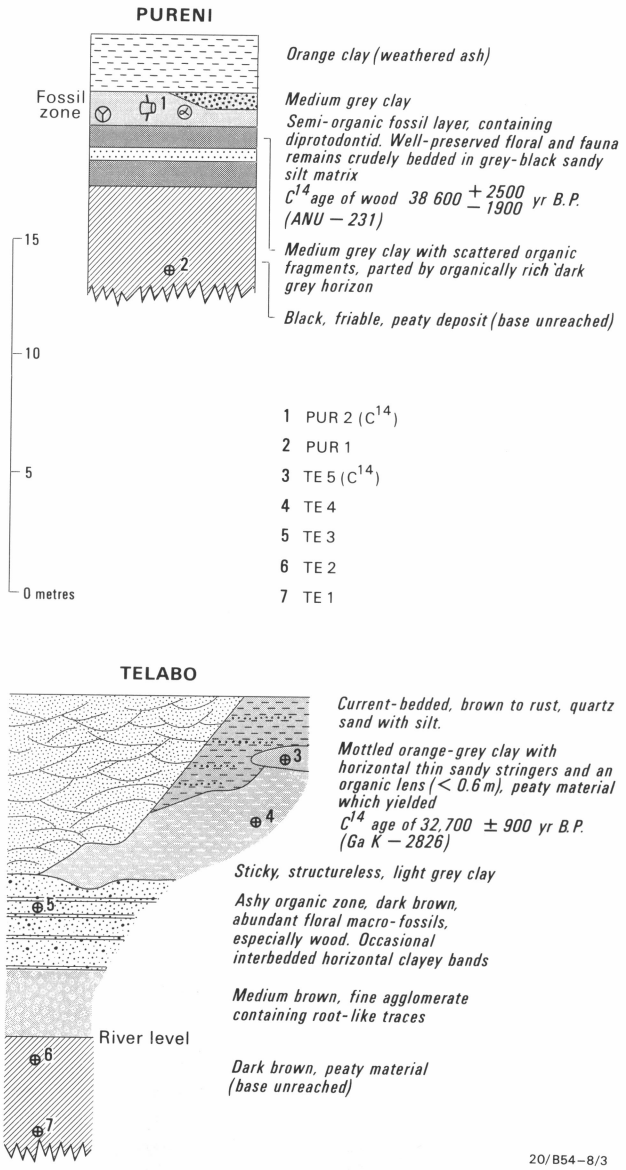

Figure 2. Detailed stratigraphic sections of fossil-producing sites (from Flannery & Plane, 1986).

Discussion

As implied by the generic diagnosis and subsequent description, the fossil bird material from Pureni is of a cassowary that is smaller and more gracile than any extant cassowary (Figs. 4-11 and Tables 1-4).

The Pureni material is similar in size and morphology to the pygmy cassowary, *Casuarius lydekkeri*, first reported by Lydekker (1891). The Pureni fossils are adult, as articular ends are fully fused to shafts, and bones are thoroughly ossified, lacking in the spongy surface texture of juvenile bone. Miller (1962) most recently reviewed this taxon and its type (now AMF50094). It is based on a right distal tibiotarsus reported to have come from the Pleistocene of New South Wales. In later publications this form was recorded from or referred to the Queensland Pleistocene (Rothschild, 1911), the diatomaceous deposits of Cooma, possibly Bingara, and the Wellington Caves (Miller, 1962). Cooma was ruled out as a possible source when a thorough examination of the specimen revealed no evidence of diatoms or diatomaceous sediments (Miller, 1962). But even though Miller (1962) concluded that the Wellington Valley was the most likely source, several experts on the preservation of bone in the Wellington Caves (J. Mahoney and L. Dawson, personal communication) were not convinced that the original material of *C. lydekkeri* could have been fossilised there. We agree with this conclusion and suggest that the source of *C. lydekkeri* is not yet established and may never be. It is even possible that it was collected in New Guinea.

We can find no significant differences between the Pureni material and the type specimen of *Casuarius lydekkeri* (AMF50094). Both are in the same size range and the configuration of their tendinal grooves and depths are similar, features which Miller (1962) thought distinctive of *C. lydekkeri*. The only possible difference that we can observe is that the condyles of the type tibiotarsus of *C. lydekkeri* may be deeper with respect to width than in the Pureni material (CPC26605d). Unfortunately, neither AMF50094 or

Table 1. Measurements (mm) of the synsacra of fossil and Recent cassowaries (Aves: Casuariidae)

	C. lydekkeri	*C. bennetti*	*C. casuarius*				*C. unappendiculatus*
	CPC26605a	AM 51415	R	M	S.D.	n	AMNH 1553 (juv.-semiadult)
Length	253.4	31.7	313-407	372	35.2	5	366
Width across antitrochanter	72.9	84.2	99-159	121	63.6	5	97.4
Depth at level of antitrochanter from top of fenestra to dorsal surface	54.3	66.2	81-95	87	5.4	5	89.1
Depth at ant. of acetabulum	57.4	77.6	85-112	101	11.8	5	90.8

CPC26605d is complete, and eroded parts make comparisons in certain areas impossible.

We choose then to use the name *Casuarius lydekkeri* for the pygmy cassowary found in late Pleistocene sediments at Pureni. Although few differences were originally noted between the type specimen of this species and living forms, given that it was an incomplete distal tibiotarsus, the additional material from Pureni shows it to be quite distinct. The greatest differences are in the synsacrum and pelvis, which are narrower and shallower than in any other known species. The femur is decidedly more gracile than that of any known species, and the shape and conformation of the proximal articular surface as well as the shallowness of the trochleae of the tarsometatarsus are distinctive for the Pureni material.

Although *C. lydekkeri* is small and has a pelvic conformation similar to that in *C. bennetti*, it does share some features with *C. casuarius*. It is, thus, not clear to which living species *C. lydekkeri* is more closely allied. Until more material comes to hand, the phylogenetic relationships of this tiny cassowary will not be clearly understood.

The only other fossil cassowary bones reported in the literature (Plane, 1967) are the distal end of a left phalanx 1, digit II and a complete phalanx 2, digit II, which articulate with each other; and a right phalanx 2, digit II. These come

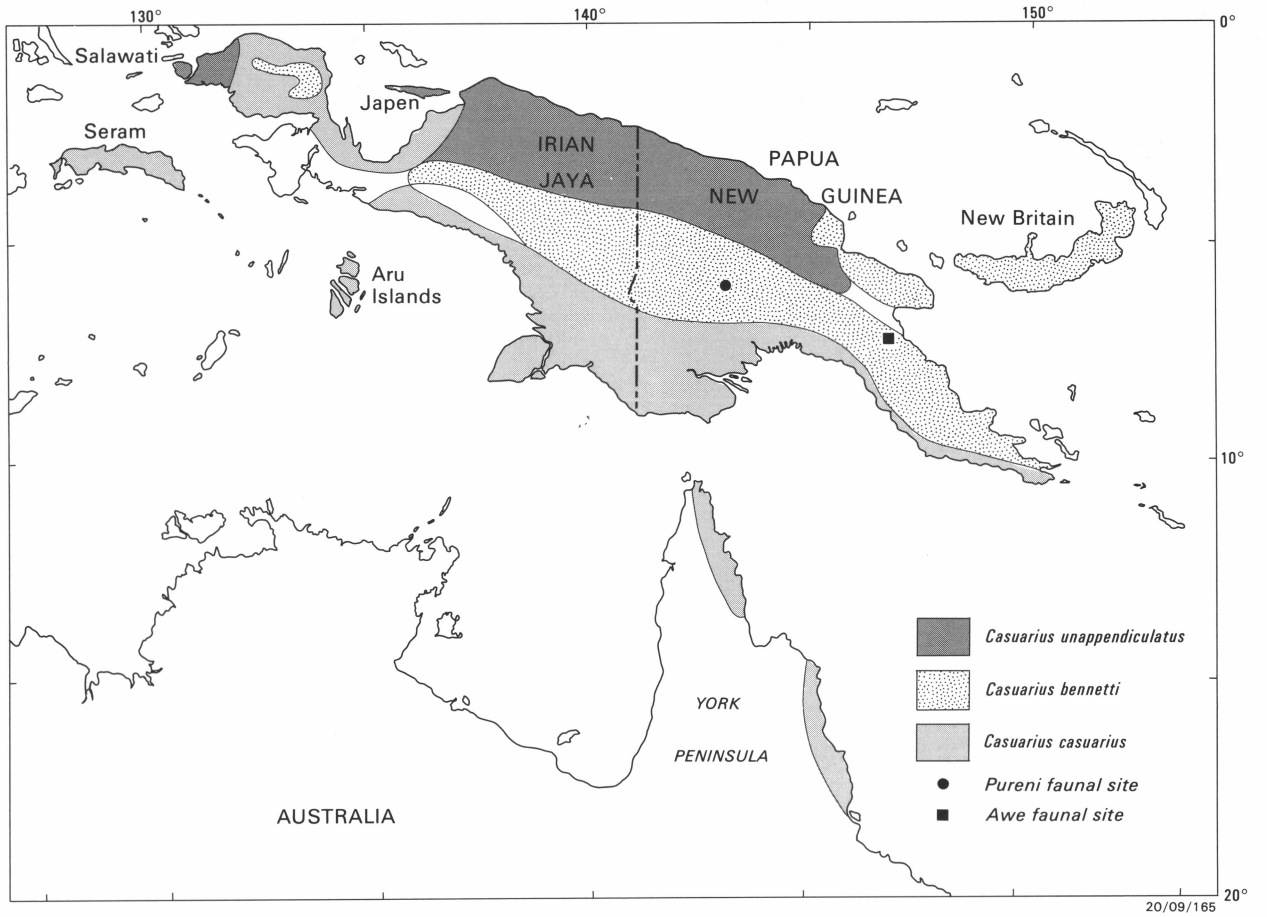

Figure 3. Ranges of extant and extinct cassowaries (after Flannery & Plane, 1986; Grzimek, 1972; Peters, 1979; Plane, 1967).

Table 2. Measurements (mm) of the femora of fossil and Recent cassowaries (Aves: Casuariidae)

	C. lydekkeri		*C. bennetti*	TPVR	*C. casuarius*				*C. unappendiculatus*
	CPC26605b	CPC26605c	AM 51415	633	R	M	S.D.	n	AMNH 1553 (juv.-semiadult)
Length	201	202	221	228	212–251	232	15.6	7	235.7
Proximal width	37.8	—	45.1	52.8	43–58	52	6.5	7	47.5
Proximal depth (across trochanter)	—	32.8	48.0	53.5	48–63	56	6.2	7	58.2
Distal width	46.4	45.8	55.0	63.7	59–74	67	6.1	7	62.9
Depth of internal condyle	34.3	38.0	48.6	53.2	47–58	51	3.1	7	52.6
Depth of external condyle	41.8	41.1	50.6	56.3	53–66	60	5.2	7	60.9
Minimum shaft width	20.9	20.8	22.8	23.6	23–30	26	3.0	7	26.3
Minimum shaft depth	—	20.5	23.7	23.1	23–30	27	2.8	7	28.4

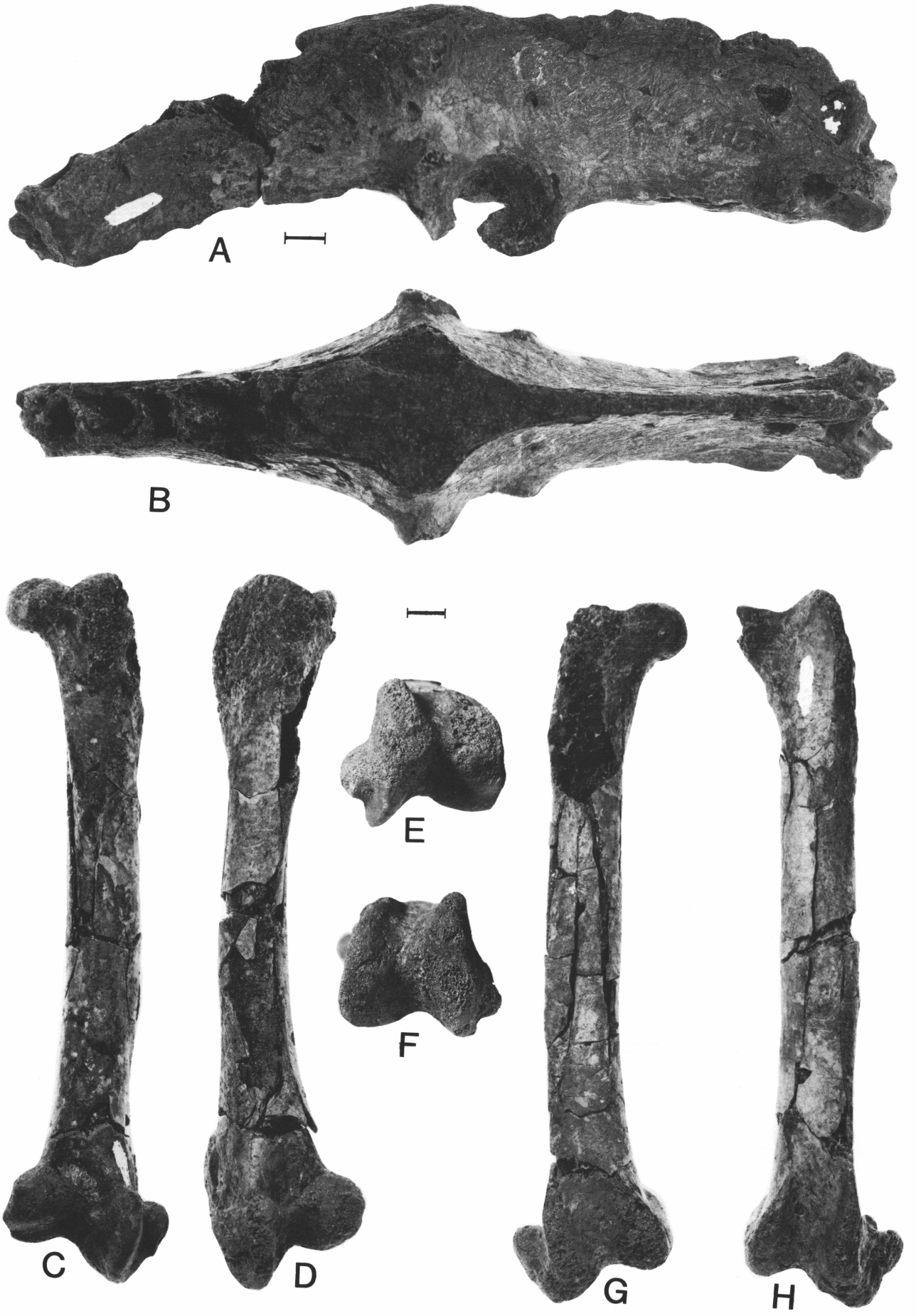

Figure 4. ***Casuarius lydekkeri*** **from Pureni, PNG.**
Pelvis and synsacrum: CPC26605a — A, lateral view; B, dorsal view. Femora: right, CPC26605b — C, posterior view; E, distal view; G, anterior view; left, CPC26605c — D, posterior view; F, distal view; H, anterior view. Scale bar = 1cm.

from the Pliocene Awe fauna of southeastern New Guinea near Bulolo. As Plane (1967) pointed out 'these bones come closest to the living *C. bennetti* Gould, 1857, but the fossils do not correspond precisely enough to warrant their being assigned to that species. The second phalanx of digit II is longer than its equivalent in *C. bennetti*, but is much smaller than those bones in the large Recent species *C. casuarius* Linnaeus, 1758 or *C. unappendiculatus* Blyth, 1860. Nor does it match the configuration of the phalanx from a young *C. casuarius* which is the same size as the fossils'.

The Awe fossils most closely resemble *C. bennetti* in morphology, being deep and mediolaterally compressed, especially in proximal and distal views. Differences exist, however, in the shape of the distal articular surface (Fig.5) and the relative depths of the internal and external condyles of phalanx 1, digit II. In the Awe fossil, the internal condyle is markedly deeper than the external. Phalanx 2, digit II in the Awe fossils is also relatively longer with respect to its width than in other cassowaries, including *C. bennetti*, and is not nearly so mediolaterally compressed.

Unfortunately, no pedal phalanges of the Pureni fossil are preserved. Thus, comparison between the Pureni and Awe forms is not possible. Both fossil cassowaries were small and were distinct from extant species. But they are of markedly different ages, one being Pliocene and the other late Pleistocene. Their relationships to one another will remain a mystery until more material is found.

Summary and conclusions

Bones of a tiny cassowary from late Pleistocene bog deposits in the Southern Highlands of New Guinea are indistinguishable from bones of *Casuarius lydekkeri* of unknown provenance. The relationship of these fossils to another small fossil cassowary from Pliocene sediments in the Bulolo area of New Guinea is unknown because of the lack of correspondence of elements. All of the fossil cassowary material known is clearly distinct from corresponding bones of extant cassowaries, and because so few bones are known, it is impossible at present to determine the relationship between the extinct and extant forms. *Casuarius lydekkeri* from Pureni occurs within the geographic range of the extant *Casuarius bennetti* as does the Awe fossil material.

Table 3. Measurements (in mm) of the tibiotarsi of fossil and Recent cassowaries (Aves: Casuariidae)

	C. lydekkeri			*C. bennetti*	TPVR	*C. casuarius*				*C. unappendiculatus*
	CPC26605d	CPC26605e	AM 50094	AM 51515	633	R	M	S.D.	n	AMNH 1553 (juv.-semiadult)
Total length	—	—	—	365	377	377–392	384	7.6	5	388
Maximum proximal depth	—	57.3	—	79.1	91.7	92–110	104	7.5	5	79.0
Proximal width	—	28.6	—	44.8	49.8	50–57	53	3.0	5	50.7
Length of fibular crest	—	50.0	—	66.4	97.6	98	—	—	1	74.3
Depth of internal condyle	—	—	—	40.6	43.2	43–50	47	2.7	5	47.5
Depth of external condyle	30.6	—	34.1	38.2	40.5	41–47	44	2.6	5	45.7
Distal width	32.6	—	35.0	40.6	46.7	47–55	52	3.1	5	53.4

Table 4. Measurements (in mm) of the tarsometatarsi of fossil and Recent cassowaries (Aves: Casuariidae)

	C. lydekkeri			*C. bennetti*				*C. casuarius*				*C. unappendiculatus*			
	CPC26605f	CPC26605g	CPC26605h	R	M	S.D.	n	R	M	S.D.	n	R	M	S.D.	n
Total length	—	—	—	194–266	229	36.0	4	255–341	300	25.2	19	196–333	269	68.4	3
Proximal width	36.2	36.0	—	32.0–43.1	36.7	5.4	4	41.0–57.4	49.2	4.0	19	38.8–56.6	48.4	9.0	3
Depth of internal cotlya	16.9	19.4	—	21.2–24.1	22.8	1.5	3	26.0–36.1	30.3	2.4	19	21.6–36.1	28.9	10.3	2
Depth of external cotyla	22.8	22.6	—	18.9–21.7	20.6	1.5	3	22.5–37.0	26.2	3.2	19	23.1–27.4	25.3	3.0	2
Depth of internal prominence to hypotarsus	—	—	—	24.4–37.1	31.8	6.6	3	36.1–54.2	42.5	3.9	19	39.1–46.1	42.6	5.0	2
Minimum shaft width	—	—	—	12.5–28.0	18.4	7.4	4	18.2–38.8	22.5	4.4	20	15.9–23.0	19.6	3.6	3
Minimum shaft depth	—	—	—	8.6–17.3	11.5	4.0	4	11.4–14.6	13.0	0.9	20	10.6–13.9	12.0	1.7	3
Distal width	—	—	40.6	36.0–49.2	42.5	6.5	4	46.1–69.8	55.2	6.2	20	46.3–60.0	53.5	6.9	3
Width of trochlea II	—	—	12.1	9.4–17.9	12.3	3.9	4	12.6–19.4	15.6	2.0	20	12.1–15.9	13.9	1.9	3
Width of trochlea III	—	—	17.1	15.2–20.0	17.3	2.4	4	19.4–28.4	22.6	2.2	20	20.4–25.4	22.7	2.5	3
Width of trochlea IV	—	—	13.2	10.6–14.0	12.6	1.5	4	12.2–21.4	16.0	2.2	20	13.6–15.4	14.8	1.0	3
Max. depth of trochlea II	—	—	18.2	12.6–19.8	15.0	4.1	3	18.8–28.0	21.5	2.5	20	16.2–22.0	20.0	3.2	3
Max. depth of trochlea III	—	—	19.1	16.6–24.0	19.4	3.5	4	23.4–32.8	26.2	2.8	20	19.6–26.9	24.2	4.0	3
Max depth of trochlea IV	—	—	18.4	13.0–20.1	16.6	5.0	2	17.8–28.4	21.2	3.0	20	17.4–28.3	23.4	5.5	3

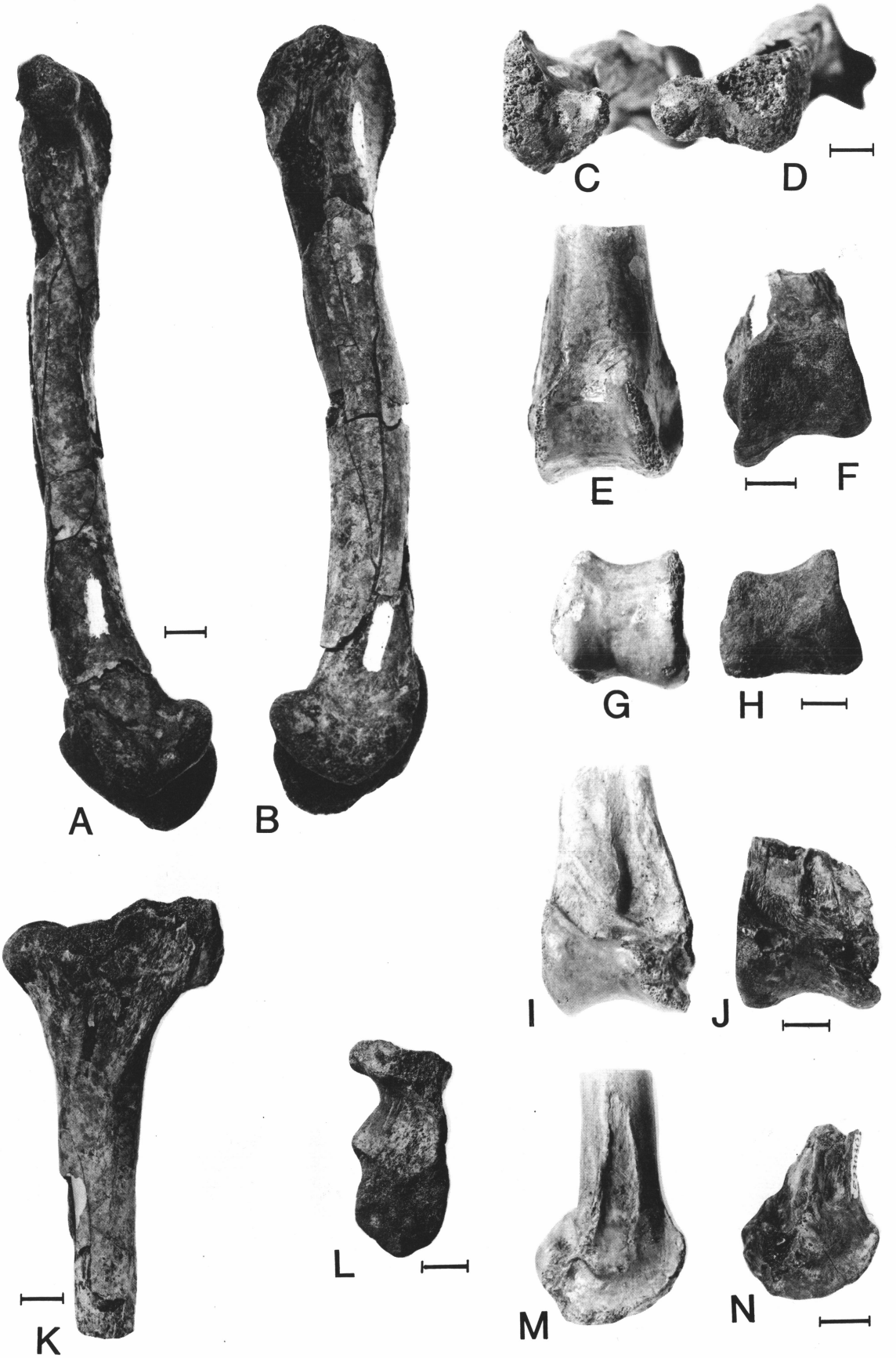

Figure 5. ***Casuarius lydekkeri.***
Femora: right, CPC26605b — A, internal view; D, proximal view; left, CPC26605c — B, internal view; C, proximal view. Tibiotarsi: right, AMF50094 — E, posterior view; G, distal view; I, anterior view; M, internal view; right, CPC26605d — F, posterior view; H, distal view; J, anterior view; N, internal view; left, CPC26605e — K, internal view; L, proximal view. Scale bar = 1cm.

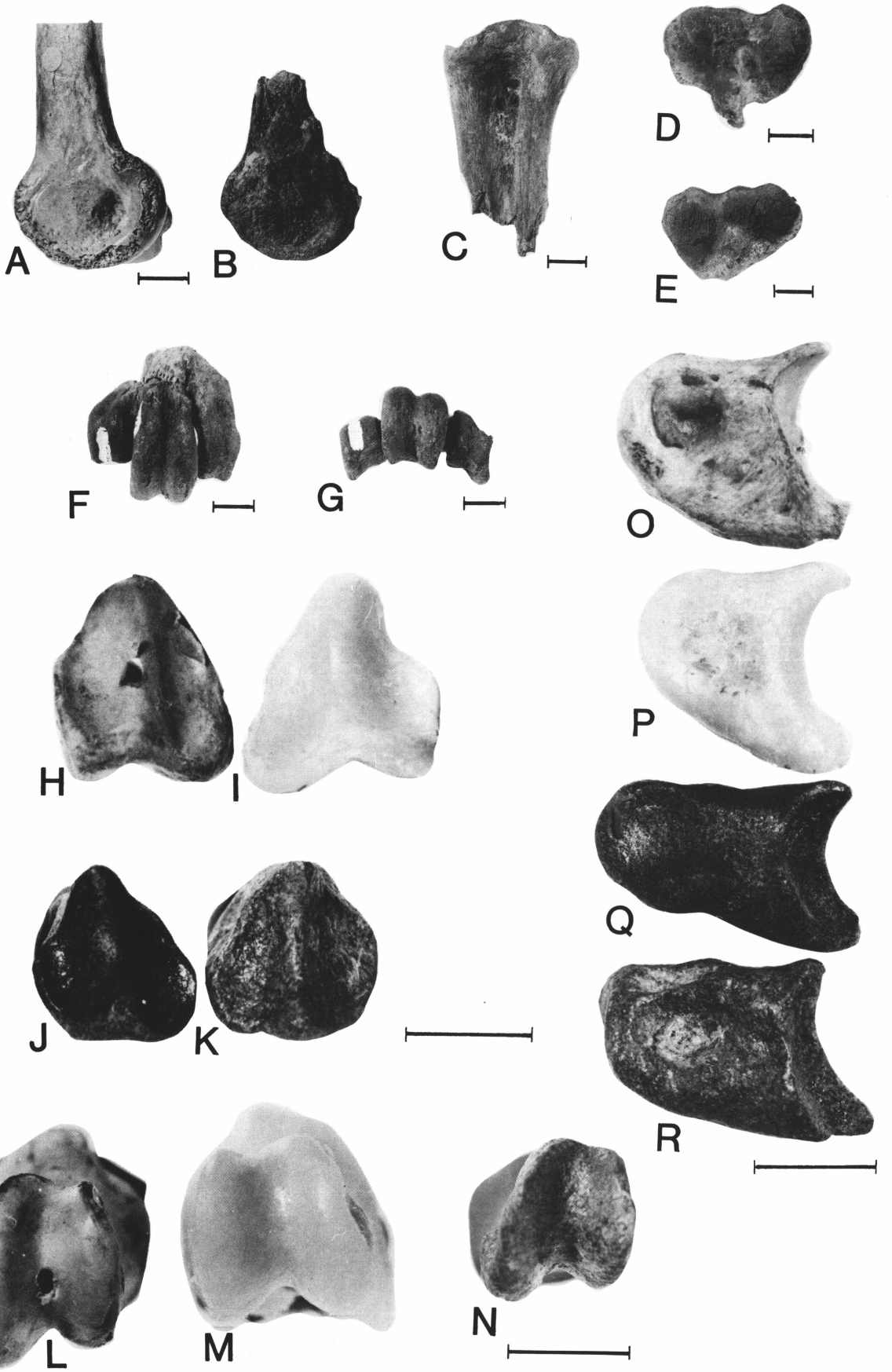

Figure 6. ***Casuarius lydekkeri.***
Tibiotarsi: right, AMF50094 — A, external view; right, CPC26605d — B, external view. Tarsometatarsi: right, CPC26605f — C, anterior view; E, proximal view; left, CPC26605g — D, proximal view; left, CPC26605h — F, anterior view; G, distal view. Phalanges: *Casuarius* phalanx 2 digit II: *C. bennetti*, left — H, proximal view; L, distal view; O, lateral view; *C. casuarius*, right — I, proximal view; M, distal view; P, internal view; *C.* sp. from Awe, PNG: UCMP 70129, left — J, proximal view; N, distal view; Q, lateral view; UCMP 70129, right — K, proximal view; R, internal view. Scale bar = 1cm.

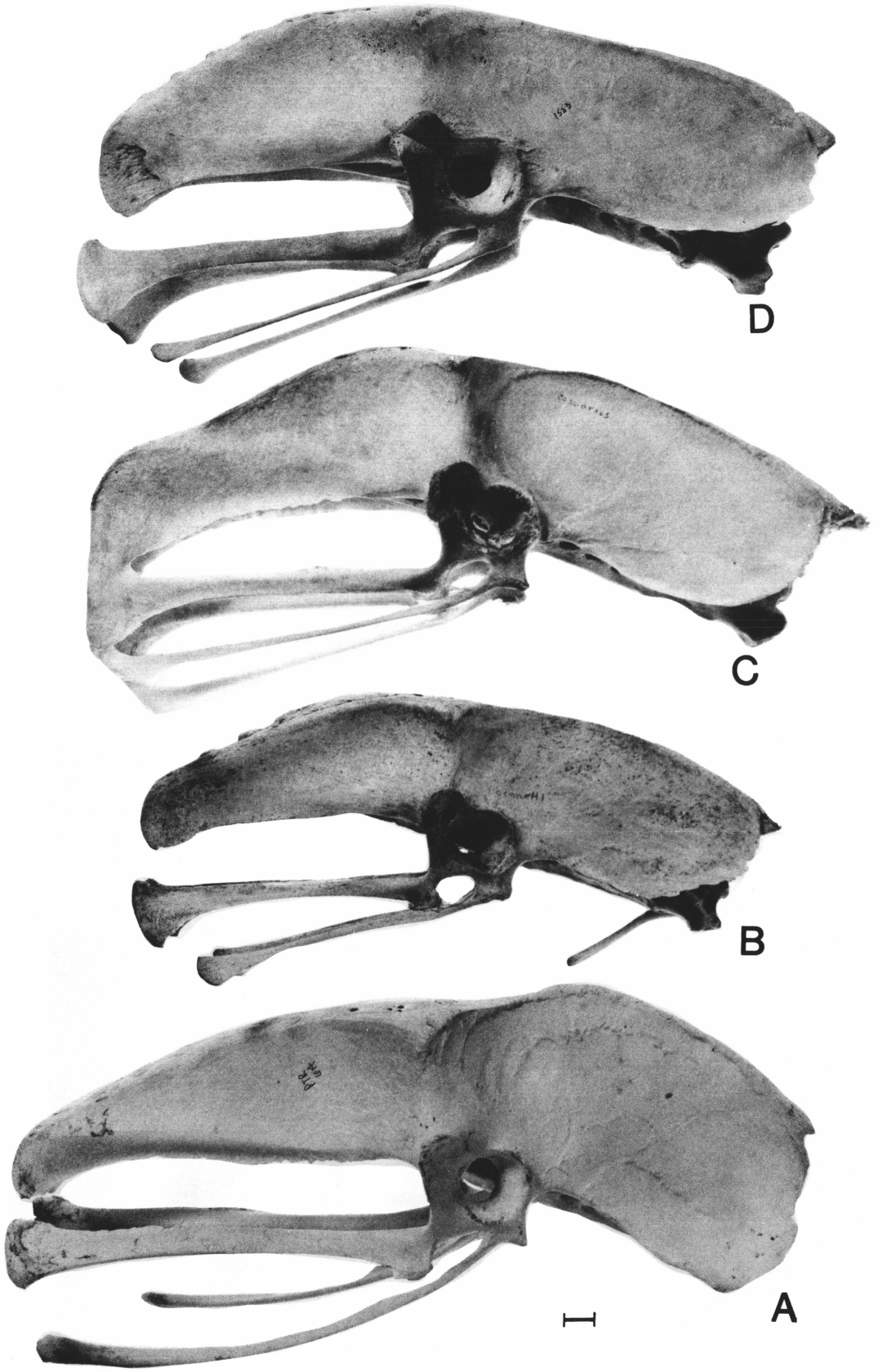

Figure 7. Pelves and synsacra of living cassowaries, *Casuarius*, and the Emu, *Dromaius*, in side view.
A, *D. novaehollandiae*; B, *C. bennetti*; C, *C. casuarius*; D, *C. unappendiculatus* (juv.). Scale bar = 1cm.

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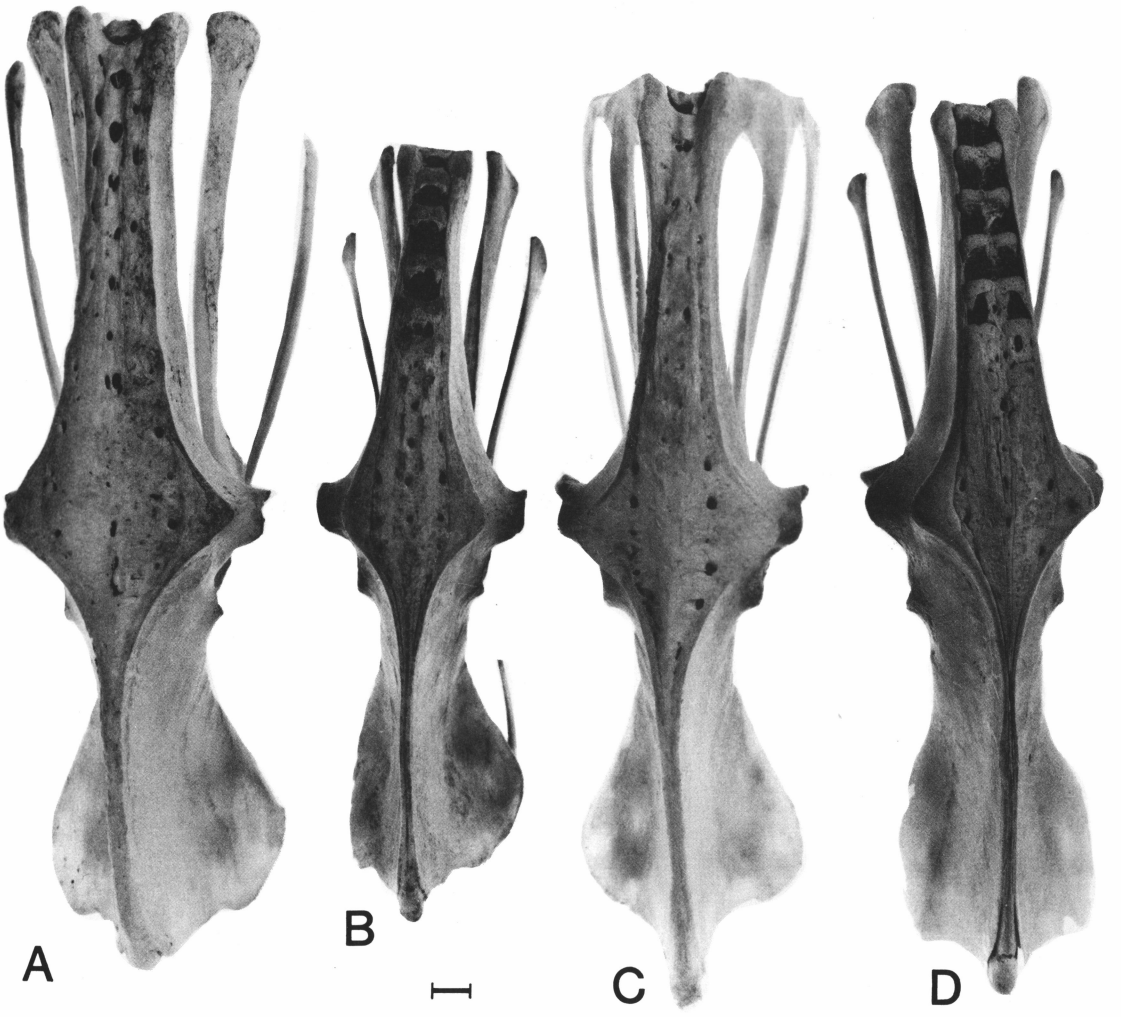

Figure 8. Pelves and synsacra of living cassowaries, *Casuarius*, and the Emu, *Dromaius*, in dorsal view.
A, *D. novaehollandiae*; B, *C. bennetti*; C, *C. casuarius*; D, *C. unappendiculatus* (juv.). Scale bar = 1cm.

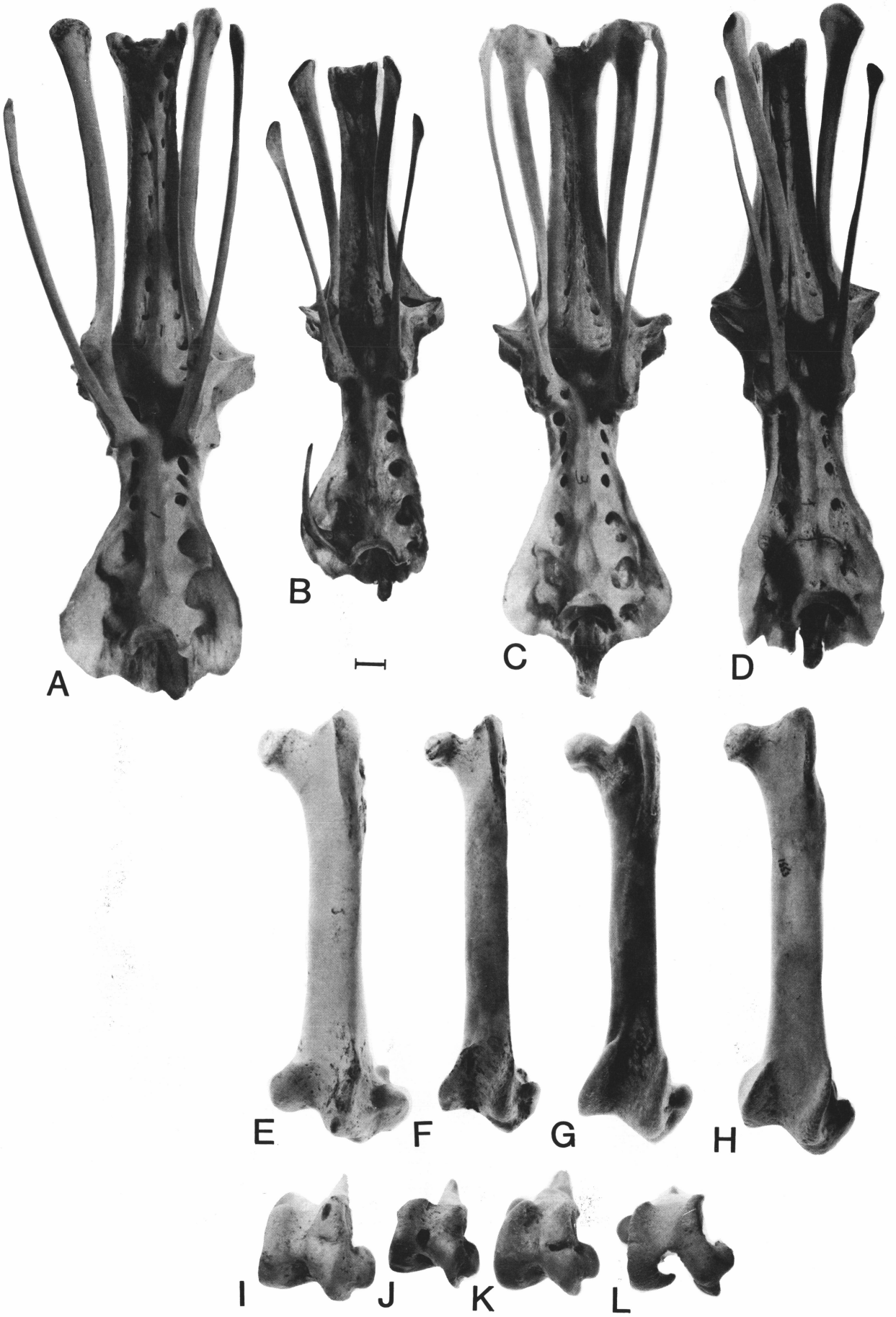

Figure 9. Pelves, synsacra, and femora of living cassowaries, *Casuarius*, and the Emu, *Dromaius*.
A,E,I, *D. novaehollandia*; B,F,J, *C. bennetti*; C,G,K, *C. casuarius*; D,H,L, *C. unappendiculatus* (juv.). A–D, pelves and synsacra, ventral view; E–H, femora, anterior view; I–L, femora, distal view. Scale bar = 1 cm.

Figure 10. Tibiotarsi of living cassowaries, *Casuarius*, and the Emu, *Dromaius*.
A,E,I, *D. novaehollandiae*; B,F,J, *C. bennetti*; C,G,K, *C. casuarius*; D,H,L, *C. unappendiculatus* (juv.). A-D, proximal view; E-H, anterior view; I-L, distal view. Scale bar = 1cm.

Figure 11. Tarsometatarsi of living cassowaries, *Casuarius*, and the Emu, *Dromaius*.
A,E,I, *D. novaehollandiae*; B,F,J, *C. bennetti*; C,G,K, *C. casuarius*; D,H,L, *C. unappendiculatus*. A-D, proximal view; E-K, anterior view; I-L, distal view. Scale bar = 1cm.