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NOTA PALEONTOLÓGICA

A NEW SPECIMEN OF *AUSTRORAPTOR CABAZAI* NOVAS, POL, CANALE, PORFIRI AND CALVO, 2008 (DINOSAURIA, THEROPODA, UNENLAGIIDAE) FROM THE LATEST CRETACEOUS (MAASTRICHTIAN) OF RÍO NEGRO, ARGENTINA

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There were considerable differences in Late Cretaceous faunas of the Northern and Southern Hemispheres, although the differences were breaking down during Campanian and Maastrichtian times with the appearance of hadrosaurids in Antarctica and South America, and titanosaurids in North America. However, theropods continued to be separated into northern and southern faunas until paravians were discovered in the Southern Hemisphere (Novas and Puerta, 1997; Forster *et al.* 1998; Calvo *et al.* 2004; Makovicky *et al.* 2005; Novas and Pol, 2005; Novas *et al.* 2008).

During the 2008 field season, a joint expedition to the Bajo de Santa Rosa (Río Negro, Argentina) recovered a second, slightly smaller specimen of *Austroraptor cabazai* Novas, Pol, Canale, Porfiri and Calvo, 2008 (Novas *et al.* 2008; Paulina Carabajal *et al.*, 2009). The specimen was identified on the basis of the morphology of the humerus, metatarsal III and pedal phalanx IV-2 (originally identified as IV-1 in the holotype, MML 195). Although the skeleton is incomplete, it preserves bones (radius, ulna, and elements of the metacarpus, metatarsus and pes) that were not recovered with the holotype of this large dromaeosaurid. The description of this second specimen is intended to complement the description of the holotype (Novas *et al.*, 2008), adding information about the limb morphology, particularly the forelimb and foot of this dinosaur.

Abbreviations. **MML**, Museo Paleontológico de Lamarque, Lamarque, Río Negro, Argentina.

SYSTEMATIC PALEONTOLOGY

Suborder Theropoda Marsh, 1881

Family Unenlagiidae Bonaparte, 1999

Genus ***Austroraptor*** Novas, Pol, Canale, Porfiri and Calvo, 2008

Type species. *Austroraptor cabazai* Novas, Pol, Canale, Porfiri and Calvo, 2008. Santa Rosa Basin, Rio Negro Province, Argentina; Allen Formation, Maastrichtian, Upper Cretaceous (Martinelli and Forasiepi, 2004).

Austroraptor cabazai Novas, Pol, Canale, Porfiri and Calvo, 2008

Figures 1–3

Holoype specimen. MML 195: The cranial material consists of a right frontal and postorbital, both lacrimals, both maxillae and dentaries with *in situ* teeth, right surangular and prearticular. The postcranial remains consist of cervicals 3, 5, 6, 7 and 8, dorsals 2 and 4, isolated ribs and gastralia, right humerus, manual ungual of digit III, left pubic shaft, left femur, and right tibia, astragalus, calcaneum, metatarsal III and pedal phalanges I-2, II-2, III-4 and IV-1 (Tab. 1).

Referred material. MML220: The cranial material consists of two maxillary fragments and two isolated teeth. The postcranium is represented by one incomplete dorsal vertebra, 12 caudal centra, left humerus, right and left radii, right and left ulnae, right and left metacarpals I, manual phalanx I-1, manual ungual phalanges I-2, II-3 and III-4, tibia (left?), fragmentary metatarsals II and III, and pedal phalanges I-1, II-1, II-2, III-1, III-2, III-3, IV-1, IV-2 and IV-5 (Tab. 1).

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Locality and age. Northeastern part (39°54.657′S–66°34.890′W) of Santa Rosa Basin, Rio Negro Province, Argentina; Allen Formation, Maastrichtian, Upper Cretaceous (Martinelli and Forasiepi, 2004).

Description. One maxillary fragment includes the bases of four alveoli, each of which is 9 mm long anteroposteriorly. The two isolated teeth are small in size and conical, resembling those of spinosaurid theropods, as in the holotype specimen of *Austroraptor* (Novas *et al*., 2008).

A badly shattered vertebra is probably from the mid to posterior dorsal series, based on its proportions, the presence of a shallow lateral depression, but the lack of a clear pleurocoel. The centrum is 96 mm long and at least 54 mm wide. It is smooth and flat ventrally. The ten caudal vertebrae recovered comprise only long, low caudal centra that range in length from 32 to 82 mm long. Based on the relative size and elongate proportions of the vertebrae, they are all from the distal half of the tail.

Table 1 **- Length of limb elements for the two specimens of Austroraptor cabazai (in mm).**

	MML 195	MML 220
Humerus	*265*	*232+*
Radius	------	*161*
Ulna	------	*188*
Metacarpal I	------	*39*
Manual I-1	------	*90.5*
Ungual I-2	------	*50+*
Ungual II-3	------	*67*
Ungual III-4	*53*	*42+*
Femur	*560*	------
Tibia	*565*	*560*
Metatarsal II	------	*325+*
Metatarsal III	*330*	*330+*
Pedal I-1	------	*41*
Pedal I-2	*?*	------
Pedal II-1	------	*61.2*
Pedal II-2	*58.8*	*58.1*
Pedal III-1	------	*98.2*
Pedal III-2	------	*56.2*
Pedal III-3	------	*48.5*
Pedal III-4	*67*	------
Pedal IV-1	*43.1*	*49.3*
Pedal IV-2	------	*33.7*
Pedal IV-5	------	*46+*

The right humerus lacks the deltopectoral crest, but the shaft is short and robust like that of the holotype (Fig. 1.1–4). In the holotype, the deltopectoral crest projects anteriorly and is laterally flat, instead of being anterolaterally oriented and laterally excavated as in *Unenlagia* Novas and Puerta, 1997, and *Buitreraptor* Makovicky, Apesteguía and Agnolín, 2005 (Novas *et al*., 2008).

The right ulna is nearly complete, and lacks only the olecranon process (Fig. 1.5–8). The preserved proximal end is 29 mm in anteroposterior diameter, but would have been larger. A more fragmentary limb element is the proximal end of the left ulna, and it has a proximal diameter of 35 mm. The minimum diameter of the gently curving shaft is 14 mm, which is about 50% greater than the shaft diameter of the radius. The shaft of the ulna is concave towards the radius, and there is a large space between the shafts of the radius and ulna, as in other paravians (Norell and Makovicky, 2004).

The long, left radius is complete (Fig. 1.9–11). As in other paravians, the radius is straight with proximal and distal articulations expanded perpendicularly to one another (Norell and Makovicky, 2004). The forearm is approximately 72% of the humerus length, whereas it is 75% in *Deinonychus* Ostrom, 1969, and 70% in *Velociraptor* Osborn, 1924 (Norell and Makovicky, 2004).

Metacarpal I is a dorsoventrally compressed element that is 38 mm long. The proximal end is subtriangular and is double the width of the distal end (Fig. 1.12–17).

One elongate manual phalanx is missing a section of the shaft, but appears to have been almost complete with a combined length of 90.5 mm. The distal end articulates smoothly with the proximal articulation of ungual phalanx I-2, and can be tentatively identified as I-1.

Four of the six manual unguals were recovered, including most of phalanx I-2 (right), both II-3 (the left one is almost complete), and most of III-4 (Fig. 1.18–21). The ungual of the first digit is the strongest and deepest proximally, that of the second is only slightly more gracile, whereas that of the third is much more lightly built. All have well-developed flexor tubercles that clearly distinguish them from the second pedal ungual. In the holotype, the manual ungual of digit III is small but strongly curved, describing an arc that is much more pronounced than in other dromaeosaurids (Novas *et al*., 2008).

A long limb bone corresponding to the left (?) tibia was collected, but has been crushed so badly that no features are visible and the only measurement that might be reliable is the length, which is about 56 cm.

The metatarsus is represented by the proximal end of metatarsal II, and the distal ends of one second and both third metatarsals. The anteroposterior length of the proximal end of the second right metatarsal is 56 mm, and has a maximum preserved width (some of the external surface is missing) of 35 mm near the anterior end. In proximal outline, the convex medial surface converges posteriorly with the shallowly concave lateral side. The proximal proportions are reminiscent of both dromaeosaurids (Ostrom, 1969) and troodontids (Wilson and Currie, 1985). The 14 cm, proximodistal length of the distal end of the left second metatarsal shows that the bone is relatively narrow and high. The distal

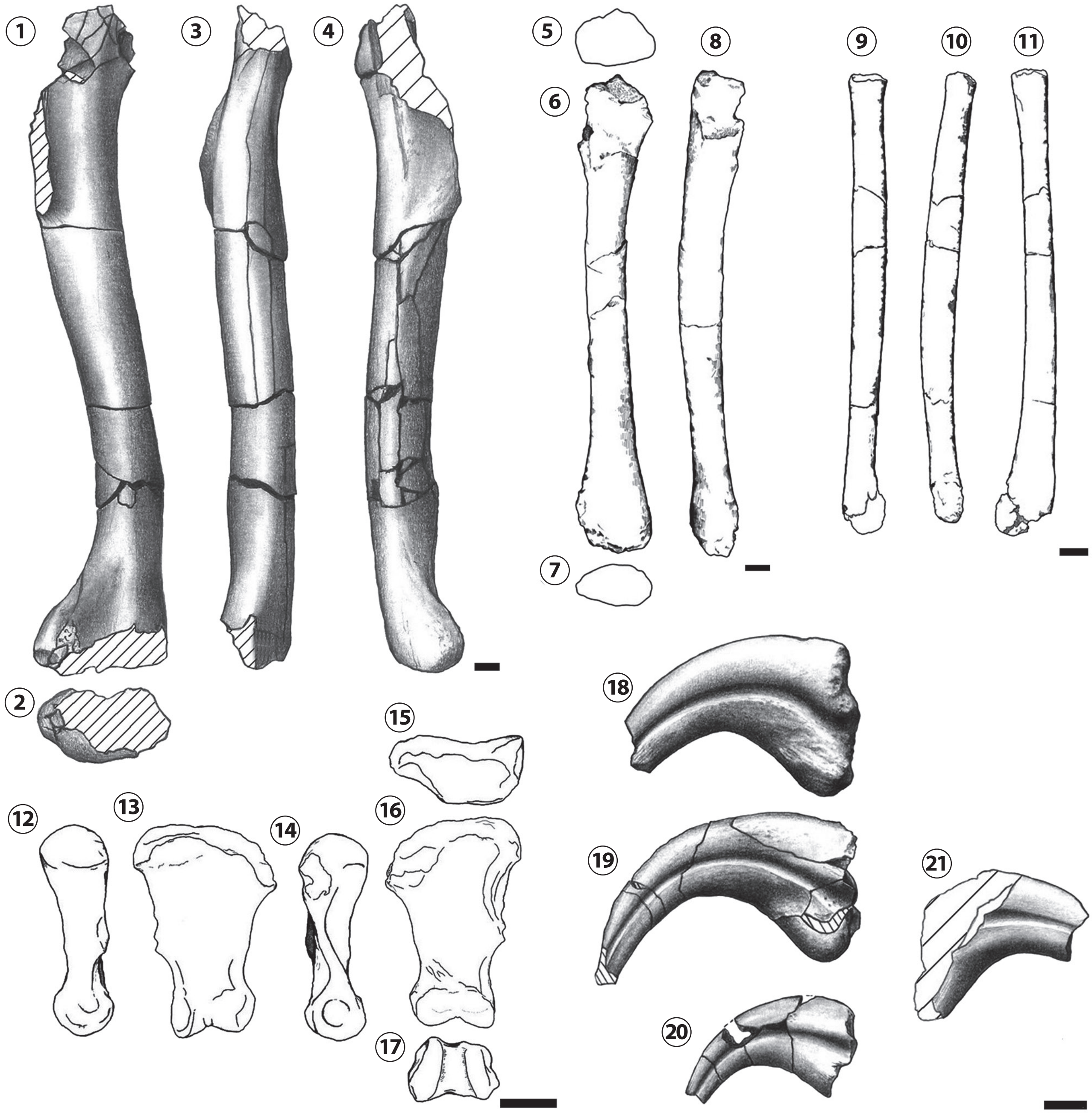

Figure 1. ***Austroraptor cabazai***, MML 220; **1–4**, left humerus in **1**, lateral; **2**, distal; **3** posterior and **4**, medial views; **5–8**, right ulna in **5**, proximal; **6**, anterior; **7**, distal and **8**, posterior views; **9–11**, left radius in **9**, anterior; **10**, lateral and **11**, posterior views; **12**–**17**, right metacarpal I in **12**, lateral; **13**, ventral; **14**, medial; **15**, proximal; **16**, dorsal and **17**, distal views; **18–21**, ungual phalanges, **18**, I-2; **19,21**, II-3 and **20**, III-4./ **Austroraptor cabazai**, *MML 220;**1–4**, húmero izquierdo en vistas **1**, lateral; **2**, distal; **3** posterior y **4**, medial; **5–8**, ulna derecha en vistas **5**, proximal; **6**, anterior; **7**, distal y **8**, posterior; **9–11**, radio izquierdo en vistas **9**, anterior; **10**, lateral y **11**, posterior; **12**–**17**, metacarpal I derecho en vistas **12**, lateral; **13**, ventral; **14**, medial; **15**, proximal; **16**, dorsal y **17**, distal; **18–21**, falanges ungueales, **18**, I-2; **19,21**, II-3 and **20**, III-4*. Scale/ *escala*= 10 mm.

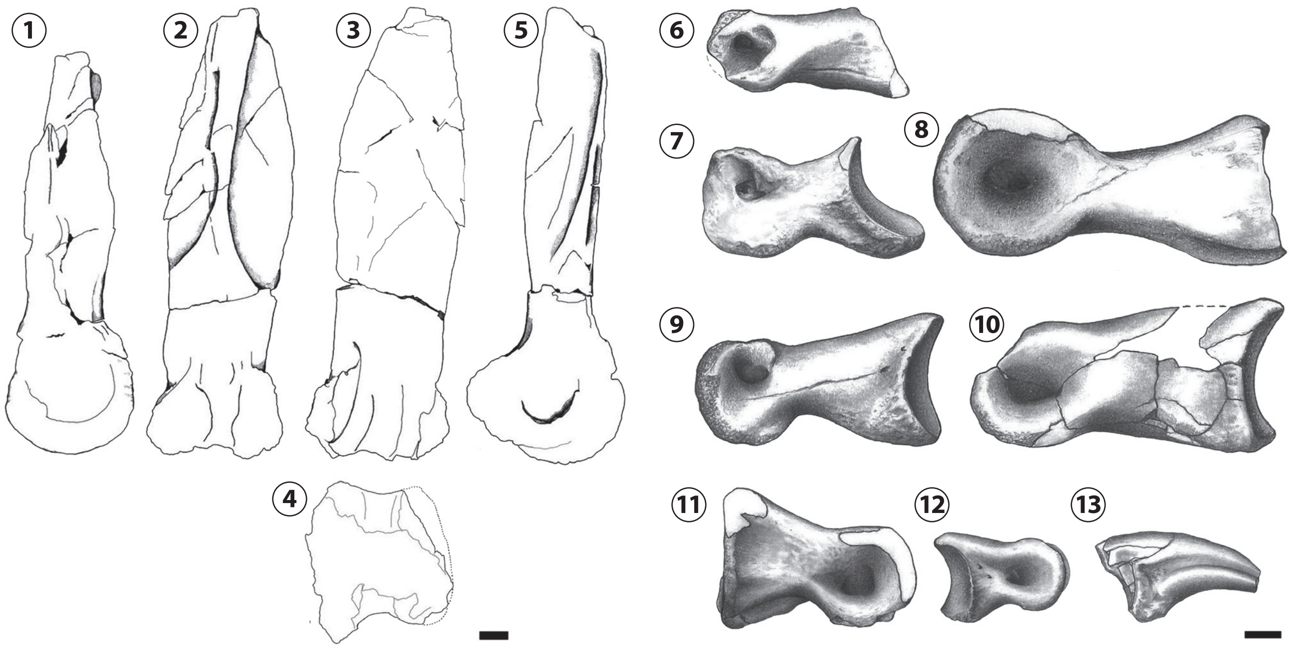

Figure 2. ***Austroraptor cabazai****,* MML 220; **1**, distal end of left metatarsal II in lateral view; **2–5**,distal end of right metatarsal III in **2**, posterior; **3**, anterior; **4**, distal and **5**, medial views; **6–8**, pedal phalanges; **6**, I-1; **7**, II-2; **8**, II-1; **9**, III-3; **10**, III-2; **11**, IV-1; **12**, IV-2; **13**, IV-5. **Austroraptor cabazai**, *MML 220; **1**, extremo distal del metatarsal II izquierdo en vista lateral; **2–5**, extreme distal del metatarsal III derecho en vistas **2**, posterior; **3**, anterior; **4**, distal y **5**, medial; **6–8**, falanges pedales; **6**, I-1; **7**, II-2; **8**, II-1; **9**, III-3; **10**, III-2; **11**, IV-1; **12**, IV-2; **13**, IV-5*. Scale/ *escala* = 10 mm.

condyle is damaged laterally, but appears to have been approximately 32 to 35 mm wide (mediolaterally), whereas it is 44 mm anteroposteriorly (Fig. 2.1). The distal articulation was clearly ginglymoid, which would have ensured a precise plane of rotation for the second toe, a feature unique to dromaeosaurids (Makovicky and Norell, 2004). The second metatarsal of some basal avialians, such as *Confuciusornis*, also have ginglymoid distal articulations (Makovicky, pers. comm.). A supposed second metatarsal was collected with the holotype, but has been crushed so badly that no features are visible and the only measurement that might be reliable is the length (325 mm).

The distal ends of both third metatarsals were recovered, and the left one is 17.5 cm long. The upper limit of the left third metatarsal is only 25 mm wide, but expanding ventrally to 49 mm where it overlaps the second and fourth metatarsals (Fig. 2.2–5). This proximal pinching of the third metatarsal in *Austroraptor* was included as one of the postcranial synapomorphies of the Unenlagiinae (Novas *et al*., 2008). The bone is roughly triangular in cross section at this level, with the largest surface facing anteriorly, the next largest surface oriented posterolaterally for contact with the fourth metatarsal, and the smallest surface turned more medially than posteriorly for contact with the second metatarsal. The transverse width of the distal end of meta-

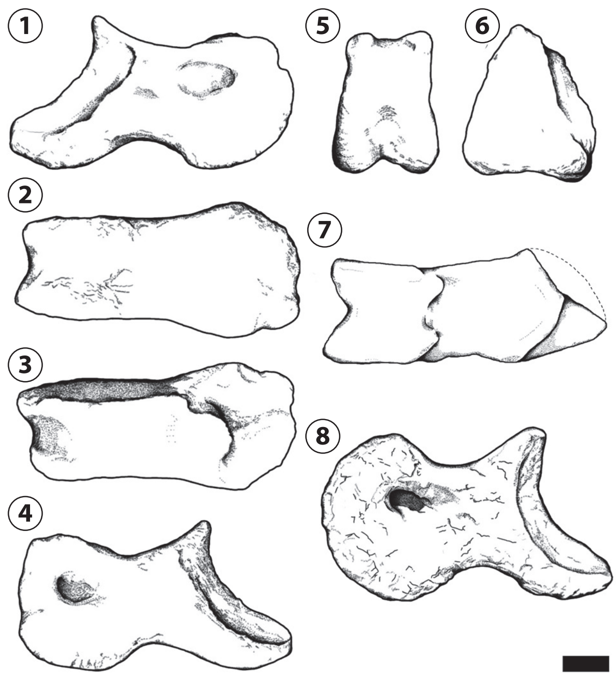

Figure 3. 1–6, ***Austroraptor cabazai***, MML 220; left pedal phalanx II-2 in **1**, medial; **2**, ventral; **3**, dorsal; **4**, lateral; **5,** proximal and **6**, distal views. **7–8**, ***Austroraptor cabazai***, MML 195; left pedal phalanx II-2 in **7**, dorsal and **8**, lateral views (Fig. 3.7 after Novas *et al*., 2008, fig. 1.k)./ ***1–6*, Austroraptor cabazai**, *MML 220; falange pedal II-2 izquierda en vistas **1**, medial; **2**, ventral; **3**, dorsal; **4**, lateral; **5,** proximal y **6**, distal. **7–8**,* **Austroraptor cabazai**, *MML 195; falange pedal II-2 izquierda en vistas **7**, dorsal y **8**, lateral (Fig. 3.7 tomada de Novas et al., 2008, fig. 1.k)*. Scale/ *escala* = 10 mm.

tarsal III is approximately 45 mm, whereas its anteroposterior length is 60 mm. The third metatarsal of the holotype is badly crushed and distorted, although most of the length seems to be represented.

The proximal articulation of pedal digit II-1 is shallowly concave, but has a weak vertical ridge near the middle that divides it into a weak ginglymoid joint.

Like all dromaeosaurids and troodontids, the proximal articulation of pedal II-2 has a well-developed 'heel' (Fig. 2.7). The length from the most anterior point of the lateral edge of the proximal articulation to the most anterior point of the medial condyle of the distal articulation is 34.7 mm, and the maximum length of II-2 including the heel is 58.1 mm. The same measurements on the holotype are 42.4 mm and 58.8 mm. As in the holotype of *Austroraptor*, phalanx II-2 has a constricted 'neck' between proximal and distal articular surfaces, and a posteroventrally projected 'heel'. This is characteristic amongst paravians, and presumably provided leverage for insertion of the enlarged flexor muscle and strengthened the joint between the first and second phalanges (Makovicky and Norell, 2004; Novas *et al*., 2008). As in the holotype, pedal phalanx II-2 is transversely narrow, contrasting with the robust pedal phalanx IV-2 and differing from other dromaeosaurids, including unenlagines, but resembling the condition of advanced troodontids (Novas *et al*., 2008). Both sides of the heel in MML 220 can be seen in dorsal view (Fig. 3.3), and this was probably also the condition in the holotype (Novas *et al*. 2008, fig. 1k), in which one side of the heel is bad preserved (Novas, pers. comm).

The ginglymoid proximal articulation of pedal phalanx III-1 (Fig. 2.8) is well developed. This is the longest pedal phalanx (98.2 mm). Pedals phalanges III-2 and III-3 (Figs. 2.10 and 2.9 respectively) are better preserved.

Pedal phalanx IV-1 is relatively small in comparison with the phalanges of the third toe (Fig. 2.11). The undivided proximal articulation is narrow (27.9 mm), but tall (37.6 mm), whereas the distal end expands to 33.3 mm. The phalanx identified by Novas *et al*. (2008) as pedal IV-2 is more likely a pedal IV-1 because of the shape of the proximal articulation. This articulation is shallowly concave in IV-1, but is a double depression in IV-2 (to articulate with the double condyle of the distal end of IV-1 in a ginglymoid joint). The relatively strong shaft of the bone identified as IV-2 by Novas *et al*. (2008) is also within the expected size range of IV-1. The length of pedal IV-1 in the holotype (MML 195) is smaller (Tab. 1), although the bone is taller (44.0 mm) and more robust. The fact that the proximal end of this phalanx is taller than wide, and narrower than the distal end, is an autapomorphy shared by both specimens that is not present in other theropod specimens. These proportions are also observed in *Neuquenraptor*, at least as far as the wider distal versus proximal articulations (Makovicky, pers. comm.).

Pedal IV-2 (Fig. 2.12) is relatively short (Tab. 1), and the triangular proximal end is taller (31 mm) than wide (28 mm). This bone articulates in a tight ginglymoid joint with the distal end of pedal IV-1. Like most dromaeosaurids (*e.g.*, *Deinonychus*, *Velociraptor* and *Neuquenraptor* Novas and Pol, 2005; Ostrom, 1969; Norell and Makovicky, 1999; Novas and Pol, 2005), the shaft of pedal phalanx II-2 is slightly narrower than the shaft of phalanx IV-2 (Novas *et al*., 2008).

CONCLUSIONS

Reports of dromaeosaurids in the Southern Hemisphere have been particularly relevant recently. A second specimen (MML 220) of the large *Austroraptor cabazai* (Novas *et al*., 2008) has been identified on the basis of the morphology of the humerus, metatarsal III and pedal phalanx IV-1. Also, MML 195 and MML 220 were found in the same geographic area at the same stratigraphic levels.

The new specimen represents an adult individual that is slightly smaller than the holotype (MML 195), which was estimated to be 5 m long (Novas *et al*., 2008). The proportions of the long elements of the forearm are similar to other dromaeosaurids. In *Austroraptor* the forearm is approximately 72% of the humerus length, and is 75% in *Deinonychus* and 70% in *Velociraptor* (Norell and Makovicky, 2004). However, the humerus of *Deinonychus* represents 76% of femoral length, whereas the humerus of *Austroraptor* is about 47% of femoral length (Novas *et al*., 2008) and about 45% in the second specimen (if we assume a subequal length for the femur and tibia). The pes in the second specimen seems to be arctometatarsalian.

The second specimen (MML 220) preserves elements not recovered for the holotype, including the radius, ulna, metacarpal I, partial metatarsals II and III, and pedal phalanges I-1, II-1, III-2, III-3, IV-2 and IV-5. The new materials add to the information of the limb anatomy in the taxon.

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