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THE RINGED KINGFISHER, *CERYLE* OR *MEGACERYLE TORQUATA* (CERYLINAE, ALCEDINIDAE, CORACIIFORMES)? AN OSTEOLOGICAL VIEW

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Resumo. – *Ceryle* ou *Megaceryle torquata* (Cerylinae, Alcedinidae, Coraciiformes)? Uma visão osteológica. – Apesar do incontestável monofiletismo da subfamília Cerylinae, há divergências na alocação de *Megaceryle torquata* nos gêneros *Megaceryle* ou *Ceryle*. Com o objetivo de se tentar elucidar a questão, é apresentado um estudo osteológico comparativo entre *Megaceryle torquata* e *Ceryle rudis*, bem como com as demais espécies de *Megaceryle* e de *Chloroceryle*. Os resultados evidenciam maiores similaridades osteológicas de *M. torquata* com as demais espécies do gênero *Megaceryle*, diferindo consideravelmente de *C. rudis*. Os dados permitiram, ainda, uma diagnose do gênero *Megaceryle*, sendo a maioria dos caracteres proveniente do esqueleto craniano. Apesar de não haver qualquer inferência filogenética, há evidências osteológicas significativas que permitem a inclusão de *Megaceryle torquata* no gênero *Megaceryle* e a manutenção do gênero *Ceryle* unicamente para recepção de *C. rudis*.

Abstract. – In spite of the unquestionable monophyly of the Cerylinae subfamily, there are divergences in considering *Megaceryle torquata* in the genera *Megaceryle* or *Ceryle*. In order to address the question, here is a comparative osteological study between *M. torquata* and *C. rudis*, as well as with the other *Megaceryle* species and *Chloroceryle*. The findings showed more osteological similarities between *M. torquata* and the other *Megaceryle* species, differing considerably of *C. rudis*. Also, the data have permitted the identification of the genus *Megaceryle*, with most of the characters from the skull. In spite of not having any phylogenetic inference, there are relevant osteological evidences that permit the consideration of *M. torquata* in the genus

Megaceryle and the maintenance of *Ceryle* only for reception of *C. rudis*. Accepted 19 June 2006.

Key words: Ringed Kingfisher, *Ceryle*, *Megaceryle torquata*, Cerylinae, Alcedinidae, Coraciiformes, osteology, systematic.

INTRODUCTION

The green and giant kingfishers (Cerylinae) are generally included as a subfamily within the Alcedinidae (Coraciiformes), together with the subfamilies Alcedininae (small blue-and-rufous kingfishers) and Daceloninae (kookaburras and halcyons). The ceryline kingfishers differ from alcedinine and daceonine in lacking blue or bright blue colors in the plumage and in having spotted flight feathers (Fry 1980). The Cerylinae subfamily includes only nine species in three genera.

Members of the Cerylinae are the only kingfishers found in the New World. The Nearctic region has the Belted Kingfisher (*Megaceryle alcyon*), which can reach Panama, north Colombia (very rare) and the coastal side of Venezuela and Guyana, mainly in winter time. In the Neotropical region, there are four endemic *Chloroceryle* species and the Ringed Kingfisher (*Megaceryle torquata*) that spreads from Mexico to Tierra del Fuego, Argentina, except for northern Chile and west-central Argentina (Fry 1979, 1980; Fry & Fry 1999). Africa has only two species, the Giant Kingfisher (*Megaceryle maxima*) and the Pied Kingfisher (*Ceryle rudis*), both widely distributed. The Pied Kingfisher extends across Asia and the Crested Kingfisher (*Megaceryle lugubris*) has the most restricted distribution, ranging from Afghanistan to Japan (Fry & Fry 1999).

The monophyly of the Cerylinae has never been questioned, but the systematic of the two genera *Ceryle* and *Megaceryle* is poorly understood. *Megaceryle torquata* has been placed in the genus *Ceryle* in many classifications (e.g., Meyer de Schauensee 1970, AOU 1983, 1998; Sick 1997), but most of them

have followed Fry (1979, 1980) in restricting *Ceryle* to the Old World *C. rudis* (e.g., Sibley & Ahlquist 1990, Sibley & Monroe 1990, Howard & Moore 1998, Fry & Fry 1999, Woodall 2001). However, data supporting either treatment are still minimal.

Thus, the main goal of this paper is to present an osteological view on *Ceryle* and *Megaceryle torquata* in comparison to the other *Megaceryle* species in order to solve the problematic, but without any phylogenetic inference. The *Chloroceryle* species were also considered.

MATERIAL AND METHODS

The study was based on 72 specimens belonging to nine species of the Cerylinae subfamily.

The osteological material was provided by the American Museum of Natural History, New York (AMNH), Field Museum of Natural History, Chicago (FMNH), Louisiana State University Museum of Natural Science, Baton Rouge (LSUMNS), Museu de História Natural de Taubaté, São Paulo (MHNT), National Museum of Natural History, Smithsonian Institution, Washington (USNM), and University of Michigan Museum of Zoology, Ann Arbor (UMMZ), as detailed in Appendix 1.

Osteology was studied comparatively and described, in most cases, using a Leika Wild M3B stereomicroscope (9.6 X 60) and a Mitutoyo 500-143B digital caliper, with 0.01 mm to 150 mm of accuracy. Most of the relevant osteological structures are pointed out in illustrations.

The osteological nomenclature follows the Nomina Anatomica Avium (Baumel & Witmer 1993) and, in some cases, Pascotto &

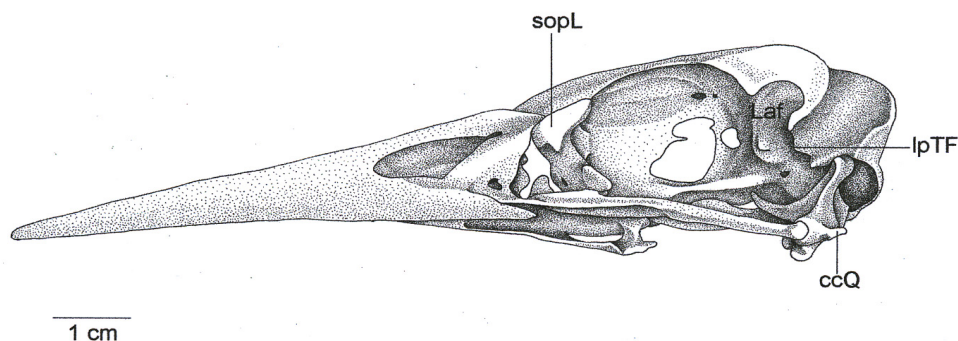


FIG. 1. Lateral view of the skull of *Megaceryle maxima* USNM 560529. ccQ – caudal condyle of the quadrate; Laf – laterosphenoid fossa; lpTF – lateral projection of the temporal fossa; sopL – supraorbital process of the lacrimal.

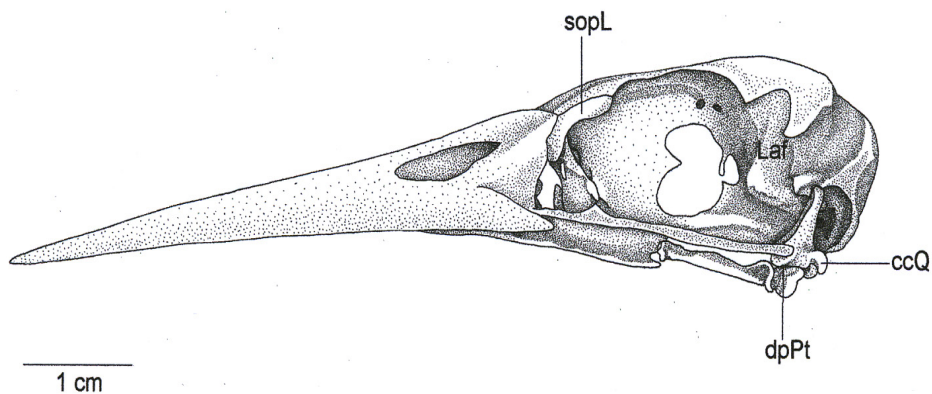


FIG. 2. Lateral view of the skull of *Ceryle rudis* USNM 322469. ccQ – caudal condyle of the quadrate; dpPt – dorsal process of the pterygoid bone; Laf – laterosphenoid fossa; sopL – supraorbital process of the lacrimal.

Donatelli (2003). All osteological terminology were translated to English. Species nomenclature followed Sibley & Monroe (1990).

RESULTS

Ossa cranii. The ventral surface of the postorbital process of *Megaceryle torquata* is completely fused to the anterior temporal crest and contributes to increase the rostroventral

edge of the temporal fossa, as in *M. lugubris*, *M. maxima* (lpTF: Fig. 1), and *M. alyon*. In *Ceryle rudis* (Fig. 2), the ventral surface of the postorbital process is smaller, resembling that of *Chloroceryle inda*, *C. americana* and *C. aenea*.

The cerebellar region of *M. torquata* resembles that of *M. lugubris* and *M. maxima* (Fig. 3), which is flattened, not forming a prominence, thus differing from *Ceryle rudis* (Pc: Fig. 4) and *Chloroceryle* species where the prominence is

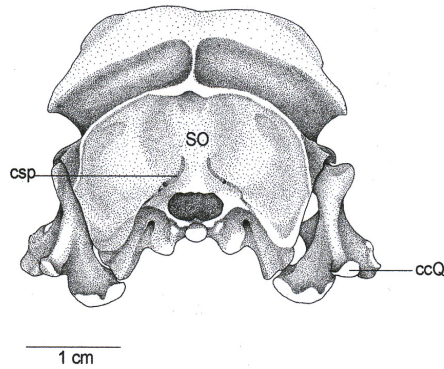


FIG. 3. Caudal view of the skull of *Megaceryle maxima* USNM 560529. ccQ – caudal condyle of the quadrate; csp – canalis semicircularis posterior; SO – supraoccipital region.

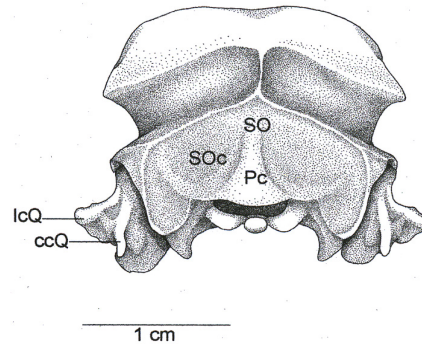


FIG. 4. Caudal view of the skull of *Ceryle rudis* USNM 430686. ccQ – caudal condyle of the quadrate; lcQ – lateral condyle of the quadrate; Pc – cerebellar prominence; SO – supraoccipital region; SOc – concavity of the supraoccipital region.

formed. As a consequence of the flatness of the nuchal region, the whole supraoccipital region below the nuchal crest in *M. torquata* is also flat, like in *M. maxima* (SO: Fig. 3) and *M. lugubris*, but different from *Ceryle rudis* and *Chloroceryle* species by having a shallow concavity just lateral to the prominence.

The canalis semicircularis posterior of *Ceryle rudis* is short and placed laterally, contrary to that of *Megaceryle* and *Chloroceryle* species, where it is longer and placed dorsolaterally to the magnum foramen (csp: Fig. 3).

As in *M. lugubris*, *M. maxima* (sopL: Fig. 1) and *M. alcyon*, the supraorbital process of the lacrimal bone is wider lateromedially in *M. torquata* than it is in *Ceryle rudis* (sopL: Fig. 2) and *Chloroceryle amazona*, in which it is narrower.

Like in *Chloroceryle* and other *Megaceryle* species, the ectethmoid bone is wide dorsoventrally and lateromedially in *M. torquata*, but shows the smallest extent only in *Ceryle rudis*. The distal extremity of the ectethmoid in *M. torquata* is forked as in *M. maxima*, *M. lugubris*, *M. alcyon* and *C. amazona*, but is sharp

in *Ceryle rudis* and the remaining species of *Chloroceryle*.

In contrast with *Ceryle rudis*, the lateral edge of the laterosphenoid fossa (also formed by the anterior temporal crest) in *M. torquata* is developed and runs laterally, as in *M. maxima* (Laf: Fig. 1), *M. lugubris* and *M. alcyon*. It is reduced in *C. rudis* (Laf: Fig. 2) and resembles that of *Chloroceryle americana*, *C. inda* and *C. aenea*.

Besides having similar palate, *Ceryle rudis* differs from *Megaceryle* and *Chloroceryle* species by presenting an almost straight maxillar process of the palatine.

The dorsal process of the pterygoid is inconspicuous in *M. torquata*, *M. lugubris*, *M. maxima* and *M. alcyon*, but is conspicuous and slender in *Ceryle rudis* (dpPt: Fig. 2), as in *Chloroceryle* species.

The caudal condyle of the mandibular process of the quadrate bone in *M. torquata* resembles that of *M. maxima* (ccQ: Figs 1 and 3), *M. lugubris* and *M. alcyon*; it is reduced and runs dorsomedially. However, in *Ceryle rudis* (ccQ: Figs 2 and 4) and *Chloroceryle* species, it is more developed and projects caudoventro-

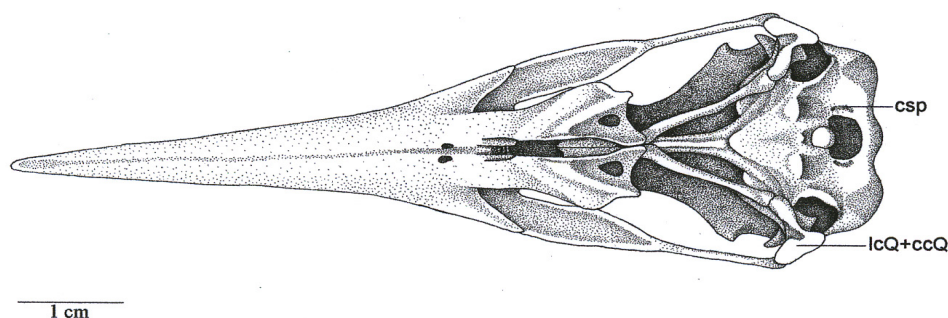


FIG. 5. Ventral view of the skull of *Megaceryle maxima* USNM 322469. csp – *canalis semicircularis posterior*; lcQ + ccQ – fusion of the lateral and caudal condyles of the quadrate.

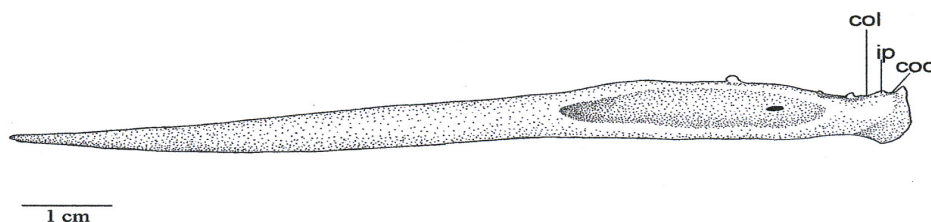


FIG. 6. Lateral view of the left mandibular rami of *Megaceryle torquata* USNM 500429. coc – caudal cotyla of the quadratic articular fossa; col – lateral cotyla of the quadratic articular fossa; ip – intercotylar process.

medially.

On its ventral face, the lateral and caudal condyles are fused in *M. torquata* as in *M. maxima*, *M. lugubris* (lcQ+ccQ: Fig. 5) and *M. alcyon*, while they are separated in *Ceryle rudis* like in *Chloroceryle* species.

The orbital process of the quadrate bone in *M. torquata* and *Ceryle rudis* are alike in form, but not in development. It is around 25% longer in *M. torquata*, as in *M. lugubris*, *M. maxima* and *M. alcyon*, than in *C. rudis*. Also, the orbital process runs rostrrodorsomedially in *M. torquata*, *M. lugubris*, *M. maxima* and *M. alcyon*, and rostromedially in *Ceryle rudis*, as in *Chloroceryle amazona*, *C. americana*, *C. inda* and *C. aenea*.

The distal portion of the orbital process of the quadrate is slightly curved backward

and wide dorsoventrally in *M. torquata*, *M. lugubris*, *M. maxima* and *M. alcyon*, while in *Ceryle rudis* it has the same orientation for the whole extension and its tip is sharp, as in *Chloroceryle*.

Ossa mandibulae. In the mandible, the medial fossa is longer in *Ceryle rudis* and in the *Chloroceryle* species than in *M. torquata*, *M. maxima*, *M. lugubris* and *M. alcyon*. In the former species, the medial fossa reaches the rostral surface of the intercotylar tubercle.

The quadratic articular fossa of the mandible is deeper and wider in *M. torquata*, *M. lugubris*, *M. maxima* and *M. alcyon* than in *Ceryle rudis*, *Chloroceryle amazona*, *C. americana*, *C. inda* and *C. aenea*, owing to the development of the transverse crest. The caudal cotyla of the qua-

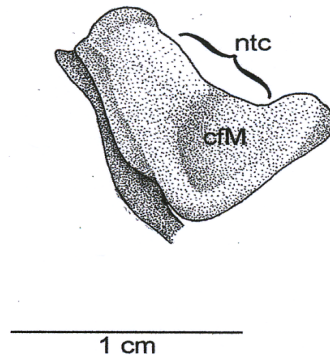


FIG. 7. Caudal view of the left mandibular rami of *Megaceryle maxima* USNM 560529. cfM – caudal fossa of the mandible; ntc – notch on the transverse crest.

dratic articular fossa is also wider and more conspicuous in the *Megaceryle* species than in *Ceryle rudis*.

In *M. torquata* (ip: Fig. 6), *M. maxima*, *M. lugubris* and *M. alcyon*, there is a reduced intercotylar process dividing the lateral (col: Fig. 6) and caudal (coc: Fig. 6) cotylae of the quadratic articular fossa. On the other hand, such a reduced intercotylar process is absent in *Ceryle rudis* and in the *Chloroceryle* species, the two cotylae being indistinct from each other.

The caudal fossa of the mandible is wider dorsoventrally in *M. torquata*, *M. maxima* (cfM: Fig. 7), *M. lugubris* and *M. alcyon* than in *Ceryle rudis*, in which it is narrow like in *Chloroceryle* species (cfM: Fig. 8). In the dorsal edge of the caudal fossa of the mandible, there is a narrow and shallow notch in *Megaceryle* species (ntc: Fig. 7), while it is wide and deep in *Ceryle rudis*, resembling that of *Chloroceryle* (ntc: Fig. 8).

Clavicula. The acrocoracoid process of the clavicle is vestigial in *M. torquata*, as in *M. maxima* and *M. alcyon*, in contrast with that of *Ceryle rudis*, in which it is present but reduced, with similar extent and width.

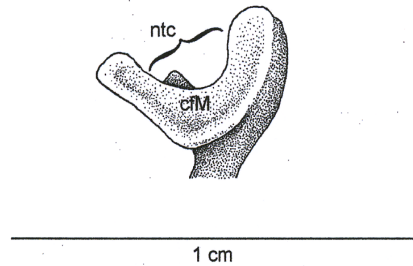


FIG. 8. Caudal view of the right mandibular rami of *Chloroceryle aenea* USNM 562563. cfM – caudal fossa of the mandible; ntc – notch on the transverse crest.

Scapulae. In *Ceryle rudis*, the dorsal edge of the scapula is straight. However, in *M. torquata*, the scapula presents a conspicuous bony projection, as in *M. maxima*, *M. lugubris*, *M. alcyon* and *Chloroceryle* (bp: Fig. 9).

Coracoideum. The medial process of the coracoid is absent in *Ceryle rudis*. In *M. torquata*, it is slightly conspicuous, as in *M. maxima* (mp: Fig. 10), *M. lugubris* and *M. alcyon*.

Vertebrae thoracicae. On the ventral face of the first toracic vertebra fused to the sinsacro, there is a conspicuous ventral bony projection in *Ceryle rudis*, like in *Chloroceryle*. In *M. torquata*, such projection is lacking as in the other *Megaceryle* species.

DISCUSSION

The increase of the temporal fossa edge is unique of *Megaceryle*, among all the Coraciiformes, Trogoniformes and Piciformes (Burton 1984, Flausino *et al.* 1999, Pascotto 2005; Pascotto *et al.* 2006). On the temporal fossa originate the flesh fibers of the *M. adductor mandibulae externus rostralis temporalis* (Burton 1984, Donatelli 1996). So, one can expect it more highly developed in *Megaceryle* than in any other species of kingfishers, but Burton

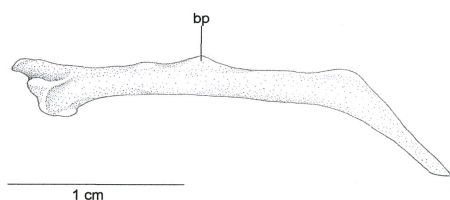


FIG. 9. Medial view of the right scapula of *Chloroceryle inda* USNM 622337. bp – bony projection.

(1984) stated that other members of Alcedinidae show an essentially similar structure of the *M. adductor externus rostralis temporalis*.

Among the kingfishers, *Pelargopsis* (Daceloninae) is the only one presenting a flattened cerebellar and supraoccipital region as in *Megaceryle* (Pascotto *et al.* 2006).

The fusion of the lateral and caudal condyles of the mandibular process of the quadrate bone, however, was also observed in Leptosomidae, Phoeniculidae, Upupidae (Pascotto *et al.* 2006), Trogonidae and Bucconidae (Pascotto 2005).

The caudal fossa of the mandible is the main attachment surface of the *M. depressor mandibulae*, responsible for depressing the lower jaw. Although Burton (1984) did not describe the variations in the *M. depressor mandibulae* of Alcedinidae, one can expect it slightly larger in *Megaceryle* than in *Ceryle* and *Chloroceryle*.

Höfling & Alvarenga (2001) also mentioned a bony projection on the dorsal edge of the scapula in *Merops apiaster* (Meropidae) and *Trogon surrucura* (Trogonidae). This structure is, however, characteristic of all Alcedininae, *Megaceryle* and *Chloroceryle* (Cerylinae) species, as well as of *Syma torotoro* (Daceloninae) and Pittidae (Passeriformes) (Pascotto 2005), but there is no known apparent function for it.

The ventral bony projection on the first thoracic vertebra fused to the sacro displays considerable individual variability in development among the Coraciiformes (Pascotto

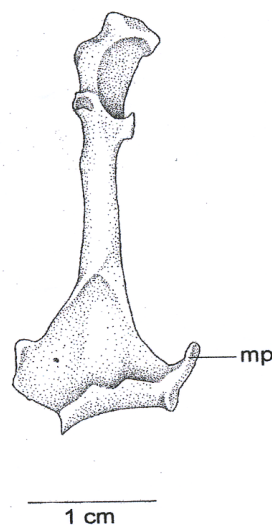


FIG. 10. Caudal view of the left coracoid of *Megaceryle torquata* USNM 500429. mp – medial process.

2005), not being a reliable character to differentiate species.

In comparing the osteology of *M. torquata* and *Ceryle rudis* with that of all Cerylinae species, it is evident that *C. rudis* differs considerably from *M. torquata*, and has several osteological similarities with *Chloroceryle*. Conversely, *M. torquata* shares many osteological characteristics with *M. lugubris*, *M. maxima* and *M. alcyon*; all four species arguably are closely related.

Most characters that distinguish *M. torquata* from *Ceryle rudis* belong to the skull and mandible, the postcranial skeleton being more conservative, specially at species level, as noticed by Höfling & Alvarenga (2001) and Pascotto (2005). The *Megaceryle* genus, nonetheless, can be diagnosed by having 1) the biggest development of the rostroventral edge of the temporal fossa; 2) the cerebellar and nuchal regions flattened (variable in *M. alcyon*); 3) a lateromedial wider supraorbital process of the lacrimal bone; 4) no dorsal process of the pterygoid; 5) the caudal condyle of the man-

dibular process of the quadrate bone projected dorsomedially and fused to the lateral condyle; 6) a longer orbital process of the quadrate bone, which projects rostradorsomedially; 7) a slightly curved backward and wider dorsoventrally distal portion of the orbital process of the quadrate; 8) a shorter medial fossa of the mandible; 9) a deeper quadratic articular fossa of the mandible; 10) the presence of a reduced intercotylar process dividing the lateral and caudal cotylae of the quadratic articular fossa; 11) a dorsoventral wider caudal fossa of the mandible, with a narrower and shallower notch on its dorsal edge; 12) no acrocoracoid process of the clavicle; and 13) by having no medial process of the coracoid. Many of the osteological characters that distinguish *M. torquata* from *Ceryle rudis*, however, may have no phylogenetic significance (Pascotto 2005), probably having evolved independently after a vicariant event.

Taken the fact that *M. torquata* shares several osteological characters with *M. maxima*, *M. lugubris* and *M. alyon*, we believe that there are relevant indications that the four species are more closely allied to each other than is *M. torquata* to *Ceryle rudis*, and that *M. torquata* should be placed into the genus *Megaceryle* in lieu of *Ceryle*. Consequently, the genus *Ceryle* should be monotypic with only *C. rudis*. These observations are, however, preliminary; a more complete assessment of their interrelationships requires a phylogenetic inference.

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APPENDIX 1. List of the Cerylinae specimens.

Megaceryle maxima (Pallas, 1769): AMNH 8037, female, Africa, Kenya; AMNH 16331, male, Liberia; USNM 560529, female, South Africa, Cape. *Megaceryle lugubris* (Temminck, 1834): USNM 292776, male, China, Szechuan; USNM 318238, indeterminate sex, China, Szechuan; USNM 319068, male, China, Szechuan. *Megaceryle alcyon* (Linnaeus, 1758): AMNH 18286, female, Morris Co., Millington; AMNH 24596, male, Hillsborough Co., Goffstown; UMMZ 107228, indeterminate sex, Michigan, Alcona Co.; UMMZ 107339, indeterminate sex, Michigan, Emmet Co.; USNM 322728, female, New York, Sing Sing; USNM 502300, female, Maryland, Gaithersburg; USNM 553851, male, Maryland, Montgomery; USNM 610992, juvenile; USNM 610994, male, Oregon, Klamath Falls; USNM 610995, male juvenile, Nevada, Pyramid Lake; USNM 621370, female, Virginia, Alexandria. *Megaceryle torquata* (Linnaeus, 1766): AMNH 447, indeterminate sex, Moluccas Island; AMNH 4654, indeterminate sex, local unknown; MHNT 127, female, Brazil, Tocantins; MHNT 378, female, Brazil, Mato Grosso; MHNT 1500, female, Brazil, São Paulo; USNM 288829, female, Guatemala, Peten; USNM 345913, male, Brazil, Mato Grosso; USNM 345914, female, Brazil, Mato Grosso; USNM 500429, male, Ecuador, Los Rios; USNM 562559, male, Panama, Bocas del Toro. *Ceryle rudis* (Linnaeus, 1758): AMNH 4228, indeterminate sex, Belgian Congo, Panga; UMMZ 204267, indeterminate sex, Egypt; UMMZ 206585, indeterminate sex, Egypt; USNM 322468, male, Cameroon, Tibati; USNM 322469, female, Cameroon, Tibati; USNM 322470, male, Cameroon, Konkwalá; USNM 430632, male, Zimbabwe, Gwaai reserve; USNM 430686, female, Zimbabwe, Suringa. *Chloroceryle amazona* (Latham, 1790): AMNH 13816, male, Mexico, Vera Cruz; MHNT 306, female, Brazil, São Paulo; USNM 227695, female, Uruguay, Rocha; USNM 559478, male, Venezuela, Amazonas; USNM 562204, male, Brazil, Pará, Altamira; USNM 613998, female, Panama, Bocas del Toro; USNM 613999, female, Panama, Bocas del Toro. *Chloroceryle americana* (Gmelin, 1788): AMNH 8556, male, local unknown; MHNT 611, female, Brazil, Tocantins; MHNT 628, male, Brazil, Mato Grosso; MHNT 767, male, Brazil, Goiás; USNM 500476, male, Ecuador, Los Rios; USNM 560164, male, Trinidad, Brasso Seco; USNM 562562, female, Panama, Bocas del Toro, Bastimentos Island; USNM 612333, female, Panama, Bocas del Toro; USNM 614650, female, Argentina, Entre Rios. *Chloroceryle inda* (Linnaeus, 1766): MHNT 1371, male, Brazil, São Paulo, Ubatuba;

FMNH 315406, male, Peru, Madre de Dios; FMNH 318863, male, Venezuela, T.F. Amazonas; LSUMNS 118212, indeterminate sex, Peru, San Martim Dept.; UMMZ 154727, indeterminate sex, Surinam; UMMZ 154728, indeterminate sex, Surinam; USNM 562207, male, Brazil, Pará, Altamira; USNM 562208, female, Brazil, Pará, Altamira; USNM 613418, female, Panama, Bocas del Toro; USNM 621406, male, Guyana, North West, Baramita; USNM 622337, male, Guyana, Karaudanawa. *Chloroceryle aenea* (Pallas, 1764): AMNH 8324, male, Guatemala; AMNH 8326, female, Guatemala; MHNT 609, male, Brazil, Tocantins; MHNT 1416, female, Brazil, Mato Grosso; USNM 492397, male, Ecuador, Guayas Province; USNM 500553, male, Ecuador, Los Rios, Abras de Mantequilla; USNM 502492, female, Ecuador, Los Rios, Abras de Mantequilla; USNM 562563, female, Panama, Bocas del Toro, Bastimentos Island; USNM 562564, female, Panama, Bocas del Toro, Bastimentos Island; USNM 614001, male, Panama, Bocas del Toro, Island Escudo de Veraguas.