

NOTA PALEONTOLÓGICA



A new Cretaceous chelid turtle from the northern Neuquén Basin, Argentina

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Introduction

The Family Chelidae is a group of freshwater aquatic to semi aquatic pleurodiran turtles with extant species distributed in South America and Australasia (Pritchard and Trebbau, 1984; Iverson, 1992). Its fossil record is known as early as the Albian in Patagonia (Lapparent de Broin and de la Fuente, 2001), Paleocene?–Eocene in Australia (Lapparent de Broin and Molnar, 2001), and Oligocene in Tasmania (Warren, 1969). This extant disjoint geographic range and the early fossil record of this family might be a result of an old biogeographical and phylogenetic history that was developed in Gondwanan landmasses (Broin, 1987, 1988; de la Fuente, 1988, 1992, 1997; Broin and de la Fuente, 1993a, 1993b). These turtles are characterized by two main autapomorphic conditions: the formulae of articulation of the cervical vertebrae including, after the biconcave atlas, three opisthocelous (second to fourth), two biconvexes (fifth and eighth), one procelous (sixth), and one biconcave (seventh) [This condition is shown as 1((2((3((4((5))6))7((8)), *sensu* Williams (1950) notation], and the developed lateral cheek emargination with loss of quadratojugal (see Gaffney, 1977; Broin and de la Fuente, 1993b).

The knowledge of Cretaceous chelids begun in Patagonia with Broin's study of chelonian fauna of Los Alamitos Formation in the context of Bonaparte's research of the fauna of Los Alamitos (Bonaparte *et al.*, 1984; Bonaparte, 1986, 1987). The preliminary Broin's study was followed by studies of additional and more complete chelid material recovered from several localities. They were included

in synthetic articles about the Argentinean chelonian fauna (Broin and de la Fuente, 1993a, 1993b) and more detailed studies (Gasparini and de la Fuente, 2000; de la Fuente *et al.*, 2001; de la Fuente, 2003; Lapparent de Broin and de la Fuente, 2001). References about them can also be seen in abstracts (Lapparent de Broin *et al.*, 1997; Lapparent de Broin and de la Fuente, 1999; de la Fuente, 1997; de la Fuente *et al.*, 2000) or in synthetic articles about the tetrapod assemblages of Patagonia (Bonaparte, 1996; Gasparini *et al.*, 2001; Gasparini *et al.*, 2002; Goin *et al.*, 2002; Leanza *et al.*, 2004).

Recently, a new partially preserved specimen of a chelid was recovered from an Upper Cretaceous horizon of the Neuquén Group. Although there are chelid specimens represented by complete shells, cervical vertebrae and skulls from this and other basins (de la Fuente *et al.*, 2001; Lapparent de Broin and de la Fuente, 2001; Bona and de la Fuente, 2005), the specimen here described preserves an almost complete forelimb, skeletal elements unknown in Patagonian chelids. The presence of this forelimb associated with a typical plastron and cervical vertebrae remains of chelids allows us to determine the specimen of Loma del Lindero as a new taxon of this family of pleurodiran turtles.

In northwestern Patagonia, the Neuquén Group is the richest reptiles bearing unit. It comprises a thick continental succession (maximum thickness 1300 m) deposited from early Cenomanian (97 Ma) to early Campanian (74 Ma) (Leanza, 1999; Leanza and Hugo, 2001; Leanza *et al.*, 2004). In the last years, extraordinary titanosaurid sauropods were found in Rincón de los Sauces area, Northern Neuquén Province, Patagonia (Calvo *et al.*, 1997). In the Cañadón Arroyo Río Seco site, located 2 km south to Rincón de los Sauces Town, a slender Eutitanosauria named *Rinconosaurus caudamirus* (Calvo and González Riga, 2003) and *Pehuenchesuchus enderi*, a basal sebecosuchian crocodyliform (Turner and Calvo, 2005), have also been found.

The main scope of this work is to describe a new species of chelid turtle from the Río Neuquén Subgroup. The fossils were found at Loma del Lindero site (figure 1), 10 km west to Rincón de los

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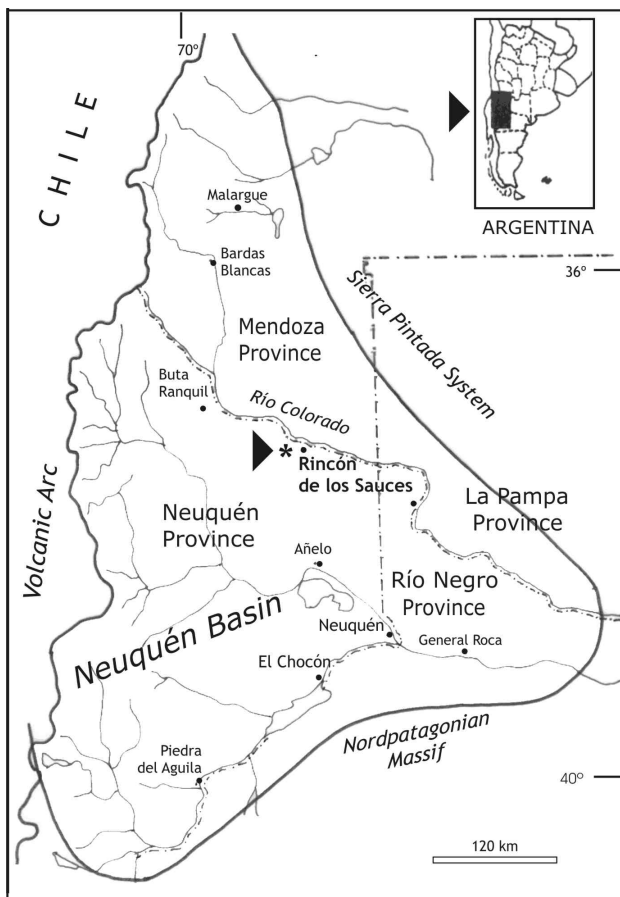


Figure 1. Location map of the Loma del Lindero locality / mapa de ubicación de la localidad de Loma del Lindero.

Sauces Town (Calvo and González Riga, 1999). This locality is an important paleontological site, that was excavated during four years (1998-2001) under the direction of Jorge O. Calvo, where numerous disarticulated titanosaur remains (nearly 300 bones) and theropods associated with the turtle specimen described herein have been found (González Riga and Calvo, 1999). The fossils were collected in mudstones and fine sandstones of overbank facies related to channel fluvial systems. In this quarry, numerous bones of titanosaur sauropods and other vertebrates are preserved in a taphonomic mode preliminary named "overbank bone assemblage" (González Riga *et al.*, 2003). Turtle specimen is housed at the "Museo Argentino Urquiza -Rincón de los Sauces" (MAU-PV).

Systematic paleontology

TESTUDINES Batsch, 1788
PLEURODIRA Cope, 1865
CHELIDAE Lindholm, 1929

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Linderochelys gen. nov.

Diagnosis. Short-necked chelid turtle having a plastron length of moderate size (290 mm) with an elongated abdominal seam. Differs from the extant taxa assigned to *Phrynops* Wagler (*sensu lato*) in the presence of cuneiform mesoplastra. Differs from *Palaeophrynops patagonicus* Lapparent de Broin and de la Fuente in the bell shape of entoplastron, and the more depressed common process of postzygapophyses. Differs from *Bonapartemys bajobarrealis* Lapparent de Broin and de la Fuente in a short plastral bridge, absence of ridges at the bridge limit of anterior plastral lobe, and in the different plastral scale formulae. Differs from *Prochelidella portezuelae* de la Fuente and the cenomanian *Prochelidella* spp. in a large and rounded anterior plastral lobe and the length of interadominal seam.

Etimology. "Lindero" from the site Loma del Lindero; "chelys" from Greek turtle.

Linderochelys rinconensis sp. nov.

Diagnosis. The same as the genus by monotypy.

Etimology. "Rinconensis" species from the town of Rincon de Los Sauces.

Holotype. MAU-PV-LL 69. A fragment of the suprapygial and the eight right costal bone of the carapace, a partially preserved plastron, one cotyle and one condyle probably of a second to fourth opisthocelus vertebrae or a seventh biconcave vertebrae, as well as fragments of two postzygapophyses of cervical vertebrae, left humerus, radius and proximal carpal elements and right metacarpals and digits, the pelvic girdle, femora and fibula, and right tibia.

Locality and age. The turtle was recovered in mudstones and fine sandstones that crop out at Loma del Lindero site, 10 km West to Rincón de los Sauces City, Neuquén Province, Patagonia, Argentina (figure 1). These rocks belong to the Río Neuquén Subgroup, Neuquén Group, Late Cretaceous late Turonian-Coniacian according to Leanza (1999), Leanza and Hugo (2001) and Leanza *et al.* (2004).

Description

Shell. The carapace is poorly preserved and is represented by several small indeterminate fragments. Only one piece might be identified as one anterolateral fragment of the suprapygial bone sutured to the medial part of the eight right costal bone. On the visceral surface of this fragment a transversal elliptic section of the proximal ilium attached to the carapace bone is recognized (figures 2.1-2.2).

The plastron (figures 3.1-3.2) is better preserved than the carapace and its length is estimated as 290 mm. Although the anterior plastral lobe is not com-

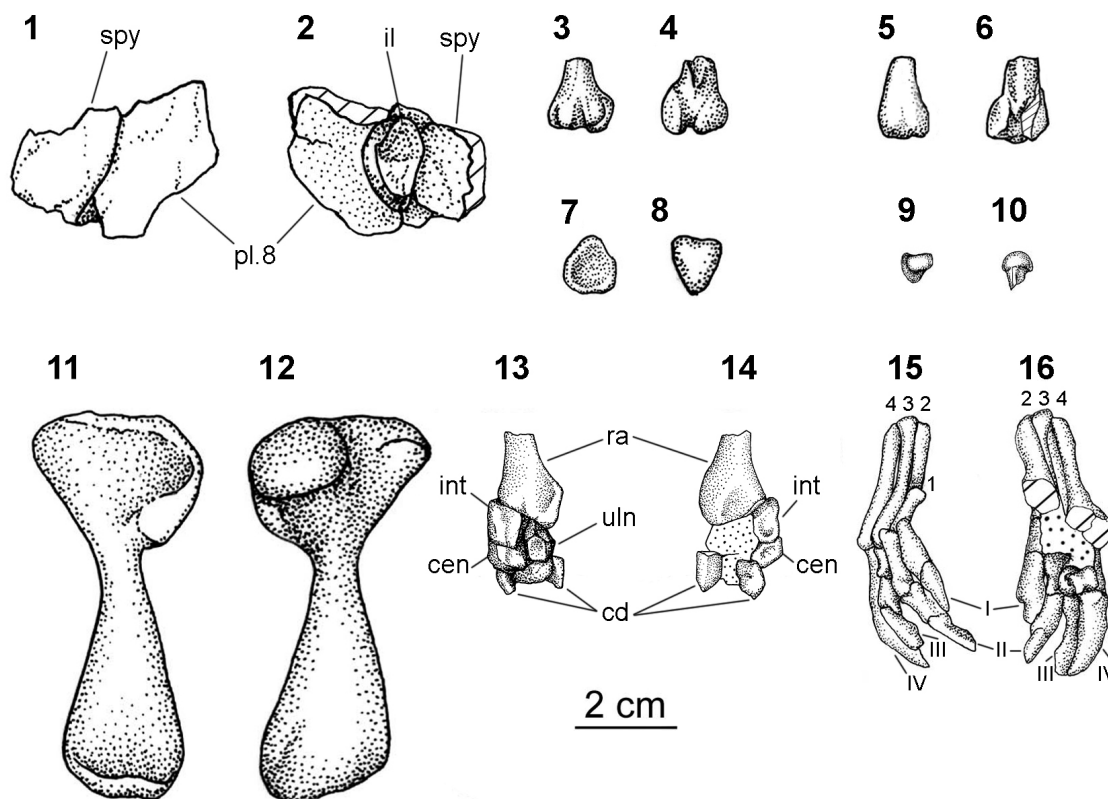


Figure 2. *Linderochelys rinconensis* gen et sp. nov. **1**, dorsal view of the carapace / *vista dorsal del caparazón*; **2**, ventral view of the carapace with remains of the ilium attached / *vista visceral del caparazón con el ilion adherido*; **3** and **5**, dorsal view / *vista dorsal*; **4** and **6**, ventral view of two posterior process of cervical vertebrae bearing postzigapophysis / *vista ventral de dos procesos posteriores de las vértebras cervicales portadores de las postzigapófisis*; **7-8**, posterior and ventral view of a cotyle of a cervical vertebra / *vista posterior y ventral de un cótilo de una vértebra cervical*; **9-10**, anterior and ventral view of a condyle of a cervical vertebra / *vista anterior y ventral de un cóndilo de una vértebra cervical*; **11-12**, ventral and dorsal view of the left humerus / *vista ventral y dorsal del húmero izquierdo*; **13-14**, dorsal and ventral view of the left radius and carpal bones / *vista dorsal y ventral del radio izquierdo y huesos carpales*; **15-16**, dorsal view of right metacarpal bones and digits / *vista dorsal de metacarpales y dígitos derechos*. References / *referencias*. **1-2-3-4**, metacarpals / *metacarpales*; **I-II-III-IV**, digits / *dígitos*; **cen**, centrals bones / *huesos centrales*; **cd**, distal carpals / *carpales distales*; **int**, intermedium; **il**, ilium, **pl 8**, pleural (= costal) bone 8 / *placa pleural (= costal) 8*; **ra**, radius / *radio*; **spy**, suprapygial bone / *placa suprapigial*; **uln**, ulnar.

plete and only the posterior part of the right plastral bridge is preserved, it is possible to estimate that the posterior plastral lobe is longer than the anterior one, and the bridge is the shortest plastral element. Likewise, the anterior and posterior plastral lobes are wider than longer. The left epiplastron is only visible in visceral view. The curved lateral margin of the left epiplastron suggests a curved anterior margin of the plastron lobe probably followed by subparallel hyoplastral margins. The epiplastron is longer than wide, and its peculiar shape in visceral view is defined posteriorly by a sinuous epi-hyoplastral suture. This sinuous suture runs from the entoplastron to the lateral margin of the anterior plastral lobe, thus resulting in an anterior and medial process of the hyoplastron that protrude the epiplastron. Although the entoplastron is partially preserved, a bell shape is recognized. Contrary to the anterior plastral bones (left epiplastron and the fragments of entoplastron), the hyo, hypo

and xiphiplastron are partially preserved in ventral and visceral sides. The hyoplastra are the largest plastral bones. The hyoplastron is also longer than the hypoplastron, but it is shorter than xiphiplastron, measured in the middle plastral line. The right mesoplastron is included between hyo and hypoplastron, and is short and wide. The scute pattern of the anterior plastral lobe is poorly preserved and only the humero-pectoral sulcus is preserved. It is strongly curved posteriorly, and is well posterior to the entoplastron. Only the left pectoro-abdominal sulcus is preserved. The pectoral scute (interpectoral seams) is the shortest preserved scute, while the abdominal scute (interabdominal seams) is the longest scute, measured in the middle plastral line. Consequently, the plastral formulae of *Linderochelys rinconensis* gen. et sp. nov. is $Ab > Fe > An > Pe$. The lateral margins of the posterior plastral lobe are slightly convergent distally ending in xiphiplastral points that delimit a U shape anal notch.

Cervical vertebrae (figures 2.3-2.10). The cervical vertebrae are represented by fragmentary remains of a posterior part of a vertebral centrum with a concave subquadrangular cotyle. It is slightly elongated and narrow and without posterior inferolateral tuberosities like the posterior cotyle of the third or fourth opisthocoelous vertebrae of the extant *Phrynops tuberculatus* Luederwaldt. Other isolated remains of a centrum belong to an anterior condyle, subtriangular in shape, of the another opisthocoelus or biconvex cervical vertebra with a well developed ventral keel, as well as fragments of two postzigapophyses oriented ventrolaterally of two cervical vertebrae.

Humerus (figures 2.11-2.12). The general morphology of left humerus is similar to other chelid species of the *Phrynops* group (e.g., *Prochelidella portezuelae* de la Fuente). However, it differs from the extant *Phrynops* and *Acanthochelys* Gray species in the robustness of this bone. It has a subtriangular articular head, a wide proximal end with a shallow intertubercular fossa lying between the large medial process and a small lateral process. The humerus narrows to a shaft, subcylindrical in section, that arches dorsally. Distally the shaft flattens dorsoventrally and ends in a broad extremity. The articular surface has a small ventrally facing capitellum where the radio articulates, and a more extensive trochlea for the ulna. An ectepicondylar open foramen and groove are recognized in a extreme distal position as it is typical in turtles.

Forearm and hand (figures 2.13-2.16). The left radius is only preserved by its expanded and flat distal end. This end contacts with displaced carpal elements. Among them it is recognized a trapezoidal inverted intermedium, an almost subpentagonal ulnar, with the long axis to 90 degree to normal horizontal position. These bones are moved from this natural position (articulate with two facets of the distal end of the ulna). Other carpal elements are interpreted as two central and two distal carpals. Some right carpal elements are also preserved. The right I to IV elongate metacarpal bones are recognizable. Only the III and IV are completely preserved. The I and II metacarpal are preserved in their distal and proximal parts. In dorsal view, the preserved distal metacarpal I overlaps the metacarpal II. Four digits (I-IV) are preserved in bad condition. As it is typical in turtles (as in many other tetrapods), the first digit is the shortest while the remaining digits are longer than the first. This difference in length between the first and the other digits suggests the presence of a typical phalangeal formulae of casichelydian turtles 2-3-3-3 for the four preserved digits.

Pelvic girdle (figure 3.1). The pelvic girdle is seen in dorsal view. The ilium, pubis and ischium are united

to compose the acetabulum, seen on the left side where the head of the femur is slightly displaced. The left and right pubis and ischium are partially preserved. They are separated each other by a large thyroid fenestra. Pubis and ischium extend ventrally and medially to the acetabulum toward the plastron midline where they almost contact each other. The pubis and the ischium are attached by suture with the xiphiplastron. The left and right ilium preserved only their acetabular portions, but the left one also lacks its dorsal end, while the dorsal end of the right ilium is attached by suture to the eight costal bone (figure 2.2).

Femur (figure 3.1). The right and left femora are preserved in good condition. The femur is slightly longer than the humerus. The left femur is exposed in posterior view, and only the trochanter major and the partial articular head are seen. The right femur is preserved in postero-anterior view, showing most of the oval articular head surface that is set off from the dorsal surface of the femur at an obtuse angle of approximately 120 degree with the longitudinal axis of the femur. The femoral shaft is subcylindric in cross section and arched dorsally as in other chelids. The condyles that bear the fibular articulation are visible in the distal end of both femora.

Tibia (figure 3.1). Only the right tibia is preserved. This bone is only slightly displaced from its natural position. The tibia is a massive bone expanded in both ends and the shaft is slightly bent. Unfortunately, the proximal and posterior ends of the right tibia are damaged and, consequently, they are not available for an accurate description.

Fibula (figure 3.1). The left and right fibula are preserved. The left fibula is partially articulated with the fibular condyle, while the right one is slightly displaced from the articular surface of the right femur, and is exposed in lateral view. As in other chelids the fibula is a slender bone, more slender than the tibia. The proximal articular surface of the right fibula is slightly rounded, while the visible distal end of the left tibia is expanded.

Discussion

Taxonomic implications

The shell and vertebrae morphology of *Linde-rochelys rinconensis* gen. et sp. nov. is comparable with that of chelid pleurodiran turtles. The pelvic girdle sutured with the shell is a recognized synapomorphy of Pleurodira (see Gaffney and Meylan, 1988, and references therein). This condition associated with the presence of a short and wide mesoplastra crossed by a humeropectoral sulci, and the presence

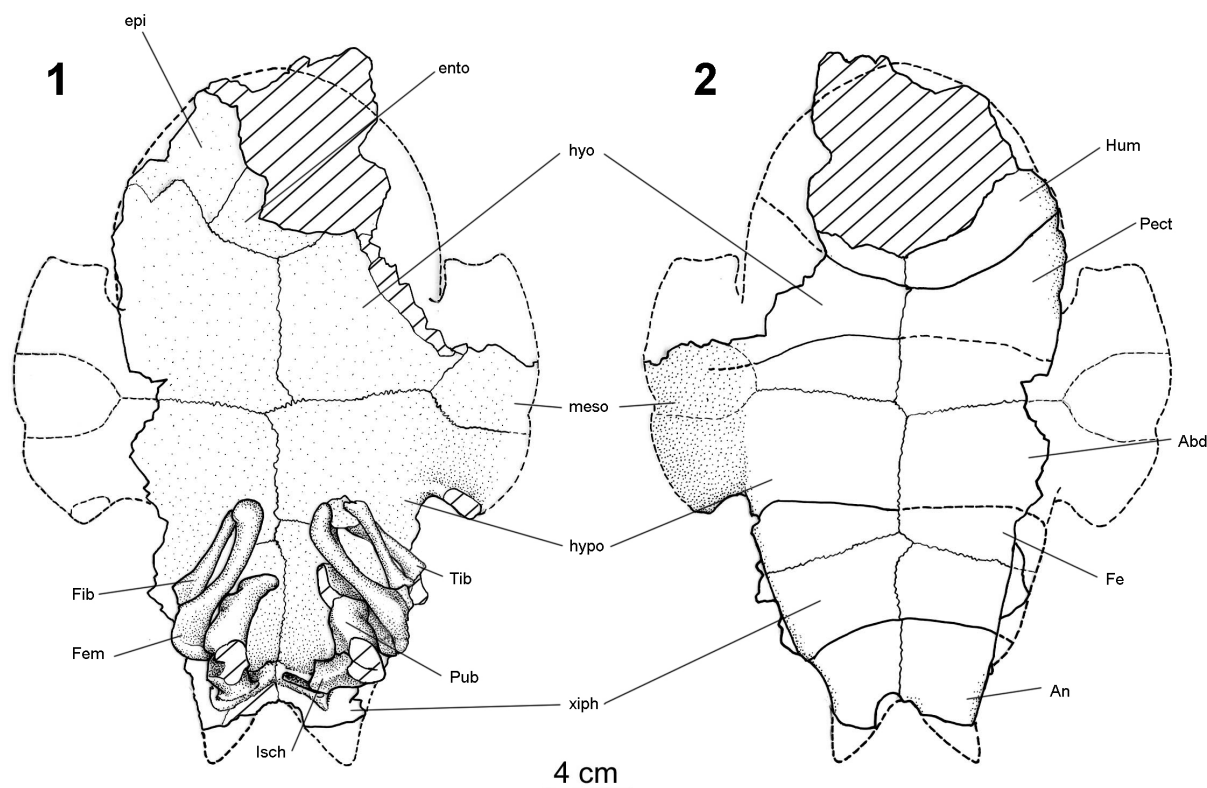


Figure 3. *Linderochelys rinconensis* gen et sp. nov. **1**, visceral view of the plastron with remains of pelvic girdle, both femora, fibula and right tibia / *vista visceral del plastrón con restos de la cintura pélvica, ambos fémures, fibulas y la tibia derecha*; **2**, ventral view of the plastron / *vista ventral del plastrón*. References / *referencias*. **Abd**, abdominal scute / *escudo abdominal*; **An**, anal scute / *escudo anal*; **ento**, entoplastron / *entoplastrón*; **epi**, epiplastron / *epiplastrón*; **Fe**, femoral scute / *escudo femoral*; **Fem**, femur / *fémur*; **Fib**, fibula / *fíbula*; **hyo**, hyoplastron / *hioplastrón*; **hypo**, hypoplastron / *hipoplastrón*; **Hum**, humeral scute / *escudo humeral*; **isch**, ischion / *isquiión*; **meso**, mesoplastral bone / *placa mesoplastral*; **Pub**, pubis / *púbis*; **Pect**, pectoral scute / *escudo pectoral*; **xiph**, xiphiplastron / *xifiplastrón*.

of opisthocoelous or biconcave cervical vertebrae, and loose carapace-plastron contact (see Lapparent de Broin and de la Fuente, 2001) allow us to assign this species to the family Chelidae.

Although isolated cervical vertebrae with similar primitive characters of the Australasian extant species of the *Emydura-Elseya* group have been recognized in the Upper Cretaceous horizon of Patagonia (Broin and de la Fuente, 1993b: pl. 1, figs. 2-3), until now all the named chelid taxa recovered from Upper Cretaceous horizons of Patagonia have been considered closely related to the South American short and long-necked chelids (Lapparent de Broin and de la Fuente, 2001; de la Fuente *et al.*, 2001). In this sense, *Linderochelys rinconensis* gen. nov. et sp. is also tentatively referred to the *Phrynops* group (*sensu* Broin and de la Fuente, 1993b) by the morphology of the preserved cervical vertebrae. These cervical vertebrae are similar to those of the extant species of the *Phrynops* group. These vertebrae are slightly elongated and lower than the cervical vertebrae of the Australasian short necked species, and are characterized by the presence of ventral keels curved and reduced posteriorly in relation to the central length.

Linderochelys rinconensis gen nov et sp. is a short-necked chelid characterized by an elongated abdominal seam. It differs clearly from the South American extant species assigned to *Phrynops* (*sensu lato*) in the presence of cuneiform mesoplastra crossed by an pectoral-abdominal sulcus. Likewise, this new taxa also differs from the hitherto known Upper Cretaceous chelids referred to the *Phrynops* group by several characters (Lapparent de Broin and de la Fuente, 2001). Differs from *Palaeophrynops patagonicus* from the Los Alamitos Formation (Late Campanian-Early Maastrichtian) in the bell shape of entoplastron, and the more depressed common process of postzygapophyses. Differs from the Bajo Barreal Formation (Turonian-Campanian) turtle *Bonapartemys bajobarrealis* in having a short plastral bridge, absence of ridges at the bridge limit of anterior plastral lobe, and in the different plastral scale formulae, and also differs from the Portezuelo Formation (Late Turonian-Early Coniacian) turtle *Prochelidella portezuelae* and the Cenomanian *Prochelidella* spp. (Lapparent de Broin *et al.*, 1997) in having a large and rounded anterior plastral lobe and in the length of interadominal seam.

Comments about the relationships among extant species of Phrynops (sensu lato) and the constraints in the inclusion of the extinct species in a phylogenetic scenario

Broin and de la Fuente (1993b) suggested to use the *Phrynops* Group (= *Phrynops sensu lato*) to recognize a South American group of short-necked chelid turtles. Among the extant forms, this group includes: a) *Phrynops* s.s. with three extant subgenera without a good definition (*Phrynops* Wagler, *Mesoclemmys* Gray and *Batrachemys* Stejenger) follows *sensu* Bour (1973) and Bour and Pauler (1987); b) *Acanthochelys*, excluded from *Platemys auctoris*; and c) *Platemys* Wagler restricted to *P. platycephala* (Schneider). Although Broin and de la Fuente (1993b) suggested that the genus *Phrynops* (s.s.) could be a paraphyletic taxon in relation to the other two genera, these authors proposed that *Acanthochelys* and *Platemys* might be sister groups and could be close relative to *Phrynops* (s.s.). According to Broin and de la Fuente (1993b), *Phrynops* (s.l.) is characterized by two synapomorphies: the dorsal inflation of the *antrum squamosum* and the inclination of the *columella-fenestra ovalis* axis. The species included in *Phrynops* (s.l.) are characterized by a short neck as the members of the *Emydura-Elseya* group, but with cervical vertebrae slightly more elongated and lower, and with ventral keels curved and reduced posteriorly in relation to the central length, relative to the cervical vertebrae of Australasian short necked species. The cotyle fragment preserved in *Linderochelys rinconensis* gen et sp. nov. is similar to that of some species of *Phrynops* (s.s.)

The Broin and de la Fuente's concept of *Phrynops sensu stricto* is only comparable to *Phrynops sensu lato* of McCord *et al.* (2001), the last reviewers of *Phrynops*. Previously to McCord's work, several authors explored the loose relationships among the extant species assigned to the genus *Phrynops* (s.l.). Gaffney (1977) was unable to find derived cranial characters among some species of *Phrynops* available in his study [*Phrynops* (*P.*) *geoffroanus* (Schweigger), *P.* (*M.*) *gibbus* (Schweigger) and *P.* (*B.*) *nasutus* (Schweigger) complex]. The monophyly of the genus *Phrynops* (s.l.) seemed to be supported by genetic data of Frair (1980, 1982) and Reed *et al.* (1991). Likewise, Shaffer *et al.* (1997) provided a phylogeny where the genus *Phrynops* (s.l.) resulted as a monophyletic taxon. This conclusion was achieved using mitochondrial DNA sequencing, morphological and paleontological data. Contrary to this proposal, Seddon *et al.* (1977) strongly supported the paraphyly among the subgenera of *Phrynops* (s.l.). This conclusion was sustained after Seddon *et al.* (1977) sequenced 411 mitochondrial 12S rRNA nucleotides of 16 species assigned to 11 chelid genera. Analysis using parsimony and neighbor-join-

ing algorithms supported the generic differentiation among the subgenera of *Phrynops* (s.l.). In this context *Mesoclemmys* was proposed as the sister taxon of *Batrachemys*, and *Phrynops* was closely related to the genus *Chelus*. Likewise, the results of Georges *et al.* (1998) studies on molecular data supported the conclusion of Seddon *et al.* (1997) about the paraphyly of the genus *Phrynops* (s.l.) and resolved to elevate once again the subgenera (*Phrynops*, *Mesoclemmys* and *Batrachemys*) to generic level. Finally, McCord *et al.* (2001) demonstrated full recognition of these taxa as genera based on morphometric analysis, skull osteology, and nuclear and mitochondrial gene sequences. These three distinguished taxa were anteriorly demoted to subgenera, and then synonymized with *Phrynops* (see Pritchard, 1979; Pritchard and Trebbau, 1984).

Contrary to the almost completeness condition of the long necked chelid species of the genus *Yaminuechelys* de la Fuente *et al.*, which allows us to include these taxa in a phylogenetic context (de la Fuente *et al.*, 2001; Bona, 2004; Bona and de la Fuente, 2005), the incompleteness nature of most of the short-necked chelid species from the Cretaceous of Patagonia prevents their phylogenetic resolution. Among them the species assigned to *Phrynops sensu lato* by Lapparent de Broin and de la Fuente (2001), and the new taxon here described, are not easy to include in McCord (2001) phylogenetic scenario. In this sense, 50 per cent of the morphological character (9 on 18) scored by these authors are not comparable in Patagonian fossil turtles and the remainder characters are not useful when the analyses is broadened to include the Patagonian Cretaceous taxa.

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