Revista peruana de biología 26(2): 189 - 200 (2019)
doi: http://dx.doi.org/10.15381/rpb.v26i2.15118
ISSN-L 1561-0837; eISSN: 1727-9933
Universidad Nacional Mayor de San Marcos

Pleistocene Fossil Turtles (Testudinoidea, Cryptodira) from the Talara Tar Seeps, Peru

TRABAJOS ORIGINALES

Presentado: 10/09/2018
Aceptado: 28/04/2019
Publicado online: 31/05/2019

Tortugas fósiles (Testudinoidea, Cryptodira) del Pleistoceno del yacimiento de brea de Talara, Perú

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Citación:
Deza A., E-A. Cadena and J-N. Martinez. 2019. Pleistocene Fossil Turtles (Testudinoidea, Cryptodira) from the Talara Tar Seeps, Peru. Revista peruana de biología 26(2): 189 - 200 (Julio 2019). doi: http://dx.doi.org/10.15381/rpb.v26i2.15118

Palabras clave: Testudines; Geoemydidae; Testudinidae; Pleistoceno; Piura.
Keywords: Testudines; Geoemydidae; Testudinidae; Pleistocene; Piura.

Abstract

A description of Pleistocene fossil turtles discovered in the Talara Tar Seeps, Tablazos deposits of the northern coast of Peru is provided in this paper. The specimens are mostly fragmentary plates of carapaces and plastra of turtles belonging to two cryptodiran families of the superfamily Testudinoidea, identified to genus level based on measurements and comparisons with extant and fossil taxa and identification of mosaic diagnostic features. Turtles of the Geoemydidae family are the most abundant, with fossil remains attributed to *Rhinoclemmys* (indeterminate species). Less abundant fossil remains belong to the Testudinidae, with specimens attributed to the genus *Chelonoidis* (indeterminate species). These fossils show that the northern coast of Peru had ecosystems that supported abundant aquatic and terrestrial turtles (tortoises) during the Pleistocene in areas where they are completely absent today.

Resumen

El presente trabajo proporciona una descripción de las tortugas fósiles del Pleistoceno descubiertas en el yacimiento de brea de Talara, en la costa norte del Perú. La mayoría de los especímenes son fragmentos de placas del caparazón y del plastrón de tortugas pertenecientes a dos familias de criptodiras dentro de la superfamilia Testudinoidea. La familia Geoemydidae es la más abundante con restos fósiles atribuidos a *Rhinoclemmys* (especie indeterminada). Los restos fósiles menos abundantes pertenecen a Testudinidae, con especímenes atribuidos al género *Chelonoidis* (especie indeterminada). Estos fósiles muestran que la costa norte del Perú tenía ecosistemas que permitieron la abundancia de tortugas acuáticas y terrestres durante el Pleistoceno, en áreas donde hoy están completamente ausentes.

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Introduction

The Talara Tar Seeps (TTS) is an asphaltic paleontological locality that consists of a series of fossil-bearing deposits, late Pleistocene in age between 13616 ± 600 and 14418 ± 500 radiocarbon years before present (Churcher 1966), where numerous fossil skeletons of megafauna and other animals have been found (Seymour 2015, Lindsey & Seymour 2015). The fossil fauna of the TTS includes: crocodylians (Alligatoridae), lepidosaurians (Boidae, Colubridae, Phyllodactylidae, Iguanidae, Gymnophthalmidae, and Teiidae), turtles (Emydidae, Geoemydidae, and Testudinidae), at least 23 families of non-passerine and 8 families of passerine birds (Campbell 1979, Oswald & Steadman 2015) and mammals represented by marsupials (Didelphidae), chiropterans (Phyllostomidae and Vespertilionidae), rodents (Hydrochoeridae and Cricetidae), carnivorans (Canidae, Felidae, Mephitidae, and Mustelidae), xenarthrans (Megatheriidae, Mylodontidae, and Pampatheriidae), artiodactyls (Cervidae, Tayassuidae, and Camelidae), perissodactyls (Equidae) and proboscideans (Gomphotheriidae) (Churcher 1959, 1962, 1965, 1966, Churcher & Van Zyll de Jong 1965, Czaplewski 1990, Lemon & Churcher 1961, Marshall et al. 1984, Moretto et al. 2017, Seymour 2015).

Most of the fossil turtle material from the TTS was collected in 1958 by an expedition of scientists from the division of Zoology and Paleontology of the Royal Ontario Museum, Toronto, Canada, and has remained housed in the collections of that museum. During the 1970s, Philip Currie completed a preliminary study of the amphibians and reptiles from the TTS as a student project. The preliminary study of this material by Currie attributed the fossil turtles to several genera and species of the Testudinoidea, including *Trachemys* sp., *Rhinoclemmys melanosterna*, and *Chelonoidis* sp. However, his work was never published, and none of these specimens have been re-evaluated since that time (Seymour 2015).

The purpose of this study is to provide a description, taxonomy and systematic paleontology of the fossil turtle material from the TTS, as well as to discuss its paleobiogeographical and paleoenvironmental implications. This work is also a contribution to a better understanding of the fossil record of Peru after the last interglacial, and before the beginning of the Holocene.

Institutional abbreviations. CRI Chelonian Research Institute, Oviedo, Florida, USA; **MTKD** Senckenberg Museum of Natural History, Dresden collections, Germany; **ROM** Royal Ontario Museum, Canada; **UF** University of Florida, Gainesville, Florida, USA; **USNM** Smithsonian Natural History Museum, Maryland, USA; **UPSE** paleontological collection, Universidad Estatal de la Peninsula de Santa Elena**,** La Libertad, Santa Elena Province, Ecuador.

Geological framework

The turtle remains described here were collected at the TTS (Fig. 1) located at 04°38′38.92″S, 81°8′9.47″W in La Brea, one of the six districts of Talara, Piura Department, Peru. The deposits overlie the Mancora Tablazo, one of the

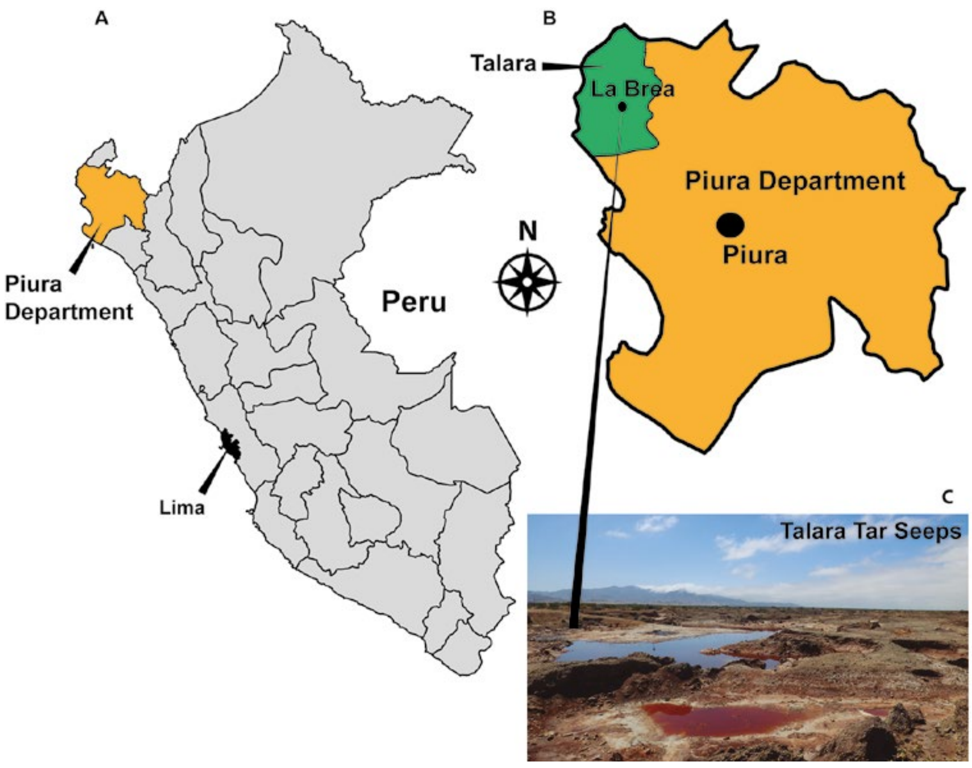

Figure 1. Map of Peru, Piura and Talara. (A) Map of Peru showing the location of Piura Department at the northwestern corner of the country. (B) Map of Piura Department showing the location of Talara and La Brea village. (C) Panoramic view of the Talara Tar Seeps.

three marine terraces uplifted during the early, middle and late Pleistocene known as *Tablazos*, which comprise a series of calcareous sandstones, siliciclastic sandstones, sandy limestones, and fine conglomerates with abundant fossil mollusks (Lemon & Churcher 1961). The *Tablazos* deposits overlie Paleogene rocks, some of which seep oil that emerges onto the surface in numerous locations, creating paleontological sites taphonomically and faunistically similar to the famous Rancho La Brea in California, U.S.A. (Lindsey & Seymour 2015).

Materials and methods

We re-examined the fossil turtle material collected in Talara in January 1958, now housed at the Royal Ontario Museum (ROM) in Toronto, Canada. All specimens correspond to isolated and in some cases highly fractured plates and long bones. We measured and photographed all the specimens and compared them with skeletons of the extant taxa *Chelonoidis nigra* (Quoy & Gaimard, 1824) (specimen USNM 59867) and extant species of *Rhinoclemmys* fully listed in Cadena et al. (2012: appendix 2), to establish their anatomical and taxonomic identification. Measurements were taken using a digital caliper with an accuracy of 0.02 mm and rounded to the nearest 0.1 mm. A summary and measurements of all the material housed in the ROM collections from TTS that can be recognized at the family or genus level is presented in Appendix 1. As most of the material is extremely fragmentary, we only describe and illustrate here the most complete and relevant bones.

Systematic Paleontology

Order Testudines Batsch 1788
Suborder Cryptodira Cope 1868
Superfamily Testudinoidea Fitzinger 1826
Family Geoemydidae Theobald 1868
Genus *Rhinoclemmys* Fitzinger 1835

Rhinoclemmys sp.

Material referred

Carapacial bones: three left costal bones 2 or 4 (ROM-42144, 42149 and 42154); two right costal bones 3 or 5 (ROM-42174 and 42138); two right costal bones 2 or 4 (ROM-42147 and 42159); four left costal bones 3 or 5 (ROM-41277, 42099, 42143 and 42175); two right costal bones 6 (ROM-42135 and 42152); one left costal bone 6 (ROM-42170); one right costal bone 8 (ROM-42134); three neural bones 1 (ROM-42179-42181); one neural bone 3 or 5 (ROM-42182); one nuchal bone (ROM-42058); ten peripheral bones of the anterior margin of the carapace (ROM-42080, 42087, 42084, 42093, 42068, 42078, 42082, 42090, 42059 and 42079); five peripheral bones of the carapace-plastron bridge (ROM-42112, 42057, 42115, 42166 and 42116); eleven peripheral bones of the posterior margin of the carapace (ROM-42076, 42083, 42150, 42101, 42091, 42153, 42074, 42094, 42131, 42088 and 41849 (previously attributed to *Trachemys* sp. in the list of Seymour 2015); one pygal bone portion (ROM-42105); one suprapygal bone (ROM-42100).

Plastral bones: two entoplastra (ROM-42183 and 42184); two right epiplastra (ROM-42070 and 42095); two left epiplastra (ROM-41848 (previously attributed to *Trachemys* sp. in the list of Seymour, 2015) and 42085); two right hyoplastra (ROM-42110 and 42114); three right hypoplastra (ROM-42102, 42104 and 42106); one left hypoplastron (ROM-42109); three right xiphiplastra (ROM-42053, 42054 and 42097); two left xiphiplastra (ROM-42055 and 42056).

Cranial bones: two hyoids (ROM-42051 and 42052).

Forelimb bones: one left humerus (ROM-42062); two right humeri (ROM-42064 and 42065); two left radii (ROM-42060 and 42061); one left ulna (ROM-42036).

Pectoral girdle bones: one left scapula and acromion (ROM-42046).

Hindlimb bones: seven right femora (ROM-42032, 42034, 42035, 42047, 42048, 42049 and 42066); eight left femora (ROM-42040, 42041, 42042, 42043, 42044, 42045, 42050 and 42186); one right tibia (ROM-42063); one left fibula (ROM-42039).

Pelvic girdle bones: three right ilia (ROM-42037, 42363 and 42364); one left ilium (ROM-42038); one left ischium (ROM-42033).

Description

Carapacial bones:

ROM-41849 is a complete left peripheral bone of the posterior margin of the carapace, potentially peripheral 9 or 10, and is very well preserved (see Fig. 2A-B). The peripheral has a trapezoidal form. In dorsal view, the two sulci between the pleural and marginal scutes are apparent.

ROM-42099 is an almost complete left costal 5. On the dorsal surface, this specimen has visible rings because of the sculpturing pattern left by the pleural 3, and the inguinal scar is visible on its ventral surface (Fig. 2E-G).

ROM-42180 is a complete neural 1. It has an almost rectangular shape. On the dorsal surface, there is a sulcus between vertebral scutes 1 and 2 (Fig. 2H-I).

ROM-42058 is a completely preserved nuchal bone. On the dorsal surface, the sulci between marginal 1 and vertebral 2 are apparent, and the cervical scute sulci exhibit a narrow rectangular shape, being narrower anteriorly than posteriorly (Fig. 2J-K). On the posterolateral portions of the nuchal bone, some of the annular lines of vertebral 5 are also visible.

ROM-42079 is a right peripheral 3. On its dorsal surface, the two sulci left by the contact between marginals 3 and 4 and pleural 1 are apparent. On its ventral surface, the axillary buttress scar forms a narrow and deep channel (Fig. 2L-N).

ROM-42093 is a right peripheral 2. On its dorsal surface, this specimen has a well defined sulcus left by the contact between marginals 2 and 3, and a sulcus between these two scutes and pleural 1 (Fig. 2O-P).

ROM-42115 may be a left peripheral 5. On its dorsal surface, the sulci left by the contact between marginals 5 and 6 are apparent (Fig. 2Q-P). Furthermore, in this specimen, the sulcus left by the contact between these scutes and the pleural scute is visible.

ROM-42105 is the posteriormost portion of a pygal bone. On its dorsal surface, the sulcus between vertebral 5 and marginals 11? is visible, at the posteromedial edge it has a shallow notch (Fig. 2S-T).

ROM-42100 is a suprapygal bone. On its dorsal surface, the sulci between vertebrals 4 and 5 and pleurals 4 are apparent (Fig. 2W-X).

Plastral bones:

ROM-41848 is a complete left epiplastron (Fig. 3A-B). On its ventral surface are two sulci dividing the epiplastron into three parts: the gular, humeral, and pectoral scutes. The first sulcus separates the gular scute from the humeral scute, and the second sulcus weakly marks the separation of the humeral scute from a small visible part of the pectoral. In ventral view, the epiplastron has a U-shape at the posterior edge. On the dorsal surface, there is evidence that the gular and humeral scutes reached the edge before the visceral surface of the bone.

ROM-42183 is an entoplastron. On the ventral surface are visible, well-defined gular-humeral and humeral-pectoral sulci on both sides of the specimen, which are nearly symmetrical (Fig. 3C-D). The humeral scutes were restricted to the anterolateral margins of the entoplastron without reaching its region of maximum width.

ROM-42070 is a partially preserved right epiplastron. On its ventral surface, ROM-42070 has a well-defined gular-humeral sulcus (Fig. 3E-F).

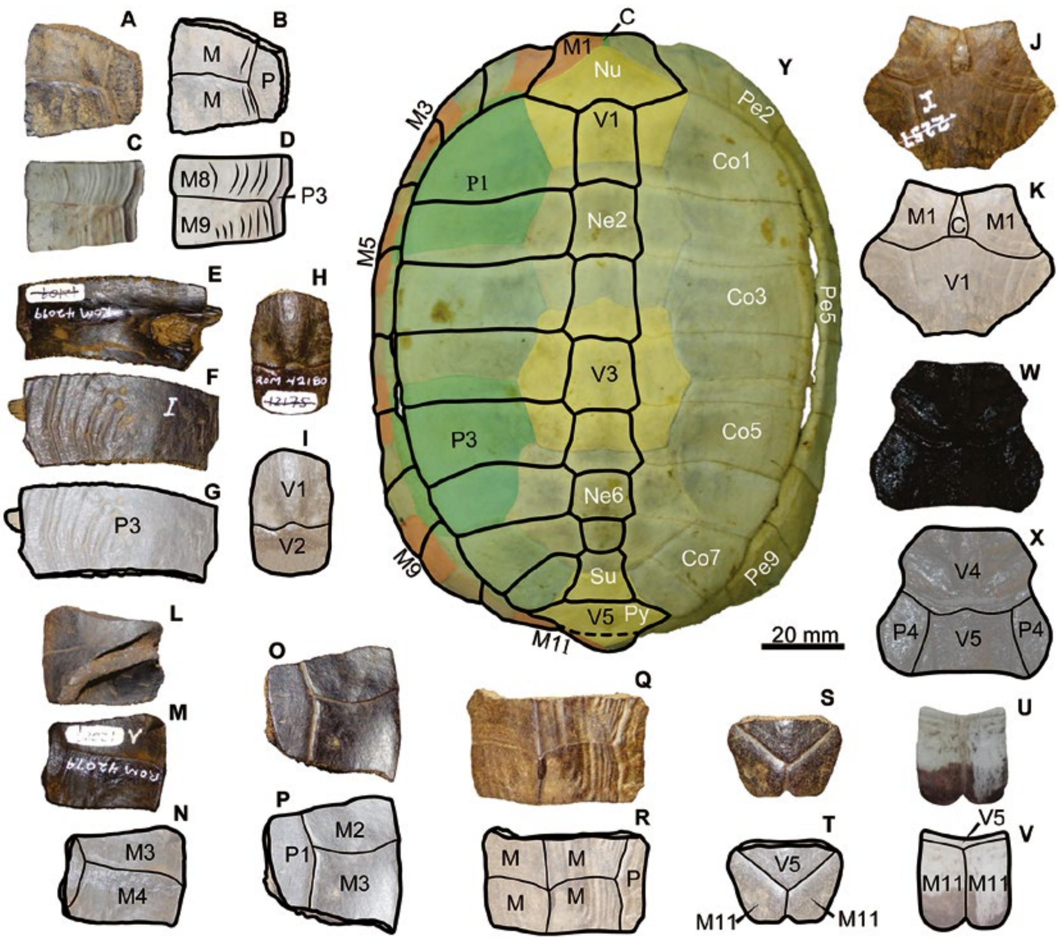

Figure 2. Geoemydidae (*Rhinoclemmys* sp.) carapacial material from Talara Tar Seeps. (A-B) ROM-41849 peripheral bone of the posterior margin of the carapace, potentially peripheral 9 or 10 in dorsal view; (C-D) peripheral 8 of *Trachemys scripta* MTKD-26593 in dorsal view; (E-G) ROM-42099 left costal bone 5, (E) ventral view, (F-G) dorsal view; (H-I) ROM-42180 neural bone 1 in dorsal view; (J-K) ROM-42058 nuchal bone in dorsal view; (L-N) ROM-42079 right peripheral bone 3; (L) ventral view, (M-N) in dorsal view; (O-P) ROM-42093 right peripheral bone 2 in dorsal view; (Q-R) ROM-42115 left peripheral bone 5 in dorsal view; (S-T) ROM-42105 pygal bone in dorsal view; (U-V) pygal of *Trachemys scripta* MTKD-26593 in dorsal view; (W-X) ROM-42100 suprapygal bone in dorsal view; (Y) carapace of the extant *Rhinoclemmys melanosterna* CRI-4898 in dorsal view. Abbreviations: C, cervical scute; Co, costal bone; M, marginal scute; Ne, neural bone; Nu, nuchal bone; P, pleural scute; Pe, peripheral bone; Py, pygal bone; Su, suprapygal bone; V, vertebral scute.

ROM-42114 is a partially preserved right hyoplastron. On the ventral surface, it has a slightly visible humeral-pectoral sulcus (Fig. 3G-H).

ROM-42102 is a fragment of the right hypoplastron. On its ventral surface, this specimen exhibits a well-preserved abdominal-femoral sulcus (Fig. 3I-J).

ROM-42053 is a complete right xiphiplastron with a well-defined femoral-anal sulcus on its ventral surface (Fig. 3K-L).

ROM-42056 is a left xiphiplastron. The femoral-anal sulcus is well preserved on its ventral surface (Fig. 3M-N).

Cranial bones:

ROM-42051 is the left hyoid process (Fig. 4A) exhibiting a slightly convex medial edge.

Forelimb bones:

ROM-42062 is a complete left humerus (Fig. 4B-C), with a narrow and deep ectepicondylar foramen at its distal lateral portion. In lateral view exhibits a very slender curved-shape with maximum arch at the shaft region.

ROM-42061 is a left radius with a broad proximal head and very narrow shaft region (Fig. 4D-E).

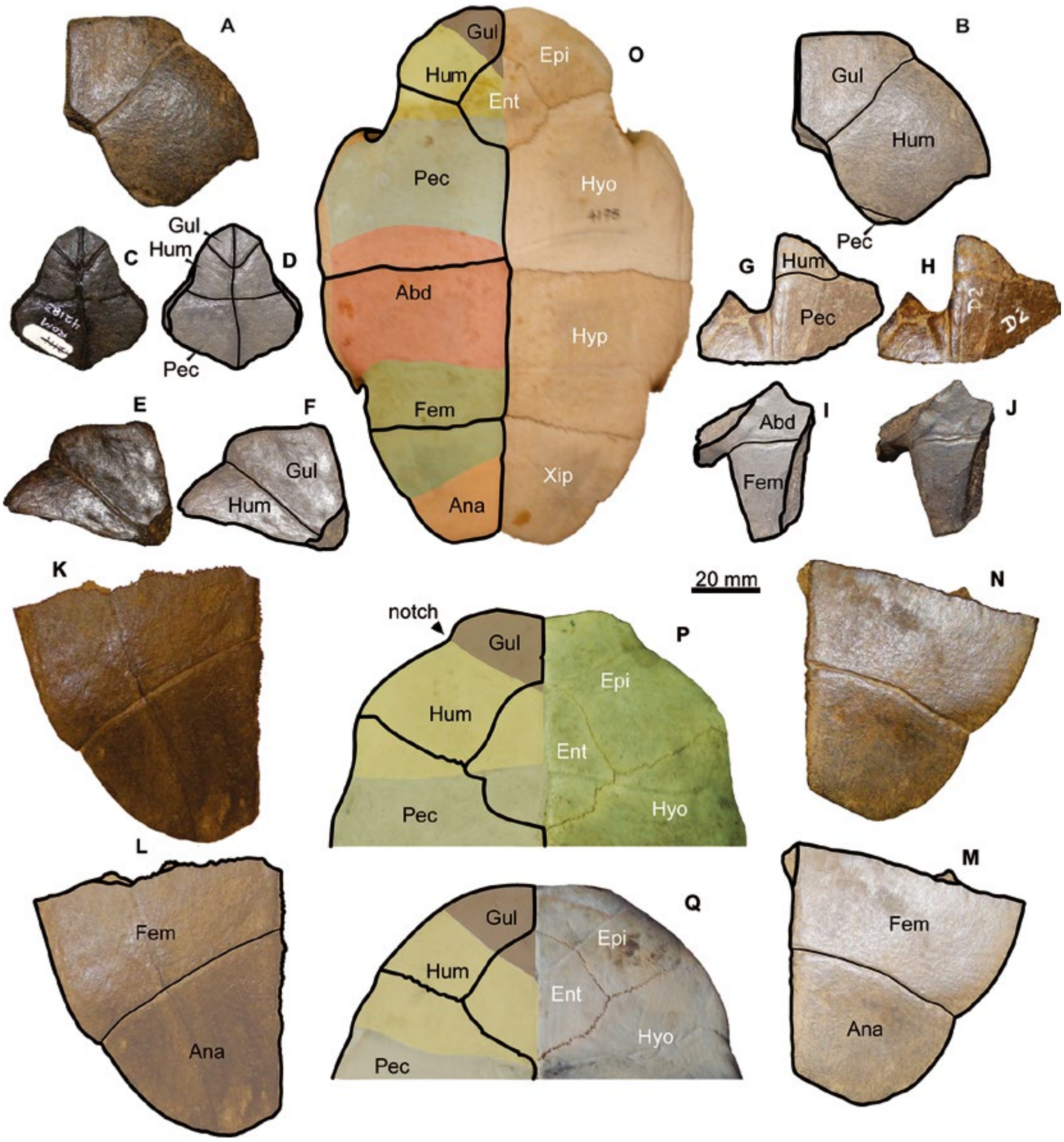

Figure 3. Geoemydidae (*Rhinoclemmys* sp.) plastral material from Talara Tar Seeps. (A-B) ROM-41848 left epiplastron in ventral view; (C-D) ROM-42183 entoplastron in ventral view; (E-F) ROM-42070 right epiplastron in ventral view; (G-H) ROM-42114 right hyoplastron in ventral view; (I-J) ROM-42102 right hypoplastron in ventral view; (K-L) ROM-42053 right xiphiplastron in ventral view; (M-N) ROM 42056 left xiphiplastron in ventral view; (O) plastron of extant *Rhinoclemmys melanosterna* CRI-4898 in ventral view. (P) anterior plastral lobe of the extant *Rhinoclemmys melanosterna* CRI-2434 in ventral view; (Q) anterior plastral lobe of the extant *Trachemys scripta* MTKD-26593 in ventral view. Abbreviations: Abd, abdominal scute; Ana, anal scute; Epi, epiplastron bone; Fem, femoral scute; Ent, entoplastron bone; Gul, gular scute; Hum, humeral scute; Hyo, hyoplastron bone; Hyp, hypoplastron bone; Xip, xiphiplastron bone.

ROM-42036 is a well-preserved left ulna exhibiting a S-shaped dorsolateral ridge, and relatively wide and flat proximal head for the articular with the humerus (Fig. 4F-G).

Pectoral girdle bones:

ROM-42046 (Fig. 4H-I) is a portion of the left scapula and acromion, exhibiting a nearly triangular glenoid, and an internal angle of approximately 80° between both processes.

Hindlimb bones:

ROM-42041 is a left femur, exhibiting a spherical and prominent head and trochanters minor and major located almost at the same level (Fig. 4J-K).

ROM-42039 is a well-preserved left fibula, with an almost straight distal edge and slightly arched proximal region (Fig. 4L-M).

Pelvic girdle bones:

ROM-42038 (Fig. 4N-O) is a left ilium with a very broad posterior ilial process, at the shaft the bone is considerably narrow.

ROM-42033 (Fig. 4P-Q) is a left ischium with a pointed and projected lateral ischial process, forming an U-shape medial edge with the medial portion of the bone .

Family Testudinidae Batsch 1788
Genus *Chelonoidis* Fitzinger 1835

Chelonoidis sp.

Material referred

Carapacial bones: three costals (ROM-42025, 42028 and 42029) and three peripheral bones (ROM-42026, 42030, and 2024).

Figure 4. Geoemydidae (*Rhinoclemmys* sp.) limb bones material from Talara Tar Seeps. (A) ROM-42051 left hyoid bone in dorsal view; (B-C) ROM-42062 left humerus in right and left lateral views respectively; (D-E) ROM-42061 left radius in dorsal and ventral views respectively; (F-G) ROM-42036 left ulna in dorsal and ventral views respectively; (H-I) ROM-42046 left acromial and scapula in ventral and proximal views respectively; (J-K) ROM-42041 left femur in right and left lateral views; (L-M) ROM-42039 left tibia in ventral and dorsal views; (N-O) ROM-42038 left ilium in lateral and medial views; (P-Q) ROM-42033 right ischium in dorsal and ventral views.

Limb bones: thirty-four osteoderms (ROM-40572-40599, 40620, 40600-40604 and 42190); one podial bone (ROM-40620).

Unidentified bones: six unidentified shell bones (ROM-42021-42024, 42027 and 42031).

Description

Carapacial bones:

ROM-42024 is a peripheral bone from the carapace-plastron bridge region. Its dorsal surface exhibits the sulcus between two marginal scutes and the sulcus between these two and the pleural scute (Fig. 5A-B).

ROM-42028 is a portion of a costal bone, showing the sulcus between pleural scutes, which is similar to a canal with high lateral walls (Fig. 5C). The dorsal surface of the bone is also characterized by fine and highly dense vermiculation without long dichotomized lines. The thickness of the bone is 23 mm on average (Fig. 5D).

Limb bones:

ROM-42190 is an osteoderm being almost spherical in shape and exhibiting a micropitted bone surface (Fig. 5E) and ROM 37737 is a triangular osteoderm, without any clear articular facet. (Fig. 5F-G).

Discussion

Taxonomic attributions

***Rhinoclemmys* sp. assignation.** The most abundant material of fossil turtles from the TTS described here is from geoemydids, and is comparable with the shell of extant species of *Rhinoclemmys* (see Cadena et al. 2012: appendix 2) characterized by costal bones with slightly straight-line sulci left by the contact between pleural scutes on the dorsal surface and a weak sculpturing pattern of the annuli on the lateral portion of the costal bones (Fig. 2F-G) (Cadena et al. 2017). The costal bones of geoemydids described here also exhibit weakly marked axillary and inguinal scars (Fig. 2E). The nuchal bone ROM-42058 described herein exhibits a cervical scute that is narrower anteriorly than posteriorly and being shorter than in *Trachemys* spp. and resembling in all aspects the nuchal of extant and fossil specimens of *Rhinoclemmys* (Cadena et al. 2017: fig. 2; Cadena & Carrillo-Briceño 2019: fig. 3). The neural bones exhibit a well-developed ridge on the

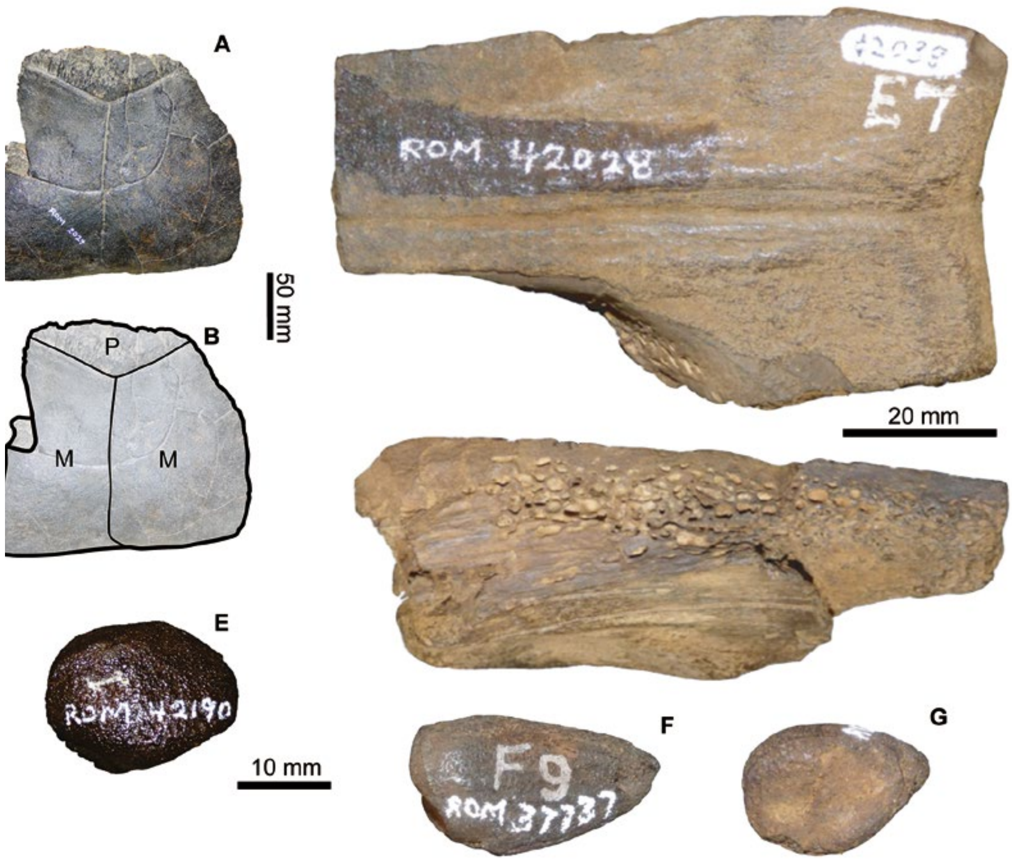

Figure 5. Testudinidae (*Chelonoidis* sp.) carapace and limb material from Talara Tar Seeps. (A-B) ROM-2024 peripheral bone from the carapace-plastron bridge region in dorsal view; (C-D) ROM-42028 partial costal bone in dorsal and posterior (cross-section) views; (E) ROM 42190 osteoderm in dorsal view; (F-G) ROM-37737 triangular osteoderm in dorsal and proximal views. 50 mm scale bar applies for A-B, 20 mm scale bar applies for C-D, 10 mm scale bar applies for E-G. Abbreviations: M, marginal scute; P, pleural scute.

dorsal surface (Fig. 2H-I), very similar as those exhibited by extant representatives of *Rhinoclemmys*, such as *Rhinoclemmys melanosterna* CRI-42056 (Fig. 2Y) (see also Cadena et al. 2017: fig. 2). The xiphiplastra of *Rhinoclemmys* sp. described here (Fig. 3K-3N) differ from extant and fossil representatives of *Chelonoidis* (Testudinidae) in that they have very large anal scutes.

In contrast to previous attributions (Currie unpublished data; Seymour 2015) of fossil turtles of the TTS to *Rhinoclemmys melanosterna*, we consider the material to be extremely fragmentary for undisputable attribution to a particular species, and therefore suggest attributing all of this material only to *Rhinoclemmys* sp. The only specimen that potentially could be attributed to *R. melanosterna* is the entoplastron ROM-42183 (Fig. 3C-D), which exhibits a bell-shaped entoplastron considered by Carr (1991) as one of the diagnostic features of this species (Fig. 3P). Also we attribute the two specimens previously considered as *Trachemys* sp. by Currie unpublished data; Seymour (2015), specimens ROM-41849 (peripheral bone, Fig. 2A-B) and ROM-41848 (left epiplastron, Fig. 3A-B) as belonging to *Rhinoclemmys* sp; based on that ROM-41849 lacks of the highly dentate margin of peripherals of *Trachemys* spp. (Fig. 2C-D) and that ROM-41848 exhibits similar lateral deep notch at the humerogular contact as in most of *Rhinoclemmys* spp. (Fig. 3P), being almost continuous or straight in *Trachemys* spp. (Fig. 3Q).

Furthermore, re-examination of all specimens housed in the ROM collections has allowed us to conclude that there is no evidence of diagnostic characters to support the occurrence of *Trachemys* (Emydidae) turtles in the TTS, considering the most complete bones, including nuchal, costal, pygal and plastral elements (See Fig. 2, Cadena et al. 2017: fig. 6; Cadena & Carrillon-Briceño 2019 for graphical comparisons between these bones in *Rhinoclemmys* and *Trachemys*). For example, the pygal bone ROM-42105 (Fig. 2S-T) described herein exhibits a vertebral 5 covering the most anterior portion of the bone in a triangular shape, as well as a very narrow and shallow medial notch at its posterior edge, similar as in *Rhinoclemmys* sp. UF-242075 from the Miocene of Panama, the extant *Rhinoclemmys areolata* UF(H)-54199 (Cadena et al. 2012: fig. 5) and *Rhinoclemmys* sp. UPSE-T0012 from the Pleistocene of Santa Elena, Ecuador (Cadena et al. 2017: fig. 2). In contrast, the posterior pygal of *Trachemys* spp. exhibits a vertebral 5 that covers only a small portion of the pygal and lacks the triangular shape, as well as develops a deeper posteromedial notch (Fig. 2U-V).

***Chelonoidis* sp. assignation.** The testudinid material of the TTS described herein resembles extant and fossil members of the genus *Chelonoidis* based on their large size and bone thickness, as well as the characteristic sulci that form a canal with high lateral walls (Fig. 5C). The dorsal surface of the bone is also characterized by fine and highly dense vermiculation without long dichotomized lines (Cadena & Jaramillo 2015). The osteoderms also support the occurrence of these tortoises in TTS. However, the fossils are too fragmentary to allow attribution to a particular species or to erect a new species within the *Chelonoidis* genus. The attribution of this material as belonging to *Chelonoidis* genus is based also on that this is the only fossil and extant testudinid genus of South America (de la Fuente et al. 2014).

Paleobiogeographical and paleoenvironmental implications

The occurrence of *Rhinoclemmys* sp. (Geoemydidae) and *Chelonoidis* sp. (Testudinidae) in the northwestern region of Peru (Talara Tar Seeps), shows a wider past (Pleistocene) geographical distribution of these two families of turtles west of the South American Andes, similar to recent reports of the same genera from southwestern Ecuador (Cadena et al. 2017) and even East of the Andes for *Rhinoclemmys* (Cadena & Carrillo-Briceño 2019). Currently, geoemydids and testudinids are completely absent along the entire western margin of Peru (Turtle Taxonomy Working Group 2017), which indicates that their geographical constriction in distribution occurred in the last 14 kyr due to potential changes in the climatic conditions of the region, particularly in the El Niño–Southern Oscillation (ENSO), which induces considerable spatial variability in annual precipitation from north to south and along the coast (Morera et al. 2017). Wetter conditions of the Talara region during the Pleistocene are inferred not only by the occurrence of the fossil *Rhinoclemmys,* but also by diving beetles, frogs, caimans, ducks, grebes, herons, ibises, rails, plovers, sandpipers, and capybaras (Seymour 2015).

Taphonomic considerations

In contrast to other tar seep fossil sites where fossil skeletons are found almost complete or relatively articulated, such as Rancho La Brea (Lindsey & Seymour 2015), the fossil turtles from the TTS are generally found disarticulated and highly fragmented, which indicates that these bones were brought to the tar seep by river activity or small-scale drainage before they were trapped and preserved by the viscous tar. The dark color of some of the turtle bones and other species of the TTS is consistent with the hypothesis that the fossils accumulated in pools of asphalt (Lindsey & Seymour 2015). A deep taphonomic study of these fossils is out of the scope of this project and should be adressed by future studies.

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Acknowledgements:
We thank Dr. Kevin Seymour, from the Royal Ontario Museum, Toronto, Canada, for the opportunity to study the Talara collections. We thank Sara J. Mason, M.Sc., from Edanz Group (www.edanzediting.com/ac) for editing a draft of this manuscript. We thank to two reviewers Dr. E. Vachlos and one anonymous for their comments and suggestions.

Competing interests:
The authors have declared that no competing interests exist.

Author roles:
A.D, examined the ROM specimens; A.D, E.A.C, wrote the paper; J.N.M. made comments on the drafts and final version of the manuscript. All authors gave final approval for publication.

Funding:
Funding for this project was granted to A. Deza from the M.A. Fritz Travel Grants for the Advancement of Studies in Palaeontology of the Royal Ontario Museum and to E.A. Cadena from the Alexander von Humboldt Foundation of Germany.

Ethics / legal:
Not applicable, material Biological is proceedent from museological collections.

Appendix 1. List and measurements of fossil turtle specimens from the Talara Tar Seeps, housed at the ROM collections, Toronto, Canada, identifiable at genus level.

Specimen code	Anatomical identity	Length (mm)	Width (mm)	Transverse diameter (mm)	Proximal width (mm)	Distal width (mm)
Geoemydidae						
Rhinoclemmys sp.						
	Carapace					
ROM 41277	Left costal 5	45.8	28.2	—	—	—
ROM 41849	Left peripheral 2	29.1	34.5	—	—	—
ROM 42068	Left peripheral 2	23.2	22.8	—	—	—
ROM 42074	Right peripheral 9	24.1	27.1	—	—	—
ROM 42076	Right peripheral 8	36.3	50.9	—	—	—
ROM 42078	Left peripheral 2	36.0	37.8	—	—	—
ROM 42079	Right peripheral 3	26.1	31.4	—	—	—
ROM 42080	Right peripheral 1	26.2	35.4	—	—	—
ROM 42082	Left peripheral 2	9.8	33.1	—	—	—
ROM 42083	Right peripheral 8	31.0	45.0	—	—	—
ROM 42084	Right peripheral 2	33.7	47.6	—	—	—
ROM 42087	Right peripheral 1	36.7	37.8	—	—	—
ROM 42088	Left peripheral 10	31.1	39.1	—	—	—
ROM 42090	Left peripheral 2	34.5	37.4	—	—	—
ROM 42091	Left peripheral 8	27.5	36.7	—	—	—
ROM 42092	Left peripheral 8	32.5	43.3	—	—	—
ROM 42093	Right peripheral 2	39.9	39.2	—	—	—
ROM 42094	Right peripheral 9	34.5	33.5	—	—	—
ROM 42099	Left costal 5	25.2	55.8	—	—	—
ROM 42100	Suprapygal	21.4	26.1	—	—	—
ROM 42101	Right peripheral 7	18.9	24.5	—	—	—
ROM 42105	Pygal	19.9	31.0	—	—	—
ROM 42112	Right peripheral 5	41.5	51.3	—	—	—
ROM 42115	Left peripheral 5	29.6	50.1	—	—	—
ROM 42116	Left peripheral 6	30	28.4	—	—	—
ROM 42131	Left peripheral 9	14.3	19.7	—	—	—
ROM 42134	Right costal 8	13.1	25.4	—	—	—
ROM 42135	Right costal 6	25.6	29.4	—	—	—
ROM 42138	Right costal 5	21.9	41.9	—	—	—
ROM 42143	Left costal 5	43.3	35.5	—	—	—
ROM 42144	Left costal 2	26.4	43.2	—	—	—
ROM 42147	Right costal 4	29.6	56.4	—	—	—
ROM 42149	Left costal 2	31.2	50.3	—		—
ROM 42150	Right peripheral 8	27.0	32.9	—	—	—
ROM 42152	Right costal 6	31.0	37.9	—	—	—
ROM 42153	Left peripheral 8	42.0	54.8	—	—	—
ROM 42154	Left costal 2	27.1	15.9	—	—	—
ROM 42159	Right costal 4	19.8	37.3	—	—	—
ROM 42166	Right peripheral 6	32.7	33.3	—	—	—
ROM 42170	Left costal 6	23.4	23.9	—	—	—
ROM 42174	Right costal 3	29.9	42.7	—	—	—
ROM 42175	Left costal 5	41.6	33.1	—	—	—
ROM 42179	Neural 1	26.1	18.8	—	—	—
ROM 42180	Neural 1	32.9	21.8	—	—	—

(Continues..)

Specimen code	Anatomical identity	Length (mm)	Width (mm)	Transverse diameter (mm)	Proximal width (mm)	Distal width (mm)
ROM 42181	Neural 1	31.8	21.3	—	—	—
ROM 42182	Neural 5	19.3	20.2	—	—	—
	Plastron					
ROM 41848	Left epiplastron	53.2	53.8	—	—	—
ROM 42053	Right xiphiplastron	71.6	80.9	—	—	—
ROM 42054	Right xiphiplastron	65.8	72.8	—	—	—
ROM 42055	Left xiphiplastron	64.9	73.6	—	—	—
ROM 42056	Left xiphiplastron	70.2	72.1	—	—	—
ROM 42053	Right xiphiplastron	71.6	80.9	—	—	—
ROM 42054	Right xiphiplastron	65.8	72.8	—	—	—
ROM 42055	Left xiphiplastron	64.9	73.6	—	—	—
ROM 42056	Left xiphiplastron	70.2	72.1	—	—	—
ROM 42070	Right epiplastron	46.6	34.6	—	—	—
ROM 42085	Left epiplastron	39.2	42.4	—	—	—
ROM 42095	Right epiplastron	37.6	25.7	—	—	—
ROM 42097	Xiphiplastron	17.5	34.6	—	—	—
ROM 42102	Right hypoplastron	9.7	46.0	—	—	—
ROM 42104	Right hypoplastron	62.3	81.5	—	—	—
ROM 42106	Right hypoplastron	20.6	41.1	—	—	—
ROM 42109	Left hypoplastron	35.7	55.7	—	—	—
ROM 42110	Right hyoplastron	60.2	45.6	—	—	—
ROM 42114	Right hyoplastron	56.6	37.5	—	—	—
ROM 42183	Entoplastron	40.6	43.4	—	—	—
ROM 42184	Entoplastron	38.6	43.3	—	—	—
	Skull—neck					
ROM 42051	Hyoid	24.3	—	3.2	—	—
ROM 42052	Hyoid	28.0	—	2.0	—	—
ROM 42185	Vertebra	—	—	4.3	—	—
ROM 42187	Vertebra	—	—	6.3	—	—
	Pectoral—Pelvic					
ROM 42046	Left scapula	28.3	—	6.3	—	—
ROM 42046	Left acromial	32.8	—	5.4	—	—
ROM 42033	Ischium	33.5	8.6	—	—	—
ROM 42037	Right ilium	38.7	—	5.9	—	—
ROM 42363	Right ilium	26.3	—	5.6	—	—
ROM 42364	Right ilium	24.6	—	5.6	—	—
	Limbs					
ROM 42032	Right femur	40.7	—	4.2	10.9	9.6
ROM 42034	Right femur	63.1	—	6.9	18.3	13.3
ROM 42035	Right femur	28.9	—	3.4	14.1	—
ROM 42036	Left ulna	34.6	—	4.3	6.6	10.9
ROM 42038	Left ilium	33.7	—	5.4	—	—
ROM 42039	Left tibia	31.9	—	2.2	6.7	6.1
ROM 42040	Left femur	20.9	—	6.3	15.9	—
ROM 42041	Left femur	50.9	—	5.0	15.4	12.8
ROM 42042	Left femur	46.6	—	4.8	14.4	8.8
ROM 42043	Left femur	44.9	—	5.3	—	17.9
ROM 42044	Left femur	36.6	—	5.2	15.1	—
ROM 42045	Left femur	43.6	—	5.6	—	—

(Continues..)

Specimen code	Anatomical identity	Length (mm)	Width (mm)	Transverse diameter (mm)	Proximal width (mm)	Distal width (mm)
ROM 42047	Right femur	38.3	—	5.2	14.7	—
ROM 42048	Right femur	48.8	—	4.5	16.1	—
ROM 42049	Right femur	41.7	—	4.4	—	10.0
ROM 42050	Left femur	33.3	—	7.0	—	10.8
ROM 42060	Left radius	31.6	—	2.6	5.2	8.9
ROM 42061	Left radius	31.4	—	3.4	6.7	9.4
ROM 42062	Left humerus	55.5	—	6.7	16.4	8.1
ROM 42063	Right tibia	35.5	—	3.3	10.2	6.2
ROM 42064	Right humerus	63.5	—	8.1	21.1	9.8
ROM 42065	Right humerus	46.9	—	7.4	20.2	—
ROM 42066	Right femur	49.9	—	5.9	18.7	—
ROM 42186	Left femur	30.2	—	5.7	12.7	—
Testudinidae						
Chelonoidis sp.						
	Carapace					
ROM 2024	Right peripheral 2	176.9	142.9	—	—	—
ROM 42025	Costal	47.2	29.9	—	—	—
ROM 42026	Peripheral	91.4	62.0	—	—	—
ROM 42029	Costal	105.3	82.8	—	—	—
ROM 42030	Peripheral	113.5	103.6	—	—	—
	Limbs					
ROM 37737	Osteoderm	26.6	14.6	—	—	—
ROM 40620	Podial	27.6	19.4	—	—	—
ROM 42190	Osteoderm	24.18	18.50	—	—	—