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A New Mesozoic Reptile for Egypt: A Dermochelyid Marine Turtle from The Late Cretaceous of Dakhleh Oasis

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Abstract

A left humerus of a dermochelyid sea-turtle has been recovered from Dakhleh Oasis, western desert of Egypt, from a presumed Late Cretaceous marine littoral context. It resembles a humerus of *Psephophorus eocaenicus* from the Late Eocene of the Fayum Depression, but differs in lacking a horn-shaped lesser trochanter, an epicondylar foramen, and in having an open intercondylar groove. It is assigned to a new genus and species, *Misremys millsi* n. genus et n. species.

Introduction

Dakhleh Oasis, Egypt, has yielded fossilized parts of many animals, both vertebrate and invertebrate [1,2] perhaps none so unique and scarce as a humerus or upper arm bone of an undescribed Late Cretaceous leatherback (dermochelyid) turtle from near Munshiya, ± 17 km northwest of Mut (Fig. 1 - 3). This bone had eroded from its presumed Dawi Variegated Shale bedrock, was used by land-surveyors in the 1930's as a weight for a bell-tent guy rope, and then left to disintegrate on the desert floor [1].

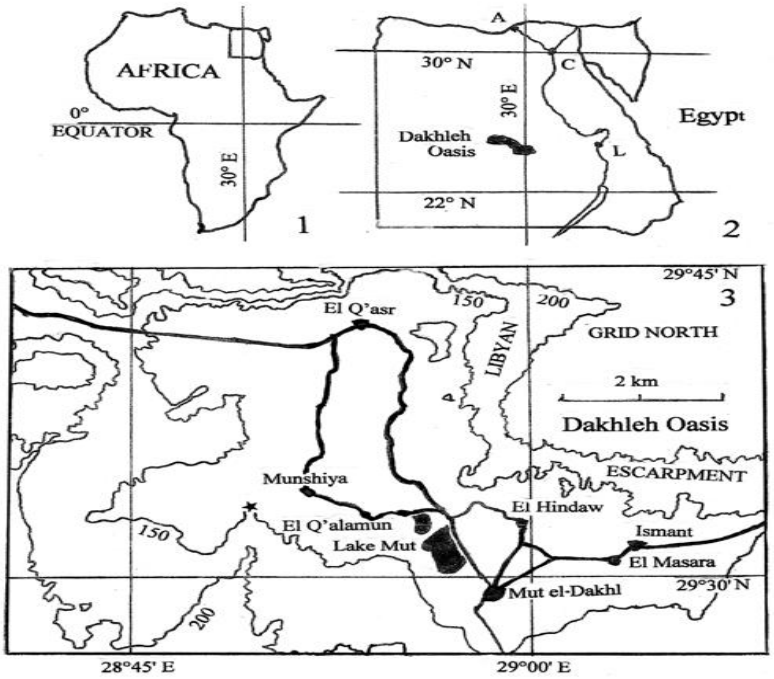

Figure 1: Sketch Maps of Africa, Egypt and Dakhleh Oasis. 1. Africa, with Egypt in NE corner. 2. Egypt and Sinai. Dakhleh Oasis (black), Alexandria (A), Cairo (C) and Luxor (L). 3. Central area of Dakhleh Oasis. Star indicates findplek of humerus of *Misrchelys millsi* n. gen, n. sp. Roads-heavy lines, contours-fine lines, heights in metres amsl. Scale=2 km. Drawn from Joint Operations Graphic Series 1501, Sheet NG 36-12, Dakhla Oasis, Ed. 1, 1985. Scale 1: 2500.

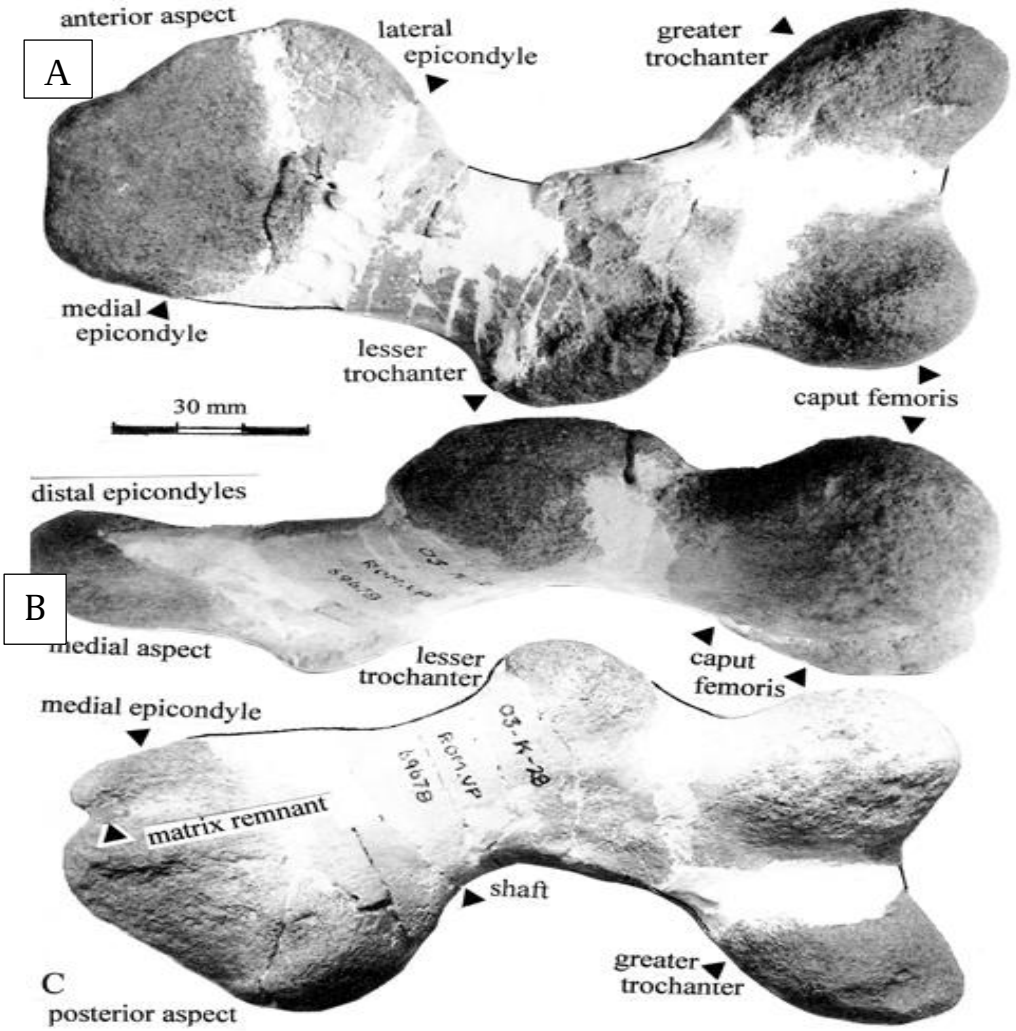

Figure 2: Left humerus of *Misrchelys millsi* n. gen, n. sp. Royal Ontario Museum, Vertebrate Palaeontological Collections No. 69678. A. Anterior aspect. B. Medial aspect. C. Posterior aspect. Scale=30mm. Note. Scale is approximate due to parallax. Inked outlines indicate limits of plaster restoration. Matrix remnant in trochlear or intercondylar groove, C, left.

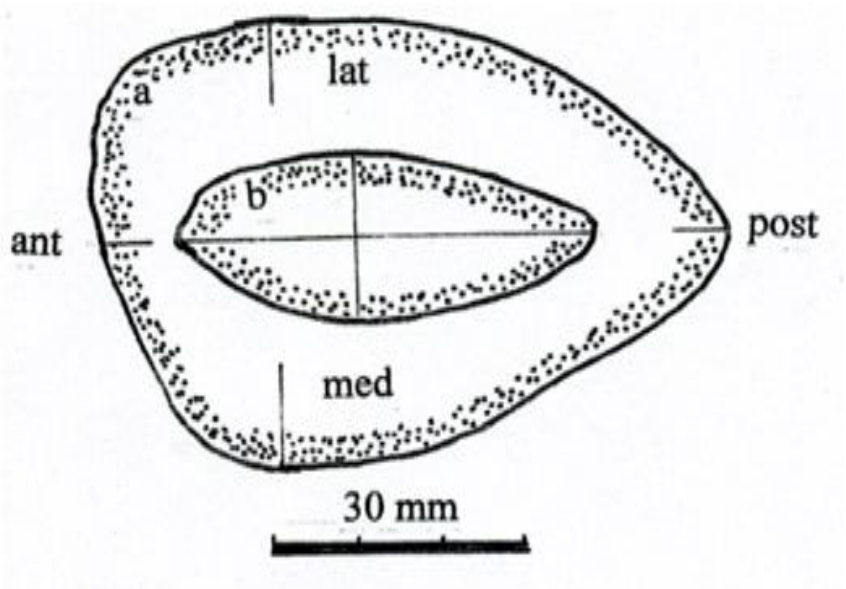

Figure 3: Sections of humeri of *Atlantochelys mortoni* (a) through the break in diaphysis [3] and of *Misrchelys millsi* (b) through the midpoint of the diphysis ('E', Fig. 3 and Table 1). Diameters of the diaphysis of *A. mortoni* are 72 and 55 mm and of *M. millsi* 50 and 19 mm. Ratios of anteroposterior width to transverse width are 2.63 in (a) and 1.30 in (b), respectively.

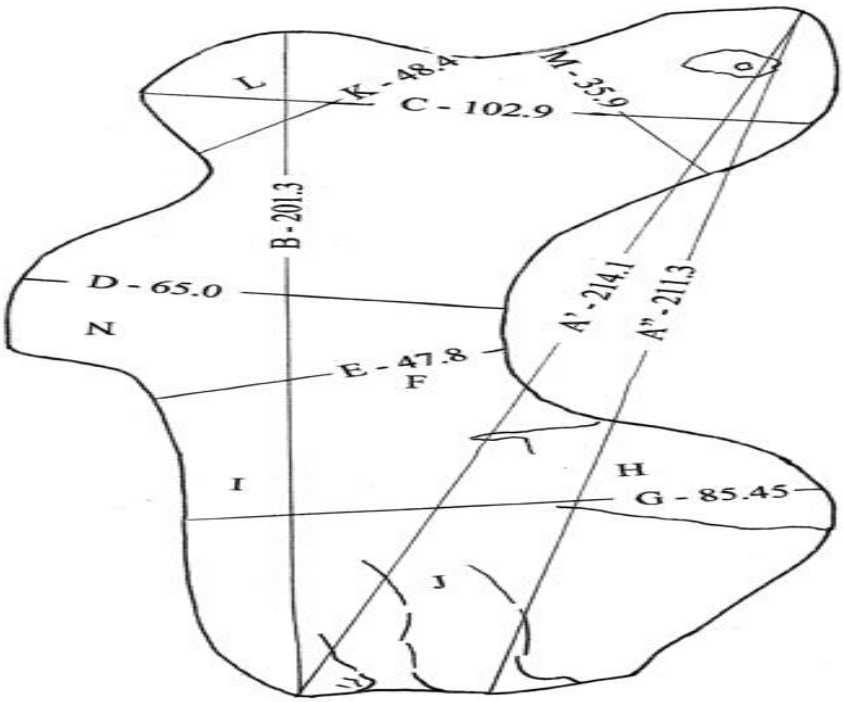

Figure 4: Ventral; or posterior outline of left humerus of *Misrchelys millsi* with dimensions from Table 1.

A' Length; greater trochanter to middle margin of medial condyle - 214.1.
A''Length; greater trochanter to middle margin of lateral condyle - 211.3.
B Length; caput humeri to distal articulation of medial condyle - 201.3
C Transverse diameter over greater trochanter and caput humeri - 102.9.
D Transverse diameter over lesser trochanter - 65.0.
E Greater diameter of diaphysis/shaft - 47.8.
F* Lersser diameter of diaphysis/shaft - 24e
G Transverse dameter over medial; epicondyle - 85.45.
H* Thickness over medial epicondyle - 21.25.
I* Thickness over lateral epicondyle - 15e.
J* Greater thickness of medial epicondyle - 23.2.
K' Transverse diameter of caput humeri - 48.4.
K''Proximo-distal; diameter of caput humeri - 42.2.
L* Proximo distal diameter of caput humeri - 43.2.
M Antero-posterior diameter of greater rochanter - 35.9.
N* Dorso-ventral diameter of lesser trochanter - 35.7.
Note: * indicates dimensions at right angles to the figure and cannot be shown. **e**= estimated measurement. Measurements in millimeters.

Table 1: Measurements of Cretaceous left humerus of *Misrchelys millsi* (ROM 69678) from Two Bell Tent Survey Camp, southwest of Munshire, Dakleh Oasis, Egypt.

After reassembly and minor restoration (Fig. 2a), it was recognized as a humerus of a dermochelyid. Fossil dermochelyids are known from Cretaceous and later strata in North and South America, Europe, Morocco, Angola, Egypt and New Zealand. A Cretaceous Dakleh record is significant because skeletal remains of Cretaceous dermochelyids are previously unknown from Egypt. Known specimens are from the Fayum Eocene and were placed in *Psephophorus* by Andrews (1901, 1906), but reassigned to *Egyptemys* by Wood (1996) [4]. Humeri of *Egyptemys* (= *Psephophorus*) *eocaenicus* are robust [5,6, plate 1], and are distinguished by the presence of prominent horn-like lesser trochanters (*processi radiales*) that replace or emphasize the ossified muscular insertion.

Dermochelyidae are known from the Early Cretaceous to the present day and are recorded from marine littoral deposits. They are large pelagic turtles with bodies up to 3.0 x 2.0 m. The extant taxon, *Dermochelys* (=*Sphargis*) *coriacea,* is known from the warmer waters of the North and South Atlantic Oceans and the Mediterranean Sea. *D. pseudostrion* is described from the Miocene of France. *Psephophorus eocaenicus* (Andrews, 1901, 1906) [5,7] is known from the Fayum of Egypt and, while of Late Eocene rather than Cretaceous age, has humeri more similar in morphology to the Dakhleh humerus than to that of *P. veronensis* [6], Fig.3). Comparisons with *Psephophorus* (= *Egyptemys*, [8] humeri are more productive despite the difference in stratigraphic ages. *Psephophorus scaldi* [9] from the Pliocene of Belgium is

morphologically similar but has a strong lesser trochanter with both a horn and a ridge, and a strong intercondylar foramen as in *Dermochelys coriacea* [10]. The humerus of the New Jersey (American) *Atlantochelys mortoni* [3], found in two pieces in 1849 and 2012, retains much of the three-dimensionality of its land-living ancestors, and is both more robust and more than twice the size (articular lengths 527 v 210 mm) of the Dakhleh species, and is thus excluded from being closely related unless these size differences reflect juvenilke versus adult morphologies. The Angolan (African) Turonian *Angolachelys mbaxi* [11], material includes no humeral remains for comparison.

A damaged proximal half of a dermochelyid left humerus named *Maorichthys wiffenae* [6,12] is known from the Eocene of South Island, New Zealand, near Dunedin. It was first assigned to *Psephophorus* by Kohler (1994) [13], but is shown to be close to *Eosphargis* in a character analysis by Karl and Tichy (2007) [6]. There is a well-developed intertubercular fossa or foramen (intercondylar or trochlear foramen) on its dorsal surface.

A left humerus of a large panchelonioid turtle has been recovered from the Ammonite Hills member of the Dakhla Shale Formation near the village of Abu Minquar, Farafra, west of West Maohouib, Dakhleh Oasis [14]. This specimen derives from a level stratigraphically higher than that which yielded the dermochelyid humerus reported here.

Many large leatherback turtles are described from Cretaceous and Early Tertiary deposits in the United States, but the taxonomy is based mainly on skulls and jaws. Taxonomic identification from isolated limb elements is difficult and seldom attempted, as descriptions or illustrations of appendicular elements are sparse or incomplete, and are usually disassociated from crania and jaws. Known fossil genera are *Cosmochelys* (Eocene of West Africa), *Eosphargis* (Eocene of Europe), *Psephophorus* (Eocene of North Africa and Pliocene of Europe) and *Protosphargis* (Upper Cretaceous of Europe and the Mediterranean Basin (*P. veronensis*, including*? P. capellini*). "In Africa, Cretaceous and Early Tertiary Cryptodiran turtles are poorly known, apart from the taxa from the Maastrichtian deposits of the Oudad Abdoun Basin in central Morocco" [15], *Psephophorus eocaenicus* from the Late Eicene Birket al-Quaran deposits of the Fayum, Egypt [5,7], and *Angolachelys mbaxi*, from an incomplete skeleton from Angola [11], there is now this isolated Egyptian occurrence.

A record of a substantially complete skeleton of the Late Cretaceous *Protosphargis veronensis* [16] from limestone near Verona, Italy, is reasonably geographically proximal to Dakhleh, is possibly quasicoeval, and might have been the possible source taxon. However, The Verona dermochelyid preserves only two-thirds of a weathered left humerus and a fragment of a right. Comparison of the Verona humeral fragments and the Dakhleh humerus shows that the Dakhlkeh humerus was more latero-medially compressed (Fig. 2b), and thus was not likely congeneric with the Verona species (*P. veronensis*, including *P. capellini*).

Description of Specimen

A damaged left humerus (Royal Ontario Museum, Vertebrate Palaeontological Collections No. 69678) was recovered from the desert surface southwest of Munshiya (Mushire) in Dakhleh Oasis on February 26th, 2003, from the Two Bell Tent Survey Canp Site, ca. Lat. 29° 33' N.; Long. 28° 49.5' E., and ca. 16,5 km. WNW of Mut (Fig. 1). It had broken into six main fragments and, when reassembled, gave an essentially complete bone (Fig. 2). Its stratigraphic age and position are assumed to be from within the Duwi Formation as this unit theoretically extends stratigraphically above the present-day topographic surface [2], and thus could be from the Quessir or Variegated (Mut) shales. It was found associated with other rocks used to stabilize tent guy ropes. When exposed to the severe annual and diurnal desert temperature and humidity fluctuations, internal stresses caused the bone to fragment into pieces by clean breaks.

The matrix in which this humerus had been entombed has been naturally sand blasted away but is represented by a small residual sandy patch distally between the dorsal ridges of the epicondyles in the trochlear groove (Fig. 2c), The surface of the bone is generally sand-abraded or spalled, and the original smooth osseous surface remains only in the diaphyseal area. Where the bone is dense: most of the surface is now finely granular and reveals the inner cortical bone. The shaft area is fractured into transverse blocks (Fig. 2) as though the bone, when *in situ* in the matrix, was undergoing shear fracturing from stratigraphic deformation. This fracturing occurred prior to its use as a guy rope weight.

The humerus has the typical 'bent' conformation of a turtle humerus with the greater trochanter lateral to the caput (Fig. 2a). The lesser trochanter is slightly damaged dorsally and lies level with the caput. The shaft or diaphysis is short and slightly less in transverse diameter than the neck distal to the caput. The epicondyles are dorso-ventrally compressed with the medial epicondyle thicker and more robust. The lateral distal epicondyle forms a stout lateral crest (Fig. 2a). Doimensions are given in Fig 3 and measurements in Table 1.

The Cretaceous tropical and subtropical seas are notable for their giant marine turtles, many of which had thick bony carapaces. Amongst this armoured turtle fauna, was a sparser fauna of leatherback turtles that possessed reduced or no bony carapaces, despite having a well-developed plastron, and all within a thick skin. Unfortunately, single or isolated skeletal elements not representing the carapace, plastron or skull do not indicate whether a turtle was bony or leatherbacked. Humeri (where known) of massive turtles resemble those of the conservative terrestrial tortoises in having the trochanters and coput not coplanar. These features lie in one plane in leaaher-backed forms. Though the humerus is more than 200 mm in functional length, and thus represents a large individual, there is no osteological clue as to whether this animal was a fully grown adult or able to have grown to a comparable length of two or more meters.

Systematic Palaeontology

- Order Chelonii Brongniart, 1800 **(Latereille, 1800)**
- Megaorder Cryptodira Gray, **1825**
- Superfamily Chelonioidea Agassiz, **1857**
- Family Drermochelyidae Gray, **1825**
- *Misrchelys millsi* n. gen, n. sp.

Etymology: Protosphargis-*'misr',* Arabic for Egypt and *'chelys'.* Latinised Greek for turtle. Species - *'millsi'* in honour of Anthony J. Mills, Director of the Dakhleh Oasis Project and Field Director of the Dig House at Ain el-Gindi, Masara, Dakhleh Oasis, without whose strong support over three decades my Egyptian fossil investigations would not have taken -place.

Systematic Significance

The archetypal tetrapod humerus is adapted for terrestrial locomotion and consists of six main parts: the head or caput humeri, a semi-circular boss on which the forelimb articulates within the glenoid fossa of the scapula or shoulder blade; the greater trochanter or main muscle insertion and lever placed laterally on the humeral shaft just distal to the caput to move the forelimb laterally; the lesser trochanter or medial lever placed on the inner or medial surface of the shaft, whose leverage pulls the forelimb towards the medial plane; the humeral shaft or diaphysus, which separates the caput and trochanters from the distal epicondyles which, in turn, articulate with the radius and ulna and allows the forelimb to fold at the elbow, and which are separated by the trochlear or intercondylar groove. The trochanters lie almost in the transverse plane that passes through the caput. The shaft is formed in dense bone and surfaced in smooth shiny skin. In chelonia, the epicondyles are separated by an intercondylar or trochlear groove; their articular facets are level and paired to match the cubitus' humeral facets.

Adaptation to chelonian and particularly to dermochelydean swimming motions has caused the humerus to lose or modify these characters. Hirayama (1997 [17], fig. 8; 1992 [18]) reviews chelonian skeletons and illustrates variation in left humeri morphology. These humeri are generally dorso-ventrally compressed and retain massive capites that approach or exceed in diameter twice the diameter of the shaft. The greater trochanters are robust and barely extend proximally beyond the caput (except in an undescribed Japanese dermochelyid [Hirayama, 1992 [18], fig. 8E] or *Dermochelys* (= *Sphargis*) *coriacea*. The lesser trochanter varies from a rough knob or crest to a strong distomedially oriented spur. In these characters *Misrchelys* falls within the ranges of variation shown by Hirayama (1992, 1997) [17,18]. The shaft is reduced in length and still forms a waist, in some cases less than half the antero-posterior diameter of the humeral ends. The distal end is a blade' formed by flattened epicondyles which are variably fused along the trochlear. groove. The epicondyles are generally subequal in size whereas in *Misrchelys* the medial epicondyle is less than 25% of the width of the lateral epicondyle, and the trochlear groove is open and shows little sign of converting into a foramen, as in *Psephophorus.* Such a foramen is not shown on the dorsal faces of chelonioid left humeri by Hirayama (1997 [17], fig. 8). The condition of an open trochlear groove may be a juvenile characteristic.

The greater trochanter is horn-like but broken on Andrews' type specimen. The distal condylar area is fused into a flattened blade where the two epicondyles may be separated by a roughly mid-dorsal foramen, which is not always present. The humerus of *Misrchelys* has a robust lesser trochlear which is not ridge or horn-like, and differs from the horn-like conformations in *Psephophorus* humeri figured by Karl (1994 [19], figs 1-4) and Karl and Tichy (2007 [6], figs 1 & 2). A spur-like trochanter may represent ossification of tendons inserting on this eminence and ossification may be the adult condition.

The evolution of the large marine turtles that possess thick ossified carapaces presents a simple adaptive lineage with carapace and plastron pacing each other. In leatherback turtles the absence of heavy carapaxial elements suggests that the leatherbacks never evolved a full carapace with Fig and marginals and lost any ossified dermal elements by reduction of eventually isolated irregular free osteoderms. In *Protosphargis veronensis* from the Late Cretaceous, both these dermal elements are absent, though reduced tooth-pick-like ribs are present.

Conclusion

An isolated left humerus of a Late Cretaceous leather-backed turtle (Dermochelyidae) from Dakhleh Oasis, near Munshire, Egypt, is identified as closely related to *Psephophorus eocaenicus* from the Late Eocene of the Quattara Depression, Egypt, and is named *Misrchelys millsi* n. gen, n. sp. The taxon is characterised by the lack of a horn-shaped lesser trochanter (*processus radialis*), a distal epicondylar foramen and fusion of unequal epicondyles into a united blade or paddle.

Footnote. The term 'epicondylar' foramen is properly applied to a bridged bony channel that is found on the medial condylar face of the humerus, as in *Testudo elephantopus* (Wieland, 1900 [10], fig. 1) and in many other vertebrates, and should not be applied to the ventral or trochlear groove that separates the two epicondyles. This groove may roof over to form a distal foramen as in *Archelon*, *Psephophorus scaldi* or *Dermochelys coriacea* (Wieland, 1900 [10], figs 17, 18, 20 & 21). This separation is referred to here as the 'trochlear' or 'intercondylar' grove.

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