

New postcranial specimens of the Anthracotheriidae (Mammalia; Artiodactyla) from the Paleogene of Fayum Depression, Egypt

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Abstract:

The fossiliferous deposits exposed north of Birket Qarun in the Fayum Depression, northeast Egypt, have produced a remarkable collection of fossil mammals from localities that range in age from earliest late Eocene (~37 Ma) to latest early Oligocene (~29 Ma). Anthracotheriidae are among the most common mammals that are preserved in these deposits.

Here we describe a new fossil specimens of the Anthracotheriidae (Mammalia, Artiodactyla) discovered in the Jebel Qatrani Formation of Fayum. The specimens consist of a seven astragalus, which is referable to *Bothriogenys* sp. from the formation. The specimens *Bothriogenys* sp. show a higher degree of size variation and some feature suggest that the anthracothere are not closely related to *Hippopotamus*.

Key word: anthracothere, *Bothriogenys*; astragalus; Fayum; Early Oligocene.

Introduction:

The fossiliferous sedimentary deposits exposed north of Birket (lake) Qarun in the Fayum Depression (Fig.1), northeast Egypt, have produced a remarkable collection of a wide variety of fish, amphibian, reptile, bird and mammal taxa (e.g. Andrews, 1906; Simons and Rasmussen, 1990; Murray et al. 2010; Rasmussen et al. 1987) from localities that range in age from earliest late Eocene (~37 Ma, early Priabonian) to latest early Oligocene (~29 Ma, late Rupelian) (Seiffert, 2006). Almost all of the area's major vertebrate fossil quarries, such as quarries A, B, E, V, I, M, O, L-41 and L-75 occur in the Jebel Qatrani Formation (Fig. 2) that have a diverse mammalian assemblages such as large-bodied hyracoids (Rasmussen and Simons, 2000), primates (Simons, 1997; Seiffert et al., 2005), elephant-shrews (Simons et al., 1991), "insectivores" (Seiffert and Simons, 2000; Seiffert et al., 2007), bats (Gunnell et al., 2008), rodents (Sallam et al., 2009; 2011) and anthracotheriid artiodactyls (Ducrocq, 1997)..

Anthracotheriidae has long been recognized as a family of artiodactyls that originated in Asia in the late Eocene and diversified in Africa, Eurasia and North America and extinct by the late Miocene. Anthracotheres are considered to be closely related phylogenetically to Hippopotomidae (e.g., Black, 1978; Boissarie and Lihoreau, 2006), however, their relationship is not globally accepted (e.g., Pickford, 2008). The Fayum anthracotheres are among the most common terrestrial mammals preserved at the fossil localities in particular at those occur in the Jebel Qatrani Formation and become larger in size stratigraphically through time. However among the most abundant components of the Jebel Qatrani Formation's terrestrial mammal faunas, little has been published about the group (Ducrocq, 1997). Only two genera, *Bothriogenys* and *Qatraniodon*, have been previously attributed to the family anthracotheriidae from

Paleogene of Egypt based mainly on craniodental materials (Andrews, 1906; Schmidt, 1913; Black, 1978; Ducrocq 2007).The oldest fossil remains of Fayum anthracotheres recorded from the underlie late Eocene Qaser El Sagha Formation (Holroyed et al., 1996). Here we describe the seven anthracothere astragalus from Jebel Qatrani Formation and compare it with *Hippopotamus* astragalus.

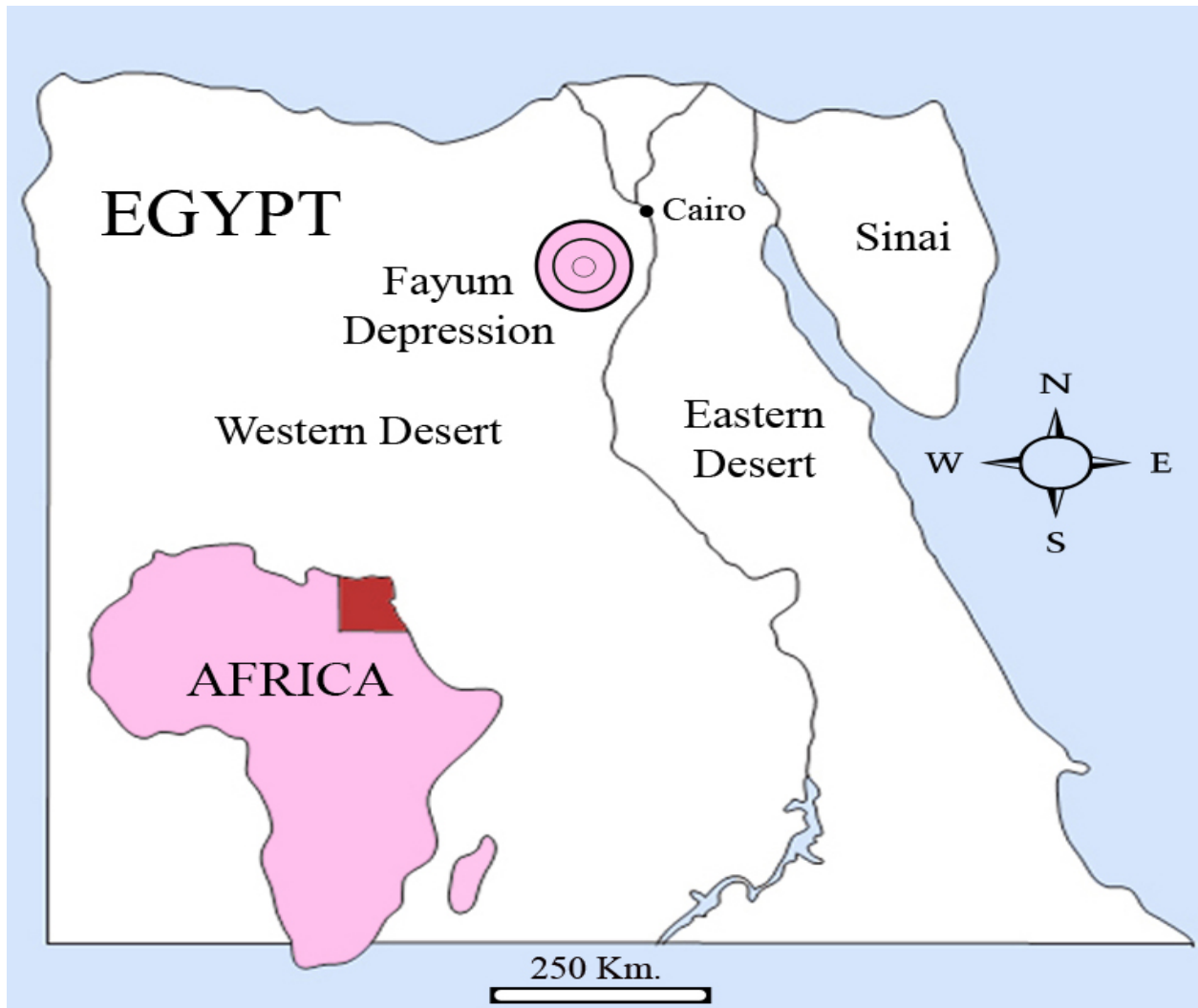


Fig. 1. Location map of the Fayum Depression in the Western Desert, northern Egypt.

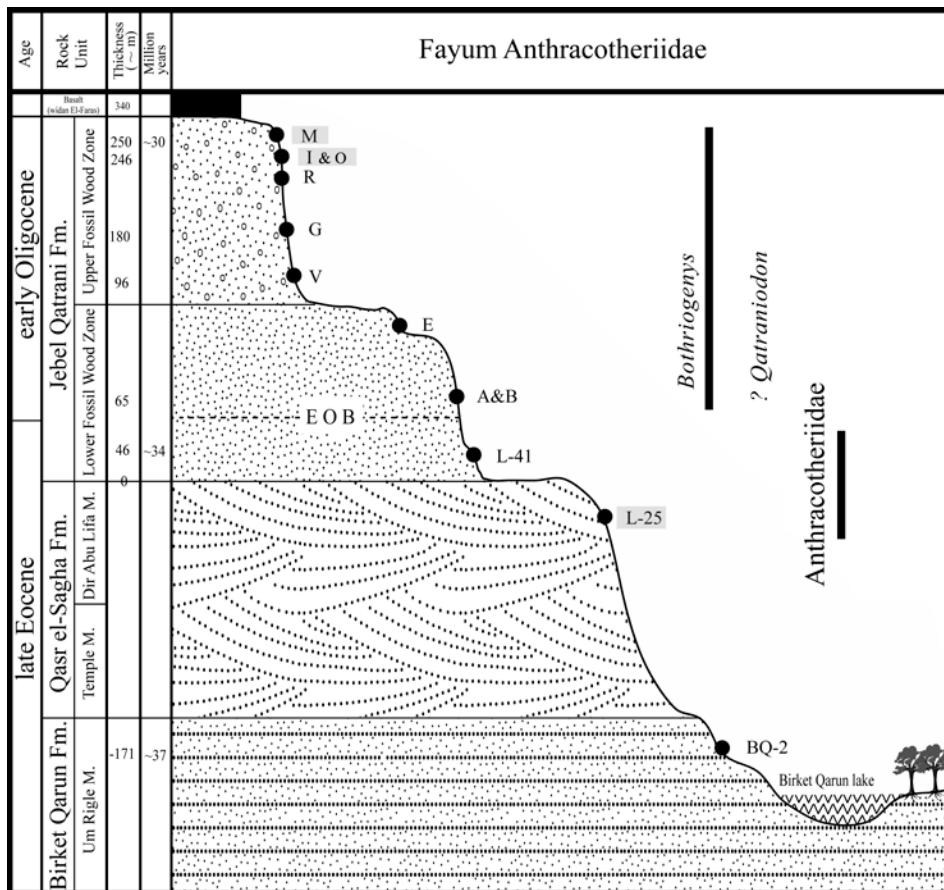


Fig. 2. Stratigraphic ranges of Fayum anthracotheres recognized in this paper and unstudied specimens (Anthracotheriidae) from older quarries. Age estimates for major mammal-bearing fossil localities, and approximate position of Eocene-Oligocene boundary, follows Seiffert (2006).

Abbreviation and materials:

Institution: CGM: Cairo Geological Museum.

Material: The specimens described here are stored in Egyptian Geological Museum (CGM). The studied specimens include the seven anthracothere astragalus represented by CGM 27363, CGM 27368, CGM 27350, CGM 27327, CGM 27416, CGM 27325 and CGM 27334. The basic anatomical terminology of astragalus indicated in Figure the terms compiled from Tsubamoto et al. (2008) (Fig.3).

Occurrence: Qasr el Sagha Formation and Jebel Qatrani Formation, Early Oligocene, Fayum Depression, Egypt.

Measurements: Shown in Table 1.

Systematic Paleontology

Class: Mammalia Linnaeus, 1758

Order: Artiodactyla Owen 1848

Family: Anthracotheriidae Leidy, 1869

Subfamily: Bothriodontinae Scott, 1940

Genus: *Bothriogenys* Schmidt, 1913

Bothriogenys sp.

Description:

Seven isolated astragali have been recovered from the Fayum Depression. All specimens are from the Jebel Qatrani Formation except for the oldest astragalus, which was collected from Quarry L-25 in Dir Abu Lifa Member, Qasr el Sagha Formation (see Simons, 1968) (Fig.4), (Fig.5) and (Fig.6). Among all of the bones of the Fayum anthracothere postcranial skeleton, astragali are the most common bone to be found, because of their robust and compact structure that makes them less likely to be eroded away like other skeletal elements.

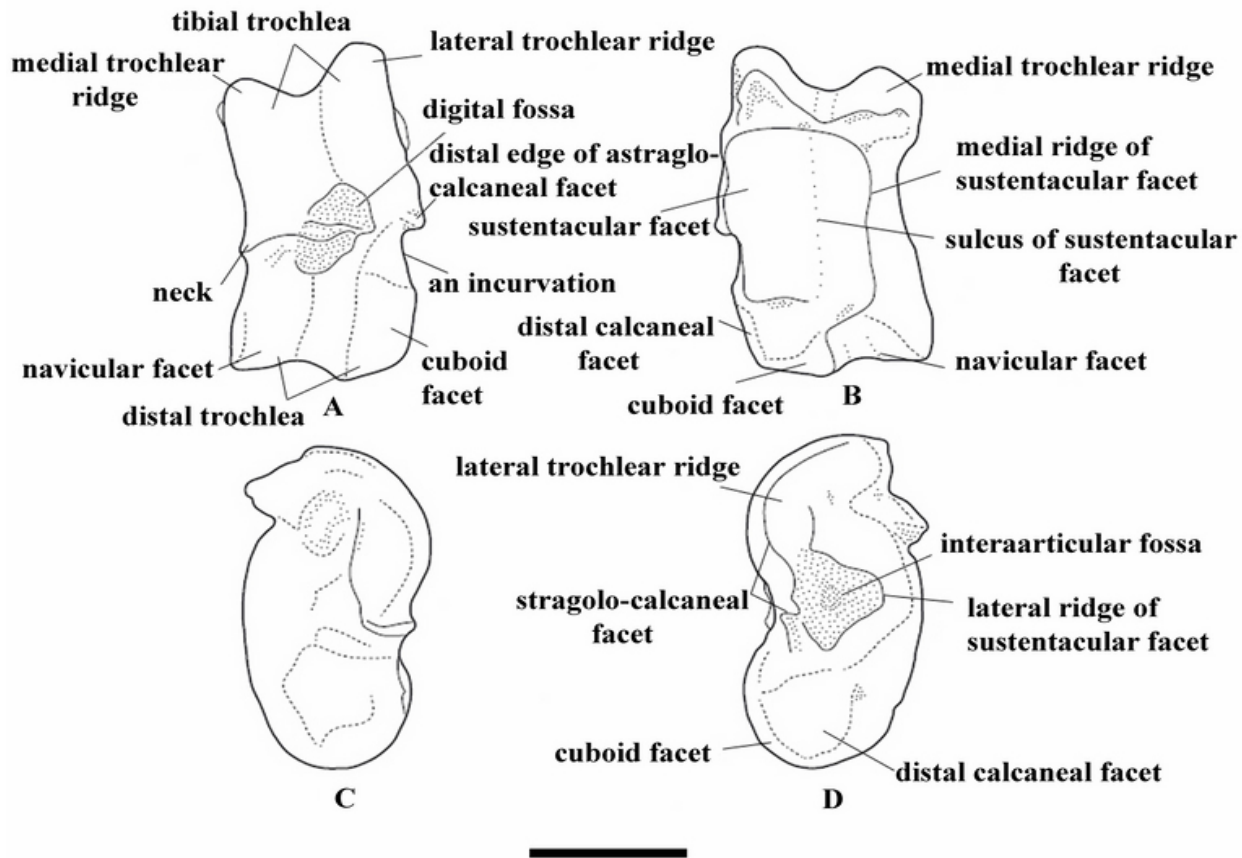


Fig. 3. Line drawing of anthracothere astragalus. (A) in anterior view, (B) in posterior view, (C) in medial view (D) in lateral view. Scale bars equal 2 cm.

Table 1. Measurements (in cm) of the anthracothere astragalus bones described in this paper.

CGM.No.	Locality	lateral proximo-distal length	medial proximo-distal length	medio-lateral width of tibial trochlea	medio-lateral width of distal trochlea	medial dorso-plantar height	lateral length (diameter) of tibial trochlea	medial length (diameter) of tibial trochlea
27363	L-25	5.03	4.62	2.2	2.57	2.24	2.46	2.56
27368	I	8.3	7.01	4.2	4.7	3.61	4.59	4.44
27350	M	8.22	7.49	4	4.37	3.7	4.1	3.97
27327	M	8.57	7.62	4.11	4.68	4.05	4.8	4.17
27416	I	9.12	8.05	4.61	5.3	4.5	5.2	4.4
27325	O	8.38	8.9	3.72	4.48	4.05	4.22	3.98
27334	I	8.2	7.2	4.04	4.31	4.9	4.2	4.28

Most Fayum anthracothere astragali are well preserved except for a few that exhibit postmortem erosion and damage.

The anthracothere astragalus has the typical artiodactyl double pulley morphology. Fayum anthracothere shows change in size through the Fayum Paleogene sequence matching with that seen in the dentitions. In dorsal view, anthracothere astragali have relatively high lateral and medial tibial trochlear ridges with the lateral ridge being slightly higher and more massive than medial trochlea ridge. There is a moderate trochlear groove, separating the medial and lateral trochlea ridges. The tibial trochlea is larger than the distal trochlea and is slightly oblique to the long axis, but not lying in the same plane as the distal trochlea. The astragalus from the Qasr El Sagha Formation CGM 27363 differs slightly from later occurring forms in being narrower and in having a very small deviation between the tibial and distal trochleae.

The distal calcaneal facet is prominent laterally and underneath it there is a small indentation. The cuboid facet is slightly wider than the navicular facet and is separated from it by a keel. In ventral view, the sustentacular facet is well developed. The lateral surface nearly convex in the proximo-distal direction. The flattened medial surface extends nearly to the sustentacular facet, but it is separated from it by a shallow sulcus of the sustentacular. The sustentacular facet is limited proximally by deep groove and distally by a broad and somewhat deep cuboid fossa. There is a cuboid facet developed at the end of distal trochlea. In the lateral

view, there is a large and well-basined inter-articular fossa. In the medial view, there are two shallow depressions, one proximally and the other distally.

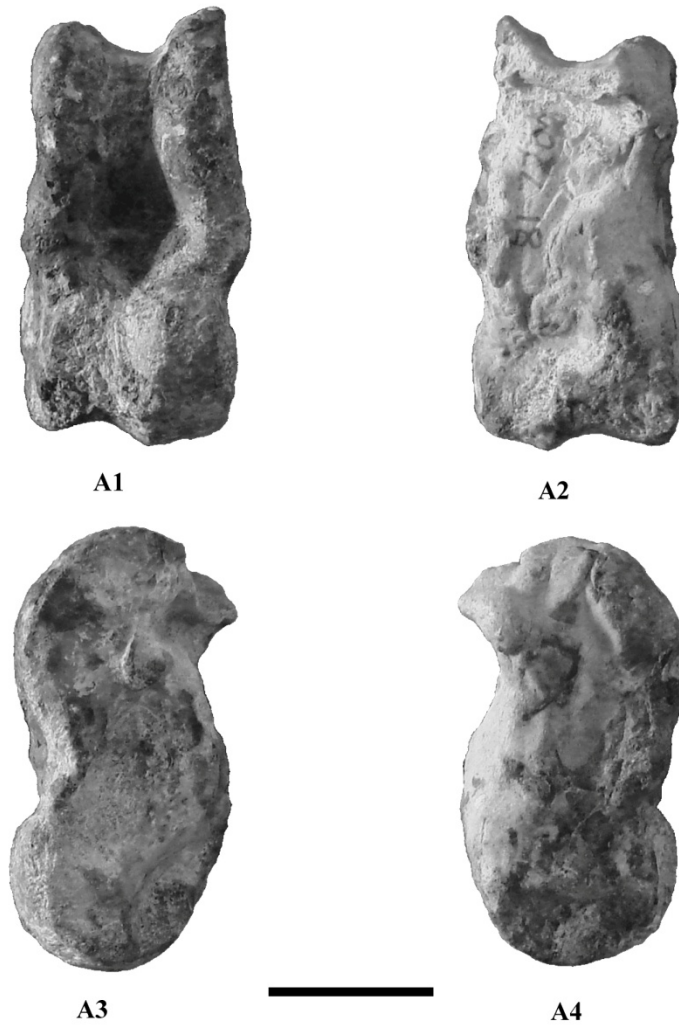


Fig.4. Anthracothere astragalus. A, CGM 27363: (A1) in anterior view, (A2) in posterior view, (A3) in medial view, (A4) in lateral view. Scale bars equal 2 cm.

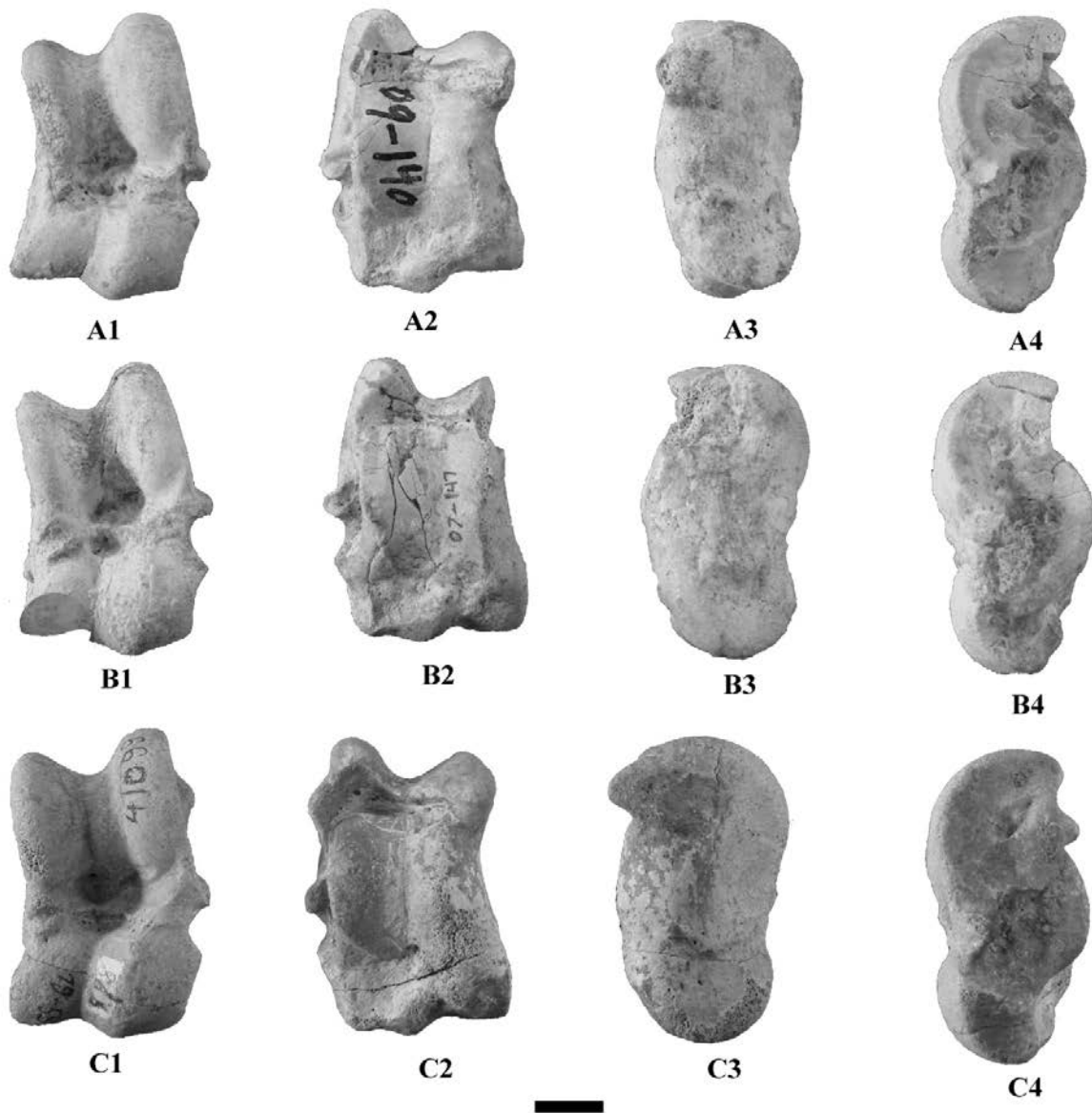


Fig. 5. Anthracothere astragalus. A, CGM 27368: (A1) in anterior view, (A2) in posterior view, (A3) in medial view, (A4) in lateral view. B, CGM 27350: (B1) in anterior view, (B2) in posterior view, (B3) in medial view, (B4) in lateral view. C, CGM 27327: (C1) in anterior view, (C2) in posterior view, (C3) in medial view, (C4) in lateral view. Scale bars equal 2 cm.

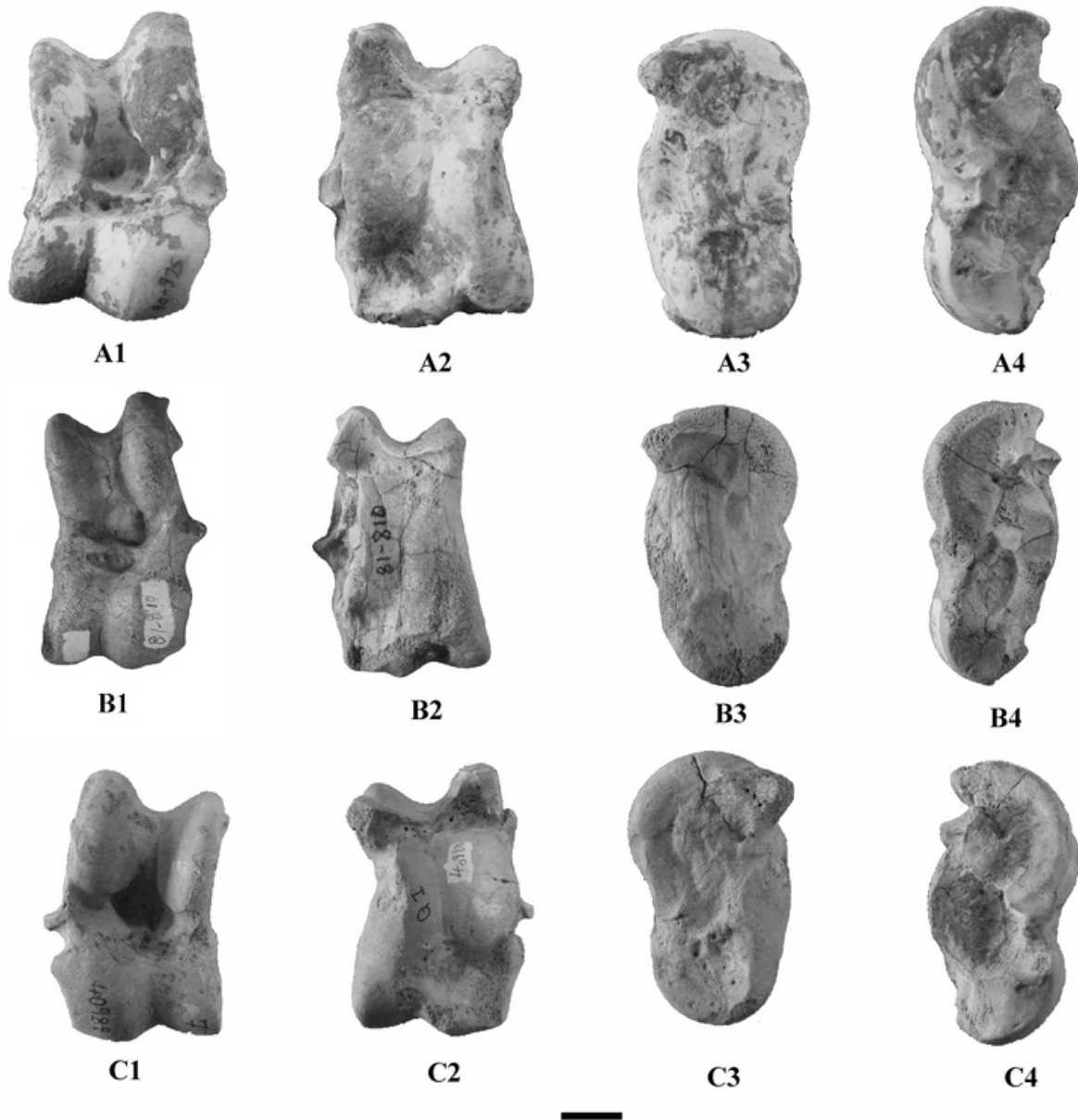


Fig. 6. Anthracothere astragalus. A, CGM 27416: (A1) in anterior view, (A2) in posterior view, (A3) in medial view, (A4) in lateral view. B, CGM 27325: (B1) in anterior view, (B2) in posterior view, (B3) in medial view, (B4) in lateral view. C, CGM 27334: (C1) in anterior view, (C2) in posterior view, (C3) in medial view, (C4) in lateral view. Scale bars equal 2 cm.

Compression:

Compared with *Hippopotamus*, Fayum anthracotheres have narrow and elongate astragali with a prominent projection on the lateral side (Fig. 7 arrow A). They also have a uniform width throughout their extent and low oblique cuboid and navicular facets (Fig. 7 arrow B). In the *Hippopotamus*, the astragalus is relatively shorter and broader, without a prominent projection on the lateral side, more oblique cuboid and navicular surfaces. In the anterior view, there is a more oblique angle between the tibial and distal trochlea than those of anthracotheres (Fig. 7 arrow C).

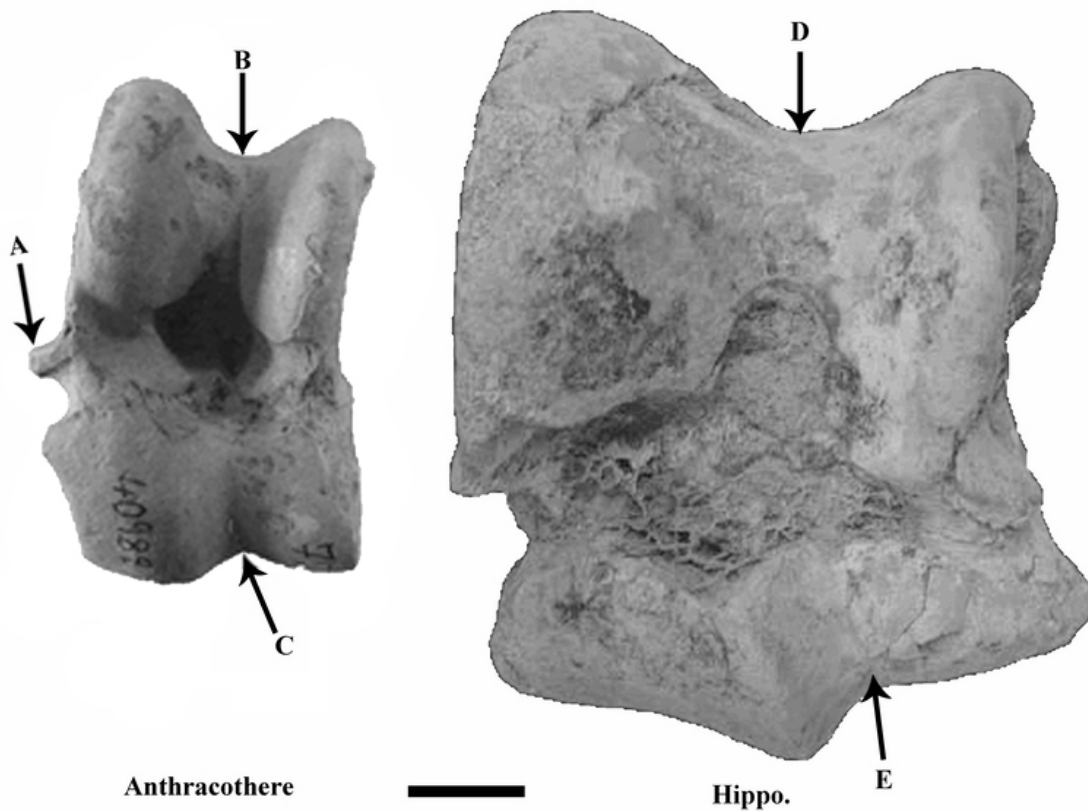


Fig.7. Morphology of astragalus of anthracothere from Fayum and astragalus of *Hippopotamus*. Scale bars equal 2 cm.

Discussion:

For a long time anthracotheres were believed to have similar habits and to have occupied similar habitats to those of the modern *Hippopotamus* (Black, 1978; Kron and Manning, 1998; Boissarie and Lihoreau, 2006). The main reason for supporting this belief was that the first described anthracothere was a large, massive species, recovered from lignite deposits indicated a swampy habitat (Cuvier, 1822; Falconer and Cautley, 1836; Rutimeyer, 1857). In addition, the pattern of tooth wear of some anthracotheres is similar with that of the extant *Hippopotamus amphibius* (Laws 1968)

But so far, the relation between anthracotheres and *Hippopotamus* has been the subject of hot debates between scholars. Recent molecular work has concluded that *Hippopotamus* are not strongly related to anthracotheres and some have suggested that the anthracotheres are not closely related to *Hippopotamus* and may be related to Palaeochoeridae (extinct artiodactyla) (e.g. Pickford, 2008) instead. The Fayum anthracothere postcranial bones reinforce Pickford's hypothesis and suggestive that these anthracotheres were adapted for a springing and bounding type of locomotion – such activities are known not to occur in *Hippopotamus*.

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