# Update of the Pliocene fauna of the Ekuma Valley, Etosha, Namibia

**Martin Pickford[1], Helke Mocke[2], Loïc Ségalen[1] & Brigitte Senut[1]**

*1. Sorbonne Universités (CR2P, UMR 7207 du CNRS, Département Histoire de la Terre, Muséum National d'Histoire Naturelle et Université Pierre et Marie Curie) case postale 38, 57 rue Cuvier, 75005 Paris.*
*(e-mail: <pickford@mnhn.fr>)*
*2. Geological Survey of Namibia, 1, Aviation Road, Windhoek.*
*(e-mail: <Helke.Mocke@mme.gov.na>)*

**Abstract**: Rescue excavations in the Ekuma River Valley, Etosha National Park, resulted in the collection of well preserved plants, invertebrates and vertebrate fossils of Pliocene age. The collections contain several new records for the Ekuma Delta Member, including a lung fish (*Protopterus*), a long-snouted crocodile (*Euthecodon*), an aardvark (*Orycteropus*), a hyaena and a gigantic suid (*Notochoerus capensis*). This article updates the fossil record of the Ekuma Delta Member and discusses its palaeoenvironment.

**Key words**: Pliocene; Namibia; Etosha; Fossils; Plants; Invertebrates; Vertebrates.

**To cite this paper**: Pickford, M. Mocke, H. Ségalen, L. & Senut, B. 2016. Update of the Pliocene fauna of the Ekuma Valley, Etosha, Namibia. *Communications of the Geological Survey of Namibia*, **17**, 113-142.

Submitted January 2016

## Introduction

In 2008, flooding in the Etosha Basin rendered palaeontological field work impracticable, but at the same time the flood waters flushed a great deal of mud out of the Ekuma Valley into Etosha Pan. By 2013, the Ekuma River had dried up, exposing outcrops which had previously been buried under thick deposits of mud. Rescue collecting was carried out before the next rainy season refilled the valley with water and mud.

This work was achieved by the authors in November, 2013 when the valley was dry and in August, 2014, by which time the river had filled with water again, drowning large areas of fossiliferous deposits, once more rendering them inaccessible. Nevertheless, excavations in shallow water and in waterlogged sediments along the river bank led to the recovery of additional fossils, notably parts of a skeleton of *Mammuthus subplanifrons*. This paper describes new elements of the fauna collected during these rescue operations, in order to update the palaeontology and biochronology of the Ekuma Delta Member.

## Historical Background

The presence of fossil mammals in the Ekuma Valley was first noted by Hipondoka (2005). A programme of palaeontological research was initiated in 2006 but was interrupted by the 2008 floods which filled the valley from bank to bank, rendering the fossiliferous sediments inaccessible. In 2014, a first description of the fossils collected in 2006 and 2007 was published (Pickford *et al*. 2014). The main conclusion was that the Ekuma Delta Member was of Pliocene age, ca 4 Ma. Palaeontological survey was recommenced in 2013 because by then the river had dried up completely, exposing the Pliocene sediments in many places in the floor of the valley. Indeed, the 2008 flooding had swept clean the bottom of the valley, gently washing vast volumes of mud into Etosha Pan, leaving behind a lag of fossils in the river bed. Rescue excavation was undertaken in 2013 when the valley was still dry, but the August 2014 excavations were hampered by new flooding, which had once again drowned most of the available outcrops.

## Material and Methods

Palaeontological survey was carried out at outcrops of the Ekuma Delta Member from the northern Boundary Fence of Etosha National Park downstream to the end of the Ekuma River Delta (Fig. 1; Table 1). In 2013, the river valley was completely dry and much of the mud which had previously obscured the Pliocene strata had been flushed into Etosha Pan by the 2008 floods (Fig. 2). Sediment exposures were mapped at intervals down the valley, notably near the Ekuma Horse Camp, at the Ekuma Rhino Site and at EK 1. By November, 2014, the Ekuma had flooded again, and most of the outcrops were inaccessible, save for a small area at EK 1 (Fig. 3, 4). The decision to carry out a rescue collection in 2013 was therefore fully justified, because the 2014 flooding episode not only rendered most outcrops inaccesssible, but also the flowing waters damaged, displaced and reburied many fossils under thick, glutinous mud.

A 260 metre long base line subdivided into 10 metre sections was laid out at Site EK1 (Fig. 2), and fossils were collected with reference to the base line. Surface fossils were located within each 10 metre quadrant, but *in situ* fossils were plotted accurately with reference to the base line and the offset east or west of the line.

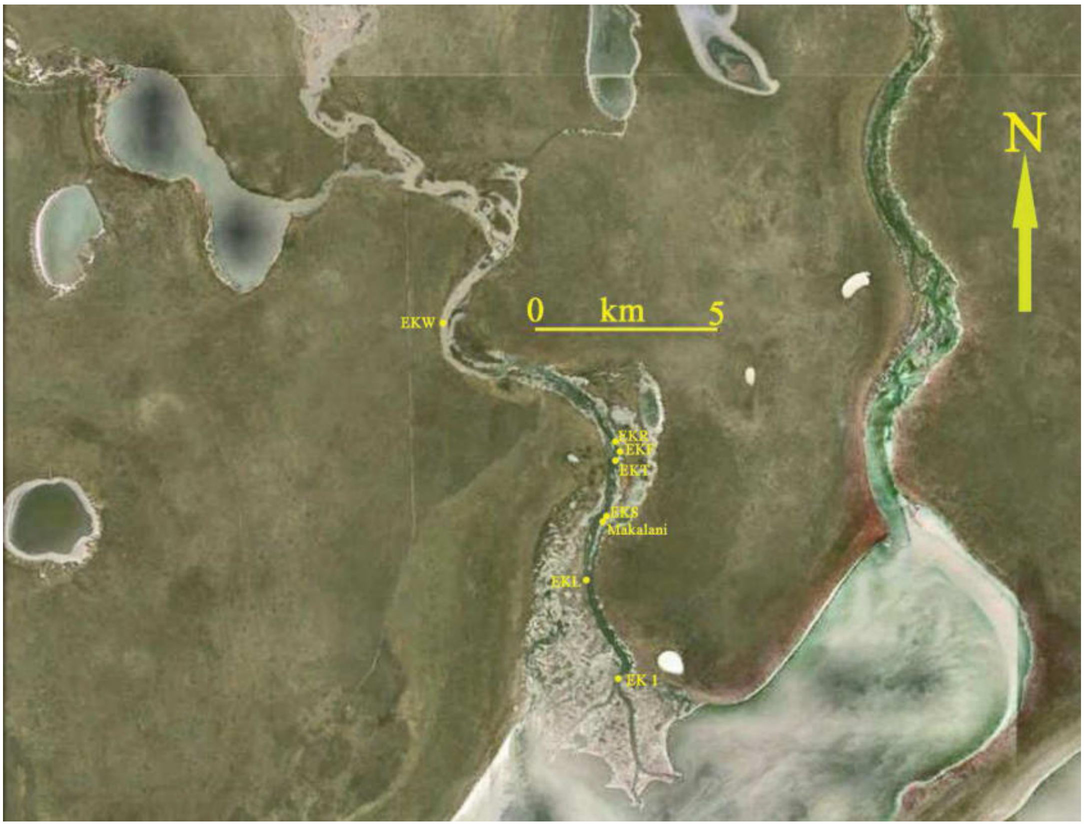


**Figure 1**. Fossiliferous outcrops in the Ekuma River Valley, Etosha National Park, Namibia, where rescue palaeontological collecting was done in 2013 and 2014. (EKW - Wilferd's Site, EKR - Rhino Site, EKF - Flamingo Site, EKT - Tusk Site, EKS - Skilpad Site, EKL - Lone Tree Site, EK 1 - Ekuma Main Site, Makalani - Site of palm tree boles). Note the north-south track 1 km west of the Ekuma Valley, and the East-West oriented Boundary Fence of Etosha Park (Map modified from Google Earth).

**Table 1.** GPS co-ordinates of sites studied in the Ekuma Valley, Namibia, November, 2013 and August, 2014.

| Locality (Abbreviation) | Latitude | Longitude | Altitude (GPS) | Content |
|---|---|---|---|---|
| Bovid Dent Site (EKD) | 18°35’43.7”S | 16°01’17.4”E | 1081m | Bovid teeth |
| Ekuma 1 (EK1) | 18°38’54.5”S | 16°01’22.9”E | 1083m | Many fossil bones & teeth |
| Flamingo Site (EKF) | 18°35’38.8”S | 16°01’19.5”E | 1086m | Greater Flamingo bones |
| Lone Tree Site (EKL) | 18°37’27.8”S | 16°00’50.6”E | 1070m | Bones |
| Makalani Palm boles | 18°36’34.2”S | 16°01’05.9”E | 1088m | Palm tree boles |
| Rhino Site tibia (EKR) | 18°35’28.8”S | 16°01’18.5”E | 1092m | Rhino tibia |
| Rhino Site mandible (EKR) | 18°35’29.4”S | 16°01’19.2”E | 1103m | Rhino mandible |
| Rhino Site Suid jaw (EKR) | 18°35’27.5”S | 16°01’18.1”E | 1084m | Suid canines and molar |
| Skilpad Site (EKS) | 18°36’31.0”S | 16°01’08.0”E | 1085m | Chelonian scutes, tree boles |
| Sitvas Plek Site (EKH) | 18°35’40.9”S | 16°01’18.0’E | 1090m | Bones |
| Ekuma Tooth Site (EKTO) | 18°38’01.3”S | 16°00’59.4”E | 1076m | Tooth |
| Tusk Site (EKT) | 18°35’38.8”S | 16°01’17.4”E | 1082m | Proboscidean tusk |
| Wilferd’s Site (EKW) | 18°33’40.4”S | 15°58’37.0”E | 1087m | Bones including *Loxodonta* |

**Figure 2.** Site EK 1 in November, 2013, showing the extensive exposures of Ekuma Delta Member and the collecting grid (piles of stones at 10 m intervals starting at the standing person). The Ekuma was completely dry, but there was deep mud in channels (two pale, salt-encrusted horizontal signatures in the distance).

**Figure 3.** Site EK 1 in August 2014 (the same area as in Fig. 2) almost completely flooded, leaving only a narrow band of Pliocene sediments exposed along the river bank, underlying Pleistocene to Holocene sand and pan-loess (vegetated slopes).

**Figure 4**. Wading across the Ekuma River in order to get access to Locality EK 1, August, 2014.

## Geological, geochronological and palaeoenvironmental contexts

The Ekuma Delta Member was described by Miller *et al*. 2010, and Pickford *et al*. 2014, studied the fauna and flora from the sediments, concluding that they accumulated approximately 4 million years ago. The deposits are fluvial, comprised of intercalated sandstone and green silts, often interfingering in a complex way. Bones are frequently embedded in sandstone with the articular ends in green silt, indicating that the silt and sand were deposited at the same time. The sandstone often has reworked fragments of bone and teeth, as well as fossils in pristine condition, suggesting some reworking of fossil material. The Ekuma Delta Member comprises freshwater deposits, containing abundant freshwater snails and bivalves preserved in their life position with the two valves closed together.

## Taphonomy

An interesting aspect of the 2008 floods in the Ekuma Valley is that abundant catfish were brought down with the floodwaters and were left stranded in pools as the river dried up (Fig. 5).


**Figure 5**. Extant catfish skulls and vertebral columns lying in the bed of the Ekuma Valley, A) complete specimen ca 75 cm long, B) partly disarticulated specimen. These fish were brought down the valley during the 2008 floods and were left stranded in small depressions in the valleys where they died in their hundreds. Many were carried to the banks of the valley where they were eaten by jackals, which left the skulls, and often the vertebral columns intact. Note the small antelope footprints in the dried mud to the right of the skull in B.

Many of the fish were carried to the banks of the valley, and sometimes slightly beyond, by jackals and other scavengers where the flesh was chewed off, leaving the skulls intact, sometimes with the vertebral column attached to the skull or lying nearby. A few pelomedusid carapaces were also found along the banks of the valley.

Opposite EK1, there is a deep section of the Ekuma Valley still covered in mud. The surface of the mud has dried, and can support the weight of small and medium sized mammals such as jackals and hyaenas. However, larger mammals such as antelopes (and people) can break through the hardened surface crust and then find themselves inextricably trapped in the gooey mud beneath. A hartebeeste cadaver at EK1 provides ample evidence of the perils of trying to traverse the valley in such places.

It is possible that the well preserved fossil catfish skulls (Fig. 6) and some of the articulated Pliocene mammal remains (Fig. 7) could have resulted from similar taphonomic processes to those observed in 2013.

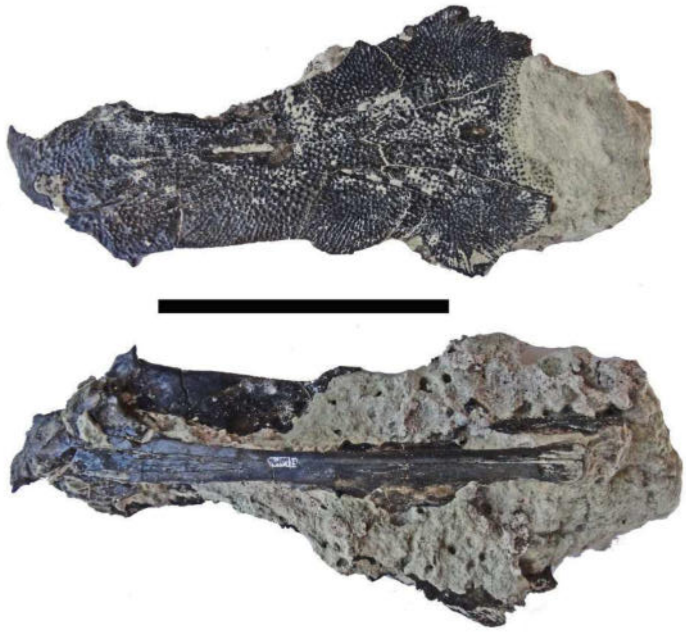

**Figure 6**. EK1 109’13, catfish skull, dorsal and ventral views (scale : 10 cm) for comparison with extant catfish skulls in Fig. 5.

**Figure 7**. EK1 266’13, articulated bovid foot comprising the distal metapodial associated with first and second phalanges, attributed to *Redunca darti* (scale : 10 cm). Was this individual trapped in mud during the Pliocene in a similar way to extant mammals that break through the surface crust overlying thick gooey mud in the Ekuma Valley?

Some of the fossils at EK1 appear to have been bitten by carnivores. A coprolite, possibly of a hyaena was found at the site. The scattered nature of the proboscidean skeleton suggests that it was subjected to scavenging activity, but it was not irrevocably damaged by such attention. Other fossils are more complete and many of the fish remains occur as articulated skeletons or parts of skeletons. Chelonian scutes are usually disassociated but found close together. The varied nature of the vertebrate fossils suggests that some of them were buried completely at the time of deposition, whereas others were exposed, or partly exposed at the surface, permitting scavengers to interfere with them. At the Sitvas Plek Site, a mammal bone was gnawed by a large rodent, probably a porcupine, indicating that it must have been exposed at the surface before being fossilised (Fig. 8).

**Figure 8**. Fossilised bone from Ekuma Sitvas Plek Site showing rodent gnawing marks. The diameter of the marks, ca 2.5 mm, their shape and their arrangement along the edge of the bone fragment suggests that they were made by a porcupine (scale : 10 mm).

## Trees in the Ekuma Delta Member


**Figure 9**. Tree boles and root systems in the Ekuma Delta Member. A) Dicotyledon bole at the Rhino Site with large roots radiating horizontally away from it; B) Palm tree boles with numerous small roots densely packed around the bases of the boles at the Ekuma Makalani Site. Diameters of the boles ca 75 cm.

Many of the sandstone outcrops exposed all along the Ekuma Valley from the Horse Camp in the north to the delta in the south, show abundant evidence of plant roots, and in places the remains of tree boles and their root systems (Fig. 9). Most of the trees are dicotyledons with large roots radiating horizontally away from the tree boles, but several of them resemble palm trees such as the Makalani Palm, with abundant small roots, close-packed all around the base of the boles.

These fossils indicate that the area was well wooded during the Pliocene, probably with Miombo Woodland types.

## Ichnofossils

### Footprints in the Ekuma Delta Member

**Figure 10**. Bird footprints (possibly flamingo) in sandstone of the Ekuma Delta Member.

There are planar outcrops of sandstone at EK1 and elsewhere in the Ekuma Delta Member. Bird footprints are quite common at EK 1 (Fig. 10). At several places there are depressions in the sandstone which have raised edges (Fig. 11). Examination of these depressions indicates that they represent footprints of medium to large mammals. Among the mammals identified are equids, bovids and possibly giraffids. The prints are generally rather poorly defined, suggesting that the surficial sediment at the ancient land surface has been eroded away, leaving only the subsurface sands with the deeper parts of the footprints.

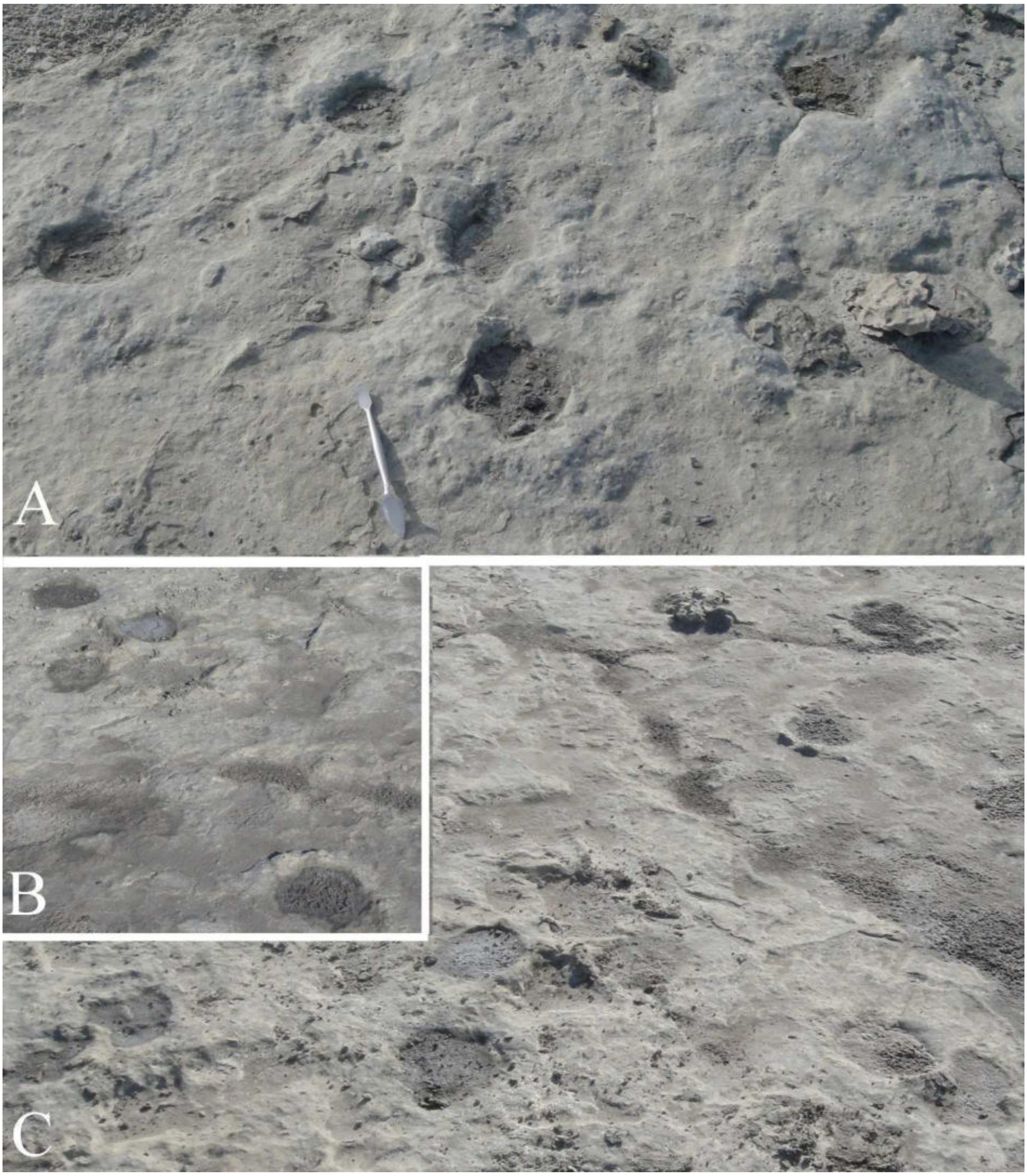


**Figure 11**. Mammal (equid and bovid) footprints in Ekuma Delta Sandstone at Site EK 1. Note the raised edges of some of the depressions. (The tool in A is 17.5 cm long).

**Ekuma Delta Member Mollusca**

The Ekuma Delta Member contains abundant shells of the freshwater snail *Bellamya unicolor*, and doublets of the bivalve *Mutela* sp. (Fig. 12). The same species occur today in the Cubango River (Mocke *et al*. 2016). The presence of these taxa in the deposits indicates that they accumulated in fresh, well-oxygenated water. The bivalves in particular are almost always found as closed doublets revealing that they died where they lived, and were not transported post-mortem.

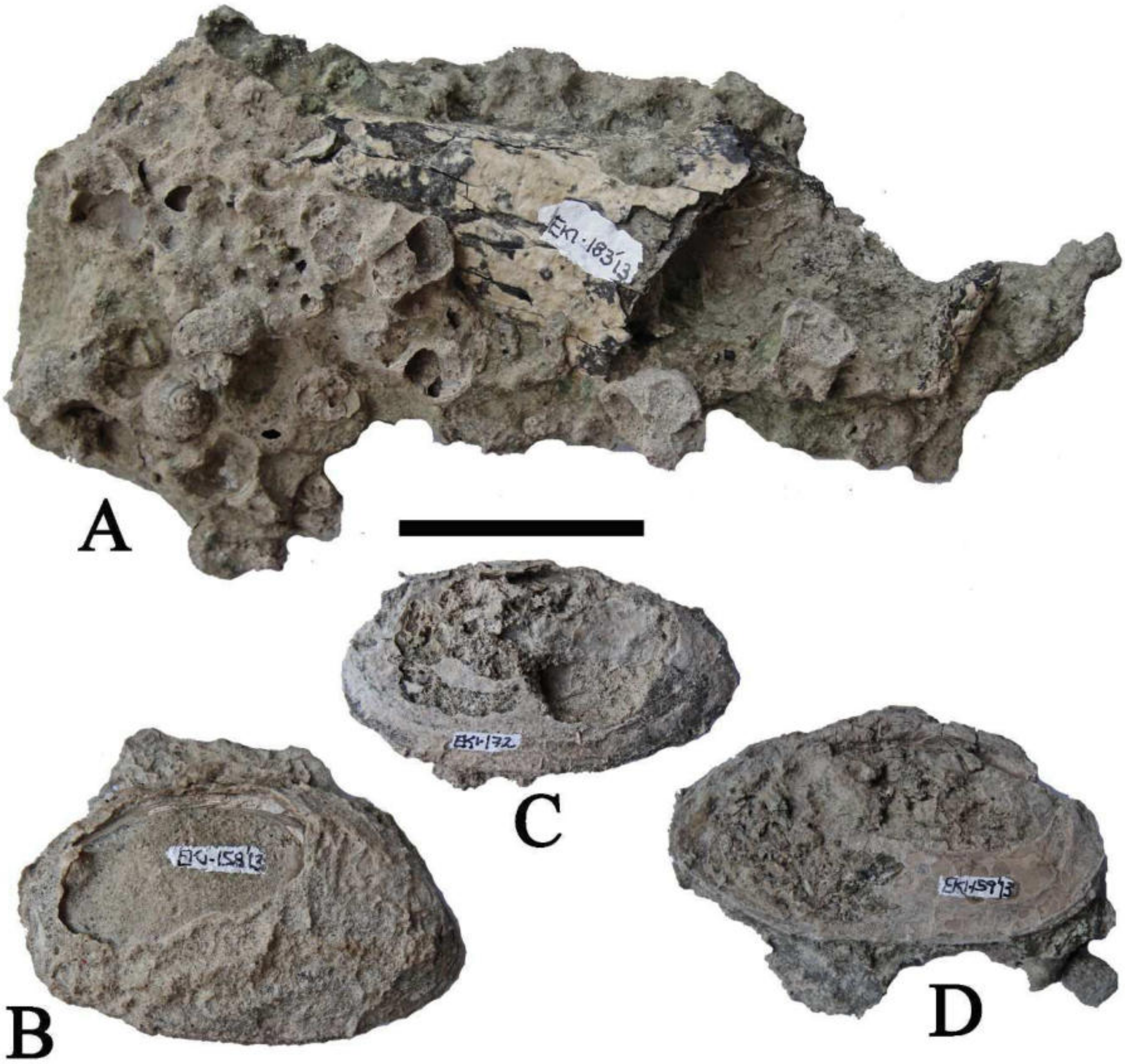


**Figure 12**. Mollusca from the Ekuma Delta Member. A) EK1 183'13, *Bellamya unicolor* shells associated with a mammalian long bone diaphysis, B) EK1 158'13, *Mutela* sp. C) EK1 172'13, *Mutela* sp. D) EK1 159'13, *Mutela* sp. (scale : 5 cm).

### Fish from the Ekuma Delta Member

The green clays at EK1 yielded two tooth plates of the lung fish, *Polypterus* (Fig. 13). This is the first record of fossil lung fishes in the Neogene of Namibia. The presence of *Polypterus* in the Ekuma deposits is of interest, because this fish is associated with freshwater, not being able to tolerate saline or alkaline conditions. It buries itself in mud during periods when the water bodies dry up, secreting a mucus with which it lines its burrow in order to prevent dessication.

Three species of fish are now known from the Ekuma Delta Member – *Clarias*, *Clarotes* (Fig. 14) and *Polypterus*.

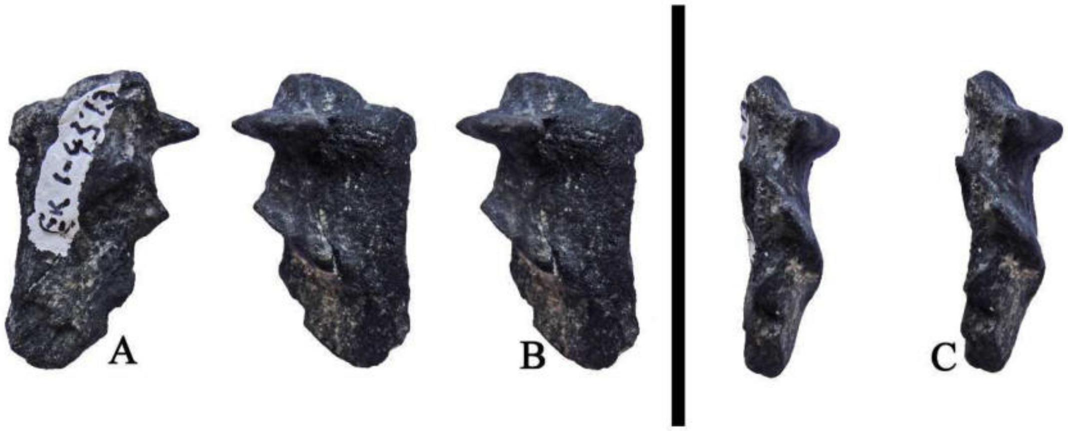


**Figure 13**. EK1 43'13, *Polypterus* tooth plate, A) mesial view, B) stereo labial view, C) stereo occlusal view (scale : 5 cm).

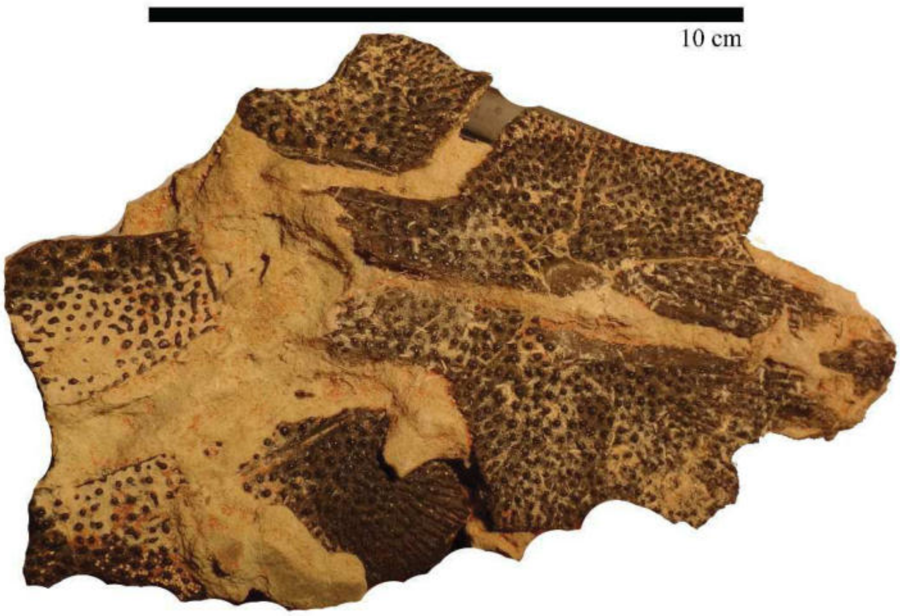


**Figure 14**. *Clarias* head plate from locality EK 1, Ekuma Delta Member (scale : 10 cm).

### Ekuma Crocodiles

The bulk of crocodilian fossils from the Ekuma Delta Member belong to *Crocodylus niloticus* (Fig. 15). However, a tooth from EK1 is taller and more slender than any of the teeth of *Crocodylus*, and the outer surface of the tooth is fluted in the style of teeth of the piscivorous crocodile *Euthecodon* (Fig. 16). If the determination is valid, then this would indicate the presence of pelagic environments within the proto-Ekuma drainage system during the Middle Pliocene.


**Figure 15**. Large crocodile tooth (*Crocodylus niloticus*) from EK 1, Ekuma Delta Member (scale : 5 cm).

**Figure 16**. EK1 85’13, isolated tooth attributed to *Euthecodon* from Ekuma Site EK1 (scale : 10 mm).

**Flamingos from the Ekuma Delta Member**

The 2007 collection from the Ekuma Delta Member yielded only a few remains of flamingos. In 2013 in contrast, several specimens were collected, not only of the Lesser Flamingo, but also of the Greater Flamingo (Fig. 17, 18).


**Figure 17**. Long bones of Lesser Flamingo (*Phoeniconaias*) from EK1, Ekuma Valley, Namibia. A) EK1 90’13, distal tibio-tarsus, B) EK1 42’13, distal tibio-tarsus , C) EK1 6’13, radius, D) EK1 89’13 distal tarsometatarsus, E) EK1 26’13, distal tarsometatarsus, F) EK 1 91’13, radius (scale : 5 cm).

**Figure 18**. EKF 1’13, phalanx of a Greater Flamingo (*Phoenicopterus*) from the Flamingo Site, Ekuma Valley, dorsal, medial, ventral and lateral views (scale : 5 cm).

**Ekuma Delta Member Orycteropodidae**

A fossil aardvark phalanx (Fig. 19) found at Ekuma Rhino Site was associated with the remains of a mandible of the giant rhino, *Diceros praecox*. This is the first record of aardvarks in the Pliocene of Namibia, but the family is known from Early Miocene deposits in the Sperrgebiet (Pickford, 2008). The specimen agrees in dimensions and morphology with the extant species *Orycteropus afer*, a long-lived taxon also found in Late Miocene to Basal Pliocene deposits at Langebaanweg, South Africa, and at several sites in East Africa of Pliocene age, such as Laetoli, Tanzania (Pickford, 2005).

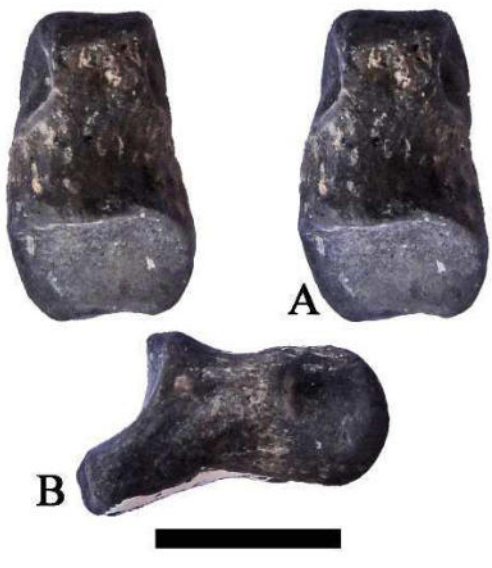


**Figure 19**. EKR 62’13, *Orycteropus* second phalanx from the Ekuma Rhino Site, A) stereo dorsal view, B) lateral view (scale : 10 mm).

**Ekuma Delta Carnivora**

A medium sized hyaena humerus lacking the proximal end (Fig. 20) was found at Ekuma Rhino Site.

Morales *et al*. (2011) described a tooth row of *Crocuta dietrichi* from Meob, Namibia, and estimated a Pliocene age for the deposits. The Ekuma hyaenid humerus is compatible in dimensions with this species, but appurtenance to another taxon cannot be excluded. The specimen confirms the presence of hyaenas in the Pliocene of Namibia.

The Ekuma deposits also yielded an unidentified metapodial fragment belonging to a jackal-sized animal (Fig. 20c).

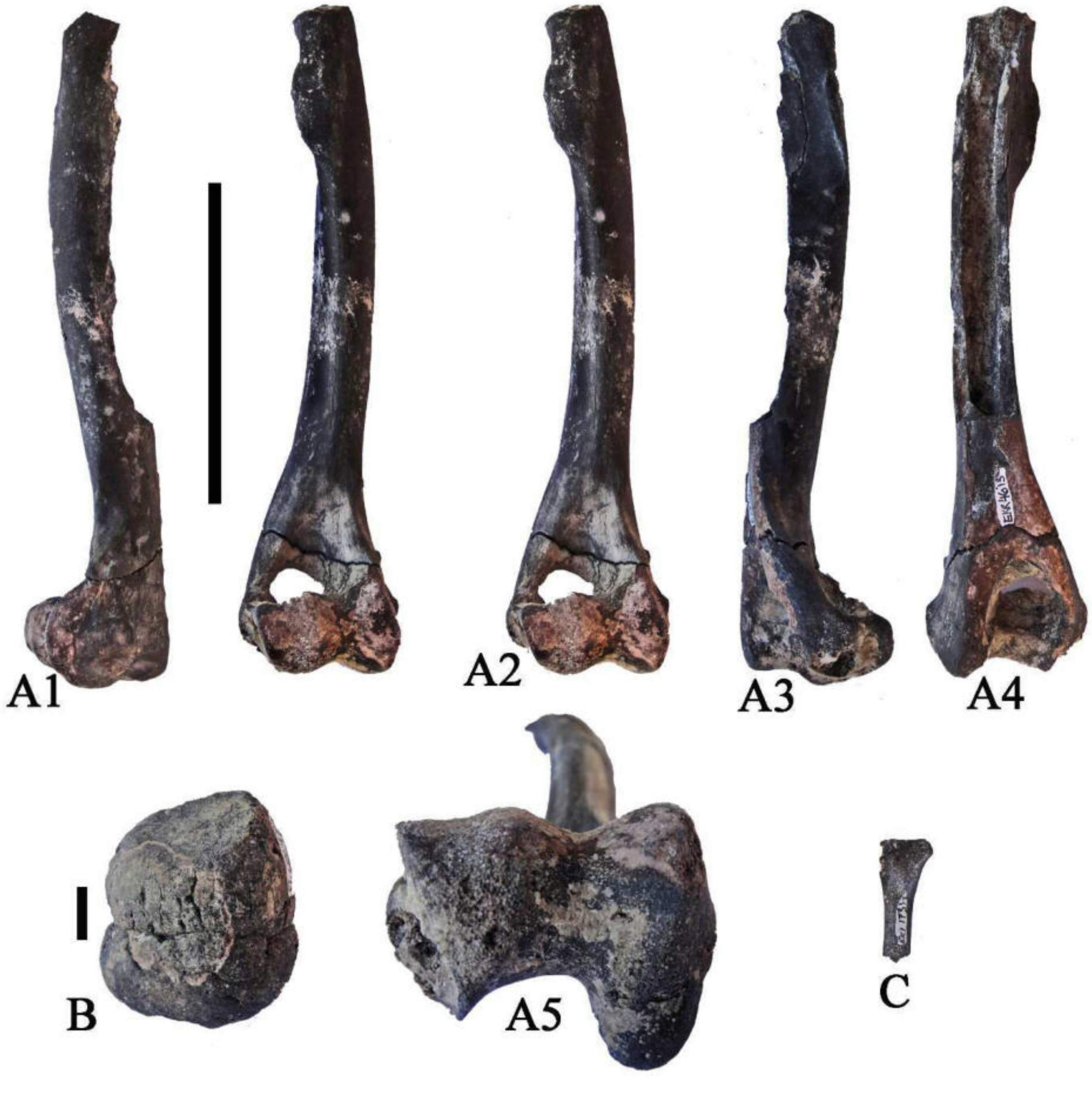


**Figure 20**. EKR 46’13, right humerus of a hyaenid from Ekuma Rhino Site. A1) medial view, A2) stereo anterior view, A3) lateral view, A4) posterior view (scale : 10 cm), A5) distal view (double scale), B) EK1 301’13, coprolite (scale : 10 mm), C) EK1 173’13, carnivore proximal metapodial medial view (scale : 10 cm).

**Ekuma Delta Proboscidea**

In 2007, elements of a proboscidean skeleton were noted at EK 1, but were left *in situ* due to the thick mud deposit almost completely burying them (Fig. 21-23). The specimen was excavated in 2014 and will form the subject of a separate study. The partial upper molars indicate that the skeleton represents *Mammuthus subplanifrons* (Osborn, 1928). In the literature, similar teeth have often been attributed to *Archidiskodon* and *Elephas ekorensis*.

Other proboscidean skeletal elements were noted during the survey, including a long bone at Proboscidean Site, a large tusk in situ at Tusk Site (Fig. 24), and a *Loxodonta* jaw at Wilferd's Site, which is in younger deposits overlying the Ekuma Delta Member.

**Figure 21**. Stereo images of teeth of *Mammuthus subplanifrons* from locality EK 1, Ekuma Delta Member, A) EK1 64'14, right d/2 (scale : 10 mm), B) EK1 61+62+63'14, upper M1/ (scale : 10 cm).

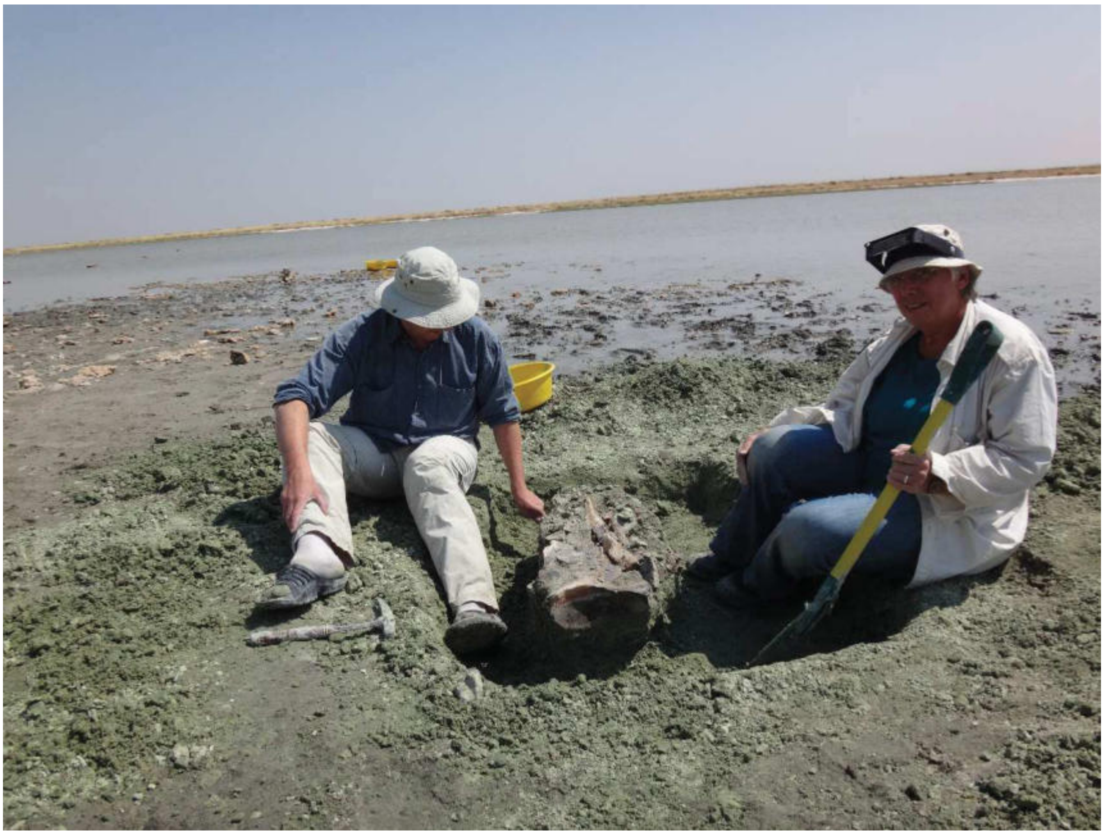

**Figure 22**. Excavating the scapula of *Mammuthus subplanifrons* at locality EK 1.

**Figure 23**. Tibia of *Mammuthus subplanifrons* in its plaster jacket prior to lifting.


**Figure 24**. Large proboscidean tusk exposed in the bed of the Ekuma River at the Tusk Site (the GPS is 16 cm tall). Both ends of the tusk are buried in sediment. The overall length of the tusk is estimated to be about 2 metres (0.75 metres is exposed). In 2014 this tusk was under 1 metre of water.

### Ekuma Rhinocerotidae

The Ekuma Rhino site previously yielded an astragalus and some phalanges of a huge rhinoceros attributed by Pickford *et al*. (2014) to *Ceratotherium praecox* Hooijer & Patterson, 1972.

The 2008 floods uncovered several more pieces of the skeleton, including parts of two femora (Fig. 26), a tibia (Fig. 27), and several carpals, tarsals, pisiforms and phalanges, as well as a left mandible with five cheek teeth (Fig. 25). The individual is considerably larger than the extant White Rhinoceros, *Ceratotherium simum*, and, following the revision of African Rhinocerotidae by Geraads (2010) it is attributed to *Diceros praecox*, a Late Miocene to Basal Pliocene form best known from Kanapoi (4 Ma) Kenya (Hooijer & Patterson, 1972). Table 2 provides measurements of the specimens in mm and calculates proportions of the fossil versus the extant White Rhinoceros. The teeth of the extinct species are considerably larger than those of *Ceratotherium simum* from Etosha Park, Namibia.

**Figure 25**. EKR 20’13, left lower cheek tooth row of *Diceros praecox*, from Ekuma Rhino Site, stereo buccal view (scale : 10 cm).

**Table 2**. Measurements (in mm) of the lower cheek teeth of *Ceratotherium simum* (SM and CS specimens housed at the Etosha Ecological Institute) and *Diceros praecox* (EKR 20’13).

| **Measurement** | **SM 14032000** | **CS 040328** | **EKR 20’13** | **Proportion EKR/SM-CS** |
|---|---|---|---|---|
| Length p/2 | 34.0 | 29.0 | -- | -- |
| Breadth p/2 | 21.5 | 19.2 | -- | -- |
| Length p/3 | 38.2 | 42.0 | 42.0+ | -- |
| Breadth p/3 | 23.8 | 25.0 | -- | -- |
| Length p/4 | 44.0 | 47.0 | 55.0 | 119% |
| Breadth p/4 | 27.7 | 27.0 | -- | -- |
| Length m/1 | 42.5 | 46.7 | 52.0 | 118% |
| Breadth m/1 | 31.3 | 29.4 | 38.0 | 126% |
| Length m/2 | 59.0 | 60.0 | 65.0 | 108% |
| Breadth m/2 | 28.6 | 28.0 | -- | -- |
| Length m/3 | 57.0 | 59.0 | 66.0 | 113% |
| Breadth m/3 | 26.2 | 26.6 | 36.0e | 137% |
| Height m/3 | -- | -- | 81.0 | -- |


**Figure 26**. EKR 2'13, proximal femur of *Diceros praecox* from Ekuma Rhino Site. Top proximal view, bottom lateral view (scale : 10 cm).

The femur is represented by a damaged proximal end which is broad mediolaterally (Fig. 26).

In contrast, the tibia, even though it has much larger articulations than those of the living species (distal articulation is 91 mm broad) is shorter (352 mm only) than that of *Ceratotherium simum*, indicating quite a difference between the locomotor repertoires of the two taxa. Indeed, the short but massive tibia, gives the impression that we are dealing with a potamophile taxon. The proportions of the tibia lend support to Geraads (2010) reattribution of this species to the genus *Diceros*.


**Figure 27**. EKR 1'13, tibia of *Diceros praecox* from the Ekuma Rhino Site longitudinal and distal views (doubled scale) (scale 10 cm).

**Ekuma Equidae**

Equid remains are reasonably common in the Ekuma Delta Member (Fig. 28). The upper molars are relatively low crowned. EK1 130'13, an unworn specimen is about 31.8 mm tall (Fig. 28a).

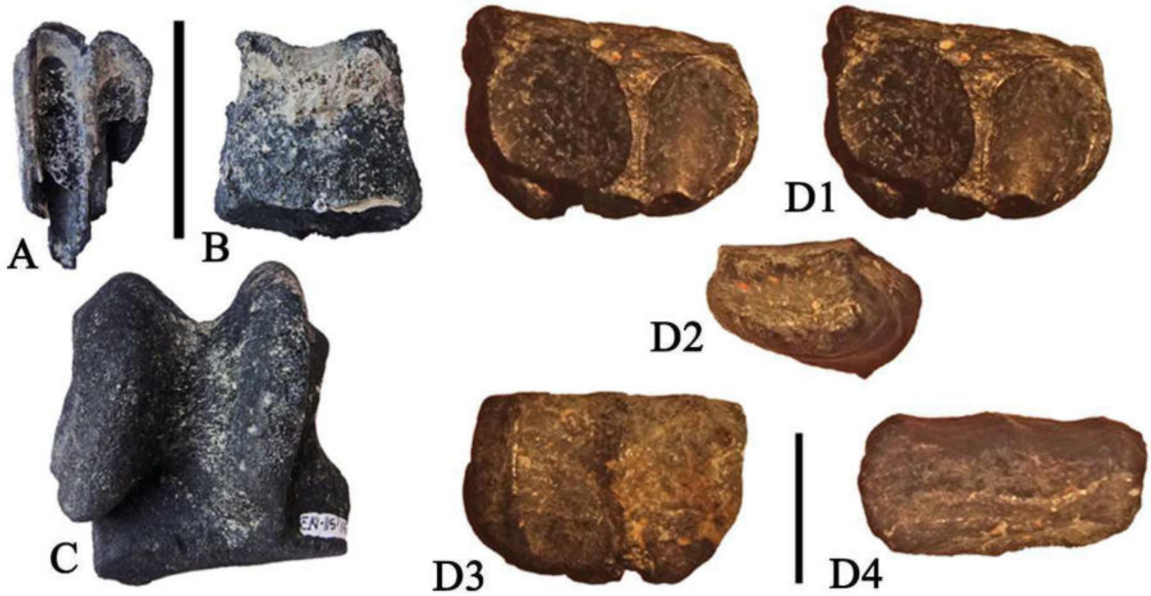


**Figure 28**. *Hipparion* sp. from EK1, Ekuma Delta Member. A) EK1 130'13, upper molar buccal view, B) EK1 112'13, second phalanx dorsal view, C) EK1 115'13, astragalus, tibial view (scale : 5 cm) D) EK1 107'14, pedal sesamoid, D1 – stereo articular view, D2 – lateral view, D3 – palmar view, D4 – anterior view (scale : 10 mm).

**Hippopotamidae from Ekuma**

*Hippopotamus* remains are rare at Ekuma. A large cuboid was found at EK1, but it does not permit species identification (Fig. 29). This specimen probably represents the same species as that from the Ekuma Rhino Site (Pickford *et al*. 2014) but it does not resolve the question of its taxonomic status.

**Figure 29**. EK1 1'13, *Hippopotamus* cuboid, stereo astragalar view and lateral view (scale : 10 cm).

## Suidae from the Ekuma Delta Member

A significant fossil was found *in situ* at Ekuma Rhino Site. It consists of two lower canines and a lower third molar of a gigantic suid (Fig. 30). The third molar is almost 10 cm long and 27.0 mm broad at the second lophid. The crown is quite low (the distal part of the talonid has just entered wear) and there are roots formed beneath the talonid cusps. The lower canines are ovoid in section with a shallow dorsal gutter, and there is no enamel present (the teeth are worn).

The specimen probably belongs to the species *Notochoerus capensis* first described from the Vaal River Gravels of South Africa (Broom, 1925). As such it is likely to be of Pliocene age. Similar very long but quite low-crowned suid teeth have been recorded from the Pliocene of Malawi, from Makapansgat, South Africa, and from Kaukausib in the Sperrgebiet, Namibia (Pickford, 2000).

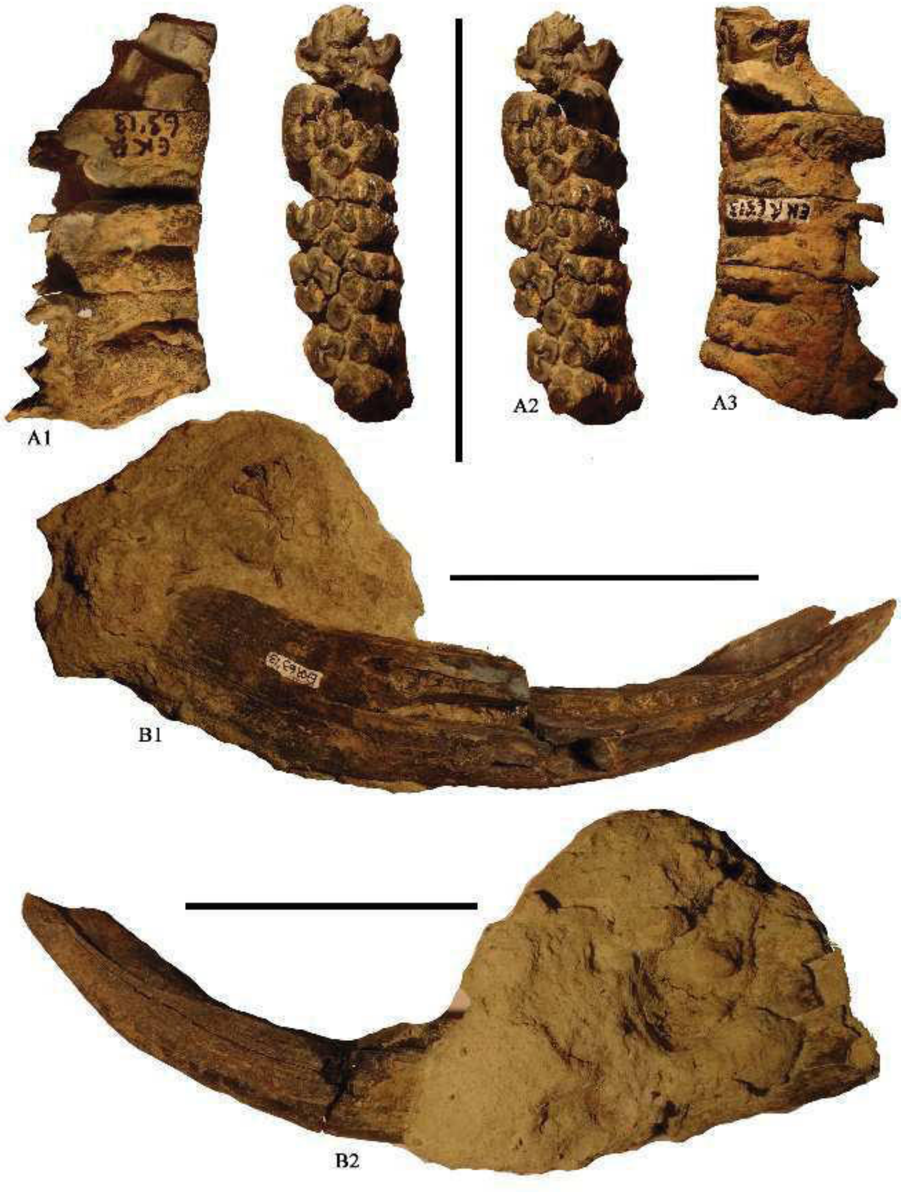


**Figure 30**. EKR 63'13, right m/3 and canine of *Notochoerus capensis* from Ekuma Rhino Site (scale : 10 cm).

### Ekuma Delta Giraffidae

Half of a giraffid astragalus was collected at Wilferd's Site, north of the Ekuma Horse Camp (Fig. 31). The specimen is quite small but has the proportions of a giraffid rather than of a large bovid. This is the first giraffid fossil from the Ekuma Delta Member.

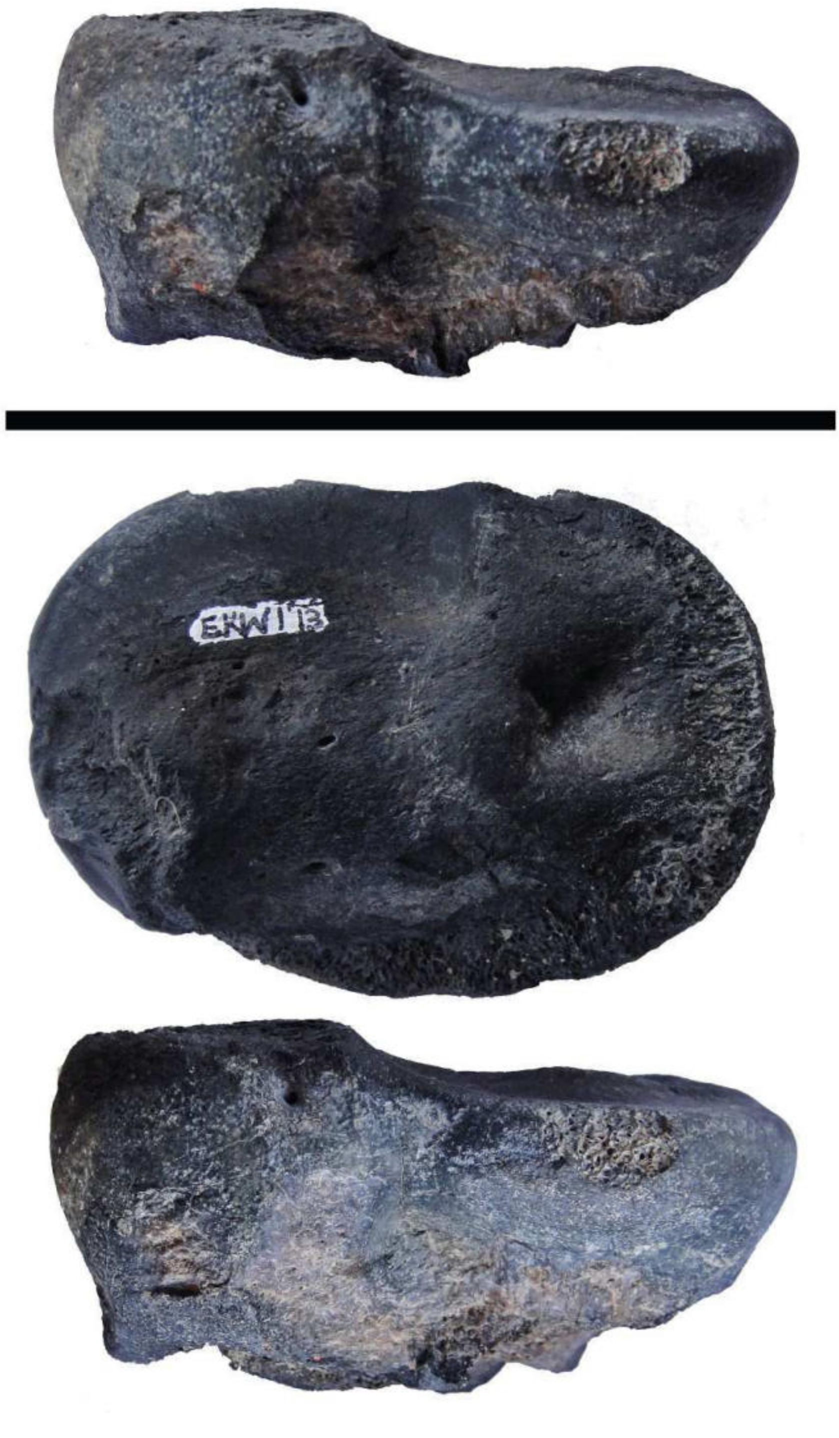


**Figure 31**. EKW 1'13, partial giraffid astragalus from Wilferd's Site, Ekuma Valley, anterior, lateral and posterior views (scale : 10 cm).

## Ekuma Delta Bovidae

Based on the dimensions of postcranial bones the Ekuma Delta Member has yielded remains of at least three bovid species. The commonest taxon appears to be *Redunca darti* Wells & Cooke, 1956, a large reed buck, which is well represented at Ekuma by horn cores, mandibles, a skull, and abundant post-cranial elements (Fig. 32-35). The type locality of this bovid is Makapansgat, South Africa.

A rarer *Oryx*-like bovid from Ekuma has about the same dimensions as *Redunca darti*, but its horn cores are straight and conical, like those of *Damalacra* (Gentry, 2010) (Fig. 36).

A small bovid, about the size of a steenbok (*Raphicerus*) is represented at Ekuma by small post-cranial bones including astragali (Table 3) but no teeth have yet been discovered.

**Figure 32.** EK1 64'13, right mandible attributed to *Redunca darti*. Top row - exposed in the sediment, B - after excavation and cleaning but prior to sticking together (scale : 10 cm).

**Figure 33.** EK1 72'13, left horn core, *Redunca darti*, from left to right - medial, frontal and lateral views (scale : 10 cm).

**Table 3**. Measurements (in mm) of the astragali of bovids from the Ekuma Delta Member.

| Catalogue | Side | External length | Internal length | Proximal breadth | Distal breadth |
|---|---|---|---|---|---|
| EK1 243'13 | Lt | -- | 27.0 | 15.2 | -- |
| EK1 103'13 | -- | -- | 28.2 | -- | 18.3 |
| EK1 21'13 | Lt | 47.0 | 44.5 | 29.3 | 30.0 |
| EK1 118'13 | Lt | 48.5 | 46.1 | 27.0 | 29.2 |
| EK1 65'13 | Rt | 48.6 | 45.5 | 27.0 | 29.2 |
| EK1 82'13 | Rt | 49.4 | 47.0 | 28.5 | 31.2 |
| EK1 121'13 | Lt | 50.8 | 48.0 | 27.8 | 28.0 |
| EKP 1'13 | Lt | 51.0 | 46.0 | 28.0 | 29.9 |
| EK1 250'13 | Rt | 51.8 | -- | 28.0 | 29.8 |
| EK1 213'13 | Lt | 51.8 | 47.2 | 30.0 | 32.2 |
| EK1 151'13 | Rt | 52.0 | 40.9 | 27.0 | 32.5 |
| EK1 22"13 | Rt | 52.7 | 46.3 | 29.0 | 31.0 |
| EKS 2'13 | Lt | 53.6 | 50.0 | 33.5 | 31.5 |

**Figure 34**. Right maxilla of *Redunca darti* and associated fish remains from site EK 1, Ekuma Delta Member, lingual and stereo occlusal views (scale : 10 cm).

**Figure 35**. Calcanea and talus of *Redunca darti* from EK 1, Ekuma Delta Member (scale : 10 cm).

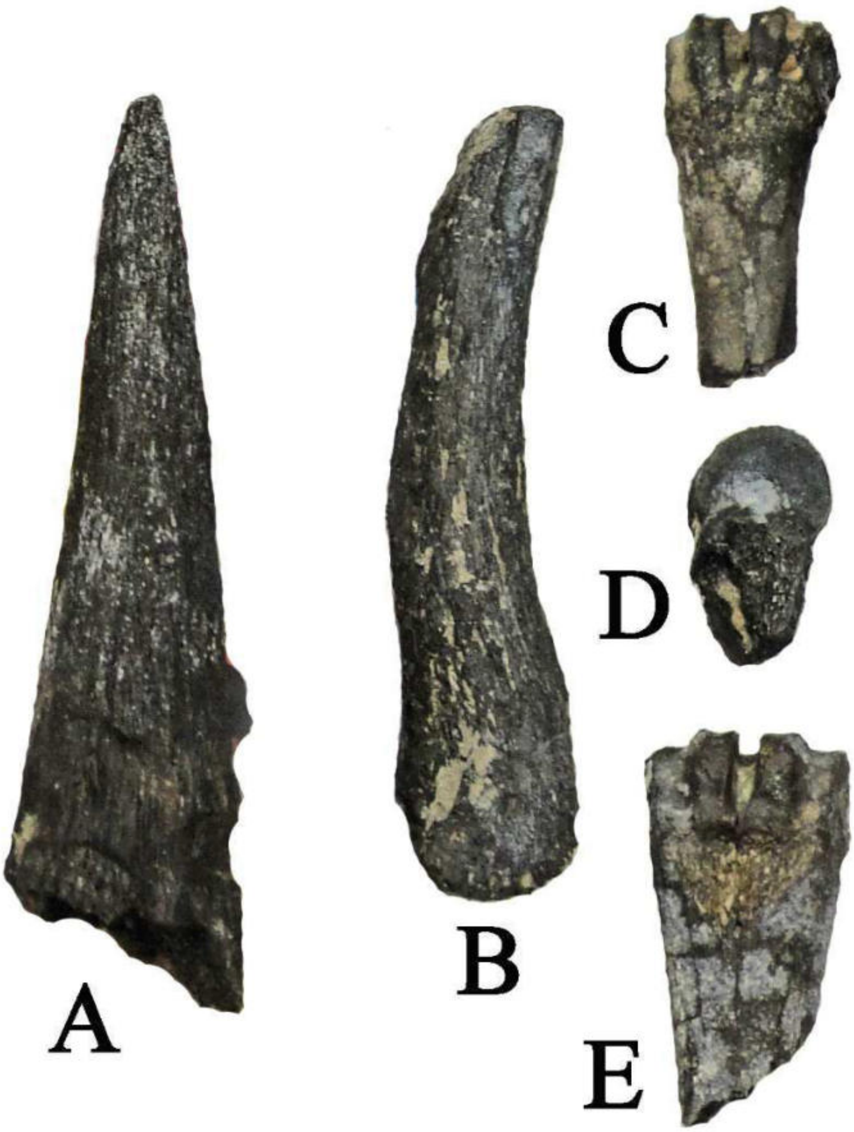


**Figure 36**. Bovidae from Ekuma site EK1. A) *Damalacra*-like horn core ca 15 cm tall, B) *Redunca darti* horn core base, C-E) distal metapodial fragments (not to scale).

**Summary and conclusions**

Rescue palaeontology at Ekuma Delta in November, 2013, and August, 2014, resulted in important additions to the Pliocene fauna of the region. The 2008 floods at Etosha swept away much of the dried mud that previously obscured most of the bottom of the Ekuma Valley, leaving behind a concentration of invertebrate and vertebrate fossils.

The Pliocene deposits exposed in the bed of the Ekuma Valley were prospected as far north as the Ekuma Horse Camp and 1 km beyond. Several new fossiliferous exposures were found, but the bulk of the fossils collected came from previously known localities, in particular EK1 and the Ekuma Rhino Site. A phalange of *Orycteropus* was recovered from the screening residue at the Rhino mandible site, from silt washed in order to recover small bits of enamel broken off the teeth by trampling. A small excavation at the Rhino Site resulted in the collection of two canines and a molar of the gigantic suid *Notochoerus*. Table 4 provides an updated floral and faunal list of the deposits.

**Table 4. Floral and Faunal List, Ekuma Delta Member.**

| | | |
|---|---|---|
| Plants | Palm tree boles and root systems | Palm trees |
| | Dicotyledon boles and root systems | Dicotyledons |
| Mollusca | *Bellamya unicolor* | Freshwater snail |
| | *Mutela* sp. | Freshwater bivalve |
| | *Egeria* sp.? | Freshwater bivalve |
| Pisces | *Clarias* sp. | Catfish |
| | *Clarotes* sp. | Catfish |
| | *Polypterus* sp. | Lung fish |
| Chelonia | *Pelusios* sp. | Freshwater turtle |
| | *Cyclanorbis* sp. | Freshwater turtle |
| | Testudinidae sp. | Land tortoise |
| Crocodylia | *Crocodylus niloticus* | Nile Crocodile |
| | *Euthecodon* sp. | Long snouted crocodile |
| Aves | *Phoeniconaias* sp. | Flamingo |
| | *Phoenicopterus ruber* | Flamingo |
| | *Struthio daberasensis* (eggshells) | Ostrich |
| Rodentia | *Propedetes* sp. | Spring Hare |
| | *Hystrix* (taphonomy gnaw marks on bone) | Porcupine |
| Orycteropodidae | *Orycteropus afer* | Aardvark |
| Carnivora | Hyaenidae sp. | Hyaena |
| | Jackal-sized carnivore | Small carnivore |
| Proboscidea | *Mammuthus subplanifrons* | Mammoth |
| Equidae | *Hipparion* sp. | Equid |
| Rhinocerotidae | *Diceros praecox* | Rhino |
| Hippopotamidae | *Hippopotamus* large sp. | Hippo |
| Suidae | *Notochoerus capensis* | Giant suid |
| Giraffidae | *Giraffa* sp.? | Giraffe |
| Bovidae | *Redunca* aff. *darti* | Reedbuck |
| | *Oryx* or *Damalacra* sp. | Oryx-like antelope |
| | *Raphicerus*-sized sp. | Steenbok-sized antelope |

It is stressed that the Ekuma Delta Member accumulated under freshwater conditions, but seasonal or infrequent drying out of water bodies is not excluded. The saline conditions that typify the extant Etosha environment and the lower Ekuma Valley did not get established until the Pleistocene or Recent.

The presence of palm tree boles at several localities suggests that the Middle Pliocene palaeoclimate in the Ekuma Delta area was more humid than it is today. It would have been like the present day conditions occurring in the region extending from Grootfontein to the Okavango River, where palm trees are common. The vegetation in this area comprises Miombo Woodland.

The Ekuma Delta fauna accords with such a scenario, containing as it does, freshwater snails, bivalves, lung fish, fish-eating crocodiles, two genera of freshwater turtles, flamingos and bovids akin to the extant reed buck.

It is postulated that there was an abundance of grass in the region, as several of the mammals have hypsodont teeth (*Propedetes* sp. *Diceros praecox*, *Hipparion* sp. *Mammuthus subplanifrons*, *Notochoerus capensis*, bovids).

Finally, the mammals in the Ekuma Delta faunal list tend to support a Pliocene age for the Ekuma Delta Member, as already suggested by Pickford *et al*. 2014. The closest correlation is to the Pliocene site at Makapansgat, South Africa, but there are some indications of slightly earlier faunal elements, including a bovid close to *Damalacra* which is found at Langebaanweg, South Africa (Gentry, 2010) and the primitive elephant *Mammuthus subplanifrons* which is found widely in African deposits aged about 4 +/- 0.5 Ma.

Herries *et al*. (2013) refined the age estimates of the Makapansgat deposits, placing Makapansgat Members 3 and 4 between 3.03 Ma and 2.58 Ma. *Notochoerus capensis* ranges in age from ca 3.8 – 2.4 Ma, but the specimen from the Ekuma Rhino Site is a relatively low crowned form, indicating an age closer to 3.8 Ma than to 2.4 Ma. *Redunca darti* is known from the period 3.4 – 3.2 Ma in South Africa (Gentry, 2010).


## Acknowledgements

The NPE thanks the French Embassy in Namibia (M. J.-L. Zoël, Mme J. Bassa-Mazzoni), the Cooperation Service of the French Embassy in Windhoek (M. J.-P. Martin, M. P. Portes-Gagnol), the Muséum National d'Histoire Naturelle, Paris, UMR 7207 and CR2P (CNRS, MNHN) (S. Crasquin).

In Windhoek, Dr Gabi Schneider, Director of the Geological Survey of Namibia, provided help and encouragement. We thank Mrs Jane Eiseb for administrative help.

Thanks to Alma Nankela of the Namibian National Heritage Council for arranging authorisation to carry out research in Namibia. The Ministry of Environment and Tourism is thanked for authorising the field survey at Ekuma. The Etosha Park Headquarters are thanked for their help (Shane Kötting, Wilferd Versfeld, Marthin Kasaona, Claudine Cloete, Mr Kaseba, Gerson Kamub, Otto Manjara, Peter). Thanks to Dick Mol and his team for funding and participating in the excavation of the EK 1 mammoth skeleton.


## References


Broom, R. 1925. On evidence of a giant pig from the late Tertiaries of South Africa. *Records of the Albany Museum, Grahamstown*, **3**, 307-308.

Gentry, A. 2010. Bovidae, *In*: L. Werdelin & W.J. Sanders (Eds) *Cenozoic Mammals of Africa*. Berkeley, Los Angeles, London, University of California Press, Chapter **38**, 741-796.

Geraads, D. 2010. Rhinocerotidae. *In*: L. Werdelin & W.J. Sanders, (Eds) *Cenozoic Mammals of Africa*. Berkeley, Los

Angeles, London, University of California Press, Chapter **34**, 669-683.

Herries, A.I.R. Pickering, R. Adams, J.W. Curnoe, D. Warr, G. Latham, A.G. & Shaw, J. 2013. A multi-disciplinary perspective on the age of *Australopithecus* in Southern Africa. *In*: Reed, K. Fleagle, J. & Leakey, R. (Eds) *The Paleobiology of Australopithecus*. Dordrecht, Springer Science+Business Media, pp. 21-40.

Hipondoka, M. 2005. *The Development and Evolution of Etosha Pan, Namibia.* PhD Thesis, Würzburg, 152 pp.

Hooijer, D.A. & Patterson, B. 1972. Rhinoceroses from the Pliocene of northwestern Kenya. *Bulletin of the Museum of Comparative Zoology*, **144**, 1-26.

Miller, R. McG. Pickford, M. & Senut, B. 2010. The geology, palaeontology and evolution of the Etosha Pan, Namibia: implications for terminal Kalahari deposition. *South African Journal of Geology*, **113**, 307-334.

Mocke, H. Nankela, A. Pickford, M. Senut, B. & Ségalen, L. 2016. Fossil Freshwater Molluscs from Simanya in the Kalahari System, Northern Namibia. *Communications of the Geological Survey of Namibia*, **17**, 68-86.

Morales, J. Senut, B. & Pickford, M. 2011. *Crocuta dietrichi* from Meob, Namibia: implications for the age of the Tsondab Sandstone in the coastal part of the Namib Desert. *Estudios geologicos*, **67** (2), 207-215.

Osborn, H.F. 1928. Mammoths and Man in the Transvaal. *Nature*, **121**, 672-673.

Pickford, M. 2000. Neogene and Quaternary vertebrate Biochronology of the Sperrgebiet and Otavi Mountainland, Namibia. *Communications of the Geological Survey of Namibia*, **12**, 359-365.

Pickford, M. 2005. *Orycteropus* (Tubulidentata, Mammalia) from Langebaanweg and Baard's Quarry, Latest Miocene to Early Pliocene of South Africa. *Comptes Rendus Palevol*, **4**, 1-12.

Pickford, M. 2008. Tubulidentata from the Northern Sperrgebiet, Namibia. *Memoir of the Geological Survey of Namibia*, **20**, 311-314.

Pickford, M. Senut, B. Hipondoka, M. Person, A. Ségalen, L. Plet, C. Jousse, H. Mein, P. Guerin, C. Morales, J. & Mourer-Chauviré, C. 2014. Mio-Plio-Pleistocene geology and palaeobiology of Etosha Pan, Namibia. *Communications of the Geological Survey of Namibia*, **15**, 16-68.

Wells, L.H. & Cooke, H.B.S. 1956. Fossil Bovidae from the Limeworks Quarry, Makapansgat, Potgietersrus. *Palaeontologia africana*, **4**, 1-55.