Chrysochloridae (Mammalia) from the Lutetian (Middle Eocene) of Black Crow, Namibia

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Abstract: The freshwater and carbonatitic limestones at Black Crow, Sperrgebiet, Namibia, have yielded an interesting mammalian and non-marine molluscan fauna of Lutetian age. Among the mammals found in 2007 were a primitive arsinoithere, a hyracoid, some creodonts and rodents, as well as a macroscelidid and a possible sloth-like animal (Xenarthra). Further work has led to the recovery of a few additional mammalian fossils, including the earliest known chrysochlorid which comprises the focus of the present study. A new genus and a new species are erected for this early chrysochlorid.

Key Words: Chrysochloridae, Afrotheria, Eocene, Namibia

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Introduction

Lutetian continental deposits were discovered at Black Crow, Sperrgebiet, Namibia, in 2007 and published in 2008 (Pickford *et al.* 2008a, 2008b) (Fig. 1-3). The fossiliferous deposits at Black Crow comprise freshwater limestones with abundant pedotubules, suggesting accumulation in a swampy setting. There is a 20 cm thick bed of carbonatite breccia intercalated in the fossiliferous limestone which indicates that carbonate deposition occurred contemporaneously with volcanic activity at the Ystervark Carbonatite Centre 15 km to the east of Black Crow. Indeed, the Ystervark Centre was the primary source of the limestones which accumulated at Black Crow and elsewhere in the Northern Sperrgebiet (Silica North, Silica South, Chalcedon Tafelberg, Graben and several other places).

Much of the limestone represents airfall carbonatite tuff (Werfkopje, White Ring and Plaquette Limestone in the Eocliff sector) but the deposits with pedotubules represent reworked limestone, both clastic and precipitated out of aqueous solution.

The mammalian fauna from Black Crow described by Pickford *et al.* (2008b) comprised large and small mammals, but the deposits also yielded a low diversity of terrestrial molluscs (*Dorcasia*, *Trigonephrus*) characteristic of Southern African regions with winter rainfall.

Continued surveys at Black Crow have led to the recovery of a few more specimens of crocodiles and mammals, among which is the earliest known representative of the super-family of golden moles (Chrysochloridea) which comprises the raw material for the present article.

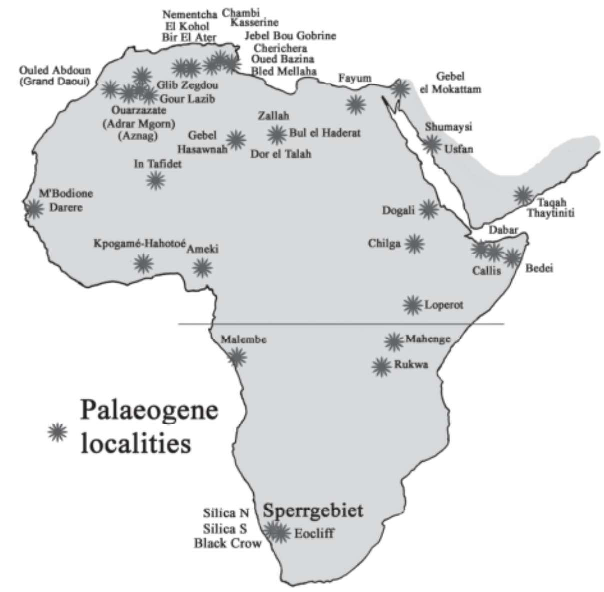

Figure 1. Location of Palaeogene mammal-bearing deposits in Africa and the Arabian Peninsula. During the Eocene Namibia was closer to South America than it was to the Fayum in Egypt.

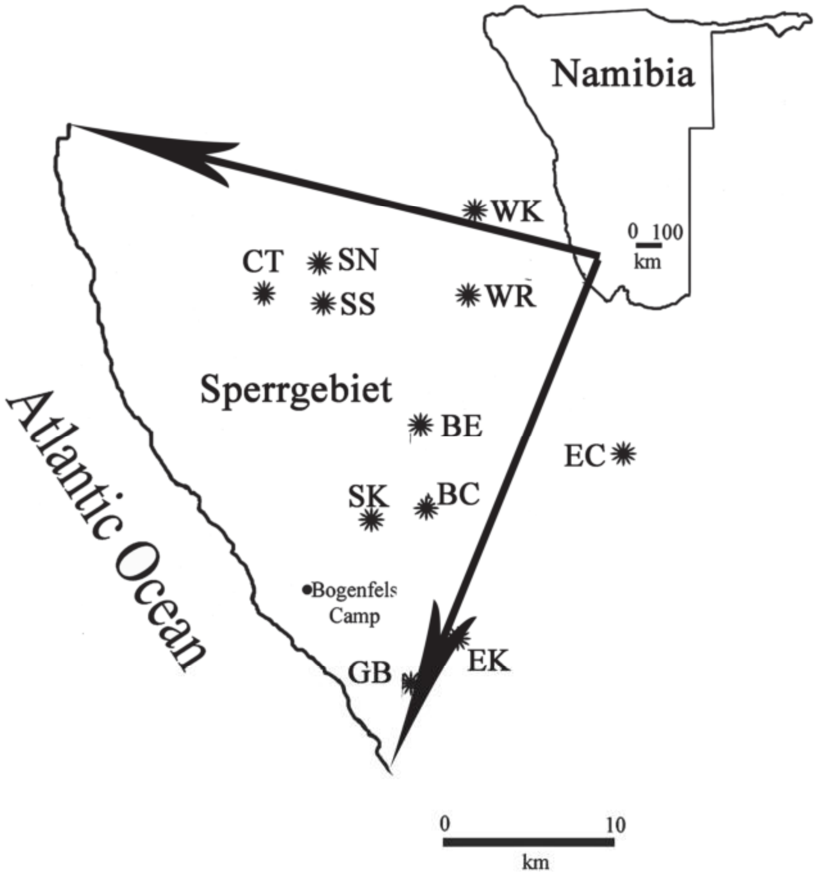

Figure 2. Distribution of Eocene limestone deposits in the Sperrgebiet, Namibia. BC – Black Crow, BE – Bull's Eye, CT - Chalcedon Tafelberg, EC – Eocliff, EK – Eisenkieselklippenbake, GB – Gamachab, SK – Steffenkop, SN – Silica North, SS – Silica South, WK – Werfkopje, WR - White Ring. All these carbonates are attributed to the Ystervark Formation.

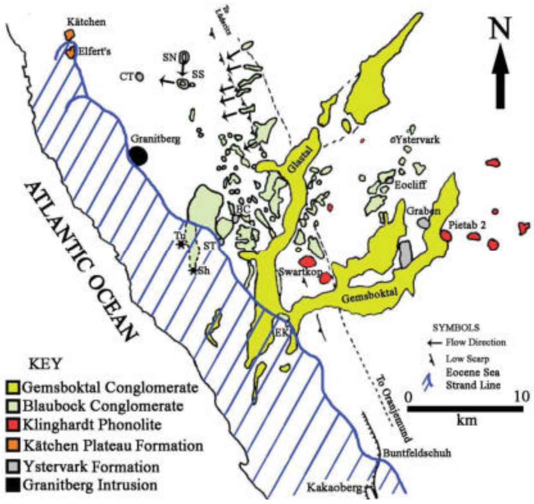

Figure 3. Geological setting of the Black Crow Limestone, Northern Sperrgebiet, Namibia. BC – Black Crow, CT – Chalcedon Tafelberg, EK – Eisenkieselklippenbake, SN – Silica North, SS – Silica South, ST – Steffenkop, Sh – Langental Shark Site (Priabonian), Tu – Langental *Turritella* Site (Priabonian).

Geological context

The Black Crow Limestone is a localised deposit of palustral carbonates about 10 metres thick containing a 20 cm thick layer of carbonatite breccia (Fig. 4). The limestone overlies Proterozoic dolomites of the Gariep Group, Pomona Quartzite (Early Tertiary), silicified Plaquette Limestone of the Ystervark Carbonatite Formation (Lutetian) and is overlain by Blaubock Conglomerate (probably Oligocene), Gemsboktal Conglomerate (Late Miocene), Namib 1 Calc-Crust (Late Miocene) and loose sand (Pickford *et al.* 2008a).

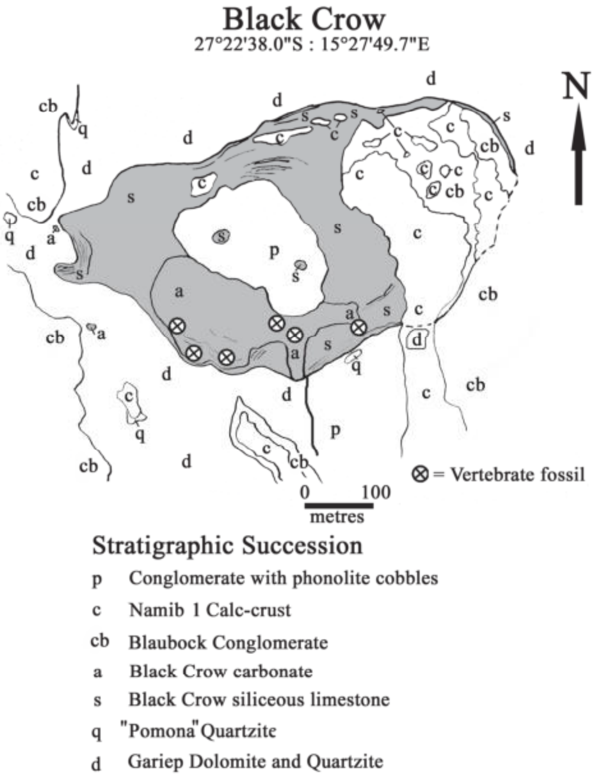

Figure 4. Geological map of the Black Crow Basin, Northern Sperrgebiet, Namibia, showing the fossil mammal occurrences.

Age

Faunal correlations indicate that the Black Crow Limestone is considerably older than any of the mammal-bearing deposits of the Fayum, Egypt, which range in age from Priabonian to Rupelian (Fig. 5). It is older than the Eocliff Limestone and the suite of limestones occurring at Silica North and Silica South. Pickford *et al.* (2008b) correlated Black Crow to the Lutetian, which has been accepted (Marivaux pers. comm.) and Pickford *et al.* (2013) suggested that it was older than 42.5 Ma on the basis of radio-isotopic age determinations on phonolite cobbles from the overlying Gemsboktal Conglomerate.

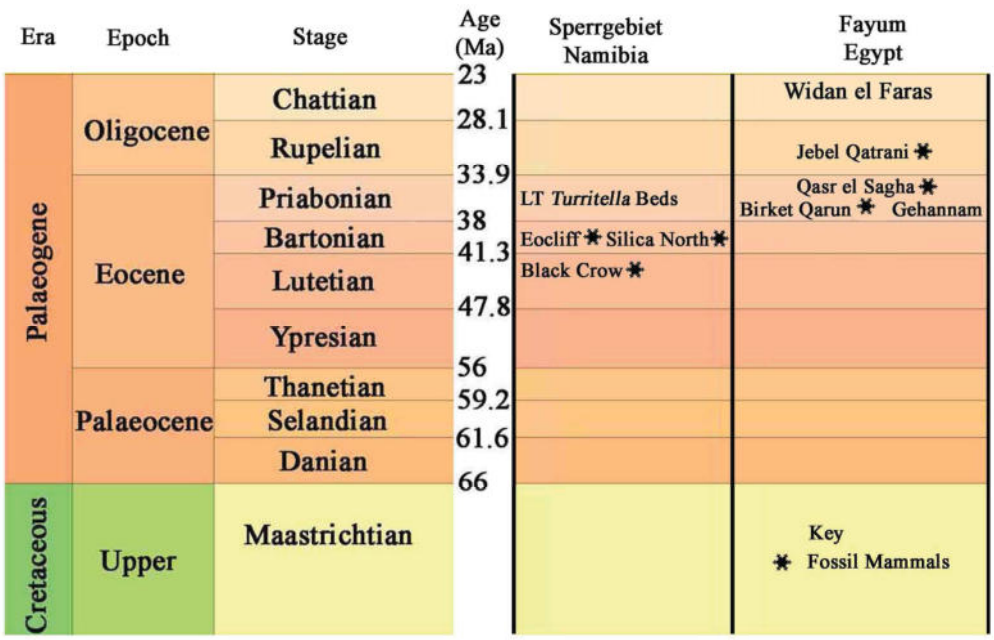

Figure 5. Correlations of the Namibian and North African Eo-Oligocene fossiliferous deposits.

Associated fauna

Table 1. Fauna from the Lutetian limestones at Black Crow, Namibia.

Gastropoda *Dorcasia* sp. *Trigonephrus* sp.
Todralestidae *Namalestes gheerbranti*
Chrysochloridae
Macroscelididae Genus indet.
Erinaceidae? Genus indet.
Hyaenodontinae *Pterodon* sp
Proviverrinae Genus indet.
Xenarthra?° Genus indet.
Hyracoidea *Namahyrax corvus*
Arsinoitheriidae *Namatherium blackcrowense*
Primates *Notnamaia bogenfelsi*+
Rodentia *Glibia namibiensis**

(° previously listed as a pholidote.
+ originally called *Namaia*, but the genus name is preoccupied by an ostracod from Canada, so a new genus name has been proposed (Pickford & Uhen, 2014).
* Marivaux *et al.* 2011, consider that this species is better housed in *Zegdoumys* than *Glibia*).

Materials and methods

The fossil described herein was released from a block of Black Crow Limestone using formic acid (7%) buffered with calcium triphosphate, and was consolidated using a weak solution of glyptol. Stereoscopic images captured with a Sony digital camera placed over the eye pieces of a binocular microscope, were enhanced using Photoshop Elements 03. The scale was added manually.

Dental nomenclature
Nomenclature of molar cusps is explained in Fig. 6;

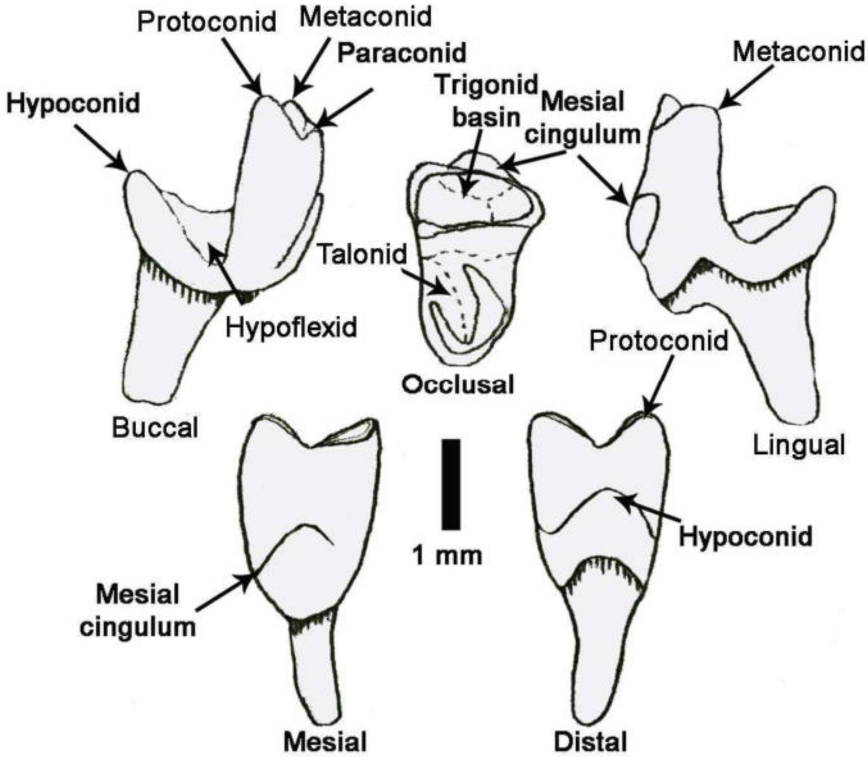

Figure 6. Nomenclature of right lower molar of *Diamantochloris inconcessus* from Black Crow, Namibia (scale: 1 mm).

Systematic description

Superfamily Chrysochloridea Broom, 1915

Family Chrysochloridae Gray, 1825

Genus *Diamantochloris* nov.

Etymology.- *Diamantochloris* combines "*Diamond*" (for the Diamond Area, Namibia) and "*chloris*" the Greek Godess of Flowers, a termination often used for naming "golden moles".

Type species. *Diamantochloris inconcessus*

Diagnosis.- Chrysochloridae in which the lower molars have large talonids slightly longer than the trigonid, vestigial paraconid close to the metaconid and as a consequence the trigonid basin is reduced in mesio-distal dimensions.

Differential diagnosis.- *Diamantochloris* differs from *Namachloris* by the longer talonid in the lower molars, with a well-developed talonid basin. It differs from all extant chrysochlorids by the enlarged talonid (vestigial or absent in most living forms). Trigonid basin slightly larger than in extant chrysochlorids. *Diamantochloris* differs from *Eochrysochloris tribosphenus* from Egypt by its more reduced paraconid, smaller trigonid basin and its talonid longer than the trigonid. Indeed on the basis of the differences between these two genera, it is inferred that *Eochrysochloris* is probably not a Chrysochloridae.

Species *Diamantochloris inconcessus* nov.

Etymology.- The species name is the Latin word "*inconcessus*" referring to the "Forbidden Zone" (Sperrgebiet) where the fossil was found.

Holotype.- GSN BC 17'08, right lower molar (possibly m/3).

Diagnosis.- As for the genus.

Description

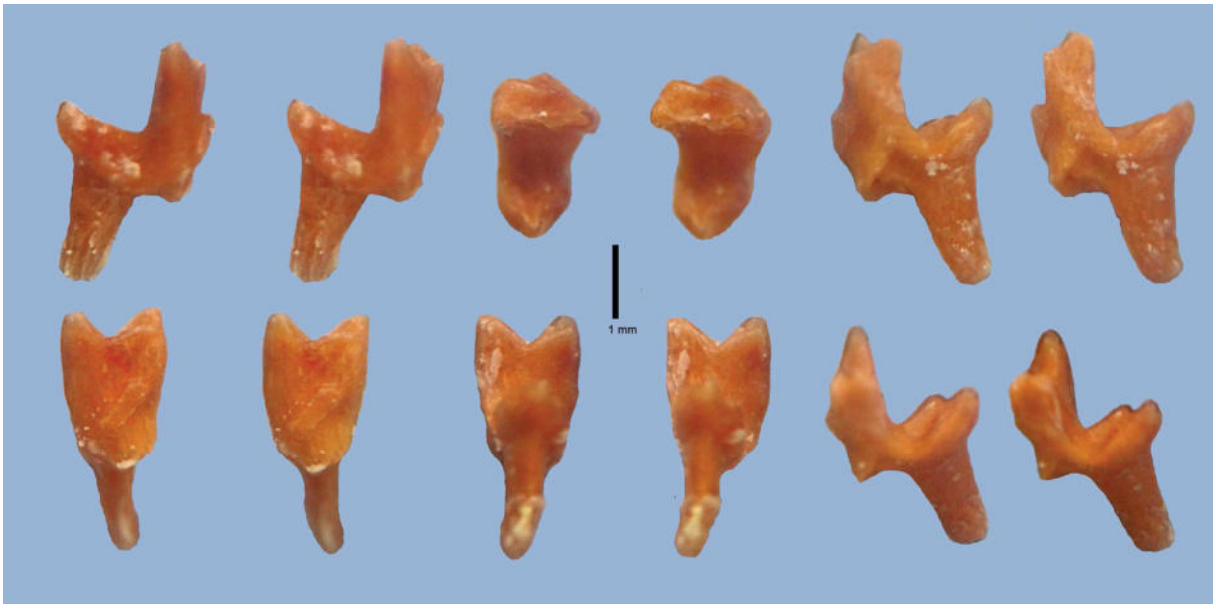

Figure 7. GSN BC 17'08, stereo views of the holotype right lower molar of *Diamantochloris inconcessus* from Black Crow, Namibia. A) lingual, B) occlusal, C) buccal, D) mesial, E) distal, F) slightly oblique buccal view to show the talonid basin to advantage (scale: 1 mm).

The holotype lower molar (Fig. 7) has a blade-like trigonid in which the paraconid is vestigial and is closely applied to the metaconid but low down. Cristids descend from the protoconid and metaconid and meet in the midline of the crown, forming a transversely oriented cutting edge with a v-shaped profile in mesial and distal views. There is a low mesial cingulum which slopes from the base of the protoconid upwards towards the midline of the tooth before descending a short way where it fades out well before reaching the base of the metaconid. Its apex is at about half the height of the trigonid in the midline beneath the v-shaped notch in the cutting edge of the trigonid.

The talonid is large, comprising slightly more than half the length of the tooth. It has a buccal basin surrounded buccally, distally and lingually by a curved ridge of enamel separated from the hypoflexid by the lingual part of the ridge. The hypoconid slopes upwards distally, its apex being about half the height of the trigonid. There are two roots, the mesial one broken off leaving a small remnant distally, the distal root leaning slightly buccally.

Discussion

There has been considerable doubt about the origins and affinities of the golden moles, family Chrysochloridae (Broom, 1915; MacPhee & Novacek, 1993). Hitherto, the fossil record of this family was poor, with a few specimens known from the Early Miocene of Kenya and Uganda (Butler, 1984, 1985; Butler & Hopwood, 1957) and the Pliocene and Pleistocene of South Africa (Asher & Avery, 2010; Broom, 1941; De Graaf, 1957). A supposed fossil golden mole from the Early Oligocene (Rupelian) of Egypt (*Eochryso-chloris tribosphenus* Seiffert *et al.* 2007) is more likely to belong to Tenrecoidea than to Chrysochloridea, the trigonid of the lower molars being comprised of three subequal cusps outlining a capacious trigonid basin, unlike the mesio-distally compressed basin with a vestigial paraconid that helps define the family Chrysochloridae.

For a long time included in "Insect-ivora" the golden moles were shifted to the Lipotyphla (Haeckel, 1866) once it was realised that the Insectivora was an unrealistic grouping of heterogeneous taxa with diverse origins. Here they remained for over a century

(Dobson, 1883; De Witte & Frechkop, 1955; McDowell, 1958; Butler, 1988) despite the opinion of Broom (1915) that they belonged to their own superfamily Chrysochloridea.

On the basis of molecular analyses, there has been a recent tendency to include the Chrysochloridae in the Afrotheria (Stanhope *et al.,* 1998), a theme reiterated by Asher & Hofreiter (2006) and Seiffert *et al.* (2007) who indicated that extant *Chryochloris* has a sister-group relationship with Tenrecoidea. The Chrysochloridea possess a long suite of autapomorphic characters of the cranium, dentition and post-cranial skeleton (MacPhee & Novacek (1993) which, ironically, makes them difficult to compare cladistically with other mammals. Many of these autapomorphies existed in the Bartonian taxon *Namachloris arenatans* Pickford (2015) with indications that some of the features are even present in Lutetian *Diamantochloris inconcessus* from Black Crow. The dichotomy between Chrysochloridae, Potamogalidae and Tenrecidae is likely to have occurred a substantial period of time before the Lutetian (Pickford, 2015).

Conclusions

The Black Crow Limestone has yielded a low diversity of Lutetian mammals, among which there is a primitive member of Chrysochloridae in which the lower molar talonid is large (longer than the trigonid). A new genus and a new species, *Diamantochloris inconcessus*, are erected to accommodate this primitive golden mole. It has a larger talonid in the lower molars than that of *Namachloris arenatans* from slightly younger deposits at Eocliff in the Sperrgebiet, Namibia, which in its turn has longer and better defined talonids than in extant golden moles. In accordance with the large talonid of *Diamantochloris*, its distal root is further from the mesial root than it is in *Namachloris* and later Chrysochloridae. The trend for talonid reduction in Chrysochloridae thus began during the Late Lutetian or Early Bartonian.

In contrast, the reduction of the paraconid in the lower molars of chrysochlorids was already achieved by the Lutetian of Black Crow, such that the trigonid is reduced to a transverse lophid with a v-shaped apical edge, and a much reduced, mesio-distally compressed trigonid basin in front. This indicates that the somewhat younger genus *Eochrysochloris* from the Fayum, Egypt (Seiffert *et al.* 2007), which possesses a well formed trigonid with a large paraconid well separated from the metaconid bordering a capacious trigonid basin, is probably not a chrysochlorid, and should perhaps be assigned to Tenrecoidea rather than to Chrysochloridea.

The Black Crow chrysochlorid has derived lower molar trigonid morphology, indicating that the family diverged from its sister-group well before the Lutetian. Whether the sister-group was the Tenrecoidea or some other group remains to be determined.

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References

Asher, R.J., & Avery, D.M., 2010. New Golden Moles (Afrotheria, Chrysochloridae) from the Early Pliocene of South Africa. *Palaeontologia Electronica*, **13**, Issue 1; 3A, 1-12.

Asher, R.J., & Hofreiter, M., 2006. Tenrec Phylogeny and the Noninvasive Extraction of Nuclear DNA. *Systematic Biology* **55**,181–194.

Broom, R., 1915. On the Organ of Jacobson and its relations in the "Insectivora". Part II. *Talpa*, *Centetes* and *Chrysochloris*. *Proceedings of the Zoological Society of London,* **25**, 347–354.

Broom, R., 1941. On two Pleistocene golden moles. *Annals of the Transvaal Museum*, **20**, 215-216.

Butler, P.M., 1984. Macroscelidea, Insectivora and Chiroptera from the Miocene of East Africa. *Palaeovertebrata*, **14**, 117-200.

Butler, P.M., 1985. The history of African Insectivores. *Acta Zoologica Fennica*, **173**, 215-217.

Butler, P.M., 1988. Phylogeny of the Insectivores. *In*: M.J. Benton (Ed.), *The Phylogeny and Classification of the Tetrapods*, *Volume 2: Mammals*, Clarendon Press, Oxford, pp. 117–141.

Butler, P.M., & Hopwood, A., 1957. Insectivora and Chiroptera from the Miocene rocks of Kenya Colony. *Fossil Mammals of Africa*, **13**, 1-35.

De Graaff, G., 1957. A new chrysochlorid from Makapansgat. *Palaeontologia africana*, **5**, 21-27.

De Witte, G.F., & Frechkop, S., 1955. Sur une espèce encore inconnue de mammifère africain, *Potamogale ruwenzorii*, sp. n. *Bulletin de l'Institut royal des Sciences naturelles de Belgique*, **31**, 1 – 11.

Dobson, G.E., 1883. *Monograph of the Insectivora Part II, Including the Families Potamogalidae, Chrysochloridae, Talpidae*. London, John van Voorst, 172 pp.

Gray, J.E., 1825. An outline of an attempt at disposition of Mammalia into tribes and families with a list of the genera apparently appertaining to each tribe. *Annals of Philosophy*, *London*, **26**, 337-344.

Haeckel, E., 1866. *Generalle Morphologie der Organismen, allgemeine Grundzüge der organischen Formen-Wissenschaft, mechanisch begründet durch die von Charles Darwin reformierte Descendenz-Theorie*. Berlin, Georg Reimer.

MacPhee, R.D.E., & Novacek, M.J., 1993. Definition and relation of Lipotyphla. *In*: Szalay, F.S., Novacek, M.J., & McKenna, M.C., (Eds) *Mammal Phylogeny, Vol 2: Placentals*, *Insectivora*, Springer-Verlag, New York, pp. 13-31.

Marivaux, L., Essid, E.M., E., Marzougui, W., Ammar, H.K., Adnet, S., Marandat, B., Merzeraud, G., Ramdarshan, A., Tabuce, R., Vianey-Liaud, M., & Yans, J., 2014. A Morphological Intermediate between Eosimiiform and Simiiform Primates from the Late Middle Eocene of Tunisia: Macroevolutionary and Paleobiogeographic Implications of Early Anthropoids. *American Journal of Physical Anthropology*, **154**, 387-401.

McDowell, S.B., 1958. The Greater Antillean insectivores. *Bulletin of the American Museum of Natural History*, **115**, 115-213.

Pickford, M., 2015. Late Eocene Chrysochloridae (Mammalia) from the Sperrgebiet, Namibia. Co*mmunications of the Geological Survey of Namibia*, **16**, 169-215.

Pickford, M., Senut, B., Morales, J., & Sanchez, I.M., 2008a. Fossiliferous Cainozoic Carbonates of the Northern Sperrgebiet. *Memoir of the Geological Survey of Namibia*, **20**, 25-42.

Pickford, M., Senut, B., Morales, J., Mein, P., & Sanchez, I.M., 2008b. Mammalia from the Lutetian of Namibia. *Memoir of the Geological Survey of Namibia*, **20**, 465-514.

Pickford, M., Sawada, Y., Hyodo, H., & Senut, B., 2013. Radio-isotopic age control for Palaeogene deposits of the Northern Sperrgebiet, Namibia. *Communications of the Geological Survey of Namibia*, **15**, 3-15.

Pickford, M., & Uhen, M., 2014. *Namaia* Pickford *et al.*, 2008, preoccupied by *Namaia* Green, 1963: proposal of a replacement name. *Communications of the Geological Survey of Namibia*, **15**, 91.

Seiffert, E., Simons, E.L., Ryan, T.M., Bown, T.M. & Attia, Y., 2007, New remains of Eocene and Oligocene Afro-soricida (Afrotheria) from Egypt, with implications for the origin(s) of afro-soricid zalambdodonty. *Journal of Vertebrate Paleontology*, **27**, 963-972.

Stanhope, M.J., Waddel, V.G., Madsen, O., de Jong, W.W., Hedges, S.B., Cleven, G.C. *et al*., 1998. Molecular evidence for multiple origins of Insectivora and for a new order of endemic African insectivore mammals. *Proceedings of the National Academy of Science of the USA*, **95**, 9967-9972.