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First finds of Pleistocene *Macaca sylvanus* (Cercopithecidae, Primates) from the North Sea

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Abstract
Three fossils of cercopithecine monkeys were recently found on the beaches of Maasvlakte 2 and Hoek van Holland (the Netherlands), initially originating from a source area some 10-20 km off the coast. They are attributed to the Barbary macaque, *Macaca sylvanus*. The absence of rocky outcrops in the area of the present North Sea area suggests that the animals, which prefer to climb to elevated spots, lived in (partly) forested areas. The age of the fossils is difficult to assess. A mandibular fragment with complete M_3 is suggested to be of Eemian (Marine Isotope Stage = MIS 5e) age, while the two isolated dental elements may be stratigraphically older. Moisture and temperature balancing Atlantic climate influences presumably controlled one or more advances of *Macaca* from the Mediterranean to NW Europe and the North Sea region.

Keywords
Cercopithecine monkey, Barbary macaque, dentition, Maasvlakte, Hoek van Holland, The Netherlands, Eemian.

Résumé
Premières découvertes de *Macaca sylvanus* (Cercopithecidae, Primates) du Pléistocène de la Mer du Nord.- Trois restes fossiles de singes cercopithécinés ont été trouvés récemment sur les plages de Maasvlakte 2 et de Hoek van Holland (Pays-Bas). Ces restes proviennent d'une région d'extraction de sable, à une distance de 10 à 20 kilomètres de la côte. Les fossiles sont attribués au magot, *Macaca sylvana*. L'absence totale de reliefs rocheux dans la région de la Mer du Nord implique que ces animaux devaient vivre dans un environnement en partie forestier.
L'âge des fossiles est difficile à déterminer. Le fragment mandibulaire avec M3 pourrait dater de l'Eémien (MIS 5e), tandis que les deux éléments dentaires peuvent être stratigraphiquement plus anciens. Il est possible que les influences climatiques de l'Atlantique, stabilisant l'humidité et la température, contrôlaient la migration de *Macaca* dans le nord-ouest de l'Europe et la région de la Mer du Nord.

Mots-clés
Cercopithéciné, magot, dentition, Maasvlakte, Hoek van Holland, Pays-Bas, Eémien.

1. INTRODUCTION

The coastline of the Netherlands consists largely of sandy beaches that often need sediment supplementations in order to avoid loss of sand and to guarantee safety. In addition, the port of Rotterdam has recently been extended with an artificial peninsula called Maasvlakte 2, thus greatly enlarging the surface of portuary facilities. Maasvlakte 2 is bordered by a sandy beach of several kilometres length. Both sediment supplementations and harbour extension are and were done by suction dredgers, large vessels dredging sand from a source area some 10 to 20 kilometres offshore that is subsequently deposited on the destined locality. The beaches, both the supplemented ones and the ones bordering Maasvlakte 2 (and its predecessor Maasvlakte 1) have been known for decades to yield late middle and late Pleistocene fossils. These mammalian and avian fossils have been described in numerous publications (see Mol *et al*., 2008 and Mol, 2016 for an overview). Most numerous are remains of the late Pleistocene *Mammuthus-Coelodonta* faunal complex: besides the typifying species woolly mammoth (*M. primigenius*) and woolly rhinoceros (*C. antiquitatis*), these are steppe bison (*Bison priscus*), reindeer (*Rangifer tarandus*), giant deer (*Megaloceros giganteus*), several species of caballine horses (*Equus*), cave lion (*Panthera spelaea*), cave bear (*Ursus spelaeus*), etc. Sometimes rarer species are discovered of presumably older stratigraphic

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provenance, such as forest elephant (*Palaeoloxodon antiquus*), forest rhino (*Stephanorhinus kirchbergensis*) and hippopotamus (*Hippopotamus amphibius*). Here we describe three specimens of a hitherto undescribed North Sea species, the Barbary macaque *Macaca sylvanus*.

2. MATERIAL AND METHODS

Three *Macaca* specimens have been found on the beaches of Maasvlakte 2 and Hoek van Holland, presumably originating from the sand source area: a left upper canine tooth (C sup. sin.) found by and in the collection of Mr. Henk Houtgraaf, Papendrecht (the Netherlands), inv. nr. HHO-0420 (Fig. 1); a right upper second molar (M^2 dex.) found by and in the collection of Mr. and Mrs Hans and Karin Verhulsdonck, Nijmegen (the Netherlands), inv. nr. 00177 HvH (Fig. 2); and one right mandibular fragment with the lower third molar (M_3 dex.) preserved, found by Mr. Cock van den Berg, collection Natural History Museum Rotterdam, inv. nr. NMR999100010537 (Fig. 3).
In addition we studied and measured recent specimens of *Macaca sylvanus* in the collection of the Phyletisches Museum (Institute of Special Zoology and Evolutionary Biology) of the Friedrich-Schiller-University Jena, Germany. Measurements were done with vernier calipers with digital reading. Photographs were made at the Senckenberg Research Station of Quaternary Palaeontology, Weimar, Germany.

3. DESCRIPTION

Order Primates Linnæus, 1758
Suborder Haplorrhini Pocock, 1918
Parvorder Catarrhini E. Geoffroy Saint-Hilaire, 1812
Family Cercopithecidae Gray, 1821
Genus *Macaca* Lacépède, 1799

***Macaca sylvanus* (Linnæus, 1758)**

Specimen 1: a left upper canine (Fig. 1)
According to its dimensions, the left upper canine (C sup. sin.) is attributable to a male individual. Its measurements are: height of the tooth (from crown apex to tip of root) 36.3 mm; height of the crown (from apex to mesio-buccal dentine-enamel junction) 16.4 mm; mesio-distal length 10.0 mm; lingual-distal width 6.8 mm. Note that the measured heights of tooth and crown are lower than that of the intact tooth, as the apex of the crown is somewhat damaged. The tooth has a triangular circumference, the buccal side is smooth, the anterior (mesial) side has a long and deep groove running along both root and crown; the distal side is provided with a similarly deep groove along the root, while its crown presents the wear facet with the lower third premolar (P_3 sin.).

Fig: 1: Left upper canine (C sup. sin.), coll. Houtgraaf, inv. nr. HHO-0420. a: buccal view, b: anterior (mesial) view, c: lingual view, d: posterior (distal) view. Bar = 10 mm.

Specimen 2: a right upper second molar (Fig. 2)
The right upper second molar (M^2 dex.) is slightly damaged, that is, its two buccal roots have broken off and so has a fragment of the enamel on the buccal side of the metacone. The tooth is strongly worn, obliterating some details of the dental pattern. A contact facet with M^3 is visible on the posterior (distal) side. The anterior (mesial) fovea is better developed than the barely discernible posterior (distal) one. The most striking feature of this tooth is the presence of a lingual cingulum, not only below the hypocone as in some other (recent) specimens, but also below the valley between protocone and hypocone, and on the anterior side of the protocone. The uppermost part of the broad, distally bending lingual root shows some dissolution; we cannot decide if this is either the result of gum retraction during life of this aged animal, or a diagenetic feature. Measurements are in Table 1.

Specimen 3: fragmentary right mandible with M_3 (Fig. 3)
The mandibular fragment bearing M_3 is characterized by a relatively light brown coloration; the tooth itself is not black either, but greyish with some black spots. Within the context of the North Sea fossils and their way of preservation, this could imply a relatively young geological age of this specimen, i.e. not late early or middle Pleistocene, but rather late Pleistocene. The molar is hardly worn. On the anterior (mesial) side a wear facet can be seen due to contact abrasion with M_2. The tooth is bilophodont, with a well-developed posterior basin. Its measurements (see Table 2) show that it is slightly longer than the molars of recent female Barbary macaques and the female from the late early Pleistocene (Epivillafranchian) fauna of Untermassfeld, but considerably smaller than the male from the same palaeopopulation (Zapfe, 2001, p. 890f.).

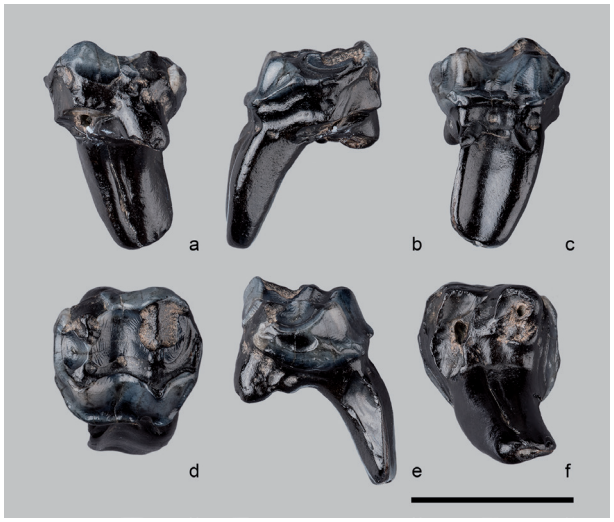

Fig: 2 Right upper second molar (M^2 dex.), collection Verhulsdonck, inv. nr. 00177 HvH. a: buccal view, b: anterior (mesial) view, c: lingual view, d: occlusal view, e: posterior (distal) view, f: ventral (root) view. Bar = 10 mm.

Fig. 3: Right mandibular fragment with lower third molar (M_3), collection Natural History Museum Rotterdam, inv. nr NMR999100010537. a: anterior (mesial) view, b: occlusal view, c: buccal view, d: lingual view. Bar = 10 mm.

Table 1: Measurements of M^2 (in mm)

specimen	L	AW	PW
collection Verhulsdonck, inv. nr. 00177 HvH	8.9	8.3	7.8
Untermassfeld, IQW 2013/41 540 (Mei. 36 886)	9.6	8.8	8.2
M. sylvanus, extant, Phyletisches Museum Jena 8020, dex. (♀)	9.6	8.7	7.6
M. sylvanus, extant, Phyletisches Museum Jena 8020, sin. (♀)	9.7	8.5	7.5
M. sylvanus, extant, Phyletisches Museum Jena 8021, dex. (♀)	8.9	8.6	7.4
M. sylvanus, extant, Phyletisches Museum Jena 8021, sin. (♀)	9.1	8.8	7.3
M. sylvanus, extant, Phyletisches Museum Jena 7387, dex. (♀)	9.2	8.6	7.9
M. sylvanus, extant, Phyletisches Museum Jena 7387, sin. (♀)	9.4	8.7	7.7

Table 2: Measurements of M_3 (in mm)

specimen	L	AW	PW	
NMR 999100010537	12.1	7.8	7.5	
Untermassfeld, IQW 1984/20 021 (Mei. 19 541) (♂)	13.8	8.7	7.5	(own measurement)
Untermassfeld, IQW 1984/20 021 (Mei. 19 541) (♂)	13.4	8.4	7.4	(Zapfe, 2001)
Untermassfeld, IQW 1980/16 566 (Mei. 16 087) (♀)	11.3	8.2	7.2	(own measurement)
Untermassfeld, IQW 1980/16 566 (Mei. 16 087) (♀)	11.0	7.4	7.0	(Zapfe, 2001)
M. sylvanus, extant, Phyletisches Museum Jena 7387, dex. (♀)	11.2	8.2	7.1	

4. DISCUSSION

4.1 Stratigraphy

The stratigraphic origin of the fossils is difficult to assess. All North Sea fossils are found out of their geological context (e.g., Mol *et al*., 2008; Mol, 2016). The sediments used for building Maasvlakte 2 and the supplementation of the Hoek van Holland coastline originate from the North Sea floor, some 10-20 km off the coast of the province of South Holland. These fluviatile sediments of late Pleistocene age have been deposited by the ancient Rhine and Meuse rivers, containing reworked fossil remains of both marine and terrestrial mammals. We have to refer to the associated fauna. Most of the finds belong to the so-called mammoth steppe fauna (*Mammuthus-Coelodonta* Faunal Complex *sensu* Kahlke, 1999), but this fauna, adapted to dry and cold environmental conditions, will certainly not be the source of our *Macaca*. Fossil remains dating from the Eemian are sometimes found, such as *Palaeoloxodon antiquus*, *Hippopotamus amphibius*, and *Stephanorhinus kirchbergensis*. *Macaca* has been reported from the Eemian (MIS 5e) and even later periods in Central Europe and the Iberian Peninsula (e.g., Fladerer, 1991; Castaños *et al*., 2011), although Schreve (1998) initially mentioned its extinction in the British Isles after MIS 9. The presence of *Macaca* during the European late Pleistocene was subsequently shown by Elton & O´Regan (2014), who even suggested that *Macaca* became extinct in a late Pleistocene extinction wave together with *Palaeoloxodon antiquus* and *Stephanorhinus hemitoechus*. Weichselian macaques were also reported from as far north as northern Bavaria in a Neanderthal context (Rosendahl *et al*., 2011) and were also found in Italy in a context with Mousterian implements (Mazza *et al*., 2005), both localities postdating the Eemian. Therefore, and as a hypothesis only, we propose an early late Pleistocene, i.e. possibly Eemian, age for the Maasvlakte mandible fragment.
The two loose teeth described above show a different facies, they are blacker and appear more heavily mineralized. Their age cannot be estimated but it might be older than Eemian, given the fact that *Macaca* is also known from the site of Tegelen, the Netherlands, which is an early Pleistocene locality (Van den Hoek Ostende & De Vos, 2006) and La Celle-sur-Seine in northern France, dated to the middle Pleistocene MIS 11 (Limondin-Lozouet *et al*., 2006). If the two isolated finds predate the Eemian indeed, *Macaca* would have advanced more than once into the area of today's North Sea.

4.2 Palaeoecology

Present-day macaques live preferably in mountainous areas with a diverse vegetation, such as dry or mediterranean shrub (maquis), oak forests or conifer stands; the majority of animals live in stands of Atlas cedar (*Cedrus atlantica*), in other places also in dryer ecosystems with dwarf palms (*Chamaerops humilis*) and oak (*Quercus*; Blanco, 1998). Such circumstances are not found in the area around the North Sea Basin during the Pleistocene, but through time habitat preferences may differ as a result of influences of geography, soil, climate, predators, competitors and possible other environmental factors. Blanco (1998) also mentioned the fact that the present habitat preference of macaques is the result of human persecution. This effect was absent during the Pleistocene, allowing for a broader habitat range. Important are the climbing abilities of the animals; they prefer to sit in elevated spots as it apparently makes them feel safer. There were no rock outcrops in the region where the fossils originate from, but trees could have served the same purpose. Therefore, a forested or partly forested environment can be assumed for the respective habitats of the three considered finds. The advance of *Macaca* from the Mediterranean area to NW Europe, inclusive of the North Sea region, was certainly controlled by Atlantic climate influences.

4.3 Taxonomy

The literature provides ample discussions about the taxonomy of Pliocene to Recent European macaques. Three fossil subspecies are so far being recognized from continental Europe (Sardella *et al*., 2015). There is a large overlap in sizes and no diagnostically clearcut morphological difference between Pliocene *Macaca sylvanus priscus* Gervais, 1859, late Pliocene to early Pleistocene *M. sylvanus florentina* (Cocchi, 1872), late Pleistocene *M. sylvanus pliocena* Owen, 1846 and Recent *M. sylvanus sylvanus*. In this framework Castaños *et al*. (2011, p. 819) noted in a study of late Pleistocene *M. sylvanus* from Lezetxiki II cave (Basque Country, Iberian Peninsula): "The comparative morphometric study of the teeth with those of Plio-Pleistocene fossils and a sample of modern female macaques confirms the great size variability of this species and the absence of reliable criteria for the attribution of the specimen to either of the two subspecies recorded from the Pleistocene." This seems to confirm the remark already made by Delson (1975, p. 207), who wrote: "Most if not all European and later North African *Macaca* are referable to the modern *M. sylvanus*, perhaps as temporal-geographic subspecies (…)"; see also Delson (1974). Delson (1980, p. 16) elaborated further on the subject, writing: "The fossil macaques of the circum-Mediterranean region have been given about a dozen nominally distinct species designations, but in fact only a few, if any, are significantly distinguishable morphologically from the living *M. sylvanus*, let alone from each other". Similar remarks about the taxonomy were made subsequently by Fladerer (1991), Rook *et al*. (2001), Zapfe (2001) and Alba *et al*. (2008, 2011). An interesting remark

was made by Zapfe (2001, p. 893), who wrote in his publication on the Untermassfeld *Macaca* (translated from German): "As can be deduced from the above explanations, the teeth from Untermassfeld show neither morphological criteria nor criteria in size and proportions that may distinguish them with certainty from recent *Macaca sylvanus sylvanus* L. (? proportions of P_4). It is, however, quite probable that the geologically relatively old material from Untermassfeld belongs to an already known subspecies from the Pleistocene. The question can however not be resolved with the scanty material and the present state of our knowledge. Therefore, the teeth from Untermassfeld should be indentified as *Macaca sylvanus* ssp. indet."

We wish to add a general note to this conclusion. First, we would prefer to adhere to the principle that if things (in this case, fossils) are not different, they are identical. (This principle is popularly expressed in the proverb 'if something looks like a duck, walks like a duck, and quacks like a duck, it is most probably a duck'.) Therefore, we agree with the identification of the Untermassfeld material as *Macaca sylvanus* as such. But, secondly, the stratigraphical disclaimer and the suggestion of an as yet unnamed subspecies that Zapfe then add, seem superfluous. Vertebrate species can survive for several millions of years in relatively unaltered state; they may show some variations over time, just as they may reflect regional (geographic) variations. Sometimes such variations are taxonomically expressed as subspecies, but the subspecies concept is a biological concept that is preferably to be avoided in palaeontology. The age difference between the Untermassfeld macaques and the recent ones is around 'only' 1 million years, which is well within the possible lifespan of a taxonomic mammal species.
Adhering to the above principle, we prefer to identify our middle and late Pleistocene macaques from the North Sea Basin as *Macaca sylvanus*, without a subspecific epithet.

5. CONCLUSIONS

Three finds of a cercopithecine monkey from the beaches of Maasvlakte 2 and Hoek van Holland and originally originating from the North Sea can be attributed to the Barbary macaque, *Macaca sylvanus*. The absence of rocky outcrops in the area suggests that the animals that prefer to climb to elevated spots, lived in a (at least partly) forested area. The age of the fossils is difficult to assess. The mandible fragment with M_3 could be of Eemian (MIS 5e) age; the two isolated teeth may be older. Moist and temperature balancing Atlantic climate influences controlled one or even more advances of *Macaca* from the Mediterranean area to NW Europe and the North Sea region.

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