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Europe's last anthracothere (*Artiodactyla*, *Mammalia*) from Ribolla (MN 12) Italy

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Abstract

Anthracotheres are generally considered to have gone extinct in Europe at the end of the early Miocene (summit MN 4 to base MN 5, Burdigalian) whereas they persisted in Africa until the latest Miocene and in India into the Pleistocene. However, in 1910, Stehlin described an anthracothere upper molar in a fragment of maxilla, reported to be from Monte Massi (Casteani) Italy (late Miocene - Turolian): *Anthracotherium* (?) *meneghinii* but its affinities have remained elusive ever since its description, partly due to the fact that the specimen is poorly preserved and the only tooth is deeply worn. The fossil has been described as being somewhat larger than *Microbunodon*. Herein, an additional fossil anthracothere fossil is described from the lignites of Ribolla, Italy. It comprises a left mandible fragment with well-preserved m/3 and the roots of m/2. It represents a hitherto unknown genus and species of anthracothere, probably related to *Microbunodon*, and proves the presence of this family of mammals in Europe at the end of the Miocene (Turolian, MN 12).

Key Words :- Anthracotheriidae, Biogeography, Biochronology, Palaeoecology, University of Florence

Introduction

A widespread view in European mammalian palaeontology is that the family Anthracotheriidae went extinct in the continent at the end of the early Miocene (Burdigalian) (Antunes & Ginsburg, 2003) although Van der Made (1999) postulated that *Anthracotherium*? persisted into the late Miocene in Tuscany as part of an island fauna (Hürzeler, 1982). The family is well represented in the Eocene and Oligocene deposits of Europe (Stehlin, 1910) but the disappearance of *Brachyodus* at the end of MN 4 has long been considered to be of biostratigraphic importance, the teeth of the genus being easily recognised on account of their dimensions and the presence of wrinkled enamel. The family persisted in Asia until the Pleistocene (*Merycopotamus* Falconer & Cautley, 1836) and in Africa until the latest Miocene (*Libycosaurus*, Bonarelli, 1947).

In the Sezione di Geologia e Paleontologia., Museo di Storia Naturale, Università di Firenze, previously known as the Istituto di Geologia di Firenze (IGF) there is a mandible of a small anthracothere with bunodont dentition from Ribolla (Figs 2-3). The m/3 in the mandible is well-preserved and is only lightly worn, and it confirms the presence of an anthracothere in the late Miocene of Europe.

The aim of this paper is to describe and interpret the systematic position, palaeoecology and palaeobiogeography of the small anthracothere mandible from Ribolla.

Locality, Geological context and Age

The fossil described herein was collected from the Lignite picea (good quality lignite) in the Ribolla Mine (labels with the specimen) (Fig. 1, 2). Ribolla was one of a series of lignite mines in Tuscany, others being Baccinello, Montebamboli and Casteani (Benvenuti et al. 1999a, 1999b, 2001, 2015; Rook et al. 2000, 2011; Rook, 2016). The exact level from which the fossil was collected is not known, but the preservation of the specimen indicates that it was preserved in lignite. The lignites in the Baccinello-Cinigiano Basin have been correlated to the late Miocene on faunal grounds, and they occur within a thick pile of sedimentary deposits that, according to palaeomagnetic stratigraphy, span the period +8.1 Ma (base of V1 level) to 6.4 Ma (top of V3 level) (Rook et al. 2011). Levels V1 and V2 yielded the enigmatic ape-like *Oreopithecus bambolii*, whereas by the onset of the V3 level at 6.7 Ma, this hominoid is considered to have gone extinct. According to one of the referees, there is a

possibility that the anthracothere fossil was not from Ribolla, but from another occurrence of lignite, possibly of Oligocene age. For the purposes of this paper we accept that the labels accompanying the fossil accurately record its provenience.

The fauna from Ribolla has been discussed by several authors (Merciai, 1907; Del Campana, 1918; Hürzeler, 1982; Kotsakis, 1984a; Gentili et al. 1998; Abbazzi et al. 2008) and the general opinion is that the deposits that yielded the fossils are of late Miocene age (Turolian, MN 12).

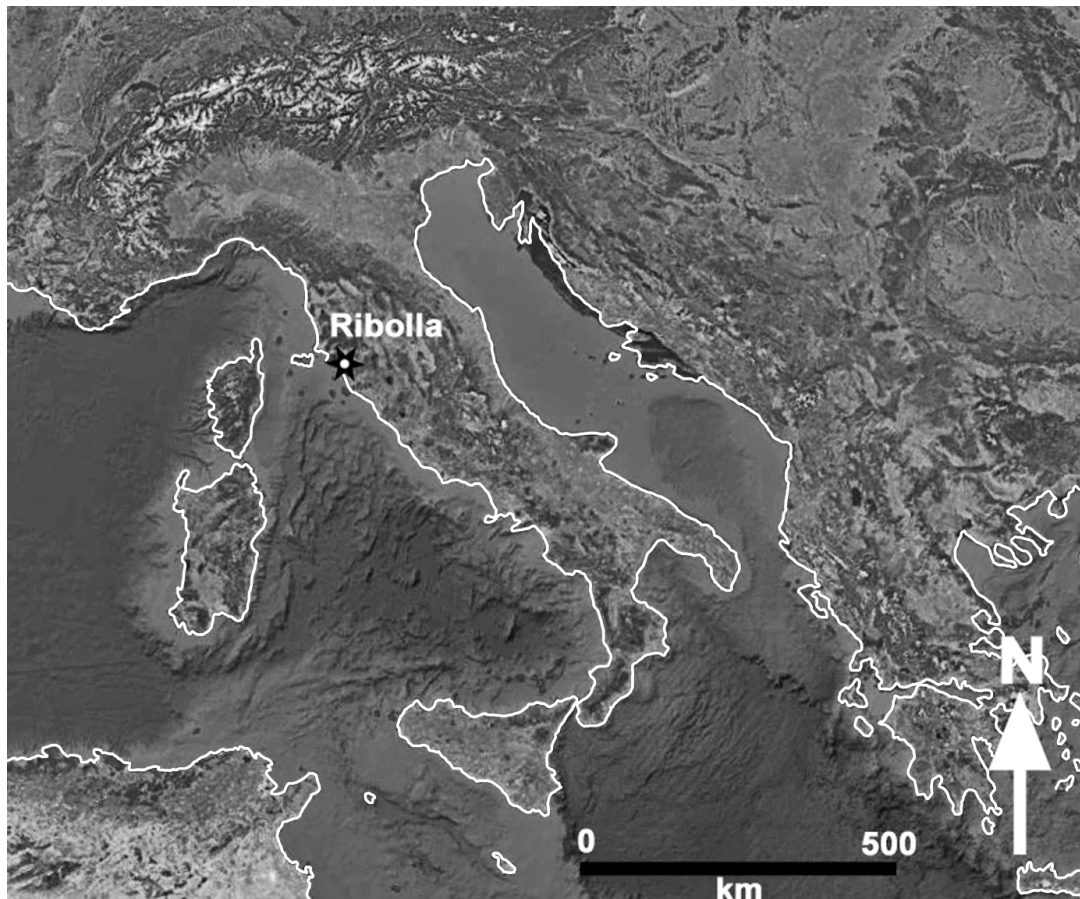


Figure 1. Location of Ribolla, Italy (Turolian, MN 12).

Material and Methods

I am indebted to E. Cioppi (Universita di Firenze) for the following information about the fossil anthracothere from Ribolla and for images of the labels and the original fossil.

The specimen is curated at the University of Firenze under catalogue number IGF 3988 (IGF is an abbreviation of « R. Istituto Geologico Firenze », and is still used for the catalogue of specimens, even though the name of the institute has changed to Sezione di Geologia e Paleontologia. Il Museo di Storia Naturale)

The specimen is a fragment of mandible containing a complete m/3 and a fragmentary m/2. Labels with the fossil indicate that it was collected from the lignite mine at Ribolla which was active from 1870 until 1954, when the mine was closed following a disaster. At this mine, *lignite picea* (good quality lignite) was extracted.

Two of the labels with the specimen are old, there is no year written on them, but « N° 3988 » is an old number in the catalogue, suggesting that the entry was made sometime during the years 1870-1880

(Fig. 2). One label attributes the fossil to *Sus cherodes* (sic) Pomel, and has « Miocene, Ligniti di Ribolla » written on it. The second label identifies the specimen as "Suide ind. Miocene. Ligniti di Ribolla". Alterations to the second label comprise two corrections concerning its identification: the first is in pencil "*Listriodon* n.sp." in the handwriting of Dr A. Azzaroli. There is a line scored through the names, correcting both to "Anthracotheride. Hü." (evidently J. Hürzeler). A third label mentions IGF 3988 and M 173 (= mould 173).

Images of the original fossil and the cast have been prepared.

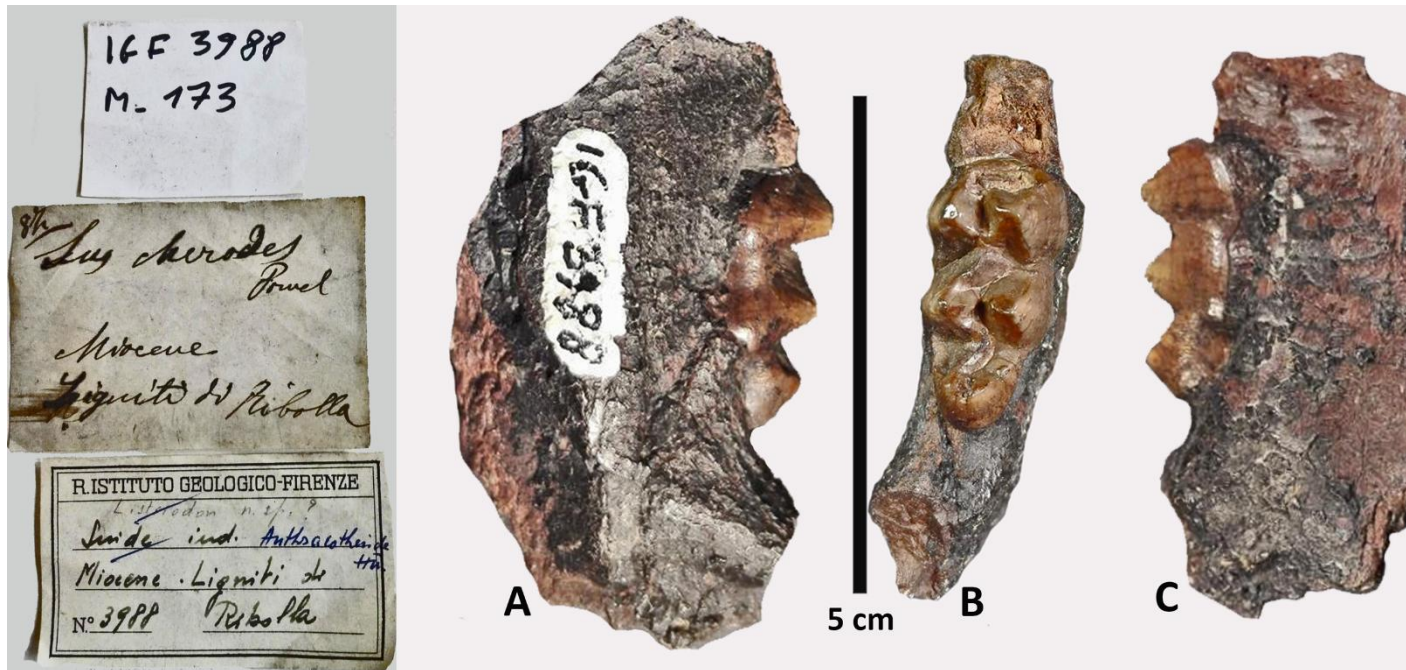


Figure 2. Labels associated with the holotype of *Etruscotherium ribollaense*, gen. et sp. nov. The lower and middle labels in black ink date from the late 1800's, the lower one with additions in pencil by A. Azzaroli and in blue ink by J. Hürzeler. The top label refers to the mould from which cast was made. A) buccal, B) occlusal, and C) lingual views of original fossil (images courtesy E. Cioppi).

Systematic Description

Order Artiodactyla Owen, 1848

Family Anthracotheriidae Gill, 1872

Genus *Etruscotherium* nov.

Diagnosis :- Small anthracothere with relatively bunodont dentition; in m/3 no junction between the preentocristid and prehypocristid; distal opening of the valley between the hypoconid and entoconid narrow, slit-like; slightly subdivided hypoconulid; hypoconulid located in mid-line of the tooth; lightly wrinkled enamel

Species *Etruscotherium ribollaense* nov.

Diagnosis :- As for genus, m/3 +/- 27 mm long.

Derivatio nominis :- *Etruscotherium* combines the root *Etrusco* (for the ancient Etruscan civilization of Central Italy) and *therium* - Greek for beast. The species name is for Ribolla, the type locality.

Type specimen :- IGF 3988, left mandible fragment with roots of m/2 and complete m/3.

Age :- Turolian : MN 12 (Kotsakis, 1984a, 1984b), between 8.1 and 6.4 Ma (Rook et al. 2011).

Description

The left mandible from Ribolla (IGF 3988) contains the roots of m/2 and a complete, lightly worn m/3 (Figs 2-4). There is a long retromolar space, the mandible is slightly broader than the molars, but the base of the jaw is missing so its depth cannot be measured.

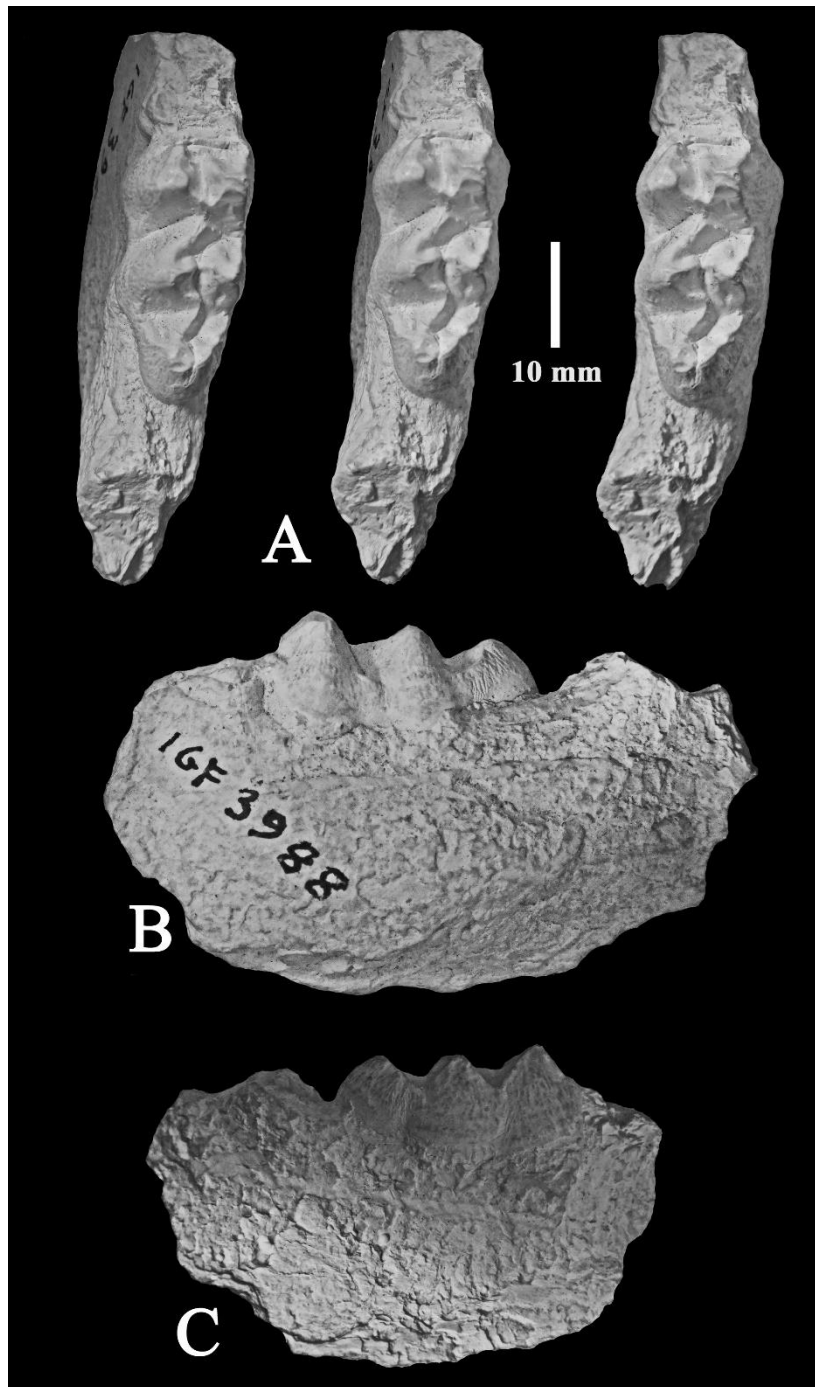


Figure 3. IGF 3988, cast of mandible of *Etruscotherium ribollaense* from Ribolla, Italy (MN 12). A) stereo occlusal views, B) buccal view, C) lingual view (scale : 10 mm).

The m/2 was about 12 mm broad at the posterior lophid and the length would have been ca 18 mm (estimated from the broken roots). The m/3 is 27.0 mm long, 14.0 mm broad at the first lophid, 13.2 mm at the second lophid and 9 mm at the third lophid.

The crown of the m/3 is comprised of three lophids, the mesial and central ones each with two cusps, and the third with a single centrally positioned cusp. The mesial lophid (protoconid and metaconid) is slightly broader than the second lophid (hypoconid and entoconid) which, in its turn, is much broader than the third lophid (hypoconulid). There is a mesial cingulid (partly broken away). The enamel of the tooth is lightly wrinkled.

The protoconid has two prominent crests (preprotocristid and postprotocristid) both of which descend from the apex of the cusp towards the midline of the tooth. The metaconid likewise has two crests which lead towards the midline, the premetacristid stopping short of the preprotocristid, and the postmetacristid coalescing with the postprotocristid to wall off the rear of the trigonid basin. In addition to these main crests, the protoconid has a subtle posterior crest that descends vertically towards a small remnant of buccal cingulum in the anterior transverse valley, while the metaconid has a mesiolingual cristid that descends towards a small stylid at the mesio-lingual corner of the tooth, and a distolingual cristid that descends towards the lingual end of the anterior transverse valley, terminating close to a tiny pimple of enamel at the end of the valley. In distal view, the posterior part of the mesial lophid shows a pattern of four crests analogous to the M-structure that characterises tragulid lower molars (Fig. 4).



Figure 4. Oblique distal stereo view of a cast of the left m/3 of *Etruscotherium ribollaense*. The arrow points to the M-structure on the distal face of the mesial lophid. Note the slit-like distal opening of the basin between the hypoconid and entoconid (second lophid) and the slight subdivision of the hypoconulid (note the wrinkled enamel) (scale at hypoconulid : 10 mm).

The hypoconid has three crests, a prehypocristid that descends mesiolingually towards the centre-line of the tooth, forming a prominent wall in the middle of the anterior transverse valley. The posthypocristid descends into the middle of the posterior transverse valley where it coalesces with a cristid emanating from the hypoconulid, thereby forming a wall in the centre of the posterior transverse valley. Finally the hypoconid has a third swollen cristid that descends into the talonid basin, almost subdividing it into two. The entoconid has three cristids. The mesiolingual entocristid runs mesially ending close to the postmetacristid, but without joining it. The distolingual entocristid is directed steeply distally, but does not block the posterior transverse valley. The preentocristid, which is swollen, extends mesio-buccally towards the anterior transverse valley. The hypoconulid is centrally positioned and has a weak subdivision at its apex, expressed as a narrow groove on its mesial and distal surfaces. From the buccal half of the hypoconulid, there is a swollen cristid (prehypocristulid) leading mesio-lingually, subdividing the posterior transverse valley into two halves. The same buccal part of the hypoconulid has a low cristid that extends from its apex along the buccal side of the crown terminating at the base of the hypoconid. The lingual part of the hypoconulid forms a crest (posthypocristulid) which extends to the base of the entoconid.

In side view, the apices of the protoconid, hypoconid and hypoconulid are observed to be at the same height. The tooth is thus bunodont, but with slight selenodont and cristodont tendencies.

Discussion

The morphology and dimensions of the m/3 in the Ribolla mandible show some resemblances to specimens of *Microbunodon* Depéret (1908) from Pakistan, notably *Microbunodon milaensis*, but there are significant differences (Fig. 5, 6, Table 1). The bunodont morphology of the tooth from Ribolla is radically different from the selenodont molars of *Merycopotamus* and *Libycosaurus* (Fig. 5).

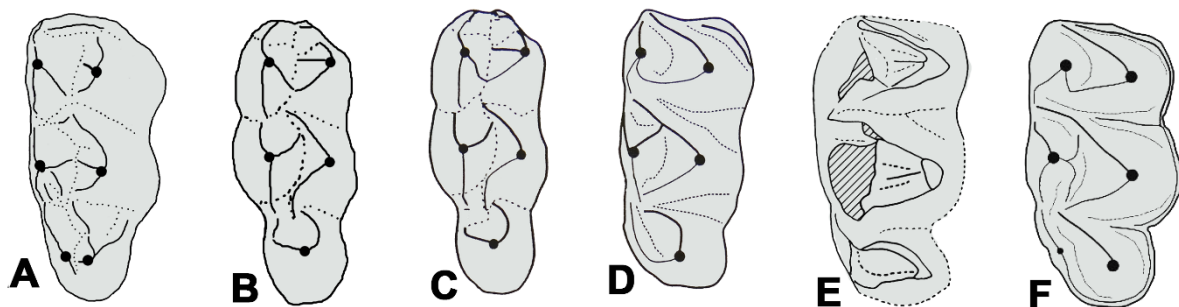


Figure 5. Morphology of right m/3s of Mio-Pliocene anthracotheres. A) *Etruscotherium ribollaense* (left m/3 reversed), B) *Microbunodon milaensis* (image modified from Lihoreau et al. 2004), C) *Microbunodon silistrensis* (image modified from Lihoreau (2003), D) *Merycopotamus pusillus* (image modified from Lihoreau, 2003), E) *Merycopotamus dissimilis* (image modified from Tsubamoto et al. 2012), F) *Libycosaurus garhi* (image modified from Lihoreau et al. 2014). For ease of comparison, the images have been brought to the same length. Note the relatively short precrisids and postcrisids on the protoconids and hypoconids of *Etruscotherium* (A) and *Microbunodon* (B, C) which terminate close to the midline of the crown, contrasting with the elongated cristids in *Merycopotamus* (D, E) and *Libycosaurus* (F) which extend well towards to the lingual margin of the crown.

Lihoreau et al (2004) described the lower molars of *Microbunodon milaensis* in the following terms :- « Junction between preentocristid and prehypocristid. Distally open longitudinal valley between hypoconid and entoconid. Looplike hypoconulid on m/3, centred on longitudinal axis of tooth and mesiodistally expanded. No entoconulid ». The Ribolla tooth has no junction between the preentocristid and the prehypocristid, the two crests being separated by a narrow groove and the hypoconulid is not mesio-distally expanded but is appreciably shorter than the second lophid. Similarities to, and differences from, *Microbunodon milaensis* are listed in Table 1.

Table 1. Comparison of morphology of the m/3s of *Microbunodon milaensis* and *Etruscotherium ribollaense*.

Character	<i>Microbunodon milaensis</i>	<i>Etruscotherium ribollaense</i>
Junction between preentocristid and prehypocristid	Yes	No
Distally opened longitudinal valley between hypoconid and entoconid	Yes	Yes, but slit-like
Loop-like hypoconulid on m/3	Yes	No, subdivided
Hypoconulid centred on longitudinal axis of tooth	Yes	Yes
Hypoconulid mesio-distally expanded	Yes	No, short

Comparison of the Ribolla fossil with the Briatexte (Tarn, France) mandible described by Astre (1926) as *Brachyodus porcinus*, reveals some differences. Among them the hypoconulid is distinctly subdivided into two parts by a deep, obliquely oriented mesio-distal groove (which produces a seleno-like hypoconulid) (Pickford, 2020), whereas in *Etruscotherium*, the groove is shallow and narrow.

The fossils from St Henri, France, attributed to *Brachyodus borbonicus* by Geais (1934) but more likely representing a *Bothriodon*, show the prehypocristid crossing the crown almost to the lingual margin of the tooth, much as in *Sivameryx*, *Merycopotamus* and *Libycosaurus* (Fig. 5) The teeth of this species are thus appreciably more selenodont than those of *Etruscotherium*.

There are some similarities between the m/3s of *Etruscotherium* and *Myaingtherium* Tsubamoto et al. 2011, from the Eocene Pondaung Formation of Myanmar, but the hypoconulid in the latter genus is clearly subdivided into two parts (buccal cusp of hypoconulid and entoconulid), unlike the narrow, shallow groove that subdivides the hypoconulid of *Etruscotherium*. In addition, the M-structure on the distal face of the first lophid (distobuccal protocristid and distolingual metacristid) is more clearly expressed in *Myaingtherium*. One can postulate rather similar diets for *Myaingtherium kenyapotamoides* and *Etruscotherium ribollaense*.

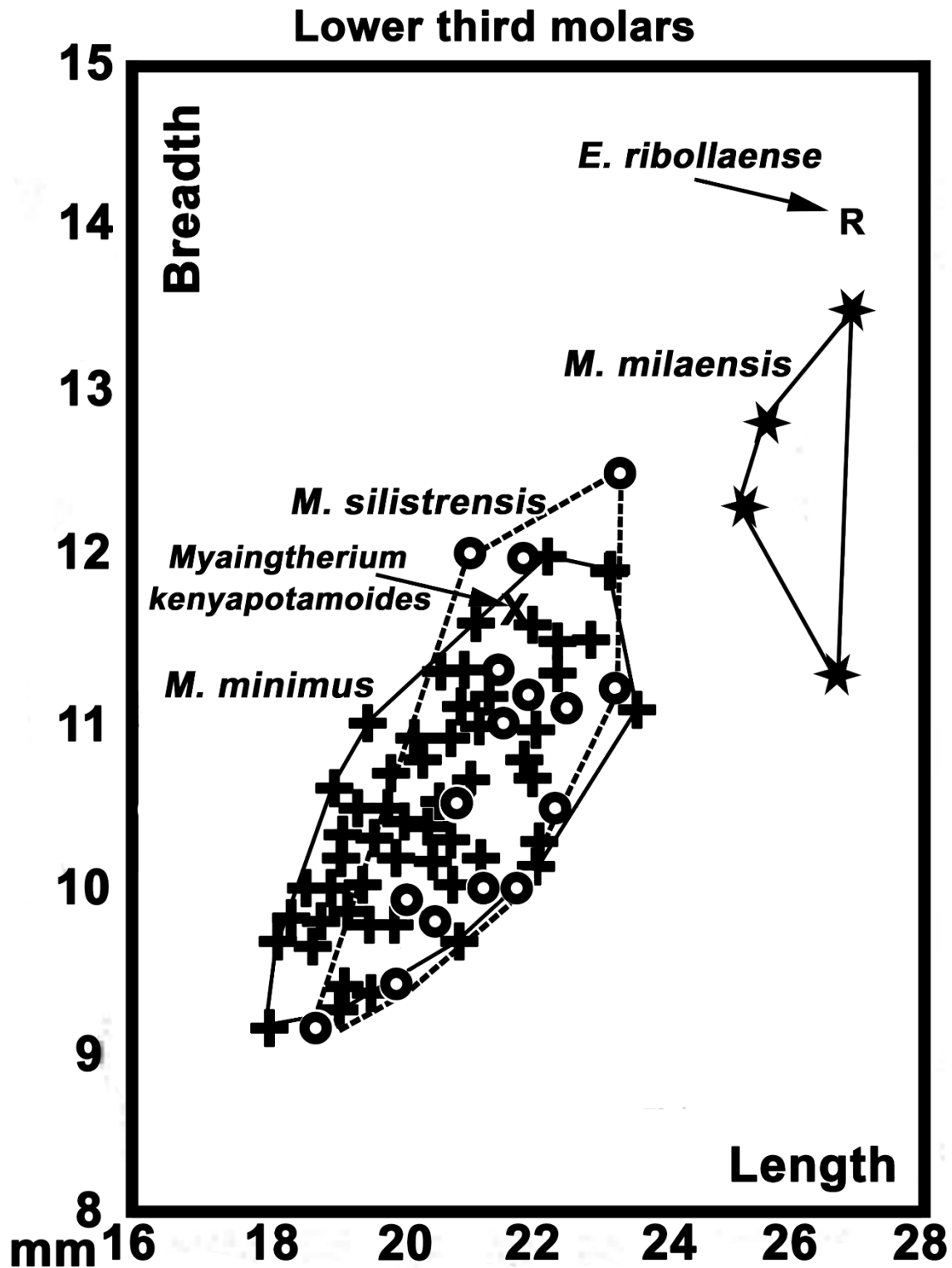


Figure 6. Bivariate (length-breadth) plots of m/3s of small anthracotheres, *Microbunodon minimus* (Cuvier, 1822) from Europe (+), *Microbunodon silistrensis* (Pentland, 1828) from the Indian Subcontinent (O), *Microbunodon milaensis* (Lihoreau et al. 2004) from Pakistan (star), and *Etruscotherium ribollaense* from Italy (R) (Data for *Microbunodon* is from Lihoreau et al. 2004; that for *Myaingtherium* (x) is from Tsubamoto et al. 2011).

In 1910, Stehlin described a maxilla fragment with a worn and damaged upper second molar from the Miocene lignite of Grosseto (Monte Massi) housed in the Museum in Pisa, Italy (Fig. 7) (the current whereabouts of the fossil are not known). He called it *Anthracotherium* (?) *meneghinii* and remarked that it was a complete anachronism, an allusion to the commonly held view that anthracotheres went extinct in Europe during the early Miocene. This fossil had previously been mentioned by Forsyth Major (1872) who thought the maxilla might represent a juvenile individual with a deciduous tooth. Hurzeler (1958, 1975) considered that the fossil came from a greenish silty-sand deposit beneath the lignites, rather than from the lignite. The history of study of this fossil was summarised by Kotsakis (1984a) who concluded that it was unlikely to have been collected from Casteani. Until further research is done, the provenience of this fossil will remain in doubt. Given the uncertainty about the affinities and provenience of the holotype of *Anthracotherium* (?) *meneghinii* allied to doubts concerning the meristic position of the tooth that it contains, it is recommended that the name should apply only to the type specimen (i.e. it is a nomen vanum).

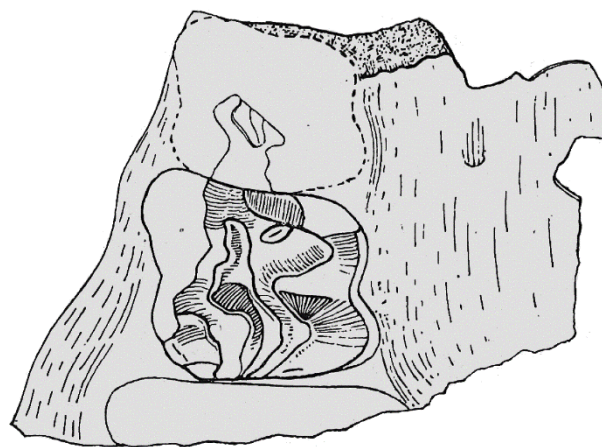


Figure 7. Sketch of the holotype right maxilla fragment of *Anthracotherium*(?) *meneghinii* Stehlin (1910) from Monte Massi (Casteani), Italy. Occlusal view of tooth interpreted to be the M2/ with the reconstructed occlusal outline of M1/ and mesial alveolus of M3/. Drawing by Dr Fucini (not to scale).

Kotsakis (1984a, 1984b) suggested that, if the maxilla described by Stehlin (1910) really did come from Miocene deposits then its affinities might lie with *Merycopotamus* in the sense of the North African records of this genus (Black, 1972, 1978) which are today recognised as being distinct from the Indian members of the genus, the Libyan, Chadian, Tunisian, Algerian and Ugandan material being attributed to *Libycosaurus* Bonarelli, 1947 (Pickford, 1991a, 1991b, 2005, 2006; Lihoreau et al. 2014). The hypothesis of a relationship between *Anthracotherium* (?) *meneghinii* and *Libycosaurus* can be discarded because the latter genus has much more selenodont, quadricuspidate molars and is considerably larger.

Hernandez-Pacego & Dantin Cereceda (1915) published detailed descriptions of teeth, jaws and post-cranial elements of *Listriodon splendens* from Cerro del Ortero, Spain, attributing the fossils to the large subspecies *major*. The authors also discussed and illustrated what they considered to be an unknown artiodactyl. H.G. Stehlin (in Hernandez-Pacego & Dantin Cereceda, 1915) in a written communication to the authors commented that, after examining casts of the latter specimens, he considered that they showed affinities to *Hyopotamus* and more particularly to a specimen from Monte Massi, Italy, that he had identified as *Anthracotherium?* *Meneghinii* (sic) but probably representing a new genus of anthracothere. In fact all the Spanish fossils concerned are juveniles of *Listriodon splendens major* and are not in any way related to anthracotheres.

Comparisons between *Etruscotherium ribollaense* and the bunodont tragulid *Dorcabune anthracotherioides* Pilgrim, 1910 (Fig. 8), reveals some similarities such as the bunodont morphology of the crown and the presence of wrinkled enamel but in detail there are several important differences, so attribution of the Ribolla specimen to Tragulidae can be discounted. However, it is possible that the ecology of *Etruscotherium* could have been rather similar to that of *Dorcabune*, the similarities in dental morphology being an expression of convergent evolution due to selection in two distantly related taxa which have similar diets (in this case probably dominantly frugivorous, but with omnivorous tendencies and some folivory).

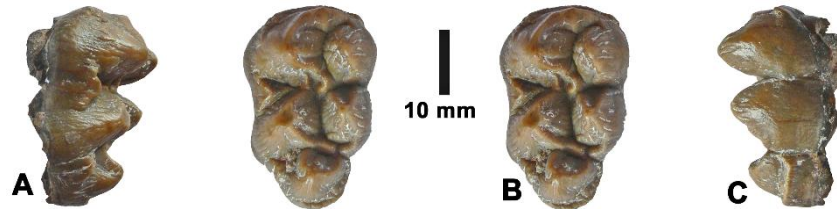


Figure 8. Left m/3 of *Dorcabune anthracotherioides* from the Siwaliks of India, specimen curated in the Wadia Institute of Himalayan Geology, Dehra Dun, India. A) buccal view, B) stereo occlusal view, C) lingual view (scale : 10 mm).

Out of the known Miocene anthracotheres of Asia and Africa, *Etruscotherium* shows the closest affinities to *Microbunodon* from Indo-Pakistan. The highly selenodont molar morphology of taxa such as *Merycopotamus* and *Libycosaurus* is divergent from the bunodont molars of *Microbunodon* and *Etruscotherium*. It is possible therefore, that a lineage such as *Microbunodon* dispersed from Asia to Europe during the late Middle Miocene or early late Miocene, where, in the insular conditions of Tuscany at the time of deposition of the late Miocene faunas, it gave rise to *Etruscotherium*.

Conclusions

A mandible with m/3 from Ribolla, Italy (MN 12, Turolian) is attributed to a new genus and species of anthracothere, *Etruscotherium ribollaense*. Its closest relative is *Microbunodon*, but the differences from this genus are sufficient to warrant creation of a new genus to accommodate it. This is the last documented record of anthracotheres from Europe.

It was previously widely accepted that anthracotheres went extinct in Europe at the end of MN 4 (Antunes & Ginsburg, 2003) and none has been reliably recorded from the middle Miocene and most of the late Miocene. Apart from the doubtfully provenienced holotype of *Anthracotherium? meneghinii*, the Ribolla specimen is the only anthracothere known from the late Miocene of Europe, which suggests that after going extinct in the continent at the end of MN 4, a separate lineage of anthracotheres managed to disperse back to Europe during the late middle Miocene or early late Miocene (broadly Turolian according to Kotsakis (1984a, 1984b). The latter author hinted at relations with North African anthracotheres which survived into the Late Miocene, but in fact the Ribolla specimen reveals closer affinities with *Microbunodon* from the Indian Subcontinent than with *Libycosaurus* from Libya and Tunisia, suggesting a dispersal from Asia to Europe, rather than from Africa to Europe.

Acknowledgements

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