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Equids in Time and Space

Papers in Honour of Véra Eisenmann

Edited by
Marjan Mashkour

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13. Discriminating *Equus* skulls: the Franck's Index and the new Palatal Index

Véra Eisenmann

Assessment of the Franck's Index reliability for discriminating extant Caballine skulls from other extant species. Introduction of the new, more reliable, 'Palatal Index'. Results of their use in fossil Caballines of Eurasia and North America. Discussion of controversial attributions of North American and Eurasian species: E. scotti *and* E. excelsus*,* E. suessenbornensis *,* E. coliemensis *and* E. verae*,* E. ferus *and* E. niobrarensis*.*

Introduction

In equids, various axial lengths of the skull (Fig. 1) seem to maintain reasonably stable reciprocal relations inside specific groups. Moreover, they are little subject to taphonomical distorsions – an important point when dealing with fossils. Relations between two axial segments have proven the most reliable and possibly unique way to separate primitive (*Plesippus* and *Allohippus*) from modern (*Equus*) horses (Eisenmann and Baylac 2000).

Another relation, known as the Franck's Index, is commonly supposed to characterize true (i.e. caballine) *Equus*, and discriminate them from other extant *Equus* (Forsten and Eisenmann 1995). The Franck's Index compares the distance from Staphylion (posterior border of palate) to Hormion (posterior border of vomer), and the distance from Hormion to Basion (anterior border of foramen magnum). In true horses, contrary to Asses and Donkeys, the latter is longer than the former.

Contrary to common belief, the discrimination of Caballines versus other species is not so simple. It seems thus appropriate to present the results of simple comparisons based on rich and reliable samples of all extant (or very recently extinct in the case of Hemippes and Cape Quaggas) specific groups for the Franck's Index and for another combination that may be called the 'Palatal Index'. The Palatal Index compares the palatal length (between a line uniting the anterior borders of P2 and the Staphylion) to the distance from Staphylion to Hormion (also used for the Franck's Index, Fig. 1).

Extant *Equus*

Material and methods

The data were obtained in various collections (see Acknowledgments) and include Caballines (*E. przewalskii* and *E. caballus*), Asinines (*E. africanus* or Asses and *E. asinus* or Donkeys), Hemiones (Kiangs of Tibet (*E. kiang*), Djiggetais of Mongolia (*E. hemionus hemionus*), Hemippes of Syria (*E. h. hemippus*), Onagers of Iran (*E. h. onager*), Kulans of Turkmenstan (*E. h. kulan*), Khurs of India (*E. h. khur*), Grevy's zebas (*E. grevyi*), Mountain zebras (*E. zebra*), Plains zebras (*E. burchelli*) and Cape quaggas (*E. quagga*). The extant sample comprises more than 600 skulls. Simple scatter diagrams were drawn for both 'Indices'.

Results

By definition, the Franck's Index considers as 'caballine' all skulls where the distance from Hormion to Basion (Fig.1:4) is longer than the distance from Staphylion to Hormion (Fig. 1:3). In other words, on a scatter diagram

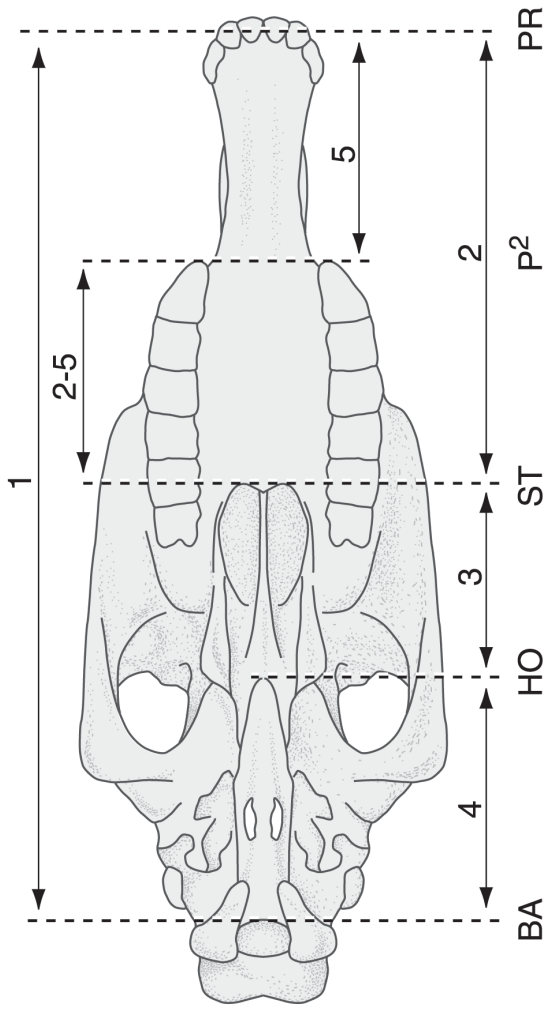

Fig. 1. Schematic ventral view of an Equus *skull. 1: basilar length, from Prosthion (PR : between the I1) to Basion (BA : anterior border of foramen magnum); 2: overall palatal length, from Prosthion to Staphylion (ST : posterior border of the palate); 3: vomero-palatal length, from Staphylion to Hormion (HO : posterior border of Vomer); 4: cranial length, from Hormion to Basion; 5: muzzle length, from Prosthion to a line connecting the front of the second upper premolars (P2); 2 – 5: palatal length, from P2 to Staphylion.*

the boundary line between Caballine and other skulls is "y=x". Figure 2 shows that this line leaves just a few Caballines wrongly placed among 'Other'. Unfortunately, the overlap is considerable and quite a great number of 'Other' are wrongly placed among Caballines.

In Caballines, the Palatal length (Fig. 1:2–5) is always longer than the distance between Staphylion and Hormion (Fig. 1:3) but again, many 'other' skulls are placed on the caballine side of y=x. If, however, this boundary line is shifted up the y axis, the overlap is reduced. In Figure 2, the boundary line, tentatively placed 20mm up ("y=x+20"), separates quite well caballine from other species. This rough discrimination will no doubt be refined by statistical elaboration, but for all practical purposes, the new Palatal Index may already prove useful as it is.

Tables 1 and 2 give the observed number of caballine Franck's and Palatal indices and their percentages for various taxa. Were classified as 'caballine' according to Frank's Index the skulls where measure 3 is ≤measure 4. Were classified as 'caballine' according to Palatal Index the skulls where measure 3(in mm) + 20mm is ≤measure 2–5.

Table 1 and Figs 2 – 7 (left side) show that Asinines and Caballines (Fig. 2) are the only specific groups very well separated by the Franck's Index. According to it, the recently extinct Cape Quaggas would be 'caballine', and so would be most of Plains zebras (Fig. 6). Grevy's and Mountain zebras (Figs 5 and 7) have caballine proportions in about 50%, Hemiones and Kiangs – in about 15% (Fig. 4).

Table 2 and Figs 2–7 (right side) show that, using the Palatal Index, the percentages of correct identifications is less for caballine skulls but notably better for all other extant species except Asinines (1,1% of 'caballine' instead of 0%).

Another interesting point is that the Palatal Index may be used when the posterior – cranial – part of the skull is missing or damaged while the Franck's Index may be used in the opposite case – when the damage concerns the anterior – facial – part of the skull. Thus, the indices are somewhat complementary and may be alternatively used in fragmentary skulls, keeping in mind the restrictions noted above.

Holocene and Pleistocene caballine skulls

Material

The attribution to the caballine specific group is beyond any discussion for historic domestic horse skulls. The sample includes skulls of Kurganes (Ukraine) and Iron Age skulls (France and Switzerland). There are no problem either with the Pleistocene skulls of Europe usually referred to *E. chosaricus* (Volga: Russia), *E. gallicus* (Jaurens, Le Quéroy, Siréjol, Aven Valérie: France), to *E. latipes* (Mezin: Ukraine), to *E. antunesi* (Fontainhas: Portugal and Val di Chiana: Italy), or the probably Late Pleistocene specimens of Siberia, usually referred to *E. lenensis*, and of Alaska and Yukon, including the types of *E. alaskae* and *E. lambei*. The problem of the mid-Pleistocene *E. cf. scotti* skull of northeastern Siberia will be discussed later. The total sample amounts to about 100 fossil skulls studied in various collections (see Acknowledgements).

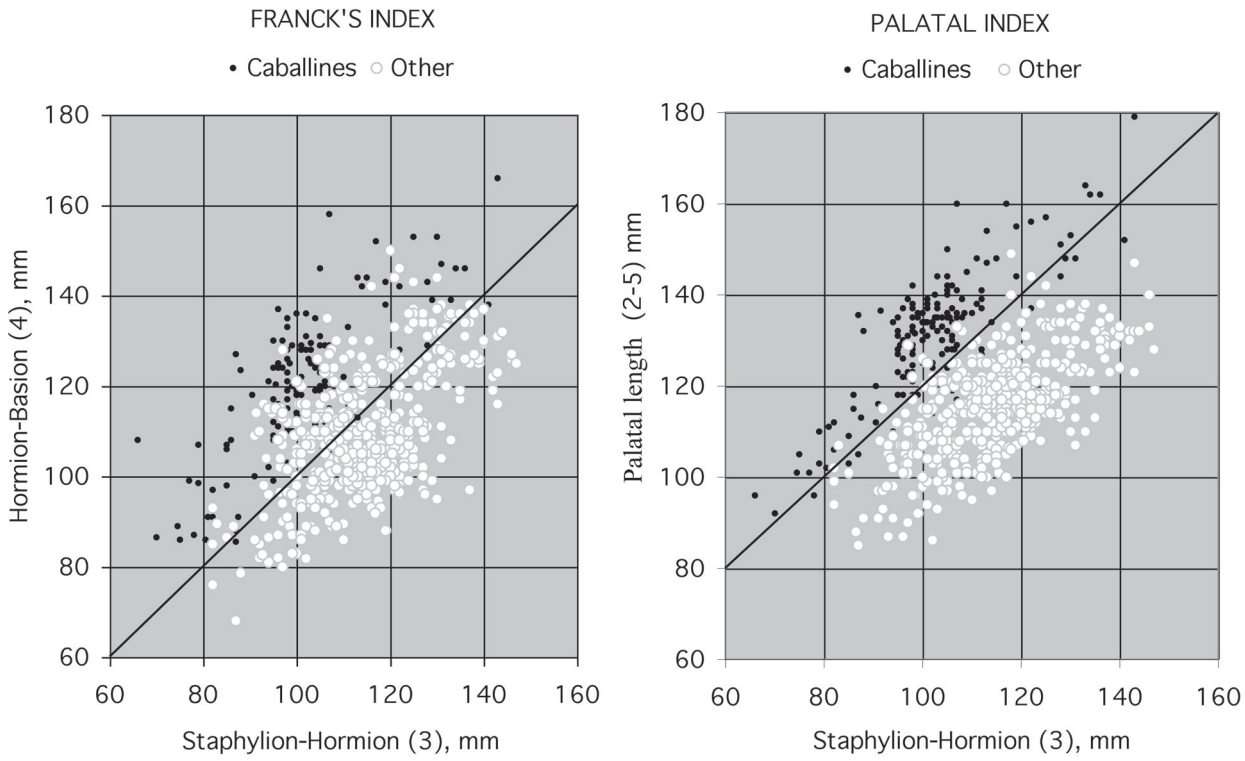

Fig. 2. Franck's and Palatal Indices in extant Caballines and other extant species of Equus.

Table 1. Occurrence of caballine Franck's indices (n caballine) in extant Equus. *n: total number of observations.*

	n	n caballine	%
E. caballus and *E. przewalskii*	156	151	96.8
E. quagga	12	12	100
E. burchelli	57	46	80.7
E. zebra	87	45	51.7
E. grevyi	59	29	49.2
E. hemionus	125	21	16.8
E. kiang	36	5	13.9
E. asinus and *E. africanus*	94	0	0.0
Fossil Caballines	96	94	97.9

Table 2. Occurrence of caballine Palatal indices (n caballine) in extant Equus. *n: total number of observations.*

	n	n caballine	%
E. caballus and *E. przewalskii*	161	141	87.6
E. quagga	12	4	33.3
E. burchelli	57	0	0,0
E. zebra	89	0	0,0
E. grevyi	59	3	5.1
E. hemionus	122	5	4.1
E. kiang	39	0	0,0
E. asinus and *E. africanus*	93	1	1.1
Fossil Caballines	106	100	94.3

Results

Tables 1 and 2 show that both indices are caballine for more than 90% of the skulls *a priori* identified as such, and that the Franck's Index gives a higher percentage (about 98%) of correct attributions than the Palatal Index (about 94%).

Are placed as 'not-caballine' by the Franck's Index two skulls of Alaska (AMNH 30702 and 60021). Six skulls have not-caballine indices according to the Palatal Index. Two of them come from Alaska (AMNH 60003 and the type of *E. alaskae*), one from Siberia (PIN 301–53), one from Missy, Russia (MGRI 1842), one from Val di Chiana, Italy (VDC 13963), and one (historic) from Chalon, France (82–25–68). After other data on these skulls were checked, it appeared that they do belong to true Caballines and must therefore be considered as wrongly determined by the indices.

For both indices, the percentages of 'correct' identifications is slightly higher in fossils than in extant Caballines.

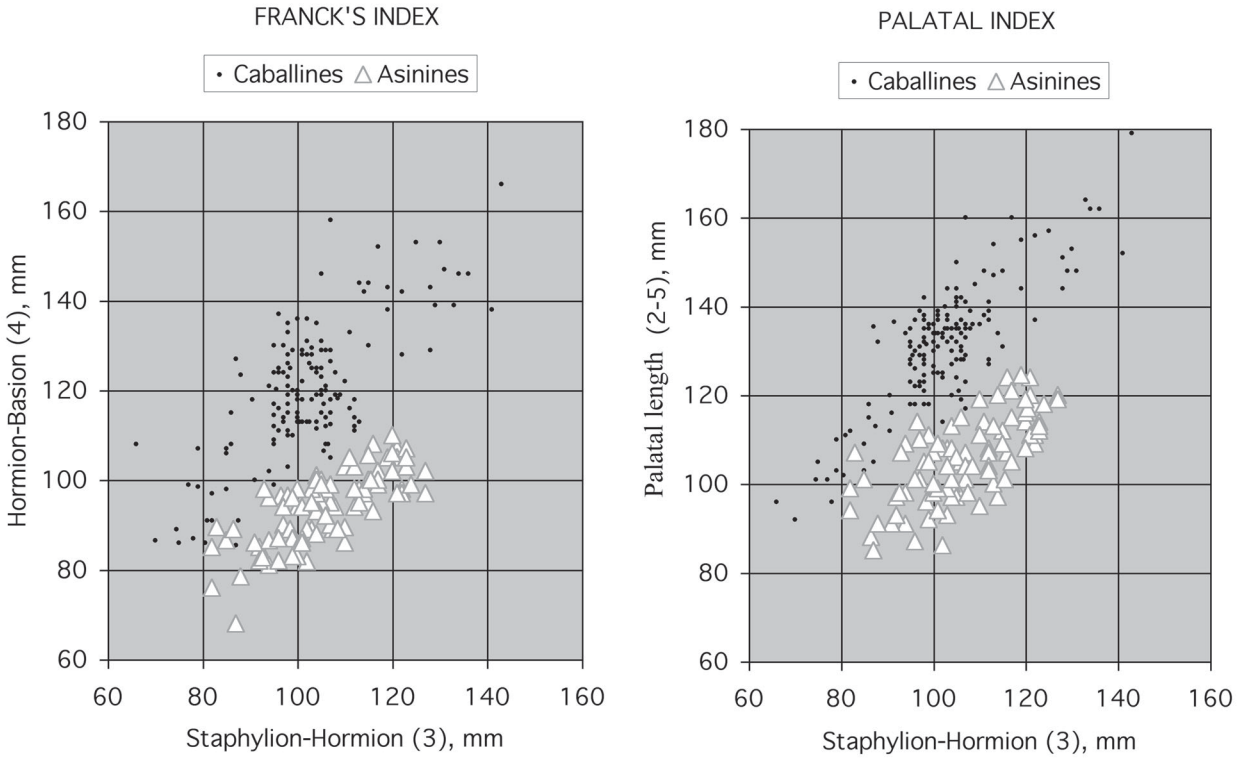

*Fig. 3. Franck's and Palatal Indices in extant Caballines and Asinines (*E. africanus *and* E. asinus*).*

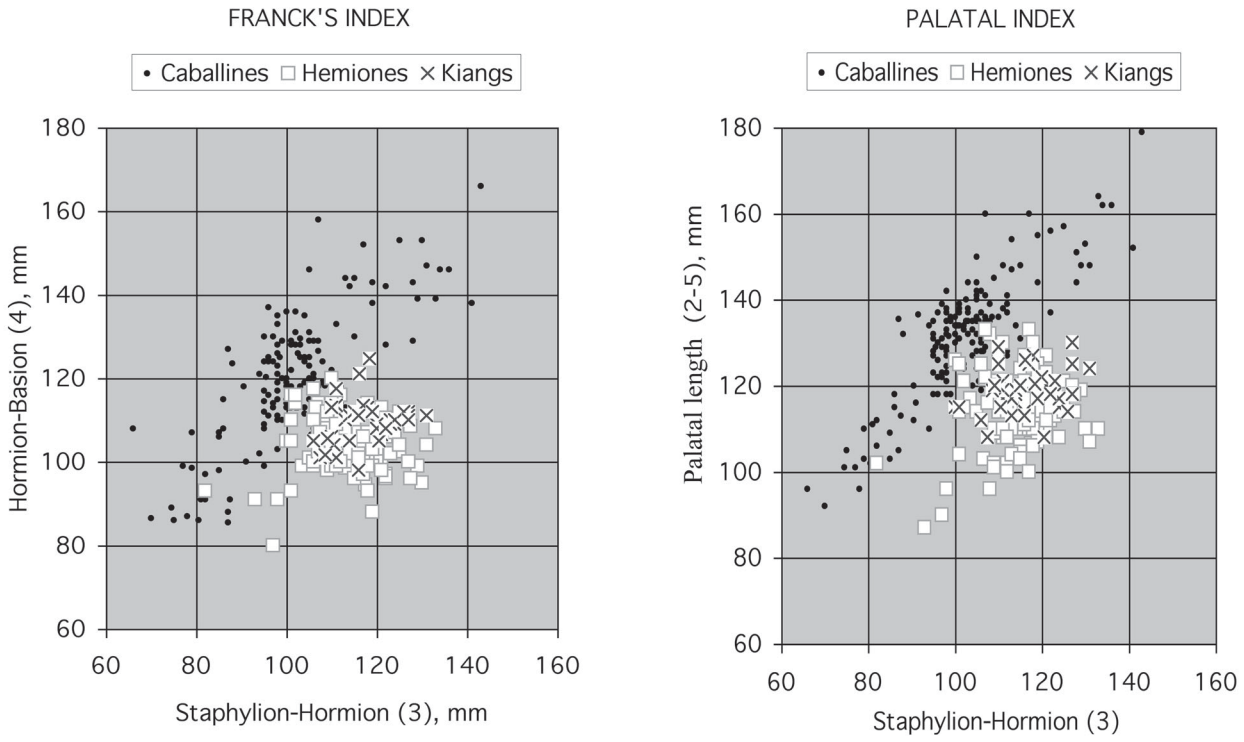

*Fig. 4. Franck's and Palatal Indices in extant Caballines and Hemiones (*E. hemionus *and* E. kiang*).*

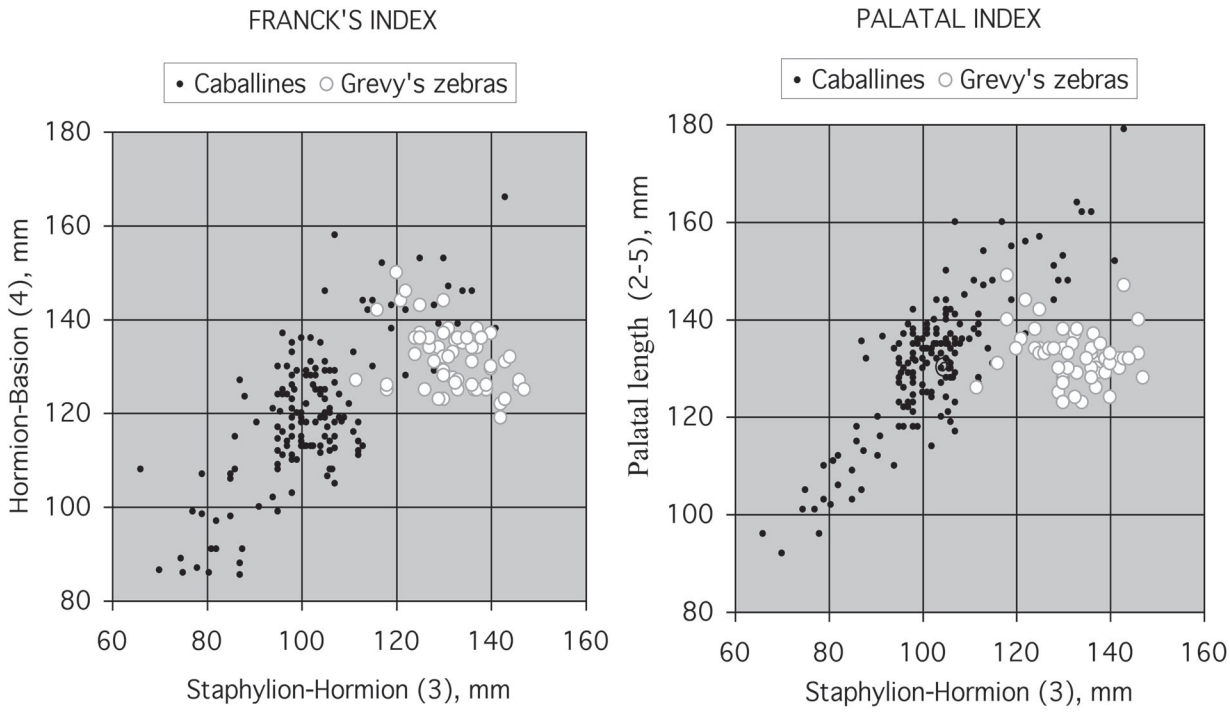

*Fig. 5. Franck's and Palatal Indices in extant Caballines and Grevy's zebras (*E. grevyi*).*

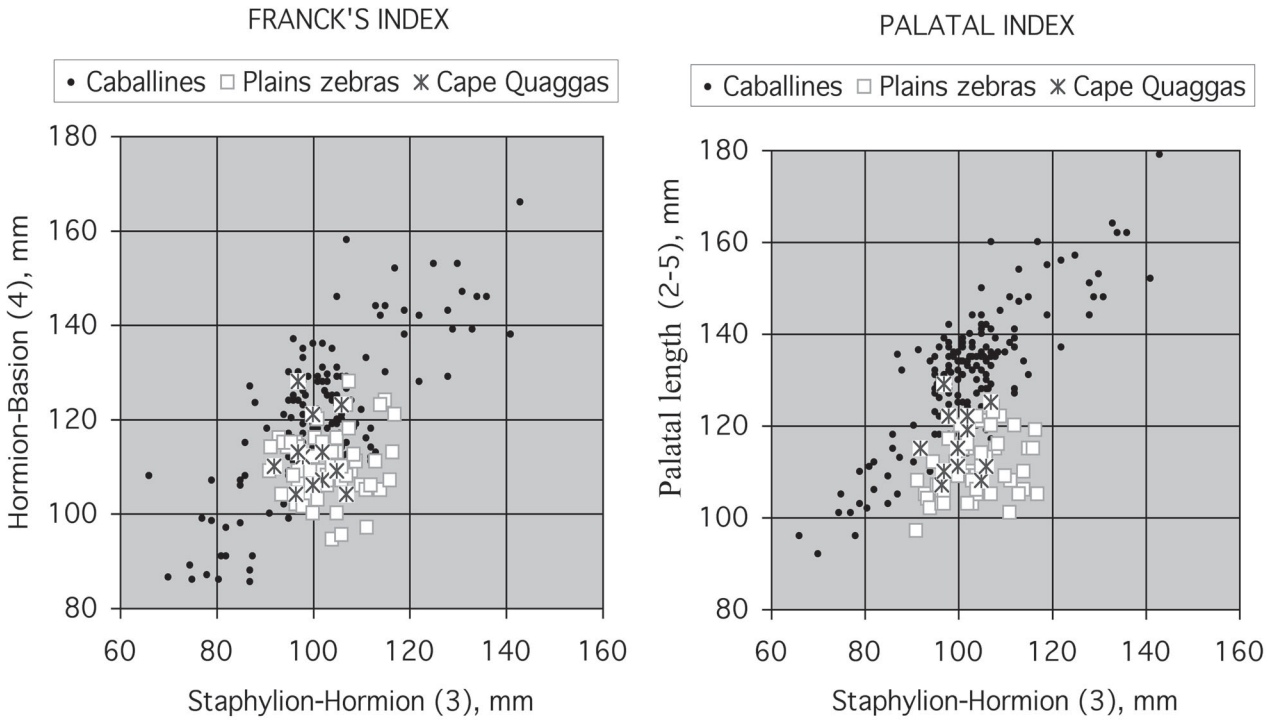

*Fig. 6. Franck's and Palatal Indices in extant Caballines, Plains zebras and Quaggas (*E. burchelli *and* E. quagga*).*

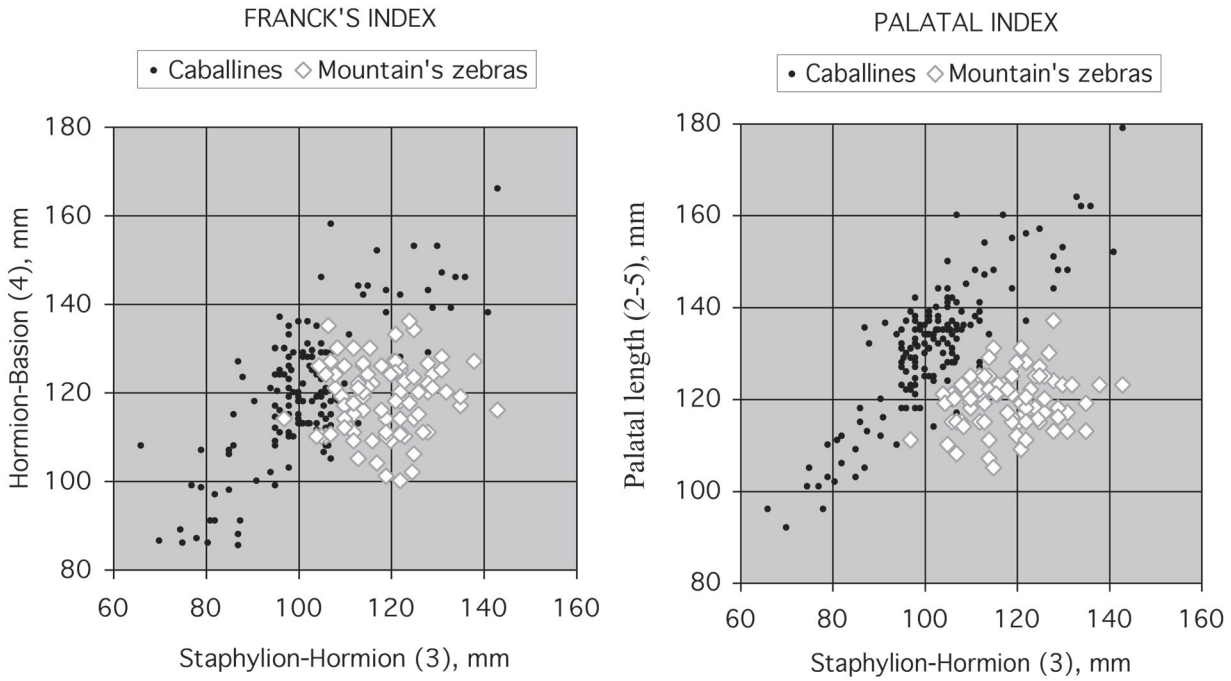

*Fig. 7. Franck's and Palatal Indices in extant Caballines and Mountain's zebras (*E. zebra*).*

Problematic caballoid skulls

The lack of consensus in the attribution of some of these skulls and the confused and debatable taxonomy of Middle Pleistocene equids in general, and of American Pleistocene equids especially, are naturally linked. The problems cannot be rapidly resolved although the descriptions of Azzaroli and the recent ecological interpretations of Pichardo (in particular in this volume) have clarified the situation. Hopefully, the following remarks will also bring some light.

E. scotti – E. excelsus

After first considering *E. scotti* as a true caballine horse (1982, 79) Azzaroli (1995, 213) and (1998, 10) put it in synonymy with *E. excelsus*. The latter is so poorly known that the name was considered as *nomen vanum* by Savage (1951).

E. scotti, Rock Creek, Texas, on the other hand, is probably the best represented Middle Pleistocene horse (skulls and skeletons). Unfortunately the type (Gidley 1901, Plate XX) is a mounted skeleton (AMNH 10606) which apparently no one could study in detail. The skull AMNH 10612 figured by Gidley (1900, fig.3) is not the type skull. However, both well preserved and accessible skulls (AMNH 10612, New York and NMC 2381, Ottawa) as well as the skull published by Johnston (1937) are caballine according to Franck's and Palatal indices (Fig. 8).

The muzzle is moderately long and broad. The upper cheek teeth (Fig. 9) are plicated, with well developed plis caballins and long bilobed protocones. The lower cheek teeth (Fig. 10) have caballine or caballoid double knots and shallow ectoflexids.

At Ann Arbor there is a large skull broken in two fragments (V 46899a and b) from the Seymour Formation, Texas. It was wrongly referred to an *E. grevyi*-like form by Eisenmann and Baylac (2000) because of an error in the data. The referral to *E. scotti* by Hibbard and Dalquest (1966) is probably correct. Both indices may be estimated as caballine (Fig. 8). The upper dentition of another specimen (V 46898) figured by these authors can also be easily referred to *E. scotti*.

E. excelsus is based on one fragment of skull (USNM 667) collected in Nebraska 'somewhere along the Loup River' (Hay 1913, 592), south of Hay Springs, probably near Seneca (Pichardo 2000, 291). The age is not known but could be Late Irvingtonian according to Azzaroli (1998). In contrast with *E. scotti* of Rock Creek, the Figure 1b of Plate 16 (Azzaroli 1998) shows a narrow premaxillary branch tapering near the top of the naso-incisival notch. This notch seems rather deep. The posterior palatine foramen opens opposite to M2 while it is more posteriorly placed in *E. scotti*. The P4,M1,M2 and M3 (Fig. 11) are not very plicated and have no pli caballin. On the P4, the postprotoconal valley is very deep. The protocones are long and not grooved. All these characters are also present in *E. occidentalis* of Rancho La Brea.

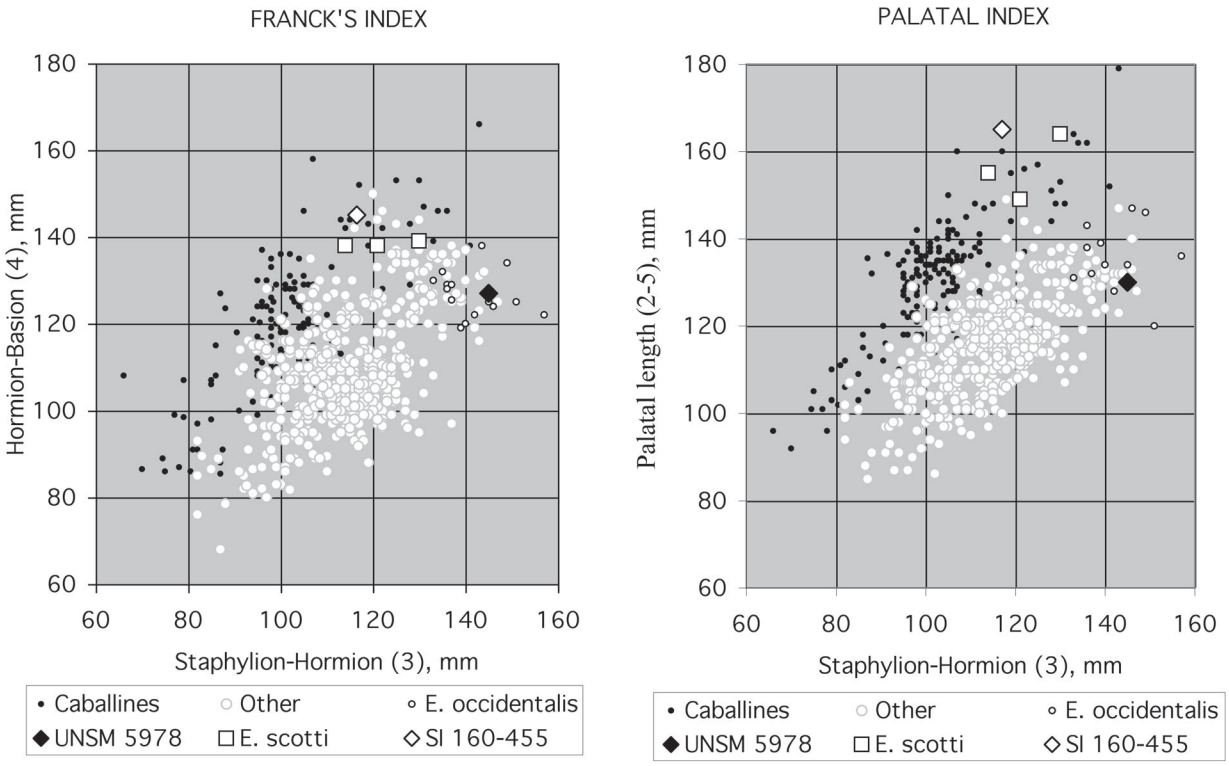

*Fig. 8. Franck's and Palatal Indices in extant Caballines and not caballines, and in fossil skulls of Rancho La Brea (*E. occidentalis*), Rock Creek (*E. scotti*), Northeastern Siberia SI 160-455 (*E. *cf.* scotti*), Hay Springs UNSM 5978 (*E. *cf.* excelsus *or* E. *cf.* occidentalis *?).*

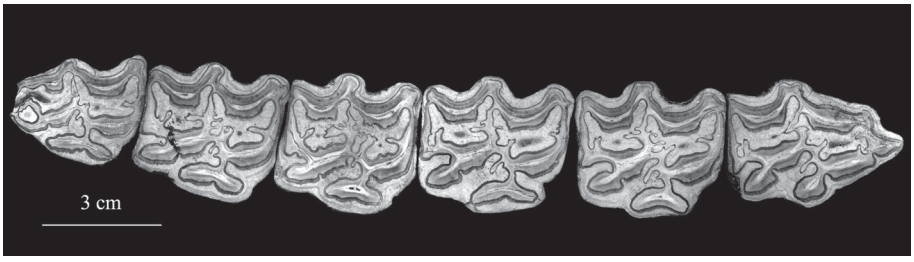

Fig. 9. Occlusal view of sectioned upper cheek teeth of E. scotti *(Rock Creek, AMNH 10607).*

Azzaroli refers to *E. excelsus* the excellently preserved skull UNSM 5978 from the Sheridan beds, Unit 5, Hay Springs, Nebraska. Like in *E. excelsus*, the posterior palatine foramina are opposite to M2, but the premaxillary is not tapering and the naso-incisival notch is not deep. Both Franck's and Palatal indices are not caballine (Fig. 8). The upper cheek teeth resemble those of the type *E. excelsus*. There are no associated lowers. The general size and proportions of the skull are close to *E. occidentalis*. This skull may, or not, belong to *E. excelsus* but it is very different from *E. scotti*.

Thus, figure 8 shows that the synomymy proposed by Azzaroli is not justified and misleading: 1. if the skull UNSM belongs indeed to *E. excelsus*, this species was related to *E. occidentalis* as indicated both by its upper cheek tooth pattern and by its basicranial not caballine indices. 2. *E. scotti* was a true caballine by its upper and lower cheek teeth as well as by its basicranial indices.
I referred to *E. cf. scotti* (Eisenmann 1992) a very well preserved skull collected at Ulakhan Bet Sular, along the Adycha river (affluent of the Iana, northern Siberia). It is preserved at the Severtsov Institute of Moscow as SI 160–455 (ex 'Bet 55'). Size, proportions and location of the posterior palatine foramina are very close to *E. scotti* but the frontal region is flat instead of bulging. Both Franck's and Palatal indices are caballine (Fig. 8). The upper cheek

teeth also resemble those of *E. scotti*; the lowers are not known. According to Sher (pers. comm.), the skull comes from magneto-positive deposits probably inside the lower Brunhes. Lazarev (1980, 55) supposes this skull belongs to *E. nordostensis*.

Given the distance between Siberia and Texas, I understand why Pichardo (this volume) expresses some doubts concerning my referral. I stick to it however for two reasons:

1. I believe that determination is, and must be, based first on comparison. Although zoogeographically founded, the synonymy by Azzaroli of the caballine *E. scotti* with the poorly known *E. excelsus*, and the referral to this 'chimera' of a not-caballine skull (that may, or may not, represent *E. excelsus*) leads to abusively consider stable craniological characters as variable. On the other hand, my referral of a Siberian skull to a Texan taxon is not 'geographically founded' but emphasizes the fact that very similar Caballines lived in Texas and in Siberia at the beginning of the Middle Pleistocene. I do not know whether the resemblance is directly genetic or results from parallel evolution inside two lineages, but both lineages must have been caballine.
2. I do not believe that our present knowledge of the caballine evolution justifies a splitting in so many formal species. As repeatedly pointed by Pichardo (this volume), equids adapt to different ecological conditions as the climate changes and as migrations and competition with other species occur. At a paleontological scale, very few caballine characters are stable and reliable. Two of them concern basicranial proportions and were discussed above. Size, muzzle shape, proportions of the limbs, plication of the enamel, length of the protocone, depth of the ectoflexid do not seem to be stable characters among Caballines. They are governed by Bergman's and Allen's rules or other environmental pressures. In my experience, it is impossible to distinguish clear caballine 'lineages' because there are no, or few, 'anatomical markers'. Furthermore, at a paleontological scale, the intra-Caballine variation is very large. Moreover, migrations of outsiders into areas previously occupied by morphologically distinct aborigenes is always possible. That is not to say that populations cannot be recognized at a local and chronologically short scale (see Bignon, this volume). But paleontological names as *E. latipes*, *E. gallicus*, *E. arcelini*, *E. missi*, *E. ferus*, etc. are just convenient conventions. They do not qualify species, and probably not even sub-species.

E. verae – E. suessenbornenis

Pichardo (this volume) proposes an interesting hypothesis according to which the Siberian skull, SI 160-455, I referred to *E. scotti* could belong to a caballoid *E. verae-E. suessenbornensis*.

It is true that the basicranial proportions of *E. mosbachensis* and *E. suessenbornensis* are not known. However the rest of the material (lower cheek teeth, metapodials) strongly suggests that *E. mosbachensis* was a true caballine horse in contrast to *E. suessenbornensis*. Moreover we may have a guess about *E. verae* skull. Lazarev (1980) described as *E. coliemensis* a fragmentary skull (Iakutsk, 1741) from the Lower Pleistocene of Chukochya (northeastern Siberia). Although the exact position of the Hormion cannot be determined, both Franck's and Palatal indices may be estimated as not caballine. The upper cheek teeth have short and plump (stenonine) protocones and strange plis caballins (large and the base, sometimes bifurcated at the end, or very long and pointed) reminding some teeth of Süssenborn and many teeth referrable to *E. verae*. The lower cheek teeth of *E. coliemensis* are not known but those of *E. verae* are certainly not caballine. The age of *E. verae* is around Jaramillo or older. In short, there is evidence of a Caballine at Adycha in the lower Brunhes (there are also at Adycha caballine lower cheek teeth, unfortunately not associated nor exactly dated). There is no evidence that the Jaramillo or older *E. verae* and *E. coliemensis* from Chukochya could be caballine or even 'caballoid'. *E. suessenbornensis* is probably related to the *E. verae-E. coliemensis* group (Eisenmann and Kuznetsova, 2004; Eisenmann, in press).

E. ferus – E. niobrarensis

E. ferus is based on the recently extinct Russian Tarpan. Osteologically it is represented by two skulls of two castrated males (the Moscow specimens S 94535 has extremely worn upper cheek teeth and lacks the mandible) and the associated skeleton of one of them (LG 521). The material is far from satisfactory (Gromova 1959, 1965). Both skulls mainly differ from *E. przewalskii* by more caballine Franck's and Palatal indices. On LG 521, the protocones are very short, like in *E. missi*. The skeleton has exceptionally short metapodials and short first posterior phalanges. Proportions and size are close to an Island pony. To my knowledge there is no clear evidence of a similar conformation anywhere in the Late Pleistocene (no associated bones at Missy). All the common late Pleistocene horses (*E. latipes*, *E. gallicus*, etc.) have completely different conformations and may not be referred to *E. ferus s.str*. However some authors use *E. ferus* in the meaning of 'wild caballine' to replace the 'domestic' *E. caballus* (although both Tarpans having been castrated, their status of 'wild' is somehow impaired).
In the meaning of 'wild caballine', Azzaroli (1998, 2) refers to *E. ferus* all North American Late Pleistocene Caballines except *E. lambei*, who could have been the dwarfed descendant of *E. niobrarensis*, a distinct caballine species according to this author (1998, 4–5).

One of the skulls referred by Azzaroli to *E. ferus*, UCMP 32879, (1998, Plate 1, figs 1) from the

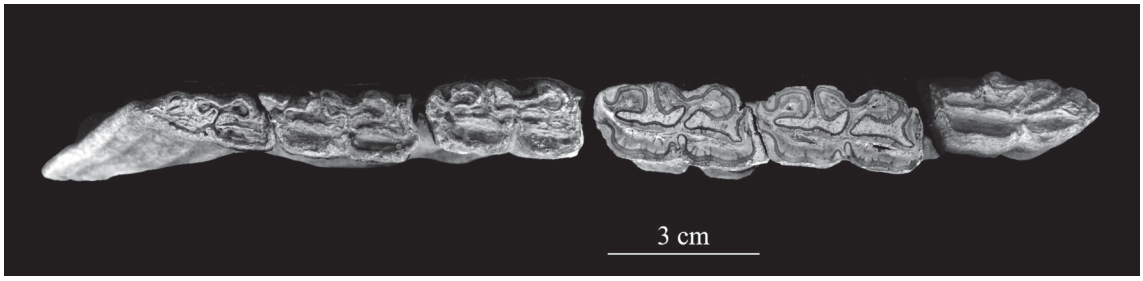

Fig. 10. Occlusal view of lower cheek teeth of E. scotti *(Rock Creek, AMNH 10604).*

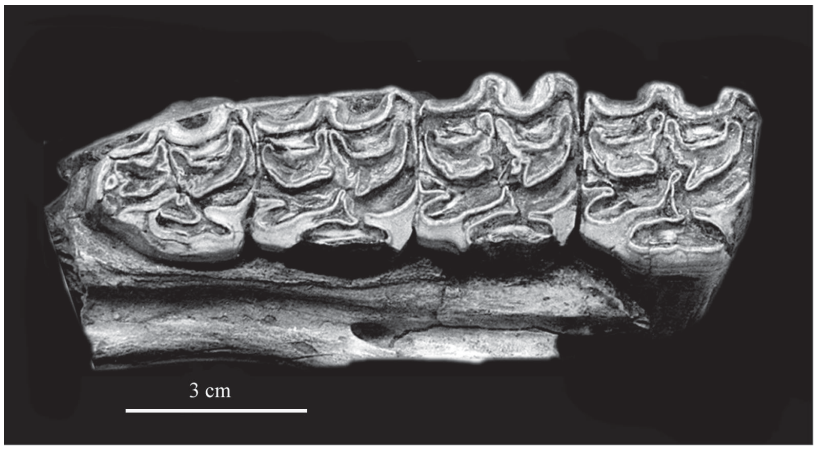

Fig. 11. Occlusal view of type upper cheek teeth of E. excelsus *(south of Hay Springs, USNM 667).*

Irvingtonian locality V 3605 of California lacks the muzzle and the occiput (no Franck' Index) but the palate is short (125mm) relative to the ST-HO distance (about 119mm): the Palatal index is not caballine.

E. niobrarensis is supposed to differ from *E. ferus* by a deeper narial notch (Azzaroli 1998, 4). A scatter diagram of the nasoincisival length (from Prosthion to the top of the narial notch) versus the cheek length (from the top of the narial notch to the anterior border of the orbit) of all my data on caballine equids shows indeed that in *E. niobrarensis* type (unfortunately the naso-incisival length is approximate), the cheek length seems relatively long. The same is true for two specimens of Alaska (AMNH 60019 and 60021) and specimen UNSM 5981 of Hay Springs. But on the diagram this peculiarity looks like an extreme of variation more than a specific or subspecific character (Fig. 12).

Another metrical distinctive character would be the rather small molars of *E. niobrarensis* (Azzaroli, *ibidem*). A scatter diagram of premolar length versus molar length in fossil caballines shows a very large variation, and probably relatively large molars in *E. scotti*. The types of *E. niobrarensis* and *E. hatcheri* do not have specially long molars. Specimen USNM 5982 from Hay Springs does have large molars, but specimen UNSM 5981 also from Hay Springs, has short molars (Fig. 13). There again, the diagnostic character proposed by Azzaroli does not seem reliable.

E. niobrarensis is also said to differ from *E. ferus* (Azzaroli, *ibidem*) by "generally a more open angle" between face and cranium. Without entering in details, the strong deflection of the face relative to the basicranium is interpreted as either an adaptation to grazing (Osborn 1912, Ewart 1907 – quoted by Osborn), or a primitive feature characteristic of the Pliocene *Dinohippus* (26°), *Plesippus* (about 25°) and *Allohippus*, but also of the extant Hemiones and Asses (Azzaroli 1966,7,9; 1979, 44; 1982, 76, 79; 1988, 68; 1995, 213; 1998, 10; Azzaroli and Voorhies 1993, 179). I have measured the cranio-facial angle on photographs of profiles for several fossil skulls. The results are:

E. occidentalis of Rancho La Brea. AMNH 14396: 16°; George C. Page Museum 3500—21: 18°; 3501: 30°.

E. niobrarensis type: 15°.

E. scotti of Rock Creek AMNH 10612: 20°.

The uncertainties and difficulties in measuring this deflection (especially in fossil skulls), the ignorance of the variation in other taxa than domestic horses (where the range is from 10° to 31° according to Osborn) and *E.*

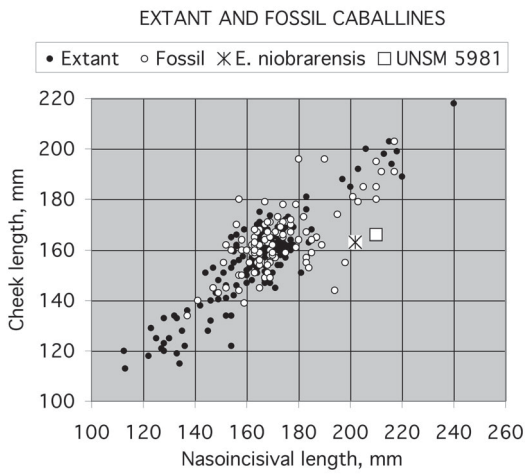

Fig. 12. Scatter diagram showing the relative depth of the narial notch in extant and fossil Caballines. See text for discussion.

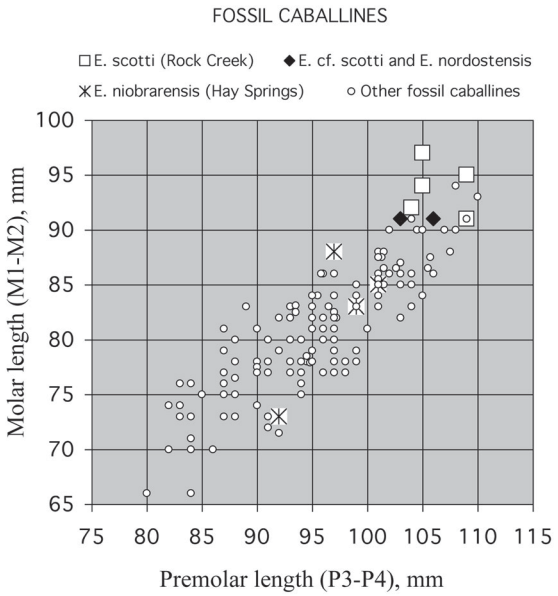

Fig. 13. Scatter diagram of relative length of premolars and molars. See text for discussion.

occidentalis (where the range is already from 16° to 30° in the three skulls mentioned above), and the lack of consensus on its interpretation (primitive feature or adaptation to grazing), recommend caution in its use.

Caballine skulls

There are no clear cuts between caballine skulls. It may be said that in general *E. scotti* are very large, have long muzzles and not very long Hormion-Basion distances. But in the skull described by Johston (1937) the Hormion-Basion distance is long while the skull UNSM 5981 of Hay Springs is quite smaller. Another small and long-muzzled skull from Hay Springs bears the number 13 in the collections of the AMNH. Its Franck's and Palatal indices cannot be documented. The type skull of *E. niobrarensis* was 'extensively restored' (Azzaroli 1998). The muzzle appears rather short. A short muzzle is also found in the specimen UNSM 5980 of Hay Springs and in the skull of Fort Qu'Appelle, Saskatchewan (Khan 1970). The latter has a very long Hormion-Basion distance, as well as the immature specimen UNSM 1346 and possibly UNSM 5982 of Hay Springs. In *E. niobrarensis*, the Franck's and Palatal indices are subject to caution, they are utterly unknown in *E. hatcheri*. Anyway, sizes and morphologies always overlap.
To sum up:

1. I see no reason to distinguish *E. niobrarensis* from *E. ferus*.
2. *E. scotti*, although certainly a Caballine, is possibly a distinct species (large teeth, possibly longer molars, possibly more deflected face).
3. *E. excelsus* is not a Caballine. It is probably related to *E. occidentalis*.
4. *E. coliemensis*, *E. suessenbornensis* and *E. verae*, probably related (Eisenmann and Kuznetsova, 2004; Eisenmann, in press), are certainly not Caballines, while *E. mosbachensis* is certainly a true horse.

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Véra Eisenmann
UMR 5143 et UMR 5197 du CNRS
Paléontologie
8 rue Buffon
75005 Paris
France
E-mail: vera@mnhn.fr