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EQUIDAE (PERISSODACTYLA, MAMMALIA): EXTINCTIONS SUBSEQUENT TO THE CLIMATIC CHANGES.

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ABSTRACT

The present knowledge of global climatic changes allows us to infer its possible influence in the extinction(s) of assemblages or faunistic groups. In the Equidae family the extinctions of both *Anchitherium* and *Hipparion* could be deduced, based upon climatic changes. The replacement of the *Anchitherium* faunal assemblage by that of *Hipparion* at about 13-12 MA in the Mediterranean area, could be related to the Serravallian climatic crisis. During this crisis there was a less warm period and drier conditions. On the other hand, the extinction of *Hipparion* and its replacement by *Equus* seems to be linked with the first cold period as approximately 3.0-2.5 MA (Alberdi, in press; Alberdi & Bonadonna, 1987 a y b).

Keywords: *Anchitherium, Hipparion, Equus* **Morphotypes. Climatic changes. Extinctions. Eurasia and Africa.**

RESUMEN

El actual conocimiento de los cambios climáticos globales nos permite inferir su posible influencia en la extinción o extinciones de asociaciones o grupos faunísticos. En la familia Equidae podríamos deducir la extinción tanto de *Anchitherium* como de *Hipparion* en base a cambios climáticos. El reemplazo de la asociación faunística de *Anchitherium* por la de *Hipparion* entorno a 13-12 MA, en el área Mediterránea puede relacionarse con la crisis climática del Serravaliense que implica un periodo menos cálido y más seco. Por otra parte la extinción de *Hipparion* y su reemplazo por *Equus* parece poder estar enlazada al primer enfriamiento ocurrido alrededor de 3,0-2,5 MA (Alberdi, en prensa; Alberdi & Bonadonna, 1987 a y b).

Palabras clave: *Anchitherium, Hipparion, Equus.* **Morfotipos. Cambios climáticos. Extinciones. Eurasia y Africa.**

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INTRODUCTION

The presence of fossil remains of the Family Equidae (Gray, 1821) during the Neogene are frecuently abundant. This is favoured by the fact of this family belonging to those which live in herds.

A recent work by Alberdi (in press) gives a whole view of the paleobiology and phylogeny of the *Hipparion* genus of Eurasia and Africa. She groups the different species and subspecies of *Hipparion* into 6 Morphotypes *sensu lato* based on a combination of the morphological and morphometrical characteristics and the type of skeleton structure, giving each one of them a generalized schematic classification. These six Morphotypes, related directly with the global climatic trend (Shackleton, 1984; Shackleton & Hall, 1984; redrawn), show a major or minor presence according to a greater or smaller cold period, even reaching its extinction after the lowest temperatures (about 3 MA). This period can be considered as the replacement of *Hipparion* by *Equus* (Alberdi, in press; Alberdi & Bonadonna, 1987). The lowest sea level recorded at this time (Vail *et al.*, 1977; Summerhayes, 1986; redrawn), could be related with this migratory flux (Alberdi, in press; Alberdi & Bonadonna, 1987).

On the basis of this information, we have tried to analyse this phenomenon in other groups of the Equidae family (*Anchitherium, Hipparion* and *Equus*), during the Neogene and Quaternary, to see if there is a correlation between the presence or absence of these groups and global climatic changes.

DATA AND DISCUSSION

The entrance of *Anchitherium* in Eurasia at about 24-22 MA seems to be linked to a lower recorded sea level. At this moment and during the development of *Anchitherium* in Eurasia, the climate is rather warmer and probably more humid, thereby favouring the expansion of this group in Eurasia (Gabuina, 1985). A lower sea level is recorded again between 13-12 MA which could favour the entrance of *Hipparion* into Eurasia from North America. In addition, the Serravalian climatic crisis in the Mediterranean, could favour the replacement of *Anchitherium* by *Hipparion* with a slighlty less warm climate but certainly drier. This could harm the former species and favour the latter ones, as they are a dry climate species. The *Hipparion* fauna was well developed in the Vallesian age, while some scarce remains of *Anchitherium* could be recorded at the beginning of this period (Forsten, 1986; Alberdi, 1972, 1974).

The first climate cooling, between 3.0-2.5 MA, gave rise to the development of the first artic ice sheet and brought about a remarkable drop in sea level (probably the latter was the result of both tectonics and eustatism). This phenomenon could have favoured the *Equus* migration from North America and the replacement of *Hipparion* by it.

Previously, relating the global climatic trend during the first registered drop in sea level, about 6 MA, the genus *Hipparion* could survive due to the warm climate, even though it had some oscilations. This could also give favourable conditions for the entrance of a second wave of *Hipparion* in Eurasia from North America, starting from *Neohipparion* (?) (Zhegallo, 1978; Forsten, 1982). This wave gave rise to a wide dispersion of the *Hipparion* caballine forms throughout Europe and Africa, mainly during the early Villafranchian (Alberdi, in press; Alberdi & Bonadonna, 1987). These forms, although more resistant, could not survive the coldest climate about 3.0-2.5 MA in Eurasia. Perhaps the *Equus* genus, better adapted to survive the climatic change, occupied the ecological niche of *Hipparion,* thereby determining its extinction (Alberdi & Bonadonna, 1987).

The distinct distribution of the 6 Morphotypes of *Hipparion* in space and time seems to depend on whether the environment is favourable or not, especially in relation to the climate (Alberdi, in press; Alberdi & Bonadonna, 1987). In the same way, the distribution of the *Equus* genus during the Quaternary can be examined based on the general construction of the skeleton, and the morphology and morphometry of the remains (principally the teeth, the most abundant remains).

The genus *Equus* can be classified into 2 Morphotypes *sensu lato* (zebras, asses, "*hemionus*", "*hydruntinus*", etc. are excluded).

Morphotype 1.— Includes the "stenonian" types which existed between 2.5-0.9 MA.

Morphotype 2.— Includes the "caballine" types which existed from 0.9 MA up to the present.

The appearance of Morphotype 1, concomitant with the entrance of *Equus* in Eurasia, is recorded during the climatic deterioration period, between 3.0-2.5 MA. The replacement of Morphotype 1 by Morphotype 2 corresponds more or less with the now called Glacial Pleistocene, 0.9-0.8 MA. This period coincides with the first cooling after the first real cooling around 2.5 MA (Alberdi & Bonadonna, 1987).

In the late Pleistocene, the situation is much more complicated, as there is a great proliferation of specific and subspecific names. This can be compared (although in greater proportion) to what happens in the last 3.0 MA of the existence of *Hipparion* in Eurasia. During this period, this form diversified into distinct Morphotypes, as if trying to adapt itself to better morphology for survival (Alberdi & Bonadonna, 1987). In the case of *Equus* it becomes complicated for an uncorrected use of the nomenclature.

In the case of *Anchitherium*, its classification in Morphotypes is not so clear at present (Alberdi, in press) it is necessary to bear in mind that its remains are generally more scarce, both from a quantitative and qualitative point of view.

At present, the presence of *Anchitherium* in Eura-

sia (its presence in Africa is unknown) may be roughly grouped into three entities which cannot be readily included in the *sensu lato* Morphotype category.

These entities are:

1.— *Anchitherium* of small size, which represent the first known forms of this genus dating from aproximately NM3-NM4 Mein zones (1977).

2.— *Anchitherium* of medium size, of an enormous individual variety and having a wide distribution in space and time, about 18-13 MA. This form characterizes the greater part of the Aragonian age (Fahlbusch, 1976). This group is clearly a Morphotype. What is not clear yet is whether any or none of the other groups correspond to this Morphotype or what is the relationship between them.

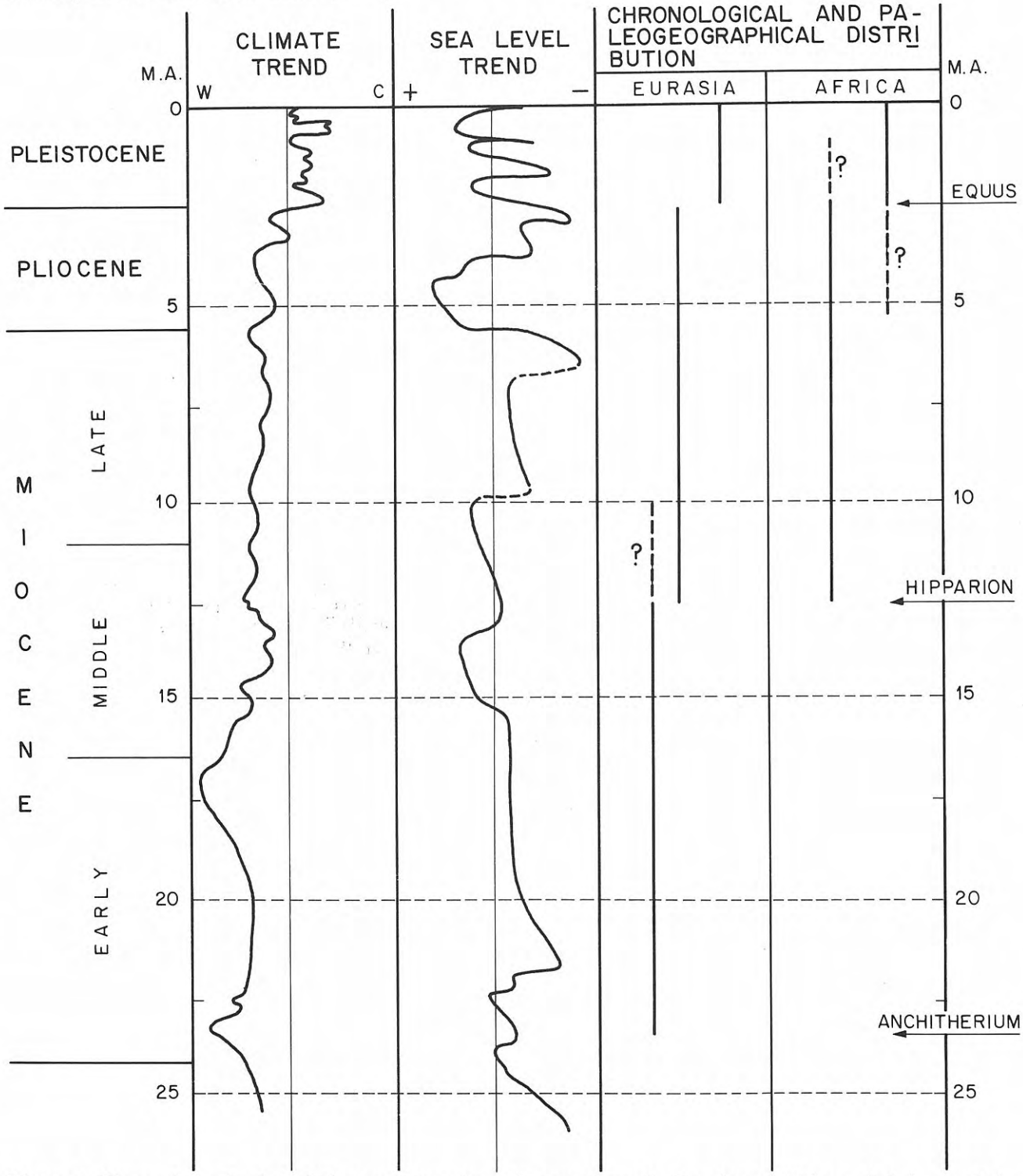

Figure 1. Dispersal sketch of *Anchitherium, Hipparion* and *Equus* throught Eurasia and Africa and their correlation with the climatic and sea-level trends. Paleoclimatic diagram from Sckackleton (1984) and Schackleton & Hall (1984) (redrawn). Sea-level oscillations from Summerhayes (1986) and Vail *et al.* (1977) (redrawn). For stratigraphical correlations see Alberdi & Aguirre (Eds.) (1977, Tables 1,2 and 3).

3.— *Anchitherium* of large size, probably coexisting with *Hipparion* in some places (Forsten, 1968; Alberdi, 1974; etc.). It is found around 13-12 MA in Europe.

These data are at present insufficient to be able to determine:

1. If these three groups of *Anchitherium*, which are clearly grouped over a long period of time, correspond with one and the same Morphotype or with several in the same way we have seen in *Hipparion* and *Equus*.

2. If the relationship between them is concomitant with the global climatic trend.

SUMMARY

Summarizing, the relatively lower level of the overall sea level could have favoured the *Anchitherium* entrance in Eurasia and the replacement of *Anchitherium* by *Hipparion* and *Hipparion* by *Equus* (Figure 1.).

The different Morphotypes of *Hipparion* and *Equus* in Eurasia and Africa could be directly related to the general climatic changes.

The *Hiparion* genus is grouped in 6 Morphotypes which are related to the global climatic changes (Alberdi, in press, Figure 4).

The global climatic situation about 12.5 MA supports the first immigration wave of *Hipparion* in Eurasia from North America represented by Morphotypes 1 and 2 until 6.5-5.5 MA. The presence of *Hipparion* decreases considerably during the Upper Miocene (Messinian). It is only represented by the rare Morphotype 3 followed by two different and short lived Morphotypes: 4 and 5 (between 5 and 4 MA).

The following immigration wave of *Hipparion* causes the replacement of the latter by the well adapted Morphotype 6 ("caballine" type) that definitely dissappears, in Eurasia about 3.0-2.5 MA.

At this time, *Hipparion* is replaced by *Equus* favoured by the global climatic situation about 3.0-2.5 MA (the first ice sheet growth).

The immigration wave into Eurasia from North America of *Equus* is represented by Morphotype 1: *Equus, "stenonis"* like. It survives up to about 0.9 MA, related to a overall global climatic change (Thunell & Williams, 1983). At this moment it is replaced by the Morphotype 2: *Equus*, "caballine" like, that survives to this day.

With regard to *Anchitherium* the present knowledge is not enough to group this genus into different Morphotypes and neither to relate them to the global climatic change.

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