INTERCONTINENTAL DISPERSAL EVENTS, EUSTATIC SEA LEVEL AND EARLY AND MIDDLE MIOCENE STRATIGRAPHY

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ABSTRACT

Five intercontinental faunal dispersal events are recognized (Fig. 1). Their value for local and intercontinental correlation is discussed.

Key-Words: Stratigraphy, Miocene, Ramblian, Aragonian, Dispersal events

RÉSUMÉ

Cinq événements de dispersion faunistique intercontinental sont reconnus (Fig. 1). Leur valeur pour les corrélations locales et intercontinentales est discutée.

Mots-clés: Stratigraphie, Miocène, Ramblien, Aragonien, Évenements de dispersion

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INTRODUCTION

Intercontinental dispersal events are well known and widely accepted in vertebrate palaeontology. They are caused by changes in climate or geography. Examples are the faunal exchange between south and north America during the Pliocene, when both land masses became connected, the Proboscidean Event, when Africa became connected to Eurasia during the Early Miocene and the dispersal events of *Anchitherium*, *Hipparion* and *Equus*.

Intercontinental dispersal events usually involve more than one dispersal of a taxon in a particular continent and frequently include simultaneous dispersals in more than one continent (Pickford & Morales 1994). The stage of evolution of a taxon dispersing in a continent should permit gross correlation to a continuous lineage in its continent of origin. This should enable correlation of dispersal events in these continents. Magnetostratigraphy, radiometric dating and correlations to the marine sequence should enforce the scheme and enable to correlate to global events. Such a method allows for the recognition of a series of time slices that can be recognized in various continents.

Evolutive stages of lineages are usefull for correlation in the area where these lineages are found. Dispersals of single taxa are usefull in the areas where the dispersals occurred. Biostratigraphical correlations in large areas are probably only possible using more complex systems. Ideally, major dispersal events should be recognized in biostratigraphy and frequently are recognized, though not allways explicitly. Pickford (1981) calculated faunal distance between East African Faunas to establish the "Faunal Sets". Dispersal events caused abrubt changes, which are reflected in the results of such calculations. The zonation of the Ramblian and Aragonian tends to capture global events (Van der Meulen & Daams 1992).

MN units pretend to subdivide according to "taxonomic similarity and similarity of stage-in-evolution" and are claimed to be imprecise, not because of the system, but, because of the mammal record (De Bruijn *et al.* 1990: 66-67). However, no calculations on taxonomical similarity have ever been produced, nor is the use of stage-in-evolution explained. It is claimed that the limited number of

Haq *et al.* 1987	MN units "Aragonian"		European + Anatolian localities	Entries W + C Europe	Pakistan Stratigraphy	Entries Pakistan + India	F. Sets	Localities Africa + Arabia	Entries Africa + Arabia
TB3.1	H	MN 9	Doué-la-Fontaine	*Hipparion*	Nagri	*Hipparion*	VI	Ngorora E	*Hipparion*
TB2.6	G	MN 7+8	La Grive		Chinji		V	Ngorora C Ngorora B	
		MN 6l	Arroyo del Val Manchones	*Tethytragus* *Hispanomeryx* *Griphopithecus*					
TB2.5	F	MN 6e	Sansan		Chinji		IV	Majiwa	
	E	MN 5	Faluns de T & A Pontlevoy Puente Vallecas Göriach	*Conohyus* *Pliopithecus* *Crouzelia* *Cricetodon*		*Sivoreas* *Protragocerus* Hypsodontinae		Fort Ternan Al Jadidah Nyakach Muruyur	*Gentrytragus* *Protragocerus*
TB2.4	D	MN 4l	Langenau I Gerlenhofen		Kamlial		IIIb	Maboko Ad Dabtiya	
TB2.3	C	MN 4m	La Romieu Lisboa Vb Armantes I Lisboa Va	*Deinotherium* *Bunolistriodon* *Dorcatherium* *Megacricetodon* *Eumyarion*	Kamlial?	*Conohyus* *Dionysopithecus* *Giraffokeryx*	IIIa	Moruorot Gebel Zelten Buluk	
TB2.2	B	MN 4e	Lisboa IVb		Murree?		II	Karungu Rusinga	
TB2.1	Z + A	MN 3	Wintershof W Brüttelen Lisboa II	*Anchitherium* *Brachyodus*	Bugti	Creodonta Deinotheridae Elephantoidea Hyracidae	I	Langenthal Songhor Iriri	Carnivora Suoidea Rhinocerotidae *Chalicotherium*
TB1.5	Y	MN 2	Laugnac				0	Meswa Bridge	

Figure 1.— Correlation chart. The thick lines represent correlations based on intercontinental faunal dispersal events.
Figure 1.— Charte de corrélation. Les lignes épaisses représentent les corrélations basées sur des événements de dispersion faunistique intercontinentale.

reference localities compared to length of the period covered "excludes the discussion on boundaries between these units" (De Bruijn *et al.* 1992: 66). However, it is more likely that the use of vague "similarities" for correlation and the avoidance of discussion on criteria is an important cause for imprecision, rather than the mammal record. It should be noted however, that several of the authors of "De Bruijn *et al.* 1992" do mention criteria, such as the entry of a genus, for the transition of one MN unit to the other.

If anything defines a MN unit, it is the tables with localities. In the tables, there are clear lines between each unit and this seems to be the case also in the mind of the persons who made and revised them: localities change easily position within a unit, but not so easily between units. This would not be the case, if the MN units were a scale without boundaries of any kind.

The contents of MN units are chosen in such a way, that dispersal events frequently are within units, and do not mark the transition from one unit to the other. A potential for correlation is left unused.

Within one geographical area dispersal events present a rupture between one fauna and the other. Even if one calculates in a more or less objective way the "resemblance" of one fauna to the other (comparing faunal lists), the effect of a migration event is likely to tip the balance. Therefore such events are very usefull tools for stratigraphy in one bioprovince. However, whenever possible, the synchroneity of such events should be checked.

Dispersals of mammals into areas with a favorable environment may be as rapid as 13 km/year (Van der Made 1992). Two types of dispersal events should not be confused. One is, when the boundaries of a particular environment change and when the species living in that environment change their distribution accordingly. Such changes occurred during the Pleistocene when the distributions of "glacial" and "interglacial" faunas changed according to the climate. Similar changes may have occured within northern Eurasia during the Miocene and may have been diachronous. The other type is when a "barrier" disappears and when a faunal exchange occurs between two or more areas with a similar environment. The latter type seems to be the more usefull for correlation and most of the cases discussed below belong to that type.

MAJOR RAMBLIAN AND ARAGONIAN DISPERSAL EVENTS

When, during the Early Miocene, the eastern Tethys became shallow, eustatic sea level changes allowed repeatedly for faunal exchange between Africa, the Indian Subcontinent, SE Europe + Anatolia and Eurasia. The sea level changes are related to global climatical events (Miller *et al.* 1995), which also may have had a direct effect on biogeography. The following scheme (Fig. 1) presents sea level cycles after Haq *et al.* (1987) and dispersals in various continents. These events have been discussed before, with particular emphasis on the Listriodontinae (Van der Made 1996) and Bovidae (Van der Made 1995). Here the emphasis is on a comparison with the MN scale.

THE EARLY RAMBLIAN FAUNAL EXCHANGE

This event includes the first major faunal exchange between Africa and Europe after a long period of isolation. It coincides with the beginning of MN3, zone Z of the Ramblian, Faunal Set I of Pickford (1981) and with the instatement of the "Bugti Fauna". The faunal exchange is related to the regression at the onset of the TB2.1 cycle of Haq *et al.* (1987).

The major effect of this exchange was in **Africa**. Most of the taxa indicated by Thomas (1985) for the NDP1 event arrived during this exchange in Africa. Felidae, Canidae, Mustelidae, Rhinocerotidae, Chalicotheriidae, Suidae, and Palaeochoeridae (*Sanitherium*) entered in Africa. All these families have a previous record in Eurasia.

In the **Indian Subcontinent** there is no good record previous to this event, but probably the first Proboscidea (Deinotheriidae and Elephantidae), Hyracidae and *Brachyodus* (Anthracotheriidae) entered at this moment (Pickford 1988). All of them of african origins. The first giraffids may have entered, coming from Asia.

Brachyodus entered **Europe**. The first Elephantidae may have entered Europe at this moment or later during MN 3 (Bulot & Ginsburg 1993) or at the beginning of MN 4 (zone B) (De Bruijn *et al.* 1992). The record of Elephantidae is scarce in MN 3. Therefore one should be cautious with the interpretation of this taxon. *Anchitherium*, an equid of American origin, entered Eurasia.

THE EARLY ARAGONIAN FAUNAL EXCHANGE

This event is situated within MN 4, it marks the transition of zone B to zone C of the Aragonian, as well as the transition of Faunal Set II to Set II and is related to the regression at the onset of cycle TB2.3 of Haq *et al.* (1987).

The event had its major impact in **Europe**, with the entry of *Deinotherium*, *Bunolistriodon*, *Dorcatherium*, *Chalicotherium*, *Megacricetodon* and *Eumyarion*. Mein (1979) took the entry of several of these genera as marker for the MN 3-4 transition, but later changed this to the previous state (Mein 1977, 1990). *Deinotherium*, *Bunolistriodon* and *Dorcatherium* have a previous record in the Indian Subcontinent and in Africa (Barry & Flynn 1990; Van der Made 1996; Pickford 1981, 1986) and may or may not have been present in Turkey and SE Europe. *Eumyarion* and *Megacricetodon* had a previous record in Turkey (De Bruijn & Saraç 1991).

The suid *Conohyus* and the primate *Dionysopithecus* (Bernor *et al.* 1988) appeared for the first time in the **Indian Subcontinent**. The suid may have originated in Asia, and the primate originated in Africa.

The first bovids and giraffids entered **Africa**. Bovids had their origin in Asia and had a previous record in Eurasia (Ginsburg & Heintz 1968; Chen 1988) and in the Indian Subcontinent (Solunias *et al.* 1995). Giraffids had a previous record in Eurasia and the Indian Subcontinent (Moyà-Solà 1987).

THE MIDDLE ARAGONIAN FAUNAL EXCHANGE

This event marks the beginning of MN 5 (old sense; De Bruijn *et al.* 1992), zone E of the Aragonian and Faunal Set IV in Africa and is related to the regression of the TB2.5 cycle of Haq *et al.* (1987).

In **Europe** the primates *Pliopithecus* and *Crouzelia* entered as well as the suid *Conohyus* (Ginsburg 1986; Van der Made 1989). The only occurrence of *Sanitherium* in Europe is of this age and is in Austria, but *Sanitherium* has a previous record in Africa and the Indian Subcontinent (Pickford 1984). *Conohyus*, as we have seen, has its first record in the Indian Subcontinent and the primates have an African Origin. All of them must have passed through Anatolia and SE Europe, but only *Sanitherium* is recorded there. The cervid *Dicrocerus*, of Asian origin, entered Europe. The rodent *Cricetodon* was present in Anatolia in MN 1, but only in MN 5 it dispersed into central and western Europe (De Bruijn & Ünay 1996).

A number of bovids entered the **Indian Subcontinent**: *Sivoreas*, *Protragocerus*, *Kubanotragus*, *Sivaceros* and *Helicoportax* (Barry & Flynn 1990). Fossils from MN 4 in Europe, as well as a small bovid in Belometchetskaia (Russia; MN 5) are assigned to *Protragoceros* (Köhler 1987). *Sivoreas* is also found in Turkey in an early MN 6 locality (material in MTA) and *Kubanotragus* as well as *Hypsodontus* are present in Belometchetskaya (Gabunia 1973). The latter genus is also found in Pakistan (Thomas 1985). Most of these bovids are considered to be Boselaphini and the others are Hypsodontinae; all probably have their origin in Asia.

The bovids *Gentrytragus* and *Protragocerus* appear at this moment in **Africa**. Both are of Asian origin. *Gentrytragus* is probably closely related to *Tethytragus*, which also is found in Turkey in early MN 6 localities. The geographical separation following the disperesal to Africa may have caused the separation into two genera.

THE LATE ARAGONIAN FAUNAL EXCHANGE

This event is within MN 6, it marks the beginning of Zone G of the Aragonian, the beginning of Faunal Set V and is related to the regression at the onset of cycle TB2.6 of Haq *et al.* (1987).

This event is best recognized in **Europe**, with the entry of the bovid *Tethytragus* (= "*Caprotragoides*"), the primitive bovoid *Hispanotherium* and the primate *Griphopithecus*, all having a previous record in Turkey. The entry of the bovid was given great importance by Agustí & Moyà Solà (1991). At the same time, the cervid *Euprox furcatus* made its first appearance in western Europe, but the small cervid *Euprox minimus* was already present in central Europe. The suid *Parachleuastochoerus steinheimensis* entered Europe, but its area of origin is not known.

Sivapithecus entered the **Indian Subcontinent**.

THE INTRA MN 6 ZONE F–G TRANSITION

This transition is reflected by an important dispersal in western and central Europe and seems to have had a moderate effect elsewhere.

THE MN 6–7 TRANSITION

The transition of MN 6 to MN 7 does not seem to be related to any important event. Few new genera appear and no rodent, no large mammal genus enters in western and central Europe simultaneously, nor are there important extinctions as indicated by De Bruijn *et al.* (1992).

Agustí & Moyà Solà (1991) have suggested to include the later part of MN 6 in MN 7. Zone G of the Aragonian includes the later part of MN 6 and MN 7+8. It seems indeed less usefull to maintain the MN 6-7 transition where it is now.

THE MN 8–9 TRANSITION

This transition is marked by the *Hipparion* dispersal. The genus came from the New World and seems to have entered nearly everywhere in the Old World in a rather short period. Therefore the marker seems to be very usefull and the appearance of any taxon with an origin in the Old World is expected to be less synchronous in such a large area.

CONCLUSIONS

A series of dispersal events are recognized, which seem to have value for correlation, not only in Europe, but also between Europe and other parts of the Old World. The synchronity of such events can and should be tested by other means, such as magnetostratigraphy.

It does not seem advisable to change the MN system continously. However, when changes are made, it seems advisable to chose for changes which enable intercontinental correlations. If it is felt that local (European) events and changes in single evolutive lineages, that at present are used, should be preserved, this should be as subdivisions.

If any new biostratigraphic scheme for Europe is designed, the potential of intercontinental dispersal events should be used. However, the zones of the Ramblian, Aragonian and Vallesian and the Faunal Sets of Africa recognize these events already.

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