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Biostratigraphy or biochronology? Lessons from the Early and Middle Miocene small Mammal Events in Europe☆

Biostratigraphie ou biochronologie ? Leçons des événements à petits mammifères du Miocène inférieur et moyen en Europe

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Abstract

Since the proposition in 1975 of the European Neogene Mammal (MN) scale by Pierre Mein, the amount of taxonomical, stratigraphical and chronological information around Europe has increased exponentially. In this paper, the stratigraphical schemes of three of the best studied areas for the Lower and Middle Miocene, the Aragonian type area in Spain and the Upper Freshwater Molasse from the North Alpine Foreland Basin in Switzerland and Bavaria, are compared. The correlation of their local biostratigraphies are discussed. Sixteen rodent's events are studied and ranked in the three areas according to their local biostratigraphy. This study shows, and quantifies for the first time, the significant asynchronies of the different included rodent events. The MN-system is discussed in the light of those results. In accordance, we propose that it is still useful but only in a biochronological way, as a sequence of time-ordered reference localities allowing coarse long-distance correlations. In order to obtain better temporal resolution, this system has to be combined with local biostratigraphies that are well calibrated to the time scale, implementing the information about synchrony and diachrony of mammal events in different areas.

Keywords: Rodentia; Chronology; MN-system; Asynchrony; Central Europe; Spain

Résumé

Depuis la proposition par Pierre Mein, en 1975, de l'échelle des mammifères néogènes d'Europe (MN), la quantité d'information taxinomique, stratigraphique et chronologique en Europe a augmenté exponentiellement. Dans cet article, les séquences stratigraphiques de trois des régions les plus étudiées pour le Miocène inférieur et moyen, la région-type de l'Aragonien en Espagne et la Molasse supérieure du Bassin Nord-Alpin en Suisse et en Bavière, sont comparées, et la corrélation de leurs biostratigraphies locales discutée. Seize événements à rongeur sont étudiés et ordonnés dans les trois régions d'après leur biostratigraphie locale. Cette étude montre et quantifie pour la première fois, les importantes asynchronies de ces différents événements. Le système MN est discuté à la lumière de ces résultats. En conséquence, nous proposons que ce système reste utile seulement d'un point de vue biochronologique, comme séquence ordonnée dans le temps de localités-repères permettant des corrélations grossières à longue distance. Afin d'obtenir une meilleure résolution temporelle, ce système doit être combiné avec des biostratigraphies locales bien calibrées dans le temps, en intégrant les informations de synchronie et de diachronie des événements à mammifères dans différentes régions.

Mots clés : Rodentia ; Chronologie ; Système MN ; Asynchronie ; Europe centrale ; Espagne

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1. Introduction

The non-recurrent compositional and evolutionary changes of the European mammal fauna history have been extensively used as a relative-age tool for the continental sediments in which they are found. Based on these characteristics, Mein (1975a, 1975b) proposed the subdivision of the Miocene-Pliocene record into 17 successive Mediterranean Neogene units based on mammals (MN). The strength of this scheme lies in its simplicity and it is one of the reasons why the MN-system has become the primary biochronological framework for faunal correlation of the European Neogene. After 35 years, the system still facilitates communication between scientists working in different regions, and doubtlessly it contributed a great deal to the success of European mammal palaeontology.

The MN-system has been extensively used for correlations from local to continental scale, although not always with the same philosophy (De Bruijn et al., 1992). Thus, various authors consider the MN-system as biostratigraphical (e.g., Steininger, 1999; Agustí et al., 2001), while according to others it should be used as a biochronological scheme (De Bruijn et al., 1992; Van Dam, 2003). Using the MN-system as a biostratigraphical scheme is in itself tempting, given the exponential increase of the stratigraphical information. However, biostratigraphy involves not only the fossil content but also the bodies of rock that include it. Therefore, in our opinion, the MN-system as defined by Mein (1975a, 1975b) and modified by the Regional Committee on Mediterranean Neogene Stratigraphy (RCMNS; De Bruijn et al., 1992) can never be considered as a biostratigraphical scale, because it is exclusively based on fossil associations and the biological evolution that they reflect (Fahlbusch, 1991; Van Dam et al., 2001).

Since the introduction of the MN-system, the number of localities has soared. Hundreds of publications have tightened our grip on the taxonomy and phylogeny of Neogene mammals. For some areas we have detailed stratigraphical information, allowing us to track faunal development to a degree unheard of in 1975. This increase in the local biostratigraphical knowledge and the recognition of the different MN units in various geographical regions, have resulted in the local recognition of 'MN boundaries' and the assignation of very different ages for each of them (Bolliger, 1997; Heissig, 1997; Kälin, 1997; Kempf et al., 1997; Daams et al., 1999a, 1999b; Agustí et al., 2001; Abdul Aziz et al., 2008, 2009; Kälin and Kempf, 2009). Most of those boundaries between successive MN units have been characterized by a single or a combination of bioevents that were not necessarily always coincident in the different regions.

In order to avoid circular reasoning on the isochrony or diachrony of any faunal event, the mammal history obviously has to be independently calibrated to the time scale. Such calibrations (usually palaeomagnetical or radiometrical) are local by definition because they are based on properties of the rocks from which the fossils derive, or from other rocks with which they are closely associated. The distribution of both localities and mammal taxa is patchy in space as well as in time; consequently, the locally-obtained ages for first and last occurrences of taxa (FO's and LO's, respectively), used as dates for continent-wide immigrations and extinctions, are a priori to be mistrusted as long as synchrony and/or diachrony of the various events have not been demonstrated.

In order to demonstrate the synchrony or diachrony of bioevents and its magnitude, we analyze and discuss the sequence and timing of several small mammal events recognizable in areas were an independent calibration to the time scale has been proposed, and compare them with what can be observed in other European records. Previous to this main goal we discuss the chronologies established for three different Early and Middle Miocene micromammal records: the Aragonian type area in north Central Spain (Daams et al., 1999a; Van der Meulen et al., 2005, in press; Van Dam et al., 2006); the Upper Freshwater Molasse (OSM) of the North Alpine Foreland Basin (NAFB) in Switzerland, recently updated by Kälin and Kempf (2009); and the OSM of the North NAFB in Bavaria, Germany (Abdul Aziz et al., 2008, 2009). Probable correlations between existing local biostratigraphies are suggested. Finally, we discuss the different approaches to the European mammal chronology, paying special attention to the original definition and current uses of the MN-system.

2. Chronology of local biostratigraphies

Irrespective of whether one is interested in long distance correlations or in the regional faunal history, each study tracking changes through time starts with establishing a local biostratigraphy, necessarily linked to the local lithostratigraphical record, and ultimately to chronostratigraphy and geochronology by other independent stratigraphical disciplines (magnetostratigraphy, cyclostratigraphy, etc.). Despite the recent increase of new independent correlations to the time scale, there still exists a strong need of spatially distributed absolute dates (Van Dam, 2003). Moreover, in our opinion, a number of the existing numerical age determinations are not rigorous enough to be reliable (Daams et al., 1999b). This is due to the use of:

- second or third order correlations;
- radiometric ages with very large uncertainty intervals;
- insufficient number of recorded palaeomagnetical chrons, making independent correlation to the Geomagnetic Polarity Time Scale (GPTS) impossible;
- the use of poor-quality polarity signals.

In Europe, there are three overlapping Lower to Middle Miocene records that have been tied to the time scale, at least in a large part:

- the record of the Aragonian type area in north Central Spain (Daams et al., 1999a; Van der Meulen et al., 2005, in press; Van Dam et al., 2006);
- the mammal fauna sequence from the Upper Freshwater Molasse (OSM) of the North Alpine Foreland Basin in Switzerland (Bolliger, 1997; Kälin, 1997; Kempf et al., 1997; Kälin and Kempf, 2009);