Synopsis of the Dutch-Spanish collaboration program in the Aragonian type area, 1975-1986

R. Daams and M. Freudenthal

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A review is given of more than 10 years of paleontological and stratigraphical work in the type area of the Aragonian. Methods and techniques are described, and an outline is given of the most important biostratigraphical and chronostratigraphical results.

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Introduction

In April 1975 the 'International Symposium on Mammalian Stratigraphy on the European Tertiary' took place in Munich (Germany). The participants of this symposium concluded that it would be necessary to establish a number of new chronostratigraphic units for continental Miocene deposits that had previously been indicated by inappropriate names such as Aquitanian, Burdigalian, Vindobonian, and Helvetian. Such new units should be based, if possible, on stratified deposits containing fossil mammal

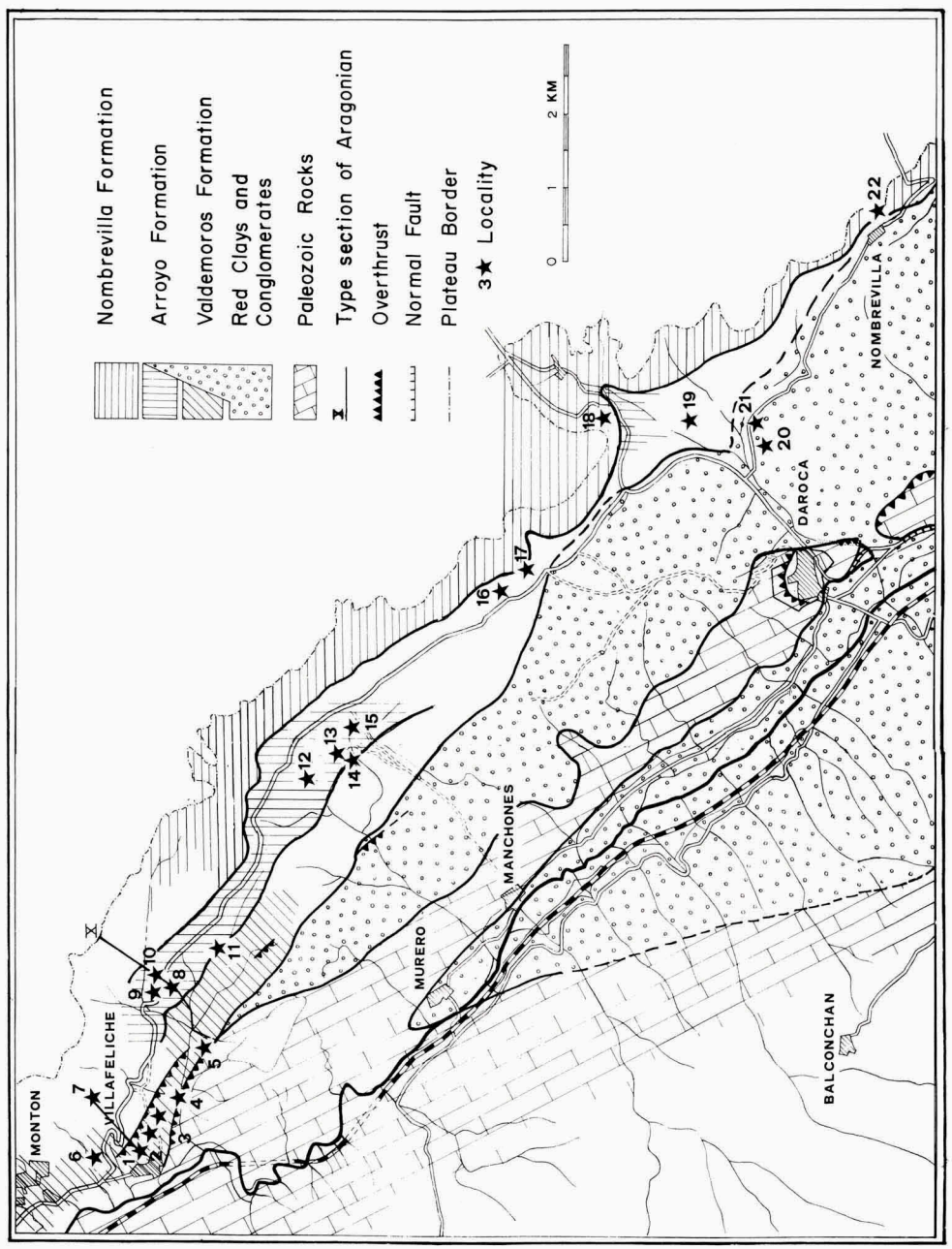

Fig. 1. Geological map of the Daroca-Villafeliche area (slightly modified after Freudenthal, 1963). 1-7 is the Olmo Redondo section, X is the type section of the Aragonian.

1. Olmo Redondo 1-9.
2. San Roque 1 + 2.
3. Villafeliche 2A.
4. Vargas 1A.
5. Valdemoros 1A, 3B, 3D, 3E.
6. Villafeliche 4.
7. Villafeliche 9.
8. Las Planas 5B.
9. Las Planas 5K + 5L.
10. Las Planas 5H.
11. Las Planas 4.
12. Arroyo del Val.
13. Manchones.
14. Borjas.
15. Solera.
16. Alcocer 2.
17. Carrilanga.
18. Pedregueras 2A + 2C.
19. Toril
20. Valalto 2B + 2C.
21. Valalto 1.
22. Nombrevilla.

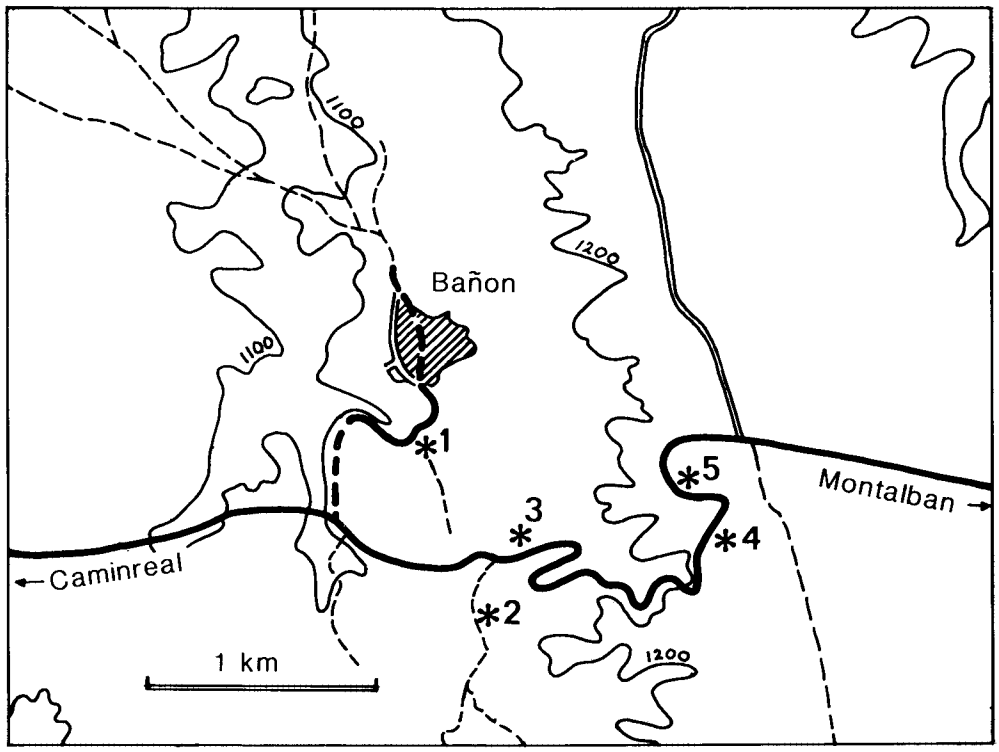

Fig. 2. Map of the Bañon area.

localities, or, even better, sequences of such localities, and they would gain in importance if palynological zonations could be tied in. Daams, Freudenthal and van de Weerd were asked to prepare a proposal for a new Miocene stage, the Aragonian, with its stratotype in fossiliferous deposits in the Calatayud-Teruel Basin, Spain. This stage was officially defined in 1977 by the same authors, and has subsequently been subdivided into Lower, Middle and Upper Aragonian.

Our work in the Calatayud-Teruel Basin concentrated on three areas: Daroca-Villafeliche (Fig. 1), Bañón (Fig. 2), and Navarrete del Río (Fig. 3).

During the 1976-1986 excavations in the type area of the Aragonian and adjacent areas, pre-Aragonian faunas were found, and for these faunas another stage was created, the Ramblian, with its stratotype in northern Teruel (Daams et al., 1987).

The excavations yielded many faunas with abundant micromammal and some macromammal remains. Lithostratigraphic control for the majority of the fossiliferous levels enabled us to establish a sequence of the Miocene faunas, without having studied in great detail the mammalian remains yet.

The micromammal faunas collected contain the following groups: Cricetidae (hamsters), Gliridae (dormice), Sciuridae (squirrels), Castoridae (beavers), Eomyidae (an extinct family), Ochotonidae (piping hares), and Insectivora (moles, hedgehogs and shrews). Some papers on representatives of these groups have been published already: López (1984) on the Ochotonidae; Daams (1985) on the Glirinae (Gliridae), Sesé (1987) on *Eucricetodon* and *Melissiodon* (Cricetidae), Alvarez (1987) on the Eomyidae, and Cuenca (1988) on the Sciuridae. Furthermore a paper on the Artiodactyla has been published by Morales & Soria (1984). In this volume members of our Dutch-Spanish team present a further detailed analysis of the mammalian remains.

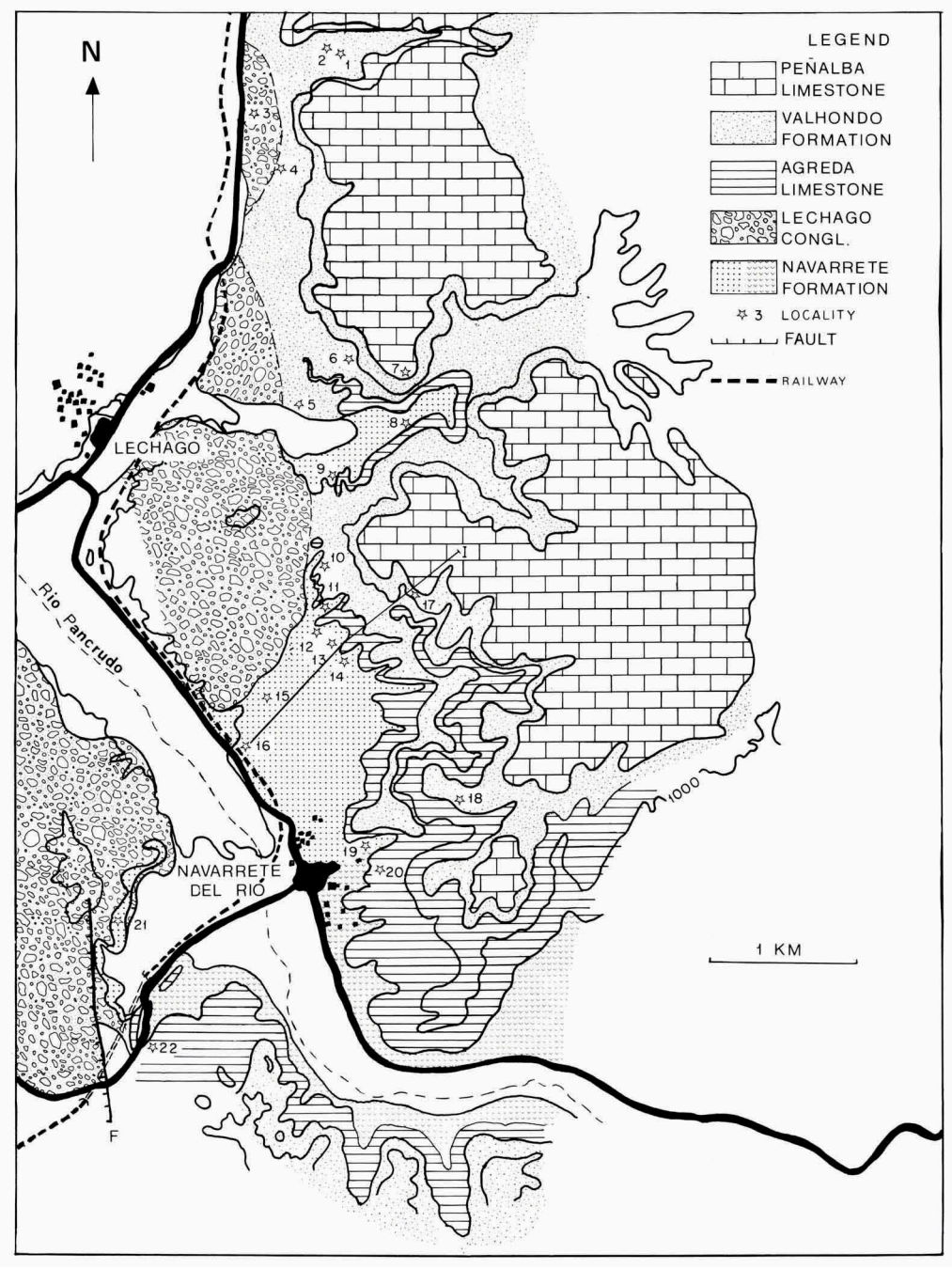

Fig. 3. Map of the Calamocha-Navarrete area.

METHODS

Freudenthal and de Bruijn were the first to start a systematic research on rodents in the Calatayud-Daroca area, and when they published the first results in the sixties they had at their disposal a considerable number of newly discovered and relatively rich localities. Although the first studies on these micromammals were mainly taxonomical, an attempt to establish a biostratigraphic subdivision of the Miocene sediments was made by de Bruijn & van Meurs (1967). They recognized three Assemblage Zones: the *ibericus* Zone, the *collongensis* Zone, and the *grivensis* Zone. As more fossil material became available over the past twelve years, this zonation appeared not to be functional. It was never generally accepted.

When the Munich Symposium in 1975 decided that the Calatayud-Daroca area should serve as the basis for the new stage Aragonian, we soon realized that, in order to get a good idea of the Aragonian and its faunal succession, a much more detailed knowledge of the type area was indispensable. This would mean discovering new fossiliferous localities that would fill in the gaps between the ones discovered and exploited by Freudenthal and de Bruijn in 1960 through 1963, and, if possible, extend the stratigraphic sequence upwards and downwards.

The sediments in the Daroca-Villafeliche and Calamocha areas consist of conglomerates, sands, silts, clays, limestones, and marls, in a very discontinuous pattern. Conglomerates, limestones and red facies are nearly always void of concentrations of vertebrate remains. The most favourable sediments for fossil accumulation appeared to be clays, silts, marls and in some cases sands. Discontinuous beds of these favourable sediments with lignitic contents and/or concentrations of freshwater or terrestrial molluscs nearly always proved to contain relatively abundant micromammal remains. The richness of these sediments varies between 1 and 16 teeth per 5 kg. One locality (Manchones, now renamed as Manchones 1) consisted of a pocket with a mixture of large and small mammals, interbedded in horizontal sands and conglomerates, yielding more than 60 dental remains per kilogram of sample.

When we started our campaigns in 1976 the richest and most evident localities had been discovered already. Moreover, we intended to reduce as much as possible the vertical intervals between sampled levels. So, we would have to make the best of relatively poor fossiliferous beds. In order to obtain statistically reliable samples, very large quantities of matrix had to be processed. Thousands of kilos of sediment per sample are certainly not an exception. These samples were excavated, transported to Daroca, and left on the floor over the ovens of the brick factory for several days, so they would dry thoroughly. Unfortunately brick factories have been modernized during the past few years, and nowadays for drying our samples we have to rely on the sun. We normally build up a stock of about 10 000 kg or more during the first days of the field campaign. Then we start alternating sampling days and sieving days in such a way that the stock of dry sediment is kept at a sufficiently high level.

Sieving was done in the Jiloca river. We transport about 3000 kg of dried sediment to the river and distribute part of this quantity over about 150 washing-up bowls which will contain some 6 or 7 kg each, and which are than filled with water. While this material is left soaking for about an hour, the sieving equipment is mounted.

The sieve is a foldable construction containing four sieves with mesh sizes of 10 mm, 2.5 mm, 0.7 mm, and 0.5 mm. The fraction under 0.5 mm is discarded since practice has shown that it contains hardly any teeth, and the few teeth found in it seem to be of no diagnostic value. In many cases we even dismount the 0.5 mm sieve and take the 0.7 mm as our lower limit; this is done for example in trial samples where we are not so much

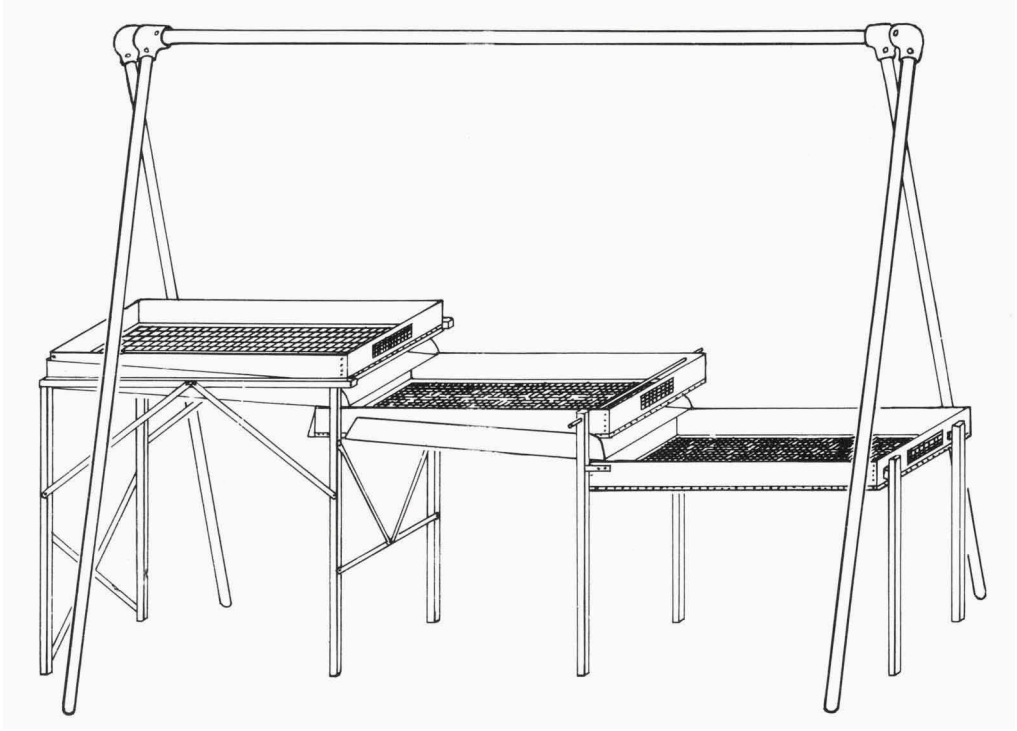

Fig. 4. Sketch of the sieving equipment.

interested in the actual contents of the sample, but where we simply want to know whether a certain locality is fossiliferous or not. Also, we may neglect the 0.5 mm to 0.7 mm fraction in stratigraphic levels where no significant material is expected in this fraction. The surface of the sieves is about 100 × 50 cm. The 10 mm sieve is placed inside the 2.5 mm mesh sieve, which stands on legs about 1 m high. The 0.7 mm mesh sieve is placed beside the first one at a lower level, and a slightly sloping aluminium plate with high rims catches the mud that passes through the 2.5 mm sieve, and guides it into the lower one. The 0.5 mm mesh sieve, standing about 50 cm high, receives the muddy water passing through the 0.7 mm sieve by means of a similarly sloping aluminium plate. A sketch of the equipment is given in Fig. 4. The entire installation takes a space of about 100 × 50 × 20 cm when folded. It takes two persons about 15 minutes to mount it. People interested may request a working-drawing from the second author.

Over the sieve we build a construction of ordinary gas-pipes and coupling-pieces: a horizontal bar on four oblique legs. From the horizontal bar three hose-pipes are hung over the sieves.

We use a 1.25 HP Bernard motor-pump which accomodates four hose-pipes. Three pipes are used for the actual sieving, one is used to refill the washing-bowls with water after new sediment has been put in for soaking. Furthermore we use 25 sieves with 0.5 mesh, measuring 50 × 50 cm, for drying the residues. The sides of these sieves are oblique, so they may be nested and take a minimum of space when transported.

The standard sieving routine is as follows: one or two persons carry the washing-bowls with soaked sediment to the sieve and throw the contents on the highest sieve, then return and refill the bowls. Two others pass the hose-pipes over the sieves and clean the contents.

When any of the sieves becomes too full it must be emptied or water may flow over the edges, and material may get lost. The two lower sieves are simply emptied by hand into one of the drying-sieves, which are left in the sun to dry. The contents of the 10 mm sieve are generally inspected quickly, and then thrown away, because hardly any larger fossils are found in our material. The 2.5 mm sieve is fitted with a funnel on the front side (left side in Fig. 4); the sieve can be rotated upwards, so that the material in it will slide through the funnel into a drying-sieve held under it. Sieves are emptied as need be, until the entire amount of a sample has been washed. Then the remaining sediment in each of the sieves is washed carefully into one of the drying-sieves, and the equipment is cleaned thoroughly with a strong jet from the hose-pipes, and an iron-brush. Then the next sample may be processed. At the end of the day the drying-sieves are brought to the brick-factory and left to dry over the ovens.

On the next sieving-day the residues of the previous day are soaked in water and washed again. This second washing, after the residues have been thoroughly dried, will often eliminate a considerable amount of mud in a very short time. Trying to clean the sample in only one sieving operation is very time-consuming and often hardly possible, and may cause damage to the fossils.

After the residues have been washed a second time, those samples that contain much lime are left for half a day in a 10 % solution of acetic acid until most of the lime is dissolved, and then washed and dried again.

We have two kinds of samples: test-samples of about 100 kg of sediment, and production samples of 1000 to 5000 kg or more. When we discover a new locality we take a test-sample, sieve it as described above, and pick the residue under the microscope as soon as possible. The fossil content is evaluated, and on the basis of this evaluation we decide whether the locality is important, and if so, calculate the size of the production sample. It normally takes a week to have the results of a test-sample available for evaluation. So, generally, a newly discovered locality is tested and exploited during the same field campaign. The residues of the production samples are processed after the field campaign in the laboratory.

During our field campaigns in the Calatayud-Teruel Basin a total of well over 125 000 kg of sediment has been processed, yielding over 50 000 mammal teeth. This material is kept in the Rijksmuseum van Geologie en Mineralogie, Leiden, the Netherlands. During one of the field campaigns a reference collection was made from a number of selected localities. This collection is kept in the Universidad Complutense, Madrid, Spain.

Acknowledgements

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But still, all our efforts would have been in vain, hadn't we met with the help and hospitality of all our friends in Daroca and surroundings, of whom we wish to name especially D. Rafael Estebán Lorente, known to his friends as 'el marques', D. Carlos Langa Sebastian, a gifted discoverer of fossil localities, the entire staff of Hotel Legido, and the owners and personnel of the Rubio brick factory.

Participants in our campaigns

Gerlof Abels (Utrecht), Maria Teresa Alberdi (Madrid), Maria Angeles Alvarez (Madrid), Jeannet Bakema (Groningen), André Berends (Utrecht), Gloria Cuenca (Zaragoza), Remmert Daams (Madrid), Jaep van Dijk (Groningen), Javier Esteban (Madrid), Matthijs Freudenthal (Leiden), Eduardo García (Madrid), Rodolfo Gozalo (Zaragoza), Ester Herraez (Madrid), Gerd-Jan Jaspers (Groningen), Fred de Jong (Groningen), Frans Jordens (Leiden), José Ignacio Lacomba (Valencia), Nieves López (Madrid), Javier Martínez (Madrid), Eduardo Mayoral (Zaragoza), Albert van der Meulen (Utrecht), Joop Moltzer (Haarlem), Alfredo Monje (Madrid), Jorge Morales (Madrid), Geert Nijboer (Leiden), Marij Orbons (Nijmegen), Maria Angeles Sacristán (Madrid), José Manuel San Martin (Zaragoza), Carmen Sesé (Madrid), Dolores Soria (Madrid).

Lithostratigraphy

The type section of the Aragonian was published by Daams et al. (1977) and that of the Ramblian by Daams et al. (1987). Since 1977 many new localities were discovered in the Aragonian type section. For that reason we remeasured this section (Fig. 5). Fig. 6 is the section of Olmo Redondo, which is of special interest, because it fills the gap between the two type sections mentioned before.

Biostratigraphy

The zonal subdivision of the Ramblian, Aragonian, and Lower Vallesian has been made using the following criteria: 1) the presence of one or more taxons; 2) the absence of one or more taxons; 3) evolutionary stages; 4) abundance.

The most ideal subdivision of our Neogene succession would be on the basis of entry features solely. However, using only the entry of one or more taxons as a criterion, the zonation would be too rough, and therefore the other features, mentioned above, are used as well in several cases. Consequently, some of our zones have sharp lower limits (B and C, for instance), but others have gradual ones (A, G2, and G3 for instance).

In the first place the assemblage zones described below are meant to be of 'local' importance for correlations, 'local' referring to the faunas of a restricted area. It is suggested that each bioprovince have its own local biozonation, which in a later stage may be correlated with the local biozonation of other areas. If various of our biozones are recognized in other areas, it is stressed that we do not pretend that these correlations have strict chronological implications. Within the same bioprovince, the local zones may have diachronical boundaries, and the possibility of diachronism increases over larger distances.

The correct way to establish the faunal succession is through lithostratigraphic control. In many cases this has been possible, but several faunas had to be keyed in using only biostratigraphic criteria. Consequently, the succession of localities within each biozone does not always represent a succession in time. For instance, in zone Z, the

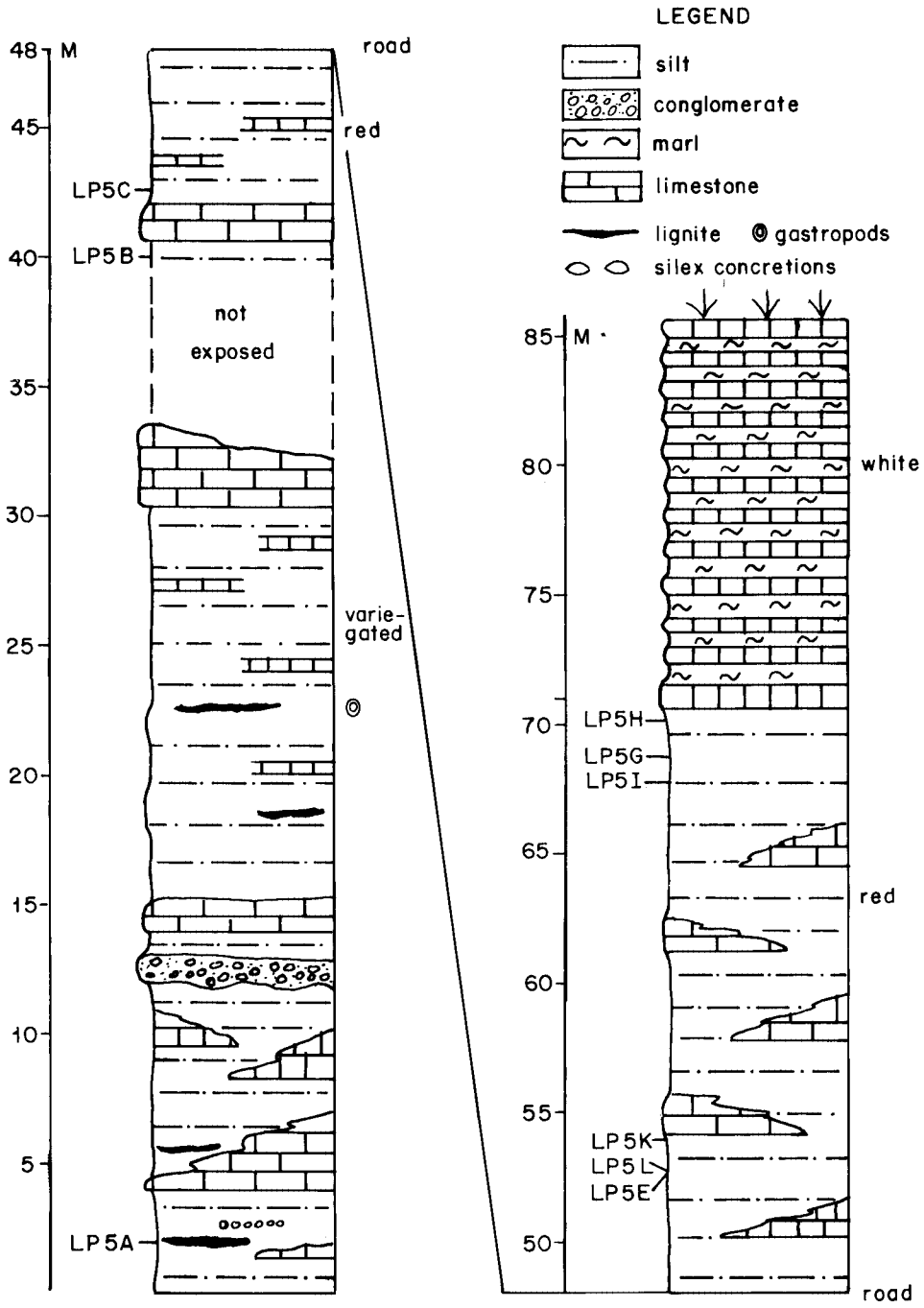


Fig. 5. Upper portion of the type section of the Aragonian. The situation of the section is indicated by the X in Fig. 1 . LP5A - LP5H refer to the fossiliferous levels.

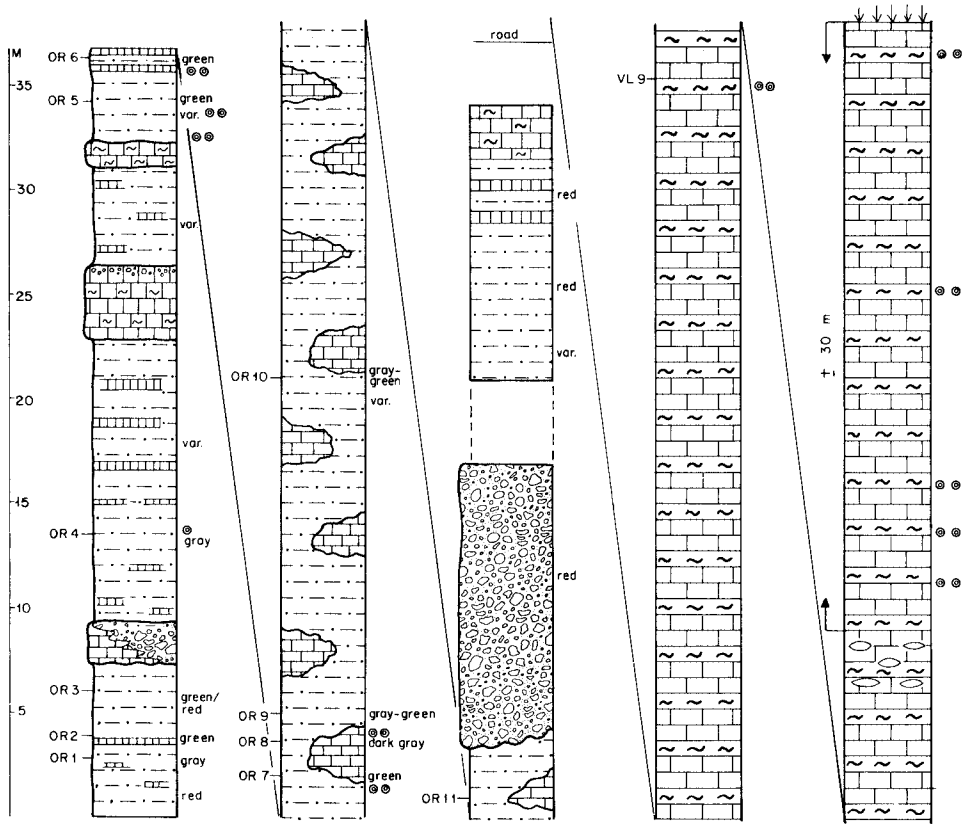


Fig. 6. Lithostratigraphic section of Olmo Redondo. OR 1 - 10 and VL 9 refer to the fossiliferous levels. The situation of the section is indicated in Fig. 1, from point 1 to 7. Legend see Fig. 5.

localities of Navarrete del Río, Ramblar 1, and Ramblar 3B are in lithostratigraphic superposition. The localities of Ramblar 4A, 5, and 7 are situated in a similar lithostratigraphic level as Ramblar 3B. Using a marker bed, the localities of Valhondo 1 and 3A are keyed in between Ramblar 1 and 3B. The correlation of our sections and the fossil localities they contain is given in Fig. 7.

Our state of knowledge is not such that we can assure that correlations by means of (micro)mammal faunas have chronological implications. Not even absolute datings may serve, as their standard error is generally larger than the precision of biostratigraphic correlation. Perhaps, after obtaining a dense faunal documentation during a relatively long time span in various areas, the qualitative and quantitative changes inferred from paleoecological and paleoclimatic conditions may serve as a further tool for more precise correlation.

The assemblage zones described below still bear the letters Z and A to I. In the future, when all the material is described in detail, a formal biozonation may be created. It is possible that by then definitions of some zones will undergo corrections.

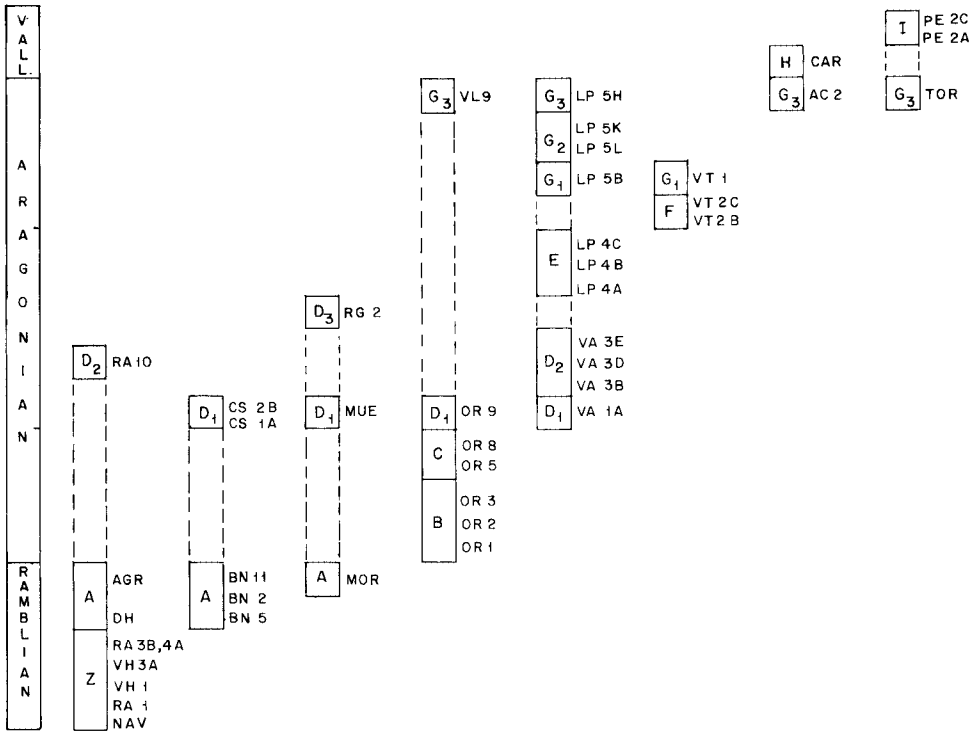


Fig. 7. Succession of micromammal faunas based on lithostratigraphic control in the Calatayud-Teruel Basin.
AC = Alcocer, AGR = Agreda, BN = Bañón, CAR = Carrilanga, CS = Casetón, DH = La Dehesa, LP = Las Planas, MOR = Moratilla, MUE = Muela Alta, NAV = Navarrete del Río, OR = Olmo Redondo, PE = Pedregueras, RA = Ramblar, RG = Regajo, TOR = Toril, VA = Valdemoros, VH = Valhondo, VL = Villafeliche, VT = Valalto.

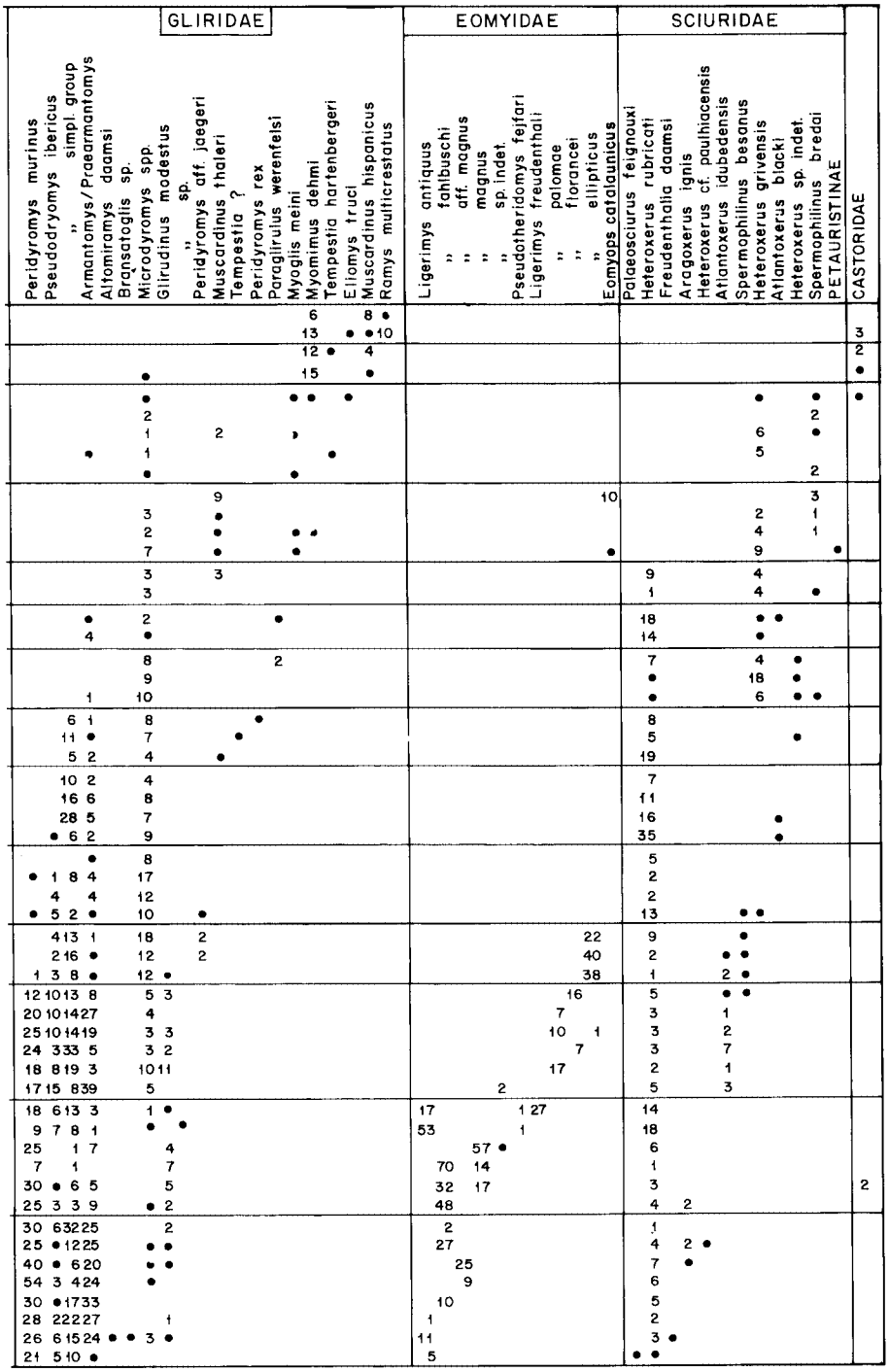
DEFINITION OF THE STAGE BOUNDARIES AND BIOZONATION OF THE RAMBLIAN, ARAGONIAN AND LOWER VALLESIAN

The Aragonian was defined by Daams, Freudenthal & van de Weerd in 1977, and has subsequently been subdivided into the Lower, Middle, and Upper Aragonian. Daams & Freudenthal (1981) described a more detailed subdivision of the Aragonian and Lower Vallesian. The Lower Aragonian contains zone A, the Middle Aragonian zones B, C, D, and E, the Upper Aragonian zones F and G, and the Lower Vallesian zones H and I. Daams, Freudenthal & Alvarez (1987) define the pre-Aragonian stage Ramblian, and change the definition of the lower limit of the Aragonian. The Ramblian contains zones Z and A, the Lower Aragonian zones B and C, and the rest of the zonation is as above. These results are compiled in Fig. 8.

At the Munich Symposium in 1975 the authors of the Aragonian agreed with the other participants to define the lower and upper limits of the stage by the entry of *Anchitherium* and *Hipparion* respectively. However, after various sampling campaigns, the chosen criteria appeared to be unfortunate ones. First of all, remains of *Anchitherium* appeared to be extremely scarce in the Aragonian type area, and secondly it is more

CONTINENTAL STAGES		LOCAL BIOZONATION	Rodent genera and species / LOCALITIES	N M 1,2	CRICETIDAE: Melissiodon cf. dominans	Eucricetodon aff. aquitanicus	" aff. infralactorensis	" aquit.-infralact.	" sp.	Democricetodon hispanicus	Eumyarion valenciennum	Megacricetodon primitivus	Fahlbuschia koenigswaldi	Democricetodon sp.	Pseudofahlbuschia jordensi	Eumyarion cf. medium	Megacricetodon collongensis	Cricetidae gen. et sp. indet.	Fahlbuschia freudenthali	Renzimys lacombai	Fahlbuschia darocensis	Cricetodon spp.	Megacricetodon rafaeli	" coll.-crus.	Democricetodon gaillardi	Megacricetodon minor crusafonti	" crus.-ibericus	Fahlbuschia cf. crusafonti	Democricetodon sulcatus	Megacricetodon ibericus	Hispanomys spp.	Megacricetodon debruijni	Cricetulodon hartenbergeri
VALLESIAN	lower	I	PEDREGUERAS 2C	767																								5	22	24	34	
			" 2A	614																								1	46	13	11	
		H	CARRILANGA 1	647																								2	15	19	46	
			NOMBREVILLA	233																					15			4	29	37		
ARAGONIAN	upper	G_3	SOLERA	1190																	2	19			•	7	43	•				
			LAS PLANAS 5H	290																	1	13			3	7	72					
			TORIL	745																	11	1			2	7	7•					
			ALCOCER 2	187																	5	11			1	7	6					
			VILLAFELICHE 9	511																	2	2			•	9	5					
		G_2	LAS PLANAS 5K	152																		10		5	7	5	6					
			" " 5L	159																	2	2			1	8	9					
			BORJAS	917											•						21	2			•	3	6	8				
			MANCHONES 1	2397																	31	6			1	4	6					
		G_1	VALALTO 1	75																	5	4		7	1							
			LAS PLANAS 5B	483																	2	•		84	•	5						
		F	VALALTO 2C	879																	5	21	9	53								
			" 2B	179																	2	3	8	69								
	middle	E	LAS PLANAS 4C	61													70				7	1										
			" " 4B	126													50				21	•										
			" " 4A	82													46				36	1										
		D_3	VALHONDO 4	138													46		25	6												
			REGAJO 2	1444													24		46	6												
			VALDEMOROS 3E	443											•		46		25													
		D_2	" 3D	322												13	64															
			VILLAFELICHE 4B	84												24	31															
			" 4A	838												19	25	•														
			VALDEMOROS 3B	708												•10	39															
		D_1	CASETON 2B	342											78	•	8															
			" 1A	990											36	•	• 32															
			VALDEMOROS 1A	189											50	27	• •															
			OLMO REDONDO 9	432										•	8	34	27															
	lower	C	" " 8	496										•	29	2																
			" " 5	488										4	3	14	4															
			VARGAS 1A	1799										•	1	16	18															
		B	VILLAFELICHE 2A	229										28																		
			SAN ROQUE 2	869										13																		
			" " 1	926										10																		
			OLMO REDONDO 3	119										13																		
			" " 2	286										10																		
			" " 1	175										6																		
RAMBLIAN	upper	A	MORATILLA	1225																												
			BAÑON 11	278	2																											
			" 2	298	•																											
			" 5	131																												
			AGREDA	1053																												
			LA DEHESA	119											•																	
	lower	Z	RAMBLAR 5	101			2																									
			" 7	746	•		3																									
			" 3B	1216	•		•																									
			" 4A	370																												
			VALHONDO 3A	189	1		4																									
			" 1	494			16																									
			RAMBLAR 1	837	2	8																										
			NAVARRETE	325	•	56																										

Fig. 8. Range chart of Ramblian, Aragonian, and Lower Vallesian rodent taxons.


GLIRIDAE
EOMYIDAE
SCIURIDAE
CASTORIDAE
Peridyromys murinus
Pseudodryomys ibericus
" simpl. group
Armantomys/Praearmantomys
Altomiramys daamsi
Bransatoglis sp.
Microdyromys spp.
Glirudinus modestus
" sp.
Peridyromys aff. jaegeri
Muscardinus thaleri
Tempestia ?
Peridyromys rex
Paraglirulus werenfelsi
Myoglis meini
Myomimus dehmi
Tempestia hartenbergeri
Eliomys truci
Muscardinus hispanicus
Ramys multicrestatus
Ligerimys antiquus
" fahlbuschi
" aff. magnus
" magnus
" sp. indet.
Pseudotheridomys fejfari
Ligerimys freudenthali
" palomae
" floroncei
" ellipticus
Eomyops catalaunicus
Palaeosciurus feignouxi
Heteroxerus rubricati
Freudenthalia daamsi
Aragoxerus ignis
Heteroxerus cf. paulhiacensis
Atlantoxerus idubedensis
Spermophilinus besanus
Heteroxerus grivensis
Atlantoxerus blacki
Heteroxerus sp. indet.
Spermophilinus bredai
PETAURISTINAE
CASTORIDAE

useful to choose micromammnal events in delimiting a stage which is further subdivided on the basis of the micromammal content too. Therefore, Daams et al. (1987) changed the definition of the lower limit of the Aragonian, and chose the entry of the first modern cricetid (*Democricetodon*) as a more reliable criterion. They did not suggest a different upper limit, as the Aragonian-Vallesian transition is not represented in the Aragonian type area by a continuous faunal documentation as it is the case in the Duero Basin, for instance (Alvarez et al., 1985).

Ramblian

The lower limit of the Ramblian is the extinction level of an ancient group of Eomyidae (*Rhodanomys – Ritteneria*). Two zones are distinguished, Z and A.

Zone Z is characterized by *Eucricetodon* aff. *aquitanicus*, *E.* aff. *infralactorensis*, and *Melissiodon* cf. *dominans* although in low numbers. Furthermore large numbers of Gliridae are present; *Peridyromys murinus*, the *Pseudodryomys simplicidens* group, *P. ibericus*, and *Armantomys*. *Ligerimys* is present in proportions varying from 1 - 27 %. The boundary between zones Z and A is not a sharp one.

Zone A is characterized by the predominance of Eomyidae (*Ligerimys* and *Pseudotheridomys*). *Melissiodon* may be present, and *Eucricetodon* is extremely rare. The Gliridae fauna is represented by more or less the same genera as those in zone Z, although in lower numbers. Castoridae may be present, and *Glirudinus* is a consistent component of the faunas of zone A.

Lower Aragonian

The Lower Aragonian contains zones B and C.

Zone B is characterized by *Democricetodon* as the only cricetid present. The Gliridae fauna is comparable to that of zones Z and A. *Glirudinus modestus* and *Microdyromys* are common glirids. *Ligerimys* is present, but in relatively low numbers.

Zone C houses *Megacricetodon primitivus*, *Fahlbuschia*, and *Eumyarion*. *Ligerimys ellipticus* is predominant, and Gliridae are less abundant.

Middle Aragonian

The Middle Aragonian houses zones D1, D2, D3, and E.

Zone D1 is characterized by the presence of *Fahlbuschia koenigswaldi*, *Megacricetodon primitivus*, or *M. collongensis*. *Eumyarion*, *Democricetodon*, and *Peridyromys murinus* may be present in low numbers. Eomyidae are absent.

Zone D2 houses *Pseudofahlbuschia jordensi* and *Megacricetodon collongensis*. *Fahlbuschia koenigswaldi*, *Peridyromys murinus*, and *Eumyarion* are absent.

Zone D3 is characterized by *Fahlbuschia freudenthali*, *Renzimys lacombai*, and *Megacricetodon collongensis*. *Pseudodryomys ibericus* is absent, and *P. simplicidens* is common.

Zone E: *Cricetodon* is present though not common. *Megacricetodon collongensis* and *Fahlbuschia darocensis* are common, and the Gliridae fauna is poor. *Microdyromys* is present and *Paraglirulus* is very rare.

Upper Aragonian

The Upper Aragonian contains zones F, G1, G2, and G3.

Zone F is characterized by two *Megacricetodon* species: *M. collongensis – crusafonti* and *M. rafaeli*. *Fahlbuschia darocensis* and *Cricetodon* are present in low numbers, and the Gliridae fauna is even more impoverished quantitatively than in the previous zone.

Zone G1: two *Megacricetodon* species are present: *M. collongensis – crusafonti* and *M. minor*. *Fahlbuschia darocensis* and *Cricetodon* are present in low numbers. The Gliridae fauna is poor.

Zone G2: *Megacricetodon crusafonti* and *M. minor* are present, accompanied by *Cricetodon* and *Fahlbuschia darocensis*. Qualitatively the Gliridae fauna is relatively diverse (two *Microdyromys* species, *Myomimus dehmi*, *Muscardinus thaleri*, *Myoglis meini*), but they occur in very low numbers. *Eomyops* (Eomyidae) may be present.

Zone G3 is characterized by *Megacricetodon crusafonti – ibericus* and *M. minor*. *Cricetodon* is relatively common, as well as *Fahlbuschia darocensis*. *F.* cf. *crusafonti* may be present. The Gliridae fauna is comparable to that of zone G2. Castoridae may be present.

Lower Vallesian

The following zones (H and I) belong to the Lower Vallesian.

Zone H is characterized by the presence of *Megacricetodon ibericus* and *M. minor* or *M. debruijni*. *Hispanomys* is frequent, and *Fahlbuschia* cf. *crusafonti* is present in low numbers. *Myomimus dehmi* is frequent, *Muscardinus hispanicus* and Castoridae are present in low numbers. *Hipparion* is present in one locality (Nombrevilla).

Zone I houses only one *Megacricetodon* species: *M. debruijni*. *Cricetulodon* is present, *Hispanomys* is well-represented, and *Democricetodon sulcatus* is present in low numbers. *Ramys multicrestatus* is a new element, and *Muscardinus hispanicus* and *Myomimus dehmi* are relatively common. Castoridae are present in low numbers. *Hipparion* is present in both localities.

Chronostratigraphy

The Ramblian may be roughly subdivided into a lower and an upper part. The lower portion houses abundant Myomiminae, a large variety of *Ligerimys* species and some *Eucricetodon* species. The upper part consists of predominantly Eomyidae-faunas, quantitatively impoverished but qualitatively similar Gliridae-faunas, and very few ancient Cricetidae.

The Lower Aragonian is still characterized by a large variety of *Ligerimys*-species. Characteristic are the progressive immigrations of modern Cricetidae. The Gliridae-fauna is qualitatively comparable to that of zones Z and A.

In the Middle Aragonian the Cricetidae-fauna is very diverse, and the Gliridae become less abundant, both in species and in numbers. Eomyidae are absent, and Sciurinae are well represented.

In the Upper Aragonian the Cricetidae is the most abundant family, and it may constitute up to 98 % of the rodent fauna. Gliridae are present in very low numbers, but in relatively high species diversity, different from those of the Middle Aragonian.

The Lower Vallesian is still characterized by a diverse Cricetidae-fauna, and the Gliridae are present in larger numbers. Beavers are present too, although never in large numbers.

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