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BRYOZOA AND STRATIGRAPHY IN PALEOGENE TIMES THROUGH THE STUDY OF PALEOGENE SPECIES FROM EUROPE*

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ABSTRACT

The interest in Stratigraphy of Bryozoa is discussed, through the study of the Paleogene fossil species recognized in European basins (excluding the former USSR). It seems that the utility of these fossils in biostratigraphy, mainly within each basin, has been demonstrated. Their interest may be accepted given the great abundance of species found in different Paleogene chronostratigraphic units. Further research is needed to define the status of this phylum for stratigraphic analysis.

Keywords: Bryozoa, Stratigraphy, Paleogene, Europe.

RESUMEN

Un análisis de las especies de briozoos fósiles en las distintas cuencas paleógenas de Europa (excluyendo las de la antigua URRS) permite ver la importancia de este grupo fósil y su interés en Bioestratigrafía. En los análisis intracuenca parece evidente que puede ser utilizado con mucho provecho. Para establecer correlaciones entre cuencas distintas pueden ser muy útiles si se usan con la circunspección necesaria. Para todo ello conviene incrementar la investigación sobre los Briozoos y la Estratigrafía en otras regiones y en sucesiones de otras edades.

Palabras clave: Briozoos, Estratigrafía, Paleógeno, Europa.

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INTRODUCTION

In the First International Conference on Bryozoa of the International Bryozoology Association, held in the buildings and with the sponsorhip of the AGIP Direzione Mineraria in San Donato Milanese (Italy), the first group of contributions were on "The Bryozoa in oil research". The contributions within this group by Enrico Annoscia, Richard S. Boardman and Yves V. Gautier made a plea for the use of Bryozoa in oil research, i. e. in biostratigraphical research. Gautier (1968, p. 34-35) said "...it does not seem that Bryozoa have been admitted really as useful microfossils; yet recent treatises of Paleontology are dealing with them... but only as to a basic research group. That is why we have in the IBA to show that may be used as well as Ostracoda and even, sometimes, as Foraminifera; what we have to do is to write a treatise analogous of Ellis and Messina's treatise on Foraminifera: there is no doubt that this is our duty and there is good hope that will be done in the next ten years".

Unfortunately, twenty five years later, there is no a treatise like that cited by Ellis and Messina. Nor has the use of Bryozoa in biostratigraphy achieved significant targets, in spite of very interesting stratigraphic considerations and data in nearly all monographs on Bryozoa published. On the other hand, some other approaches in the study of bryozoans related to stratigraphic work must be also considered. One of them is that concerning to the use of Bryozoa in paleoenvironmental analysis, through the study of zoarial forms. Stach (1936), Lagaaij and Gautier (1965), Labracherie and Prud'homme (1966), Schopf (1969), Nelson *et al.* (1988) and Bianchi *et al.* (1990) are important contributions in this aspect. I myself (Reguant, 1993) have also summarized some of the contributions of the bryozoans to paleoecologic and sedimentologic analysis. Another approach refers to the general contribution of the bryozoans in rock formation and the different taxa present in each chronostratigraphic unit. With this approach it is possible to discern the history of phylum Bryozoa and the general stratigraphic interest of this kind of fossils.

In this contribution I discuss the presence of bryozoans in a part of stratigraphic scale, the Paleogene period, through the analysis of European Paleogene bryozoan species recognized in the literature, preceded by some analytical observations on Paleogene bryozoan genera. With them I will contribute to the fulfilment of the desire expressed by the cited bryozoologists in the IBA First Conference after the publication of the proceedings of the 9th IBA Conference (Hayward, Ryland and Taylor, 1994).

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THE PALEOGENE GENERA

General information about Paleogene genera is difficult to obtain. It is possible to take data from Bassler (1953), with minor corrections available from Sepkoski (1982, 1992). Some confusion arises from the fact that Danian was considered as belonging to the Cretaceous in Bassler's compilation. Another problem is the difficulty in determining which part of the Cretaceous time-span is included when a genus is given simply as Cretaceous. With these cautions I present three Tables (Table 1 to 3) devoted, respectively, to Cyclostomata, Anasca and Ascophora, with indications of genera present in each epoch (Paleocene; Eocene, Oligocene) considered, and the first (FA) and last (LA) appearances. The numbers of Late Cretaceous last appearences are indicated to show the importance of K/T extinction in Bryozoa.

There are more genera found in Eocene and Oligocene beds, than in Paleocene. This is particularly true in Ascophora and, to a lesser extent in Anasca. The decrease in the number of genera present in Oligocene may be biased by the lower abundance of marine bed outcrops, at least in Europe, as we can see below when the European Paleogene bryozoan species are discussed.

The number of genera that disappeared before the beginning of the Tertiary is very important in Anasca, because they include Cribrimorpha, of which 68 genera became extinct, as did 59 genera of Cyclostomata. This order did not recover the generic diversity attained in preceding times. In contrast Cribrimorpha achieved a slight recovery. The family diversity of these two groups also decreased as shown by Taylor (1993). The predominance of Ascophora, and in general of Cheilostomata, began in the Paleogene, and last to the recent seas.

Epochs	Present	FA	LA
OLIGOCENE	47	5	4
EOCENE	56	21	14
PALEOCENE	39	4	6
L. CRETACEOUS			59

Table 1. Number of Cyclostomata genera present and FA and LA in each Paleogene epoch.

Epochs	Present	FA	LA
OLIGOCENE	89	7	4
EOCENE	96	38	14
PALEOCENE	62	10	4
L. CRETACEOUS			90

Table 2. Number of Anasca genera present and FA and LA in each Paleogene epoch.

Epochs	Present	FA	LA
OLIGOCENE	120	9	6
EOCENE	139	102	28
PALEOCENE	38	26	1
L. CRETACEOUS			15

Table 3. Number of Ascophora genera present and FA and LA in each Paleogene epoch.

PALEOGENE EUROPEAN SPECIES

A collection of monographs on European (excluding the former USSR) Paleogene Bryozoa have been published in this century, with additions, corrections and up-to-date revisions. The following analysis concern all those I have could examine. The areas envisaged are (Fig. 1): Southeast and Northeast Pyrenees; Aquitaine; Paris; Belgium; United Kingdom; Austria; Germany; Northeast and Central Italy; Polish, Hungarian, Roumanian and Czecho-Slovakian Carpathians; Central Poland, and Scandinavia (including Rügen Island).

The more complete successions of the Paleogene beds containing Bryozoa are from Aquitaine with 35 to 140 species recognized in distinct Paleogene units, except Paleocene with only 12 species. The Paris basin has abundant bryozoan faunas in Lower and Middle Eocene; no bryozoans in Upper Eocene; and very few in Paleocene and Oligocene. A very poor fauna is present during all Paleogene units in Belgium, except the rich Lutetian fauna. There are, more or less, rich faunas belonging to different specific Paleogene units in some other European areas: very rich in Scandinavia Danian, in Priabonian from different Carpathian areas, and in NE Italy Priabonian and Oligocene; more or less abundant faunas are found in Austria Paleocene, in C Poland Danian, in NE Pyrenees Sparnatian (accepted as Upper Paleocene), and in Germany Oligocene.

PALEOCENE (MAINLY DANIAN) BRYOZOAN FAUNAS

Table 4 shows the number of species cited in the works studied for each area considered. For Scandinavia Danian: Berthelsen (1962), Brood (1972), Voigt (1968,

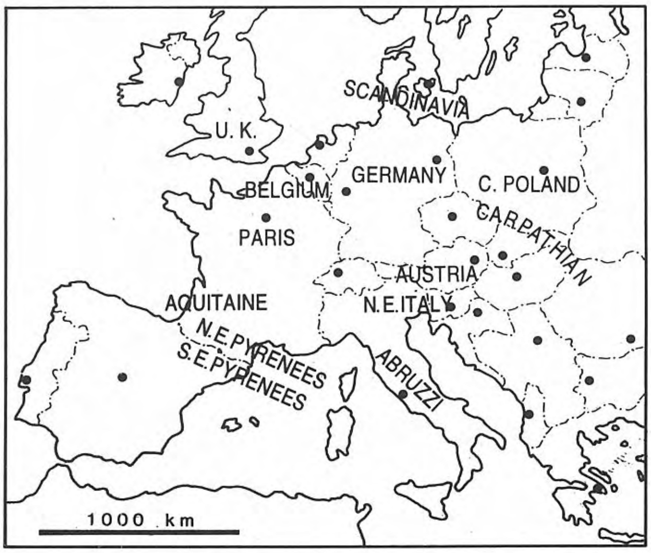

Figure 1. Europe sketch map with approximate situation of the areas containing Paleogene Bryozoa.

1989), Cheetham (1971), and Jurgensen (1971); for North Germany: Voigt (1968); for Central Poland: Voigt (1964) and Maryanska (1969); for Austria Danian and Paleocene: Kühn (1930), and Vávra (1978, 1979, 1988b and in print); for Paris Basin Danian: Braga and Bignot (1986); for Paris Basin Montian and Thanetian: Buge (1964); for Belgium Montian: Voigt (1956); for Northeastern Pyrenees Sparnatian (accepted as equivalent to Thanetian): Plaziat and Balavoine (1964), and Plaziat (1970); for Aquitaine Paleocene: Debourle (1974); for Northeast Italy Pre-Eocene: Braga (1968).

The Scandinavia Danian has abundant fauna which allows a stratigraphical analysis to understand their relationships with Late Cretaceous and Middle and Late Paleocene faunas, or exceptionally with more recent faunas.

The Table 5 shows the stratigraphic range of Scandinavian bryozoan species from Danian.

All species of Scandinavia Danian ranges between Late Cretaceous and Paleocene, except one Anasca that lasts until Eocene times. More than 50 % are exclusively Danian; 26 % are known from Late Cretaceous to Danian times and 16 % only from Maastrichtian; only near 6 % last to younger times than Danian. It seems clear that there are two important changes in Bryozoa close to the Cretaceous/Tertiary boundary: one corresponding to this boundary, and other between Danian/Middle-Late Paleocene. However the most important finding is the proximity of Danian to Cretaceous bryozoan fauna and the distinctiveness of Danian to Middle and Late Paleocene and, evidently, to Tertiary fauna, as Voigt (1985) pointed out. This fact also found in other faunas, mainly in North Europe, is the chief argument against the location of the Cretaceous-Tertiary boundary in the Maastrichtian-Danian boundary, instead of in the Danian-Post Danian boundary (Voigt, 1981).

EARLY EOCENE FAUNAS

Some confusion may arise from the different use and interpretation of chronostratigraphic units according the different authors. From the authors consulted

Chronostr. unit	Area	CY	AN	ASC	TOTAL
DANIAN	Scandinavia (incl. Rügen)	75	101	22	198
DANIAN	North Germany	0	0	1	1
DANIAN	Central Poland	6	9	7	22
DANIAN	Austria	5	7	1	13
DANIAN	Paris	1	3	1	5
DANO-MONTIAN	Central Poland	9	9	10	28
MONTIAN	Central Poland	3	0	2	5
MONTIAN	Paris	1	4	1	6
THANETIAN	Paris	1	0	0	1
THANETIAN	Northeast Pyrenees	3	12	2	15
PALEOCENE	Aquitaine	6	4	2	12
PALEOCENE	Austria	8	11	1	20
PRE-EOCENE	Northeast Italy	2	0	2	4

Table 4. Number of Paleocene bryozoan species described in different European areas (CY = Cyclostomata; AN = Anasca; ASC = Ascophora). Only in Central Poland some species are cited from more than one Paleocene stage.

I have accepted that Sparnatian from NE Pyrenees corresponds to the upper part of Late Paleocene. On the other hand, the clear distinction between Thanetian and Sparnatian faunas in the Paris basin allows us to consider the Sparnatian of Paris basin as lowermost Early Eocene. In this case the problem has no particular importance. Only one species was cited from Thanetian and also a unique species was accepted as Sparnatian in the Paris basin. As accepted by many stratigraphers, Ypresian and Early Eocene are considered here as synonymous, except in the Paris basin as pointed out previously.

Table 6 shows the number of bryozoan species recognized in the European Lower Eocene in each area studied, according to the following authors: Aquitaine (Labracherie, 1970, and Debourle, 1974); Paris (Buge, 1964 and 1979); SE Pyrenees (Faura and Canu, 1916, and Reguant, 1967); NE Pyrenees (Canu, 1918); and Belgium (Canu and Bassler, 1929).

MIDDLE AND LATE EOCENE FAUNAS

Remarks on the use of these units

Some variations, through time, in the use of these terms make it diffcult to discern the exact situation in the chronostratigraphic scale of some bryozoans cited in the literature. This is particularly true in the very important contribution of Labracherie (1970) to our knowledge of Aquitaine Eocene bryozoans. This author accepts the division of Eocene in Early, Middle and Late following Veillon (1962). According the more recent revisions of Tethyan Paleogene, mainly by Schaub (1981) it seems clear that Middle Eocene of Veillon, and then of Labracherie, includes only Lutetian (and perhaps some part of the uppermost Early Eocene). Late Eocene includes both Bartonian, now accepted as Middle

Order or Suborder	1	2	3	4	5	6	7	Total
CYCLOSTOMATA	15	31	19		1	9		75
CHEIL. ANASCA	72	1	25				1	99
CHEIL. ASCOPHORA	13		7	1				21
Total	100	32	51	1	1	9	1	195

Table 5. Number of Danian bryozoan species from Scandinavia according to each stratigraphic range accepted: (1) only known as Danian. (2) known also as Maastrichtian. (3) known also as Late Cretaceous. (4) known from Danian to Middle or Late Paleocene. (5) known from Maastrichtian to Middle or Late Paleocene. (6) known from Late Cretaceous to Middle or Late Paleocene. (7) known from Late Cretaceous to Eocene.

Area	CY	AN	ASC	TOTAL
AQUITAINE	17	18	9	44
PARIS	6	13	14	33
BELGIUM	0	1	1	2
NE PYRENEES	1	0	0	1
SE PYRENEES	0	2	1	3

Table 6. Number of Early Eocene bryozoan species described in difeerent Europeas areas.

Eocene (Cavelier and Pomerol, 1986), and Priabonian. However, none of the localities discussed in Schaub (1981) are cited in bryozoan localities studied in Labracherie (1970). This fact makes it very difficult to determine the exact situation of Bryozoa collected in relationship with accepted chronostratigraphic scales. On the other hand very few species (less than 10 %) reported as Late Eocene, have been found as Bartonian by other authors. We accept, therefore, as a more realistic supposition and for practical purposes, that all species identified as Late Eocene by Labracherie are really Priabonian.

As indicated above, Lutetian and Bartonian are accepted here as the lower and the upper part, respectively, of the Middle Eocene, and Priabonian as Late Eocene. The data gathered on Middle Eocene European Bryozoa are from: Aquitaine (Labracherie, 1970, and Debourle, 1974); Paris (Buge, 1964, 1979); Belgium (Canu and Bassler, 1929); United Kingdom (Burton, 1929, 1933; Davis, 1934, and Cheetham, 1966); Northeast Pyrenees (Canu, 1918); Southeast Pyrenees (Neviani, 1905; Canu, 1913; Faura and Canu, 1916; Barroso, 1949, and Reguant, 1990). In the interest of a more precise comparison betweeen some areas, besides the analysis of total Middle Eocene faunas, some particular considerations are first offered on the species recognized more precisely as Lutetian and Bartonian.

Area	CY	AN	ASC	TOTAL
AQUITAINE	54	51	52	157
PARIS	53	47	53	153
BELGIUM	15	22	21	58
UNITED KINGDOM	1	13	14	28
NE PYRENEES	9	11	7	27

Table 7. Number of Lutetian brytozoan species described in different European areas.

Area	CY	AN	ASC	TOTAL
AQUITAINE	19	11	10	40
PARIS	4	15	16	35
UNITED KINGDOM	2	20	22	44
SE PYRENEES	14	19	38	71

Table 8. Number of Bartonian bryozoan species described in different European areas.

Area	CY	AN	ASC	TOTAL
AQUITAINE	57	54	58	169
PARIS	53	56	65	174
UNITED KINGDOM	2	32	36	70
BELGIUM	15	22	21	58
NE PYRENEES	9	11	7	27
SE PYRENEES	14	19	38	71

Table 9. Number of total Middle Eocene bryozoan species described in different areas.

Lutetian and Bartonian faunas

Tables 7 and 8 show the number of Lutetian and Bartonian bryozoan species recognized in different areas.

The recognized Lutetian faunas from Aquitaine and Paris are very rich, and richer than Bartonian fauna. On the other hand the Bartonian fauna from UK is richer than Lutetian fauna from the same region. The fauna from SE Pyrenees, really found in Ebro and Central Catalan basin is more important than the number of species identified may suggest. The poor preservation of minute structures necessary to identify the bryozoan species prevents the identification of a very abundant fauna in Bartonian beds of many localities in the center of Catalonia and in northern Aragón.

Total Middle Eocene faunas

Taking into account all recognized Middle Eocene species, Table 9 shows the number of total bryozoan faunas recognized in different areas.

Late Eocene (Priabonian) faunas

The Bryozoa Priabonian faunas are rich in the different Carpathian areas, in Northeast Italy and in Aquitaine. A small Priabonian fauna was recognized in Belgium. The data were gathered from Malecki, 1963 (Polish Carpathians); Ghiurca and Mongereau, 1981 (Hungary and Roumania), Zagorsek, 1992 (Czecho-Slovakia Cyclostomata); Labracherie, 1970, and Debourle, 1974 (Aquitaine); Braga and Munari, 1972, Antolini, Braga and Finotti, 1980, Ghiurca and Mongereau, 1981, Annoscia, Braga and Finotti, 1983, Accorsi, Braga and Ungaro, 1988, Braga and Barbin, 1988, Braga, 1991 (NE Italy); Canu and Bassler, 1929 (Belgium).

Table 10 shows the number of Upper Eocene bryozoan faunas recognized in different areas.

Area	CY	AN	ASC	TOTAL
AQUITAINE	21	30	44	95
NE ITALY	57	38	86	181
CARPATHIAN	129	63	79	271
BELGIUM	0	3	2	5

Table 10. Number of Late Eocene bryozoan species described in different areas.

area	CY	AN	ASC	TOTAL
AQUITAINE	47	66	83	196
NE ITALY	27	17	27	71
ABRUZZI	0	0	14	14
AUSTRIA	1	1	1	3
GERMANY	16	10	20	46
PARIS	1	3	6	10
BELGIUM	1	4	2	7

Table 11. Number of Oligocene bryozoan species described in different areas.

OLIGOCENE FAUNAS

The data on Oligocene bryozoan faunas were gathered from Péniguel, 1959, and Debourle, 1974, Labracherie, 1974 (Aquitaine); Antolini, Braga and Finotti, 1980, Braga and Barbin, 1988, and Braga, 1991 (NE Italy); Ceretti and Poluzii, 1973 (Abruzzi); Vavra, 1979, and in print (Austria); Buge, 1949 (Basse-Alsace, considered together with German faunas); David and Pouyet, 1968, David *et al.*, 1968, Vavra, 1983 and 1988a, Cook and Voigt, 1989 (Germany); Buge, 1964, and 1975 (Paris); Canu and Bassler, 1931 (Belgium).

Table 11 shows the number of total Oligocene bryozoan faunas recognized in different areas.

COMPARATIVE ANALYSIS OF DIFFERENT FAUNAS FOR EACH CHRONOSTRATIGRAPHIC UNIT

The comparison of the lists of species recognized in different areas for each chronostratigraphic unit is a necessary condition to establish the paleogeographic closeness of these areas, through the similarity of faunas, during the time-span considered. Nevertheless, even though the authors from whom the lists were gathered are reliable, they are not all contemporary, and some biases both in species identification, and in use of chronostratigraphic units have inevitably been produced. On the other hand, in some areas the number of species recognized is very low and the comparison between faunas may be poorly significant. For this reasons, the

DANIAN:		SCAND.	C POL.	AUSTRIA
	SCANDIN.		0.15	0.13
	C POLAND			0.06
	AUSTRIA			

L. EOC.:		AQUIT.	PARIS
	AQUIT.		0.08
	PARIS		

M. EOC.:		AQUIT.	PARIS	UK	BELGIUM	NE PYR.	SE PYR.
	AQUIT		0.29	0.21	0.12	0.10	0.09
	PARIS			0.22	0.15	0.05	0.06
	UK				0.11	0.02	0.01
	BELGIUM					0.09	0.05
	NE PYREN.						0.02
	SE PYREN.						

U. EOC.:		AQUIT.	NE ITALY	CARPAT
	AQUIT.		0.17	0.08
	NE ITALY			0.38
	CARPAT			

OLIGO.:		AQUIT.	NE ITALY	GERM.
	AQUIT.		0.14	0.08
	NE ITALY			0.10
	GERMANY			

Table 12. Dice similarity coefficients in total bryozoan species from different European areas with more than 20 species recognized for each choronostratigraphic unit.

general comparison will be made only between richer faunas. Therefore, the Dice similarity coefflcient were applied only to faunas containing more than 20 bryozoan total species. The Dice coefficient discussed by Cheetham and Hazel (1969) allows comparison of two faunas analysing the relationship between the species present in both areas (common species) and total species in each of the two areas according to the following formula:

$$Da,b = 2\ Ca,b\ /\ (Na + Nb)$$

in which Da,b is the Dice similarity index with respect to the number of species in the two areas considered (a and b); Ca,b is the number of common species in the same both areas; and N is the number of species present in each area: Na in a, and Nb in b.

Table 12 and the corresponding Fig. 2 show the Dice similarity coefficients in each chronostratigraphic unit with respect to the richer bryozoan faunas in Europe.

Some significant suggestions can be inferred analyzing the Table 12 and the corresponding Fig. 2 with respect to the bryozoological faunas compared and then to the content in Bryozoa of the each Paleogene chronostratigraphic unit. Moreover the lists obtained from the references mentioned in preceding paragraphs, allows us to add some comments to point out some special features of the comparisons between rich faunas and also between all faunas considered in this work.

a) Danian (and Paleocene) faunas

Danian faunas are concentrated mainly in Northern countries. In fact, it is known that at the end of Cretaceous time and of the lowermost Paleocene a Northern sea covered from the South Scandinavia to Crimea through Central Poland. (Pomerol, 1973). The relatively high value of the similarity coefficient between Scandinavia and Central Poland faunas is thus understandable. In fact, nearly 50 % of the species recognized in Central Poland are found in Scandinavia.

The information of Austrian Paleocene fauna is given by the authors partly as Danian, and partly as Paleocene without more precise determination, as indicated in Table 4. Some different considerations allow us to accept that all fauna recognized in Paleocene Austrian beds may be assigned to Danian. This Austrian fauna is less similar to the Scandinavian than that from Central Poland, and the similarity of this and Austrian seems to be small.

The marine beds are poorly represented in Danian age in Western Europe, and the Middle and Upper Paleocene have given only poor bryozoan faunas in Paris and Belgium and in Mesogean basins (Aquitaine, NE Pyrenees and NE Italy). Of the very few species present both in Danian and in Middle and Late Paleocene of different European basins, *Spiropora verticillata* Goldfuss, is present in Scandinavia, Central Poland, and Austrian Danian and also in Montian from Paris, and in Paleocene, without more precision, from Aquitaine.

b) Early Eocene faunas

Only the Aquitaine Basin, and, to a lesser extent, Paris Basin present relatively rich Early Eocene faunas.

The number of species common to both basins is very small. Only 2 cyclostome species out of 17 and 6 species respectively from Aquitaine and Paris; 1 anascan species out of 18 and 13; and no ascophoran species common between Aquitaine and Paris. This is in agreement with the low value of Dice coefficient (Table 12).

With respect to other, poorer, faunas the lists show that: the two species from Belgium are not present either in Aquitaine or in Paris Basin; the species *Reticulopora nummulitorum* d'Orbigny is present in NE Pyrenees and in Aquitaine; and the species *Lunulites punctata* Leymerie, is present in SE Pyrenees and in Aquitaine.

c) Middle Eocene faunas

During the Middle Eocene there were rich bryozoan faunas in all Western Europe, from Paris, England and Belgium basins to the areas surrounding Pyrenees. Table 12 shows clearly that the more similar faunas (Dice coefficient exceeding 0.20) are those from Aquitaine, Paris and United Kingdom. Paris/Aquitaine coefficient is near 0.30. Belgium presents a Dice coefficient that exceeds 0.10 in respect of three faunas mentioned. Both Eastern Pyrenees faunas show very low values of similarity coefficient. This is also true for their mutual coefficient. When separing Lutetian from Bartonian faunas, some similarity is found between NE Pyrenees cyclostome and anascan fauna and that from Aquitaine and Paris.

d) Late Eocene faunas

As shown in Table 10 a very poor fauna is present in Late Eocene from Belgium. In contrast very rich faunas are present in different Carpathian areas considered and in NE Italy, and, to a lesser extent, in Aquitaine. The NE Italy/Carpathian similarity coefficient is the highest in all European Paleogene units studied, as shown by Table 12 and Fig. 2. This fact was partially considered by Braga and Ghiurca (1969), and Ghiurca and Mongereau (1981). A more precise consideration shows that the closest faunas are the Cyclostomata. The similarity of Aquitaine fauna and NE Italy is important, but not that of Aquitaine and Carpathian faunas.

e) Oligocene faunas

In the Oligocene marine beds of different European basins the bryozoans are present, but the number of species is very small in Austria, Paris and Belgium, and only some Ascophora are present in the Abruzzi. As shown in Table 11, only Aquitaine has a rich fauna, and to a lesser extent, NE Italy and Germany. The greatest similarity is between NE Italy and Aquitaine fauna, and the least is that between Aquitaine and Germany (Table 12).

FAUNAL SUCCESSIONS

Some successions, as indicated above, include more-or-less complete Paleogene successions. I therefore discuss the quantitative stratigraphic range through the number of species present in the different chronostratigraphic units in some selected areas.

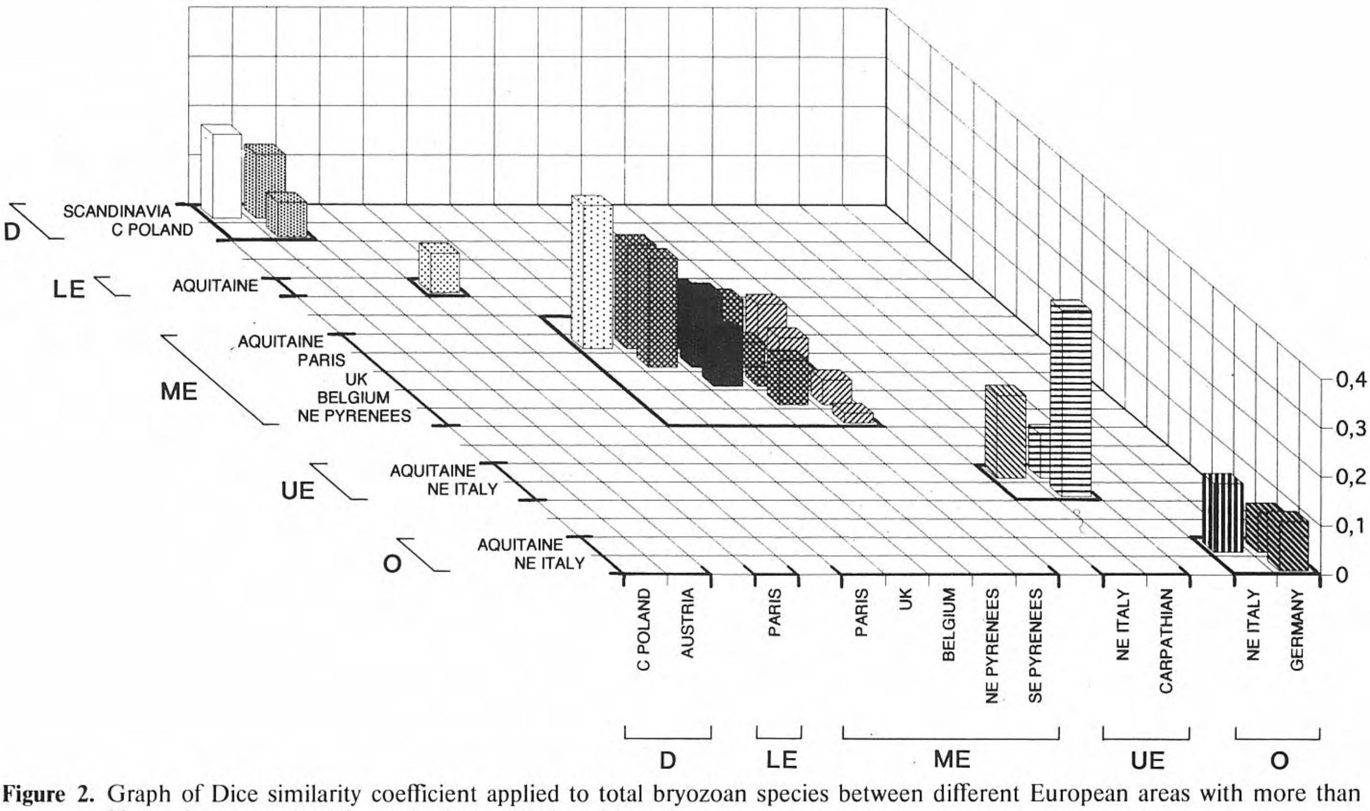

Figure 2. Graph of Dice similarity coefficient applied to total bryozoan species between different European areas with more than 20 species recognized in each chronostratigraphic unit.

a) Aquitaine

In Aquitaine basins there are bryozoans in all Paleogene units considered. Table 13 shows the total number of bryozoan species in each kind of stratigraphic range. Numbers in bold indicate the number of species exclusive to each Paleogene chronostratigraphic unit. The total number of exclusive species is 240. This represents the 71 % of total species found.

b) Paris

In Paris basin we have more detailed chronostratigraphic scale. Most units are defined in this basin. The Upper Eocene, however, is not present in marine facies. On the other hand the bryozoans are scarce in Paleocene and in Oligocene (Stampien). Table 14 shows the number of total species in each stratigraphic range within Paris Paleogene strata.

n. sp\chron. u	PALEOCENE	L EOCENE	M EOCENE	U EOCENE.	OLIGOCENE
6	=====				
1	=====	=====			
1	=====	=====	=====		
4	=====	=====	=====	=====	=====
21		=====			
8		=====	=====		
3		=====	=====	=====	
8		=====	=====	=====	=====
77			=====		
22			=====	=====	
44			=====	=====	=====
9				=====	
5				=====	=====
127					=====

Table 13. Total number of Bryozoa species in each stratigraphic range within Aquitaine Paleogene strata.

n. sp\chr. un	DANIAN	MONT.	THANET.	YPRES.	LUTET.	BARTON.	STAMP.
5	=====						
6		=====					
1			=====				
8				=====			
20				=====	=====		
6				=====	=====	=====	
120					=====		
7					=====	=====	
1					=====	=====	=====
22						=====	
9							=====

Table 14. Total number of Bryozoa species in each stratigraphic range within Paris Paleogene strata.

n. sp\chron. un	PRIABONIAN	OLIGOCENE
115	=====	
66	=====	=====
6		=====

Table 15. Total number of Bryozoa species in each stratigraphic range within Northeast Italy Priabonian and Oligocene.

As in preceding Table, the bold numbers indicate the number of species exclusive to each Paleogene chronostratigraphic unit. The total number of exclusive species is 167. This represents 83 % of total species found.

c) Northeast Italy

In NE Italy there are an abundant bryozoan fauna belonging to Priabonian and Oligocene. In contrast only 4 species are found in Paleocene strata. In Table 15 only Priabonian and Oligocene faunas are considered. This Table shows that all Oligocene species are common with Priabonian with the exception of 6 species.

SOME CONCLUSIVE CONSIDERATIONS

A glimpse at these three faunal successions in relationship with chronostratigraphic units shows two different patterns. In Paris and Aquitaine basins the exclusive species predominate, and then the bryozoans may be a powerful tool in determining the age of the strata containing them. In contrast in NE Italy, nearly all Oligocene species are also present In Priabonian strata. Therefore the Oligocene cannot be characterized by bryozoans. The presence of an important number of exclusive species, however, may allow us to identify some strata as Priabonian.

STRATIGRAPHIC RANGE OF SOME AQUITAINE EXCLUSIVE SPECIES

From all the data gathered, the data on Aquitaine Bryozoa supplied by Labracherie (1970, 1971) seem to be the easiest to analyze, as a sample, to ascertain the biostratigraphic value of the presence of the bryozoan species for the stratigraphic correlation between sections located in different basins. The results of this analysis may weaken or strengthen the value of Bryozoa as a useful tool in biostratigraphic regional research.

The exclusive Aquitaine species in each accepted geochronologic unit (Early Eocene, Middle Eocene. Late Eocene and Oligocene) were selected from the list by Labracherie (1971), excluding the new species created by this author, and the poorly identified species. Taking the information available from Labracherie (1970) Table 16 shows the stratigraphic range of these species. Labracherie taken this information from different authors who described bryozoan species in distinct, nearly exclusive European, areas.

As the Table 16 shows most exclusive Aquitaine species are found in Middle Eocene and in Oligocene. Taking into account all the species mentioned in the table, only 19 are exclusive to a specific geochronologic unit in Aquitaine and other areas; 38 species have a broader stratigraphic range than that recognized in Aquitaine. Except the new species from Aquitaine, no Early or Late Eocene exclusive species are really exclusive to these units elsewhere. Otherwise, 13 out of 24 (54 %)

species\geochronologic unit	K	P	EE	ME	LE	O	M	Pl	Q	R
exclusive EARLY EOCENE in Aquitaine										
Membranipora elliptica (Hagenow)	x	x	x							
Heterocrisina communis (d'Orbigny)	x	x	x							
Crisisina carinata (Roemer)	x	x	x							
Idmonea triforata Canu			x	x						
Tervia? serrata (Reuss)			x	x	x					
Circibipora grignonensis (Canu)			x	x						
Tubucella contorta (Canu)			x	x						
Kelestoma biarritzensis (Canu)			x	x						
Pleuronea pertusa (Reuss)			x	x	x	x	x			
exclusive MIDDLE EOCENE in Aquitaine										
Stenosipora simplex (Koschinsky)				x	x					
Oncousoecia macrostoma (Milne-Edwards)			?	x	?	?				
Dakaria beyrichi (Stoliczka)			x	x	x	x				
Ogivalina? dimorpha (Canu)			?	x						
Entomaria dutempleana (d'Orbigny)			?	x						
Ditaxiporina granulosa (Canu)				x						
Adeonellopsis punctata (Canu)				x	x					
Schizostomella magnoaperta (Gregory)				x						
Escharella hörnesi Reuss				x	x	x				
Gaudryanella variabilis Canu				x						
Berenicea vlesi (Canu)				x						
Reticulipora nummulitorum				x						
Prosthenoecia lerichei (Canu)				x						
Prosthenoecia lateralis (d'Orbigny)				x						
Reptotubigera elatior d'Orbigny				x						
Microecia? hirsuta (Canu)				x						
Stomatopora granulata (Milne-Edwards)	x	x	x	x	x	x	x	x	x	
Setosella fragilis Canu			?	x						
Membraniporella radiata (Reuss)			?	x	x					
Umbonula leda (d'Orbigny)				x						
Escharella selseyensis Cheetham				x						
Crisia corbini Canu				x						
Labioporella dartevellei Cheetham			?	x	?					
Tubucella aviculifera Canu & Bassler				x						
exclusive LATE EOCENE in Aquitaine										
Schizostomella curryi Cheetham				x	x					
Umbonula bartonense Gregory				x	x					
Electra concatenata (Reuss)		?	?	?	x	?				
exclusive OLIGOCENE in Aquitaine										
Diastopora frireni Canu				x	x	x				
Porella? excentrica (Reu.) *rarecostulata* Canu						x				
Scrupocellaria brendolensis Waters					x	x				
Ogivalina? dimorphocella (Canu)						x				
Rosseliana brevipora Canu & Lecointre						x	x			
Calpensia nobilis (Esper)						x	x	x	x	x
Entomaria spinifera (Canu)						x	x			
Schizoporella indistincta Vigneaux						x	x			
Schizoporella unicornis (Johnston)						x	x	x		
Myriapora tenuitruncata (Vigneaux)						x				
Schizostomella heteromorpha (Reuss)						x				
Onychocella angulosa (Reuss)						x	x	x	x	x
Margaretta aquitanica (Canu)						x	x			
Adeonellopsis cingulata (Reuss)						x				
Steginoporella elegans (Milne-Edwards)						x	x			
Cellaria mutabilis Canu						x	x			
Cellaria rhombifera (Münster)					x	x	x			
Schizoporella perincisa (Duvergier)						x	x			
Teichopora ovalis (Canu)						x				
Hornera frondiculata Lamouroux			?	?	?	x	x	x	x	x
Hornera striata Milne-Edwards			x	x	x	x	x	x		

Table 16. Stratigraphic range of species accepted as exclusive in Aquitaine by Labracherie (1971): (K) Cretaceous; (P): Paleocene; (EE) Early Eocene; (ME) Middle Eecene; (LE) Late Eocene; O = Oligocene; M = Miocene; Pl = Pliocene; Q = Quaternary; R = Recent.

Middle Eocene and 6 out of 21 (29 %) Oligocene exclusive species from Aquitaine seem also to be exclusive of these respective units elsewhere.

These results, which should be tested with a broader analysis, force to have an accurate attention when the Bryozoa will be used on inter-basin correlation. This should be a target in the future research on Bryozoa and Stratigraphy.

GENERAL SUMMARY AND CONCLUSIONS

On the basis of the data included and discussed in preceding chapters it is possible to summarize the main facts adduced.

1. The Paleogene genera, according the information supplied by Bassler (1953), range from 39 in Paleocene to 56 in Eocene. It seems that the major change occurs in the Cretaceous/Tertiary boundary, when near 60 bryozoan genera disappear. The first appearances in the Eocene are important: 21 genera. Moreover 14 genera disappear during this time-span. The number of new Paleocene and Oligocene genera is small in comparison with the genera present in both chonoestratigraphic units.

2. The European areas considered are: Southeast and Northeast Pyrenees; Aquitaine; Paris; Belgium; United Kingdom; Austria; Germany; Northeast and Central Italy; Polish, Hungarian, Roumanian and Czecho-Slovakian Carpathians; and Scandinavia. In all areas abundant Paleogene Bryozoa faunas are recognized.

3. The more important Paleocene fauna is found in Scandinavia (near 200 species recognized). This fauna is more close to the Cretaceous fauna, than to the Middle and Late Paleocene. More than 50 % of species, however, are exclusively Danian. There is, therefore, a break between Cretaceous and Danian, but also a major break between Paleocene and younger times. This allows us to understand the opinion of some researchers who make a plea for the acceptation of the Cretaceous-Tertiary boundary between Danian and Post-danian, instead of accepted between Maastrichtian and Danian. Paleocene faunas outside Scandinavia are represented by a small number of species.

4. Early Eocene faunas are poor. Only in Aquitaine and in Paris do they surpass 30 species.

5. Middle Eocene faunas are very rich, mainly in Aquitaine and Paris with nearly 170 species in each area. In general the Lutetian fauna is richer than Bartonian fauna with the exception of Bartonian faunas from Southeast Pyrenees and United Kingdom, which reach 71 and 44 species in these two areas respectively.

6. The bryozoan Priabonian (Late Eocene) faunas are rich in Carpathian areas (271 species recognized), in Northeast Italy (181) and in Aquitaine (95).

7. The richest Oligocene faunas are found in Aquitaine with 196 species recognized. Secondarily in NE Italy (71 species) and Germany (46 species).

8. Applying the Dice coefficient of similarity for each chronostratigraphic unit in different European areas with more than 20 species recognized, it appears that the highest similarity is found:

a) In Paleocene between Scandinavia and Central Poland.

b) In Middle Eocene between Aquitaine, Paris and United Kingdom. Some similarity also occurs between Belgium and the three areas mentioned.

c) In Late Eocene between NE Italy and Carpathian. This is the maximum value reached by Dice coefficient of all cases analyzed.

d) In Oligocene between Aquitaine and NE Italy.

The comparison of all other areas, especially the Early Eocene of Aquitaine and Paris show a small similarity between them.

9. Studying some selected successions with more or less continuous presence of bryozoans in successive chronostratigraphic units, it is possible to show that:

a) The number of exclusive species in each chronostratigraphic unit in Aquitaine and Paris successions represents 71 and 83 per cent respectively.

b) The number of exclusively Priabonian species in NE Italy is nearly double the number of species present both in Priabonian and Oligocene.

10. The analysis of species exclusive to Aquitaine for each definite chronostratigraphic unit shows that a significant number of them are not exclusive to this specific unit outside the Aquitaine basin.

All these data allows us to deduce some general conclusions:

A) The Bryozoa are important components of some Paleogene successions in Europe.

B) The minor universality of species, in comparison with other mierofossils used in biostratigraphy, and the relatively greater difficulties in the specific identification may be the reason of the scarce use of this kind of fossils in oil research.

C) The usefulness of Bryozoa as biostratigraphic markers is demonstrated, giving the exclusive presence of many species in each geochronologic unit in the more complete stratigraphic successions studied. This is particularly true within a definite basin. The bryozoans as a biostratigraphic tool in inter-basin correlation may be used with caution and through an accurate analysis.

D) The use of fossil Bryozoa in the stratigraphical studies of Paleogene beds should not be overlooked, given their abundance. As demonstrated in other works, their use is particularly significant in paleogeographic and paleoenvironmental analysis. It seems that it is also very interesting in classical biostratigraphy if this use is made with the right criteria. In general, the topic Bryozoa and Stratigraphy needs further and deeper research as the authors mentioned in the Introduction pointed out.

Finally, some cautions should be mentioned in general on the general subject of this contribution besides the information taken out of books and papers cited.

a) There are no intensive studies on Paleogene Bryozoa in some European areas. Then, the information available is different according to different European basins.

b) Most Bryozoa have subspherical, non feeding, shortlived type of larvae that have poor chances to colonize wide areas far from mother colonies. Then, these bryozoan species have fewer opportunities to achieve a wide distribution in the oceans, and this fact diminishes the potential value of bryozoans in stratigraphic correlations at great distance.

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