

PHYLOGENETIC SEQUENCES OF LOWER CRETACEOUS BENTHIC FORAMINIFERA AND THEIR USE IN BIOSTRATIGRAPHY¹

HELMUT BARTENSTEIN²

ABSTRACT

Bartenstein, H. (1978). Phylogenetic sequences of Lower Cretaceous benthic foraminifera and their use in biostratigraphy. *Geol. Mijnbouw*, 57, p. 19-24.

Ten stratigraphically important phylogenetic sequences of benthic index foraminifera in the Lower Cretaceous are described. Their distribution is examined in North West Germany, which belongs to the north temperate facies realm, and they are also found to be, in part, of stratigraphic importance in the Lower Cretaceous throughout the world, including the tethyan facies realm.

The development and importance of such phylogenetic sequences for biostratigraphic determinations is emphasized; the paper concludes with a supplementary note about the validity of statistical analyses as applied to phylogenetic lineages.

INTRODUCTION

The first attempts at a micropalaeontological subdivision of the Lower Cretaceous were carried out in laboratories of the German petroleum industry in the 1930's and 1940's, mostly using individual species of foraminifera (and also ostracodes). By the 1950's phylogenetic connections between genera and/or species had been observed and examined in detail (BETTENSTAEDT, 1968: Historical Review). At the same time the importance of phylogenetically changing smaller foraminifera for a specific biostratigraphic zonation of the Lower Cretaceous stages and substages had been recognized (BARTENSTEIN & BETTENSTAEDT, 1962), and in particular cases these were more successful than other groups of fossils, and were not so affected by changes in lithology.

In this publication ten selected phylogenetic sequences of important benthic species of foraminifera are described which are important as Lower Cretaceous stratigraphic markers in Germany and also in some cases, in other parts of Europe and throughout the world (Figs. 1 and 2). These sequences also have a regional validity in the tethyan facies realm, as well as a

local value in the north temperate facies realm. The selection has been made in such a way that besides simple phylogenetic sequences (transformations into 2 and 3 species), more complicated phylogenetic lineages (transformations into 4, 8 and 9 species) are also presented. It is intended to make use of the possibilities of species diversification as far as possible.

It would appear that selected examples of these phylogenetic lineages (e.g. example 9 and 10 on Fig. 1) allow relatively fine stratigraphic determinations to be made in the Lower Cretaceous.

The examples mentioned here, can be extended by further sequences of foraminifera as enumerated by BETTENSTAEDT (1968, p. 340).

The following genera and species of benthic foraminifera have already been examined in the Lower Cretaceous (arranged in historical order):

Vaginulina procera [ALBERS, 1952]

Conorotalites [BETTENSTAEDT, 1952, 1958]³

Ammobaculites, *Haplophragmium*, *Lituola* [BARTENSTEIN, 1952]

Gaudryina, *Spiroplectinata* [GRABERT, 1959]³

Marssonella, *Spiroplectamina*, *Frondicularia*, *Lagena* [ZEDLER, 1961]³

Globorotalites, *Conorotalites* [KAEVER, 1961]

Vaginulina procera, *Gaudryina* and *Spiroplectinata*, *Conoro-*

¹ Manuscript received: 1977-05-05.

Revised manuscript received and accepted: 1977-12-23.

² Spoerckenstrasse 102, D-3100 CELLE, Germany.

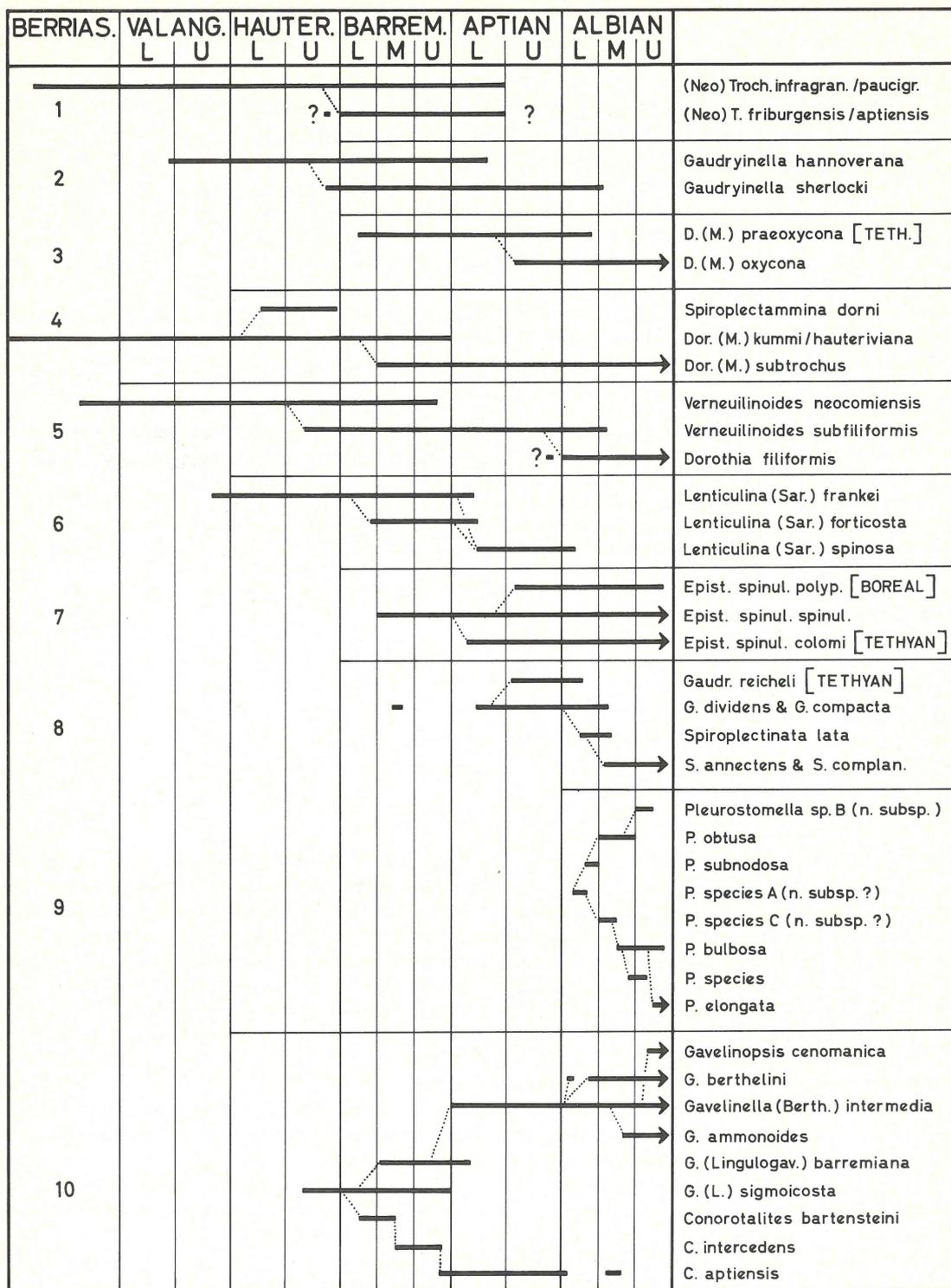


Fig. 1

Phylogenetic sequences of selected benthic foraminifera in the Lower Cretaceous and their stratigraphic distribution.

[tethyan] [boreal] Exclusive occurrence of the respective species in the listed facies realm.

(Neo) Trocholina, Dorothia (Marssonella), Gavelinella (Berthelina), Gavelinella (Lingulogavelinella) = Two different generic names according to differing nomenclatural interpretation by the cited authors. The same is true of the two different species names (e.g. infragranulata/paucigranulata, kummi/hauteriviana).

(Sar.) Saracenaria = Subgenus of Lenticulina.

→ Ending of distribution in the Upper Cretaceous.

? Occurrence of the respective species uncertain.

..... Transition to another species.

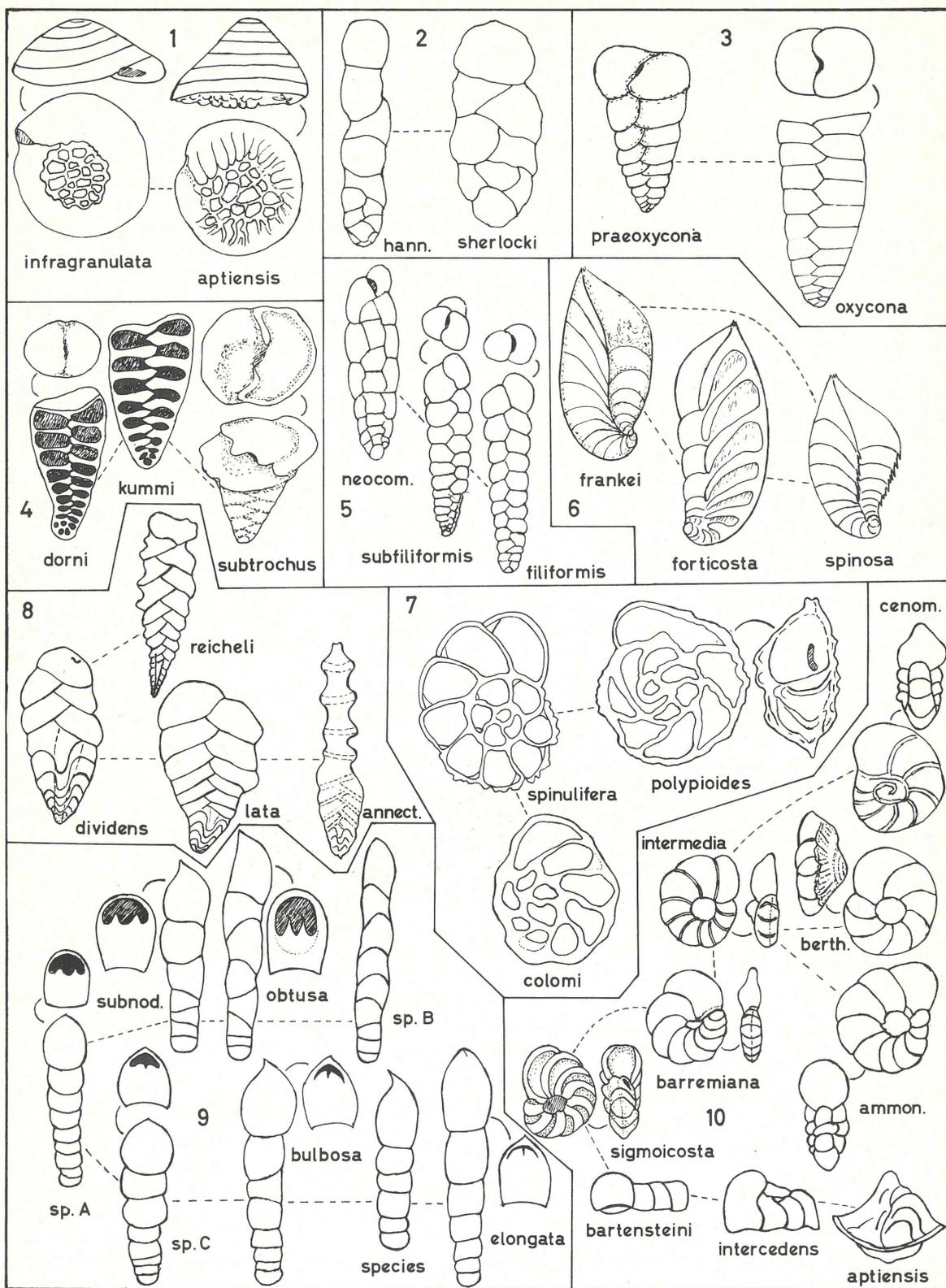


Fig. 2
Generalized pictures of the foraminiferal species listed in Fig. 1.

----- Transition to another species.

1, 2, 3 The same numbers of the phylogenetic sequences as in Fig. 1.

talites [BARTENSTEIN & BETTENSTAEDT, 1962]³
Haplophragmium, *Triplasia* [GERHARDT, 1963]
Gavelinella, *Gavelinopsis* [MICHAEL, 1966]³
Lagena haueriviana, *Vaginulina procera* etc. [BETTENSTAEDT, 1973]
Lagena haueriviana and related species or subspecies [BETTENSTAEDT & SPIEGLER, 1975]
Lenticulina nodosa [BARTENSTEIN, 1974, AUBERT & BARTENSTEIN, 1976]
Falsogaudryinella [BARTENSTEIN, 1977b]³
 (And the following unpublished reports)
Verneuilinoides [AL-ABAWI, 1964]
Pleurostomella [BETTENSTAEDT & SPIEGLER, 1965]
 (mentioned with figured chart in BETTENSTAEDT, 1968)³
Citharina [KROBOTH, 1966]

All the foraminifera described here represent well-known species in the Lower Cretaceous of the northern hemisphere. Therefore only a simplified list of references to the ten phylogenetic sequences is necessary, with additional remarks amplifying only special problems.

PHYLOGENETIC SEQUENCES

1: *(Neo)Trocholina* (2 species)

Guillaume & Reichel 1957; Jovcheva 1962, p. 55; Moullade 1966, p. 60-62; Neagu 1975, p. 117-118.

Occurrence: worldwide between East Canada and Trinidad (in the west), Europe and Asia Minor (in the east), in the boreal and tethyan facies realm.

Taxonomic problems still exist in the denomination of *Trocholina infragranulata* NOTH 1951 or *Trocholina paucigranulata* MOULLADE 1960 as well as of *Neotrocholina friburgensis* GUILLAUME & REICHEL 1957 or *Trocholina aptiensis* JOVCHEVA 1962.

2: *Gaudryinella* (2 species)

Michael 1967, p. 29-30; Neagu 1975, p. 36; Bartenstein 1977b, p. 388-392; Bartenstein & Bolli 1977, p. 547.

Occurrence: same as 1.

Recent examination of European material from the boreal and tethyan facies realms (BARTENSTEIN, 1977b) has proved the validity, systematic connection and stratigraphic importance of both species. The same is also true for the occurrences in Trinidad, East Venezuela and also (?) North California (BARTENSTEIN & BOLLI, 1977).

3: *Dorothia (Marssonella)* (2 species)

Bartenstein & Bolli 1973, p. 396-397; 1977, p. 548-549.

Occurrence: Trinidad and Europe, tethyan (both species) and boreal (*oxycona*) facies.

Differing generic interpretations of *Dorothia* and *Marssonella* depend on the evaluation of their shell construction: side view, transverse section, apertural view (see also 4).

The described lineages of Nos. 1-3 which always have two species seem to include relatively limited phylogenetic sequences compared with the following Nos. 4-9 which have up to nine species connections. But sequences Nos. 1-3 always occur with either a greater number of calcareous species (No. 1) or arenaceous species (Nos. 2 and 3), yet until the present time their phylogenetic development has not been sufficiently or conclusively examined.

For example the various species of (*Neo*)*Trocholina* have been under discussion for many years; whether they might be locally developed and specialised growth forms ('ecological variants'), or geographically influenced foraminiferal races ('subspecies'), or that they may represent true phylogenetic sequences (BARTENSTEIN, BETTENSTAEDT & KOVATCHEVA, 1971, p. 148-149).

4: *Spiroplectammina* and *Dorothia (Marssonella)* (3 species)

Zedler 1961, p. 30-34; Michael 1967, p. 28-29; Bartenstein, Bettenstaedt & Kovatcheva 1971, p. 130-133; Bartenstein & Bolli 1977, p. 548-549.

Occurrence: throughout the world in the boreal and tethyan facies realms between America (Trinidad) and Europe, in Asia Minor and North Africa, with the exception of *Spiroplectammina dorni* (up till now only found in Germany).

Dorothia haueriviana (MOULLADE 1961) should be synonymous with *Dorothia kummi* (ZEDLER 1961).

5: *Verneuilinoides* and *Dorothia* (3 species)

Bartenstein 1952, p. 308-310; Bartenstein & Bettenstaedt 1962, p. 253, 271; Michael 1967, p. 28-29; Bartenstein & Bolli 1977, p. 546-547.

Occurrence: same as 4.

6: *Lenticulina (Saracenaria)* (3 species)

Bettenstaedt 1952, p. 271-273; Bartenstein & Bettenstaedt 1962, p. 280, 284; Michael 1967, p. 40; Neagu 1975, p. 64-66; Bartenstein & Bolli 1977, p. 552-553.

Occurrence: same as 4.

7: *Epistomina* (3 species and subspecies)

Bartenstein & Bettenstaedt 1962, p. 281, 288; Ohm 1967, p. 140-144; Bartenstein 1977a, p. 33, 36; Bartenstein & Bolli 1977, p. 557.

Occurrence: worldwide between America and Europe, and Asia Minor and North Africa, the principal form occurring in both facies realms. The derivative subspecies are developed in the boreal (*polypoides*) and tethyan (*colomi*) facies.

8: *Gaudryina* and *Spiroplectinata* (4 species)

Grabert 1959, p. 42-45; Bartenstein, Bettenstaedt & Bolli 1966, p. 142-143, 169-170; Bartenstein, Bettenstaedt & Kovatcheva 1971, p. 132; Bartenstein 1977a, p. 36-37.

Occurrence: Trinidad and Europe, in both facies realms. Exceptions: *Gaudryina reicheli* BARTENSTEIN, BETTENSTAEDT &

³ Sequences totally or in part in this publication. The names in brackets refer to the reference and not to the author of the genera or species.

BOLLI 1966 up till now only found in Trinidad, *Spiroplectinata lata* GRABERT 1959 only in North West Germany and *Gaudryina compacta* GRABERT 1959 only in the Mediterranean region.

9: *Pleurostomella* (8 species and unspecified forms)

Bettenstaedt 1968, p. 370-373.

Occurrence: up till now has only been found in North West Europe including North West Germany.

10: *Gavelinella*, *Gavelinopsis* and *Conorotalites* (9 species)

Bettenstaedt 1958, p. 119-121; Bartenstein & Bettenstaedt 1962, p. 275-278; Michael 1966, p. 443-454; 1967, p. 80-82; Bettenstaedt 1968, p. 349, 368-371; Neagu 1975, p. 118-121; Bartenstein 1977a, p. 36-37.

Occurrence: throughout the world in the boreal and tethyan facies realms from America in the west, to Europe, Asia Minor and North Africa in the east.

This phylogenetic development is one of the best examined and most impressive sequences of foraminifera in the Lower Cretaceous.

Regarding the connection between the various *Conorotalites* species, it is hoped that sufficient material from the tethyan area between Trinidad and North California will soon be available so that in the Upper Barremian and Lower Aptian sediments the phylogenetically changing characteristic shape of the tests of *Conorotalites intercedens* – *aptiensis* can be investigated by more detailed variation statistics.

The same is true for the *Conorotalites* species in the higher part of the Lower Cretaceous in the tethyan facies of Rumania and Bulgaria.

Because the phylogenetic transformations are entirely independent of palaeoclimatic zones, they are not subject to any palaeogeographic or temporal limitations. This means, that they can be used in any kind of Lower Cretaceous stratigraphic chart throughout the world (BARTENSTEIN, 1976b, fig. 1; 1977a, tables 1-2) and whether in the west or east, in the boreal or tethyan (mediterranean) facies, in neritic or bathyal deposits, they are always useful in the subdivision of formations.

SUPPLEMENTARY NOTE: VALIDITY OF PHYLOGENETIC SEQUENCES, ESPECIALLY OF VARIATION STATISTICAL MEASUREMENTS

In his noteworthy paper ARNOLD (1966) explained, giving useful examples, the problems and limits of the application of phylogenetic sequences of foraminiferal species for biostratigraphic purposes. I support these explanations, especially his conclusions (1966, p. 545-547) concerning 'space and time' in biostratigraphic or biochronological applications.

The combined knowledge of

- (1) the taxonomic distinction of related species or subspecies;
- (2) the local or regional occurrence of these forms including migration routes between temperate and tethyan facies realms;
- (3) the stratigraphic distribution through different Lower

Cretaceous stages, substages or horizons at one or at several localities;

(4) the critical and restricted application of phylogenetic ideas with the aid of variation statistical methods, should make it possible to bring together the divergent concepts of ARNOLD (1966), BETTENSTAEDT (1952-1975) and his pupils GRABERT (1959), ZEDLER (1961) and MICHAEL (1966).

Statistical variation studies are very important in tracing a palaeontological 'trend' which has already been clearly recognized with the arrangement of species and subspecies in binomial or trinomial nomenclature together with the accepted position of such forms in the stratigraphic column. The proving of phylogenetic sequences by statistical variation methods only, should remain, because of the numerous existing difficulties and possible mistakes, a tentative conception in accordance with Arnold's statements.

REFERENCES

- Al-Abawi, T. 1964 Phylogenetische und ökologische Untersuchungen an *Verneulinoides* (Foram.) aus der nordwestdeutschen Unterkreide – Diplomarbeit, Techn. Univ. Braunschweig.
- Albers, J. 1952 Taxonomie und Entwicklung einiger Arten von *Vaginulina* D'ORB. aus dem Barrême bei Hannover (Foram.) – Mitt. geol. Staatsinst. 21: 75-112.
- Arnold, H. 1966 Grundsätzliche Schwierigkeiten bei der biostratigraphischen Deutung phyletischer Reihen – Senck. lethaea 47: 537-547.
- Aubert, J. & H. Bartenstein 1976 *Lenticulina* (*L.*) *nodosa*, additional observations in the worldwide Lower Cretaceous – Bull. Centre Rech. Pau-SNPA 10: 1-33.
- Bartenstein, H. 1952 Taxonomische Revision und Nomenklator zu FRANZ E. HECHT 'Standard-Gliederung der Nordwestdeutschen Unterkreide nach Foraminiferen' (1938). Teil 2: Barrême. Taxonomische Bemerkungen zu den *Ammobacilites*, *Haplophragmium*, *Lituola* und verwandten Gattungen (For.) – Senckenbergiana 33: 297-342.
- 1974 *Lenticulina* (*Lenticulina*) *nodosa* (REUSS, 1863) and its subspecies – worldwide index foraminifera in the Lower Cretaceous – Eclogae Geol. Helv. 67: 539-563.
- 1976a Practical applicability of a zonation with benthonic foraminifera in the worldwide Lower Cretaceous – Geol. Mijnbouw 55: 83-86 (with comprehensive list of respective references).
- 1976b Benthonic index foraminifera in the Lower Cretaceous of the northern hemisphere between East Canada and North West Germany – Erdöl Kohle 29: 254-256.
- 1977a Stratigraphic parallelisation of the Lower Cretaceous in the northern hemisphere – zonation with benthonic index foraminifera – Newsl. Stratigr. 6: 30-41.
- 1977b *Falsogaudryinella* n.g. (Foraminifera) in the Lower Cretaceous – N. Jb. Geol. Paläont. Mh. 1977/7: 385-401.
- Bartenstein, H. & F. Bettenstaedt 1962 Marine Unterkreide (Boreal and Tethys) – In: Leitfossilien der Mikropaläontologie B7: 225-297.
- Bartenstein, H., F. Bettenstaedt & T. Kovatcheva 1971 Foraminiferen des bulgarischen Barrême. Ein Beitrag zur weltweiten Unterkreide-Stratigraphie – N. Jb. Geol. Paläont. Abh. 139: 125-162.
- Bartenstein, H. & H. M. Bolli 1973 Die Foraminiferen der Unterkreide von Trinidad, Teil 3 – Eclogae Geol. Helv. 66: 389-418.
- 1977 The Foraminifera in the Lower Cretaceous of Trinidad,

- W.I., Part 4 – *Eclogae Geol. Helv.* 70: 543-573.
- Bettenstaedt, F. 1952 Stratigraphisch wichtige Foraminiferen-Arten aus dem Barrême vorwiegend Nordwest-Deutschlands – *Senckenbergiana* 33: 263-295.
- 1958 Phylogenetische Beobachtungen in der Mikropaläontologie – *Paläont. Z.* 32: 115-140.
- 1968 Wechselbeziehungen zwischen angewandter Mikropaläontologie und Evolutionsforschung – *Beih. Ber. naturhist. Ges.* 5: 337-391 (with comprehensive list of all micropaleontologically important publications).
- 1973 Zur Phylogenie und Paläökologie einiger Foraminiferen und Ostrakoden aus dem Ober-Hauterive und Mittel-Barrême von Helgoland – *Senck. lethaea* 54: 265-279.
- Bettenstaedt, F. & D. Spiegler 1965 Die Evolution der Gattung *Pleurostomella* (Foram.) im NW-deutschen Alb – Bericht Deutsche Forschungsgemeinschaft.
- 1975 Zur Evolution von *Lagena* (Foram.) in der tieferen Unterkreide NW-Deutschlands – *Mitt. Geol.-Paläont. Inst. Univ. Hamburg* 44: 11-44.
- Gerhardt, H.-D. 1963 Biometrische Untersuchungen zur Phylogenie von *Haplophragmium* und *Triplasia* (Foram.) aus der tieferen Unterkreide Nordwestdeutschlands – *Boll. Soc. Paleont. Ital.* 2/2: 9-74.
- Grabert, B. 1959 Phylogenetische Untersuchungen an *Gaudryina* und *Spiroplectinata* (Foram.) besonders aus dem nordwestdeutschen Apt und Alb – *Abh. senckenberg. naturforsch. Ges.* 498: 1-71.
- Guillaume, H. & M. Reichel 1957 *Neotrocholina friburgensis* n. sp., foraminifère de l'Urgonien alpin – *Eclogae Geol. Helv.* 50: 285-288.
- Iovcheva, P. M. 1962 Foraminifera from the oolitic limestones of the Aptian along the Rusenski Lom river – *Rev. Bulgar. geol. Soc.* 23: 41-61.
- Kaever, M. 1961 Morphologie, Taxonomie und Biostratigraphie von *Globorotalites* und *Conorotalites* (Kreide-Foram.) – *Geol. Jb.* 78: 378-438.
- Kroboth, K. 1966 Untersuchungen an *Citharina* D'ORB. (Foram.) aus dem Neokom Nordwest-Deutschlands – Diss. math.-naturwiss. Fak. Univ. Tübingen.
- Michael, E. 1966 Die Evolution der Gavelinelliden (Foram.) in der NW-deutschen Unterkreide – *Senck. lethaea* 47: 411-459.
- Moullade, M. 1966 Etude stratigraphique et micropaléontologique du Crétacé inférieur de la 'Fosse vocontienne' – *Doc. Lab. Géol. Fac. Sci.* 15: 1-369.
- Neagu, T. 1975 Monographie de la faune des foraminifères éocénés du couloir de Dîmbovicioara, de Codlea et des Monts Persani (couches de Carhaga) – *Mém. Inst. Géol. Géoph.* 25: 1-141.
- Ohm, U. 1967 Zur Kenntnis der Gattungen *Reinholdella*, *Garantella* und *Epistomina* (Foramin.) – *Palaeontographica* 127 Abt. A: 1-188.
- Zedler, B. 1961 Stratigraphische Verbreitung und Phylogenie von Foraminiferen des nordwestdeutschen Oberhauterive – *Paläont. Z.* 35: 28-61.