Cretaceous ostracode biochronology of Morocco

Autor(en): **Andreu, Bernard**

Objekttyp: **Article**

Zeitschrift: **Eclogae Geologicae Helvetiae**

Band (Jahr): **95 (2002)**

Heft 2

PDF erstellt am: **21.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-168951

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.
Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.
Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Ein Dienst der *ETH-Bibliothek*
ETH Zürich, Rämistrasse 101, 8092 Zürich, Schweiz, www.library.ethz.ch

http://www.e-periodica.ch

0012-9402/02/020133-20
Birkhäuser Verlag, Basel, 2002

Eclogae geol. Helv. 95 (2002) 133–152

Cretaceous ostracode biochronology of Morocco

BERNARD ANDREU

Key words: Biochronology, ostracode assemblages, Cretaceous, Northern Morocco
Mots clés: Biochronologie, Associations d'Ostracodes, Crétacé, Maroc septentional

ABSTRACT

In the Barremian-Maastrichtian of Northern Morocco, ostracode assemblages enable us to propose a regional scale adjusted against the standard chronostratigraphic scale. 71 genera are indexed; their first and last appearance levels, compared with the stage boundaries, are used as biostratigraphic guide markers of important Cretaceous periods. From the ostracode assemblages 166 named species are recognized. The Aptian-Campanian interval can be subdivided into six assemblage biozones and two subzones, three distribution biozones, two abundance biozones and one interval biozone. This biostratigraphic scale is compared with scales proposed for the South Tethyan margin countries: Algeria, Tunisia and Israel.

RÉSUMÉ

Dans les séries du Barrémien-Maastrichtien du Maroc septentrional, les associations d'ostracodes nous permettent de proposer une échelle régionale calée sur l'échelle chronostratigraphique standard sur laquelle sont portés les âges en millions d'années. 71 genres sont répertoriés; les niveaux de première et de dernière observation, mis en parallèle avec les limites d'étages, sont utilisés comme repères biostratigraphiques à des périodes charnières du Crétacé. Les associations d'espèces, 166 espèces nominées ayant été reconnues, subdivisent l'intervalle Aptien-Campanien en six biozones et deux sous-zones d'associations, trois biozones de distribution, deux biozones d'abondance et une biozone d'intervalle. Cette biozonation est comparée á celles déjá proposées pour les pays de la marge sud-téthysienne: Algérie, Tunisie et Israël.

Introduction

In the Moroccan Cretaceous series, the ostracode species associations can be divided essentially into assemblages-biozones which identify whole stages or part stages. Ostracodes are particularly important in intervals which lack ammonites or foraminifers, especially in the Wealdian continental or lagoonal deposits.

Moroccan Cretaceous ostracodes have been studied for many years. Masoli (1966) and Oertli (1966), in two separate publications, analysed ostracodes from the Tarfaya Coastal Basin. Reyment (1978, 1979, 1980a, 1980b, 1982a, 1982b, 1982c, 1982d, 1987) described and figured some new species, but worked essentially on population statistical analysis, evolution of species and paleobiogeographic distribution. Ferrandini et al. (1983) showed the stratigraphy and paleoenvironments of the Cenomanian-Turonian carbonate platform of the Erfoud-Errachidia area (South-East Morocco). Babinot (1984, 1985) and Babinot & Colin (1988) delineated the ostracode paleobiogeography of the Upper Cretaceous of the Tethyan North-African margin and compared it to the West European margins. Damotte & Taj-Eddine (1989) presented the Berriasian species of the Atlantic Haha Basin. Symonds (1990) figured the species *Cytheropteron glintzboeckeli* Donze & Le Fèvre (1981). Finally, several theses cover this topic: Slimane (1978), El Kamali (1990), Aadjour (1992), Rossi (1992) and Ettachfini (1993), described the Cretaceous stratigraphy and figured some ostracode species which were studied again in different biostratigraphical, paleontological and paleobiogeographical publications by Andreu (1986, 1989a, 1989b, 1991, 1992a, 1992b, 1992c, 1993a, 1993b, 1995, 1996a, 1996b) and Andreu et al. (1986, 1988, 1993, 1994a, 1994b, 1995, 1996a, 1996b, 1998) on the Northern Moroccan Cretaceous series.

The studied Cretaceous outcrops are located in the North of the Anti-Atlas, in several basins of the following domains (Saadi 1975; Fig. 1): 1, Anti-Atlasic: Tarfaya (T on Fig. 10 to 19) on the Atlantic coast and Pre-African Trough (Erfoud-Errachidia area D) in the center and the east of Morocco; 2, Atlasic: Agadir (A) and Essaouira (E) along the Atlantic Coast,

---

Paul Sabatier University, Toulouse III, Dynamics of Sedimentary Basins Laboratory, 39 allées Jules Guesde, 31000 Toulouse, France.
E-mail: andreu@cict. fr

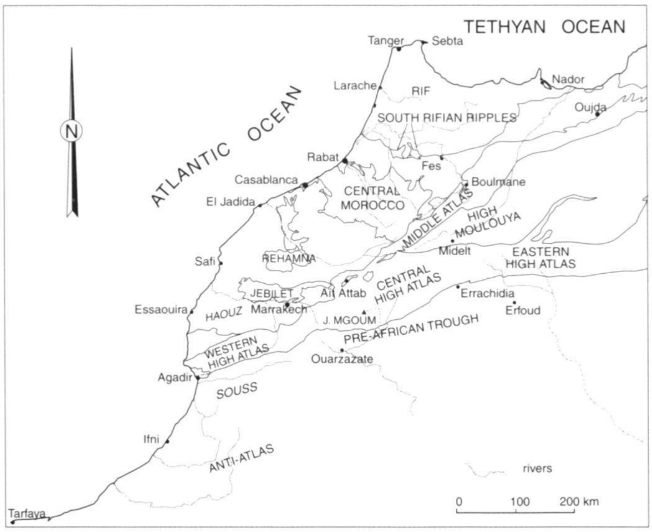

Fig. 1. Geographic location of the Cretaceous outcrops studied in Northern Morocco.

NUMBER of OSTRACODE SPECIES and GENERA in the STAGES	Number of species (genera) in the stage	Number of species (genera) whose distribution coincide with the stage	Number of species (genera) which come from older stages	Number of species (genera) crossing into younger stages	Number of species (genera) appearing	Number of species (genera) disappearing	Age of the stage in My	Species (genera) appearance rate in the stage	Species (genera) disappearance rate in the stage	Species (genera) turnover rate
SPECIES										
BARREMIAN	20	3	?	9						
APTIAN	69	10	9	13	19	12	8,8	2,2	1,4	1,4
ALBIAN	61	10	13	12	16	17	13,3	1,2	1,3	-0,1
CENOMANIAN	140	26	12	22	45	35	5,4	8,3	6,5	1,8
TURONIAN	51	6	22	11	8	19	4,5	1,8	4,2	-2,4
ONIACIAN-SANTONIA	93	48	11	15	59	55	5,5	10,7	10	0,7
CAMPANIAN	32	8	15	4	8	19	12,2	0,7	1,6	-0,9
MAASTRICHTIAN	11	0	4	?			6,3			
GENERA										
BARREMIAN	16	?	?	9						
APTIAN	28	3	9	10	6	5	8,8	0,7	0,6	0,1
ALBIAN	32	4	10	13	9	6	13,3	0,7	0,5	0,25
CENOMANIAN	57	6	12	29	24	8	5,4	4,4	1,5	2,9
TURONIAN	34	0	29	24	0	5	4,5	0	1,1	-1,1
ONIACIAN-SANTONIA	47	11	24	19	19	24	5,5	3,5	4,4	-0,9
CAMPANIAN	26	3	19	4	3	18	12,2	0,25	1,5	-1,3
MAASTRICHTIAN	10	0	4	?			6,3			

Fig. 2. Data about ostracodes species and genera (number of species (genera) in the stage; number of species (genera) whose distribution coincide with the stage; number of species (genera) which come from older stages; number of species (genera) crossing into younger stages; number of species (genera) appearing; number of species (genera) disappearing; age of the stage in million years (My); species (genera) appearance rate in the stage; species (genera) disappearance rate in the stage; specific (generic) turnover rate = species (genera) appearance rate - species (genera) disappearance rate).

High Atlasic Synclines in the Central High Atlas (C), High Moulouya (H) between Central High Atlas and Folded Middle Atlas, Middle Atlas synclines in the folded Middle Atlas (M); 3, South-Rifian: South-Rifian-Ripples (R).

The sole purpose of this work is to present the distribution of the ostracode genera and species and to display the distinctive assemblages in order to recognize the Aptian to Campanian stages on the Cretaceous Moroccan platforms and, less frequently, in the continental facies. The distributions are adjusted to the standard chronostratigraphic scale (Thierry in: Rey J. (ed.) 1997).

The links between ostracode distribution, global eustatic curves and anoxic phenomena will be discussed in a subsequent publication.

Biochronological interest of the Ostracode assemblages: Discussion

166 named (and published) species (especially *sensu* Andreu 1991, but see also more recent papers) from 71 genera, and more than 200 species in open nomenclature from about 70 genera, are distributed in the Barremian-Maastrichtian interval, subdivided into 9 stages covering a period of 49 million years. All species (species in open nomenclature and named species) are taken into account only in the calculation of the diversity; the species in open nomenclature are not considered in the analyses of stratigraphic distributions because of the difficulty of verifying such determinations when the individuals are either poorly preserved or unpublished.

The following data are presented: ostracode species and genera (Fig. 2), number of ostracode genera and species respectively that characterise each stage (Fig. 3), genera and species appearing or disappearing within the stage, or whose distributions coincide with the stage, or which are from older stages and continue into younger stages (Fig. 4), the species (Fig. 5) or genera (Fig. 6) appearance and disappearance rates, the species and genera turnover rate (Fig. 5, 6, 7).

The species assemblages, rather than particular index-taxa, are the most useful aid to the recognition of the stages and in building a relative biochronological scale. The level of resolution changes from 14 My for the Albian to 2 My for the Upper

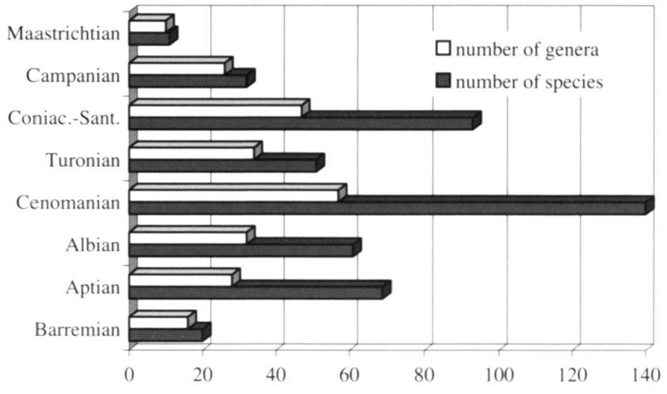

Fig. 3. Number of species and genera.

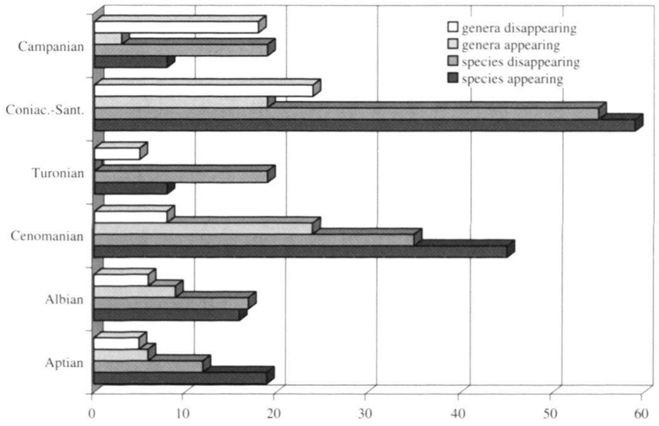

Fig. 4. Species and genera appearing and disappearing.

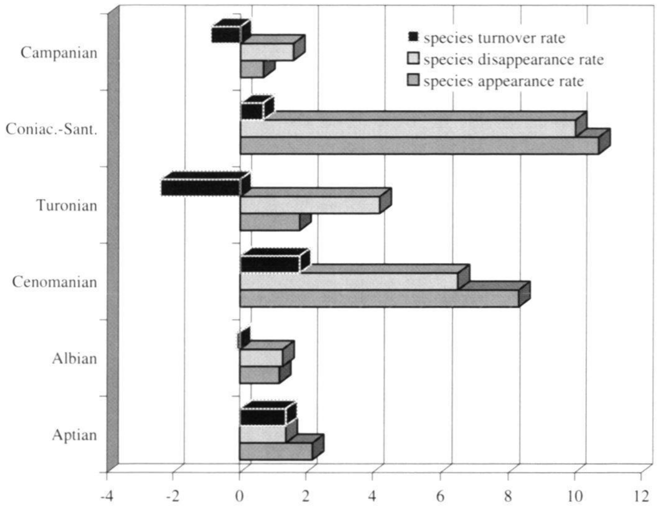

Fig. 5. Species appearance, disappearance and turnover rate.

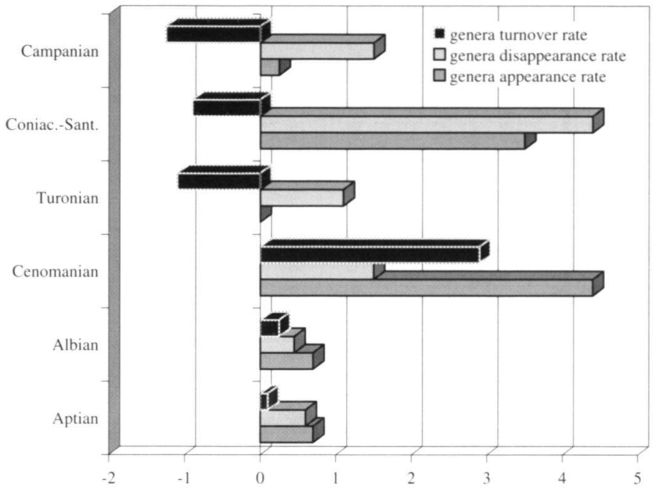

Fig. 6. Genera appearance, disappearance and turnover rate.

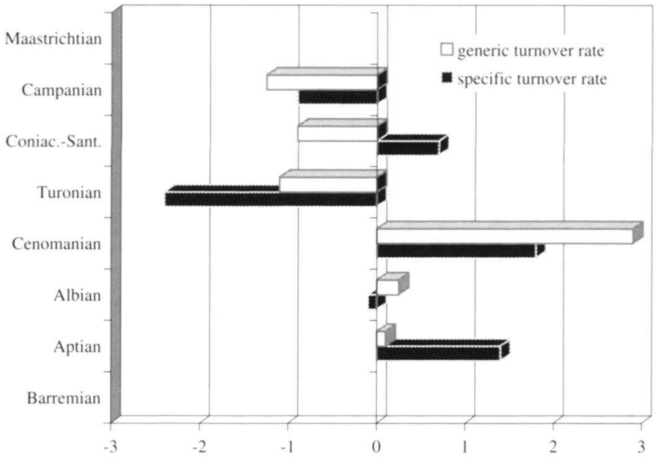

Fig. 7. Comparison between specific and generic turnover rate.

Santonian and less than 2 My for the Upper Cenomanian. Genera and species appearances and disappearances are superimposed on these species assemblages in the different Cretaceous stages.

Meanwhile, there is a control of the stratigraphic and geographic distribution of the assemblages by environmental factors. The lacustrine environment (freshwater) is characterised by species of the genus *Cypridea* in the Wealdian (Barremian to Aptian) facies. In the Lower Cretaceous, the genera *Virgatocypris*, *Mantelliana* and *Loxoconcha* colonized freshwater to oligohaline water; *Antepaijenborchella* and *Fabanella* inhabited brackish to polyhaline water.

In the Aptian and Upper Cretaceous, the environments were essentially marine. Salinity, substrate, energy, dissolved oxygen and feeding are the main environmental factors that are believed to have controlled the distribution of the ostracodes.

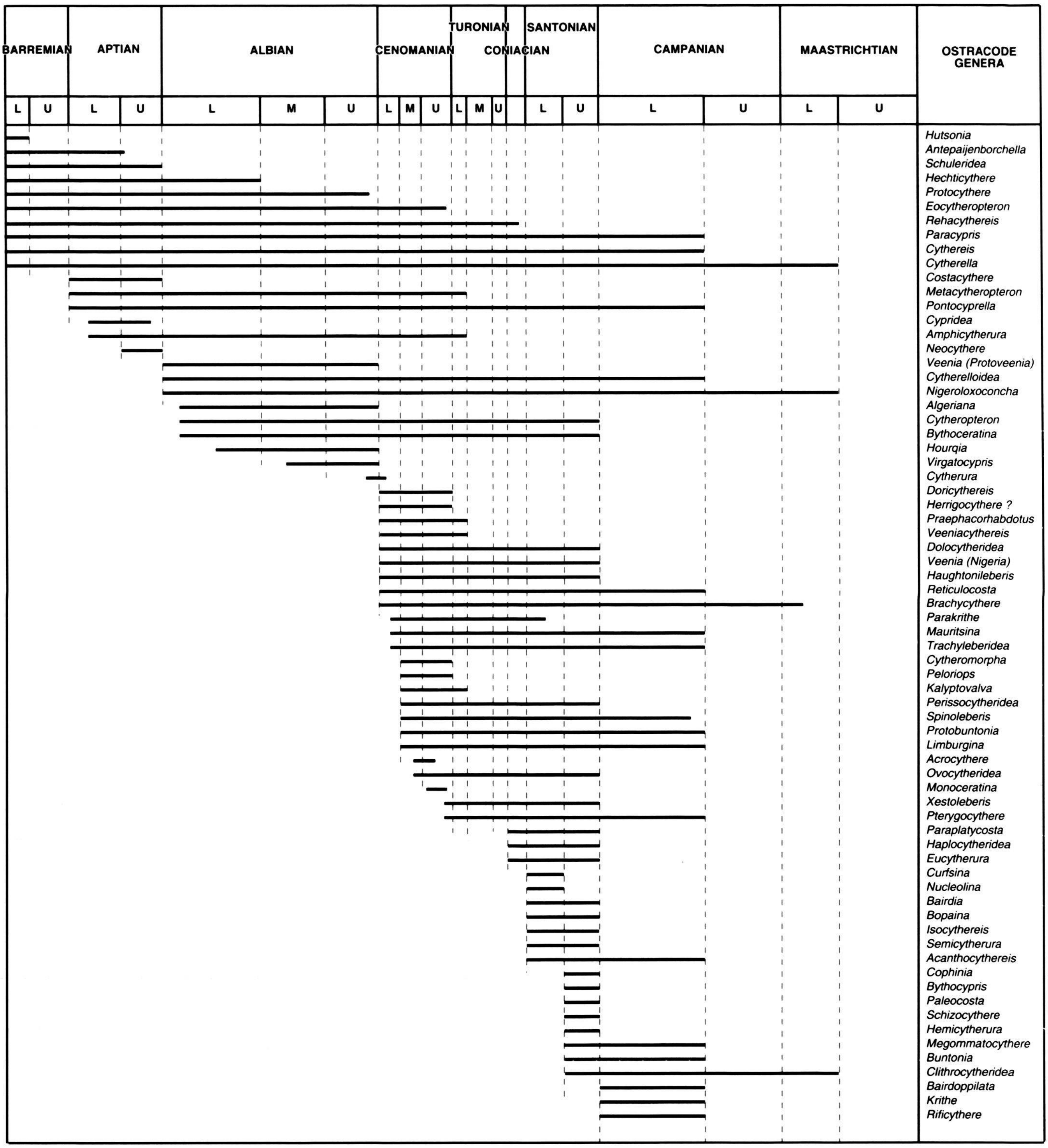

Fig. 8. Ostracode genera distribution, from the Barremian to the Maastrichtian, according to first occurrence.

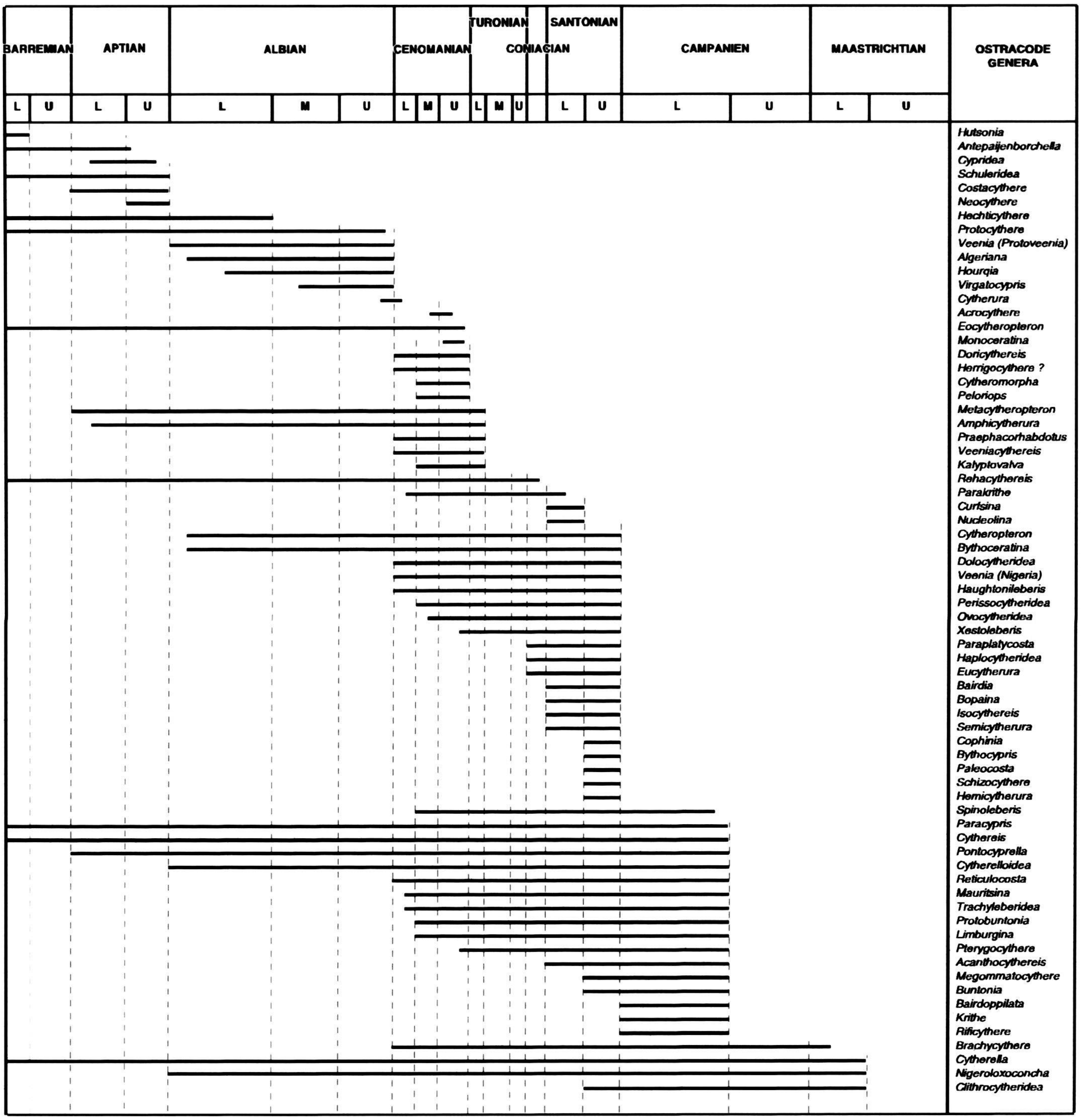

Fig. 9. Ostracode genera distribution, from the Barremian to the Maastrichtian, according to last occurence.

In the infralittoral environments, on the inner to the middle platform, some genera lived preferentially on a carbonate bottom and displayed generally strong and ornamented carapaces: *Cythereis*, *Spinoleberis*, *Veenia*, *Oertliella*; others, such as *Cytherella* and *Paracypris*, lived on muddy bottoms; monospecific *Cytherella* and *Dolocytheridea* appeared in quiet mud flats. The genera *Cytherelloidea*, *Paracypris*, *Veenia* and *Reticulocosta* were tolerant of significant decreases in dissolved oxygen. Low levels of dissolved oxygen led to the monospecifism of *Reticulocosta* gr. *tarfayaensis*, a species adapted to suboxic to dysoxic conditions. Many opportunist genera appeared: *Antepaijenborchella*, *Cytherella*, *Paracypris*, *Dolocytheridea*, *Loxoconcha*, *Eocytheropteron*, *Cythereis*, *Veenia*, *Oertliella*. In the circalittoral environments, food supply was less abundant than in the infralittoral environments and the ostracodes lived on plants. Some ostracodes were epibiontic: *Eocytheropteron*, *Cythereis*, *Procytherura*, *Bythoceratina*; some endobiontic: *Cytherelloidea* and *Parexophthalmocythere*; some were pelagic: *Conchoecia* (for more details, see Andreu 1992).

1 - From a genus point of view

The generic diversity (Fig. 1) varies from 16 for the Barremian, to 28 for the Aptian, 32 for the Albian, 57 for the Cenomanian, 34 for the Turonian, 47 for the Coniacian-Santonian, 26 for the Campanian and 10 for the Maastrichtian; average diversity is close to 30 genera per stage. The Coniacian, not specified in the studied areas, is associated with the Santonian. The Maastrichtian contains 10 genera and will not be described in detail because of a lack of samples and fauna.

71 genera (linked only with named species) have been indexed; their distribution is presented in Fig. 8 and 9, where they are ordered according to first and last occurrence respectively.

The genera are ordered according to the first occurrence in Fig. 8; 4 distinct levels, generally linked with transgressive maxima, emerge: the first is located at the base of the Cenomanian (9 genera), the second at the base of the Middle Cenomanian (7), the third at the base of the Santonian (7) and the fourth at the base of the Upper Santonian (9).

The first occurrence of each of the following marine genera (Fig.8) is stratigraphically interesting: *Nigeroloxoconcha* in the Aptian, with a species in open nomenclature (Andreu et al. 1998), *Algeriana* in the lower part of the Albian, *Doricythereis*, *Veenia (Nigeria)* and *Reticulocosta* at the base of the Cenomanian, *Mauritsina* and *Trachyleberidea* in the Lower Cenomanian, *Cytheromorpha*, *Kalyptovalva*, *Perissocytheridea*, *Spinoleberis*, *Protobuntonia* and *Limburgina* at the base of the Middle Cenomanian, *Ovocytheridea* in the Middle Cenomanian, *Paraplatycosta* at the base of the Coniacian-Santonian, *Nucleolina* and *Bopaina* at the base of the Santonian, *Cophinia* and *Paleocosta* at the base of the Upper Santonian.

In Israel, the genus *Nucleolina* appears, with the species *Nucleolina zihorica* Honigstein et al. (1985), at the Turonian-Coniacian boundary (?) or at the base of the Coniacian (Honigstein et al. 1985), but J. P. Colin is not in agreement on that determination (pers. com.); in Spain, *Nucleolina* (*N. quadrata* Babinot & Rodriguez-Lazaro, 1990) appears in the Upper Coniacian (Babinot & Rodriguez-Lazaro, 1990).

The genera are in order of last occurrence in Fig. 9. Isolated disappearing genera are stratigraphically important: *Hutsonia* in the Barremian, *Costacythere* in the Uppermost Aptian and *Hechticythere* at the base of the Middle Albian. Moreover, 5 levels of disappearance and/or of last observation are characteristic: 1 at the base of the Cenomanian (4 genera disappear, two of which are *Veenia (Protoveenia)* and *Hourqia*), 2 at the base of the Turonian (4 genera) and 3 at the base of the Middle Turonian (5 genera), but these three levels are not very important, 4 at the base of the Campanian (20 genera) and 5 at the base of the Upper Campanian (17 genera), these last two levels show the disappearance of a drastic number of taxa.

The genera turnover rate (Fig.6, 7) is nearly non-existent during the Aptian (+0. 1) and Albian (+0. 25); it is positive during the Cenomanian (+2. 9), associated with the global eustatic transgression at the Upper Cenomanian-Lower Turonian period (Charrière et al. 1997, Ciszak et al. 1999) that covers the Northern African Craton border. Genera turnover is negative from the Turonian (-1. 1) to the Coniacian-Santonian (-0. 9) and Campanian (-1. 25).

The occurrences of about fifteen genera, not noted above or shown in the figures of species distribution because these species are in open nomenclature, are nevertheless worthy of note: *Pedicythere* and *Isohabrocythere* in the Santonian of the South Rifian Ripples; *Pseudomonoceratina* in the Turonian-Santonian, *Eucytherura (Vesticytherura)*, *Paracytheridea* and *Procytherura* in the Upper Santonian, *Costa* in the Maastrichtian of the Middle Atlas; *Parexophthalmocythere (Parexophthalmocythere)* and *Fabanella* ? in the Aptian, *Macrocypris* in the Upper Aptian, *Parexophthalmocythere (Amphiexophthalmocythere)* in the Upper Aptian-Albian, *Navarracythere* in the Lower Cenomanian of the Essaouira Basin; *Phlyctocythere* ? in the Upper Cenomanian of the Agadir Basin; *Asciocythere* in the Upper Aptian of the High Atlas; *Dordoniella* in Aptian-Albian of Northern Morocco.

2 - From a species point of view

The coexistence of different species in the assemblages allows us to propose 6 assemblage biozones and 2 assemblage subzones (the name of the zones is chosen according to the most abundant and dominant, or the most characteristic or known species in the assemblage), 3 distribution biozones, 2 abundance biozones and 1 interval biozone.

Species diversity (Fig. 2; all species, named and in open nomenclature, are taken account in the calculation of the diversity) varies from 20 in the Barremian, to 69 in the Aptian, 61 in the Albian, 140 in the Cenomanian, 51 in the Turonian, 93 in the Coniacian-Santonian, 32 in the Campanian and 11 in the Maastrichtian; average diversity is about 60 per stage. The Coniacian is not known in the studied areas and has been grouped with the Santonian. The Maastrichtian contains only 11 species and will not be taken into account because it was poorly preserved and sampled.

The species turnover rate is positive (Fig. 4, 7) in the Aptian (+1. 4; associated with the Atlantic Aptian transgression on the High and Middle Atlas; Andreu 1991, Charrière & Vila 1991); in the Cenomanian (+1. 8; in association with the global eustatic increase at the Upper Cenomanian-Lower Turonian boundary); in the Coniacian-Santonian (+0. 7; associated with the basal Santonian transgression; Andreu 1996).

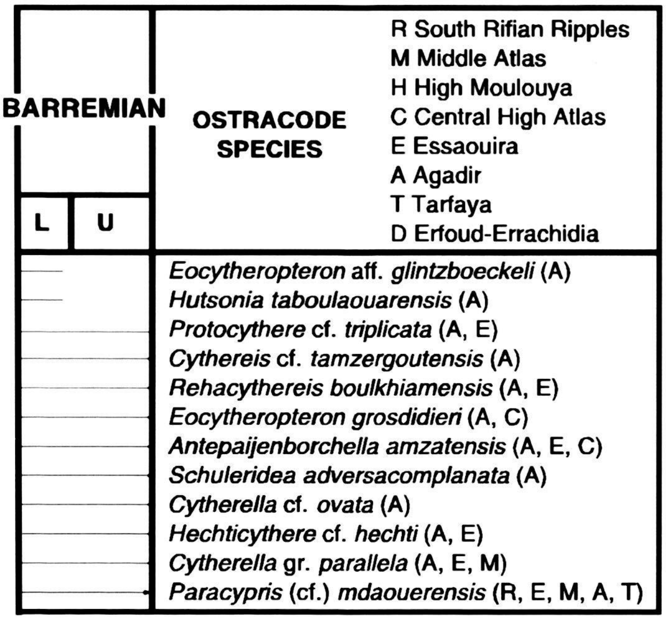

Fig. 10. Stratigraphic distribution of the ostracode species in the Barremian.

The species turnover rate is negative, near 0, in the Albian (-0. 1), in the Turonian (-2. 4) and in the Campanian (-0. 9) following the establishment of inner or anoxic facies.

The Barremian (Fig. 10) contains an assemblage of 12 named species. Data on the Hauterivian series are not yet available (Rossi, University of Marrakech, in *prep.*) and it is not possible to specify the base of the Barremian. Two species disappear in the upper part of the Lower Barremian in the Agadir Basin: *Eocytheropteron* aff. *glintzboeckeli* and *Hutsonia taboulaouarensis*, and 1 species, *Protocythere* cf. *triplicata*, at the top; on the other hand, 9 species, 64 %, cross to the Aptian.

1 *Protocythere* gr. *bedoulensis* assemblage biozone, Aptian

This biozone (Fig. 11) consists of an assemblage of 28 named species; 9 species (35 %) come from the Barremian and 13 (50 %) pass to the Albian. 10 species (36 %) characterize the stage: first, an assemblage of 8 marine species that overlap and take over from one another in time and space: *Protocythere* gr. *bedoulensis*, *Costacythere ? yahyiaensis*, *Protocythere (P.) tazemmourtensis*, *Cythereis tamzergoutensis*, *Schuleridea attabensis*, *Rehacythereis saidensis*, *Neocythere* cf. gr. *vanveenae* and *Cythereis ouaouizaghtensis*, secondly an assemblage of two non-marine species, typical of the Wealdian facies: *Cypridea* cf. *ventriosa* and *Cypridea boulmanensis*. At the lowermost part of the stage appear *Protocythere bedoulensis*, *Costacythere ? yahyiaensis*, *Pontocyprella agadirensis*, *Rehacythereis* aff. *bartensteini*, *Protocythere (P.) derooi*, *Rehacythereis punctatafoveolata*, *Metacytheropteron ? imintanoutensis* and *Paracypris* cf. *dubertreti*; at the uppermost part *Schuleridea adversacomplanata*, *Protocythere bedoulensis*, *Costacythere ? yahyiaensis*, *Rehacythereis saidensis*, *Neocythere* cf. gr. *vanveenae* and *Cythereis ouaouizaghtensis* disappear. We cannot yet consider the assemblage of *Cypridea* as an assemblage biozone because of the poverty of the populations in the Moroccan Wealdian facies (studies in prep.), and the restricted paleogeographic distribution.

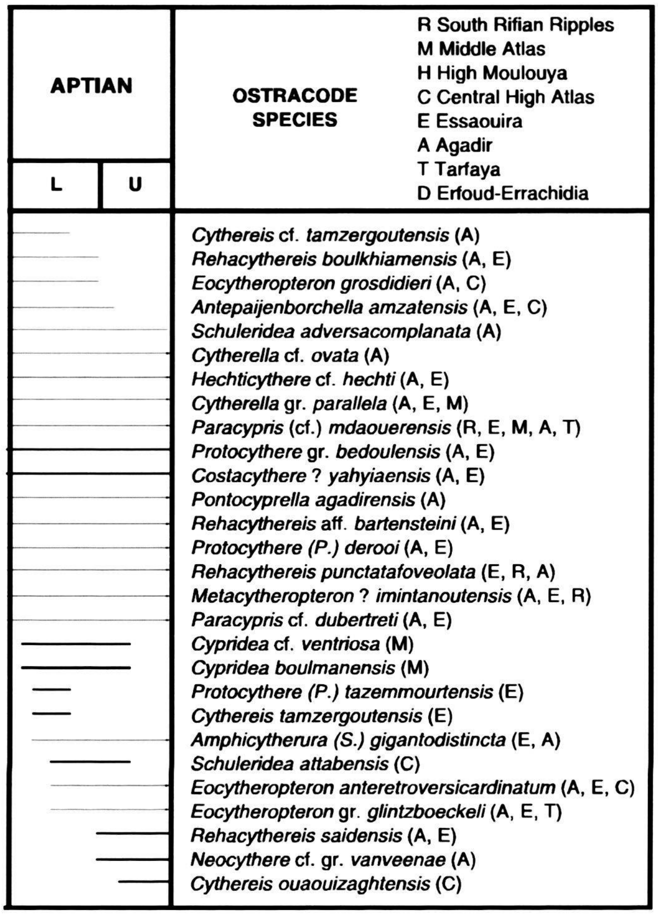

Fig. 11. Stratigraphic distribution of the ostracode species in the Aptian.

2 *Veenia (Protoveenia) florentinensis* assemblage biozone, Albian

The Albian (Fig. 12) presents an assemblage of 29 named species; 13 (45 %) were already in the Aptian or Barremian and 12 (41 %) pass into the Upper Cretaceous. 10 typical species (36 %) can be found throughout the stage, 9 in marine facies: *Cytherelloidea sourensis*, *Metacytheropteron triquetrum*, *Veenia (P.)* cf. *florentinensis*, *Rehacythereis sopeirensis*, *Cytheropteron ? mheridensis*, *Bythoceratina amsittenensis*, *Al-*

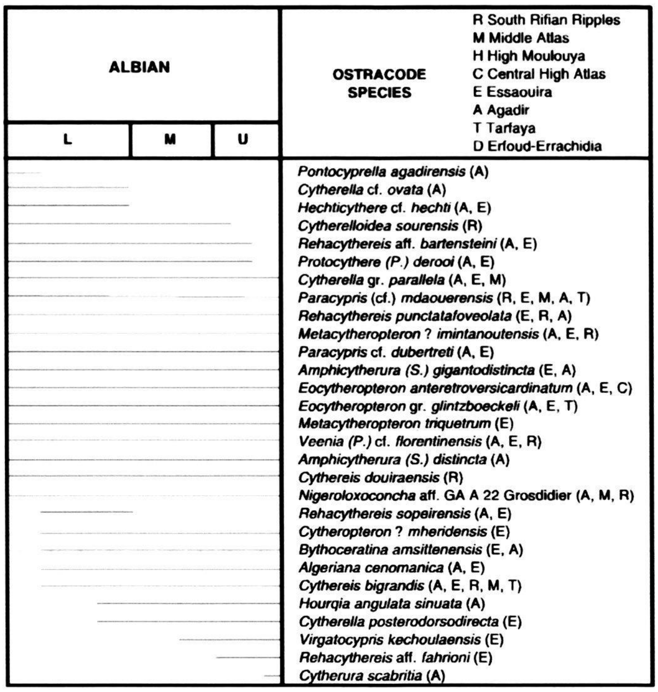

Fig. 12. Stratigraphic distribution of the ostracode species in the Albian.

geriana cenomanica, *Hourcqia angulata sinuata*, *Cytherella posterodorsodirecta*, and 1 in non marine facies:*Virgatocypris kechoulaensis*. The first occurrence, in the lowermost part of the stage, of *Cytherelloidea sourensis*, *Metacytheropteron triquetrum*, *Veenia (Protoveenia)* cf. *florentinensis*, *Amphicytherura (Sondagella) distincta*, *Cythereis douiraensis* and *Nigeroloxoconcha* aff. GA A 22 Grosdidier, and the last occurrence, in the uppermost part, of *Rehacythereis punctatafoveolata*, *Metacytheropteron ? imintanoutensis*, *Metacytheropteron triquetrum*, *Veenia (P.)* cf. *florentinensis*, *Cytheropteron ? mheridensis*, *Bythoceratina amsittenensis*, *Algeriana cenomanica*, *Hourcqia angulata sinuata*, *Cytherella posterodorsodirecta* and *Virgatocypris kechoulaensis*, mark the limits of the stage.

Two species, *Rehacythereis* aff. *fahrioni* and *Cytherura scabritia* may characterize the Albian-Cenomanian boundary; the latter species occupies the same stratigraphic period, Vraconian-Lower Cenomanian, in Algeria and Tunisia (Andreu 1992) and its range would then constitute a distribution biozone (*Cytherura scabritia* distribution biozone in the Maghreb).

We consider that the presence of *Virgatocypris kechoulaensis* and *Eocytheropteron anteretroversicardinatum*, and two species belonging to the genera *Loxoconcha* and *Mantelliana*, in the brackish facies from the Essaouira area, could be used as a regional distribution biozone (*Virgatocypris kechoulaensis* distribution biozone) characteristic of the Vraconian (Andreu 1992).

Furthermore, the species *Conchoecia* sp. 1 Andreu (1991) not noted in the different stratigraphic figures because of the open nomenclature, is a biostratigraphical index for the Upper Albian-Lower Cenomanian interval. The genus *Conchoecia* is essentially pelagic. It belongs to the Halocyprididae family of which there are few examples and preservation is poor. Nevertheless, the species are included in a distribution biozone (*Conchoecia* distribution biozone) in the Albian-Lower Cenomanian period of a province that covers the Tethys and the South Atlantic Ocean bounded to the South by the Walvis ridge (Colin & Andreu 1990). The zonation proposed by Honigstein et al. (1985) for the Cretaceous of Israel therefore presents different species of *Conchoecia* or aff. *Conchoecia* in deep marine environments in the upper part of the Albian and lower part of the Cenomanian.

A first attempt at Tunisian ostracode biozonation in the Upper Albian to the Middle Turonian was carried out by Bismuth et al. (1981); it is based on the appearance or disappearance of index-species. The authors distinguish two zones in the Upper Albian-Vraconian: *Protocythere alexanderi* biozone at the base (base not determined; top: disappearance of *P. alexanderi*) and *Dicrorygma* aff. GA A22 at the top and in the lowermost Cenomanian (base: disappearance of *P. alexanderi*). *P. alexanderi* was not recognized in Morocco. Meanwhile, because it is very difficult to separate *P. alexanderi* from *Protocythere (P.) derooi*, Babinot et Colin (1988) combined the species into an *alexanderi-derooi* group. In Morocco, *P. (P.) derooi* is known in the Aptian-Albian (non-uppermost) interval. Furthermore, *Dicrorygma* aff. GA A22 is a synonym of *Nigeroloxoconcha* aff. GA A 22 in Andreu (1991) in the Albian-Turonian interval of the outer Moroccan platform facies; this species is common in the Albian and Cenomanian Moroccan series. In short, the boundaries and characteristics of our Moroccan biozonation do not agree with those proposed by Bismuth et al. for Tunisia; the Moroccan species are more widely distributed in time.

Four species in common with Morocco were mentioned by Majoran (1989) in the Middle to Upper Albian of northeastern Algeria: *Cytherella* cf. *ovata*, *Eocytheropteron glintzboeckeli*, *Amphicytherura distincta* and *Rehacythereis* aff. *fahrioni*, but a zonation was not given.

3 *Reticulocosta boulhafensis* assemblage biozone, Cenomanian

The Cenomanian (Fig. 13) contains an assemblage of 57 named species; 12 (21 %) come from the Albian and 22 (39 %) cross into the Turonian. An assemblage of 29 species (51 %) is enclosed within the boundaries of the stage and define it: *Rehacythereis curva*, *Doricythereis talerzahensis*, *Veenia (Nigeria)* cf. *rotunda*, *Rehacythereis huescaensis*, *Herrigocythere ? hajerensis*, *Reticulocosta* gr. *jezzineensis*, *Reticulocosta boulhafensis*, *Cythereis ? magnei*, *Dolocytheridea atlasica*, *Brachycythere* aff. *ekpo*, *Cytherella gigantosulcata*, *Parakrithe* cf. *losaensis*, *Trachyleberidea* aff. *arta*, *Mauritsina tamazirtensis*, *Rehacythereis innflasensis*, *Perissocytheridea ? laminensis*, *Perissocytheridea tamaensis*, *Cytheromorpha taderdourtensis*, *Peloriops* gr. *zigerensis*, *Amphicytherura zemzenensis*, *Protobuntonia semmamaensis*, *Peloriops* (cf.) *talbourinensis*, *Bythoceratina tama-*

rae, *Acrocythere bizourganensis*, *Monoceratina trituberculata*, *Metacytheropteron* cf. GA A 32 Grosdidier, *Xestoleberis igammoudensis*, *Pterygocythere ? neknaffiensis* and *Haughtonileberis exilis*. The first 26 species mentioned above would appear to characterize the Lower and Middle Cenomanian, and the last 11 species the Upper Cenomanian. The lower and upper boundaries are distinguished respectively by the appareance of 16 species and the disappearance of 20.

Several important facts should be pointed out. The disappearance, in the Upper Cenomanian, of *Eocytheropteron* gr. *glintzboekeli*, *Amphicytherura (Sondagella) distincta* and *Cythereis douiraensis*, and the appearance of *Cytherelloidea oudrarensis*; these two groups of species are never found together (Andreu 1992); the location of the interval which contains no important stratigraphic subject matter could form an interval biozone in the *Reticulocosta boulhafensis* association biozone.

Generally, in the majority of the sections studied in the Middle to Upper Cenomanian and particularly in the uppermost Cenomanian, forms belonging to the genus *Dolocytheridea* and probably to the species *Dolocytheridea (Parasternbergella) transatlasica* Andreu (1996) appear in great numbers. This unusual abundance is a chronostratigraphic guide to the Upper part of the Cenomanian in infralittoral environments of Northern Morocco; it could be regarded as a regional abundance biozone (*Dolocytheridea (Parasternbergella) transatlasica* abundance biozone). The same interpretation may be applied to the first maximum of forms belonging to *Reticulocosta* gr. *tarfayaensis* in infralittoral to circalittoral environments; this species is an excellent guide to the Cenomanian-Turonian boundary interval and the first maximum must be considered as a significant abundance biozone (*Reticulocosta* gr. *tarfayaensis* abundance biozone).

Although the specific and generic turnover rates do not illustrate the evolution of the diversity for each million years, the decrease in the values in the Cenomanian-Turonian boundary interval corresponds to a major biological crisis in marine ecosystems. In that interval, the specific diversity decreases from +1. 8 to –2. 4 and the generic from +2. 9 to –1. 1 (Fig. 4); this crisis killed 25 of the 47 Cenomanian named species (53 %); the genera are concerned to a lesser degree, with a disappearance of 6 genera out of 35 (17 %). The development of an oceanic anoxic event explains the disappearance of benthic ostracode populations and benthic and planktonic foraminifers such as *Helvetoglobotruncana*, *Marginotruncana* and *Rotalipora;* at the surface of the water, the small sized foraminifers *Hedbergella*, *Whiteinella*, *Dicarinella* and *Heterohelix* were not affected by the anoxic event during the global eustatic increase (Andreu 1993). Some species of ostracodes survived in refugia (Lazarus Effect) and developed again in the Middle Turonian when the living conditions returned to normal; *Reticulocosta gr. tarfayaensis* probably took refuge in the shallow waters of the inner platform, in association with some species of *Cytherella* and *Dolocytheridea* (Andreu 1991).

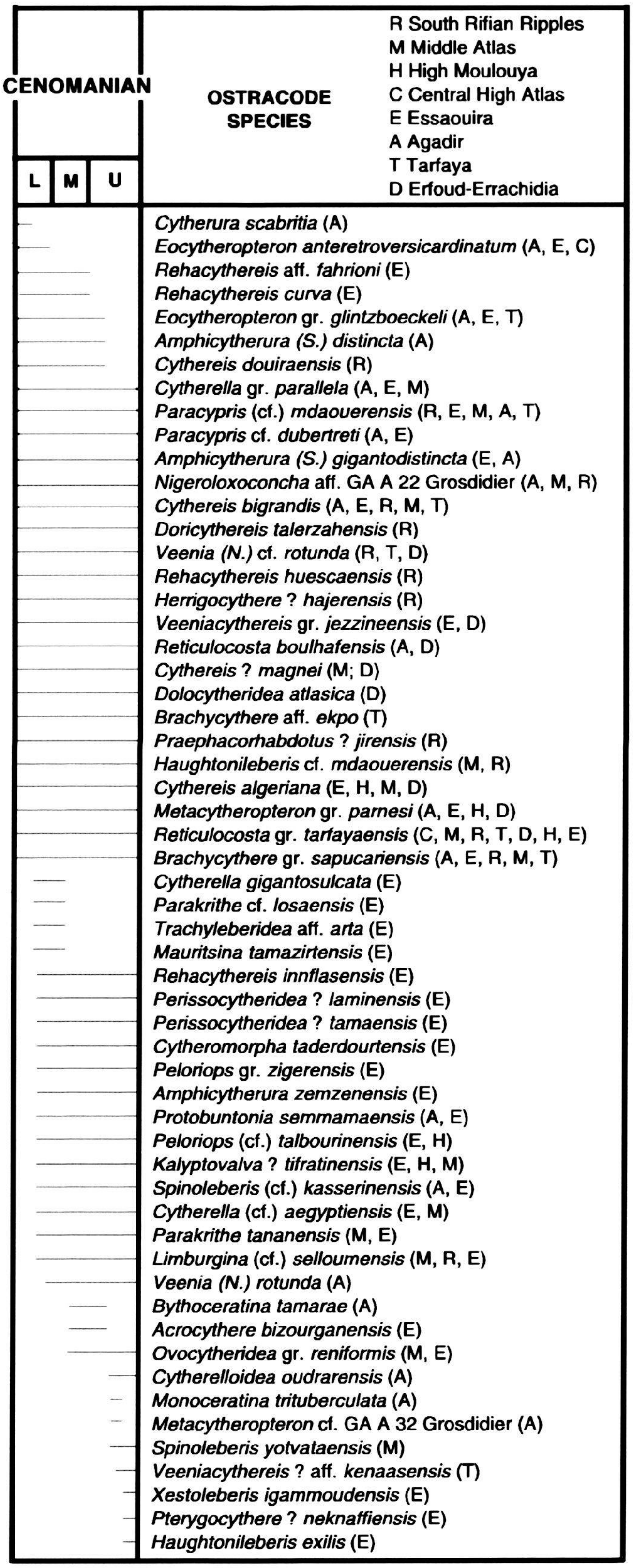

Fig. 13. Stratigraphic distribution of the ostracode species in the Cenomanian.

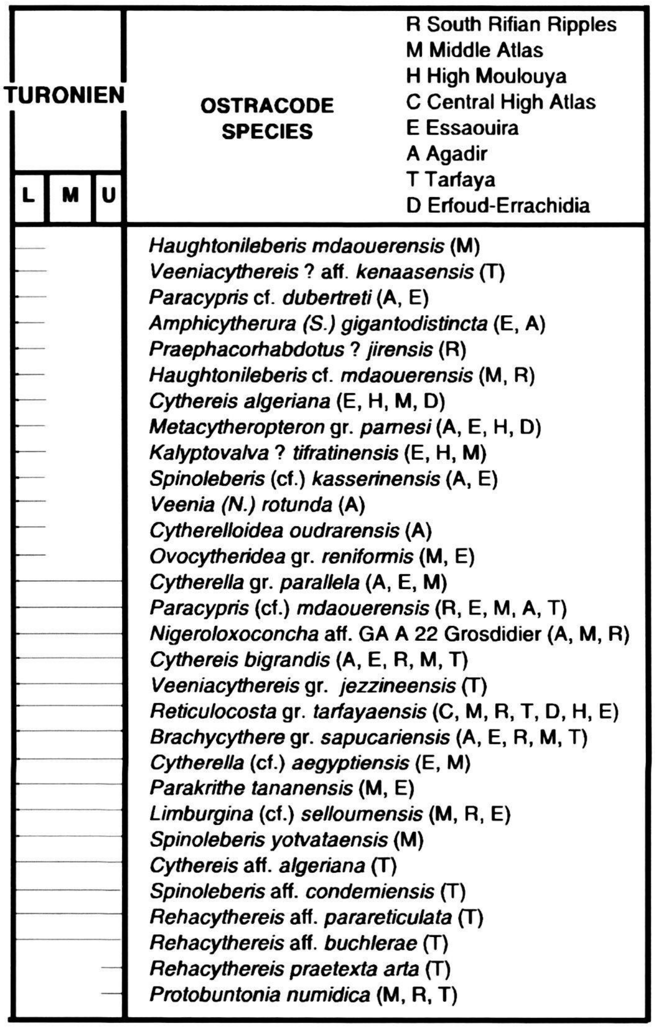

Fig. 14. Stratigraphic distribution of the ostracode species in the Turonian.

There are many typical species from the North-African and South-Tethyan Cenomanian and finding all or some of these allows a recognition of the stage with certainty: *Cytherella gigantosulcata*, *Cytherella aegyptiensis*, *Metacytheropteron* gr. *parnesi* (synonym of *M. berbericus* Bassoullet & Damotte 1969, of *M. pleura* Al-Furaih 1983 in Andreu 1991, 1992), *Cythereis algeriana*, *Peloriops* cf. *ziregensis*, *Protobuntonia semmamaensis*, *Limburgina* cf. *selloumensis*, *Reticulocosta* gr. *jezzineensis*, *Spinoleberis* cf. *kasserinensis* and *Dolocytheridea transatlasica* (in Andreu 1992).

The most important of these species were noted by Honigstein et al. (1985) in the Cretaceous biozonation of Israel, based on the presence-absence and abundance of characteristic species. Israeli biozones (5 for the Cenomanian and the Cenomanian-Turonian crossing; Fig. 21) are more numerous than Moroccan biozones and the distributions of the index species cover a smaller time scale.

The Tunisian biozonation (Bismuth et al. 1981) split the Cenomanian into 5 biozones: Ostracode B3 Glintzboeckel & Magné zone (synonym of *Reticulocosta boulhafensis* in Vivière 1985 and in Andreu 1991; at the base: appearance of B3 and at the top: disappearance of B3) and *Veeniacythereis streblolophata schista* zone (synonym of *Veeniacythereis* gr. *jezzineensis* in Vivière 1985 and in Andreu 1991; at the base, disappearance of B3 and at the top, disappearance of *Veeniacythereis streblolophata schista*) in the Lower Cenomanian; with *Protobuntonia semmamaensis* (at the base, disappearance of *Veeniacythereis streblolophata schista*; at the top, disappearance of *Protobuntonia semmamaensis*) in the Middle Cenomanian; with *Cythereis algeriana* (at the base, disappearance of *Protobuntonia semmamaensis* and at the top, appearance of *Veeniacythereis maghrebensis*) and *Veeniacythereis maghrebensis* (synonym of *Veeniacythereis* gr. *jezzineensis* in Vivière 1985; at the base, appearance of *Veeniacythereis maghrebensis* and at the top, disappearance of *Veeniacythereis maghrebensis*) in the Upper Cenomanian. Our zoning does not correspond with this one; the Moroccan species and particularly the typical South Tethyan Cenomanian species (see above) cover a more extended time scale.

In Northeastern Algeria, Majoran (1989) proposed, but without zonation, eight species in common with Morocco: *Eocytheropteron glintzboeckeli*, *Amphicytherura distincta* ?, *Paracypris dubertreti* ?, *'Veeniacythereis'* aff. *streblolophata* (synonym of *Veeniacythereis* gr. *jezzineensis*, see above), *Peloriops ziregensis* ?, *Metacytheropteron berbericus* (synonym of *M. parnesi* and *M. pleura*, see above), *Spinoleberis kasserinensis* and *Bythoceratina tamarae*; the last three are also common in the Uppermost Cenomanian.

4 *Spinoleberis yotvataensis* assemblage biozone, Turonian

The Turonian (Fig. 14) is characterized by an assemblage of 30 named species; 22 (73 %) come from the older stages, essentially the Cenomanian, and 11 (37 %) cross to the younger stages, essentially to the Coniacian-Santonian. Six species only are distributed across the stage: *Haughtonileberis mdaouerensis* at the base, *Cythereis* aff. *algeriana*, *Reticulocosta jezzineensis*, *Spinoleberis* aff. *condemiensis*, *Rehacythereis* aff. *parareticulata* and *Rehacythereis* aff. *buchlerae*, throughout the whole stage; their appearance and/or disappearance are linked with the Turonian boundaries.

In the Turonian of Tunisia, 2 zones are distinguished (Fig. 21): *Cythereis mdaouerensis* zone (at the base, disappearance of *Veeniacythereis maghrebensis* and at the top, appearance of *Spinoleberis yotvataensis*) in the lower part and *Spinoleberis yotvataensis* (at the base, appearance of *Spinoleberis yotvataensis* and at the top, not given) in the upper part (Bismuth et al. 1981). These 2 zones show different boundaries and characteristics compared with the Moroccan biozones proposed in this work, the Moroccan species extending across a wider time scale. Apart from ubiquitous species such as *Cytherella* gr. *parallela*, *Cytherella* gr. *ovata* and *Paracypris mdaouerensis*, only the species *Spinoleberis yotvataensis* and *Haughtonileberis mdaouerensis* were found in Israel in the Lower Turonian (Honigstein et al. 1985).

5 *Paraplatycosta talayninensis* assemblage biozone, Coniacian-Santonian

In Morocco, the Coniacian is not distinguished by ostracode assemblages (Fig. 15). It is the equivalent of a bridge in time between Cenomanian-Turonian and Santonian fauna. It has been known thus in Algeria too (Vivière 1985); it marks the stratigraphic transition between 2 stages where blooming of the fauna is at a maximum in the Cretaceous.

The main *Paraplatycosta talayninensis* Coniacian-Santonian assemblage biozone is divided into 2 assemblage subzones: *Nucleolina circinata* subzone in the Lower Santonian and *Megommatocythere solideornatus* subzone in the Upper Santonian.

The Coniacian-Santonian (Fig. 15) displays a very important assemblage of 70 named species. Among them, 11 (16 %) are from the Cenomanian and 15 (21 %) cross into the Campanian-Maastrichtian. 7 species develop in the two stages: *Paraplatycosta talayninensis*, *Cytherelloidea tigignitensis*, *Haplocytheridea tninensis*, *Eucytherura aitabbesensis*, *Xestoleberis santoniensis*, *Ovocytheridea* cf. *acuta* and *Veenia (Nigeria)* cf. *nigeriensis*. The Lower Santonian is covered by 10 species in the *Nucleolina circinata* assemblage subzone; it contains *Nucleolina circinata*, *Curfsina delicateornata*, *Cythereis dupliciterornatus*, *Protobuntonia cretacea*, *Mauritsina* cf. *speciosa*, *Isocythereis* (cf.) *distortus*, *Perissocytheridea konatei*, *Xestoleberis* cf. *derorimensis*, *Parakrithe malleolus* and *Acanthocythereis doliaris*; the Santonian has 11 species which pinpoint the boundaries of the stage by their appearances and disappearances: *Bairdia sbaensis*, *Ovocytheridea* cf. *producta*, *Perissocytheridea salmacida*, *Xestoleberis* cf. *tunisiensis*, *Ovocytheridea* sp. B780 Bellion et al., *Brachycythere angulata*, *Xestoleberis dissimilissummis*, *Semicytherura adversainflata*, *Cytherella mediatlasica*, *Paracypris posteriusacuminatus*, *Bopaina* cf. *bopaensis*; the Upper Santonian has 20 species in the *Megommatocythere solideornatus* assemblage subzone: *Spinoleberis sklouensis*, *Isocythereis triangulus*, *Acanthocythereis ? tighboulaensis*, *Paleocosta firma*, *Megommatocythere solideornatus*, *Haughtonileberis propeplanus*, *Cythereis* cf. (aff.) *douiraensis*, *Dolocytheridea transatlasica*, *Cophinia* aff. *ovata*, *Schizocythere spelunculus*, *Cytheropteron ? soricinus*, *Hemicytherura sexangula*, *Cytheropteron piscatorius*, *Cytherelloidea desupertriangula*, *Schizocythere tegeratus*, *Bythoceratina adversasulcata*, *Cytheropteron lekefense*, *Bythocypris gohrbandti*, *Cytherella* cf. *sarakundaensis* and *Paleocosta* aff. *pervinquieri*.

The zonation proposed by Honigstein et al. (1985) in Israel divides the Coniacian-Santonian into 3 zones with 35 species. *Protobuntonia numidica* is the only species that has a larger distribution in Morocco.

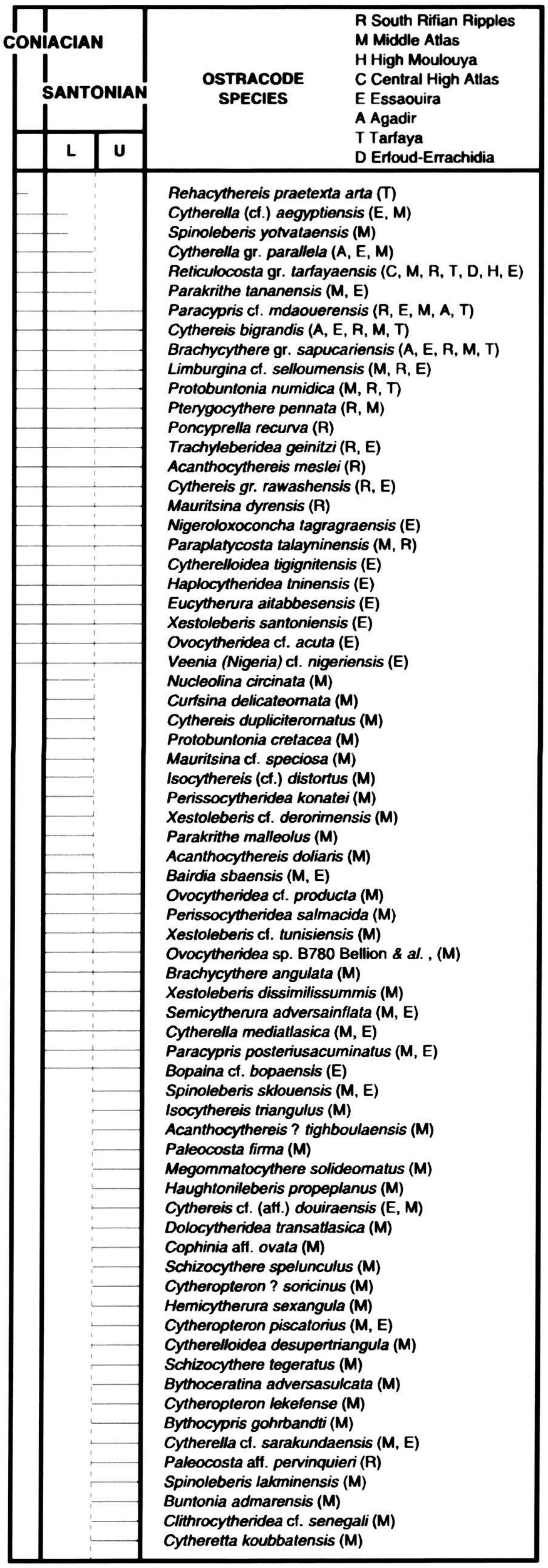

Fig. 15. Stratigraphic distribution of the ostracode species in the Coniacian-Santonian.

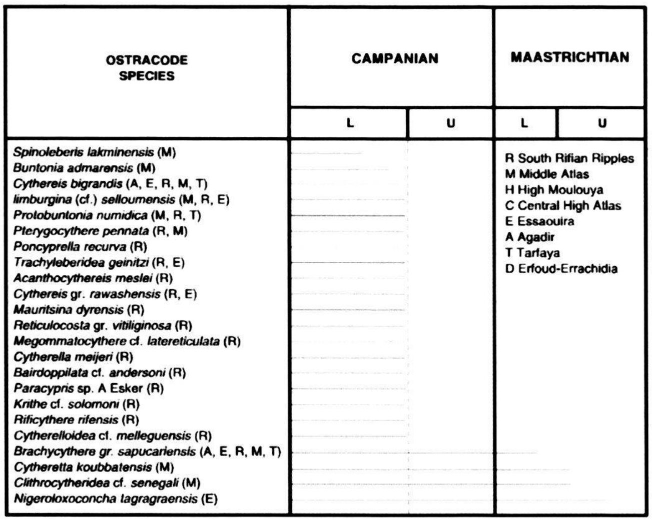

Fig. 16. Stratigraphic distribution of the ostracode species in the Campanian-Maastrichtian.

6 *Rificythere rifensis* assemblage biozone, Lower Campanian

23 named species colonize the Campanian (Fig. 16); 15 (65 %) are from the lower stages and 4 (17 %) cross into the Maastrichtian. 8 species are known in the Lower Campanian: *Reticulocosta* gr. *vitiliginosa*, *Megommatocythere* cf. *latereticulata*, *Cytherella meijeri*, *Bairdoppilata* cf. *andersoni*, *Paracypris* sp. A Esker, *Krithe* cf. *solomoni*, *Rificythere rifensis* and *Cytherelloidea* cf. *melleguensis*.

Krithe cf. *solomoni* is present in the same interval, Lower Campanian, in Israel; meanwhile, the appearance of an Upper Campanian oceanic anoxic event in Morocco makes it impossible to compare the two distributions and to frame one biozone.

The 4 species that appear in the Maastrichtian (Fig. 16) come from the Campanian and are not typical in the Maastrichtian. The disappearance of these species: *Brachycythere* gr. *sapucariensis* in the Lower Maastrichtian, *Clithrocytheridea* cf. *senegali* and *Cytheretta koubbatensis* at the top of the Lower Maastrichtian, and *Nigeroloxoconcha tagragraensis* in the Upper Maastrichtian, could be a guide to characterizing this stage and its boundaries.

The general distribution of the whole Barremian to Maastrichtian species is shown in Fig. 17, 18 and 19, and the different biozones in Fig. 20 and 21.

Conclusions

The distribution of the characteristic ostracode assemblages, essentially on the Moroccan carbonate platforms, enables us to recognize the Aptian to Campanian stages in Northern Morocco.

The first levels of occurrence of the most important genera are generally associated with the maximum transgression levels; in contrast, the last occurrence levels are not linked with regressions but generally with the positions of inner or anoxic facies (the global phenomena are not discussed in this work).

Six marine assemblage biozones, and 2 subzones, are proposed: 1 *Protocythere* gr. *bedoulensis* biozone, Aptian, 2 *Veenia (Protoveenia) florentinensis*, Albian, 3 *Reticulocosta boulhafensis*, Cenomanian, 4 *Spinoleberis yotvataensis*, Turonian, 5 *Paraplatycosta talayninensis*, Coniacian-Santonian (divided into *Nucleolina circinata* subzone, Lower Santonian, and *Megommatocythere solideornatus* subzone, Upper Santonian), 6 *Rificythere rifensis*, Lower Campanian; three distribution biozones: genus *Conchoecia*, Albian-Lower Cenomanian (mostly in pelagic facies), *Virgatocypris kechoulaensis*, Upper Albian (in non marine facies), and *Cytherura scabritia*, Upper Albian-Lower Cenomanian (in marine facies); two abundance biozones: *Dolocytheridea (Parasternbergella) transatlasica*, Upper Cenomanian (inner platfform), and *Reticulocosta* gr. *tarfayaensis* (rather outer platform), Upper Cenomanian-Lower Turonian; and one interval biozone, in the Upper Cenomanian, located between the disappearance of *Eocytheropteron* gr. *glintzboeckeli*, *Amphicytherura (Sondagella) distincta* and *Cythereis douiraensis,* and the appearance of *Cytherelloidea oudrarensis*.

Environmental factors partly control the distribution in time and space of the ostracode assemblages in the different Moroccan basins or depositional areas, and some genera are restricted in their vertical distribution, in comparison with their full distribution known from the literature, because of regional facies or palaeogeographical variations.

This Moroccan zonation is compared with the Tunisian and Israeli zonation. It must be noted, however, that the definitions of the biozones in these areas are very different; they are based on the appearance or disappareance of index-species in Tunisia, and on the presence-absence and abundance of characteristic species in Israel; in this work, we propose assemblages biozones and the name of the biozones is chosen according to the most abundant and dominant or the most characteristic or known species in the assemblage.

The study of the ostracode assemblages in the Moroccan Lower Cretaceous will enable us in the near future to complete the overall results and propose a Cretaceous regional stratigraphic scale.

Acknowledgements. We are most grateful to Hilary KOZIOL (Bordeaux 2 University) and David HORNE (University of Greenwich) for the english translation, Paule EICHENE (Toulouse III University) for the carrying out of the Fig. 1 and 21, Jean-Paul COLIN and Alexander LIEBAU for their constructive review and helpful suggestions.

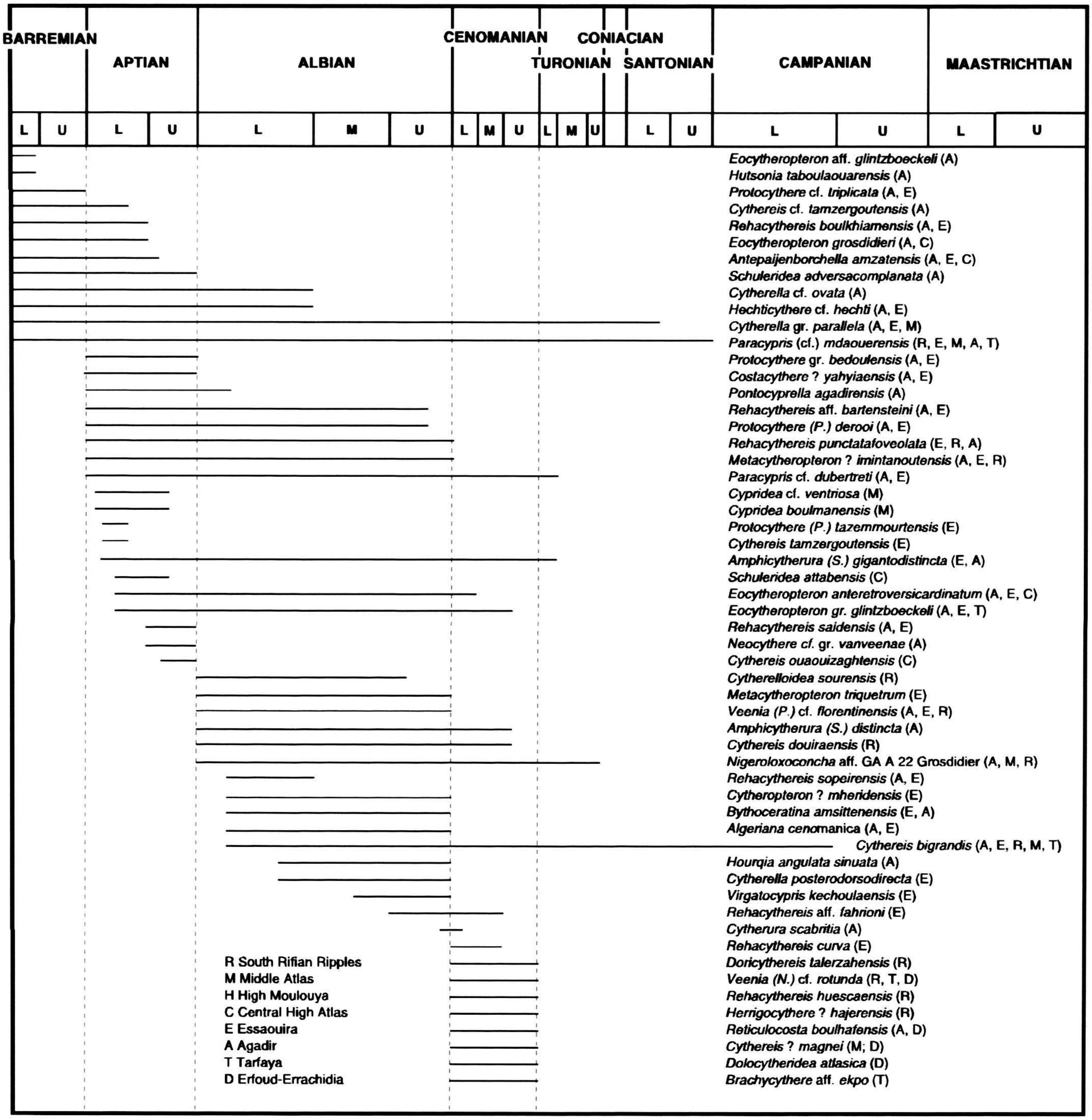

Fig. 17. Stratigraphic distribution of the ostracode species, from the Barremian to the Maastrichtian, according to the first appearance, part 1.

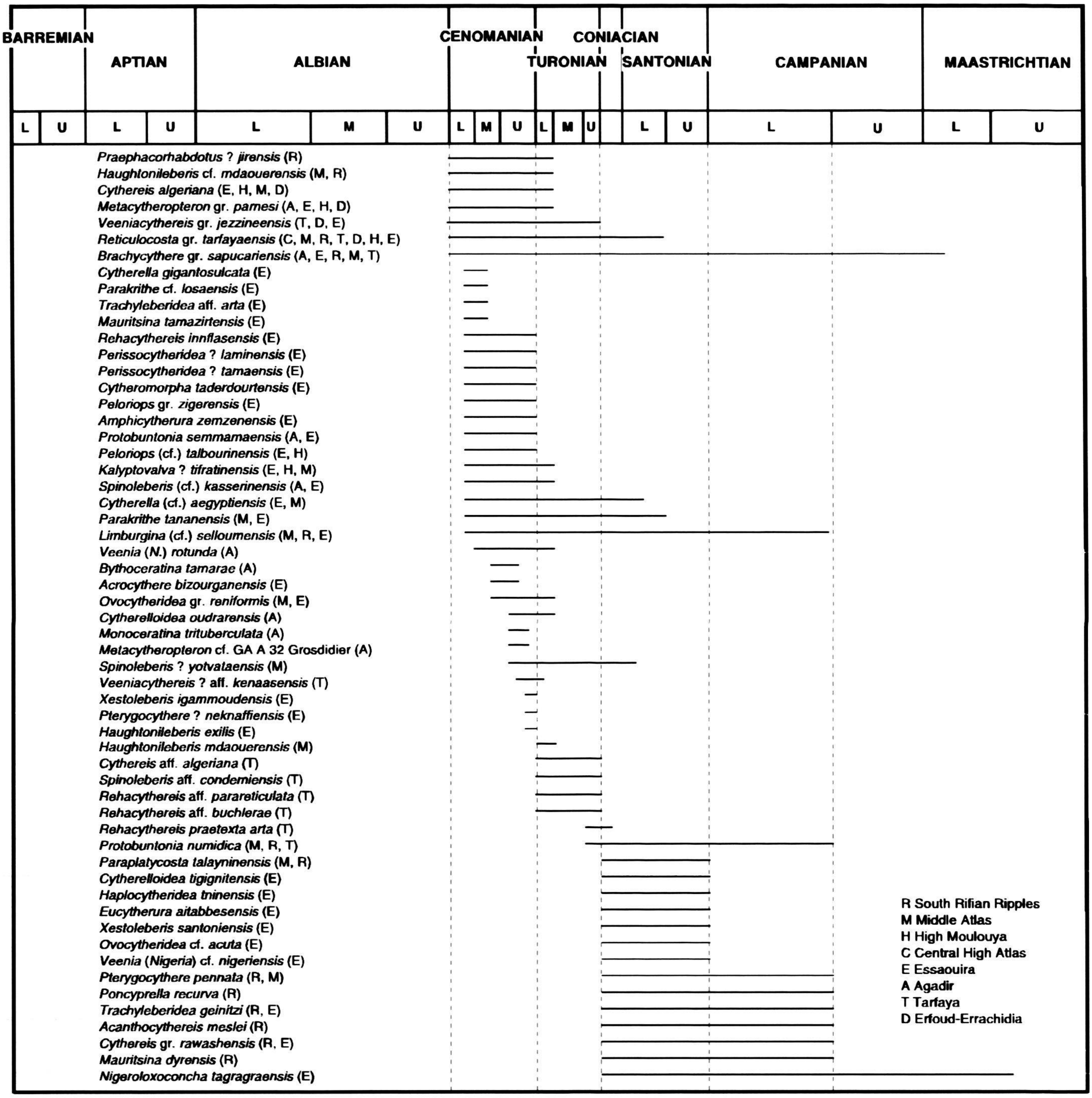

Fig. 18. Stratigraphic distribution of the ostracode species, from the Barremian to the Maastrichtian, according to the first appearance, part 2.

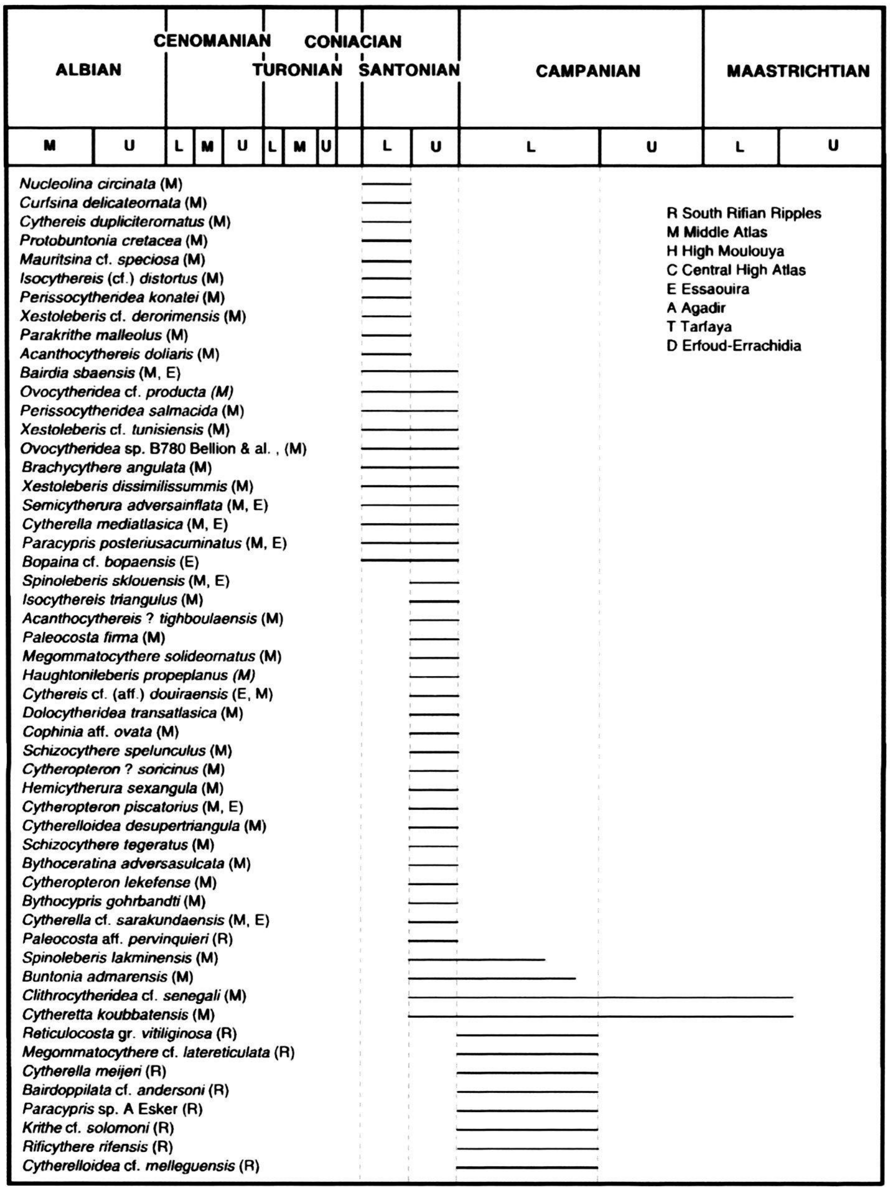

Fig. 19. Stratigraphic distribution of the ostracode species, from the Barremian to the Maastrichtian, according to the first appearance, part 3.

REFERENCES

Aadjour, M. 1992: Étude stratigraphique et micropaléontologique du Barrémien-Aptien de la région d'Agadir (Haut Atlas Atlantique, Maroc). Thèse de Doctorat de 3° Cycle, Université Cadi Ayyad, Marrakech, 1–181.

Andreu, B. 1986: Evolution paléogéographique du Crétacé moyen sur une transversale Agadir-Nador (Maroc). Rev. Fac. Sciences Marrakech, PICG-UNESCO n°183, Marrakech 1985, n° sp. 2, 515–517, 3 fig.

- 1989a: Le Crétacé moyen de la transversale Agadir-Nador (Maroc): précisions stratigraphiques et sédimentologiques. Cretaceous Research 10, 49–80.
- 1989b: Les Ostracodes barrémiens de la région d'Agadir (Maroc): systématique, paléoenvironnements et affinités paléobiogéographiques. Rev. Micropaléont. 32/4, 243–260.
- 1991: Les Ostracodes du Crétacé moyen (Barrémien à Turonien), le long d'une transversale Agadir-Nador (Maroc). Thèse de Doctorat d'Etat, Strata, Toulouse, 2, 14, 1–756.
- 1992a: Associations d'ostracodes et paléoécologie du Crétacé (Barrémien à Turonien) le long d'une transversale Agadir-Nador (maroc). Palaeogeogr., Palaeoclimatol., Palaeoecol. 99, 291–319.
- 1992b: Distribution stratigraphique des ostracodes du Barrémien au Turonien, le long d'une transversale Agadir-Nador (Maroc). Géologie Méditerranéenne, Marseille 19/3, 165–187.
- 1992c: Les ostracodes du Crétacé moyen (Albien à Turonien) des marges téthysiennes et atlantiques, et la province paléobiogéographique Afrique du Nord - Moyen Orient. 14° RAST, Toulouse, résumés, 6.
- 1993a: Associations d'ostracodes des marges téthysiennes et atlantiques de l'Albien au Turonien. Geobios 26/1, 69–84.

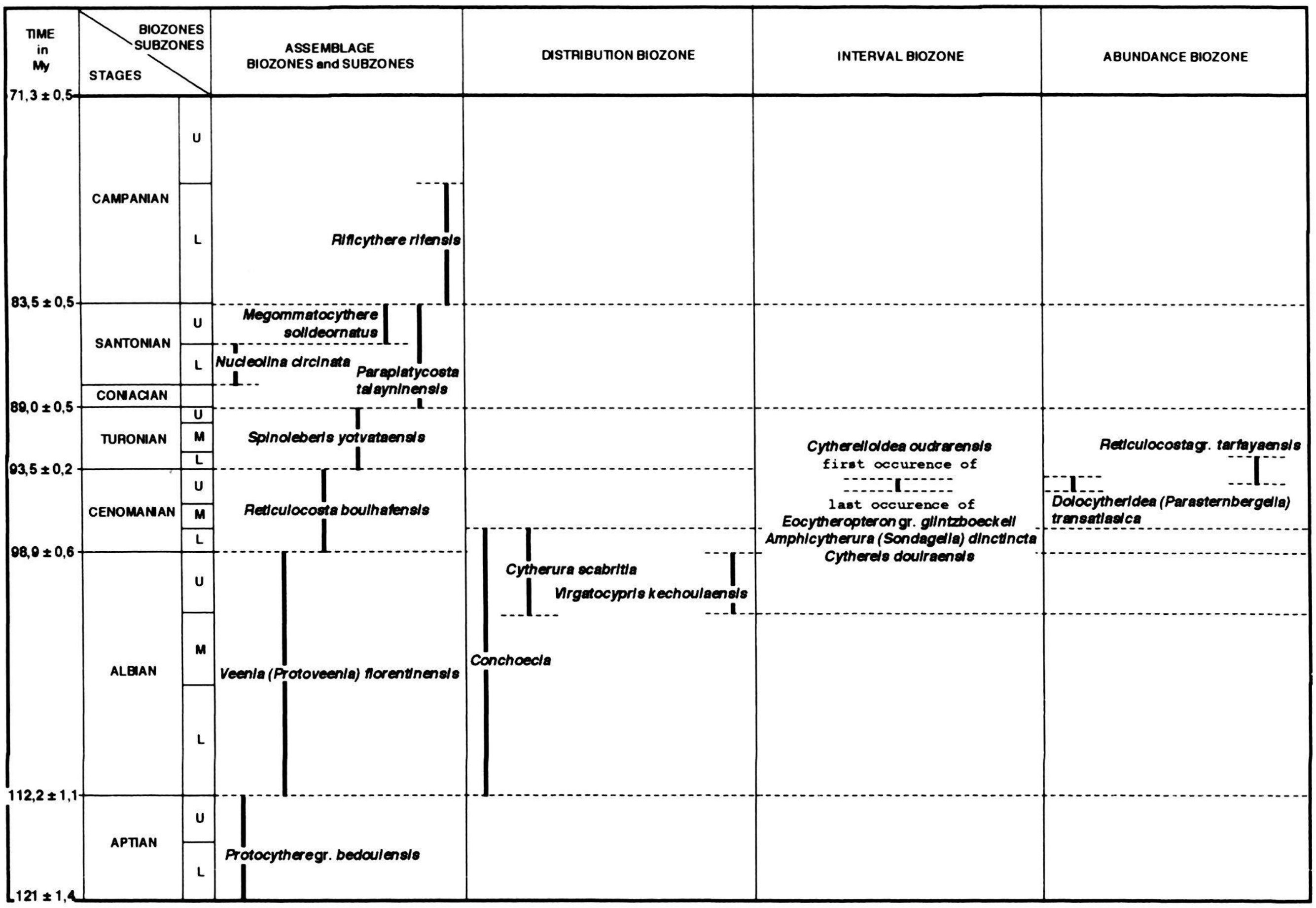

Fig. 20. Ostracode biozonations, in the Aptian to Campanian, in Northern Morocco.

- 1993b: Associations d'Ostracodes et Paléoenvironnements au passage cénomanien-turonien dans les régions d'Agadir (Haut Atlas) et de Boulmane (Moyen Atlas), Maroc. Cretaceous Research 14, 409–429.
- 1995: Trachyleberididae (ostracodes) du Turonien supérieur (?)-Santonien de la région de Boulmane, Moyen Atlas (Maroc): systématique et biostratigraphie. Rev. Españ. Micropaleont. 27/1, 85–142.
- 1996a: Nouvelles espèces d'ostracodes du Coniacien (?)-Santonien de la région de Boulmane, Moyen Atlas, Maroc: systématique, biostratigraphie et paléoécologie, paléobiogéographie. Géologie de l'Afrique et de l'Atlantique Sud: Actes Colloque Angers 1994, Pau, 483–509.
- 1996b: Ostracodes du Crétacé supérieur-Paléocène des Rides Sud-Rifaines, Maroc Septentrional. Rev. Micropaléont. 39/2, 93–123.

ANDREU, B., AADJOUR, M. & WITAM, O. 1993: Ostracodes Cytherettidae et Trachyleberididae du Barrémien-Albien basal dans le Bassin d'Agadir (Haut Atlas Occidental, Maroc). Rev. Españ. Micropaleont. 25/2, 95–124.

ANDREU, B., BILOTTE, M., ETTACHFINI, EL M. & GRAMBAST-FESSARD, N. 1996a: Microfaunes (Foraminifères, Ostracodes) et microflores (Algues, Charophytes) du Cénomanien et du Turonien du Bassin d'Essaouira (Haut Atlas Occidental, Maroc). Géologie de l'Afrique et de l'Atlantique Sud: Actes Colloque Angers 1994, Pau, 521–539.

ANDREU, B., BOUTCHICH, K. & CHBANI, B. 1998: Nouvelles espèces d'ostracodes du Coniacien-Santonien-Maastrichtien du Bassin d'Essaouira (Atlas Atlantique, Maroc). Rev. Micropaléont. 41/2, 91–106.

ANDREU, B., CANEROT, J., CHARRIERE, A., & FEIST, M. 1988: Mise en Evidence du Wealdien (Barrémien) dans le Moyen Atlas (région de Boulmane, Maroc). C. R. Acad. Sci. (Paris) 307, II, 2069–2075.

ANDREU, B., & CHARRIERE, A. 1986: Données stratigraphiques et sédimentologiques nouvelles sur le Crétacé du synclinal de Tighboula (Moyen Atlas, Maroc). Rev. Fac. Sc. Marrakech, PICG-UNESCO 183, Marrakech 1985, n sp. 2, 5–30.

ANDREU, B., CHARRIERE, A., MAGNE, J., TRONCHETTI, G. & VILA, J. M. 1995: Le Sénonien du synclinal de Tighboula, Moyen Atlas, Maroc: biostratigraphie et paléoenvironnements. Geobios 28/3, 281–291.

ANDREU, B. & ETTACHFINI, EL M. 1994a: Nouvelles espèces d'ostracodes du Cénomanien du Bassin d'Essaouira (Maroc). Implications paléoécologiques. Rev. Micropaléont. 37/1, 3–29.

ANDREU, B. & TRONCHETTI, G. 1996b: Ostracodes et foraminifères du Crétacé supérieur du synclinal d'El Koubbat, Moyen Atlas, Maroc: biostratigraphie, paléoenvironnements, paléobiogéographie, systématique des ostracodes. Geobios 29/1, 45–71.

ANDREU, B. & WITAM, O. 1994b: Nouvelles espèces d'ostracodes de l'intervalle Barrémien-Albien de la région d'Agadir, Maroc: systématique et résultats biostratigraphiques. Rev. Micropaléont. 37/3, 169–180.

BABINOT, J. F. 1984: Quelques réflexions sur la répartition paléobiogéographique des Ostracodes du Crétacé supérieur des marges européenne et nord-africaine. Strata 1/1, 124–128.

- 1985: Paléobiogéographie des Ostracodes du Crétacé supérieur des marges ouest-européennes et nord-africaines de la Téthys. Bull. Soc. Géol. France 8/I, 5, 739–745.

BABINOT, J. F. & COLIN, J. P. 1988: Paleobiogeography of Tethyan Cretaceous Marine Ostracods. In: Evolutionary biology of Ostracoda (Ed. by HANAI T., IKEDA N. ET ISHIZAKI K.); Elsevier 11, 823–839.

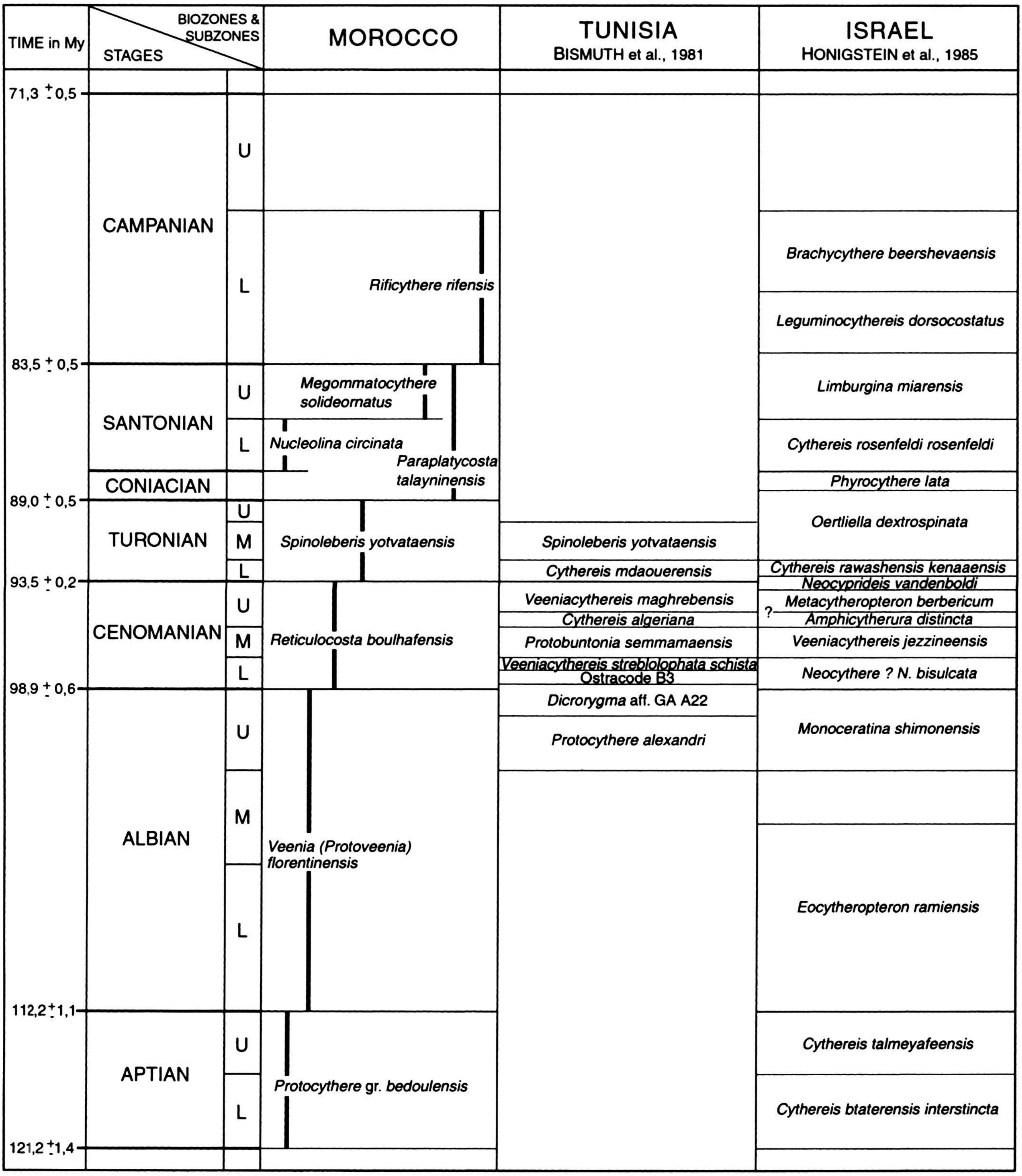

Fig. 21. Ostracode biozonations, in the Aptian to Campanian, in Northern Morocco, Tunisia (Bismuth et al., 1981) and Israel (Honigstein et al., 1985): a comparison.

Babinot, J.-F. & Rodriguez-Lazaro, J. 1990: Les associations d'ostracodes à *Nucleolina quadrata* n. sp.: leur intérêt pour une comparaison entre les marges provençales (sud-est France) et cantabriques (nord Espagne) au Santonien supérieur. Rev. Micropaléont. 33/1, 24–39.

Bismuth, H., Donze, P., Le Fevre, J. & Saint-Marc, P. 1981: Nouvelles espèces d'Ostracodes dans le Crétacé moyen et supérieur du Djebel Semmama (Tunisie du Centre-Nord). 8° Coll. Afric. Micropal., Paris 1980. Cah. Micropaléont. 3, 51–69.

Burollet, P. F. 1989: Table ronde: Evènements téthysiens au cours de la partie moyenne du Crétacé (compte-rendu). Geobios, mém. sp. 11, p. 309–310.

Charriere, A., Andreu, B., Ciszak, R., Kennedy, W. J., Rossi, A. & Vila, J.-M. 1997: La transgression du Cénomanien supérieur dans la Haute Moulouya et le Moyen Atlas méridional (Maroc). Biostratigraphie, Paléoenvironnements et Paléobiogéographie. Geobios 31/5, 551–569.

Charriere, A. & Vila, J.-M. 1991: Découverte d'Aptien marin à foraminifères dans le Moyen-Atlas (Maroc): un golfe mésogéen à travers la Terre des Idrissides ? C. R. Acad. Sci. (Paris) 313, II, 1579–1586.

Ciszak, R., Andreu, B. Charriere, A., Ettachfini, El M. & Rossi, A. 1999: Le Crétacé antéturonien du Moyen Atlas méridional et de la Haute Moulouya, Maroc: stratigraphie séquentielle et paléoenvironnements. Bull. Soc. géol. France 170/4, 451–464.

Colin, J. P. & Andreu, B. 1990: Cretaceous Halocyprid Ostracoda. In: Ostracoda and Global Events. Brit. Micropalaeont. Soc. Publication Series, (Ed. by C. Whatley et C. Maybury), 515–526.

Damotte, R. & Taj-Eddine, K. 1989: La coupe de Sidi Bouskri, Bassin du Haha, Atlas atlantique, Maroc: Ostracodes du Crétacé basal (Berriasien). Rev. Micropaléont. 32/2, 110–117.

El Kamali, N. 1990: Le Cénomano-Turonien du Bassin d'Agadir (Haut Atlas occidental, Maroc): biostratigraphie, sédimentologie et essai de caractérisation des séquences de dépôt. Thèse de Doctorat de 3° Cycle Sci., Univ. Cadi Ayyad, Fac. Sci. Marrakech, 1–128.

Ettachfini, El M. 1993: Le Vraconien, Cénomanien et Turonien du Bassin d'Essaouira (Haut Atlas Occidental). Thèse de Doctorat Univ. Paul Sabatier, Toulouse III, 1992, Strata, Toulouse, 2, 18, 1–245.

Ferrandini, M., Philip, J., Babinot, J. F., Ferrandini, J. & Tronchetti, G. 1985: La plate-forme carbonatée du Cénomano-Turonien de la région d'Erfoud-Errachidia (Sud-Est marocain): stratigraphie et paléoenvironnements. Bull. Soc. Géol. France (8), I, 4, 559–564.

Haq, B. W., Hardenbol, J. & Vail, P. R. 1988: Mesozoic and Cenozoic chronostratigraphy and eustatic cycles. In Wilgus et al. Eds., Sea-level changes: an integrated approach. Soc. Econ. Paleont. Mineral., Spec. Public. 42, 71–108.

Honigstein, A., Raab, M. & Rosenfeld, A. 1985: Manual of Cretaceous Ostracodes from Israel. Isr. Geol. Surv., Spec. Publ., 5, 1–25.

Majoran, S. 1989: Mid-Cretaceous Ostracoda of northeastern Algeria. Fossils and Strata 27, 1–67.

Masoli, M. 1966: Sur quelques Ostracodes fossiles mésozoïques (Crétacé) du Bassin Côtier de Tarfaya (Maroc Méridional). Coll. Intern. Micropal., Dakar 1963, 119–134.

Oertli, H. J. 1966: Etude des Ostracodes du Crétacé supérieur du Bassin Côtier de Tarfaya. Notes Mém. Serv. Géol. Maroc, Rabat, 175, 265–279.

Rey, J. 1997: Stratigraphie, Terminologie Française. Bull. Centres Rech. Explor.-Prod. Elf Aquitaine, Mém. 19, 1–164.

Reyment, R. A. 1978: Quantitative biostratigraphical analysis exemplified by Moroccan Cretaceous Ostracodes. Micropaleontology, London, 24, 1, 24–43.

- 1979: Signification paléobiogéographique de la répartition d'*Oertliella tarfayaensis* au Maroc. Revue de Micropaléontologie, Paris, 22, 3, 186–190.
- 1980a: Beobachtungen uber die Ostrakoden der Coniac-transgression im Saharagebiet. N. Jb. Geol. Palaont. Mh., Stuttgart, 4, 252–256.
- 1980b: Biogeography of the saharan Cretaceous and Paleocene epicontinental transgressions. Cretaceous Research, London, 1, 4, 299–327.
- 1982a: Analysis of trans-specific evolution in Cretaceous Ostracodes. Paleobiology, New-York, 8, 3, 293–306.
- 1982b: Quantitative-genetic analysis of secular changes in fossil foraminifers and ostracods. Colloques internationaux du C. N. R. S., 330, Modalités, Rythmes, Mécanismes de l'Évolution Biologique, Dijon 1982, 319–326.
- 1982c: Note on upper Cretaceous Ostracods from South-Western Morocco. Cretaceous Research, London, 3(4), 405–414.
- 1982d: Speciation in a late Cretaceous lineage of *Veenia* (Ostracoda). J. Micropalaeont., London, 1, 37–44.
- 1987: Spanish and North African region of Tethys in the late Cretaceous. In: Mc Kenzie KG. (ed.), Shallow Tethys 2, 309–317.

Rossi, A. 1992: Le Crétacé inférieur de l'anticlinal d'Ida Ou Zemzem (Atlas Atlantique, Maroc): stratigraphie séquentielle et évolution géodynamique. Thèse de Doctorat de 3° Cycle, Université Cadi Ayyad, Marrakech, 1–238.

Saadi, M. 1975: Schéma Structural du Maroc (Provinces du Nord), échelle 1/4000000. Notes et Mémoires du Service Géologique du Maroc, Rabat, 278 C.

Slimane, H. 1978: Etude stratigraphique et micropaléontologique de la couverture Crétacé-Paléocène du Dhar En Nsour (Maroc septentrional). Thèse de Doctorat de 3° Cycle, Univ. Paris VI, Paris, 1–255.

Symonds, R. 1990: On *Cytheropteron glintzboeckeli* (Donze & Le Fèvre). Stereo-Atlas of Ostracod Shells, London, 17(11), 61–64.

Thierry, J. 1997: V La biostratigraphie. In: Rey J. (Ed.) 1997. Stratigraphie, Terminologie française. Bull. Centres Rech. Explor. -Prod. Elf-Aquitaine, Pau, Mém. 19, 164 p., 63–89.

Viviere, J. L. 1985: Les Ostracodes du Crétacé supérieur (Vraconien à Campanien basal) de la région de Tébessa (Algérie du Nord-Est): Stratigraphie, Paléoécologie, Systématique. Thèse de Doctorat de 3° Cycle, Univ. P. et M. Curie, Paris, 1–261.

Manuscript received November 28, 2000
Revision accepted June 3, 2002

Annex: Species Index, Author's names and year of description

Acanthocythereis ? *tighboulaensis* Andreu (1995)
Acanthocythereis doliaris Andreu (1995)
Acanthocythereis meslei Donze et Oertli (1982)
Acrocythere bizourganensis Andreu et Ettachfini (1994)
Algeriana cenomanica Majoran (1989)
Amphicytherura (Sondagella) distincta Gerry et Rosenfeld (1973)
Amphicytherura (Sondagella) gigantodistincta Andreu (1991)
Amphicytherura zemzenensis Andreu (1991)
Antepaijenborchella amzataensis Andreu (1989)
Bairdia sbaensis Andreu (1994)
Bairdoppilata cf. andersoni Dingle (1981)
Bopaina cf. bopaensis Apostolescu (1961)
Brachycythere aff. *ekpo* Reyment (1960)
Brachycythere angulata Grékoff (1951)
Brachycythere gr. *sapucariensis* Krömmelbein (1964)
Buntonia admarensis Andreu (1994)
Bythoceratina adversasulcata Andreu (1994)
Bythoceratina amsittenensis Andreu (1991)
Bythoceratina tamarae Rosenfeld (1974)
Bythocypris gohrbandti Esker (1968)
Clithrocytheridea senegali Apostolescu (1961)
Cophinia aff. *ovata* Apostolescu (1963)
Costacythere ? *yahyiaensis* Andreu et al. (1993)
Curfsina delicateornata Andreu (1995)
Cypridea boulmanensis Andreu (1991)
Cypridea cf. *ventriosa* Brenner (1976)
Cythereis (aff.) *algeriana* Bassoullet et Damotte (1969)
Cythereis (cf., aff.) *douiraensis* Andreu (1991)
Cythereis ? *magnei* Donze et Saint Marc (1981)
Cythereis ? *tamzergoutensis* Andreu (1991)
Cythereis bigrandis Majoran (1989)
Cythereis cf. *tamzergoutensis* Andreu (1991)
Cythereis dupliciterornatus Andreu (1995)
Cythereis gr. *rawashensis* Van Den Bold (1964)
Cythereis ouaouizaghtensis Andreu (1991)
Cytherella (cf.) *aegyptiensis* Colin et El Dakkak (1975)
Cytherella cf. *ovata* Roemer (1841)
Cytherella cf. *sarakundaensis* Apostolescu (1963)
Cytherella gigantosulcata Rosenfeld (1974)
Cytherella gr. *parallela* (Reuss, 1846)
Cytherella mediatlasica Andreu (1994)
Cytherella meijeri Esker (1968)
Cytherella posterodorsodirecta Andreu (1991)
Cytherelloidea cf. *melleguensis* Damotte et Said (1982)
Cytherelloidea desupertriangula Andreu (1994)
Cytherelloidea oudrarensis Andreu (1991)
Cytherelloidea sourensis Andreu (1991)
Cytherelloidea tigignitensis Andreu (1998)
Cytheretta koubbatensis Andreu (1994)
Cytheromorpha taderdourtensis Andreu et Ettachfini (1992)
Cytheropteron ? *mheridensis* Andreu (1991)
Cytheropteron ? *soricinus* Andreu (1994)
Cytheropteron lekefense Esker (1968)
Cytheropteron piscatorius Andreu (1994)
Cytherura scabritia Vivière (1985)
Dolocytheridea atlasica Bassoullet et Damotte, 1969
Dolocytheridea transatlasica Andreu (1994)
Doricythereis talerzahensis Andreu (1991)
Eocytheropteron anteretroversicardinatum Andreu (1991)
Eocytheropteron gr. (aff.) *glintzboeckeli* Donze et Le Fèvre (1981)
Eocytheropteron grosdidieri Donze et Le Fèvre (1981)
Eucytherura aitabbesensis Andreu (1998)
Haplocytheridea tninensis Andreu (1998)
Haughtonileberis (cf.) *mdaouerensis* Bassoullet et Damotte (1969)
Haughtonileberis exilis Andreu et Ettachfini (1994)
Haughtonileberis propeplanus Andreu (1995)
Hechticythere cf. *hechti* (Triebel, 1938)
Hemicytherura sexangula Andreu (1994)
Herrigocythere ? *hajerensis* Andreu (1991)
Hourqia angulata sinuata Krömmelbein et Weber (1971)
Hutsonia taboulaouarensis Andreu et Witam (1994)
Isocythereis distortus Andreu (1995)
Isocythereis triangulus Andreu (1995)
Kalyptovalva ? *tifratinensis* Andreu (1991)
Krithe cf. *solomoni* Honigstein (1984)
Limburgina (cf.) *selloumensis* Vivière (1985)
Mauritsina cf. *speciosa* Babinot (1980)
Mauritsina dyrensis Vivière (1985)
Mauritsina tamazirtensis Andreu et Ettachfini (1992)
Megommatocythere cf. *latereticulata* Bassiouni et Luger (1990)
Megommatocythere solideornatus Andreu (1995)
Metacytheropteron ? *imintanoutensis* Andreu (1991)
Metacytheropteron cf. GA A 32 Grosdidier (1979)
Metacytheropteron gr. *parnesi* Sohn (1968)
Metacytheropteron triquetrum Andreu (1991)
Monoceratina trituberculata Rosenfeld (1974)
Neocythere cf. gr. *vanveenae* Mertens (1956)
Nigeroloxoconcha aff. GA A 22 Grosdidier (1979)
Nigeroloxoconcha tagragraensis Andreu (1998)
Nucleolina circinata Andreu (1995)
Ovocytheridea cf. *acuta* Apostolescu (1963)
Ovocytheridea cf. *producta* Grékoff (1962)
Ovocytheridea gr. *reniformis* Van Den Bold (1964)
Ovocytheridea sp. B780 Bellion et al. (1973)
Paleocosta aff. *pervinquieri* Donze et Said (1982)
Paleocosta firma Andreu (1995)
Paracypris (cf.) *mdaouerensis* Bassoullet et Damotte (1969)
Paracypris cf. *dubertreti* Damotte et Saint Marc (1972)
Paracypris posteriusacuminatus Andreu (1994)
Paracypris sp. A Esker (1968)
Parakrithe cf. *losaensis* Rodriguez Lazaro (1988)
Parakrithe malleolus Andreu (1994)
Parakrithe tananensis Andreu et Ettachfini (1992)
Paraplatycosta talayninensis Andreu (1995)
Peloriops (cf.) *talbourinensis* Andreu (1991)
Peloriops gr. zigerensis (Bassoullet et Damotte, 1969)
Perissocytheridea ? *laminensis* Andreu et Ettachfini (1994)
Perissocytheridea ? *tamaensis* Andreu et Ettachfini (1994)
Perissocytheridea konatei Vivière (1985)
Perissocytheridea salmacida Andreu (1994)
Pontocyprella recurva Esker (1968)
Pontocyprella agadirensis Andreu et Witam (1994)
Praephacorhabdotus ? *jirensis* Andreu (1991)
Protobuntonia cretacea (Grékoff, 1951)
Protobuntonia numidica (Grékoff, 1953)
Protobuntonia semmamaensis Bismuth et Le Fèvre (1981)
Protocythere (Protocythere) derooi Oertli (1958)
Protocythere (Protocythere) tazemmourtensis Andreu (1991)
Protocythere cf. *triplicata* Roemer (1841)
Protocythere gr. *bedoulensis* Moullade (1963)
Pterygocythere ? *neknaffiensis* Andreu et Ettachfini (1992)
Pterygocythere pennata Vivière (1985)
Rehacythereis aff. *bartensteini* (Oertli, 1958)
Rehacythereis aff. *buchlerae* (Oertli, 1958)
Rehacythereis aff. *fahrioni* (Bischoff, 1963)
Rehacythereis aff. *parareticulata* Colin (1974)
Rehacythereis boulkhiamensis Andreu (1989)
Rehacythereis curva Andreu (1991)
Rehacythereis huescaensis Andreu (1983)
Rehacythereis innflasensis Andreu et Ettachfini (1992)
Rehacythereis praetexta arta (Damotte, 1971)
Rehacythereis punctatafoveolata Majoran (1989)

Rehacythereis saidensis Andreu et al. (1993)
Rehacythereis sopeirensis Andreu (1983)
Reticulocosta boulhafensis Vivière (1985)
Reticulocosta gr. *tarfayaensis* (Reyment 1978)
Reticulocosta gr. *vitiliginosa* (Apostolescu, 1961)
Reticulocosta jezzineensis (Bischoff, 1963)
Rificythere rifensis Andreu (1995)
Schizocythere spelunculus Andreu (1994)
Schizocythere tegeratus Andreu (1994)
Schuleridea adversacomplanata Andreu et Witam (1994)
Schuleridea attabensis Andreu (1991)
Semicytherura adversainflata Andreu (1994)
Spinoleberis (cf.) *kasserinensis* Bismuth et Saint Marc (1981)
Spinoleberis ? *yotvataensis* Rosenfeld (1974)
Spinoleberis aff. *condemiensis* Breman (1976)
Spinoleberis lakminensis Andreu (1995)
Spinoleberis sklouensis Andreu (1995)
Trachyleberidea aff. *arta* (Damotte, 1971)
Trachyleberidea geinitzi (Reuss, 1874)
Veenia (Nigeria) (cf.) *rotunda* Reyment (1978)
Veenia (Nigeria) cf. *nigeriensis* Reyment (1960)
Veenia (Protoveenia) cf. *florentinensis* Damotte (1961)
Veeniacythereis ? aff. *kenaanensis* (Rosenfeld, 1974)
Veeniacythereis gr. *jezzineensis* (Bischoff, 1963)
Virgatocypris kechoulaensis Andreu (1991)
Xestoleberis cf. *derorimensis* Rosenfeld et Raab (1974)
Xestoleberis cf. *tunisiensis* Esker (1968)
Xestoleberis dissimilissummis Andreu (1994)
Xestoleberis igammoudensis Andreu et Ettachfini (1992)
Xestoleberis santoniensis Andreu (1998)