Systematics, palaeoecology and taphonomy of Turonian oysters from the northern Gabon Coastal Basin

Benjamin MUSAVU MOUSSAVOU
Université des Sciences et Techniques de Masuku et URESTE, Faculté des Sciences,
Département de Géologie, boîte postale 943, Franceville (Gabon)
musavu@yahoo.fr

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ABSTRACT
The systematic, paleoecology and taphonomy of the Turonian (Azilé Formation) oysters fauna from the geological section PK 12, South of Libreville – Gabon, are carried out. Twelve species from seven genera are described. Genera *Curvostrea* Vyalov, 1936 ; *Gryphaeostrea* Conrad, 1865 ; *Gyrostrea* Mirkamalov, 1963 ; *Ilymatogyra* Stenzel, 1971 ; *Ostrea* Linnaeus, 1758 ; *Rhynchostreon* Bayle, 1878 and all species are recorded herein for the time in Gabonese coastal basin. The assemblage is dominated by representatives of the genus *Ostrea* and can be regarded as parautochthonous. The oyster shells are thin and thick with medium to large size. The paleoecological study indicates a nearshore shallow marine environment with high energy, nutrient-rich and well oxygenated water column. Taphonomic observations show that shells of oyster are affected by disarticulation. Bioerosion, traces of predators and encrustation are scarcity or absence. Abrasion, breackage and high fragmentation of shell are generally lacking.

KEY WORDS
Taphonomy,
paleoecology,
systematics,
Cretaceous,
Azilé Formation,
Turonian,
oysters,
Gabon costal basin.

RÉSUMÉ
Systématique, paléoécologie et taphonomie des huîtres du Turonien du bassin côtier Nord Gabon.
Une étude intégrant la systématique, la taphonomie et la paléoécologie des huîtres du Turonien (Formation de l'Azilé) du Sud de Libreville au Gabon a été menée à partir de la coupe du PK 12. Douze espèces appartenant à sept genres ont été décrites. Les genres *Curvostrea* Vyalov, 1936 ; *Gryphaeostrea* Conrad, 1865 ; *Gyrostrea* Mirkamalov, 1963 ; *Ilymatogyra* Stenzel, 1971 ; *Ostrea* Linnaeus, 1758 ; *Rhynchostreon* Bayle, 1878 et l'ensemble des espèces sont signalés pour la première fois au sein du bassin côtier gabonais. L'assemblage est dominé par les représentants du genre *Ostrea* et est interprété comme étant parautochtone. L'étude paléoécologique indique un environnement marin de faible profondeur à niveau d'énergie élevé, riche en nutriment avec une colonne d'eau bien oxygénée. Les observations taphonomiques montrent que les coquilles des huîtres sont désarticulées. Les traces de prédations, les incrustations et les bioérosions sont rares à absents. Les abrasions, les cassures et des grandes fragmentations des coquilles sont généralement absents.

MOTS CLÉS
Taphonomie,
paléoécologie,
systématique,
Crétacé,
Formation de l'Azilé,
Turonien,
huître,
bassin côtier du Gabon.

INTRODUCTION

The marine Cretaceous sedimentary deposits exposed in the Gabonese coastal basin exhibit a rich and diversified assemblage of macrofossils which has been previously studied by several authors such as: Kossmat (1893), Lombard (1930), Furon (1931, 1950), Choubert (1935), Dartevelle & Brébion (1956), Dartevelle & Freneix (1957), Freneix (1959, 1966), Weydert & Collignon (1981), Meister *et al*. (1996, 2003), Musavu Moussavou *et al*. (2013a, b; 2014a, b), Musavu Moussavou & Mabicka Obame (2015), Musavu Moussavou (2015). Oysters have been mentioned but they have received little attention.

In fact, the systematic descriptions of Gabonese coastal oysters have been carried out only by Lombard (1930), Dartevelle & Freneix (1957) and Musavu Moussavou *et al*. (2013a, 2014a). There are no known works on their taphonomy and palaeoecology. Therefore the oyster fauna and its ecology are still unknown, despite their presence in the deposits.

This paper is an attempt to improve this situation based on oyster collected from the so-called PK 12 road cut section which located at Libreville region at GPS coordinates 0°24.080'N, 9°31.611'E.

GEOLOGICAL AND GEOGRAPHICAL SETTING

The Libreville region is situated in North-Western of Gabon (Fig. 1). It belongs to the Gabon sedimentary coastal basin, which extends 800 km along the West African Coast between 1°N and 4°S latitude with a surface of 90 000 km^2 (Teisserenc & Villemin 1990). The age of the deposits in the Libreville region is assigned to the Cenomanian?-Turonian by ammonites (Hourcq & Hausknecht 1954; Meister *et al*. 2003). In the Libreville region, the sedimentary sequence, which belongs to Azilé Formation (Turonian), is mainly composed of limestone, marls and clays with locally inter-bedded sandstone (e.g. Hourcq & Hausknecht 1954; Gérard 1958; Weydert 1981; Mbina Mounguengui 1998). Also small coral bioherms have been reported within the limestone (Weydert 1981). The deposits contain a varied marine fauna (Lombard 1930; Hourcq & Hausknecht 1954; Dartevelle & Brébion 1956; Hudeley & Belmonte 1970; Meister *et al*. 1996, 2003; Mbina Mounguengui 1998; Chevalier *et al*. 2002; Musavu Moussavou *et al*. (2013a, b; 2014a). In total seven species of oysters have been reported from the Mesozoic of the Libreville region (Table 1).

The PK 12 section (Figs 1; 2) studied here is located at 12 Km in east of Libreville town along national road 1. The sedimentary succession of this section ranges from Upper Cenomanian to Lower/Middle Turonian. Cenomanian is represented only by 1 meter of red argillite. In Turonian, we distinguish two sedimentary series separated by one angular unconformity. Series situated below consists of argillaceous siltstone, greyish to purplish-blue argilite and fine to mean sandstone beds. There are mud ball, sand ball, current ripple, trough bedding, channels and flasers. Series situated above consisting on greyish to purplish-blue argillite, argillaceous siltstone, white-grey carbonated sandstone, white-grey argillaceous sandstone beds.

MATERIAL

Study of oysters was carried out based on a total of 204 specimens collected from PK 12 section. All specimens are collected from above series within the bed 30 (Fig. 2). From the collected specimens, 149 (89 right valves and 60 left valves) are disarticulated and 55 are articulated. In general, all specimens are well-preserved.

The material is deposited at the collection of the Geology Department, Faculty of Sciences Masuku University of Franceville (Gabon), under collection number MDG/LBV/Lm.

SYSTEMATIC PALEONTOLOGY

In the descriptions, the terms small, medium and large are defined by the following size ranges: small, up to 10.0 mm long; medium, 10.1 to 30 mm; large 30.1 mm and over. Follow abbreviations are used LV for Left valve, RV for Right valve. The classification used here is that of Carter *et al*. (2011).

Class BIVALVIA Linnaeus, 1758
Order OSTREIDA Férussac, 1822
Family GRYPHAEIDAE Vyalov, 1936
Genus *Gryphaeostrea* Conrad, 1865

Gryphaeostrea sp.
(Fig. 3D-F)

MATERIAL. — 3 specimens (MDG/LBV/Lm-7.1 to Lm-7.3).

OCCURRENCE. — Turonian of Gabon (this study).

DESCRIPTION

Shell is large, inequivalve, elongated to oval in outline. LV is strongly convex, inflated. RV is only slightly convex. LV beak is opisthogyrally spiral. Anterior wall of LV is spirally curved. Attachment area is small to large, depressed occupies the posterodorsal portion of the left valve. Ornamentation of LV consists of growth lamellae which adjoining the attachment area. RV is flat to slightly convex. Ornamentation consists of dense, fine growth squamae.

REMARK

The northern Gabon Coastal Basin specimens show great similarities with young specimen of *Gryphaeostrea vomer* Stephenson, 1941 from the Upper Cretaceous which illustrated and described by Pugaczewska (1977). It differs from the present material by having larger space between growth lamellae.

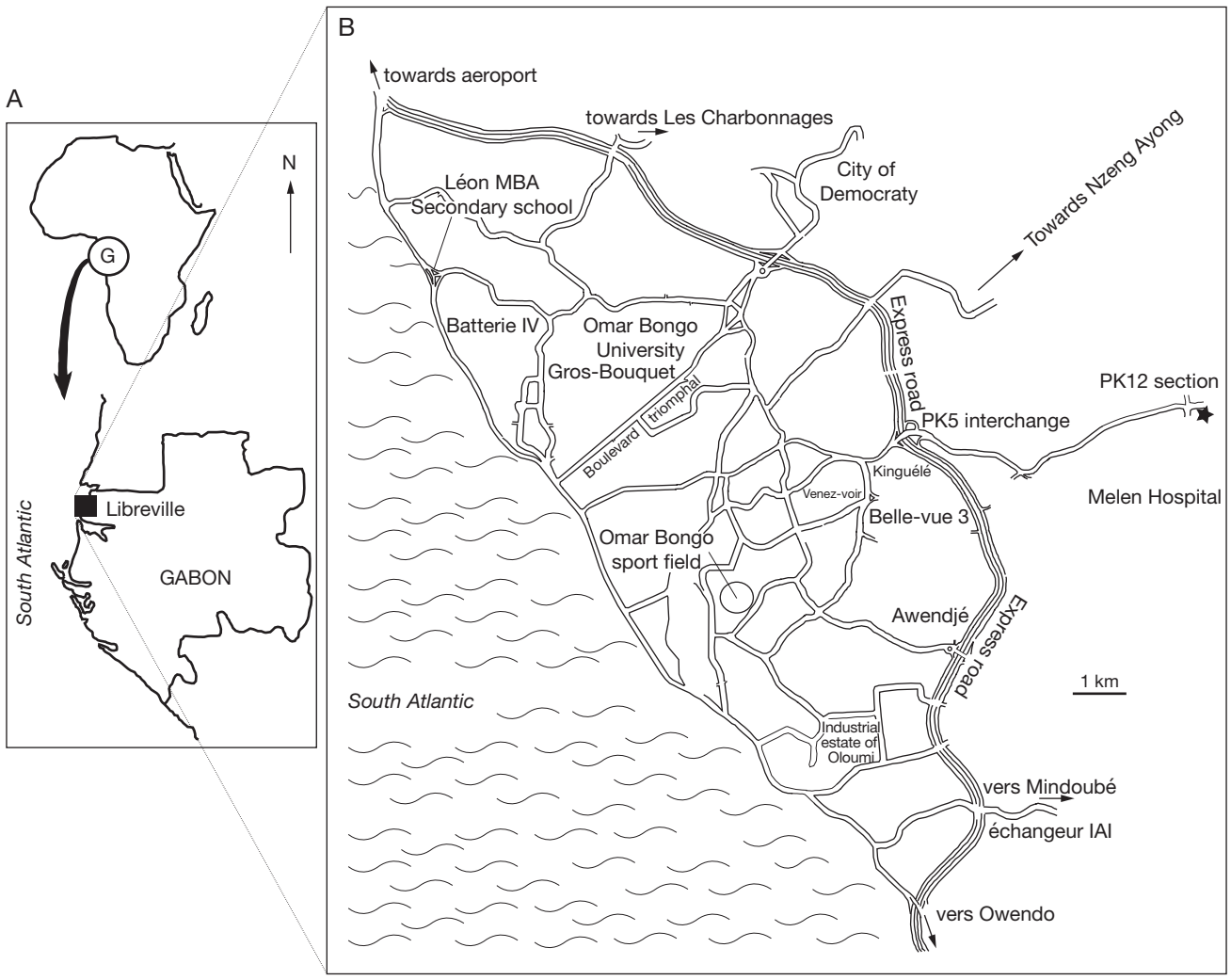

FIG. 1. — Location map of Gabon and Libreville (**A**) and PK 12 section (**B**).

TABLE 1. — List of oyster fauna of Libreville. After Lombard (1930), Dartevelle & Freneix (1957), Musavu Moussavou *et al*. (2013a, 2014a) and the present study.

No.	Species	Lombard (1930)	Dartevelle & Freneix (1957)	Musavu Moussavou *et al*. 2013a	Musavu Moussavou *et al*. 2014a	This study
1	*Curvostrea tevesthensis* (Coquand, 1862)	–	–	–	–	×
2	*Exogyra olisiponensis* Sharpe, 1850	–	×	–	–	–
3	*Gryphaeostrea* sp.	–	–	–	–	×
4	*Gyrostrea delettrei* (Coquand, 1862)	–	–	–	–	×
5	*Gyrostrea* sp. A	–	–	–	–	×
6	*Gyrostrea* sp. B	–	–	–	–	×
7	*Ilymatogyra* (*Afrogyra*) *africana* (Lamarck, 1801)	–	–	–	–	×
8	*Liostrea* ? aff. *roachensis* (Fourtau, 1917)	×	–	–	–	–
9	*Liostrea* ? *cellea* (De Stefani, 1913)	–	×	–	–	–
10	*Lopha lombardi* Dartevelle & Freneix, 1957	–	×	×	–	–
11	*Lopha* ? *dieneri* (Blanckenhorn, 1890)	–	×	–	–	–
12	*Ostrea* sp. A	–	–	–	–	×
13	*Ostrea* sp. B	–	–	–	–	×
14	*Ostrea* sp. C	–	–	–	–	×
15	*Ostrea* sp. D	–	–	–	–	×
16	*Pycnodonta vesicularis* (Lamark, 1806)	–	×	–	–	–
17	*Pycnodonte* sp.	–	–	–	–	×
18	*Rastellum* sp.	–	–	×	×	–
19	*Rhynchostreon* cf. *suborbiculatum* (Lamarck, 1801)	–	–	–	–	×

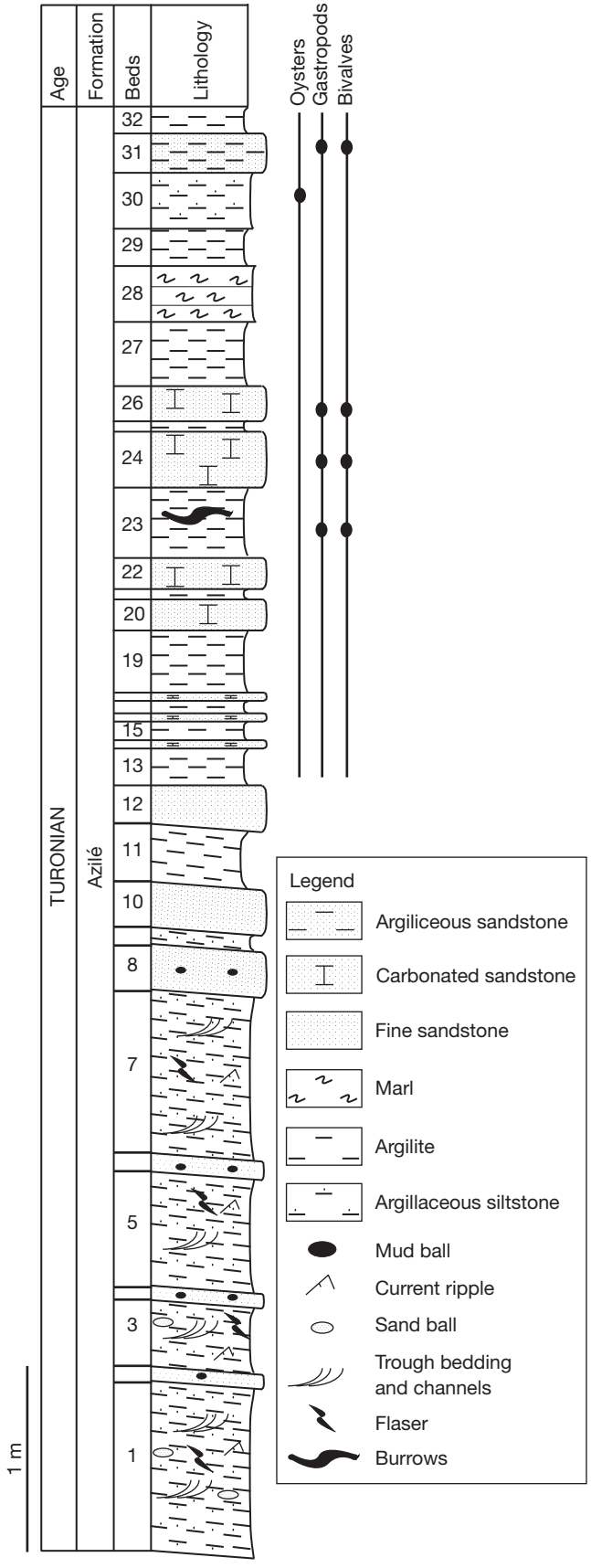

Fig. 2. — Lithostratigraphy of the PK 12 section plotted against occurrence of oysters, gastropods and bivalve.

Genus *Ilymatogyra* Stenzel, 1971

Ilymatogyra* (*Afrogyra*) *africana (Lamarck, 1801)
(Fig. 3I-M)

Gryphaea africana Lamarck, 1801: 399, pl. 189, figs 5, 6.

Ostrea auressensis Coquand, 1862: 233, pl. 22, figs 12, 13.

Ostrea africana – Coquand 1869: 134, pl. 39, figs 5, 6; pl. 55, figs 10-12.

Exogyra africana – Trevisan 1937: 72, pl. 3, fig. 18; pl. 5, figs 1-4.

Ilymatogyra (*Afrogyra*) *africana* 'forma crassa' – Malchus 1990: 121-124, pl. 7, figs 6, 8, 9, 11, 12, 14-20; pl. 8, figs 1-3.

Ilymatogyra (*Afrogyra*) *africana* – Seeling & Bengtson 1999: 58, fig. 9d-g. — Berndt 2002: 110; pl. 3, figs 5-7. — Ayoub-Hannaa 2011: 84, pl. 7, figs 4-6; text-fig. 3.7.

Material. — 6 specimens (MDG/LBV/Lm-8.1 to Lm-8.6).

Occurrence. — Cenomanian of North Africa (Coquand 1862; Ayoub-Hannaa 2011), Europe (Trevisan 1937), Brazil (Seeling & Bengtson 1999). In Gabon, this species is recorded for the first time.

Description
Shell is large, inequivalve, elongated to tear-shaped in outline. Umbo is broken. Left valve is convex. This ornamentation consists of strong scaly growth lamellae. Right valve is flat to moderately convex ornament consisting of fine growth line which becoming lamellose towards ventral margin.

Remark
Malchus (1990) erected two varieties of *Ilymatogyra* (*Afrogyra*) *africana*, 'forma typica' and 'forma crassa'. For difference between these two varieties, the reader is referred to Malchus (1990). All the specimens from the northern Gabon Coastal Basin seem to correspond to 'forma crassa' *sensu* Malchus (1990).

Genus *Rhynchostreon* Bayle, 1878

Rhynchostreon* cf. *suborbiculatum (Lamarck, 1801)
(Fig. 3B, C)

Gryphaea cf. *suborbiculata* Lamarck, 1801: 398, figs *in* Knorr (1801: pl. 62; figs 1, 2).

Rhynchostreon cf. *columbum mermeti* – Freneix 1972: 89, pl. 5, figs 4, 5.

Rhynchostreon cf. *suborbiculatum* – Fischer 1980: 250, pl. 121; figs 7, 8. — Malchus 1990: 132-133. — Videt 2003: 24, pl. 5, figs 1-8.

Rhynchostreon mermeti – Malchus 1990: 128, pl. 8, figs 15-17; pl. 9, figs 5-21.

Material. — 1 specimen (MDG/LBV/Lm-9).

Occurrence. — Upper Cretaceous of Europe (Fischer 1980; Videt 2003), North Africa (Freneix 1972; Malchus 1990). In Gabon, this species is recorded for the first time.

FIG. 3. — **A**, *Gyrostrea* A MDG/LBV/Lm-13; **B**, **C**, *Rhynchostreon* cf. *suborbiculatum* (Lamarck, 1801) MDG/LBV/Lm-9; **D**-**F,** *Gryphaeostrea* sp.; **D**-**E**, MDG/LBV/Lm-7.1, F. MDG/LBV/Lm-7.2; **G**, **H**, *Curvostrea tevesthensis* (Coquand, 1862) MDG/LBV/Lm-11; **I**-**M**, *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck, 1801); **I**, **J**, MDG/LBV/Lm-8.3, K. MDG/LBV/Lm-8.2, L-M. MDG/LBV/Lm-8.1; **N**, **Q**, Ostreidea gen. et sp.; indet MDG/LBV/Lm-34; O, P. *Pycnodonte* sp. MDG/LBV/Lm-10. Scale bar: 1 cm.

DESCRIPTION

Shell, represented only by left valve, is large, inequivalve, elliptical shape in outline. Umbo is small, very opisthogyrate. Anterior margin is curved into approximately semicircular shape. Posterior margin is slightly curved. Attachment area is small. Ornament consists of ribs in posterodorsal part.

Remark
This morphotype is doubtfully assigned to *R. suborbiculatum* (Lamarck, 1801) because of the presence of ribs in posterodorsal part of left valve.

R. suborbiculatum shows great similarities to *R. mermeti* (Coquand, 1862). For discussion concerning this topic, the reader is referred to Freneix (1972), Freneix & Viaud (1986), Malchus (1990), Aqrabawi (1993), Cooper (1995), Seeling & Bengtson (1999). In our material we have only one specimen. For this reason we prefer to consider *R. mermeti* as a synonym *R. suborbiculatum.*

Genus *Pycnodonte* Fischer de Waldheim, 1835

Pycnodonte sp.
(Fig. 3O, P)

Material. — 1 specimen (MDG/LBV/Lm-10).

Occurrence. — Turonian of Gabon (this study).

Description
Shell, represented only by one left valve, is large, suborbicular in outline. Umbo is small. Anterior margin is curved into approximately semicircular shape. Posterior margin is straight, curving into ventral margin which is evenly rounded. Attachment area is very large (25 mm in diameter). Surface ornament consists of growth lamellae.

Remarks
Because of the poor preservation and the small number of specimens, a species designation is not possible; however, the outline and ornamentation seem to show affinity with *Pycnodonta vesicularis* (Lamark, 1806).

Family Flemingostreidae Stenzel, 1971
Genus *Curvostrea* Vyalov, 1936

Curvostrea tevesthensis (Coquand, 1862)
(Fig. 3G, H)

Ostrea tevesthensis Coquand, 1862: 227, pl. 19, figs 7-13. — Basse 1932: 6.

Liostrea tevesthensis – Pervinquière 1912: 69.

Curvostrea tevesthensis – Malchus 1990: 156. — Cooper 2002: 36, fig-text. 5.

Material. — 1 specimen (MDG/LBV/Lm-11).

Occurrence. — Cretaceous of North Africa (Pervinquière 1912; Malchus 1990), Southeast Africa (Cooper 2002). In Gabon, this species is recorded for the first time.

Description
Shell is large, inequival, inequilateral, elongated to oval in outline. LV is strongly convex, inflated. RV is only slightly convex. LV beak is opisthogyrally spiral. Anterior margin of LV is spirally curved. Its posterior margin is straight, curving into ventral margin which evenly rounded. Attachment area is small. LV ornamentation consists of commarginal growth striae and rugae separated by wide interspaces. RV is ornamented by concentric fine growth squamae.

Remark
Curvostrea rouvillei (Coquand, 1862) differs from the present material in being broader and more curved. *Curvostrea bourguignati* (Coquand, 1869) is more quadrate.

Genus *Gyrostrea* Mirkamalov, 1963

Gyrostrea delettrei (Coquand, 1862)
(Fig. 4G-N)

Ostrea delettrei Coquand, 1862: 224, pl. 18, figs 1-7. — Fourtau 1917: 34; pl. 1, figs 1-4.

Exogyra delettrei – Pervinquière 1912: 186, pl. 12, figs 18, ?19. — Trevisan 1937: 74, pl. 5, figs 5-10.

Crassostrea (*Gyrostrea*) *delettrei tarfayensis* – Freneix 1972: 98, pl. 8, figs 5-8; pl. 9, figs 1-7.

Gyrostrea delettrei – El-Sheikh *et al.* 1998: pl. 1, fig. B. — Ayoub-Hannaa 2011: 92, pl. 8, figs 3, 4.

Material. — 10 specimens (MDG/LBV/Lm-12.1 to Lm-12.10).

Occurrence. — This species has been recorded from Cenomanian to Turonian of North Africa (Pervinquière 1912; Freneix 1972; El-Sheikh *et al.* 1998; Ayoub-Hannaa 2011), Italy (Trevisan 1937). In Gabon this is the first record.

Description
Shell is medium to large, inequivalve, inequilateral, elongated, subtrigonal to elliptical shape in outline. Left and right valves are respectively convex and flat. Umbo is small and opisthogyrate. Anterior margin curved into approximately semicircular shape. Posterior margin is straight or curved. Ventral margin is evenly rounded. Attachment area is rounded and large. LV ornamentation consists of radial and continuous ribs towards umbonal area where are crossing by concentric growth lamellae. Towards ventral margin, ornamentation consists only of widely spaced imbricating concentric growth lamellae separated by wide interspaces. RV is ornamented by concentric fine growth squamae.

Remark
The specimens of *Gyrostrea delettrei* (Coquand, 1862) from Gabon Coastal Basin show some similarity to *Ostrea roachensis* (Fourtau 1917: 50, pl. 3, fig. 1), but differ in having a variable size shape, size of the attachment area.

Gyrostrea sp. A
(Fig. 3A)

Material. — 1 specimen (MDG/LBV/Lm-13).

Occurrence. — Turonian of Gabon (this study).

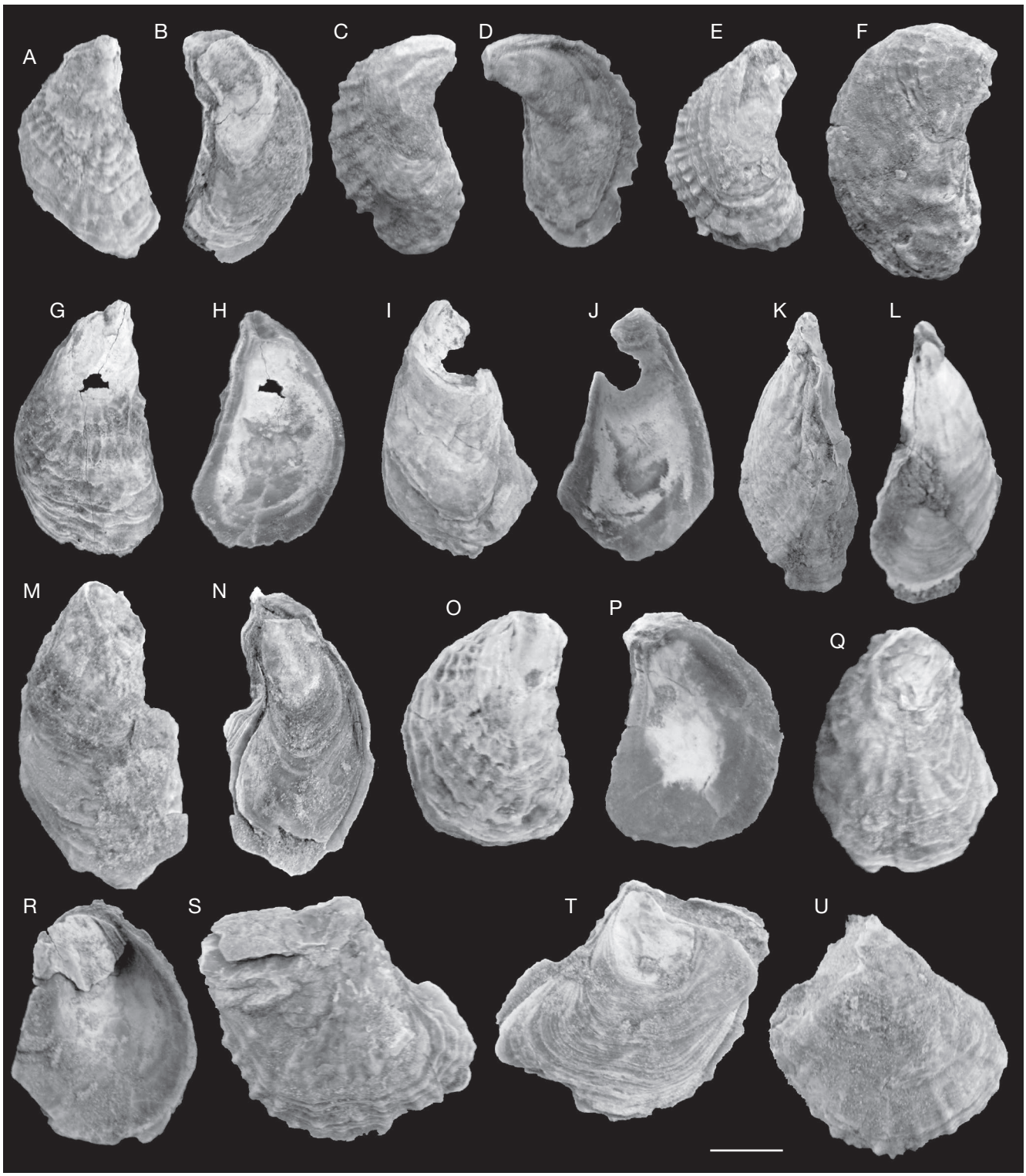

Fig. 4. — **A**-**D**, *Ostrea* sp. D: **A**, **B**, MDG/LBV/Lm-33.1; **C**, **D**, MDG/LBV/Lm-33.2; **E**, *Ostrea* sp. C MDG/LBV/Lm-32.1; **F**, *Gyrostrea* sp. B MDG/LBV/Lm-14; **G**-**N**, *Gyrostrea delettrei* (Coquand, 1862); **G**, **H**, MDG/LBV/Lm-12.1; **I**, **J**, MDG/LBV/Lm-12.2; **K**, **L**, MDG/LBV/Lm-12.3, M-N. MDG/LBV/Lm-12.4; **O**-**R**, *Ostrea* sp. B; **O**, **P**, MDG/LBV/Lm-31.1; **Q**, **R**, MDG/LBV/Lm-31.2; **S**-**U**, *Ostrea* sp. A, S-T. MDG/LBV/Lm-15.1; **U**, MDG/LBV/Lm-15.2. Scale bar: 1 cm.

Description

Shell, represented by LV, is medium, inequilateral, elongated to elliptical shape in outline. Anterior and posterior margin are curved giving semicircular shape of shell. Attachment area is small. Surface rough with growth squamae and few rough rounded irregular ribs well separated from each other.

Remarks
This species differs to *Gyrostrea delettrei* (Coquand, 1862) in having small irregular ribs.

Gyrostrea sp. B
(Fig. 4F)

Material. — 1 specimen (MDG/LBV/Lm-14).

Occurrence. — Turonian of Gabon (this study).

Description
Shell, represented only by LV, is large, inequilateral, elongated to oval in outline. Valve is strongly convex, inflated. Beak is opisthogyrally spiral. Anterior margin is spirally curved. Its posterior margin is straight, curving into ventral margin which evenly rounded. Attachment area is small. Ornamentation consisting of radial ribs near the umbonal area with concentric growth lamellae which becoming concentric ribs toward central part and margin ventral.

Remark
Gyrostrea sp. B differs from *Gyrostrea* sp. A in having concentric ribs.

Family Ostreidae Rafinesque, 1815
Genus *Ostrea* Linnaeus, 1758

Ostrea sp. A
(Fig. 4S-U)

Material. — 10 specimens (MDG/LBV/Lm-15.1 to Lm-15.10).

Occurrence. — Turonian of Gabon (this study).

Description
Shell is large, inequivalve, inequilateral, elongated, subtrigonal to suborbicular in outline. Umbo is small and prominent. Anterior and ventral margin are rounded. Posterior margin straight is angulated toward ventral margin. Attachment area is small. LV is slightly inflated. RV is flat. Ornamentation of LV consisting of numerous radial subacute ribs. This ribs start at the umbonal area, occasionally carrying small spines near ventral margin, and crossed by growth lamellae at irregular intervals. RV is ornamented by concentric fine growth squamae.

Remark
Ostrea sp. A differs from *Ostrea lateralis* Nilsson, 1827 in having an angulated posterior margin without fold.

Ostrea sp. B
(Fig. 4O-R)

Material. — 81 specimens (MDG/LBV/Lm-31.1 to Lm-31.81).

Occurrence. — Turonian of Gabon (this study).

Description
Shell is medium to large, inequivalve, inequilateral, elongated, suborbicular to elliptical shape in outline. LV slightly inflated and RV flat. Umbo is small and opisthogyrate. Ligamental area is narrow and small. Anterior margin is curved. Posterior margin is straight or curved. Ventral margin is evenly rounded. Attachment area is medium, depressed occupies the posterodorsal portion of the LV. Its ornamentation consists of numerous radial ribs which are crossing by concentric growth lamellae at irregular intervals. Ribs start at the umbonal area, occasionally carrying small spines near ventral margin. RV ornamented by concentric fine growth squamae.

Remarks
Ostrea tunetana Munier-Chalmas, 1881 shows some similarity with our material but differs in having longer and more pointed umbo and straight ligamental area.

Ostrea sp. C
(Fig. 4E)

Material. — 3 specimens (MDG/LBV/Lm-32.1 to Lm-32.3).

Occurrence. — Turonian of Gabon (this study).

Description
Shell, represented only by one LV, is medium, inequilateral, elongated to elliptical shape in outline. Umbo is small and opisthogyrate. Ligamental area is larger than high. Anterior margin and posterior margin are subparallel Ventral margin is evenly rounded. Attachment area is long and suboval occupies the posterodorsal part of valve. Ornamentation consists of numerous radial ribs which interrupted by free standing frilled delicate growth squamae.

Remarks
This species differs from *Ostrea* sp. B, in having a long and suboval attachment area and large ligamental area.

Ostrea sp. D
(Fig. 4A-D)

Material. — 25 specimens (MDG/LBV/Lm-33.1 to –33.25).

Occurrence. — Turonian of Gabon (this study).

Description
Shell is medium to large, inequivalve, inequilateral, elongated to elliptical shape in outline. LV is slightly inflated and RV flat. Umbo is small and opisthogyrate. Ligamental area is small. Anterior margin is curved. Posterior margin is straight or curved. Ventral margin evenly rounded. Attachment area is medium, depressed occupies the posterodorsal portion of the LV. Its ornamentation consists of numerous radial ribs which are crossing by concentric growth lamellae at irregular intervals. Ribs start at the umbonal area, occasionally carry ing small spines near ventral margin. RV is ornamented by concentric fine growth squamae.

TABLE 2. — Summary of life-habit and feeding mode of the oysters identified in this study. Abbreviations: **EC**, epifaunal cemented, **EF**, epifaunal free mobile; **S**, suspension feeders.

Families	Species	Life habit	Feeding mode	Abundance
Gryphaeidae	*Gryphaeostrea* sp.	EC	S	3
	Ilymatogyra (*Afrogyra*) *africana* (Lamarck, 1801)	EC	S	6
	Pycnodonte sp.	EC	S	1
	Rhynchostreon cf. *suborbiculatum* (Lamarck, 1801)	EC/EF	S	1
Flemingostreidae	*Curvostrea tevesthensis* (Coquand, 1862)	EC	S	1
	Gyrostrea delettrei (Coquand, 1862)	EC/EF	S	10
	Gyrostrea sp. A	EC/EF	S	1
	Gyrostrea sp. B	EC/EF	S	1
Ostreidae	*Ostrea* sp. A	EC	S	10
	Ostrea sp. B	EC	S	81
	Ostrea sp. C	EC	S	3
	Ostrea sp. D	EC	S	25

REMARKS

Ostrea sp. D differs to *Ostrea delettrei* (Coquand 1869: 143, pl. 47, figs 1-6) in being smooth towards umbo and in having small space between concentric growth lamellae.

PALAEOECOLOGY

DESCRIPTION

The fossil oyster assemblage from PK 12 section, which found only within bed 30 (Fig.), is rich in specimens but relatively poor in species diversity. We have identified twelve species from seven genera, namely *Curvostrea tevesthensis* (Coquand, 1862), *Gryphaeostrea* sp., *Gyrostrea delettrei* (Coquand, 1862), *Gyrostrea* sp. A, *Gyrostrea* sp. B, *Ilymatogyra* (*Afrogyra*) *africana* (Lamarck, 1801), *Ostrea* sp. A, *Ostrea* sp. B, *Ostrea* sp. C, *Ostrea* sp. D, *Pycnodonte* sp., *Rhynchostreon* cf. *suborbiculatum* (Lamarck, 1801). This oyster assemblage is dominated by representatives of *Ostrea* genus with 119 specimens (Table 2). The oysters are not associated with other organisms. Assemblage is characterized by thin and thick shells which are medium to large in size. All left valves have attachment area and prominent ornamentation. In comparison with previous studies of oyster fauna from Gabonese coastal basin (Lombard 1930; Dartevelle & Freneix 1957; Musavu Moussavou *et al*. 2013a, 2014a), oysters studied herein are provided 12 species *versus* 7 species in Gabonese coastal basin area. In addition, all species are recorded for the time in Gabonese coastal basin.

INTERPRETATION

Many studies have treated the distribution patterns of marine macroinvertebrates (e.g., Fürsich 1984, 1994; Berndt 2002; Delvene 2003; Fürsich *et al.* 2004; Harzhauser & Mandic 2004; Zuschin *et al.* 2004a, b; Fürsich & Thomsen 2005; Schneider *et al.* 2009; Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012; Bengtson *et al.* 2014). The parameters controlling faunal distribution are substrate, water energy, salinity, temperature, nutrient supply and oxygen availability. The palaeoautecology of oysters is summarised in Table 2. It is based on information by Berndt (2002), Delvene (2003), Ayoub-Hannaa (2011), Ayoub-Hannaa & Fürsich (2012), Sorensen *et al*. (2012).

According to Morrison & Brand (1986), bivalves living in cold and quiet water have thin, chalky shell, whereas those from warner climates have a thicker with more consistent growth lines. In PK 12 section, thin and thick shells of oysters are together. Because left valves have a prominent ornamentation, we consider that oyster assemblage studied herein evolved in shallow-water where are exposed to sunlight.

With respect to substrate and sedimentation rate, the absence of other organisms in bed 30, such as infaunal organisms, the presence of attachment area on all left valve indicate a firm substrate and relatively low sedimentation rate (Stenzel 1971; Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012). On the other hand, the studied oysters would have tended to sink theirs shells into a firm substrate without the danger of ultimately burial (Abdel Aal & El-Hedeny 1998).The absence of infaunal organisms may be also due to early diagenetic dissolution of aragonitic shells.

All oysters are suspension-feeders. This means that the water energy level was sufficiently high to keep organic matter in suspension and refers also to a nutrient-rich and well oxygenated water column (Berndt 2002; Delvene 2003; Fürsich & Thomsen 2005; Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012). The absence of deposit feeders suggests probably a very small amount of organic matter in the sediment or organics in the water column (Ayoub-Hannaa & Fürsich 2012). This, suggest also an environment at least intermittently influenced by waves and/or currents (Fürsich & Heinberg 1983).

TAPHONOMY

DESCRIPTION

In PK 12 section, 149 disarticulated and 55 articulated specimens are collected. Highly fragmented of shells are generally lacking. The disarticulated left and right oyster valves are almost equal in proportion. Oyster shells are non-bioeroded, scarcity encrusted (4.4 %), rarely fragmented (0.98%) and presented rare traces of predation (0.98%).

Interpretation

Many studies have used taphonomic features in order to follow the evolution of shell since its death until its final burial (e.g. Powell *et al*. 1989; Kidwell & Bosence 1991; Brett & Baird 1993; El-Hedeny 2005; Mekawy 2013; Hernandez-Ocana *et al*. 2015). Taphonomic process commonly described includes decomposition, dissolution, abrasion, bioerosion, fragmentation and the biological and hydraulic reworking of skeletal remains.

According to Boucot *et al*. (1958), the degree of disarticulation, along with abrasion and breakage, is a reliable indication of the degree of transport a bivalve has undergone since death. In this study, the stage of disarticulation of valves and fragmentation of shells, suggests that oyster community from PK12 section is transported under high-energy conditions, but of short duration and a short distance after death (Boucot *et al.* 1958; Seeling & Bengtson 1999). Therefore the assemblage of oysters can be regarded as parautochthonous.

The good quality of oyster shells, absence of bioerosion and scarcity of encrustation suggest a rapid burial rate after death and a relatively low sedimentation rate (Ayoub-Hannaa 2011; Ayoub-Hannaa & Fürsich 2012; Mekawy 2013). Only 2 (0.98%) from 204 of studied oyster specimens are presented traces of predation. This means scarcity of predators during lives of organisms. This is corroborated by the absence of other organisms in assemblage. Because the scarcity of predators, we regarded the high frequency of disarticulated oyster shells as due only to very week dysodont dentition (El-Hedeny 2005).

CONCLUSIONS

The Turonian oysters of PK 12 section are characterized by thin and thick shells which are medium to large in size. The fauna is dominated by representatives of *Ostrea*. All morphotypes are recorded here for the first time in the Gabonese coastal basin. In comparison with previous studies of oyster fauna from Gabonese coastal basin, oysters from PK 12 section have a higher diversity and differ on their systematic content.

Paleocologically, oysters were living in nearshore shallow, high-energy marine environments which are rich in nutrient and have a well oxygenated water column. After their death, they have been rapidly burial.

Taphonomically, the studied oysters are affected by disarticulation. Bioerosion, traces of predators and encrustation are scarcity or absence. Abrasion, breackage and high fragmentation of shell are generally lacking. The assemblage of oysters can be regarded as parautochthonous

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