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Contribution to the reappraisal of the mid Paleogene ichthyofauna of Western Africa with three new enigmatical elasmobranchs from Thanetian–Lutetian of Senegal

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1 **Contribution to the reappraisal of mid Paleogene ichthyofauna of Western Africa with**
2 **three new enigmatical elasmobranchs from Thanetian-Lutetian of Senegal.**

3 **Contribution à la réévaluation de l'ichtyofaune du Paléogène moyen en Afrique de**
4 **l'Ouest avec trois nouveaux élasmobranches énigmatiques du Thanétien-Lutétien du**
5 **Sénégal.**

6

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31 **Abstract.**

32 We report here three new elasmobranch fossil taxa from Thanetian-Lower Lutetian nearshore
33 marine deposits of northeastern (Matam region) and central-western (Sine-Saloum region)
34 Senegal. These three new taxa represent the oldest species of the enigmatical elasmobranch
35 *Odontorhysis*, the oldest putative representatives of marine potamotrygonid, and an uncertain
36 dasyatoid genus with the smallest grinding dentition ever described. These new taxa,
37 representing the second Cenozoic elasmobranch remains formally described from Senegal,
38 broaden our understanding of their evolutionary and biogeographic history in the equatorial
39 Eastern Atlantic during this time period. Their occurrences confirm hypothesised
40 stratigraphically correlations between the top of Matam Fm. and the base of Lam Lam Fm.,
41 refine the marine connections between these two Senegalese regions, and suggest that these
42 genera were broadly distributed within the shallow marine settings of the equatorial Eastern
43 Atlantic during latest Paleocene – early Middle Eocene.

44

45 **Keywords:** Elasmobranch, new taxa, Paleogene, Senegal.

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47

48 **Résumé.**

49 Nous rapportons ici trois nouveaux taxa de fossiles d'élasmobranches des dépôts marins
50 littoraux du Thanétien-Lutétien inférieur du Nord-Est (région de Matam) et du Centre-Ouest
51 (région du Sine-Saloum) du Sénégal. Ces trois nouveaux taxa représentent les espèces les plus
52 anciennes d'élasmobranches énigmatiques appartenant au genre *Odontorhytis*, aux
53 potamotrygonides marins et à un dasyatoïde avec la plus petite denture broyeuse jamais
54 décrite. Ces nouveaux taxa, complétant l'unique description d'élasmobranches cénozoïques
55 nouveaux au Sénégal, élargissent notre compréhension de leur histoire évolutive et
56 biogéographique de l'Atlantique Est équatorial au cours de cette période. Leurs occurrences
57 confirment des corrélations stratigraphiques hypothétiques entre le sommet de la Formation
58 de Matam et la base de la Formation de Lam Lam. Celles-ci affinent aussi les liens marins
59 entre ces deux régions sénégalaises et leur comparaison avec des occurrences reconnues en
60 Afrique du Nord et de l'Ouest suggèrent que ces genres étaient largement répartis et
61 diversifiés dans les environnements marins peu profonds de l'Atlantique Est équatorial au
62 cours du Paléocène terminal et du début de l'Éocène moyen.

63

64 **Mots-clés:** Elasmobranche, nouveaux taxa, Paléogène, Sénégal.

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72 **Introduction**

73 Biogeographic origins of African modern vertebrates have been the focus of considerable
74 research since last decade in warm Paleogene period of West Africa. Among them,
75 elasmobranch fossil record devoted to mid Paleogene was very partial with a unique
76 description of taxa such as *Lophobatis* Cappetta, 1986, preliminary reports (Pascal, 1987;
77 Cappetta and Traverse, 1988; Stevens et al., 2011), and/or ancient works that (e.g. Strömer,
78 1910, White, 1926, 1934, 1955). Biogeographic interpretations of past elasmobranch diversity
79 in Central Western Atlantic during Paleogene have been mainly evidenced based on the richer
80 northwestern (e.g. Morocco) and southwestern (e.g. Angola) African deposits (e.g.
81 Arambourg, 1952; Noubhani and Cappetta, 1997; Darteville and Casier, 1943, 1959; Solé et
82 al., 2018). However, a corresponding body of research is largely lacking for the Paleogene
83 equatorial Eastern Atlantic elasmobranchs, despite the fact that nearly all of the known
84 Cenozoic rocks along the West African coast are marine, especially near the Guinean Gulf.
85 Indeed, reappraisal of the mid Paleogene Western African faunas is essential to better
86 understand the elasmobranch evolution in the equatorial paleo-Atlantic. Currently, the
87 Senegalese elasmobranch Cenozoic fossil record is only represented by mid Paleogene taxa
88 from the phosphate ores of Matam (Pascal, 1987; Sambou et al., 2018; Sambou 2018) and
89 Taïba (Hautier et al., 2012, 2014). Other associated marine vertebrate, including bony fish
90 like amiid or scombrid (O-Leary et al. 2012, Cleason et al. 2015), sea cows and whales
91 (Hautier et al., 2012) are recovered in Early-Middle Eocene from same or different localities
92 (e.g. Gossas, Bargny). We report here, three new taxa of elasmobranchs with unambiguous
93 dental morphologies that support biostratigraphical correlations between Formations from two

94 main Senegalese areas: Matam (Pascal, 1987; Sambou et al., 2017; Sambou, 2018) and
95 Kaolack in Sine-Saloum region (Tabuce et al., 2019). These new taxa contribute to the
96 reappraisal of mid Paleogene fauna of Western Africa and improve understanding the
97 diversification of modern elasmobranchs.

98

99 **Geological setting, material and methods.**

100 Most of the specimens were found in the phosphate ore of Ndendouri-Ouali Diala near Matam
101 (sub-prefecture of Orkadiéré, Matam region, approximately 15°18'N, 13°01'W, see
102 Sambou et al., 2017 for details) located on the left riverbank of the Senegal River,
103 northeastern part of Senegal (Fig. 1). The studied material was collected in water-well
104 cuttings during ancient campaigns of M. Pascal (see Pascal, 1987) that allowed to collect an
105 amount of 450 kg of phosphatic sediment and 50 kg of sandy sediment in a series of wells
106 (collecting H.C.) and from recent wells drilled manually in the subsoil of Ndendouri-Ouali
107 Diala (collecting B.S.) and following a NW direction (see Sambou, 2018). Sambou et al.
108 (2017) recently revised the faunas from the Gorgol and Matam Fm. outcropping in the
109 phosphate ore of Matam as previously reported in Pascal (1987). 38 species of elasmobranch
110 have been recognized in the different levels of the 20 well-drilling and 33 different samples
111 along the Matam series (see Sambou et al., 2017 : Tab.1 for details). These faunas include
112 several determined and undetermined species of *Brachycarcharias*, "*Cretolamna*",
113 *Protoginglymostoma*, *Ginglymostoma*, *Nebrius*, *Rhizoprionodon*, *Physogaleus*, *Triakis*,
114 *Foumtizia*, *Rhynchobatus*, *Pristis*, *Anoxypristis*, *Eotorpedo*, *Lophobatis*, *Myliobatis*,
115 *Rhinoptera*, *Leidybatis*, *Garabatis*, *Coupatetia*, *Ouledia* and the three new taxa reported here.
116 From these, five fossiliferous associations were identified along the available
117 sedimentological successions (see Fig. 1), and confirmed the late Thanetian age of the top of
118 the Gorgol Fm. (association 1 – lithological Unit 0), the Ypresian age of the phosphate

119 deposits belonging to Matam Fm (rich associations 2-4, lithological Units 1-3), and the
120 Lutetian age of the higher clay-limestone unit of Matam Fm. (association 5, lithological Unit
121 4).

122 The other specimens come from the water-well cuttings located at Sanghaye Bele village
123 ($14^{\circ}16'55.5''\text{N}$, $16^{\circ}6'14.01''\text{W}$, Fig. 1), north of Kaolack in the Sine-Saloum region (central-
124 western part of Senegal, see Tabuce et al., 2019 for details). The fossiliferous deposits
125 attributed to the Lam Lam Fm. correspond to coquina limestone and yellow to white clayey
126 limestone alternating with marls. Material was recovered by soft acid attack (acetic 8%) of 30
127 kg of sediments (see also Tabuce et al. 2019 for details). If the base of the Lam-Lam
128 Formation is E8 in age (lower Lutetian), the top of the formation (Lam-Lam marls) yielded a
129 rich planktonic foraminifera association that indicates the E9 biozone (top of lower Lutetian)
130 (Flicoteaux 1974, Roger et al. 2009). These regional correlations indicate a confident lower
131 Lutetian age (E8-E9 biozones, 49 to 45,8 Ma ~44 M.a., Vandenberghe et al. 2012) for the
132 fossiliferous level in water-well of Sanghaye Bele (see Tabuce et al. 2019 for correlations).
133 Some elasmobranch remains were collected in the 30 kg of limestone and include for instance
134 some teeth of *Chiloscyllium* sp., *Nebrius* cf. *obliquus*, ?*Rhizoprionodon* sp., *Physogaleus* sp.,
135 *Rhynchobatus* sp., *Rhinobatos* sp., *Ouledia* sp., ?*Jacquhermania attiai*, *Arechia* sp.,
136 *Dasyatoid* indet., *Coupatanzia* sp. as well as two of the three new taxa described here. The
137 elasmobranch assemblage from the coquina limestone of the Lam Lam Fm. in Sanghaye Bele
138 would then be contemporaneous with the coquina limestone of the Ngolothie borehole near
139 Kaolack (Tabuce et al. 2019) and most probably sub contemporaneous with the elasmobranch
140 assemblage of the clay-limestone unit ending the Matam Fm. in Sambou et al. (2017).

141 [FIG.1 here](#)

142 **Systematic Palaeontology**

143 *Institutional Abbreviations*— Fossil material, including type series, is housed at the
144 University of Montpellier, France (abbreviations SES, MAM) or at the University Cheikh
145 Anta Diop of Dakar, Senegal (abbreviations SNSAN/2011/). Tooth terminology follows
146 Cappetta (2012)

147

148 Class CHONDRICHTHYES Huxley, 1880

149 Subclass ELASMOBRANCHII Bonaparte, 1838

150 SubCohort NEOSELACHII Compagno, 1977

151 Superorder BATOMORPHII Cappetta, 1980

152 Order MYLIOBATIFORMES Compagno, 1973

153 Superfamily DASYATOIDEA Compagno, 1973

154 ?Potamotrygonidae Garman, 1877

155 ?Styracurinae Carvalho et al., 2016

156

157 *Atlantitrygon nov.gen.*

158 ***Type species:*** *Dasyatis sudrei* Cappetta, 1972

159 ***Type material:*** Holotype: SES64, Sessao, Thanetian of Niger (Cappetta, 1972 : Plate 6 fig. 3)

160 refigured in figure 2 A ; paratypes SES62-63, 65-67 (Cappetta, 1972 : Plate 6 fig. 1-2,4-6)

161 partially refigured in figure 2 B-D.

162 **Etymology:** simplified Greek “*Atlanti*” refers to the past distribution of representatives,
163 currently limited to tropical Atlantic sea along the western African coast, and Greek “*trygon*”
164 meaning stingray.

165 **Diagnosis:** Dasyatoid genus characterized by gracile medium sized teeth with high crown
166 compared to root, a development in height of the lingual zone and the lingual marginal face of
167 crown (including the transversal keel); a long, slender cusp mesiodistally flattened and
168 highlighted by an occlusal median crest, a junction between the undulating transverse keel
169 and the median crest of cusp forming a three-pointed star in occlusale view ; a narrow lingual
170 face and a concave labial face of crown with finely ornamented enameloid; a root with two
171 sub-triangular lobes elongated transversally.

172 **Occurrence:** from Thanetian (Niger, Togo and Senegal) with *A. sudrei* to lower Lutetian
173 (Senegal) with *A. senegalensis* nov. sp.

174 **Discussion:** Cappetta (1972) described *Dasyatis sudrei* from Sessao, Niger. At that time,
175 diagnosis characters, e.g. the long slender cusp, were evaluated as enough peculiar compared
176 to other species of *Dasyatis* s.l. to justify the creation of a new species (Cappetta, 1972 : p.
177 207). The author suggested that this taxon could be close to genus *Himantura*, unknown at the
178 fossil state in 1972. In fact, a slender long cusp is known in many male teeth belonging to
179 some dasyatidspecies (e.g. *Dasyatis*, *Hypanus*) and many Urotrygonidae (e.g. *Urobatis*) and
180 Urolophidae (e.g. *Urolophus*) but this long cusp is usually rooted on the edge of lingual zone
181 and its top is delimited by the transversal keel that follows the upper borders of cusp. The
182 upper face of cusp, often concave, belongs in fact to the labial face, contrary to what is
183 observed in *Atlantitrygon*. The unique dasyatoid teeth that display a comparable “displaced”
184 cusp are observable in living western Atlantic “*Himantura*” *schmardae* (Werner, 1904 : see
185 Cappetta, 2012, fig. 410) recently attributed to genus *Styracura* Carvalho et al., 2016wich also

186 includes *S. pacifica* (Beebe and Tee-Van, 1941). Both these marine species, recently included
187 in Potamotrygonidae, are considered more closely related to freshwater potamotrygonins
188 (Carvalho et al., 2016). The inclusion of *Atlantitrygon* in the marine Styracurinae thus
189 remains hypothetic and is only based on global resemblances of the tooth shape and the
190 presence of a displaced main cusp. However, the teeth of *S. schmardae* are easily
191 distinguishable from *Atlantitrygon* nov. gen. by having a straight transversal keel, a second
192 transverse keel, running more or less parallel to main one, a cusp without crest and a
193 ornamentations absent, contrary to the condition seen in teeth of *Atlantitrygon* nov. gen.
194 Finally, the unique combination of characters in *Atlantitrygon* nov. gen. does support the
195 creation of this new fossil genus but its systematic position among the Potamotrygonidae
196 remains nevertheless uncertain, partly because our limited knowledge of the dental variation
197 in living batoid (Guinot et al., 2018).

198

199 *Atlantitrygon senegalensis* nov. sp.

200 ***Etymology:*** Refers to the country where the type series was found

201 ***Type material:*** Holotype Fig. 2 K, MAM-09 (well F0 9.18-9.3m, Unit 2 in Sambou et al.,
202 2017) Ndendouri-Ouali Diala, ?Early Ypresian, Matam Fm.; Paratypes Fig. 2 F-J, MAM-04
203 to MAM-08 and MAM-10 to MAM-11 (well F0 9.18-9.30m, Unit 2 in Sambou et al., 2017)
204 Ndendouri-Ouali Diala, ?Early Ypresian, Matam Fm

205 ***Additional material:*** a fifteen teeth from Lower Lutetian (E8-E9 biozones, 49 to 45,8 My) of
206 Sine-Saloum region, Senegal and also partially figured Fig. 2 N-Q

207 ***Diagnosis:*** The new species distinguishes from the unique type species of genus by having
208 teeth with higher transversal keel that looks as more protruding, undulated and often marked
209 by three rounded pseudo cusplets in lingual view. Two of these cusplets are located at the

210 margin while the third one, the highest, is situated in the cusp axis. Compared to the type
211 species, ornamentation of the enameloid of the lingual and labial faces is more finely
212 developed, especially under the transversal keel with an alveolar network shape.

213 **Occurrence:** Ypresian to Lower Lutetian of Matam and Lower Lutetian of Sine-Saloum
214 regions, Senegal, possibly in the Ypresian of Mali (Tamaguilet) and Morocco (Ouled
215 Abdoun)

216 **Description:** The tooth morphology is consistent with that of dasyatoids, a paraphyletic group
217 that includes many different families of stingrays (e.g. Dasyatidae, Urolophidae,
218 Urotrygonidae, Potamotrygonidae, Plesiobatidae) with no pavement-like arrangement. The
219 dentition is monognathic heterodont with high-crowned teeth (e.g. Fig. 2 I), which decrease in
220 size toward the commissure (e.g. Fig. 2 M, P). The holotype (Fig. 2 K) is a tooth probably
221 located medially along the jaw. It displays a high crown (Fig. 2 K2) with robust cusp (Fig. 2
222 K2). In occlusal view (Fig. 2 K1), the crown is semi-oval in shape, broader than long, with a
223 long, slender cusp with median crest on its occlusal part. This median crest does not reach the
224 apex of cusp (Fig. 2K1). The crown has a high, transverse keel, which divides the crown into
225 distinct labial and lingual parts (Fig. 2K1). The junction between the undulating transverse
226 keel and the median crest of cusp forms a three-pointed star (Fig. 2 K1). The transverse keel
227 is quite salient and forms an erected cutting edge. The upper part of the lingual face (below
228 the transverse keel) and the labial face are fully ornamented. This ornamentation is quite
229 delicate and organized as an alveolar network with larger alveolus on concave basin of the
230 labial face (Fig. 2 K3). The upper part of the ornamented labial visor (labial border of labial
231 face) is reduced to a straight crest that overhangs the lower part of the unornamented labial
232 visor. The lower part of lingual face, also unornamented below the cusp axis, is relatively
233 expanded marginally. The root is narrow in profile (Fig. 2 K2), of holaulacorhizous type with
234 two short lobes separated by a low groove. A large central foramen opens in labial part of the

235 nutritive groove. Tooth variability, in part due to heterodonty, mainly involves the general
236 shape of the crown, which is sometimes subtriangular in shape (e.g. Fig. 2 I) with often a long
237 slender cusp. This cusp is always present in all specimens suggesting no sexual heterodonty.
238 In more anterior files, the crown sometimes displays a very high, undulating transverse keel
239 that forms three pseudo rounded cusplets in lingual view (e.g. Fig. 2 L1, O1, N1). One of
240 them is located at the junction between the transverse keel and the median crest of the cusp.
241 Lingual ornamentations seemingly are absent on the lower part of lingual face and below the
242 cusp axis of all specimens, conversely to the condition seen in the whole labial face and in the
243 narrow band of lingual marginal face just under the transversal keel. In anterior teeth, this
244 ornamented upper part of lingual face is sometimes set apart from the unornamented lower
245 part by rounded transverse keels in lingual view (Fig. 2 L, N). Enameloid ornamentation is
246 quite delicate in the upper part of the lingual face (Fig. 2 H3, L2) and could be organized as
247 an alveolar network with larger alveolus on concave basin of the labial face (Fig. 2 K3, M2).
248 This ornamentation reduces gradually near the keel and crests where it takes the form of lace
249 when not abraded. The labial visor is merely variable, being often reduced to a salient and
250 straight crest delimiting the labial border of the labial face. The basal view of the crown (Fig.
251 2 H2, I1, O2) shows a broad and slightly convex crown rim at the outer part, which gradually
252 narrows down to half of its width at the inner part. The crown–root junction is located in a
253 shallow depression at the centre of the basal surface of the crown. The root is lower than the
254 crown, of holaulacorhizous type with two lobes, which are triangular (fig. 2 I1, H2) to semi-
255 circular in shape (fig. 2 O2) in basal view. The root base has a well-developed and deep
256 median nutritive groove that encloses a single large central foramen (fig. 2 M1, O2). No inner
257 or outer foramina are discernible on the specimens. The lower Lutetian material from Sine-
258 Saloum (fig. 2 N-P) is quite similar to the type series from Matam region (fig. 2 F-M) despite
259 its poorer state of conservation.

260 **Discussion:** Compared to *A. sudrei*, the new species *A. senegalensis* nov. sp. displays teeth
261 with similar shape, but its transversal keel is higher, more protruding, undulated and often
262 marked by three rounded pseudo cusplets in lingual view. Two of these cusplets are located at
263 the margin while the third one, the most developed, is situated in the cusp axis at the junction
264 of the three-pointed star. Compared to *A. sudrei*, less salient crests are present on the concave
265 labial face of the crown in *A. senegalensis* nov. sp., as observable in type series (e.g. fig. 2 B).
266 The ornamentation of the enameloid in the band of the lingual marginal face under transversal
267 keel (as those of the labial face) is more finely developed compared to *A. sudrei* with alveolar
268 network shape, except near the keel and crests where they reduce gradually. Only a few
269 specimens of *A. sudrei* have been recovered in the Thanetian of Matam, Senegal (fig. 2 E). It
270 seems more abundant in the Nigerian type locality (Cappetta, 1972) and in Togolese
271 Thanetian deposits (Guinot et al., 2020). Although badly preserved (partial crown with broken
272 cusp), the tooth crown shows that the cusp was mesiodistally flattened and that the junction
273 between the low transverse keel and the cusp formed a three-pointed star in occlusal view.
274 The enameloid of the crown concave labial face is also finely ornamented (fig. 2 E2). Some
275 teeth from Ypresian deposits of Matam (e.g. fig. 2 F, H) show a morphology very close to that
276 of *A. sudrei* teeth with a weak transverse keel. This probably indicates a close filiation
277 between the two chronospecies of the new genus. Similar teeth to *A. senegalensis* were also
278 observed (H.C. pers. observations) in the Ypresian of Morocco (Ouled Abdoun) and Mali
279 (Tamaguilet), which might indicate that *Atlantitrygon* representatives had a wider distribution
280 along the tropical western Atlantic coasts, from Niger to Morocco, during the Thanetian-
281 Ypresian period.

282 **FIG.2 here**

283

284 Superfamily DASYATOIDEA Whitley, 1940

285 Dasyatoidea INCERTAE FAMILIAE

286 *Microtriftis* nov.gen.

287 **Type species:** *Microtriftis matamensis* nov. sp.

288 **Etymology:** From Greek “*triftis*” refers to the rap shape of occlusal surface and “micro”

289 relatively to the small size of teeth.

290 **Diagnosis:** the same that the unique species referred to this new genus.

291 **Occurrence:** Ypresian to Lutetian of Matam and Sine-Saloum region, Senegal

292

293

294 *Microtriftis matamensis* nov.sp.

295 **Etymology:** Refers to the Matam area where the type series was found.

296 **Type material:** Holotype Fig. 3 D, MAM-15 (well F0 9.18-9.3m, Unit 2 in Sambou et al.,

297 2017) Ndendouri-Ouali Diala, ?Early Ypresian, Matam Fm.; Paratypes: MAM-12, 13, 14, 16,

298 (well F0 9.18-9.3m, Unit 2 in Sambou et al., 2017), Ndendouri-Ouali Diala, ?Early Ypresian,

299 Matam Fm., Senegal.

300 **Additional material:** about twenty teeth including those figured SNSAN/2011/05 to

301 SNSAN/2011/07 (Fig. 3 F-H) - lower Lutetian (E8-E9 biozones, 49 to 45,8 My) of Sine

302 Saloum region, Senegal.

303 **Diagnosis:** Myliobatoid ray with very small teeth (less than 1.3 mm in size) exhibiting

304 reduced sexual dimorphism in crown morphology. The teeth of presumed breeding males

305 have crown with small, lingually directed cusp, non-cuspidate teeth of presumed females (or

306 from the lateral files of breeding males). The crown is robust, often diamond shaped in

307 occlusal view with depressed visor suggesting a light teeth imbrication or at least a direct
308 contact between alternating teeth. The lingual face of the crown is straight and mainly
309 unornamented, excepted just under the transverse keel where it is slightly concave with an
310 enameloid marked by vertical folders. The labial face is flat, strongly ornamented with sorted
311 micrometric holes piercing the whole surface. The labial visor is medially concave and its
312 ornamentation is less homogeneous compared to labial face. The teeth roots are bilobate,
313 vertically directed, narrower than the crown and relatively high with two pinched lobes
314 separated by large but soft nutritive groove where a unique large foramen opens medially.

315 **Description:** The teeth are very small, not exceeding 1.3 mm in size. They exhibit reduced
316 sexual dimorphism in crown morphology, the crown teeth of presumed breeding males
317 bearing a short cusp lingually directed (fig 3 A-B). The base of cusp is sometimes as wide as
318 the transverse keel or medially centered (fig. 3 A-B). The non-cuspidate teeth of presumed
319 females (conceivably teeth of non-breeding male or teeth from the lateral files of breeding
320 males) display diamond-shaped occlusal outline. The holotype (fig. 3 D) probably belongs to
321 a latero-anterior file of a female jaw. The crown is high with developed lingual face, which is
322 sub-trapezoid in lingual view (fig. 3 D1). The lingual extremity is medially convex under the
323 vertical bulge and the marginal borders are straight to slightly concave near the transverse
324 keel. The enameloid is mainly unornamented except near the transverse keel where several
325 enameloid folders are easily distinguishable (fig. 3 D1). The labial face is flat, its contour is
326 diamond-shaped in occlusal view (fig. 3 D2) and displays many circular holes deeply piercing
327 the enameloid surface (fig. 3 D3). The hole size is relatively homogenous except near the
328 labial visor where the ornamentation is more unstructured. The labial visor is medially
329 concave, which suggests a light imbrication with the lingual face of tooth directly anterior to
330 it. The lower part of labial visor is thick and unornamented. The crown/root junction is
331 located in a shallow depression in the centre of the basal crown surface. The root is narrower

332 than the crown, of holaulacorhizous type with two lobes, which are semi-circular in shape in
333 basal view. The root lobes are slightly lingually directed and almost vertical in profile. The
334 root base displays a weak median nutritive groove that encloses a large central foramen. Male
335 teeth (fig. 3 A-B) are similar in shape with a development of the medial cusp that could be
336 high and as large than transversal keel, small (fig. 3 A) or reduced to a slight protuberance of
337 the transverse keel (fig. 3 B2). Such variability is probably due to different file position of the
338 teeth, the higher teeth being possibly located near the symphysis. The female teeth are less
339 variable, their crown being more or less narrow (fig. 3 C-D) or extended mesio-distally (fig. 3
340 E). The lateral teeth have a mesio-distally extended labial face, a developed labial visor, a
341 transverse keel slightly worn by functional wearing, and an oblique root lobe as in some
342 extant myliobatoid with pavement-like dentition. Despite the limited sample of this minute
343 species, teeth of female (fig. C-H) seem twice as large as those identified as belonging to
344 male, conformably with expected size difference between sexes in most batoid species. No
345 clear dental difference is obvious between specimens from the type series (Ypresian) and
346 those from the Lower Lutetian (fig. 3 F-H).

347 **Discussion:** Currently, *Microtriftis* nov. gen. is only affiliated to dasyatoid of *incertae*
348 *familiae*. If the morphology of isolated teeth (e.g. high crown with narrower root vertically
349 oriented, flat ornamented labial face with concave visor in all files) suggests that each tooth is
350 in contact with its neighbouring teeth to form a pavement-like dentition as observable in
351 living myliobatoid, there are significant difference with their living and fossil representatives.
352 In *Microtriftis* nov. gen., the root is always of holaulacorhizous type, like many dasyatoid but
353 unlike myliobatoid that present a root of polyhaulacorhizous type. The imbrication of teeth
354 (assumed here on alternating gridlines) seems light in *Microtriftis* nov. gen., the lingual face
355 of tooth and the labial visor of previous tooth file could not be interlocked, in contrast to the
356 condition observed in myliobatoid jaws. Other Paleogene dasyatoid *incertae sedis* developed

357 a grinding dentition with joined alternating teeth (e.g. *Heterobatis* Noubhani and Cappetta
358 1997, *Hypolophodon* Cappetta 1980; *Ishaquia* Noubhani and Cappetta 1997; *Myliodasyatis*
359 Noubhani and Cappetta 1997; *Phosphatodon* Cappetta 2012; *Meridiana* Case 1994). Among
360 them, only *Heterobatis* can be reasonably compared to new genus, the other genera largely
361 differing both in size and tooth morphology. The teeth of *Heterobatis* are also relatively small
362 (until 3mm tooth size) with a flat labial face sharing ornamentation of enameloid. The anterior
363 teeth display a clear dasyatid pattern with a crown face and a root directed lingually whereas
364 the lateral teeth are sometimes very large, of polyhaulacorhizous type, and remind
365 myliobatids.

366 The teeth of *Microtriftis* nov. gen. recall those of another Paleocene dasyatoid *incertae sedis*,
367 *Delpitia* Noubhani and Cappetta 1997, with similar sexual heterodonty and ornamentation of
368 the labial face. However, *Delpitia* is larger and possess a typical dasyatid root, directed
369 lingually with lobes enlarged basally. No evidence of interconnecting/joining teeth is visible
370 on type species *D. reticulata* (Noubhani and Cappetta 1997: Pl. 68, fig. 1-6). The minute new
371 taxon is only recorded in Ypresian to Lower Lutetian marine deposits of Central and
372 Northeastern Senegal (Sine-Saloum region and Matam) even if some early-middle Eocene
373 specimens collected in well drilling from Guinea Bissau (Prian, 1986, 1987) are very similar
374 (HC pers. observ.).

375 **FIG.3 here**

376

377 NEOSELACHII Compagno, 1977 *incertae ordinis*

378 *Odontorhytis* Böhm 1926

379 **Type species:** *O. pappenheimi* Böhm, 1926

380 This enigmatical taxon is commonly recovered with other elasmobranchs in Eocene nearshore
381 marine deposits of Africa and central Asia. Considering its uncertain systematic position
382 among sharks, authors generally report its occurrence with some caution. Whatever the final
383 outcome on systematic issues, this taxon could be a significant part of the Eocene nearshore
384 elasmobranch assemblages. Inappropriately attributed to a percoid fish or to a rajid by Priem
385 (1905; 1915 respectively) based on middle-late Eocene Egyptian specimens, Böhm (1926)
386 described similar teeth from Namibia as *Odontorhynchus pappenheimi*, but also considered that it
387 belongs to bony fish of family Lophiidae. Cappetta (1981) definitively attributed this taxon to
388 an undetermined elasmobranch and figured late Ypresian specimens from Ouled Abdoun
389 (Morocco) that he attributed to the unique species *O. pappenheimi* of Böhm. However, and as
390 noted Cappetta (2012 : 326), clear differences can be noted between Thanetian-Ypresian teeth
391 on one side and middle-late Eocene teeth (e.g. *O. pappenheimi* Böhm, 1926) on the other side,
392 asserting that late Ypresian material from Morocco and several other ones, must be likely
393 considered as representatives of a distinct and unnamed species (Cappetta, 1987, 2012)

394

395 *Odontorhynchus priemi* nov. sp.

396 Rajidae or Scylliidae Priem (1909: fig. 31-35)

397 *Odontorhynchus pappenheimi* Cappetta (1981 plate 1 fig. 2-4)

398 *Odontorhynchus* sp. Noubhani and Cappetta (1997: text only)

399 *Odontorhynchus* sp. Gheerbrant et al. (1993: text only)

400 *Odontorhynchus* sp. Cappetta (2012: fig. 313: C-E)

401 *Odontorhynchus* sp. Sambou et al. (2017: text only, in part)

402

403 **Type material:** Holotype: fig. 4 C, MAM-19 (well F0, 9.18-9.30 m, Unit 2 in Sambou et al.,
404 2017) – Ndendouri-Ouali Diala, ?Early Ypresian, Matam Fm. ; Paratypes: MAM-18, MAM-
405 20 (well F3, Unit 2 in Sambou et al., 2017) Ndendouri-Ouali Diala, ?Early Ypresian, Matam
406 Fm., Senegal.

407 **Additional material:** Sixteen teeth, partially broken, were mainly found in Thanetian (MAM-
408 22 to 24, well P53, Unit 0 in Sambou et al., 2017) and Ypresian levels of Ndendouri-Ouali
409 Diala (Units 1-3 in Sambou et al., 2017). We can include those from Morocco: MYB8-9,
410 DYD1-2 from Mera-el-arech (sillon A-B) and Recette 4 (Sillon D), Ouled Abdoun, Morocco
411 – Late Ypresian, figured in Cappetta (1981 plate 1 fig. 2-4) and Cappetta (2012: fig. 313: C-
412 E).

413 **Etymology:** in honours to the French paleoichthyologist F. Priem (1857-1919) who firstly
414 signalled material attributed to this new species.

415 **Diagnosis:** New species of *Odontorhysis* known by isolated teeth exhibiting reduced
416 heterodonty. The new species is mainly characterized by teeth compressed mesio-distally, a
417 fine cusp of sigmoidal profile with lateral cutting edges and marked enameloid folds on both
418 face, a pair of very low lateral cusplets sometimes reduced to minute bulges in small
419 specimens or simply lacking in the largest ones, the lack of lingual barb near the apex, and the
420 lack of a sharp median crest on the crown labial face. The root is of cordiform outline in
421 lingual or labial view, ever larger than crown with large median groove entirely developed on
422 the root depth.

423 **Occurrences:** from Thanetian to Ypresian of North and Western Africa (e.g. Mali, Senegal,
424 Morocco and Tunisia).

425

426 **Description:** The variation of the tooth morphology in this elasmobranch genus is weak and
427 only involved the presence/development of lateral cusplets compared to the overall/absolute
428 size, which prevents any inference on possible developmental heterodonty. The teeth are
429 small to medium in size and laterally compressed. The holotype is of medium size, probably
430 from one of the anterior files (Fig. 4 C). The weakly enamelled cusp is high, pointed, and of
431 sigmoid profile (fig. 4 C2). The crown labial face is rather flat towards the apex of cusp but
432 convex at its base where several fine folds run on its lower half. It extends downward,
433 overlapping the root by an expansion, high and narrow, more or less pinched laterally (fig. 4
434 C1) that may bear a sagittal keel on the probably more anterior teeth (fig. 4 B1, H1). The
435 lingual face of crown is strongly concave and bears parallel and well-marked vertical folds
436 (fig. 4 C3). These folds rarely reach the apex of cusp but a short, sharp medio-sagittal crest is
437 sometimes observable near the apex in some teeth (fig. 4 E1). The lateral cutting edges are
438 well marked on the cusp but do not reach the base of the crown on many teeth, holotype
439 included (fig. 4 C2). At the base of the cusp, a pair of very low lateral denticles is usually
440 visible near the onset of the cutting edges (fig. 4 F-H), one of the denticles can however
441 disappear in some teeth (fig. 4 D) and could be reduced to tiny or inconspicuous bulges on
442 more largest teeth, holotype included (fig. 4 B-C). The root is of cordiform outline in lingual
443 view (fig. 4 B2, C3, E1), without well-differentiated lobes. In labial view, it extends well
444 beyond the crown. Its basal face is very concave in profile (fig. 4 B3, C2, E2); it has a well-
445 marked lingual protuberance below the crown and displays an axial nutritive groove on all
446 surface (fig. 4 C3). This groove is relatively deep at the level of the protuberance where a
447 foramen opens (fig. 4 C3). Usually, the basal face lifts slightly on the edges of the groove (fig.
448 4 E1). Narrow small elliptical foramina open laterally on the labial surface of the root, near
449 the crown-root boundary (fig. 4 C1). Unfortunately, the Thanetian material (Fig 4 F-H) is
450 poorly preserved in comparison to the Ypresian sample (fig. 4 B-E). However, the root

451 morphology of the Thanetian teeth seemly resemble those of Ypresian teeth, but they are
452 smaller, more often cuspidate, and their root outline seems sharper and less thick in profile.

453 **Discussion:** Compared to the middle-late Eocene representatives of genus (including *O.*
454 *pappenheimi*, *O. bahariensis* Salame and Asan, 2019 and possible other unnamed species in
455 Tabuce et al., 2005), the cusp is thinner, strongly bent lingually and of sigmoidal profile in *O.*
456 *priemi* nov. sp. The lateral cutting edges are thin but distinct and always present in *O. priemi*
457 nov. sp. They do not reach the crown base. A pair of very low and sharp lateral cusplets is
458 sometimes present at the base of the cusp, near the beginning of cutting edges. These cusplets
459 can be weak and sometimes be reduced to minute bulges or even absent in some teeth. The
460 crown lingual face bears numerous fine folds that do not reach the apex. Compared to *O.*
461 *priemi* nov. sp., a barb may be present on the lingual side of the apex in the middle-late
462 Eocene specimens (e.g. *O. pappeheimi*, *O. bahariensis*). In the latter, the crown is more
463 strongly mesio-distally compressed and slightly curved distally in labial view. No lateral
464 cutting edge is visible on the cusp nor lateral cusplets at the base of crown. On the other side,
465 an unusual distinct and sharp median crest is present on the cusp labial face, no crest –but
466 similar fine folds– is present on the lingual face, which is transversally convex as observed in
467 *O. priemi* nov. sp.

468 In both group, the root is high with a heart-like outline (particularly in *O. priemi* nov. sp.) but
469 without differentiated lobes. The profile of its basal face is very concave; it shows a well-
470 marked lingual protuberance and bears an axial furrow on its whole surface. This furrow is
471 much deeper at the end of protuberance where some foramina can be observed. The two
472 groups of species differ from each other only by the morphology of the root (as the crown),
473 which is mesio-distally compressed in *O. pappeheimi* and *O. bahariensis* compared to *O.*
474 *priemi* nov. sp. There is an overlap in tooth size between *O. priemi* nov. sp. and *O.*
475 *pappenheimi*/*O. bahariensis* but the Thanetian-Ypresian species rarely reach more than 7mm

476 in height whereas the middle-late Eocene specimens can easily measure more than 1cm in
477 height (especially in *O. pappenheimi*). Distinction between *O. pappenheimi* and *O.*
478 *bahariensis* remains unclear. Without diagnosis, the latter seems to have smaller gracile teeth
479 than in *O. pappenheimi*, with crown relatively higher with shorter labial cutting edge (Salame
480 and Asan, 2019). Ignoring the ontogenetic heterodonty of this ambiguous neoselachian, *O.*
481 *bahariensis* could in fact represent the youngest specimens of *O. pappenheimi*, usually
482 recovered in the same areas and ages. The new species *O. priemi* nov. sp. is also present in the
483 Ypresian of Mali (Cappetta 1987), Thanetian-Ypresian of Ouarzazate and phosphate of Ouled
484 Abdoun, Morocco (Cappetta, 1981; Gheerbrant et al., 1993; Noubhani and Cappetta, 1997),
485 and in phosphates of Redeyef, Tunisia (Priem, 1909). The second morphotype (including *O.*
486 *pappenheimi* and ?*O. bahariensis*) also occurs in Senegalese deposits (Fig. 4 A) and was
487 recovered in the top level of the Matam phosphate deposits (wells P1A, P1B, R4, I1 et G0 see
488 Sambou et al. 2017) and in Sanghaye Bele water well, Sine-Saloum region. This morphotype
489 is recovered elsewhere in the middle Lutetian of Morocco (Tabuce et al., 2005), in the late
490 Lutetian-early Bartonian of Egypt (Strougo et al., 2007, Underwood et al., 2011, Salame and
491 Asan, 2019) but seems more frequent in the late middle Eocene–late Eocene from
492 southwestern Morocco (Adnet et al., 2010), Tunisia (Merzeraux et al., 2017; Sweydan et al.,
493 2018), Egypt (Priem, 1905 ; Case and Cappetta, 1990 ; Murray et al., 2010; Adnet et al.,
494 2011 ; Underwood et al., 2011 ; Murray et al., 2014), Namibia (Böhm 1926), and Pakistan
495 (Case and West, 1991). Its occurrence in the early Rupelian of Jebel Qatrani–Quarry E,
496 Fayum (Murray et al., 2014) is based on a unique broken tooth and must be confirmed by
497 additional samples. These two species do not overlap in the fossil record, suggesting a
498 replacement of taxa during the late Ypresian or near the Ypresian/Lutetian boundary.
499 However, the youngest representatives of *O. priemi* nov. sp. from Matam (e.g. fig. 4 B) show
500 a seemingly transitional morphology toward those of “*O. pappenheimi* group” in having larger

501 teeth, more compressed mesio-distally with no lateral cusplets. Murray et al. (2010) suggested
502 that *Odontorythis pappenheimi* as the other elasmobranch elements from BQ-2 locality
503 (Fayum, Egypt) probably represent freshwater-tolerant species. The co-occurrence of
504 *Odontorythis* teeth with mammals remains in different localities (e.g. Gheerbrant et al., 1993;
505 Tabuce et al., 2005; Merzeraux et al., 2016; Murray et al., 2010, 2014; Tabuce et al., 2019)
506 seems to confirm this ecological abilities even if the other listed occurrences, including those
507 of Matam or Morocco, testify that it is firstly a marine elasmobranch.

508 [FIG.4 here](#)

509

510 **Paleobiological and Paleoecological inferences.**

511 Among Potamotrygonidae, which also include the marine Styracurinae (Carvalho et al.,
512 2016), the sister subfamily Potamotrygoninae (South American river stingrays) is the most
513 diverse and famous group of obligate freshwater stingrays. South American fossils of this
514 subfamily drew particular attention this last decade (e.g. Brito and Deynat, 2004; Adnet et al.,
515 2014; Chabain et al., 2017) with evidences that they were abundant in middle Eocene deposits
516 of Peruvian Amazonia. In contrast, the living styracurines (amphi-American whipray) are less
517 abundant. They are currently frequent in the Central eastern Pacific (*Styracura pacifica*) and
518 Central western Atlantic (*S. schmarda*) shallow waters until the Amazon river mouth
519 southward (Last et al., 2016; Bloom and Lovejoy 2017). No fossil representatives of
520 Styracurine (or formally *Himantura*) are known in fossiliferous deposits along the Central
521 Eastern Pacific or Central Western Atlantic coasts (e.g. Landini et al., 2017; Carrillo-Bricenio
522 et al., 2014, 2015, 2016, 2018). However, the styracurines likely inhabited the Eastern
523 Pacific–Caribbean zone since the middle Eocene, which corresponds to the oldest occurrence
524 of their sister taxa, the potamotrygonins (Adnet et al., 2014). The attribution of *Atlantitrygon*

525 to Styracurinae is based on the similar overall shape of the teeth and the presence of a
526 displaced main cusp. Further evidences (as coeval records in Caribbean zone) are needed to
527 confirm such a systematic assumption but *Atlantitrygon* (and mainly the oldest species *A.*
528 *sudrei*) might represent one of the marine–brackish pool species of potamotrygonid.
529 Subsequently, the multiple occurrence of *Atlantitrygon* in Western Africa deposits may
530 indicate that past styracurines were widespread in the Central Atlantic from western to eastern
531 coasts during the warming period of Paleogene.

532 Solving the systematic affinities of *Microtriftis* among dasyatoid is out of scope of this study.
533 The minute teeth seem partially interlocked forming the pavement-like teeth suited for
534 crushing or grinding preys. Ornamented enameloid of labial surface in *Microtriftis* could
535 probably strengthen the grater function of pavement-like teeth as observed in many other
536 living and fossil taxa with such a dentition (e.g. *Myliobatis*, *Rhombodus*, *Coupatanzia*,
537 *Dasyatis sensu lato*, *Pastinachus*). Specialization for extreme durophagy, including an
538 extremely robust dentition with pavement-like teeth, is redundant in myliobatiform evolution
539 (e.g. Underwood et al. 2015, 2017). Their teeth can be only partially interlocked to crush
540 preys, or can be strongly interfitted and jointed together thanks to complementary faces of
541 crown to grind hard mollusc as observed in Myliobatidae and Rhinopteridae (grinding type).
542 *Microtriftis* share the same interlocking pattern than many other fossil dasyatoid (e.g.
543 *Aturobatis*, *Heterobatis*, *Hypolophodon*, *Ishaquia*, *Meridiana*, *Myliodasyatis*, *Phosphatodon*),
544 which could also be considered as grinders (high crown, polygonal outline). However, the
545 dentition of *Microtriftis* is unique in its extreme small size. The number of tooth files in
546 *Microtriftis* jaws, as in all grinding taxa with holaulacorhize root (Cappetta 2012), was likely
547 important. If we cannot surely estimate the size of occlusal surface of pavement of both jaws,
548 it unlikely exceeded two centimetres in width considering the individual tooth size (0.5 mm).
549 Living stingrays with interlocking plates of flat, pavement-like teeth are known to grind

550 molluscs and other hard-shelled prey. *Microtriftis* then represents one of the smallest
551 stingrays with grinding teeth, which raises the question on the type of preys it could predate
552 on.

553 The Thanetian-Ypresian occurrence of the enigmatical *Odontorythis* completes the fossil
554 record of the genus usually known by the middle-late Eocene. The tooth morphology of its
555 oldest species *Odontorythis priemi* nov. sp. does not clarify its systematic position among
556 Neoselachii. The presence of lateral cutting edges and additional cusplets is more common in
557 shark teeth compared to the unusual morphology observed in Lutetian-Priabonian
558 representatives, including its sister species *O. pappenheimi*. Observations of transitional
559 forms between these two chronospecies *O. priemi* nov. sp. and *O. pappenheimi* and their
560 relatives suggest that they progressively replaced each other during the latest early Eocene in
561 Senegal and elsewhere.

562

563 **Conclusions.**

564 The Senegalese Paleogene fauna is significantly rich (see Pascal, 1987 and Sambou et al.,
565 2017 for listing) with numerous other taxa recovered elsewhere. The focus on three new taxa
566 described herein confirms the dating of fossiliferous levels of the phosphate series of
567 Ndendouri-Ouali Diala (Matam) and improves the stratigraphical correlations between the
568 phosphate deposits of Matam area and those of Sine-Saloum region during the Paleogene. The
569 presence of *Odontorhynchus* cf. *pappenheimi* and absence of *O. priemi* in the top level of the
570 Matam Fm. (Matam area) and in Lam Lam Fm. in Sine-Saloum regions also confirm that both
571 deposits are penecontemporaneous (see Tabuce et al., 2019). A previous study confirmed that
572 the coquina limestone of the Lam Lam Fm. in Sanghaye Bele is subcontemporaneous with

573 those of the clay-limestone unit ending the Matam Fm., and that it is indicative of a littoral
574 environment (Sambou et al. 2017).

575 The Gorgol Fm. (Thanetian) in Matam area probably corresponds to neritic deposal as
576 suggested by analysis of the elasmobranch fauna (Sambou et al., 2017) and lithology (Pascal,
577 1987). The presence of *Atlantitrygon sudrei* in Thanetian deposits of Senegal, Niger and Togo
578 suggests the establishment of an extended marine realm with faunal connection along the past
579 Guinea Gulf. During the lower Eocene period, the Senegal basins underwent a succession of
580 transgressions and regressions that install the mesobathyal and neritic deposits in the
581 southwestern region (Thiam, 2014; Thiam and Sarr, 2014). The Ypresian marine deposits in
582 the Matam area (lower part of Matam Fm.) are mainly dominated by limestones, clays, and
583 phosphates deposited during the transgression phases that largely extended the marine area to
584 the eastern edge of the Senegal basin (Monciardini and Pascal, 1966). A preliminary study of
585 the elasmobranch fauna (see Sambou et al., 2017) enabled to reconstruct a continuous sea
586 water communication with the large and deeper southernmost gulf (Slansky, 1980) to the North
587 Gambia (Miyouna et al., 2009). Ostracods also testify that this inner platform was flooded by
588 relative warm to temperate sea waters (Thiam and Sarr, 2018). Presence of *Atlantitrygon*
589 *senegalensis* nov. sp. and *Odontorhynchus priemi* nov. sp. in subcontemporaneous deposits of
590 Mali and Morocco also suggests wider faunal connection along the Central Western Atlantic
591 coasts during the Ypresian period. Coupled with some Ypresian tectonics (Miyouna et al
592 2009), the decrease of sea level began at the end of Ypresian as previously reported in
593 Casamance area (Ly AND Anglada, 1991) and in the Mbour-Joal area (Western Senegal; Sarr
594 1999). The strong decrease in selachian diversity recovered in the higher clay-limestone unit
595 (top of Matam Fm.) coupled with the persistence of only small coastal species are clearly
596 indicative of a more littoral environment in Matam (Sambou et al., 2017) with
597 contemporaneous development of anoxic conditions in southwestern platform (Thiam and

598 Sarr, 2018). However, the co-occurrence of *Atlantitrygon senegalensis* nov. sp. and
599 *Odontorhynchus* cf. *pappenheimi* in the early Lutetian limestones of both localities also indicates
600 the persistence of a relictual Est-West marine connection in central Senegal (between Matam
601 and Sine-Saloum areas) during the early Lutetian regional regression (Thiam, 2014 ; Thiam
602 and Sarr, 2014, 2018)

603

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619

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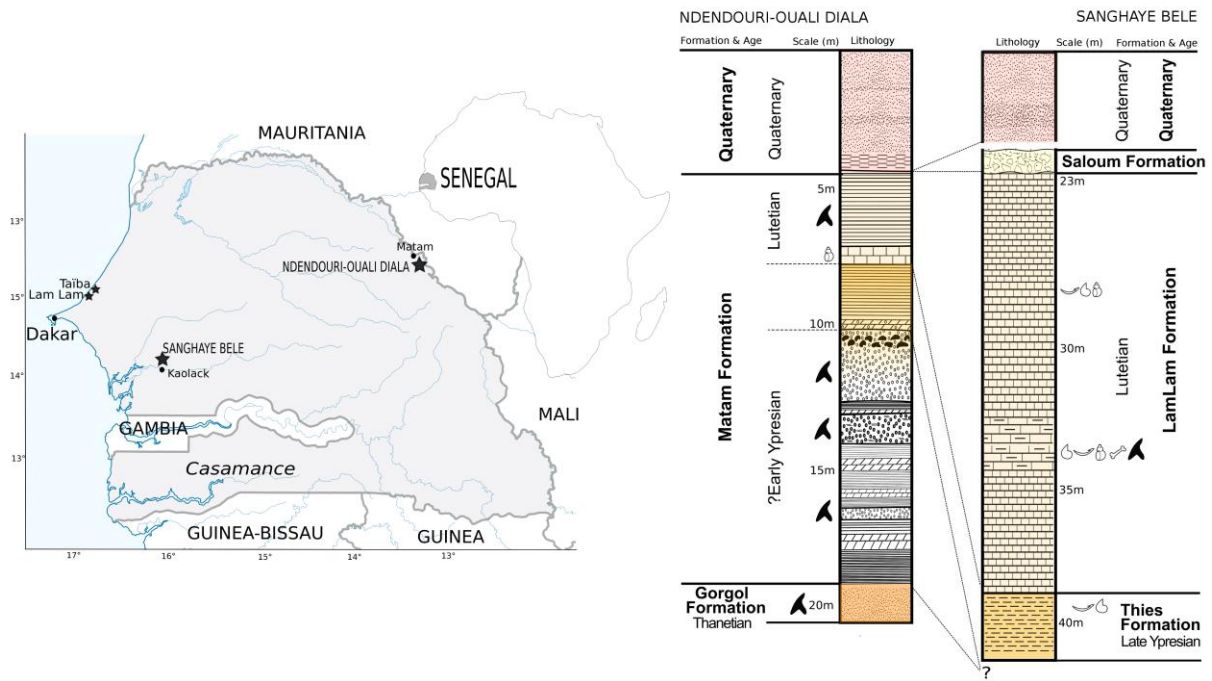
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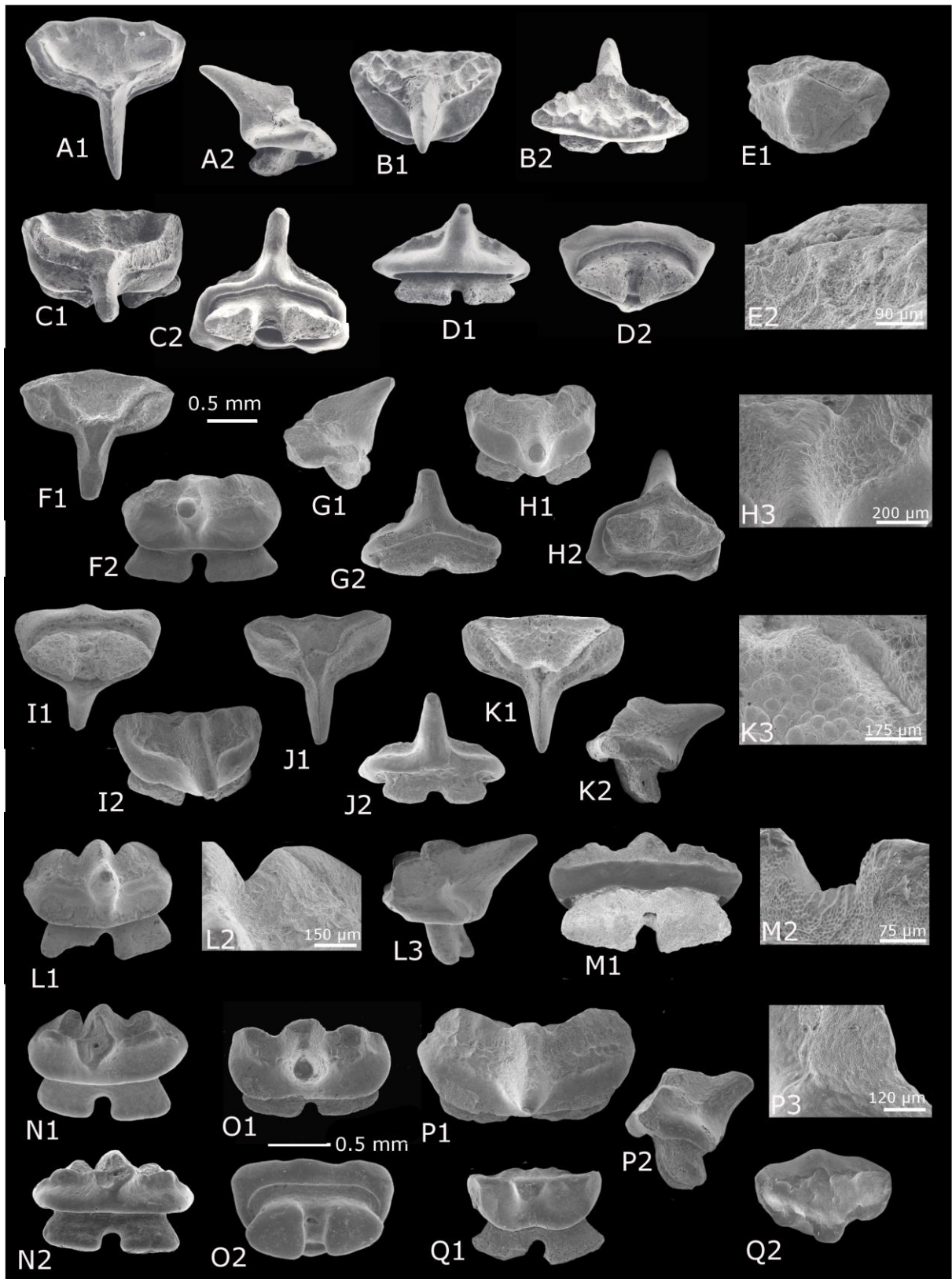
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903 **Fig. 1.** Location and hypothetical stratigraphic correlation of Senegal Paleogene deposits
 904 between studied fossil localities of Sanghaye Bele and Ndendouri-Ouali Diala. Logs and
 905 details from Tabuce *et al.* (2019) and Sambou *et al.* (2017), respectively. Black teeth outline
 906 indicating levels with elasmobranch remains.

907 **Fig. 1.** Localisation et hypothèse de corrélation stratigraphique des gisements paléogènes du
 908 Sénégal entre les localités fossilifères étudiées de Sanghaye Bélé et Ndendouri-Ouali Diala.
 909 Logs et détails des coupes issus de Tabuce *et al.* 2019 et Sambou *et al.* 2017, respectivement.
 910 Les silhouettes des dents noires indiquent les niveaux avec les restes d'élastombranches.

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914 **Fig. 2.** *Atlantitrygon sudrei* nov. sp.: Thanetian of Sessao, Niger - Fig. A. SES64 (holotype);

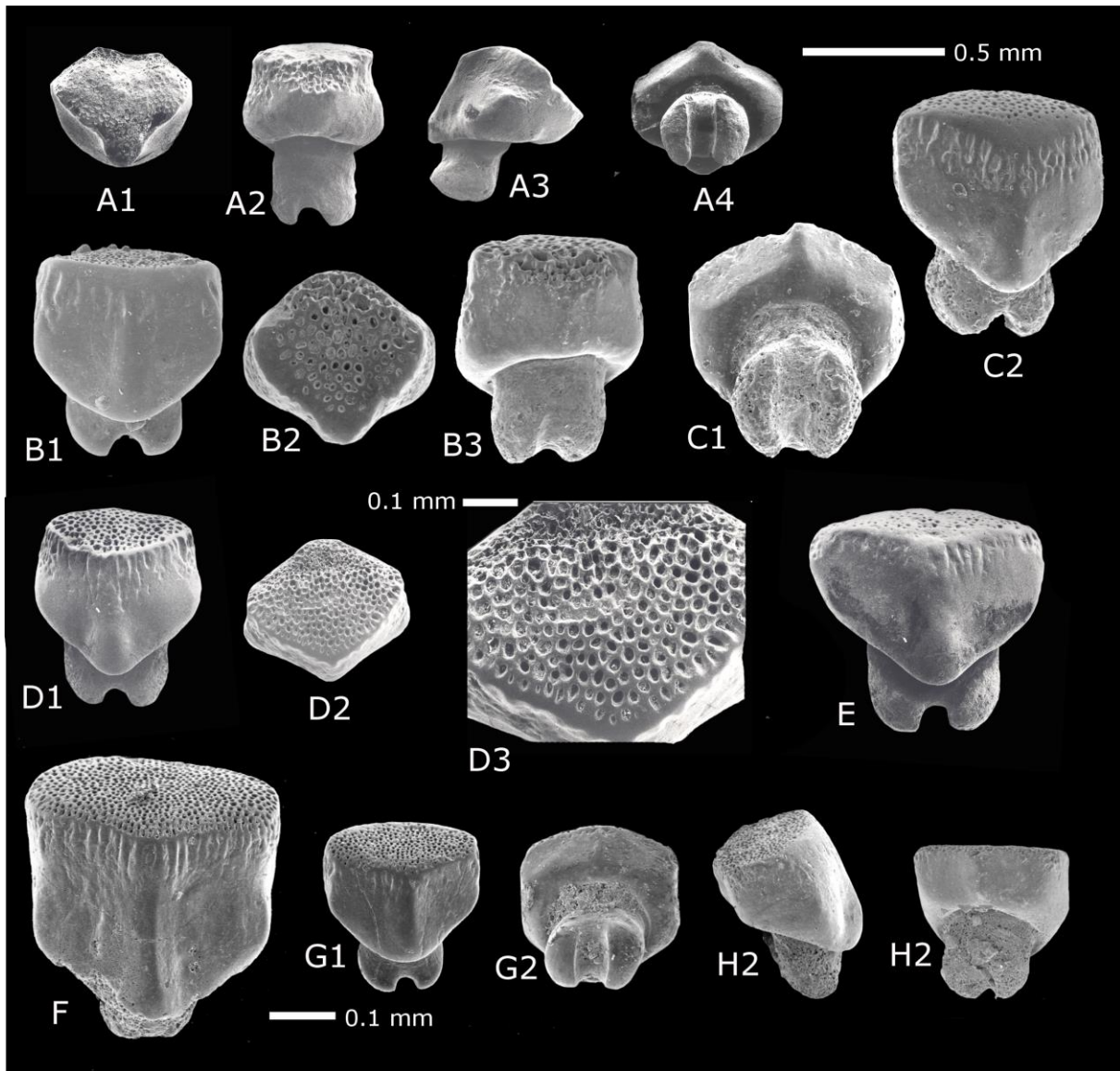
915 B. SES65; C. SES62; D. SES63; E. MAM-03 (well P53, Unit 0 in Sambou *et al.*, 2017) ;

916 *Atlantitrygon senegalensis* nov. sp.: Fig F-J: MAM-04 to MAM-08; Fig. K: MAM-09
917 (holotype); Fig. L-M: MAM-10 to MAM-11 (well F0 9.18-9.3m, Unit 2 in Sambou et *al.*,
918 2017) ?Early Ypresian, Matam Fm. ; Fig. N-Q. SNSAN/2011/01 to SNSAN/2011/04 Lower
919 Lutetian, Lam Lam Fm.

920 **Fig. 2.** *Atlantitrygon sudrei* nov. sp.: Thanétien de Sessao, Niger - Fig. A. SES64 (holotype);
921 B. SES65; C. SES62; D. SES63; E. MAM-03 (puits P53, Unité 0 dans Sambou et *al.*, 2017) ;

922 *Atlantitrygon senegalensis* nov. sp.: Fig F-J: MAM-04 à MAM-08; Fig. K: MAM-09
923 (holotype); Fig. L-M: MAM-10 à MAM-11 (puits F0 9.18-9.3m, Unité 2 dans Sambou et *al.*,
924 2017) ?Yprésien inférieur, Formation de Matam; Fig. N-Q. SNSAN/2011/01 à
925 SNSAN/2011/04 Lutétien inférieur, Formation de Lam Lam.

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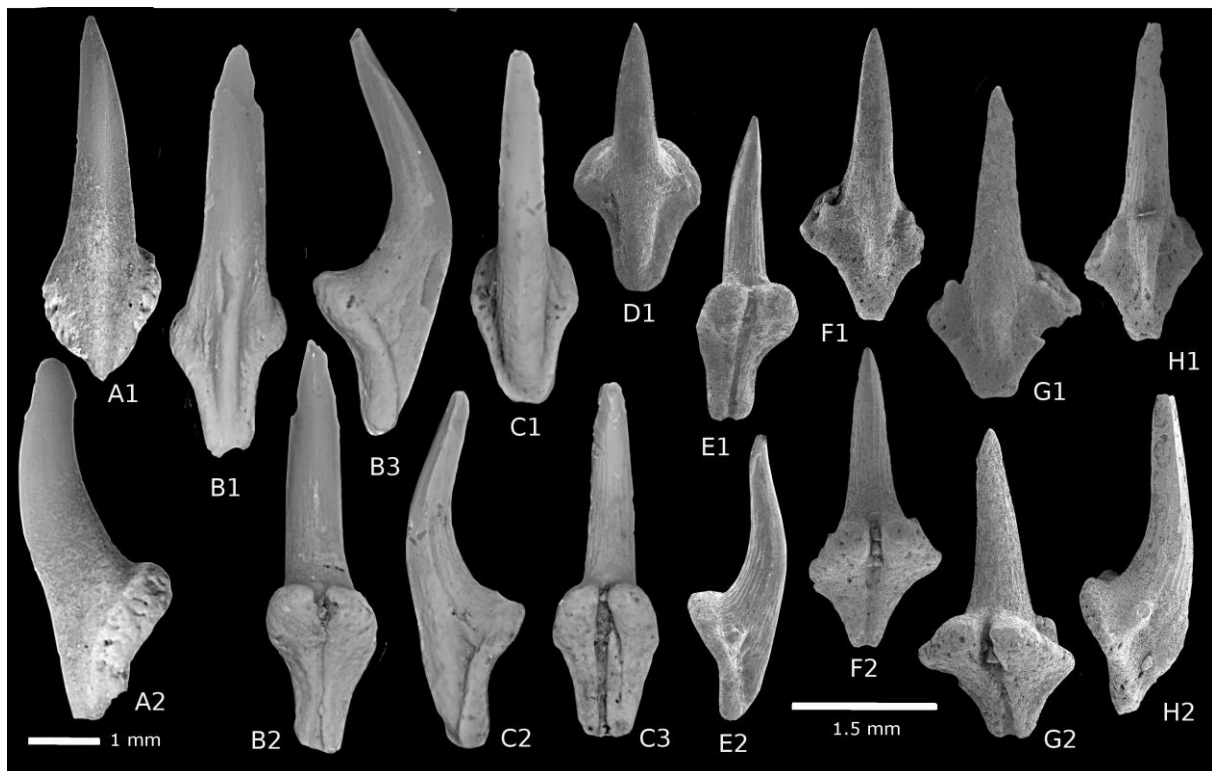
928 **Fig. 3.** *Microtriftis matami* nov. gen. nov. sp. A MAM-12 (well F0 9.18-9.3m, Unit 2 in
 929 Sambou et al., 2017) ?Early Ypresian, Matam Fm.; B-C MAM-13 and MAM-14 (well P1,
 930 Unit 2 in Sambou et al., 2017) ?Early Ypresian, Matam Fm.; D-E MAM-15 (holotype) and
 931 MAM-16 (well F0 9.18-9.3m, Unit 2 in Sambou et al., 2017) ?Early Ypresian, Matam Fm.; F-
 932 H SNSAN/2011/05 to SNSAN/2011/07 Lower Lutetian, Lam Lam Fm.

933 **Fig. 3.** *Microtriftis matami* nov. gen. nov. sp. A MAM-12 (puits F0 9.18-9.3m, Unité 2 dans
 934 Sambou et al., 2017) ?Yprésien inférieur, Formation de Matam; B-C MAM-13 et MAM-14
 935 (puits P1, Unité 2 dans Sambou et al., 2017) ?Yprésien inférieur, Formation de Matam; D-E
 936 MAM-15 (holotype) et MAM-16 (puits F0 9.18-9.3m, Unité 2 dans Sambou et al., 2017)

937 ?Yprésien inférieur, Formation de Matam ; F-H SNSAN/2011/04 à SNSAN/2011/07 Lutétien

938 inférieur, Formation de Lam Lam.

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941 **Fig. 4.** A. *O. cf. pappenheimi*: Lower Lutetian, Lam Lam. Fm., SNSAN/2011/08; B-F.
 942 *Odontorhytis priemi* nov.sp., : B: MAM-18 from (well F3, Unit 2 in Sambou et al., 2017)
 943 ?Early Ypresian, Matam Fm., C: MAM-19 (well F0 9.18-9.3m, Unit 2 in Sambou et al., 2017)
 944 (holotype) ?Early Ypresian, Matam Fm, D: MAM-20 (well F3, Unit 2 in Sambou et al., 2017)
 945 ?Early Ypresian, Matam Fm; E: MAM-21 (well P1A, Unit 2 in Sambou et al., 2017) ?Early
 946 Ypresian, Matam Fm ; F-H MAM-22 to MAM-24 (well P53, Unit 0 in Sambou et al., 2017);
 947 Thanetian, Gorgol Fm.

948 **Fig. 4.** A. *O. cf. pappenheimi*: Lutétien inférieur, Formation de Lam Lam, SNSAN/2011/08;
 949 B-F. *Odontorhytis priemi* nov.sp., : B: MAM-18 de (puits F3, Unité 2 dans Sambou et al.,
 950 2017) ?Yprésien inférieur, Formation de Matam, C: MAM-19 (puits F0 9.18-9.3m, Unité 2
 951 dans Sambou et al., 2017) (holotype) ?Yprésien inférieur, Formation de Matam, D: MAM-20
 952 (puits F3, Unité 2 dans Sambou et al., 2017) ?Yprésien inférieur, Formation de Matam; E:
 953 MAM-21 (puits P1A, Unité 2 dans Sambou et al., 2017) ?Yprésien inférieur, Formation de

954 Matam; F-H MAM-22 à MAM-24 (puits P53, Unité 0 dans Sambou et *al.*, 2017); Thanétien,

955 Formation de Gorgol.

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