1 **Cirripedes (Thoracica, Crustacea) from the Maastrichtian of Kalaat**

2 **Senan, Tunisia**

3 **Andy S. Gale ^{a,b,*}, John W. M. Jagt ^c, Stijn Goolaerts ^{d,e}**

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5 ^{a, b} *School of Environmental, Geological and Geographical Sciences, University of Portsmouth,*
6 *Burnaby Building, Burnaby Road, Portsmouth PO13QL, and Earth Science Department,*
7 *Natural History Museum, Cromwell Road, London SW75BD, United Kingdom*

8 ^c *Natuurhistorisch Museum Maastricht, de Bosquetplein 6-7, 6211 KJ Maastricht, the*
9 *Netherlands*

10 ^{d,e} *Department of Earth & History of Life, and Scientific Service Heritage, Royal Belgian*
11 *Institute of Natural Sciences, Vautierstraat 29, 1000 Brussels, Belgium*

12
13 * Corresponding author.

14 *E-mail address: andy.gale@port.ac.uk (A.S. Gale).*

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16
17 **ABSTRACT**

18 An assemblage of large and robust pedunculate scalpellomorph cirripede barnacles from
19 the Maastrichtian of Kalaat Senan (Tunisia) is described, and their stratigraphical position
20 within the Abiod and El Haria formations is noted. Four taxa are documented, three of
21 which are confined to the Kalaat Senan area, namely *Pachyscalpellum heltzeli*,
22 *Cretiscalpellum robaszynskii* sp. nov. and *Diotascalpellum* sp.; the fourth, *Diotascalpellum*
23 *curvatum*, was previously recorded only from the Maastrichtian of the Farafra Oasis in the

Western Desert of Egypt, 2,000 kilometres to the southeast. The record of *Pollicipes glaber* from this locality may well be conspecific with *C. robaszynskii* sp. nov. The new finds yield clues to the evolution of the composition of the North African cirripede assemblages during the early and late Maastrichtian, up close to the Cretaceous–Paleogene (K/Pg) boundary mass extinction. The fauna is of remarkably large size and strongly armoured for the supposedly offshore open-marine palaeoenvironment of Kalaat Senan, a faunal character that seems to have developed after the Campanian and disappeared by the Danian. The presence of *Pachyscalpellum*, a genus that was previously restricted to Australasia, indicates faunal connections with the eastern Tethys. Their documented first arrival coincides roughly with the first documented occurrence of northern American scaphitid ammonite genus *Discoscaphites*. The original description of *P. heltzeli* is extended; it is characterised particularly by a very elongated scutum. Similar scuta are shown to have evolved independently in the scalpellid genus *Regioscalpellum* of the European Upper Cretaceous. The family assignment of *Pachyscalpellum* as a scalpellid is questioned.

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Key words:

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K/Pg boundary extinction

faunal changes

1. Introduction

49 The exquisitely exposed, 5,000-m-thick and nearly continuous fossiliferous sedimentary
50 sequence spanning the Aptian up to the Eocene near the village of Kalaat Senan, central
51 Tunisia (Fig. 1), has attracted geologists and palaeontologists from as early as the last
52 quarter of the nineteenth century. During that time, the French geologist Georges Rolland
53 directed the geological branch of Ernest Cosson's exploratory scientific missions in Tunisia. It
54 was Rolland himself who focused on the geology of central Tunisia, aided by the vet and
55 amateur geologist, Philippe Thomas, in palaeontological research (Godard & Viaud, 2007).
56 The most important geologist and palaeontologist of the early days by far was the
57 Frenchman Léon Pervinquière (1873–1913), whose fieldwork from 1897 onwards
58 culminated in an in-depth study of the geology of central Tunisia (Pervinquière, 1903),
59 followed by detailed studies of Cretaceous cephalopods (Pervinquière, 1907) and bivalves
60 and gastropods (Pervinquière, 1912). Philippe Thomas finished his manuscript only in 1909
61 and clearly incorporated many of Pervinquière's observations. Pervinquière's untimely
62 death left a huge hiatus in studies of macrofossils from the Kalaat Senan area, even when
63 shortly after the Second World War, the 'Société de Recherches et d'Exploitation des
64 Pétroles en Tunisie' (SEREPT) had considerable interest in logging sections (judging from
65 numerous unpublished reports), followed by mapping (Lehotsky et al., 1978) and studies
66 primarily focused on microfauna and long-distance correlations (for an overview, see
67 Robaszynski et al., 2000). Only in 1985, when the SEREPT, the 'Société Nationale Elf
68 Aquitaine Productions' (SNEAP) and EXXON Production and Research sent out an
69 interdisciplinary team of stratigraphers, led by Professor Francis Robaszynski, to log in detail
70 and describe the rocks exposed between Kalaat Senan, Tajerouine and Kalaa Khasba, would
71 stratigraphical collection of macrofossils be resumed. The Cenomanian to Maastrichtian
72 sequences were recorded by Robaszynski et al. (1990, 1993a–c, 2000, 2007) and Hardenbol

et al. (1993), the K/Pg boundary interval by Dupuis et al. (2001), Hennebert and Dupuis (2003) and Hennebert (2012) and the Danian/Selandian boundary interval by Steurbaut et al. (2000). From 2001 to 2005, one of us (SG), under the guidance of professors Christian Dupuis, Etienne Steurbaut and Francis Robaszynski, did extensive collecting of macrofossils in Campanian and Maastrichtian strata at Kalaat Senan (as well as at Ellès, El Kef and Garn Halfaya), which resulted in papers on ammonite evolution and extinction (Goolaerts et al., 2004a, b; Goolaerts, 2010; Landman et al., 2014, 2015), and on a new isopod crustacean (Feldmann and Goolaerts, 2005). Of cirripedes, 42 dissociated plates were collected; these are the subject of the present paper. Added were three specimens, recovered in 1995 within the framework of the MSc thesis by Bénédicte Eggermont. For now, echinoids, crinoids, serpulid polychaetes, bryozoans, bivalves, gastropods, brachiopods and corals remain largely unstudied.

Of the 45 cirripede plates, 25 were described in Jagt et al. (2016) as belonging to a new species, *Pachyscalpellum heltzeli*. Most probably, records by Peron (1893, p. 385, from the southern regions of the ‘Hauts Plateaux de la Tunisie’), Pervinquière (1903, p. 132, from the upper Maastrichtian of Djebel Massouge) and Thomas (1909, pp. 670–671, from the upper Maastrichtian of Kalaat Senan) all relate to *P. heltzeli* (compare Jagt et al., 2016).

Buckeridge et al. (2008) described a new species of verrucomorph, *Verruca punica*, and noted the presence of scalpellomorph cirripedes, probably belonging to *Calantica* or *Scillaelepas*, from the lower Danian (NP2, P1b) portion of the El Haria Formation at El Kef. A few years earlier, Collins et al. (1999) had already described a new stalked form, *Arcoscalpellum gloriana*, from the upper Ypresian (Eocene) of Fedj Merabitha near Kairouan.

2. Geographical and stratigraphical setting

Material was collected from outcrops of Maastrichtian rocks situated between the villages of Kalaat Senan, Tajerouine and Khalaa Khasba in central Tunisia, also known as the Kalaat Senan area (Fig. 1). Detailed descriptions, lithologs and a composite section were published by Robaszynski et al. (2000) and Goolaerts (2010). The best-known sequence in this area by far is the K/Pg boundary section of Aïn Settara (abbreviation STW), an auxiliary section of the El Kef GSSP for the base of the Danian/Paleocene/Paleogene (Dupuis et al., 2001; Hennebert and Dupuis, 2003; Molina et al., 2009; Hennebert, 2012). Outcrops from which cirripedes were collected are situated in two clusters (Fig. 2), the Oued Raïne outcrops with the RB, RC, and RCN sections forming the first cluster and the STW and NCH sections located in the second.

Strata exposed at the Oued Raïne and STW sections have been assigned to the El Haria Formation for which two informal units can be distinguished. The lower of these (Mzita marls), around 60 metres in thickness, comprises light greyish to bluish grey marls, with intercalated 30–50-cm-thick, slightly reddish limestone beds in two intervals. The thickness of the upper unit, the Aïn Settara marls, is 128 metres. These are grey marls alternating with marly, lighter-coloured intervals that are richer in carbonate. Strata exposed at the NCH section represent the Gourbeuj, Ncham and Gouss members of the Abiod Formation and the Mzita marls of the El Haria Formation. In the NCH section, cirripedes were found only in the Ncham Member.

In addition to the above specimens, no cirripedes were found by us in Campanian strata of the Kalaat Senan area, nor in the Campanian–Maastrichtian interval of El Kef, Ellès and Garn Halfaya. Although some collection bias (as the primary field targets were

cephalopods) may be assumed, the large and robust cirripede valves would have been noted if such had been as abundant as at Kalaat Senan. In addition, no cirripede remains were found in sieving residues of (relatively limited) quantities of sediment of the upper metre below the K/Pg boundary at El Kef (Goolaerts, 2010).

3. Material and methods

In total, 45 dissociated cirripede plates from 26 samples (labelled TUC) are available (a composite lot, numbered NHMM 2015 020, for *Pachyscalpellum heltzeli* [with letter suffixes] and other NHMM numbers, as added to illustrations here), the great majority of which stem from float (Table 1). For each of these specimens, the maximum stratigraphical provenance was carefully estimated based on outcrop conditions (see Figs. 2, 3). Most plates in this lot are free from matrix and well preserved, yet incomplete. Photographs were taken of selected specimens.

To denote the repositories of specimens illustrated and/or referred to in the text, the following abbreviations are used: NHMM, Natuurhistorisch Museum Maastricht, Maastricht, the Netherlands; NHMUK, The Natural History Museum, London, United Kingdom; WAM, Western Australian Museum, Perth, Australia.

4. Systematic palaeontology

Family Cretiscalpellidae Buckeridge, 1983

144 *Diagnosis.* Pedunculate thoracicans which possess 17 plates in the capitulum (paired scuta,
145 terga, upper latera, inframedian latera, rostromlatera, upper carinolatera (CI1), lower
146 carinolatera (CI2), carina, rostrum and subcarina); upper carinolatus rectangular to
147 rhomboidal, lower triangular. Peduncular plates relatively large, in 8 to 12 columns, with an
148 inwardly directed basal ledge.

149

150 *Genera included.* *Cretiscalpellum* Withers, 1922, *Striascalpellum* Gale, 2020,
151 *Witherscalpellum* Gale, 2020 and *Jagtscalpellum* Gale, 2020.

152

153 Genus *Cretiscalpellum* Withers, 1922

154

155 *Type species.* *Pollicipes unguis* J. de C. Sowerby, 1836, by original designation.

156

157 *Diagnosis:* Smooth to weakly sculptured large cretiscalpellids, in which the tergum is
158 asymmetrically rhomboidal with a low, straight apicobasal ridge. Carinolatera, inframedian
159 latus and rostromlatus convex, bearing an oblique transverse ridge.

160

161 *Other species included.* *Pollicipes glabra* Roemer, 1841, *Polliceps bronni* Roemer, 1841,
162 *Scalpellum longissimum* Withers, 1911, *Scalpellum paucistriatum* Woodward, 1906, *C.*
163 *obtusum* Jagt and Collins, 1989 and *C. mutterlosei* Gale, 2019.

164

165 ***Cretiscalpellum robaszynskii* sp. nov.**

166 Figs. 5A-C, G-J, 6A, B

167

168 ? 1902 *Pollicipes glaber* Roemer, Wanner, p. 145, pl. 29 fig. 23

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170 urn:lsid:zoobank.org:act:C230935B-9C91-4A33-B049-B54C1ECA3B67
171

172 *Diagnosis.* Very large, robust species of *Cretiscalpellum* in which the carina is long and
173 tapers slowly; surface of tergum divided by apicobasal line into depressed carinal surface
174 and raised scutal surface; scutum with acute basitergal angle.

175

176 *Types.* The holotype, a carina, is NHMM 2019 026 (Fig. 5G-I); other plates illustrated are
177 paratypes. These include a carina (NHMM 2019 027; Fig. 5J), three terga (NHMM 2019 028–
178 030; Fig. 5A–C) and a fragmentary scutum (NHMM 2019 031; Fig. 6A, B).

179

180 *Material.* Types, plus some fragmentary specimens (Table 1).

181 *Etymology.* Named after Dr Francis Robaszynski, Professor emeritus of the Université de
182 Mons (Belgium), eminent stratigrapher, micropalaeontologist and field geologist, for his
183 tireless efforts in the study of the Cretaceous as a whole and the Tunisian Cretaceous in
184 particular.

185

186 *Type locality and horizon.* Oued Raïne (RC section), Kalaat Senan area, central Tunisia (Fig.
187 1); El Haria Formation, lowermost Aïn Settara marls, lower part of calcareous
188 nannoplankton zone CC26, upper Maastrichtian (Fig. 2).

189

190 *Description.* The carina (Fig. 5G-I, J) is tall and tapers slowly, with an apical angle of 16°. In
191 lateral aspect, the dorsal margin is gently convex, the ventral margin concave. The surface
192 sculpture comprises evenly spaced, low commarginal ridges, separated by regions with

193 numerous, indistinct minor ridges. A narrow apicobasal ridge is present, which carries low
194 nodes where it intersects with the growth increments. The incomplete terga (Fig. 5A–C) are
195 symmetrically rhombic in outline and the upper carinal/occludent margins are slightly
196 shorter than the lower carinal/scutal margins. The straight apicobasal line separates a
197 slightly depressed carinal portion of the valve surface from the raised scutal surface. The
198 sculpture comprises low, irregular ridges separating successive growth increments; in some
199 specimens (e.g., Fig. 5A) minor ridges are bundled between larger ridges, paralleling the
200 sculpture of the carinae, whereas in others (Fig. 5B) the arrangement is more irregular. A
201 slightly raised region, subparallel with the occludent margin, articulated with the tergal
202 notch on the scutum. In one specimen, the region dorsal to the scutal margin is depressed
203 and bears weak radial sculpture (Fig. 5C). Only a single, fragmentary scutum has been found,
204 representing the basal portion of the valve (Fig. 6A, B). This has a relatively acute basitergal
205 angle and a slightly obtuse rostral angle. The dorsal part of the valve carries a weak radial
206 sculpture.

207

208 *Remarks.* Wanner (1902, p. 145) described and figured a carina from (pl. 29 fig. 23) from the
209 Bab-el-Jasmund section (Egypt) as *Pollicipes glaber*. He also mentions two fragmentary
210 terga from the uppermost Cretaceous (obersten Kreide) of the Farafrah Oasis, to the east of
211 Farafrah, Egypt. It is very likely that the carina figured by Wanner is conspecific with *C.*
212 *robaszynskii* sp. nov. This species differs from *C. glabrum* (Fig. 6E) in the significantly
213 narrower, longer carina (apical angle 16°; 21–25° in *C. glabrum*) and the evenly spaced low
214 nodes on the narrow apicobasal ridge. The external surface of the carina has a very weak
215 radial sculpture, absent in *C. glabrum*. It differs from *C. filiosum*, which has an elongated
216 carina, in the absence of a grooved apicobasal ridge on the tergum (Withers, 1935, pl. 19,

217 figs. 9, 10). The terga of *C. robaszynskii* sp. nov. differ from those of *C. glabrum* (Fig. 6G) in
218 the less well-defined scutal articulation surface. They differ from those of *C. paucistriatum*
219 (Fig. 6F) in the straight, rather than gently convex, lower carinal margin. The scuta of *C.*
220 *robaszynskii* sp. nov. differ from those of *C. glabrum* and *C. paucistriatum* (Fig. 6C) in the
221 more acute basitergal angle and obtuse rostral angle.

222

223 Family Scalpellidae Pilsbry, 1916

224 Genus *Diotascalpellum* Gale, 2015

225

226 *Type species. Scalpellum diota* Hoek, 1907, by original designation.

227

228 *Diagnosis.* Scalpellids in which there is no specialised contact between the carina and
229 carinolatus, merely a crescentic concavity on the interior of the plate which forms a rim
230 slightly overlapping the upper latus; umbo of carinolatus upright, only slightly incurved,
231 dorsal margin gently convex; inframedian surface of carinolatus well demarcated and
232 slightly inset.

233

234 *Other species included. Scalpellum rubrum* Hoek, 1883, *Scalpellum indicum* Hoek, 1883,
235 *Pollicipes angustatus* Geinitz, 1843, *Scalpellum gracile* Bosquet, 1854 and *Scalpellum fossula*
236 Darwin, 1851.

237

238 *Remarks.* The genus *Diotascalpellum* was founded largely upon the morphology of the
239 carinolatus and its contact with the carina, and certain assignation of species to the genus in
240 the absence of carinolatera is not easy. However, the one known articulated specimen of *D.*

241 *fossula* (Darwin, 1851; NHMUK In. 30455, the original of Withers, 1935, pl. 26, fig. 3) and
242 that of *D. angustatum* (Geinitz, 1843; see Kočova Veselská et al., 2020, fig. 4) show the form
243 of the capitulum well, in particular, the morphology of the carinae. The tectum is flat, bears
244 basally V-ing regular growth increments and is separated from the parietes by a ridge; the
245 intraparietes are inset and crescentic and extend along the apical 25–35 per cent length of
246 the valve. The presence of a number of these features in *Scalpellum curvatum* Wanner,
247 1902, permits assignment to *Diotascalpellum* (see below).

248

249 ***Diotascalpellum curvatum*** (Wanner, 1902)

250 Fig. 5K-Q

251

252 *1902 *Scalpellum curvatum* Wanner, p. 146, pl. 19, figs. 24–27.

253 1935 *Scalpellum* (*Arcoscalpellum*) *curvatum* Wanner; Withers, p. 273, pl. 34, figs. 12–16.

254

255 *Diagnosis.* A species of *Diotascalpellum* in which the intraparietes are very narrow and
256 separated from the parietes by a ridge.

257

258 *Types.* The carina figured by Wanner (1902, pl. 19, fig. 12 see above) was designated
259 lectotype by Withers (1935, p. 273); the other illustrated can be considered paralectotypes.
260 The material described by Wanner (1902) was collected by Karl von Zittel during his
261 exploratory missions in 1873–1874 ‘in den obersten Kreideschichten vom Bâb-el-Jasmund
262 bei Dachel und in der Nachbarschaft des Dorfes Farâfrah’. Bab-el-Jasmund is the southern
263 entry point (Bab meaning port) of the Fafafra Oasis after crossing the Naqb-el-Qsar Pass
264 coming from Dakhla (Dahel) in the Egyptian Western Desert (in Wanner’s [1902] time ‘die

Lybische Wüste'), a spectacular opening between rocks that received its name from Rohlfs in 1874. The 'oberste[n] Kreideschichten' are most probably of Maastrichtian or Paleocene age and are represented today by the Khoman and/or lower part of the Dakhla formations (Hewaidy et al., 2006). Both Wanner (1902) and Withers (1935) stated that the specimens were housed in the collections of the Geologisches-Paläontologisches Museum in München, Germany.

Material. One tergum (NHMM 2019 032; Fig. 5P), three scuta (NHMM 2019 033–035; Fig. 5K, L, M, Q) and a single carina (NHMM 2019 036; Fig. 5N, O) (Table 1).

Description. The carina (Fig. 5N, O) is strongly inclined ventrally and the dorsal margin is strongly and evenly convex. The tectum is arched about the axis of the plate and apically bears a sharp median ridge, and is separated from the inflected parietes by symmetrical, rounded ridges. The surface of the tectum carries basally V-ing, evenly spaced grooves marking successive growth increments. The narrow intraparietes are separated from the parietes by a rounded, raised ridge. The tergum (Fig. 5P) is rhombic and the broader, occludent, ventral part of the valve is separated from the dorsal part by a gently curved apicobasal line. The lower carinal margin is convex, the upper carinal margin straight, the occludent margin slightly concave. The sculpture of the dorsal surface comprises evenly spaced, curved ridges which run from the apicobasal line to the upper carinal margin. The ventral surface is centrally depressed, and carries weaker commarginal ridges, restricted to the ventral portion, and weak radial lineation. The scuta (Fig. 5K, L, M, Q) are subrectangular in outline and the rostral and basitergal angles are close to 90°; the occludent margin is gently convex. The tergal margin subtends an angle of 60° to the occludent margin and the

curved apicobasal line separates a rather smooth, triangular, tergal surface from the occludent surface. This bears evenly spaced, slightly sinuous, coarse ridges which run from the apicobasal ridge to the tergal margin. The similarity of sculpture on the carna, tergum and scutum confirm the conspecificity of the different valves.

Remarks. The new material is closely similar to Wanner's original specimens, as illustrated by Withers (1935). *Diotascalpellum curvatum* differs from the closely related species *D. fossula* and *D. angustatum* principally in the unusual ridged separation of the parietes and the very narrow intraparietes.

***Diotascalpellum* sp.**

Fig. 5D–F

Material. A single fragmentary carina, NHMM 2019 037 (Table 1).

Description. The tectum is broad, weakly ridged, bearing rather irregular, basally V-ing growth increments. The separation between the tectum and the parietes is a simply angled one; the intraparietes and parietes are separated by a low, rounded ridge. The intraparietes are broad and crescentic in lateral aspect.

Remarks. The absence of a strong ridge separating the tectum and the parietes and the broad intraparieties separate this form from *Diotascalpellum curvatum*, as does the broad tectum bearing irregular growth increments. The absence of the ridge between the tectum and parietes distinguishes this specimen from material of *D. angustatum* and *D. fossula*.

313

314 Family uncertain

315 Genus *Pachyscalpellum* Buckeridge, 1991

316

317 *Type species. Pachyscalpellum cramptoni* Buckeridge, 1991, by original designation.

318

319 *Diagnosis.* Valves thickened, robust; scutum triangular, tergum bifid with excavated scutal
320 margin.

321

322 *Other species included. Pachyscalpellum debodae* Buckeridge, 1999, *Pollicipes glauerti*

323 Withers, 1926 and *Pachyscalpellum heltzeli* Jagt, Verhesen and Goolaerts, 2016.

324

325 *Remarks.* Although material of *P. heltzeli* was described in detail by Jagt et al. (2016), not all
326 specimens were illustrated, including some interesting material which has a bearing on the
327 relationships of the genus. Additionally, although *Pachyscalpellum* has generally been
328 assigned to the family Scalpellidae (Buckeridge, 1991, 1999; Jagt et al. 2016), as a form
329 convergent in its reduced, bifid tergum with genera such as the extant genus *Neoscalpellum*
330 Pilsbry, 1907, the structure of the carina in particular differs significantly from fossil and
331 living scalpellids. Newman (1996) and Jones and Hosie (2008) refer *Pachyscalpellum* to the
332 Calanticidae.

333 In scalpellids, there is consistent separation of the external surfaces of the carina
334 into a dorsal, flat or arched, tectum, with an angled separation from the lateral (dorsally
335 directed) paired surfaces called parietes. In turn, these are separated from two surfaces
336 called intraparietes (Darwin, 1851; Withers, 1935) which bear growth lines with an

orientation subparallel to the length of the valve; intraparietes are not always present in scalpellids. Forms basal to the scalpellids lack true parietes and intraparietes and include zeugmatolepadids (Fig. 4D–F), calanticids (Fig. 4A, C) and cretiscalpellids (Fig. 4B), a selection of which are illustrated here. In these, the carina is rounded in transverse cross section, with or without a narrow external median ridge. Additionally, in scalpellids, the growth increments on the external surface of the carina (tectum) either V towards the base of the valve (Fig. 4G, H) or are straight and transverse (Fig. 4I–L); in more basal taxa these are more and less strongly convex towards the basal margin. In *Pachyscalpellum* (Fig. 8) parietes and intraparietes are absent and the external growth increments are shallowly rounded and extend to the ventral margins of the valves. On the evidence of the carinal morphology, it seems possible that *Pachyscalpellum* was derived from a basal scalpellomorph, such as a calanticid, by reduction of the tergum to a bifid structure, in parallel with the more extreme reductions seen in *Neoscalpellum* and some other extant deep-water scalpellids. The species *Calantica? saskatchewanensis* Russell, 1967, from the Campanian Bearpaw Formation of Canada also bears comparison with *Pachyscalpellum* in its possession very large, robust valves, including elongated scuta with acute apical and rostral angles. More detailed comparison must, however, await redescription of the original material.

Pachyscalpellum heltzeli Jagt, Verhesen and Goolaerts, 2016

Figs. 7A–N, 8A–O

Diagnosis. *Pachyscalpellum* in which the scutum is elongated, with a straight occludent margin; tergum bifid, with a central and an occludent wing.

361

362 *Types.* The holotype is an incomplete right tergum, NHMM 2015 020w (Fig. 7M, N);
363 paratype is another fragmentary right tergum, NHMM 2015 020q (Fig. 7K, L).

364

365 *Material.* Seven scuta, two right terga (holotype and paratype) and 16 carinae, all contained
366 in the NHMM collections (Table 1).

367

368 *Description.* The scuta (Fig. 7A–J) are very robust and elongated, triangular, with a straight
369 occludent margin and a convex tergal-lateral margin. The smallest specimens found (Fig. 7I,
370 J) have an acute rostral angle (65°) and an obtuse basitergal angle (115°) and resemble
371 ordinary cretiscalpellid and scalpellid scuta. With increased size, the ventral and apical
372 portions of the valve elongate greatly, reducing the rostral angle to 25° and increasing the
373 basitergal angle to 130° . The terga, although broken (Fig. 7K–M) are bifid and possess a
374 median process and a process parallel to the occludent margin. The carinae (Fig. 8A–O) are
375 elongated and taper slowly to the apex. The dorsal surface is rounded and parietes are
376 absent; growth lines are convex. In one very large specimen (Fig. 8M–O), the carina tapers
377 to the basal margin.

378

379 *Remarks.* Of the described species to date, *P. heltzeli* is closest to *P. glauerti* from the upper
380 Santonian of Western Australia (Withers, 1935, pl. 9, figs. 3–6), in its elongated scutum and
381 strongly bifid tergum. Indeed, the terga are very similar in the two species and the scuta can
382 only be distinguished by the consistently straight occludent margin in *P. heltzeli*; this is
383 gently convex in *P. glauerti*. The scuta in these species have a very unusual morphology, in
384 their possession of an elongated occludent-basal region with an acute rostral angle. This is

paralleled by scuta from the upper Campanian Norwich Chalk in the United Kingdom (Fig. 9D, E), which have a broadly similar shape to those of *P. heltzeli*, and as in that species, developed ontogenetically from a more “upright” juvenile morphology (Fig. 9F–K). The Norwich scuta are associated with carinae in which the apical portion of the valve adjacent to the intraparietes is greatly thickened (Fig. 9P–R), for which the name *Scalpellum maximum* var. *cylindricum* Darwin, 1851 is available. The structure of the carinae (presence of parietes, intraparietes) and the scutum (elongated embayment for dwarf males) indicate affinity with the genus *Regioscalpellum* Gale, 2015. It would appear to represent a parallel evolutionary development of the scutum to that seen in *Pachyscalpellum*. The unique scutum from the Santonian Gingin Chalk of Western Australia, described as *Pollicipes aboriginalis* Buckeridge, 1983 (reillustrated herein; Fig. 9L, M) also has an elongated basal-occludent margin and is similar in its shape and robust construction to those of *Pachyscalpellum*.

5. Concluding remarks

The cirripede assemblage from the Maastrichtian of the Kalaat Senan area consists exclusively of large and robust pedunculate scalpellomorphs. It includes four species, three of which are currently confined to this area, namely *Pachyscalpellum heltzeli*, *Cretiscalpellum robaszynskii* sp. nov. and *Diotascalpellum* sp., and one which has previously been recorded only from the Maastrichtian of the Egyptian Western Desert, *Diotascalpellum curvatum*, more than 2,000 kilometres away.

408 The assemblage was collected from surface float and by limited *in-situ* excavations.
409 In the absence of wet sieving of matrix samples, it is probable that the stratigraphical ranges
410 of the species are currently underestimated, and that small species were completely
411 overlooked. The same method of collecting was applied to the Campanian and lower
412 Paleogene part of the sequence; no cirripede remains were found. In addition, the
413 Campanian and Maastrichtian intervals at Ellès, El Kef and Garn Halfaya, and some limited
414 sieving in the last metre below the K/Pg boundary at El Kef did not yield any cirripede plates
415 either.

416 The stratigraphical range of the four species (Fig. 3) reveals that the fauna of the
417 lower Maastrichtian is slightly different from that of the upper and uppermost
418 Maastrichtian. From the Abiod Formation only *D. curvatum* is now recorded. Assemblages
419 are most diverse in the lower part of the Aïn Settara marls (El Haria Formation), where *D.*
420 *curvatum*, *C. robaszynkii* sp. nov. and *P. heltzeli* co-occur. *Diotascalpellum curvatum* and *C.*
421 *robaszynskii* sp. nov. are not known from the uppermost metres below the K/Pg boundary.
422 None of the large species were found above the K/Pg boundary, and the only other Tunisian
423 cirripede record to date for the lower Danian (at El Kef; see Buckeridge et al. 2008)
424 documents a different fauna.

425 *Pachyscalpellum* is a genus that had previously been recorded exclusively from the
426 Australasian Upper Cretaceous (Santonian to Maastrichtian). The similarity between the
427 Tunisian *P. heltzeli* and *P. glauerti* from the Santonian of Western Australia is remarkable
428 and indicates that the genus had a wide distribution in the eastern Tethys (Jagt et al., 2016).
429 Its documented first appearance in the fossil record of Tunisia almost coincides with that of
430 representatives of the North American scaphitid genus *Discoscaphites* Meek, 1870
431 (*Discoscaphites gulosus* AZ, base of CC26 at Kalaat Senan, *Di. kambysis* CC25c at Monastery

432 St. Antony, Egyptian Eastern Desert; Goolaerts, 2010; note that the exact age of *Di.*
433 *kambysis* at Ammonite Hill near Abu Minqarand Gbel Tarruân, Kharga Oasis, Western Desert
434 of Quaas (1902) is unknown).

435 The original description of *P. heltzeli* is here extended; it is characterised particularly
436 by a very elongated scutum. Similar scuta are shown to have evolved independently in the
437 scalpellid genus *Regioscalpellum* of the European Upper Cretaceous. The family assignation
438 of *Pachyscalpellum* as a scalpellid is questioned. The large and robust character is
439 exceptional for an offshore open-marine environment; such strongly armoured forms are
440 generally typical of shallower, more energetic, inshore environments. However, the
441 palaeogeographical position of Kalaat Senan, at the articulation of the southern shallower-
442 water carbonate platform and the northern more basinal basin, and with a marked
443 subsidence allowing a pelagic depositional environment but still sufficiently close positioned
444 to the platform to register various faunas of the shallower-water domain (Robaszynski et al.,
445 2000) may explain this character of the cirripede assemblage described, as well as the
446 absence from other sites which are, certainly for El Kef, generally considered to be of more
447 deeper-water settings. The predominance and decreasing character noted among
448 Scaphitidae along the transect from Kalaat Senan over Garn Halfaya to El Kef within
449 ammonite assemblages in the uppermost Maastrichtian *Indoscaphites* AZ (from 76 to 60, to
450 48 per cent) also hints at a depth increase along this transect (Goolaerts et al., 2004b;
451 Goolaerts, 2010). Alternatively, with at least one species in common with the Farafra Oasis
452 in the Egyptian Western Desert, the large and robust character may be specific for
453 Maastrichtian cirripede assemblages of North Africa. This underpins again the great value of
454 the study of the sedimentary and faunal records of the Kalaat Senan area and, by extension,

of the entire region of North Africa, for a proper understanding of Late Cretaceous and early Paleogene ecosystem changes.

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Figures

673 **Fig. 1.** Map of the Kalaat Senan area (inset showing its position within Tunisia, close to the
674 border with Algeria), with sections where cirripedes were found indicated as follows: STW –
675 Aïn Settara section; RCN – Oued Raïne RCN section, 500 m west of RC and RB sections; RC –
676 Oued Raïne RC section; RB – Oued Raïne RB section; NCH – Ncham section (for details see
677 Goolaerts, 2010).

678

Fig. 2. Stratigraphical logs of the STW, RC, RB and RCN sections (see Fig. 1), with indication of sample provenance.

Fig. 3. Composite stratigraphical log of the Maastrichtian of the Kalaat Senan area, with positioning of the three samples from the lower Maastrichtian Ncham Member (Abiod Formation) of the NCH section, calcareous nanoplankton zones (after Gartner *in* Robaszynski et al., 2000), planktonic foraminifer zones (after Robaszynski *in* Robaszynski et al., 2000), ammonite zones and events (after Goolaerts, 2010) and range chart of cirripede species documented. Abbreviations are as follows: DA – Danian; Gs. – Gouss Member; Ain Se. marls – Ain Settara marls; SN – Sidi Nasseur marls; IZ – Interval Zone; PR sz – Partial Range subzone; TR sz – Total Range subzone; I sz – Interval subzone; A. – *Abathomphalus*; G. – *Ganserina*; Pl. – *Plummerita*; Gl. – *Globotruncana*; C. – *Contusatruncana*; Glo. – *Globotruncanita*; Ar. – *Archaeoglobotruncana*; Indo. – *Indoscaphites*; Hoplo. – *Hoploscaphites*; Disco. – *Discocaphites*; P. – *Pachydiscus*; N. – *Nostoceras*.

Fig. 4. Nomenclature of scalpellomorph barnacles and comparative morphology of carinae.

A–J, morphology of carinae, to show variation between families: Calanticidae (**A, C**),

Cretiscalpellidae (**B**), Zeugmatolepadidae (**D–F**) and Scalpellidae (**G–L**). **A**. external view of

700 calanticid *Scillaelepas carinata* (Phillipi, 1835) (A.S. Gale Collection). **B.** external view of
701 cretiscalpellid *Cretiscalpellum unguis* (J. de C. Sowerby, 1836), the original (NHMUK IC 1346)
702 of Gale et al. (2019, fig. 6B). **C.** external view of *Calantica* sp. (A.S. Gale Collection). **D.**
703 external view of *Etcheslepas fragilis* (Withers, 1928), the original (NHMUK IC 1099) of Gale
704 (2014, fig. 6k). **E, F.** lateral and external views of *Martillepas hollisi* (Withers, 1928), the
705 original (NHMUK IC 1123) of Gale (2014, fig. 8p, q). **G, H.** *Regioscalpellum maximum* forma
706 *sulcatum* (J. de C. Sowerby, 1829), in external and lateral views, respectively; the original
707 (NHMUK I 13663) of Withers (1935, pl. 32, fig. 6). **I, J.** *Arcoscalpellum michelottianum*
708 (Seguenza, 1876), in external and lateral aspects, respectively; note the absence of
709 intraparietes (A.S. Gale Collection). **K, L.** *Amigdaloscalpellum* sp., capitulum in dorsal and
710 lateral views, respectively; the original of Gale (2015, fig. 1A, B). Provenance: **A.** lower
711 Pleistocene, Scoppo, Sicily (Italy). **B.** upper Albian, Gault Clay, Naccolt, Kent, UK. **C.** present
712 day, Australia. **D–F.** Kimmeridge Clay, *Pavlovia pallasoides* ammonite Zone, Tithonian,
713 Portland, Dorset (UK). **G, H.** upper Campanian, *Belemnitella mucronata* belemnite Zone,
714 near Norwich, Norfolk (UK). **I, J.** lower Pleistocene, abyssal, off Rodrigues Ridge, Mascarene
715 Plateau, Indian Ocean. **K, L.** present day, off Rodrigues Ridge, Mascarene Plateau, Indian
716 Ocean. *Abbreviations:* **c**, carina; **cl**, carinolatus; **ipa**, intraparietes; **pa**, parietes; **rl**,
717 rostrolatus; **s**, scutum; **t**, tergum; **te**, tectum. Scale bars equal 5 mm (A–C, G–L) and 0.5 mm
718 (D–F).
719

Fig. 5. Cretiscalpellid (A–C, G–J) and scalpellid (D–F, K–Q) cirripedes from the Maastrichtian of Kalaat Senan, Tunisia. **A–C, G–J.** *Cretiscalpellum robaszynskii* sp. nov. **A–C.** Paratype terga, NHMM 2019 028, NHMM 2019 029, respectively, in external view,. **G–I,** Holotype carina

724 carina (holotype), NHMM 2019 026, in external, lateral and internal views, respectively,. **J**,
725 carina (paratype), NHMM 2019 027, in external view. **K-Q**, *Diotascalpellum curvatum*
726 (Wanner, 1902). **K, L, M, Q**, three scuta, NHMM 2019 033, NHMM 2019 034 and NHMM
727 2019 035 respectively, in external views (K, M, Q) and internal aspect (L). **N, O**. Carina,
728 NHMM 2019 036, in lateral and dorsal views, respectively. **P**. Tergum, NHMM 2019 032, in
729 external view,. **D-F**. *Diotascalpellum* sp., carina, NHMM 2019 037, in internal, external and
730 lateral views, respectively,. Scale bars equal 5 mm.
731

Fig. 6. Cretiscalpellid cirripedes. **A, B.** *Cretiscalpellum robaszynskii* sp. nov., paratype partial scutum, NHMM 2019 031, in external and internal views, respectively. **C, F.** *Cretiscalpellum paucistriatum* (Woodward, 1906), scutum in external view (C), the original of Woodward (1906, fig. 31) and Withers (1935, pl. 18, fig. 8) (NHMUK I. 30156) and tergum (F, lectotype; the original of Woodward (1906, fig. 32) and Withers (1935, pl. 18, fig. 9)) (NHMUK I. 30157). **D.** *Witherscalpellum matroni* (Gale, 2019), scutum in external view; the original of Gale (2019, fig. 7D), B. Matrimon Collection, University of Dijon, France. **E, G.** *Cretiscalpellum*

740 *glabrum* (Roemer, 1841), carina in external view (E, NHMUK I. 13656) and tergum in
 741 external view (G., NHMUK I. 13652). Provenance: **A, B.** Maastrichtian, Kalaat Senan, Tunisia;
 742 **C, F.** lower Maastrichtian, Trimingham, Norfolk, United Kingdom. **E, G.** upper Campanian,
 743 *Belemnitella mucronata* belemnite Zone, near Norwich, Norfolk, United Kingdom. Scale bars
 744 equal 5 mm (A, B) and 10 mm (C–F).

746

747 **Fig. 7.** *Pachyscalpellum heltzeli* Jagt, Verhesen and Goolaerts, 2016 from the Maastrichtian
748 of Kalaat Senan, Tunisia. **A–J.** Scuta to demonstrate ontogenetic changes. **A, B.** Largest
749 specimen (NHMM 2015 020q), showing extreme elongation of the rostral region, in external
750 and internal views, respectively. **C, D.** NHMM 2015 020n. **E, F.** NHMM 2015 020o. **G, H.**
751 Internal and external views, the original (NHMM 2015 020p) of Jagt et al. (2016, fig. 5H–J). **I,**
752 **J.** Smallest specimen (NHMM 2015 020b), lacking rostral extension. **K–N.** Partial terga, in
753 external (K, N) and internal (L, M) views; **K, L.** The original (NHMM 2015 020q) of Jagt et al.
754 (2016, fig. 3K, L). **M, N.** The original (NHMM 2015 020w, holotype) of Jagt et al. (2016, fig.
755 3G). Scale bars equal 5 mm.

756

Fig. 8. *Pachyscalpellum heltzeli* Jagt, Verhesen and Goolaerts, 2016 from the Maastrichtian of Kalaat Senan, Tunisia. Carinae, to show variation of form. **A–C.** NHMM 2015 20i, in external, lateral and internal views, respectively. **D–F.** NHMM 2015 020h, with change in

761 growth direction in external, lateral and internal views, respectively. **G–I.** NHMM 2015 020j,
762 showing weak radial sculpture in external, lateral and internal views, respectively. **J–L,**
763 NHMM 2015 020t, basal portion of carina, displaying narrowing towards the basal margin,
764 in external, lateral and internal views, respectively (the original of Jagt et al., 2016, fig. 5A–
765 C). **M–O,** NHMM 2015 020u, very large carina, displaying narrowing towards basal margin
766 (the original of Jagt et al., 2016, fig. 5). Scale bars equal 5 mm.

767

Fig. 9. Scalpellid and pollicipid valves to show convergent evolution with *Pachyscalpellum*.

A–C. *Regioscalpellum maximum* forma *sulcatum* (J. de C. Sowerby, 1829), carina, in external, internal and lateral views, respectively (the original of Withers, 1935, pl. 32, fig. 6; NHMUK I

13663). **D–K, P–R**, *Regioscalpellum maximum* var. *cylindricum* (Darwin, 1851). **D–K**, growth series of scuta, to show progressive elongation of rostral portion of valve with size, in parallel with *Pachyscalpellum heltzeli* (compare with Fig. 7). **D, E**, very large scutum, in internal and external views, respectively (NHMUK In.63533). **F, G**, scutum in internal and external views, respectively (NHMUK In. 26347). **H, I**, scutum, in internal and external views, respectively (NHMUK I.13664). **J, K**, small scutum, similar to those of *Regioscalpellum maximum* (compare with Withers, 1935, pls 30, 31), the original of Withers (1935, pl. 30, fig. 4; (NHMUK I. 3668). **P–R**, carina, in external, internal and lateral views, respectively, to show apical thickening (NHMUK In. 63520). **L, M**, *Pollicipes aboriginalis* Buckeridge, 1983, scutum (holotype), refigured after Buckeridge (1983, pl. 3a, b; WAM 77.3531); note similarities to figs D and E and Fig. 7A, B. Provenance: **A–C, F–K**, upper Campanian, *Belemnitella mucronata* belemnite Zone, near Norwich, Norfolk, United Kingdom. **D, E**, upper Campanian, *Belemnitella mucronata* belemnite Zone, upper Weybourne or basal Beeston Chalk, Attoe's Pit, Norwich, Norfolk, United Kingdom. **P–R**, upper Campanian, *Belemnitella mucronata* belemnite Zone, Earlham Limeworks, Norwich, Norfolk, United Kingdom. **L, M**, Gingin Chalk, upper Santonian, Perth Basin, Dundaragan, Western Australia. Scale bars equal 5 mm.

795 **Table 1.** Sample numbers, section and level of origin, stratigraphic level and CC zone (from
796 Robaszynski et al., 2000 with data from S. Gartner), taxonomy, specimen number, status
797 and figurations in Jagt et al (2016) and this paper.

798

Sample N°	Section	Level	Situ	Lithostratigraphy	CC zone	Taxonomy	NHMM numbers	Plate type	Status	Jagt et al 2016	This paper
TUC 001	STW	STW 69	ex situ	Aïn Settara or Sidi Nasseur Marls	CC26	<i>Diatoscalpellum</i> sp.	NHMM 2019 037	carina	Figured		Fig 5 D, E, F
TUC 002	STW	STW 64	in situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020a	carina			
TUC 003	STW	STW 62,5	in situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020b	right scutum	Figured		Fig 7 I,J
TUC 004	STW	STW 56,5	in situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020c	carina			
TUC 005	STW	STW 13	in situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>		fragmentary tergum			
TUC 006	STW	STW 13	in situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>	NHMM 2019 027	carina	Paratype		Fig 5 J
TUC 007	STW	STW 13,5	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020d	carina			
TUC 007	STW	STW 13,5	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020e	carina			
TUC 007	STW	STW 13,5	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020f	right scutum			
TUC 008	STW	STW 10,5	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020g	carina			
TUC 009	STW	STW 10	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020h	carina	Figured		Fig 8 D, E, F
TUC 010	STW	STW 0	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020i	carina	Figured		Fig 8 A, B, C
TUC 010	STW	STW 0	ex situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>		fragmentary tergum			
TUC 011	RB	RB 157	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020j	carina	Figured		Fig 8 G, H, I
TUC 012	RB	RB 146,5	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020k	carina	Figured	Fig 3 M-O	
TUC 013	RB	RB 143	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020l	carina			
TUC 013	RB	RB 143	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020m	carina			
TUC 013	RB	RB 143	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020n	left scutum	Figured		Fig 7 C, D
TUC 014	RB	RB 141	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020o	right scutum	Figured	Fig 3 D-F	Fig 7 E, F
TUC 014	RB	RB 141	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020p	left scutum	Figured	Fig 3 H-J	Fig 7 G, H
TUC 014	RB	RB 141	ex situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>	NHMM 2019 028	tergum	Figured		Fig 5 A
TUC 014	RB	RB 141	ex situ	Aïn Settara Marls	CC26	<i>Diatoscalpellum curvatum</i>	NHMM 2019 035	scutum	Figured		Fig 5 Q
TUC 014	RB	RB 141	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>		carina			
TUC 015	RC	RC 135	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020q	scutum	Paratype	Fig 3 K-L	Fig 7 A, B
TUC 015	RC	RC 135	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020r	tergum	Figured		Fig 7 K, L
TUC 015	RC	RC 135	ex situ	Aïn Settara Marls	CC26	<i>Diatoscalpellum curvatum</i>	NHMM 2019 034	right scutum	Figured		Fig 5 L, M
TUC 015	RC	RC 135	ex situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>		fragmentary scutum			
TUC 015	RC	RC 135	ex situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>		fragmentary tergum			
TUC 016	RC	RC 131	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020s	right scutum			
TUC 017	RC	RC 130	ex situ	Aïn Settara Marls	CC26	<i>Cretiscalepellum robaszynskii</i>	NHMM 2019 026	carina	Holotype		Fig 5 G, H, I
TUC 018	RC	RC 129	ex situ	Aïn Settara Marls	CC26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020t	carina	Figured	Fig 3A-C	Fig 8 J, K, L
TUC 019	RB	RB 123	in situ	Mzita Marls	CC25	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020u	carina	Figured	Fig 4	Fig 8 M, N, O
TUC 020	RB	RB 90	ex situ	Mzita Marls	CC25	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020v	carina			
TUC 020	RB	RB 90	ex situ	Mzita Marls	CC25	<i>Cretiscalepellum robaszynskii</i>	NHMM 2019 031	scutum	Paratype		Fig 6 A, B

TUC 021	RB	RB 121	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Cretiscalpellum robaszynskii</i>	NHMM 2019 030	tergum	Paratype		Fig 5 C
TUC 022	NCH	NCH 170	in situ	Ncham Member, Abiod Formation	CC23	<i>Diatoscalpellum curvatum</i>	NHMM 2019 036	carina	Figured		Fig 5 N, O
TUC 023	NCH	NCH 159	in situ	Ncham Member, Abiod Formation	CC23	<i>Cretiscalpellum robaszynskii</i>		fragment			
TUC 023	NCH	NCH 159	in situ	Ncham Member, Abiod Formation	CC23	<i>Cretiscalpellum robaszynskii</i>		fragment			
TUC 024	NCH	NCH 81	ex situ	Ncham Member, Abiod Formation	CC23	<i>Diatoscalpellum curvatum</i>	NHMM 2019 032	tergum	Figured		Fig 5 P
TUC 025	RC	RCN 126	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Diatoscalpellum curvatum</i>	NHMM 2019 033	scutum	Figured		Fig 5 K
TUC 026	RC	RCN 135	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020w	right tergum	Holotype	Fig 3 G	Fig 7 M, N
TUC 026	RC	RCN 135	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020x	carina	Figured	Fig 3 P-Q	
TUC 026	RC	RCN 135	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Pachyscalpellum heltzeli</i>	NHMM 2015 020y	carina			
TUC 026	RC	RCN 135	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Cretiscalpellum robaszynskii</i>	NHMM 2019 029	tergum	Paratype		Fig 5 B
TUC 026	RC	RCN 135	ex situ	Mzita Marls or Ain Settara Marls	CC25 or 26	<i>Cretiscalpellum robaszynskii</i>		tergum			