Late Albian (Early Cretaceous) ammonites from the Provincial Formation of central Cuba

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A B S T R A C T

A late Albian ammonite assemblage from the Provincial Formation of Villa Clara Province, Cuba is described. The Provincial Formation is a lithostratigraphic unit of Albian–Cenomanian age extensively exposed in central Cuba and formed within a part of the Caribbean Tethys that was volcanic during the Cretaceous. The formation is mainly composed of calcareous, terrigenous marine, and volcano-sedimentary deposits characterized by a series of micritic limestones intercalated with marls, sandstones, calcareous conglomerates, ash, and tuffaceous material. A rich assemblage of ammonites recovered from the calcareous biomicrites and marls is of late Albian (Stoliczkaia dispar Zone, Mortoniceras rostratum Subzone) age. The ammonite fauna shows a strong Tethyan affinity, and only a single hoplitid ammonite species was recorded. Although scarce, the first Cuban report of this and other boreal ammonite species now allows precise correlations to be made between Cuba and Albian sediments elsewhere in the world. (Owen and Mutterlose, 2006) provide a context for the biostratigraphical discussion of the Cuban ammonite fauna presented here.

The ammonite fauna described here includes cosmopolitan taxa that have not been recorded for Cuba or in fact anywhere else in the Caribbean region. This is significant because it allows for correlation between sediments in Cuba and those elsewhere, notably the Mediterranean part of the Tethyan region.

Ammonite zonal schemes for the Gulf of Mexico region have been proposed for the upper Albian/lower Cenomanian successions (Young, 1979; Mancini, 1979) and discussed by Kennedy et al. (2005). However, in this paper the zonation outlined by Reboulet et al. (2009) is more useful because of the Tethyan affinity of the fauna described, in contrast to the other schemes based on more endemic Gulf region assemblages.

The current debate on Albian ammonite zonation (Kennedy, in Gale et al., 1996; Wiedmann and Owen, 2001), as documented by Kennedy and Latil (2007) and Scott (2009), means that defining the Aptian/Albian boundary remains uncertain. For our purposes we have chosen to use the standard ammonite zonation scheme proposed by the IUGS Lower Cretaceous Ammonite Working Group, informally known as the “Kilian Group” (Reboulet et al., 2009).

Fossiliferous outcrops of the upper Albian Provincial Formation are well exposed in the Province of Villa Clara, Central Cuba.

1. Introduction

The geology of Cuba is among the most complex in the Caribbean region, and reconstructing its geological history is difficult (Iturralde-Vinent, 1997). The central part of Cuba is composed of volcanic deposits of Cretaceous (Berriasian–Aptian) age (Furrazola-Bermúdez et al., 2003).

These volcanic sequences were initially studied by Rutten (1936) and Thiadens (1937), who used the name ‘Tuff Series’ to refer to these thick volcano-sedimentary units, with frequent intercalations of calcareo-terrigenous and terrigenous material.

The uppermost Albian and Cenomanian part of these thick volcano-sedimentary units is known as the Provincial Formation (Thiadens, 1937). The Albian part of the formation is fossiliferous in the Villa Clara Province of central Cuba, and has yielded a rich ammonite assemblage of late Albian (Stoliczkaia (S.) dispar Zone) age (Barragán-Manzo et al., 2008). The occurrence of Albian ammonites in this volcano-sedimentary unit had been mentioned in reports of the local geology compiled during the late 20th century, e.g. Kantchev et al. (1978), but these have not been widely published and discussed elsewhere. Late Albian to early Cenomanian ammonite faunas from the Gulf of Mexico region (Adkins, 1920; Mancini, 1979; Young, 1957, 1979, 1986; Kennedy, 2004; Kennedy et al., 2005) and more recently from the Caribbean (Owen and Mutterlose, 2006) provide a context for the biostratigraphical discussion of the Cuban ammonite fauna presented here.

The ammonite fauna described here includes cosmopolitan taxa that have not been recorded for Cuba or in fact anywhere else in the Caribbean region. This is significant because it allows for correlation between sediments in Cuba and those elsewhere, notably the Mediterranean part of the Tethyan region.

Ammonite zonal schemes for the Gulf of Mexico region have been proposed for the upper Albian/lower Cenomanian successions (Young, 1979; Mancini, 1979) and discussed by Kennedy et al. (2005). However, in this paper the zonation outlined by Reboulet et al. (2009) is more useful because of the Tethyan affinity of the fauna described, in contrast to the other schemes based on more endemic Gulf region assemblages.

The current debate on Albian ammonite zonation (Kennedy, in Gale et al., 1996; Wiedmann and Owen, 2001), as documented by Kennedy and Latil (2007) and Scott (2009), means that defining the Aptian/Albian boundary remains uncertain. For our purposes we have chosen to use the standard ammonite zonation scheme proposed by the IUGS Lower Cretaceous Ammonite Working Group, informally known as the “Kilian Group” (Reboulet et al., 2009).

Fossiliferous outcrops of the upper Albian Provincial Formation are well exposed in the Province of Villa Clara, Central Cuba.
There are extensive outcrops along the National Highway between kilometre posts 291 and 292, approximately 30 km southeast of Santa Clara (Fig. 1).

The section described here is located at 02°22′16″36″N, 079°50′13″W on a small hill known as Las Nueces. It is part of a tectonostratigraphic unit that embraces the best-preserved fragments of the Cretaceous volcanic arc of the Caribbean Tethys (Díaz de Villalvilla, 1997; Furrazola-Bermúdez and Gil-González, 1997). Fig. 1 shows the location of the section and the relationship of the Cretaceous volcanic arc with other tectonostratigraphic units in the area.

3. Lithostratigraphy

The section consists of approximately 27 m of alternating beds of normal marine and volcano-sedimentary deposits. The marine beds are micritic and marly limestones, with intercalated beds of marls, sandstones, calcareous conglomerates, and ash and tuffaceous material attributed to flyschoid, relatively deep-water deposits of the Provincial Formation (sensu Thiadens, 1937).

Fig. 2 shows how the Provincial Formation fits into the stratigraphy of the volcanic arc sediments of this region (Villalvilla and García, 1994 in Díaz de Villalvilla, 1997). A distinctive feature of this particular section is the abundance of ammonites within the limestones and marly limestones. The ammonites occur in two distinctive horizons located in the middle (horizon I) and upper (horizon II) parts of the section.

4. Systematic palaeontology (O. Szives and R. Barragán)

The ammonites of the Provincial Formation are generally preserved as whole or fragmentary internal moulds, or else as shell impressions. The terminology used herein is that of the Treatise on Invertebrate Paleontology (Wright et al., 1996). Descriptions, synonyms, and references used for specific determinations are also included. In the descriptions, the following abbreviations are used for the measured parameters: D for shell diameter; U for diameter of the umbilicus; Wh for whorl height; and Ww for whorl width. All measurements are in millimetres.

All specimens are housed in the mollusc section of the invertebrate collection of the National Museum of Natural History of Cuba in La Havana under the catalogue numbers MNHNCu-92.001100–MHNHCu-92.001136 and MNHNCu-92.001269–MHNHCu-92.001270.

Suborder Lytoceratina Hyatt, 1889
Superfamily Tetragonitaceae Hyatt, 1900
Family Tetragonitidae Hyatt, 1900
Genus Protetragonites Hyatt, 1900

Type species. Ammonites quadrisulcatus d’Orbigny, 1840, p. 151, pl. 49, figs 1–3, by original designation.

Protetragonites cf. aeolus (d'Orbigny, 1850)
Fig. 3A

cf. 1850 Ammonites Aeolus d'Orbigny; p. 125.
cf. 1996 Protetragonites aeolus aeolus (d’Orbigny, 1850); Kennedy, in Gale et al., p. 544, figs. 13e, f [with additional synonymy].
cf. 2001 Protetragonites cf. aeolus aeolus (d’Orbigny, 1850); Yazikova, p. 105, pl. 2, figs 18, 19.

Material. One specimen, MNHNCu-92.001100, collected from the horizon I.

Dimensions of the figured specimen.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
<th>U</th>
<th>Wh</th>
<th>Ww</th>
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<tbody>
<tr>
<td>MNHNCu-92.001100</td>
<td>10</td>
<td>5</td>
<td>3</td>
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</tbody>
</table>

Description. Very evolute (U/D = 0.5) slightly crushed and smooth internal mould lacking clearly visible ornamentation. The periodic constrictions of the shell typical of the genus are difficult to observe because of the poor state of preservation.

Remarks. The general appearance, including the highly evolute coiling and the presence of constrictions, are a diagnostic feature of the species. In this flattened, poor state of preservation, where the exact position and form of the constrictions are poorly visible, apart from being less evolute, this specimen resembles Zelandites Marshall (1926).

Occurrence. The species has been reported from the Albian of southern France, Poland, and the Russian Far-East.

Suborder Ammonitina Hyatt, 1889
Superfamily Desmocerataceae Zittel, 1895
Family Desmoceratidae Zittel, 1895
Subfamily Desmoceratinae Zittel, 1895
Genus Desmoceras Zittel, 1884
Subgenus Desmoceras (Desmoceras) Zittel, 1895

Type species. Ammonites latidorsatus Michelin, 1838, p. 101, by subsequent designation.

Desmoceras (Desmoceras) cf. latidorsatum (Michelin, 1838)

Fig. 3B
"1838 A. latidorsatus Michelin, p. 101, pl. 12, fig. 9.

cf. 1979 Desmoceras (Desmoceras) latidorsatum (Michelin); Scholz, p. 61, fig. 18 [with cf. 1982 Desmoceras (Desmoceras) latidorsatum latidorsatum (Michelin); Renz, p. 37, pl. 5, figs. 3a, b, 4a, b, 5a, b, 7a, b, text-fig. 24b].

cf. 2000 Desmoceras latidorsatum (Michelin); Busnardo, in Monod et al., p. 386, fig. 5f.

Material. One specimen, MNHNCu-92.001101, collected from the horizon II.

Dimensions of the figured specimen.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
<th>U</th>
<th>Wh</th>
<th>Ww</th>
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</thead>
<tbody>
<tr>
<td>MNHNCu-92.001101</td>
<td>22</td>
<td>6</td>
<td>8</td>
<td>–</td>
</tr>
</tbody>
</table>

Description. The specimen is rather involute (U/D = 0.27). It is a small internal mould with flat, smooth, and wide flanks and a steep umbilical and ventrolateral edge.

Remarks. Only a single very poorly preserved specimen is referred to this species.

Occurrence. This species has been reported worldwide from rocks of mid-Aptian to late Cenomanian age.

Superfamily Hoplitaceae H. Douvillé, 1890
Family Hoplitidae H. Douvillé, 1890
Subfamily Hoplitinae H. Douvillé, 1890

Type species, Ammonites coelonotus Seeley, 1865, p. 237, by original designation.

?Discohoplites sp.

Fig. 3C

Material. One specimen, MNHNCu-92.001124, collected from the horizon I.

Dimensions of the figured specimen.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
<th>U</th>
<th>Wh</th>
<th>Ww</th>
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</thead>
<tbody>
<tr>
<td>MNHNCu-92.001124</td>
<td>34</td>
<td>12</td>
<td>12</td>
<td>–</td>
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</tbody>
</table>

Description. Moderately involute (U/D = 0.35) imprint of a cast with crowded, falcoïd ribs. Slight, narrow umbilical bullae arise on the umbilical edge and give rise to crowded, fine, slightly falcoïd ribs. There are approximately thirty ribs per half whorl, which become strongly prosirradiate and sinuous. The ribs become plicate with growth, particularly on the outer quarter of the last whorl. The venter is not visible due to flattening.

Remarks. The genus Discohoplites Spath (1925b) is characterized by a compressed whorl section with moderately evolve style of coiling and grooved, but not flat, venter. Discohoplites is ornamented with falcoïd ribs and umbilical tubercles. Based on the lateral ornamentation, the specimen MNHNCu-92.001124 is assigned to this genus. The determination is based mainly on the falcoïd ribs because the venter is not visible, making it impossible to detect the ventral groove characteristic of Discohoplites. Significantly, the specimen also resembles lateral views of Algericeras Spath (1925a). However, all the reported specimens of Algericeras are smaller, and their ribs bifurcate from the umbilical bullae. Identification of this specimen as Discohoplites therefore remains likely but tentative.

Superfamily Acanthocerataceae de Grossouvre, 1894
Family Brancoceratidae Spath, 1934

Subfamily Mortoniceratinae Douvillé, 1912
Genus Mortoniceras Meek, 1876

Type species, Ammonites vespertinus Morton, 1834, p. 40, by original designation.

Mortoniceras sp.

Fig. 3D

Material. One specimen, MNHNCu-92.001102, collected from the horizon II.

Dimensions of the figured specimen.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
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<th>Wh</th>
<th>Ww</th>
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<tbody>
<tr>
<td>MNHNCu-92.001102</td>
<td>–</td>
<td>23</td>
<td>22</td>
<td>15</td>
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</table>

Description. Compared to the other forms found at the same locality, this specimen is quite large. It is evolve with robust ornamentation. Strong primary ribs arise from the flattened umbilical seam; these ribs bear slight umbilical, lateral and ventral tubercles. Occasionally, intercalated ribs appear on the mid-flank. The venter seems to be keeled, but this feature is not clear.

Remarks. The genus Mortoniceras is characterized by an evolve style of coiling, robust trituberculate ribs, and a strongly keeled venter, as discussed by Kennedy and Latil (2007). The specimen assigned to this genus (MNHNCu-92.001102) is preserved such that the venter is not visible, and therefore it cannot be determined if it has a keel or not. However, the lateral view of this specimen is very similar to that of other specimens assigned to Mortoniceras. Nonetheless, because of the poor state of preservation identification to species level would be speculative at best.

Occurrence. The genus has been found in Albian deposits worldwide. Outside Cuba, its stratigraphic range does not reach the extreme top of the Albian stage (Wright et al., 1996, p. 142). However, in Cuba its occurrence alongside Algerites is remarkable, implying occurrence close to, but below, the Albian/Cenomanian boundary.

Genus Cantabrigites Spath, 1932

Type species, Mortoniceras (Cantabrigites) cantabrigense Spath, 1932, p. 380, by original designation.

Cantabrigites spinosum (Pervinquiére, 1907)

Fig. 3E–G

1907 Mortoniceras inflatum Sowerby var. spinosa Pervinquiére, p. 229, pl. 9, fig. 3.
2004 C. spinosum (Pervinquiére, 1907); Kennedy, p. 877, figs. 7A–E; 10A–K; 12H–W; 13 [with full synonymy].
2005 C. spinosum (Pervinquiére, 1907); Kennedy et al., p. 363, figs. 4F–J.

Material. Eight specimens, MNHNCu-92.001103–MNHNCu-92.001110, collected from the horizons I and II.

Dimensions of the figured specimens.

<table>
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<tr>
<th>Specimen No.</th>
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<th>Ww</th>
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<tr>
<td>MNHNCu-92.001104</td>
<td>18</td>
<td>7</td>
<td>5</td>
<td>–</td>
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<tr>
<td>MNHNCu-92.001105</td>
<td>14</td>
<td>6</td>
<td>5</td>
<td>–</td>
</tr>
<tr>
<td>MNHNCu-92.001106</td>
<td>23</td>
<td>8</td>
<td>7</td>
<td>5</td>
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</table>

Description. Very evolve (U/D = 0.38) internal moulds. From 20 to 22 coarse, spine-like tubercles along the umbilical shoulder. Each tubercle gives rise to a single non-branching rib that weakens in the
mid-lateral region, becoming stronger and coarser on the outer flank and ending in prominent tubercles at the ventrolateral edge. The ribs are more or less straight but become slightly prorsiradiate on the outer whors. The venter is not visible in any specimen.

Remarks. The strong, coarse, and robust ribbing and the presence of umbilical inner and outer ventrolateral tubercles differentiate this species from C. wenoensis (Adkins, 1920).

Occurrence. The species has been reported from uppermost Albian of Texas (USA), Tunisia, Sardinia, Switzerland, France and Hungary.

Cantabrigites wenoensis (Adkins, 1920)

Fig. 3H–N

1920 Schoenbachia wenoensis Adkins, p. 89, pl. 1, fig. 14.

Material. Twelve specimens, MNHNCu-92.001111–MNHNCu-92.001122, collected from the horizons I and II.

Dimensions of the figured specimens.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
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<th>Wh</th>
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<tbody>
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<td>MNHNCu-92.001115</td>
<td>18</td>
<td>7</td>
<td>6</td>
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<tr>
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<tr>
<td>MNHNCu-92.001117</td>
<td>25</td>
<td>9</td>
<td>8</td>
<td>—</td>
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<tr>
<td>MNHNCu-92.001118</td>
<td>28</td>
<td>11</td>
<td>11</td>
<td>—</td>
</tr>
<tr>
<td>MNHNCu-92.001120</td>
<td>17</td>
<td>6</td>
<td>6</td>
<td>—</td>
</tr>
<tr>
<td>MNHNCu-92.001121</td>
<td>22</td>
<td>9</td>
<td>9</td>
<td>—</td>
</tr>
<tr>
<td>MNHNCu-92.001122</td>
<td>34</td>
<td>12</td>
<td>12</td>
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</tbody>
</table>

Description. Very evolute (U/D = 0.38) internal moulds. Weak umbilical but not spinate bullae arise along the umbilical shoulder. These umbilical bullae give rise to about sixteen to nineteen single, tubercles.

Remarks. According to Kennedy (2004, p. 879), “C. spinosum is easily separated from C. wenoensis on the basis of its coarse ornamentation with strong umbilical, inner and outer ventrolateral tubercles.” The Cuban material presented herein supports this opinion, because the specimens of C. wenoensis display less coarse and less rigid ribs as well as less prominent tubercles, compared to C. spinosum. Moreover, the Cuban specimens of C. wenoensis show a higher rib index and a more involute coiling than C. spinosum.

Occurrence. C. wenoensis (Adkins, 1920) is reported from the uppermost Albian of Texas (USA) and Tunisia.

Cantabrigites cf. wenoensis (Adkins, 1920).

Fig. 30

Material. One specimen, MNHNCu-92.001123, collected from the horizon I.

Dimensions of the figured specimen.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
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</thead>
<tbody>
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<td>MNHNCu-92.001123</td>
<td>15</td>
<td>5</td>
<td>4</td>
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</table>

Description: A rather evolute (U/D = 0.33), flattened internal mould. Twelve to 14 bullae arise on the umbilical shoulder and give rise to sinuous ribs that are prorsiradiate across the flanks. Each of these primary ribs end in a spiny bulla at the ventrolateral edge. The rib index is 12–15 ribs per half whorl. Between two umbilical bullae, slight secondary and non-tuberculate ribs are found. Both the primary and the secondary ribs become weaker and smoother on the mid-flank. A keel on the venter is observed on some parts of the mould (indicated by arrows in Fig. 30).

Remarks: This specimen looks like a transitional form between C. spinosum (Pervinquiére, 1907) and C. wenoensis (Adkins, 1920). The spiny, tuberculated primary ribs resemble those of C. spinosum. However, the finer ornamentation with sinuous primary ribs and non-tuberculate, weak secondaries are more similar to those of C. wenoensis.

Occurrence: As mentioned above, the species has been reported from the uppermost Albian of Texas (USA) and Tunisia. However, besides these two occurrences of the species, Cantabrigites spp. are known from England, Sardinia, Switzerland, France and Hungary.

Family Lyelliceratidae

Stoliczkaia (Sp.)

Genus Stoliczkaia Neumayr, 1875

Subgenus Stoliczkaia (Stoliczkaia) Neumayr, 1875

Type species. Ammonites dispar d’Orbigny, 1841, p. 142, by subsequent designation.

Stoliczkaia (Stoliczkaia) cf. clavigera (Neumayr, 1875)

Fig. 4A–C

cf. 1864 A. dispar Stoliczka, p. 85, pl. 45, fig. 1 only.
cf. 1875 Stoliczkaia clavigera Neumayr, p. 933.
cf. 1994 Stoliczkaia (Stoliczkaia) clavigera (Neumayr); Wright and Kennedy, p. 576, figs. 5b; 11k–m, q, r; 12e–h, k–n; 13a–c; 14a–c [with full synonymy].

Material. Five specimens, MNHNCu-92.001125–MNHNCu-92.001129, collected from the horizons I and II.

Dimensions of the figured specimens.

<table>
<thead>
<tr>
<th>Specimen No.</th>
<th>D</th>
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<td>MNHNCu-92.001128</td>
<td>45</td>
<td>7</td>
<td>23</td>
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<tr>
<td>MNHNCu-92.001129</td>
<td>63</td>
<td>12</td>
<td>22</td>
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</table>

Description. Slightly deformed involute (U/D = 0.16) internal moulds. Weak bullae on the umbilical edge give rise to coarse and narrow primary ribs with finer ribs intercalated. In specimen MNHNCu-92.001128 (Fig. 4B), the ribs are crowded, narrow and persistent on the flank. The venter can be observed in this slightly deformed specimen, and the ribs seem to be angular and have weak tubercles on the ventral region. The rib index is more than 21 ribs per half whorl.

Remarks. The specimen assigned to Stoliczkaia superficially resemble Stoliczkaia (Lamnayella) worthense (Adkins, 1920), a species restricted to the upper Albian of Texas (USA). However, given Kennedy’s (2004, p. 882) analysis of hundreds of specimens of S. (L.) worthense, we conclude that the Cuban specimens display greater involution, stronger ornamentation, and distinct alternation of long and short ribs, and consequently believe that this material more resembles to Stoliczkaia (Stoliczkaia) cf. clavigera (Neumayr, 1875), which is also of late Albian age.

Occurrence. Although often considered to have Tethyan affinities, this cosmopolitan species has been reported from the
upper Albian of England, France, Switzerland, Romania, Hungary, Turkmenistan, Tunisia, Japan, Texas (USA) and South India.

Suborder Ancyloceratina Wiedmann, 1966
Superfamily Turrilitaceae Gill, 1871

Family Anisoceratidae Hyatt, 1900
Genus Algerites Pervinquière, 1910

Type species. Algerites sayni Pervinquière, 1910, p. 47, pl. 10 (1), figs. 21–25, by original designation.
Algerites sp.

**Material.** Two moderately well-preserved internal mould fragments, MNHNCu-92.001130 and MNHNCu-92.001131, collected from the horizon II.

**Description.** Heteromorph ammonites with fine, narrow, slightly sinuous primary ribs that straighten and become wider towards the aperture. Between the primaries, intercalated ribs appear on the outer flank. Two shallow constrictions are present on the mould, each bordered with thickened collars. There are 11 primary ribs between these two constrictions. No tubercles are visible. The venter is not visible in any of the available specimens.

**Remarks.** Because of their constrictions, these specimens are best assigned to the heteromorph genus *Algerites*. This genus is definitely known from the early Cenomanian, although there are also questionable reports from deposits of late Albian age. On the other hand, the two fragments also resemble *Anisoceras pseudolegans* (Pictet and Campiche, 1861–1864), although they lack the tuberculation of that species and indeed of any other *Anisoceras*. In common with other *Algerites*, these specimens are superficially similar to contemporary *Idiohamites* Spath, 1925b, but the lack of constrictions, branched ribs, and uniform tuberculation distinguish *Idiohamites* from *Algerites* (Wright and Kennedy, 1995, p. 312).

Even so, *Algerites* is a poorly defined genus based on limited and fragmentary material, as discussed by Kennedy (1971, p. 14). Wright and Kennedy (1995, p. 312), whose work concerned *Algerites*, in the most recent and detailed study of the genus to date, assigned four species to *Algerites*: A. sayni (Pervinquiére, 1910), A. incertus (Spath, 1939), A. ellipticus (Mantell, 1822) and A. collignoni (Föllmi, 1989), although the present authors consider the species described by Föllmi from Vorarlberg (Austria) to be a somewhat uncertain member of the genus. The Cuban specimens appear not to be identical with any of these species, but description of a new species will have to wait until more and better material is available.

**Occurrence.** These forms are found in the calcareous levels of the Provincial Formation exposed in the Province of Villa Clara, Cuba. Outside Cuba, the genus has been documented in the upper Albian *Stoliczkaia (S.) dispar* Zone of England, Austria and France; and from the lower Cenomanian *Mantelliceras mantelli* Zone, *Neostlingoceras carcitanense* Subzone of France, Poland, England and Algeria.

### Substage and Zones

<table>
<thead>
<tr>
<th>Substage</th>
<th>Zones</th>
<th>Subzones</th>
</tr>
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<tbody>
<tr>
<td>upper Albian</td>
<td><em>Stoliczkaia (S.) dispar</em></td>
<td>briacensis - dispers -</td>
</tr>
<tr>
<td></td>
<td><em>Mortoniceras inflatum</em></td>
<td>perinflatum - rostratum -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>?- - - ?- - blancheti -</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 subzones - unnamed -</td>
</tr>
<tr>
<td></td>
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<td>cristatum -</td>
</tr>
</tbody>
</table>

Fig. 4. Upper Albian ammonites of the Provincial Formation from the section studied. (A–C) *Stoliczkaia (Stoliczkaia) cf. clavigera* (Neumayr), all x1. (A) MNHNCu-92.001127. (B) MNHNCu-92.001128. (C) MNHNCu-92.001129. (D–E) Algerites sp. (D) MNHNCu-92.001130, x1. (E) MNHNCu-92.001131, x2.

Fig. 5. Standard ammonite zonation of the upper Albian Substage (after Owen, 1999 and Reboulet et al., 2009). The section discussed in this paper is considered to be part of the upper Albian *Mortoniceras rostratum* Subzone (shaded area) of the *Stoliczkaia (Stoliczkaia) dispar* Zone, which in turn is approximately equivalent to the *Stoliczkaia (Faraudiella) blancheti* Subzone of the Mediterranean standard (Reboulet et al., 2009).

### 5. Discussion and conclusions

Descriptions of the Cretaceous ammonite fauna of Cuba has been largely restricted to local reports not widely circulated outside the country, though the occurrence of Albian ammonites in the Provincial Formation has been mentioned in mapping reports, such as Kantchev et al. (1978).
The ammonites in the micritic and marly limestones of the stratigraphic section studied show that the Provincial Formation that crops out at in the study area is of late, but not latest, Albian age. The presence of Proteotragonites cf. aeolus (d’Orbigny), Desmo- ceras (Desmoceras) cf. latidorsatum (Michelin), cf. Discohoplites sp., Mortoniceras sp., C. spinosum (Pervinquière), C. wenoensis (Adkins), Stoliczkaia (Stoliczkaia) cf. clavigera (Neumayr), and Algerites sp. indicates a Tethyan assemblage typical of the uppermost Albian Stoliczkaia (Stoliczkaia) dispar Zone (Fig. 5). The presence of Mortoniceras suggests that the assemblage does not range up to the top of the Albian, though the co-occurrence of Mortoniceras with Algerites is remarkable due to the questionable late Albian record of the latter genus.

The ammonite fauna also reveals a strong Tethyan affinity, with boreal species represented. Hoplitidae are present, but scarce, and given the abundance of other ammonite fossils, this would seem to be a genuine reflection of their lack of importance within this ammonite fauna. This is important because the Albian was characterized by a division of northern hemisphere ammonite assemblages into distinct Tethyan, Boreal, and Arctic realms, a division that has been extensively discussed elsewhere (Owen, 1996, 1999, 2002; Owen and Mutterlose, 2006). Contemporaneous ammonite assemblages of the Arctic and Boreal realms differ greatly from those typical of the Tethyan Realm, particularly in the dominance of the genera Analohoplites, Discohoplites and Callihoplites in Boreal faunas compared with their absence from Tethyan ones.

Late Albian European ammonite faunas show “a general co-existence of Tethyan ammonites with the endemic hoplitid popula- tion” (Owen and Mutterlose, 2006, p. 722). In our study of the late Albian Cuban fauna, the same scenario would seem to exist, though more material is required to fully discuss and detail this phenomenon. Owen and Mutterlose (2006, p. 722) have published a revised scheme for the late Albian of Suriname relevant to the coeval ammonite assemblages of Venezuela and the South Atlantic region, but because they did not describe any ammonites from the dispar Zone of that area, contrasts cannot be made with the present discussion of the Provincial Formation ammonite fauna.

Kennedy (2004, p. 866) used the threefold zonation of Owen (1999) for the dispar Zone deposits of northeastern Texas. He reported C. wenoensis, C. spinosum and S. (S.) clavigera from the lower part of the Pawpaw Shale, which can be correlated with the rostratum Subzone of the European succession. We also regard our Cuban material as part of the Mortoniceras rostratum Subzone of the dispar Zone (sensu Owen, 1999 and Kennedy, 2004), which in turn is more or less equivalent to the Stoliczkaia (Faraudella) blancheti Subzone of the Mediterranean standard (Reboulet et al., 2009) (Fig. 5).

Ammonite provincialism continued into the early Cenomanian but was less prominent, Hypohoplites rising to dominance, whereas Schoenbachia in the Boreal and Arctic realms became steadily less important (Wright et al., 1996).

Finally, the late Albian ammonite species presented here have not been reported from Cuba or any other Caribbean locality until now. Consequently these records shed new light on the paleo- biogeographic distribution of these taxa and allow for the first time precise long-distance correlations between Cuba and other parts of the world using the “standard” Albian ammonite zonations.

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