Small Berriasian, lower Valanginian and Barremian heteromorphic ammonites from the Río Argos succession (Caravaca, southeast Spain)

Zdeněk Vašíček & Philip J. Hoedemaeker

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Z. Vašíček, VŠB – Technical University of Ostrava, 17 listopadu 15, 708 33 Ostrava-Poruba, Czech Republic (zdenek.vasicek@vsb.cz); Ph. J. Hoedemaeker, Nationaal Natuurhistorisch Museum, Postbus 9517, NL-2300 RA Leiden, The Netherlands (hoedemaeker@naturalis.nnm.nl).

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The small heteromorphic ammonites from the Berriasian, lower Valanginian and Barremian strata of the Río Argos succession (west of Caravaca, southeast Spain) are described. One new genus is introduced, *Sabaudiella* (type species *Ancyloceras sabaudianum* Pictet & de Loriol, 1858), and three new species, *Sabaudiella argosensis* (small paraspinoid shell), *Protancyloceras obscurocostatum* (weak retroverse ribs with small ventrolateral tubercles) and *P.? evolutum* (evolute shell with occasional fibulation).

Contents

Introduction	11
Systematic descriptions	12
Palaeoecological remarks	25
References	25

Introduction

The Lower Cretaceous outcrops along the Río Argos, west of Caravaca, southeast Spain, has become the standard succession for the pre-upper Aptian in Spain. It is the most complete and best preserved succession known from Spain; only upper Aptian and lower and middle Albian sedimentary rocks are missing due to a hiatus. The succession was deposited in a rather deep water environment (estimated depth *c.* 300 m; Hoedemaeker & Leereveld, 1995), and consists of a rhythmic alternation of marlstone and marly *Nannoconus* limestone beds.

Only the 1500 m thick succession of Berriasian up to lowest Aptian has been studied in detail; the upper Albian has yet to be examined. A preliminary collection and determination of the ammonites (Hoedemaeker, 1982; Hoedemaeker & Leereveld, 1995; Aguado *et al.*, 2000), belemnites (Janssen, 1997) and aptychi (Vašíček & Hoedemaeker, 1997) revealed that all ammonite zones from Berriasian up to lowest Aptian are present. The calpionellids (Allemann *et al.*, 1975; Hoedemaeker & Leereveld, 1995; Aguado *et al.*, 2000), dinoflagellates (Hoedemaeker & Leereveld, 1995; Leereveld 1997a, b), nannofossils (Grün & Allemann, 1975; Hoedemaeker & Leereveld, 1995) and planktonic foraminifers (Coccioni & Premoli Silva, 1994) have been studied, whereas the benthic foraminifers and radiolarians are still to be determined. The cyclostratigraphy



Fig. 1. Fragment of the suture-line of *Protancyloceras obscurocostatum* n. sp. at H = 5.8 mm. Spec. RGM 365230 from bed Y266.

(Ten Kate & Sprenger, 1989; Sprenger & Ten Kate, 1992) and sequence stratigraphy (Hoedemaeker, 1995b, 1998, 1999, 2001) of the succession has been examined as well as the magnetostratigraphy, although the sedimentary rocks appear to have been remagnetized during the Neogene (Hoedemaeker *et al.*, 1998).

In this paper the small heteromorphic ammonites are described. They were selected from the ammonite collection as protancyloceratids and leptoceratoids, but several of them appear to be small ancyloceratids. Some of the protancyloceratids were incorrectly identified by Hoedemaeker (1982).

Ammonite biozones are referred to as, for example, *Subthurmannia boissieri* Zone (italics, genus name and species name), whereas the chronostratigraphic counterparts of these biozones, the biochronozones, are referred to as, for example, Boissieri Zone (roman, only species name, but with a capital).

Systematic descriptions

Herein, we do not follow the concept of Wright *et al.* (1996) with respect to the phylogenetics of the Ancyloceratina, but instead prefer the phyletic hypothesis of Cecca (1997). We presuppose that, just as the splitting of the family Choristoceratidae in the Triassic and the family Spiroceratidae in the Middle Jurassic from the main evolutionary line of the suborder Ammonitina, similarly the heteromorphic

family Bochianitidae split off at the beginning of the Tithonian, roughly at the same time as the subfamily Protancyloceratinae developed. However, exact data on their beginning are still missing. Provisionally, we consider the family Bochianitidae to be of higher rank than the Protancyloceratinae, although the opposite cannot be excluded. Only in the late Valanginian did true ancyloceratids (Ancyloceratoidea) appear, which formed the basis of the suborder Ancyloceratina. In our view, the quadrilobate suture in the evolutionary line of ammonites was thus iterativelly achieved at several different times.

The following morphological abbreviations are used: D, diameter; H, whorl height; W, whorl width; U, umbilical diameter. Suture symbols: E, external lobe; L, lateral lobe; U, umbilical lobe; I, internal lobe. The described material is deposited in the Nationaal Natuurhistorisch Museum (National Museum of Natural History), Leiden, The Netherlands (RGM).

Suborder Ammonitina Hyatt, 1889 Superfamily Perisphinctoidea Steinmann, 1890 Family Bochianitidae Spath, 1922 Subfamily Protancyloceratinae Breistroffer, 1947

Diagnosis — Small, free coiled heteromorphs with annular ribs, a round or oval whorl section, with or without marginal tubercles. Lower Tithonian to Barremian.

Genus Protancyloceras Spath, 1924

Type-species — *Ancyloceras Guembeli* Oppel *in* von Zittel, 1870. Tithonian, Poland.

Protancyloceras punicum Arnould-Saget, 1953 Pl. 1, figs. 1-2.

1953 Protancyloceras punicum nov. sp. — Arnould-Saget: 114, pl. 11, figs. 1-3.
1953 Protancyloceras depressum nov. sp. – Arnould-Saget: 116. pl. 4 a-c, 8 a-e.
1985 Protancyloceras punicum Arnould-Saget — Company & Tavera: 158, pl. 1, figs. 1-8 (cum syn.).
1987 Protancyloceras punicum Arnould-Saget — Company: 89, pl. 1, figs. 1-6.
1997 Protancyloceras punicum Arnould-Saget — Faraoni et al.: pl. 3, fig. 14.
1999 Protancyloceras cf. punicum Arnould-Saget — Vašíček & Michalík: fig. 6/7.

Material — Three incomplete shell preserved as impressions; RGM 365 224 from bed M43, RGM 365 229 from bed X258, RGM 365 225 from bed Z227.

Description — Loosely coiled shells of small to medium size. The shells bear relatively thin and dense subradial to faintly S-shaped ribs that are projected near the venter. The largest specimen has a diameter of c. 35 mm.

Remarks — The larger shell, RGM 365 229, belongs, by virtue of the density of its ribbing, to the group of shells described by Arnould-Saget (1953) as *P. depressum*. They were put into synonymy with *P. punicum* by Company & Tavera (1985). On the other hand, the type of ribbing and the whorl height of the largest specimen is similar to the most juvenile portion of the holotype of the Tithonian species *Protancyloceras kurdistanense* Spath, 1950 (pl. 9, fig. 1). With respect to the expected shape of the juvenile

whorls of the latter species (Spath, 1950, pl. 9, fig. 5), we do not consider the identity of the largest shell from the Río Argos with *P. kurdistanense* to be probable.

Distribution — From the upper Berriasian (Boissieri Zone) to lower Valanginian (Pertransiens Zone) of Spain (Company, 1987), from southeast France (Blanc *et al.*, 1992, 1994; Bulot *et al.*, 1993) and from the middle Berriasian of Tunisia (Arnould-Saget, 1953). Recently a specimen from the lower Valanginian (Otopeta Zone) of the Central Appennines in Italy was illustrated (Faraoni *et al.*, 1997). One redeposited fragment of a small whorl was also found in the Lower Cretaceous deposits in the locality of Stramberg (Czech Republic).

Occurrence — Río Argos, middle Berriasian, Occitanica Zone, Subalpina Subzone; upper Berriasian, Alpillensis Zone.

Protancyloceras bicostatum Arnould-Saget, 1953 Pl. 1, fig. 3.

1953 Protancyloceras bicostatum nov. sp. — Arnould-Saget: 119, pl. 11, figs. 11a-f. 1997 Protancyloceras bicostatum Arnould-Saget — Faraoni *et al.*: pl. 4, figs. 2-4.

Material — Only half a whorl, partly preserved as an external cast and partly as an impression (RGM 212 416 from bed Z195 in the highest part of Grandis Subzone). It lacks the juvenile whorls. Unfortunately, preparation has made the peripheral spines somewhat more conspicuous than they really were in life.

Description — A loosely coiled shell of medium size. On the adult whorl the sharp and thin subradial ribs are well preserved. Some of the ribs unite in pairs in ventrolateral spines on the periphery (fibulation); others remain simple, each provided with a similar spine; a small number of ribs remain simple and do not bear spines. The shell has a maximum diameter of *c*. 23 mm and a whorl height of 5.2 mm measured between the peripheral spines; H/D = c. 0.22.

Remarks — *Protancyloceras bicostatum* is characterized by the common fibulation of ribs. However, on the Tunisian holotype no simple inserted ribs without spines are visible.

Distribution — The holotype comes from the locality of Djebel Nara (Tunisia), which according to Busnardo *et al.* (1976) is of middle Berriasian age (Subalpina Subzone). The Italian material of the Central Appennines is from the lower Valanginian Pertransiens Zone.

Occurrence — Lower Berriasian, section Z, Grandis Subzone.

Protancyloceras sp. aff. P. gracile (Oppel, 1865) Pl. 1, figs. 4-5.

1950 Protancyloceras sp. aff. gracile (Oppel) - Spath: 122, pl. 9, fig. 6.

Material — Two incomplete shells preserved as casts or their impressions (RGM 365 227 from bed X258 in the top part of the Alpillensis Subzone; RGM 212 417 from bed Y266 in the Otopeta Zone).

Description — Curved shells with a slowly increasing whorl height, bearing simple, dense, straight ribs, which become less dense in the more adult part of the shell. The

ribs are slightly proverse, passing over the venter without interruption.

Remarks — On the ventral side of the smaller shell (RGM 212 417) the ribs bend in a chevron-fashion and rather small tubercles are visible. The density of the ribs, their course and the shape of RGM 365 227 are very similar to the shell described by Spath (1950) as *P*. sp. aff. *gracile*. However, the holotype of *P*. *gracile* (von Zittel, 1870, pl. 36, fig. 3) differs a little from Spath's specimen as well as those from Spain, being smaller and more prominently ribbed. Another related species is *P*. *passendorferi* Wierzbowski, 1990, which has a straight shell and less obvious ribs, which are more oblique and interrupted on the ventral side.

Distribution — Typical representatives of *P. gracile* and probably also Spath's cited specimen come from the middle Tithonian.

Occurrence — Río Argos, upper Berriasian, Alpillensis and Otopeta Zones.

Protancyloceras obscurocostatum n. sp. Fig. 1; Pl. 1, figs. 6-8.

Holotype — RGM 365 230 from bed Y266B, Otopeta Zone, Los Miravetes along the Río Argos, Caravaca, Murcia, Spain.

Derivatio nominis — obscurocostatum, Latin, meaning obscurely ribbed.

Diagnosis — A loosely coiled criocone. Ribs weak, retroverse. Small ventrolateral tubercles.

Material — The holotype is the only known specimen and is largely preserved as an impression. A quarter of a whorl at the end of the phragmocone is preserved as a distorted steinkern with the remains of suture lines.

Description — Shell of medium size (diameter *c*. 35 mm) with loosely coiled whorls. Whorls of medium height and only faintly curved. Weak, rather dense ribs, convex towards aperture and visibly retroverse. A few small ventrolateral tubercles present on phragmocone. At the end of the phragmocone these tubercles are accompanied by ribs that become stronger towards the periphery. Beginning of living chamber indicated by marked change in slightly distorted whorl height. Living chamber occupies a little more than half a whorl, and covered by dense, weak ribs with a curvature similar to those on phragmocone. Some pairs of ribs unite in prominent, distant ventrolateral tubercles.

Suture-line — Some imperfectly preserved suture lines at the end of the phragmocone (H = 5.8 mm) show a narrow lateral (L) and a less deep umbilical (U) lobe. Both are subdivided in a rather simple finger-fashion.

Measurements — Diameter of shell *c*. 35 mm. When D = 33.4 mm, H is 9.5mm (0.28) and U = 18.5 mm (0.55).

Remarks — The style of coiling of the shell and the shape of the suture line are diagnostic of the genus *Protancyloceras*. The suture line correspond best to the one depicted by Arnould-Saget (1953, text-fig. 60). The most characteristic features of the new species are the suppressed ribbing and the distant ventrolateral tubercles on the periphery.

Occurrence — Río Argos, uppermost Berriasian, Otopeta Zone.

Protancyloceras? evolutum n. sp. Pl. 2, fig. 7.

Holotype — RGM 365 226 from bed M80, middle Berriasian (Subalpina Subzone and possibly a part of the Privasensis Subzone), Río Argos, north of Cortijo Las Oicas de Enmedio.

Diagnosis — An evolute, densely ribbed shell. The ribs end in ventrolateral tubercles. Occasional fibulation occurs.

Material — The holotype is the only specimen known. An complete distorted external mould of which the innermost whorls are not preserved. The periphery of the last quarter of a whorl, which belongs to the incomplete living chamber, is not well preserved.

Description — A small evolute shell; the whorls are just in contact. The living chamber occupies a little more than a quarter of the last whorl. The whorls are slightly curved and rather high. The shell is densely ribbed. On the inner whorl the ribs are simple; on the living chamber a tendency of the ribs to be in pairs in the vicinity of the umbilicus can be discerned. The peripheral ends of the ribs are not preserved on the inner whorl nor on the living chamber. On the remaining part all ribs bear small ventrolateral tubercles and sporadical fibulation is evident. Two ribs originate sporadically from a common point at the umbilicus. Altogether the ribs are subradial to slightly S-shaped and slightly projected.

Measurements — The shell attains a maximal diameter of 29.5 mm. At a diameter of 25.5 mm the whorl height (H) is 10.6 mm (0.415) and the umbilical width (U) is 10.0 (0.39).

Remarks — The generic assignment of this species is rather problematic. No suture line is known. Occasional fibulation supports the genus *Protancyloceras*, but the evolute coiling and the trend of the ribs on the living chamber to fork in the vicinity of the umbilicus are features that can be regarded as anomalous for this genus.

Occurrence — Río Argos, middle Berriasian, Subalpina Subzone.

Genus Leptoceras Uhlig, 1883

Type-species — Ancyloceras Brunneri Ooster, 1860. Berriasian, Switzerland.

Leptoceras studeri (Ooster, 1860) Fig. 2; Pl. 2, figs. 1-4.

1860 Ancyloceras Studeri — Ooster: 26, pl. 36, figs. 7-15.

1966 Leptoceras studeri (Ooster) - Thieuloy: 291, pl. 1, figs. 2-6, pl. 2, figs. 2-8 (cum syn.).

- e.p. 1985 *Leptoceras studeri* (Oooster) Company & Tavera: 160, pl. 1, figs. 10-14, 16 (cum syn.); non figs. 15, 17 (= *Leptoceras brunneri* Ooster).
- e.p. 1987 *Leptoceras studeri* (Ooster) Company: 91, figs. 8-9; non figs. 7, 10 (= *L. brunneri*). 1987 *Leptoceras studeri* (Ooster) — Immel: 115, pl. 11, fig. 5.

Material — Almost twenty specimens are imperfectly to fragmentally preserved as external moulds distorted in the plane of bedding, or as impressions (for example from the Subalpina Subzone: RGM 365 219 from bed M35; from the higher part of the Alpillensis Subzone: RGM 352 474 from bed M194A, RGM365 205 from bed X244, RGM 365 206 from bed X 249, six fragments from bed X249, RGM 365 209 from bed Y240-249, RGM 365 210, RGM 365 211and RGM 365 213 from bed X (or Y) 245-251, RGM 365 217

from bed Y249; from the Pertransiens Zone: RGM 365 222 from bed Y316) and two limonitic undistorted fragments of the adult whorl (RGM 365 208 from bed Y233-259 and RGM 365 207 from bed X251, both from the higher part of the Alpillensis Subzone). On a few specimens a well preserved suture-line can be seen (RGM 365207).

Description — Shells of small to medium size. Adult shells are usually evolutely coiled, sometimes with loose whorls, which increase rapidly in height. The relatively high whorls bear prominent, simple, subradial to convexly curved, retroverse ribs. On strongly deformed whorls the ribs can even be S-shaped. The ribs do not bear tubercles and pass over the venter without interruption and weakening. Ribs crossing the venter of heavily distorted shells sometimes give the impression that they bear peripheral spines. Most shells have a diameter of 20-25 mm.

Suture-line — The suture-line of the adult whorl (H = 3.6 mm) is rather divided. The outer lobe (E) is not deep and has a low secondary saddle. The rather wide lateral lobe (L) is almost twice as deep as the outer lobe. It is divided into many sub-lobes without apparent symmetry. The lobe U is small, narrow and trifid. The internal lobe (I), which is not perfectly preserved, is narrow, almost as deep as the outer lobe, and probably asymmetric. The lateral saddle is conspicuously bipartite. The remaining saddles are faintly divided. The U/I saddle is the widest of all. The adult suture-line corresponds better to the suture-line of *L. studeri* depicted by Thieuloy (1966, text-fig. 3) than to the suture-lines given by Wiedmann (1969, text-fig. 9).



Fig. 2. The complete suture-line of *Leptoceras studeri* (Ooster, 1860) at H = 3.6 mm and B = 3.1 mm. Spec. RGM 365207 from bed X251.

Remarks — Morphologically *L. studeri* is a very variable species, which was documented best by Nikolov (1967) in his detailed description of Bulgarian specimens. However, he designates them by invalid genus and species names, viz. *Proleptoceras jelevi* Nikolov, which is a synonym of *L. studeri* (see, for example, Dimitrova, 1967; Company & Tavera, 1985). The differences are obvious, especially in the density of the ribbing of the specimens, which led Nikolov (1967) to define three subspecies: a densely ribbed form *P. j. mazenoti*, a medium ribbed form *P. j. jelevi* and a sparsely ribbed form *P. j. sapunovi*. In the material from the Río Argos, the morphotype with the medium density of ribbing dominates and probably occurs in all known localities given in literature. Only one specimen (from bed X267) corresponds to the sparsely ribbed type "*sapunovi*" (Pl. 2, fig. 5).

Distribution — *Leptoceras studeri* is known from the upper Berriasian (Boissieri Zone) to the lower Valanginian (Otopeta Zone and base of Pertransiens Zone) of the Mediterranean province: Switzerland, southeast France, Spain, Northern Calcareous Alps, and Bulgaria.

Occurrence — Río Argos, upper Berriasian and lower Valanginian, higher part of the Alpillensis Zone, Otopeta Zone and lowest part of the Pertransiens Zone.

Leptoceras brunneri (Ooster, 1860) Pl. 2, fig. 6.

1860 Ancyloceras Brunneri - Ooster: 31, pl. 37, figs. 10-13.

1966 Leptoceras brunneri (Ooster) — Thieuloy: 290, pl. 1, figs. 1a-b, pl. 2, fig. 1.

e.p. 1985 Leptoceras studeri (Ooster) - Company & Tavera: pl. 1, figs. 15, 17.

e.p. 1987 Leptoceras studeri (Ooster) - Company: pl. 1, figs. 7, 10.

1987 Leptoceras brunneri (Ooster) — Immel: 115, pl. 11, fig. 6.

?1990 Leptoceras brunneri (Ooster) — Avram: 44, pl. 1, figs. 3-4.

Material — One nearly complete shell with a limonitized phragmocone (RGM 212 418 from bed Y267) and in addition one fragment of the whorl (specimen RGM 365 221 from bed M216).

Description — The shell is of medium size with irregularly shaped free whorls. The ribbing of the adult whorls is subradial to curved with an adoral concavity and is very dense and irregular.

Remarks — The related species *L. studeri* (Ooster) differs from *L. brunneri* in the higher whorls, the usually less dense ribbing, the retroverse direction of the ribs in a part of the adult whorls and usually in a higher degree of coiling of the adult whorls, which are commonly in contact with each other.

Distribution — *L. brunneri* is known from the late Berriasian of Switzerland, southeast France, Spain, the Northern Calcareous Alps, and perhaps from Rumania.

Occurrence — Río Argos, upper Berriasian, Otopeta Zone; lower Valanginian, lower Pertransiens Zone.

Genus Sabaudiella n. gen.

Type species — Ancyloceras Sabaudianus Pictet & de Loriol, 1858. Lower Barremian, France.

Diagnosis — Small to medium sized, hooked to paraspinoid shells with a juvenile portion coiled in an open spiral. On the periphery of the adult, small marginal tubercles are present on the ribs, in which fibulation appears from time to time. The suture-line is complex with an asymmetrically trifid L and bipartite saddles.

Discussion — The manner of coiling of the juvenile parts of the shells of the genus *Sabaudiella* generally resembles the juvenile shells of *Crioceratites* Léveillé. They differ from those of the latter genus by the absence of main tuberculated ribs. Moreover, the complex suture-line of the Spanish specimens excludes the inclusion of *Sabaudiella* into the group of leptoceratoid ammonites which have very simple suture-lines. However, the suture-line at the equivalent diameter of the shell corresponds only little to that of the genus *Crioceratites* or *Emericiceras* (Wiedmann, 1963, fig. 3; Vašíĉek & Klajmon, 1998, fig. 2).

As to the shape of the shell, a certain similarity can be observed with the late Barremian species *Toxoceratoides sudalpinus* Cecca & Landra, 1994, or with the fragment described as *Toxoceratoides* sp. by Delanoy (1992, pl. 6, fig. 12); it may be designated as a toxoceratid shell (Aguirre Urreta, 1986, fig. 7E). Another similarity lies in the fibulation of the ribs and the basic features of the suture-line, but *Toxoceratoides* is characterized by periodic trituberculated ribs.

In addition to the type species, the new species *S. argosensis* can be assigned to the genus *Sabaudiella* and probably also an indeterminate species (see below). Another new species from Cuba, of which a specimen was illustrated by Myczynski & Triff (1986, pl. 1, fig. 9) under the name *Crioceratites* sp. cf. *stubelensis* Dimitrova, 1967 probably belongs to *Sabaudiella*.

Sabaudiella sabaudiana (Pictet & de Loriol, 1858)

- e.p. 1858 Ancyloceras Sabaudianus, Pictet et de Loriol Pictet & de Loriol: 29, pl. 6, figs. 1-2, ?4, ?10; non figs. 3, 5, 6-9, 11-12.
- ? e.p. 1860 Ancyloceras Fourneti Astier Ooster: 22, pl. 34, figs. 10-11; non fig. 9.
- non 1863 Ancyloceras Sabaudianum Pictet et Loriol Ooster: 10, pl. C, figs. 5-7.
- non 1902 Crioceras (Leptoceras) Sabaudianum Pictet et de Loriol Sarasin & Schöndelmayer: 150, pl. 20, figs. 5-6, pl. 21, fig. 1.
 - 1955 Leptoceras (?Lytocrioceras) sabaudianum Pictet et de Loriol Sarkar: 139.
- non 1995a Hamulinites sabaudianus (Pictet & de Loriol) Hoedemaeker: 239, pl. 8, figs. 7-8 (sed S. argosensis).

Holotype — *Ancyloceras Sabaudianus* Pictet & de Loriol, 1858, pl. 6, fig. 2. Lower Barremian, Hivernages, France. Deposited in the Collection of Pictet in the Museum of Natural History in Genève (Switzerland).

Description — Shells of medium size. The crioceratid spiral of the young shell passes into the hooked adult with subparallel shafts. On the adult shell short marginal spines are present. Occasionally two ribs unite in one spine (fibulation).

Remarks — On the original illustration of the holotype, neither spines nor fibulation is visible. However, they are clearly depicted in the reconstruction of the holotype carried out by Pictet & de Loriol (1858, pl. 6, fig. 1).

The systematic position of the species "sabaudianum" was a long time unclear, because Sarasin & Schöndelmayer (1902), who described this species in detail, had at

their disposal the rich original material of Ooster (1863), but probably not that of Pictet & Loriol (1858). Ooster's material is characterized by shafts running close to each other. Further, it follows from Sarasin & Schöndelmayer's analysis that the size of *S. sabaudiana* varies considerably. These authors distinguished a group with small shells and a group with large ones. The latter allegedly could reach a total length of 100 mm (small and large specimens according to Sarkar, 1955). Besides size, the specimens differ considerably in the trituberculation (according to the original figuration of Ooster) or bituberculation of ribs (according to the description of Sarasin & Schöndelmayer (1902) both varieties are connected by transitions. However, the different tuberculation assigns the set of Ooster's shells (which forms the foundation for Sarasin & Schöndelmayer, 1902) to another genus or genera.

Distribution — According to the literature, *S. sabaudiana sensu stricto* is only known from ?lower Barremian deposits in France.

Sabaudiella argosensis n. sp. Figs. 3-4; Pl. 3, figs. 1–6.

?1923 Holcodiscus gr. H. evolutus Fall. et Term. — Fallot & Termier: pl. 5, figs. 22-23.

1995a Hamulinites sabaudianus (Pictet & de Loriol) — Hoedemaeker: 239, pl. 8, figs. 7-8.

1995 "Paraspinoceras" evolutum (Fallot & Termier) — Cecca et al.: pl. 1, figs. 13-16.

Holotype — RGM 212 419, specimen from block N, derived from one of the beds between W35 and W46. Lower Barremian, Río Argos, Spain.

Type locality and horizon — Section W, 100 m west of Case de Alguacil. West of Caravaca, lower Barremian, Catulloi Subzone, Río Argos.

Diagnosis — Small paraspinoid shells. The juvenile shell is crioconic, ornamented with dense simple ribs. On the adult part, at first ribs with marginal tubercles alternate irregularly with ribs without them. Fibulation is present. On the hooked living chamber, all ribs bear marginal tubercles.

Material — Eight fragmentary specimens diagenetically flattened on the bedding surfaces, of which usually only an area around the hooked bend (flexus) is preserved (RGM 212 420, specimens from bed W34A-35, and from block D, block F, and block N derived from one of the beds between W35-46) or only an incomplete juvenile coiled part (RGM 387 948 and RGM 212 421 from blocks N and M respectively from one of the beds between W35-46); no shell is complete. Sculpture moulds prevail generally accompanied by counter-impressions; in three cases imperfectly preserved remains of suture-lines are visible.

Description — Paraspinoid shells of small, but non-uniform, size with an open rounded hook and therefore, rather distant shafts. The juvenile portion is coiled in an open crioconic spiral (the embryonal part is unknown). This part is covered by thin, dense, simple, uniform ribs. The diameter of the juvenile spiral is *c*. 16-20 mm. The ribs are straight to slightly convex, faintly prorsiradiate. A well preserved section of the most juvenile part in one of the specimens shows weak constrictions or rather broad interspaces separated by 5 to 7 normally spaced ribs (not successfully photographed). Because of the imperfectly preserved periphery of the coiled portion of the shell, the periodic presence of marginal tubercles with short spines (which occur on

well preserved parts of the first shaft) cannot be ascertained.

In the transition between the juvenile spiral and the slightly curved shaft (proversum), the ribs gradually strengthen and become less dense. They are slightly convex in the direction of the shell aperture. At first, nearly every second rib ends in a rather small marginal tubercle. The rib between two tuberculated ribs may or may not join the marginal tubercle (fibulation). Towards the hook (flexus) simple ribs gradually disappear and almost all ribs bear marginal tubercles. The marginal tubercles are situated rather close to the siphonal line; the narrow ventral furrow between them is probably emphasized by deformation (Fig. 3).

On the hook almost all ribs bear marginal tubercles, maybe less marked than those on the proversum.

Fig. 3. *Sabaudiella argosensis* n. sp., reconstruction of the complete shell.

Measurements — The most complete shell (RGM 387 948 from block N derived from one of the beds between W35 and W46) reaches the total shell height of *c*. 42 mm. Its spiral part has the maximum diameter of 17 mm, whilst in the specimen from block M (derived from one of the beds between W35 and W46) it is 18.5 mm. The height of the hook (in the specimen from block N) only slightly exceeds 9 mm; on a specimen from block F (derived from one of the beds between W35 and W46) it is only 7.8 mm.

Suture line — The incomplete suture lines of all the shells are complicated. In all cases only lateral lobes (L) with adjacent saddles are preserved (Fig. 4). The saddles are probably bifid, the oblique lateral lobes are asymmetrically trifid.

Remarks — The specimens from the Río Argos belong to the category of small sized shells, perhaps microconchs, but dimorphism in *Sabaudiella* is hitherto unknown. The paraspinoid shape of the shells is variable; also the size of the Spanish specimens is not uniform, ranging from c. 35 to 45 mm. The size of the holotype of *S. sabaudiana* (Pictet & de Loriol) is larger, reaching 57 mm. Besides the greater dimensions, the type species differs from *S. argosensis* in the subparallel course of shafts.

In the original picture of the holotype of *S. sabaudiana*, no marginal tubercles are depicted. However, the reconstruction by Pictet & de Loriol (1858, pl. 6, fig. 1) shows both the marginal spines and fibulation. Similarly, on the curved shafts of *S. argosensis* the tuberculation and fibulation are visible. They can be suppressed or conspicuous (see also Hoedemaeker, 1995a, pl. 8, fig. 8). A similar situation also exists with the less perfectly preserved shells identified as "*Paraspinoceras*" evolutum Fallot & Termier and illustrated by Cecca *et al.* (1995, pl. 1, figs. 13-16). Specimens in Cecca *et al.* (1995, figs. 14, 16) show fibulation (their "buckled ribs"); the remaining specimens being without fibulation.



Fig. 4. Fragment of the suture-line of *Sabaudiella argosensis* n. sp. at H = 5.5 mm. Specimen RGM 212 426 from block F from a bed between beds W35 and W46.



Fig. 5. *Sabaudiella*? sp. indet., RGM 387 971 from block F from a bed between beds W35 and W46. Reconstruction of the shell (without the unknown embryonal part). On the periphery the small spines are significant.

One of the specimens illustrated by Myczynski & Triff (1986, pl. 1, fig. 9) under the name *Crioceratites* sp. cf. *C. stubelensis* Dimitrova, is probably close to *S. argosensis*. It is distinguished, as far as it can be assessed from the poor quality of the illustration, by the marked fibulation of the ribs on the hook.

Distribution — Sabaudiella argosensis is known from Italy (Umbria-Marche Apennines) from the lower Barremian Hugii Zone. It probably occurs also in the Balearic Isles.

Occurrence — Río Argos, lower Barremian, Catulloi Subzone.

> Sabaudiella? sp. indet. Fig. 5; Pl. 3, fig. 7.

1995a Hamulinites paroulus paroulus (Uhlig) — Hoedemaeker: 240, pl. 8, fig. 10.

Material — One shell preserved as a

mould in combination with a counter-impression, in both cases with the juvenile part missing (specimen RGM 387971 from block F derived from one of the beds between W35 and W46).

Description — An open hooked shell of dwarf size. The juvenile portion was probably coiled as a loose spiral. The preserved portion bears simple, fine and dense proverse ribs. At both sides of the venter small marginal tubercles are present (Fig. 5). Under the microscope small adapically curved spines are visible on most ribs of the slightly curved shaft (proversum). Some ribs are simple. However, at the beginning of the hook, uncommon spines occur on some ribs in contrast with the retroversum, possibly due to imperfect preservation.

Measurements — The height of the entire shell is 18.5 mm. Ho in the bend is c. 4.5 mm.

Remarks — The broad spiral juvenile part and primarily peripheral spines excludes the assignment of this specimen to the genus *Hamulinites* Paquier. Unfortunately, the suture-line of the specimen is not preserved. The small size of shell and the absence of fibulation do not allow the unambiguous determination of the specimen.

Occurrence — Río Argos, lower Barremian, Catulloi Subzone.

Suborder Ancyloceratina Wiedmann, 1966 Superfamily Ancyloceratoidea Gill, 1871 Family Hamulinidae Gill, 1871 Genus *Anahamulina* Hyatt, 1900

Type species — *Hamulina subcylindrica* d'Orbigny, 1850. Hauterivian/Barremian boundary, France.

Anahamulina sp. aff. A. boutini (Matheron, 1879) Pl. 3, fig. 8.

1995 Anahamulina boutini (Matheron) — Cecca et al.: pl. 3, fig. 7.

Material — One imperfectly preserved sculpture mould (RGM 212 423 from bed A158).

Description — A small hooked shell with its subparallel shafts in contact. The sculpture on the proversum close to the bend consists of curved, oblique, simple ribs. On the bend, the ribs strengthen and bifurcate from the base. The retroversum, which is broader in comparison to the proversum, bears very strong, simple ribs (subhorizontal to slightly concave adoral).

Measurements — The preserved height of the shell without the substantial section of the juvenile part amounts to 32 mm.

Remarks — Matheron's holotype (1879, pl. C-18, fig. 6) differs from the shells given in synonymy by its larger size, its shafts being out of contact and the ribs not bifurcating on the bend. Although the Río Argos specimen is not identical with *A. boutini*, it is related nevertheless.

The Spanish specimen described herein differs from *Anahamulina* sp. ind. (Pl. 3, figs. 9, 10) in its obliquely running ribs on the proversum, its biplicate ribs on the bend, its shafts being in contact and probably also in its greater total size. The genus

Hamulinites Paquier, which usually has a curved proversum, lacks bifurcating ribs on the bend.

Distribution — Italian and Carpathian specimens come from the lower Barremian (Hugii Zone).

Occurrence — Río Argos, lower Barremian, Catulloi Subzone.

Anahamulina sp. indet. Fig. 6; Pl. 3, figs. 9-10.

?1994 ?Anahamulina sp. - Cecca & Landra: 407, pl. 1, figs. 9-10.

Material — Two incomplete shells imperfectly preserved as external moulds (RGM 212 424 from bed A163-195) and partly as steinkerns (internal moulds) with incomplete suture-lines (RGM 212 425 from bed A153).

Description — Small hooked shells with subparallel shafts, which are not in contact, but close to each other. The slender proversum bears simple straight ribs, which are perpendicular to the direction of the proversum. Their thickness equals the spaces between the ribs. On the bend, the ribs are convex and retroverse. On the incompletely preserved retroversum the ribs are oblique.

Measurements — The preserved part of the shells without the substantial part of the juvenile section measures 25 mm. On the bend the whorl height is *c*. 6 mm.

Suture-line — The two last incomplete suture-lines at the end of the phragmocone are characterized by a rather asymmetrically bifid lateral lobe (L) and two-branched saddles at both the sides of the lobe (Fig. 6).

Remarks — The prominent ornamentation, consisting of uniform ribs without tubercles, and the subparallel shafts correspond to the basic morphology of the genera



Fig. 6. A part of the suture-line of *Anahamulina* sp. ind. at H = 4.1 mm. Spec. RGM 212 425 from bed A153.

Hamulinites Paquier and *Anahamulina*. However, the suture-lines of the representatives of the genus *Hamulinites* differ in the shape of the lateral lobe. The Río Argos specimen differs from most species of *Anahamulina* in the small size of the shell and in the bifidity of the lateral lobe of the Spanish specimens instead of the narrow trifidity of the lobes of other species of *Anahamulina* (e.g., by Uhlig, 1883). However, the lateral lobe of the species *Anahamulina distans* Vašíček, 1972, is bifid (Vašíček & Wiedmann, 1994, text-fig. 4). Moreover, it is known that in the related genus *Ptychoceras* d'Orbigny, even within the framework of one species (*Ptychoceras minimum* Rouchadze), there are individuals that have bifid as well as trifid lateral lobes (Wiedmann *et al.*, 1990). With regard to the external morphology of the shell and to the more complicated shape of the suture-lines, which are similar to the suture-line of *Anahamulina distans*, we assume that the described shells should belong to the genus *Anahamulina*.

Distribution — The representatives of *Anahamulina* occur from the upper Hauterivian Angulicostata auctorum Zone to and including the lower part of the upper Barremian.

Occurrence — Río Argos, lower Barremian, Catulloi and Hugii Zones.

Palaeoecological remarks

Hoedemaeker (1995a) concluded that these small heteromorphic ammonites probably exhibited an opportunistic behaviour, because they flourished just after the ammonite mass extinctions caused by high-amplitude sea-level falls. The great frequency and diversity of *Protancyloceras* and *Leptoceras* in the Berriasian Subalpina and Alpillensis Subzones, respectively (Arnould-Saget, 1953; Hoedemaeker, 1982), and the similar massive re-appearance and great diversity of leptoceratoids in the Catulloi Subzone are good examples of this behaviour. Cecca (1997) determined that the representatives of Protancyloceratinae must have had a planktonic life habit and spread with the circum-equatorial surface currents. They originated in the Tithonian at the same time as the nannoconids became abundant. At the beginning of their evolution they developed cyrtoconic to gyroconic shells, but ancyloconic morphologies soon developed indicating an up and down movement in the water column.

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Plate 1

Figs. 1-2. *Protancyloceras punicum* Arnould-Saget, 1953. 1: RGM 365 229 from bed X258, ? 1. Impression. Section X (Los Miravetes), higher part of Alpillensis Zone. 2: RGM 365 225 from bed Z227, ? 1. Section Z (Barranco de Tollo), Subalpina Subzone.

Fig. 3. *Protancyloceras bicostatum* Arnould-Saget, 1953. RGM 212 416 from bed Z195, ? 1. Section Z (Barranco de Tollo), Grandis Subzone.

Figs. 4-5. *Protancyloceras* aff. *gracile* (Oppel, 1865). 4: RGM 365 226 from bed Y266, ? 2. The straightness of the shaft and the apparently hooky end of the shell do not correspond to reality; they are induced by a rather unsuitable preparation. Section Y (Los Miravetes), Otopeta Zone. 5: RGM 365 227 from bed X258, ? 1. Badly preserved impression. Section X (Los Miravetes), higher part of Alpillensis Zone.

Figs. 6-8: *Protancyloceras obscurocostatum* n. sp. Holotype, RGM 365 230, from bed Y266B, section Y (Los Miravetes), Otopeta Zone. 6: ? 1; 8: ? 2; 7: fragment of the outer part of whorl showing the marginal tubercles, ? 2.

Photos: K. Mezihoráková, University of Ostrava. All figured specimens were coated with ammonium chloride before photographing.



Plate 2

Figs. 1-4: *Leptoceras studeri* (Ooster, 1860). 1: RGM 365 217, from bed Y249, ? 2. Usual mode of coiling and preservation. Berriasian, Section Y (Los Miravetes), higher part of Alpillensis Zone. 2: RGM 365 205, from bed X244, ? 1. Berriasian, Section X (Los Miravetes), higher part of Alpillensis zone. 3-4: RGM 365 207, from bed X251. Fragment with preserved suture-lines. 3: ventral view, ? 1; 4: lateral view, ? 2. Same locality and zone as fig. 2.

Fig. 5. ?Leptoceras studeri (Ooster, 1860), morphotype "sapunovi" sensu Nikolov. RGM 365 223, from bed X276, ? 2. Same locality as fig. 2, Pertransiens Zone.

Fig. 6. Leptoceras brunneri (Ooster, 1860). RGM 212 418, from bed Y267, ? 2. Section Y (Los Miravetes), Otopeta Zone.

Fig. 7. *Protancyloceras? evolutum* n. sp. Holotype, RGM 365226, from bed M80, ? 1. Section M (Las Oicas de Enmedio), Subalpina Subzone.

Photos: K. Mezihoráková, University of Ostrava. All figured specimens were coated with ammonium chloride before photographing.



Plate 3

Figs. 1-6. *Sabaudiella argosensis* n. sp. 1-3: Holotype RGM 212 419 from block N from a bed between beds W35 and W46 (Catulloi Subzone). 1: impression of the juvenile part of the shell, ? 2; 2: detail of the proversum, ? 2; 3: contra-impression of the juvenile part and the proversum preserved as a sculpture mould, ? 1. 4: RGM 212 421 from block M from a bed between beds W35 and W46 (Catulloi Subzone). Juvenile part of the specimen with the partially preserved suture-line, ? 2. 5: RGM 387 948 from block N from a bed between beds W35 and W46 with the hook area (Catulloi Subzone), ? 1. 6: RGM 212 426 from block F from a bed between beds W35 and W46. Fragment of the proversum (with the preserved suture line on its beginning) and a part of the bend (Catulloi Subzone), ? 1.

Fig. 7. Sabaudiella? sp. indet. RGM 387 971 from block F from a bed between beds W35 and W46 (Catulloi Subzone), ? 2.

Fig. 8. Anahamulina aff. boutini (Matheron, 1879). RGM 212 423.from bed A158 (Catulloi Subzone), ? 1.

Figs. 9-10. Anahamulina sp. indet. RGM 212 425 from bed A153 (Base Catulloi Subzone) with a fragmentary preserved suture-line. 9: ? 1, 10: ? 2.

Photos: K. Mezihoráková, University of Ostrava. All figured specimens were coated with ammonium chloride before photographing.

