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Aalenian ammonites from the Catria Mts (Central Apennines, Italy)

Alberto Ferretti

Via don Mariano Mariotti, 13, I-61043 Cagli, Italy. E-mail: frralb@tin.it

Dedicated to the memory of
Serge Elmi and René Mouterde
"en très amical hommage et en souvenir
des journées passées ensemble
à chercher les ammonites
de la Catena del Catria".

Abstract

This paper describes ammonites collected from some outcrops of Catria Mts (Central Apennines). The taxa discussed are *Phylloceras*, *Holcophylloceras*, *Lytoceras*, *Alocolytoceras*, *Tmetoceras*, *Leioceras*, *Ludwigia*, *Brasilia*, *Graphoceras*, *Bredyia*, *Euaptetoceras*, *Planammatoceras*, *Erycites*, *Abbasitoides*, *Fontannesia*, *Zurcheria*, *Riccardiceras*. In particular, *Erycites* (macroconchs) and *Abbasitoides* (microconchs) have two stages of growth, the first involute with a depressed section and the second evolute with a compressed section. Hence, these stages are divided by a short stage showing an isodimensional section. By means of an analytic research it is possible to demonstrate the progressive transition of this section from large to little sizes during the Aalenian. These ontogenetic developments followed a specialized direction leading to the whorls of *Riccardiceras*.

Keywords

Ammonites, morphometry, ontogeny, biostratigraphy, Aalenian, Central Apennines.

Riassunto

Ammoniti aaleniane del gruppo montuoso del Catria (Appennini Centrali).- L'Appennino umbro-marchigiano settentrionale è costituito, procedendo da NNW a SSE, dai gruppi montuosi del Nerone (1525 m), del Petrano (1161 m), del Catria (1701 m) e del Cucco (1566 m). La ricchezza delle faune fossili, in particolare quelle ad ammoniti del Giurassico, la buona esposizione delle sezioni e interessanti eventi tettonico-sinsedimentari, hanno fatto di questa catena, fin dai secoli scorsi, un archivio della storia geologica delle regioni mediterranee. In questo lavoro sono descritte le ammoniti aaleniane raccolte nel gruppo del Catria, una parte in un affioramento del M. Acuto e per il resto, in tre piccoli affioramenti situati nel versante di destra della gola del fiume Burano, tra Cantiano e Cagli. Gli esemplari del M. Acuto sono in discreto stato di conservazione, ma quelli del versante del Burano, che fanno parte di depositi di bacino, mostrano segni marcati di risedimentazione. In tempi recenti, ammoniti d'età aaleniana sono state raccolte e descritte in più lavori da Cresta nel gruppo del Nerone, ma per la prima volta con questo lavoro sono descritte ammoniti aaleniane del gruppo montuoso del Catria. I taxa esaminati sono *Phylloceras*, *Holcophylloceras*, *Lytoceras*, *Alocolytoceras*, *Tmetoceras*, *Leioceras*, *Ludwigia*, *Brasilia*, *Graphoceras*, *Bredyia*, *Euaptetoceras*, *Planammatoceras*, *Erycites*, *Abbasitoides*, *Fontannesia*, *Zurcheria*, *Riccardiceras*. In particolare, *Erycites* (macroconca) e *Abbasitoides* (microconca) hanno due stadi di sviluppo, il primo involuto con una sezione depressa e il secondo evoluto con una sezione compressa. Questi stadi pertanto devono essere separati da una sezione di eguali dimensioni. Mediante indagini analitiche è stato possibile dimostrare una progressiva transizione di questa sezione da taglie grandi verso taglie sempre più piccole nel corso dell'Aaleniano. Queste tendenze ontogenetiche proseguirono in una precisa direzione la quale condusse ai giri di *Riccardiceras*.

Parole chiave

Ammoniti, morfometria, ontogenesi, biostratigrafia, Aaleniano, Appennini Centrali.

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INTRODUCTION

The Catria chain, in the northern part of the Central Apennines, includes from NNW to SSE the groups of M. Nerone (1525 m), M. Petrano (1161 m), M. Catria (1701 m) and M. Cucco (1566 m). The regional depositional history began during Late Triassic times as part of the Tethys.
Some aspects of local Tethyan topography, characterized by the oceanic basins and the high seamounts from which slipped large slumpings, are recorded in the gorges of Candigliano, Biscubio, Bosso and Burano rivers (Bernoulli, 1971, 1972).
The Aalenian sequence of the Marche-Umbria Apennines is distributed in two formations: the "Calcari e Marne a Posidonia" (late Toarcian-Bathonian) and the "Bugarone" Formation (late Toarcian-Tithonian). The first is a basin sequence of calcareous mudstones with resedimented deposits and reworked ammonites; the second is a condensed sequence of nodular or marly limestones, typical of seamount deposits (Cecca *et al.,* 1990).
Zittel (1869b) was the first to disclose the association of "*Ammonites fallax, A. murchisonae, A. scissus, A. gonionotus, Phylloceras ultramontanum, P. connectens, P. circe"* in the Catria chain. This fauna was attributed to the lower Middle Jurassic and compared with the Oolite of San Vigilio (Benecke, 1865) and with the *Posidonomya* and *Rhynchonella bilobata* formation of Tyrolese and Venetian Alps.
In further works, researchers improved the knowledge of the Middle Jurassic fauna; however for a long time a dispute arose about the variable thickness of the jurassic sedimentary rocks in the Central Apennines (Bonarelli, 1893, pp. 215-220). The dispute came to a conclusion after the results of Bernoulli (1971, 1972).
Bonarelli (1893, pp. 242-244) pointed out that "la fauna oolitica dell'Appennino Centrale è formata esclusivamente di cefalopodi e per quante ricerche abbia eseguito negli affioramenti di Val d'Urbia, Camponecchio, ecc. non sono ancora riuscito a trovarvi altro fuorché ammoniti. […] Nell'Appennino Centrale gli strati a *L. opalinum*, gli strati a *L. murchisonae* e quelli a *L. concavum* costituiscono litologicamente e paleontologicamente un tutto ben armonico, tanto da giustificare la loro riunione in un piano distinto al quale propongo sia conservato il nome *Aleniano* conferitogli da Mayer Eymar nel 1864".

MATERIALS AND METHODS

The whole material studied in the present work has been collected bed-by-bed in four sections, one in the summit of M. Acuto (Fig. 1B), the others in the Burano gorge (Fig. 1A) between Cagli and Cantiano, on the right side covered by abundant detritus. All specimens are housed in the Paleontological Section of the Museo Archeologico di Cagli (Italy).
Shell parameters considered in this work are: D (shell diameter), H (whorl height), W (whorl width), U (umbilical diameter), K (whorl height diametrically opposed to H), R (radius of the ventral spiral, i.e. the minimum distance between the coiling axis and the opposite point in the medial ventral line), N (number of primary ribs per half whorl). These parameters are measured on the same diameter, by which $D = H + U + K$.
The dimensions of the ammonoid shell have not often isometric growth among them, thus the ratios of the parametric measurements do not remain constant, indicating changes in their allometric relationships during growth.
The equations of the curves based on the shell measurements allow to compare, by means of their statistical parameters, the differences of shell-shape between different groups. In this work, the species have been compared by means of the curves U/D% (umbilical width), L/H% ("compression" of the whorl, but see Vecchia, 1945 who has suggested "rettangolarità" as a concise and clear denomination of this ratio) and K/H% (proportionate increment of the whorl), all against shell diameter D.
On the graphs U/D% vs D is plotted as dotted lines, L/H% as lines and K/H% as dashes lines. The regression analysis has been performed with Excel Microsoft.

SYSTEMATIC PALEONTOLOGY

Order Ammonitida Fisher, 1882
Suborder Phylloceratina Arkell, 1950
Superfamily Phylloceratoidea Zittel, 1884
Family Phylloceratidae Zittel, 1884
Subfamily Phylloceratinae Zittel, 1884
Genus *Phylloceras* Suess, 1865
Type species: *Ammonites heterophyllus* Sowerby, 1821.

Phylloceras baconicum Hantken in Prinz, 1904, *Phylloceras perplanum* Prinz, 1904, *Phylloceras trifoliatum* Neumayr, 1871

Material: *P. baconicum*: AU 1; RN 1; RX 1-RX 8; XN 1-XN 4. *P. perplanum*: AU 2-AU 4; RN 3-RN 4; RX 9-RX 13; XN 5-XN 7. *P. trifoliatum*: RX 14-RX 15; XN 14-XN 15.
Description: The species *P. trifoliatum* Neumayr, 1871, *P. baconicum* Hantken in Prinz, 1904 and *P. perplanum* Prinz, 1904 occur in some Catria faunal levels (Figs 23-26). Their curves L/H% vs D and K/H% vs D are compared in Figs 2-3 respectively. *P. baconicum* has a wide whorl section (L/H% 60-80%), convex flanks and a widely rounded venter; *P. perplanum* has a slightly larger size and a high and narrow section (L/H% 40-60%); *P. trifoliatum* shows intermediate characteristics between the former species (L/H% 50-70%). These species have

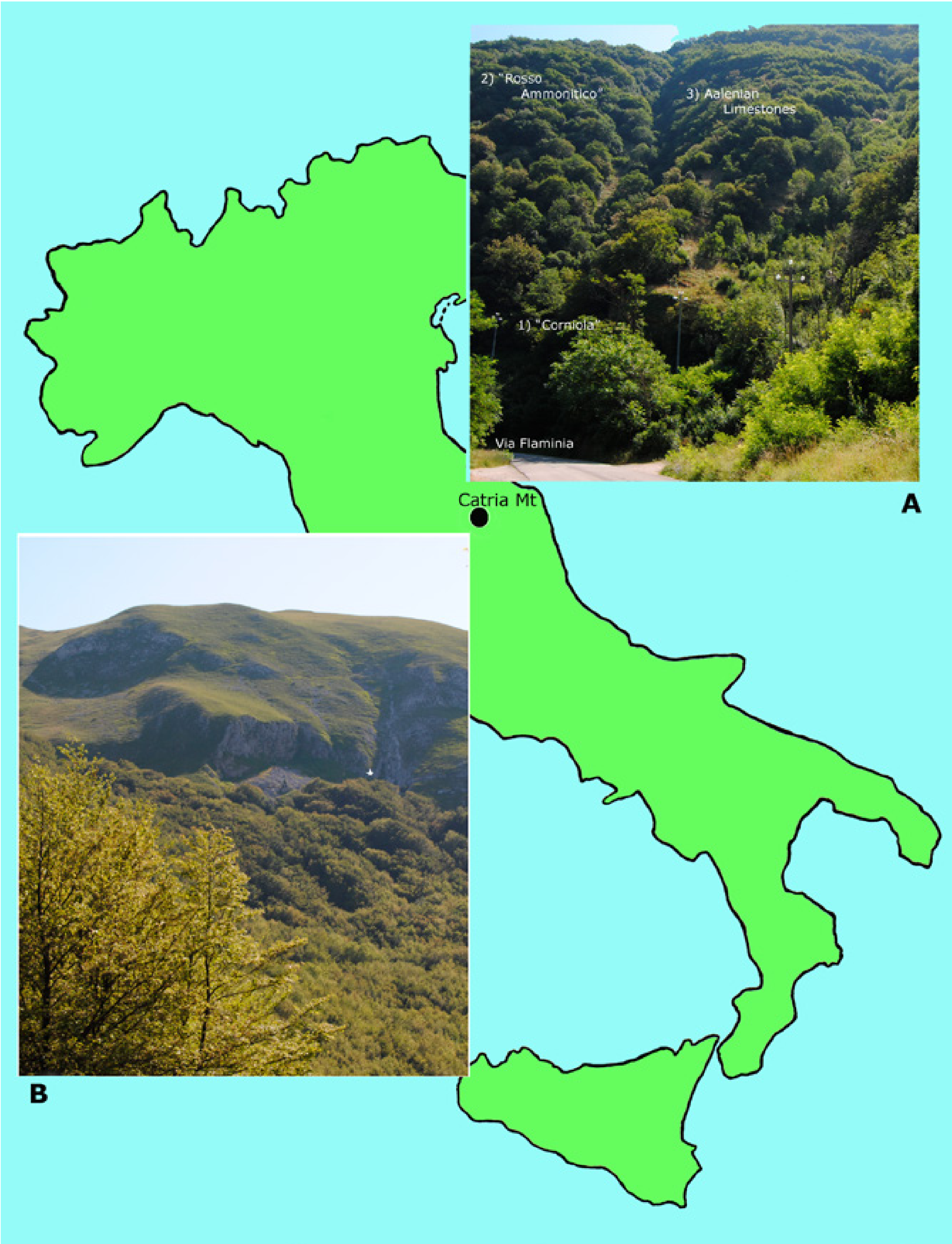
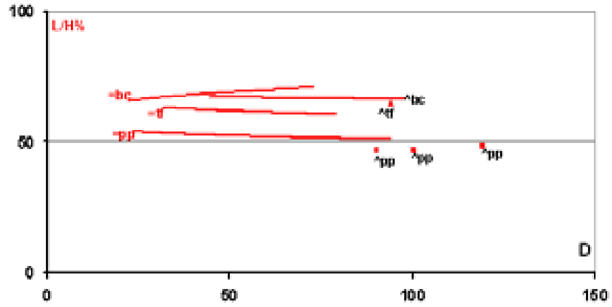
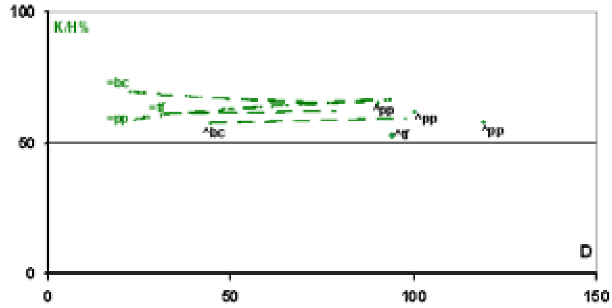


Fig. 1: A) Burano gorge, the right side above the "Fontacce" in Via Flaminia, between Cagli and Cantiano. B) M. Acuto, side NE. The white asterisk indicates the section AU.



Figs 2: *Phylloceras baconicum* (bc), *Phylloceras perplanum* (pp) and *Phylloceras trifoliatum* (tf). Curves L/H% vs D (in mm); "^" for specimens from the literature and "=" for specimens of Catria sections. Sets of measurements from Cresta (2002), D'Arpa (2002), Géczy (1967). Single specimen: "pp" from Géczy (1967); "tf" from D'Arpa (2002).
Phylloceras baconicum
Catria Mts specimens
L/H% = 4.4 Ln(D) + 51.8
auctorum specimens
L/H% = -1.2 Ln(D) + 72.1
Phylloceras trifoliatum
Catria Mts specimens
L/H% = -3.2 Ln(D) + 74.3
Phylloceras perplanum
Catria Mts specimens
L/H% = -2.4 Ln(D) + 61.9



Figs 3: *Phylloceras baconicum* (bc), *Phylloceras perplanum* (pp) and *Phylloceras trifoliatum* (tf). Curves K/H% vs D (in mm); "^" for specimens from the literature and "=" for specimens of Catria sections. Sets of measurements from Cresta (2002), D'Arpa (2002), Géczy (1967). Single specimen: "pp" from Géczy (1967); "tf" from D'Arpa (2002).
Phylloceras baconicum
Catria Mts specimens
K/H% = -3.9 Ln(D) + 81.7
auctorum specimens
K/H% = 2.7 Ln(D) + 47.1
Phylloceras trifoliatum
Catria Mts specimens
K/H% = 1.1 Ln(D) + 57.1
Phylloceras perplanum
Catria Mts specimens
K/H% = 5.3 Ln(D) + 42.2

a narrow but deep umbilicus and the septal suture lines are very similar.

Discussion: Some *Phylloceras* collected in the outcrops of the Burano gorge have marks of reworking and erosion. Nevertheless, they can be classified according to some ontogenetic characteristics as the proportionate increment of the whorls and the shape of the section.

Phylloceras loczyi Prinz, 1904 is similar to *P. baconicum*, but Géczy (1967) pointed out that "A une bonne lumière des dépressions rayonnantes très peu profondes sur le moule interne… Au voisinage de l'ombilic les constrictions sont plus distinctes, tandis que dans la partie extérieure elles disparaissent complètement". Moreover Géczy (1967, p. 22) points out "les rapports de dimensions du type de *trifoliatum* étant inconnus, il est impossibile de corréler les espèces".

It is possible to assume that *P. baconicum, P. perplanum* and *P. trifoliatum* belong to a single species because of their presence in the same faunal levels and the partial superimposition of the parametric ratios.

Calliphylloceratinae Spath, 1927

Holcophylloceras Spath, 1927

Type species: *Phylloceras mediterraneum* Neumayr, 1871

Holcophylloceras ultramontanum **(Zittel, 1869)**

1869a. *Phylloceras ultramontanum* Zittel, p. 66, pl. 1, figs 4-6.
1967. *Holcophylloceras ultramontanum* Zittel.– Géczy, p. 49, pl. 14, figs 1-3.
2002. *Holcophylloceras ultramontanum* Zittel.– Cresta, p. 60, Text-fig. 26.
2004. *Holcophylloceras ultramontanum* Zittel.- Pallini *et al.,* p. 4, pl. 2, fig. 2; pl. 3, fig. 2; pl. 15, fig. 13 (cum syn.).

Material: Specimens: AU 5-AU 14; RN 5-RN 12; RX 16-RX 24; XN 10.

Remarks: Zittel (1869b) collected some specimens of this species in Cagli. From the literature I considered measurements of 22 specimens and 23 sets of measurements from 18 specimens collected in the Catria sections (Pl. I, fig. 1). Their curves L/H% vs D and K/H% vs D are congruent (Fig. 4). The whorls have a few strong sigmoid constrictions adorally recurved on the rounded venter. The umbilicus is narrow. There are some fine but marked ribs parallel to the constrictions on the ventro-lateral portion of the side. In the Catria Mts sections specimens the septal suture lines are incomplete.

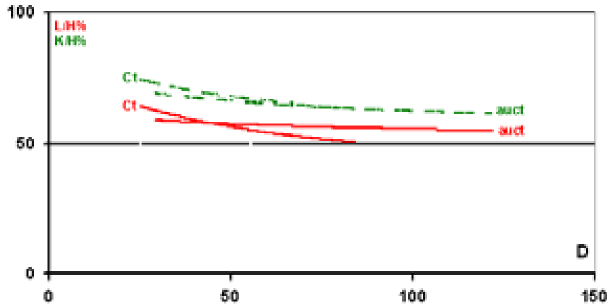


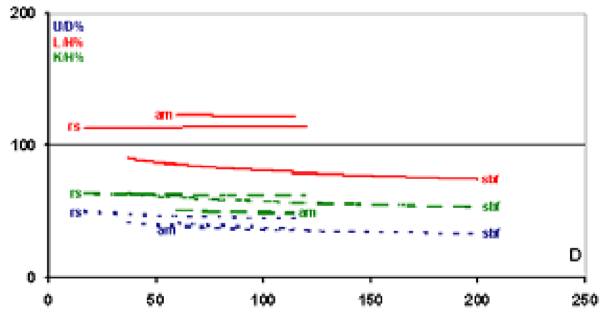
Fig. 4: *Holcophylloceras ultramontanum*. Curves L/H% and K/H% vs D (in mm); sets of measurements from Cresta (2002), Géczy (1967), Negri (1936).
Holcophylloceras ultramontanum
Catria Mts specimens (Ct)
L/H% = -11.6 Ln(D) + 101.5
K/H% = -9.4 Ln(D) + 104.6
auctorum specimens (auct)
L/H% = -2.9 Ln(D) + 68.4
K/H% = -5.5 Ln(D) + 87.6

Suborder Lytoceratina Hyatt, 1889
Superfamily Lytoceratoidea, Neumayr, 1875
Family Lytoceratidae Neumayr, 1875
Subfamily Lytoceratinae Neumayr, 1875
Genus *Lytoceras* Suess, 1865
Type species: *Ammonites fimbriatus* Sowerby, 1817

Lytoceras subfrancisci Sturani, 1964

1886. *Lytoceras francisci* Vacek, p. 60, pl. 23, figs 2-4.
1964. *Lytoceras subfrancisci* Sturani, p. 13.
1967. *Lytoceras vaceki* Géczy, p. 68, pl. 22, fig. 3; pl. 23, fig. 2; pl. 44, figs 22-23; Text-fig. 71 (cum syn.).
2002. *Lytoceras subfrancisci* Sturani.– Cresta, p. 92, Text-fig. 48.

Material: Specimens: AU 15-AU 17; RN 13-RN 14; XN 11.
Remarks: In the outcrops of Catria Mts I have collected 6 specimens (Pl. I, fig. 2) that I have compared with *Lytoceras subfrancisci* Sturani, 1964 because they have congruent allometric curves (Fig. 7).
Discussion: The Aalenian species attributed to *Lytoceras* and well supported by measurements of shell parameters are *L. amplum* (Oppel, 1862), *L. rasile* Vacek, 1886 and *L. subfrancisci*. Allometric curves U/D%, L/H% and K/H% vs D of these three species are shown in Fig. 5. *Lytoceras subfrancisci* has a more compressed whorl section, but all these species have more or less congruent umbilical width and proportionate increment of the whorls.
Dumortier (1874), Géczy (1967), Vacek (1886) have described other species of *Lytoceras* but based on just one or two specimens and consequently it is not possible to process their allometric curves. Nevertheless, these



Figs 5: *Lytoceras amplum* (am), *Lytoceras rasile* (rs) and *Lytoceras subfrancisci* (sbf). Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Galácz & Kassai (2012), Géczy (1967), Pompeckj (1896), Vacek (1886).
Lytoceras amplum
auctorum specimens
U/D% = -5.8 Ln(D) + 64.1
L/H% = -2 Ln(D) + 130.9
K/H% = -2.7 Ln(D) + 61.3
Lytoceras rasile
auctorum specimens
U/D% = -2.6 Ln(D) + 57.2
L/H% = 0.5 Ln(D) + 111.5
K/H% = - Ln(D) + 66
Lytoceras subfrancisci
auctorum specimens
U/D% = -4.3 Ln(D) + 56.4
L/H% = -10 Ln(D) + 124.3
K/H% = -11.1 Ln(D) +108.2

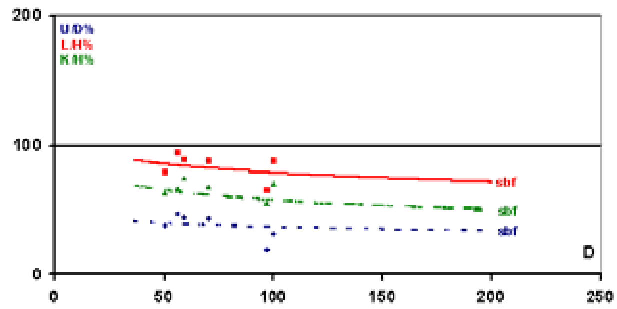


Fig. 6: *Lytoceras rubescens*, *Lytoceras liocyclum*, *Lytoceras gubernator*, *Lytoceras wrighti, Lytoceras rugulosum*: the distribution of rhombs, squares, triangles that represent U/D%, L/H% and K/H% respectively of these species, is compared with the allometric curves of *Lytoceras subfrancisci*.

species i.e. *Lytoceras rubescens* (Dumortier, 1874), *L. liocyclum* Brasil, 1894, *L. gubernator* (Simpson, 1843), *L. wrighti* Buckman, 1888 and *L. rugulosum* Vacek, 1886 are represented (Fig. 6) for comparison with *L. subfrancisci*. Their distribution seems to represent the variation of a single species (see Rulleau, 1998, for a different interpretation).

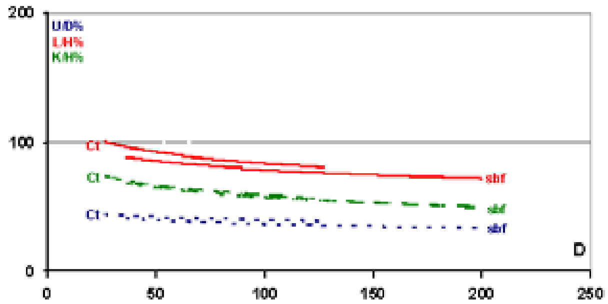


Fig. 7: The Catria Mts specimens (Ct) and *Lytoceras subfrancisci* (sbf): curves U/D%, L/H% and K/H% vs D (in mm).
Lytoceras subfrancisci
Catria Mts specimens
U/D% = -3.1 Ln(D) + 53.8
L/H% = -13 Ln(D) + 132.9
K/H% = -10.9 Ln(D) + 109

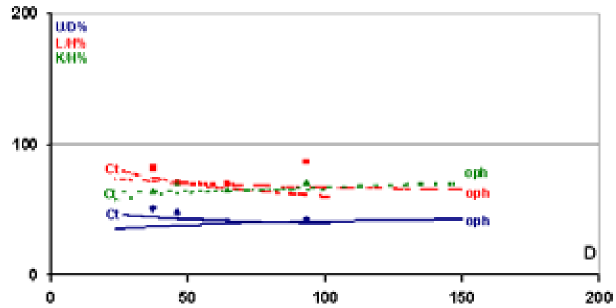


Fig. 8: *Alocolytoceras ophioneum* (oph) and Catria Mts specimens (Ct).
Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Cresta (2002), Géczy (1967), Dezi & Ridolfi (1978), Bourrilot *et al.* (2008).
Rhombs for U/D%, squares for L/H% and triangles for K/H% concerning *Alocolytoceras* aff. *irregulare* (D = 93 mm in Géczy, 1967) and three *A. sisyphus* (D = 37 mm; D = 46 mm; D = 61.5 mm respectively in Cresta, 2002).
Alocolytoceras ophioneum
auctorum specimens
U/D% = 3,8 Ln(D) + 23,1
L/H% = -4.3 Ln(D) + 86.8
K/H% = 6.7 Ln(D) + 36.1
Catria Mts specimens
U/D% = -5.4 Ln(D) + 63.5
L/H% = -14.6 Ln(D) + 126.9
K/H% = 1.3 Ln(D) + 58.7

Subfamily Alocolytoceratinae Spath, 1927
Genus *Alocolytoceras* Hyatt, 1900
Type species: *Ammonites germaini* d'Orbigny, 1845

Alocolytoceras ophioneum **(Benecke, 1865)**

1865. *Ammonites ophioneus* Benecke, p. 172, pl. 6, fig. 5.
1967. *Alocolytoceras ophioneum* Benecke.– Géczy, 1967, p. 81, pl. 24, figs 1-2 (cum syn.).
2002. *Alocolytoceras ophioneum* Benecke.– Cresta, p. 100, text-fig. 54.

Material: Specimens: AU 18-AU 25; RN 15-RN 18; RX 25-RX 33; XN 12-XN 13.
Remarks: In Catria Mts sections I have collected 23 specimens (Pl. I, fig. 3), several of them fragmentary. They are compared with *A. ophioneum* because they have congruent curves (Fig. 8) and some constrictions well marked.
Discussion: Hoffmann (2010) has attributed to *Alocolytoceras* 11 species distributed between the Pliensbachian and the Aalenian. Only *A. ophioneum*, *A. sysiphus* (Gemmellaro, 1886) and *A.* aff. *irregulare* (Pompeckj, 1896) are Aalenian. Some specimens of *A. sysiphus* and *A.* aff. *irregulare,* described in the literature, have a congruent morphology with *A. ophioneum* (Fig. 8).

Suborder Ammonitina Fischer, 1882
Superfamily Hildoceratoidea Hyatt, 1867
Family Hildoceratidae Hyatt, 1867
Subfamily Tmetoceratinae Spath, 1936
Genus *Tmetoceras* Buckman, 1892
Type species: *Ammonites scissus* Benecke, 1865

Tmetoceras scissum **(Benecke, 1865)**

1865. *Ammonites scissus* Benecke, p. 170, pl. 6, fig. 4.
1964b. *Tmetoceras (Tmetoceras) scissum* Benecke.– Westermann, p. 428, pl. 72, figs 1-2; Text-figs 32, 34 (cum syn.).
1994. *Tmetoceras scissum* Benecke.– Callomon & Chandler, pl. 5, figs 2-3; pl. 6, fig. 3; pl. 8, figs 2-4 (cum syn.).
2002. *Tmetoceras scissum* Benecke.– Sandoval, p. 163, Text-figs 101-102.

Material: Specimens: AU 26-AU 31; AU 19; RX 34-RX 43.
Remarks: *Tmetoceras scissum* is characterized by an evolute coiling throughout ontogeny with a wide umbilicus, a rectangular whorl section but with slightly convex flanks and a sulcate venter without keel. The ribs are simple and strong, slightly concave, usually slightly rursiradiate, distant, projected near the ventro-lateral margin. There are rare constrictions (Pl. I, figs 4-5).
The curves U/D%, L/H% and K/H% vs D of *Tmetoceras scissum* (M) (Fig. 11) and the Catria Mts specimens are congruent.
Discussion: Westermann (1964b), Fernandez-Lopez *et al.* (1999), Sandoval (2002), Howarth (2013) admitted *Tmetoceras* dimorphism because some small sized specimens have lappets. Moreover Westermann (1964b) put in evidence that the microconchs ("*Tmetoites*") have very dense ribbing. Nevertheless, it is difficult from specimens without lappets to distinguish the microconchs from the inner whorls of the macroconchs. For this

reason I have elaborated the curves N vs D of *Tmetoceras* macroconchs and microconchs. The allometric curves of the Catria Mts sections specimens (Ct) are congruent with those of *Tmetoceras scissum* (M) (Fig. 9).

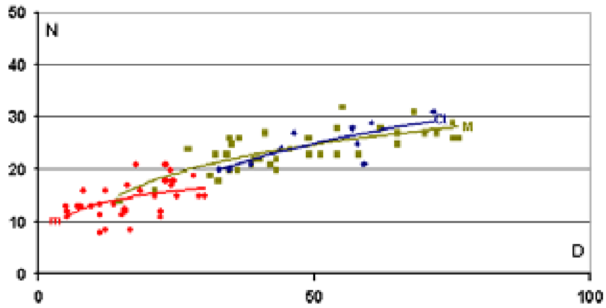


Fig. 9: *Tmetoceras*. Equations of curves; sets of measurements from Benecke (1865), Callomon & Chandler (1994), Elmi & Rulleau (1993), Kovacs (2010), Myczynski (2004), Rulleau *et al.* (2001), Sandoval (2002), Vacek (1886), Westermann (1964b).
Circles for *Tmetoceras* microconchs auctorum, squares for *Tmetoceras* macroconchs auctorum and rhombs for Catria Mts specimens Ct.
Curves N vs D (in mm)
Tmetoceras microconchs (m)
auctorum specimens
N = 3 Ln(D) + 6.2
Tmetoceras macroconchs (M)
auctorum specimens
N = 7.9 Ln(D) – 6
Tmetoceras macroconchs
Catria Mts specimens
N = 11.9 Ln(D) – 21.7

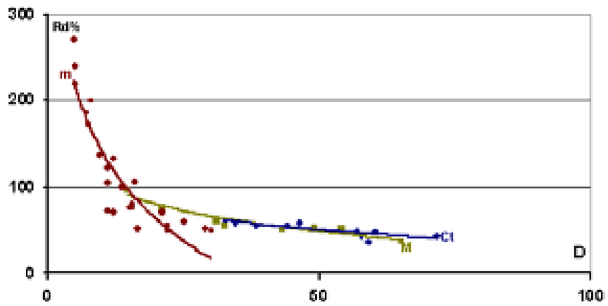


Fig. 10: *Tmetoceras*. Equations of curves; sets of measurements from Benecke (1865), Callomon & Chandler (1994), Elmi & Rulleau (1993), Kovacs (2010), Myczynski (2004), Rulleau *et al.* (2001), Sandoval (2002), Vacek (1886), Westermann (1964b).
Circles for *Tmetoceras* microconchs auctorum, squares for *Tmetoceras* macroconchs auctorum and rhombs for Catria Mts specimens Ct.
Curves Rd% (Rd% = N/D%) vs D (in mm).
Tmetoceras microconchs (m) - auctorum specimens
Rd% = -99.1 Ln(D) + 372.5
Tmetoceras macroconchs (M) - auctorum specimens
Rd% = -36.4 Ln(D) + 192.8
Tmetoceras macroconchs - Catria Mts specimens
Rd% = -26 Ln(D) + 151.5

The curves (Fig. 10) emphasize that small-sized specimens (D <= 30 mm) have Rd% equal or greater than large-sized specimens. The juvenile whorls of the macroconchs overlap with the juvenile and adult whorls of the microconchs.

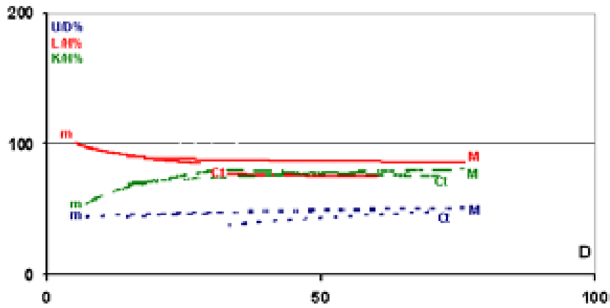


Fig. 11: *Tmetoceras*: microconchs (m), macroconchs (M) and Catria Mts specimens (Ct): curves U/D%, L/H% and K/H% vs D (in mm).
Sets of measurements from Benecke (1865), Callomon & Chandler (1994), Elmi & Rulleau (1993), Kovacs (2010), Myczynski (2004), Rulleau *et al.* (2001), Sandoval (2002), Vacek (1886), Westermann (1964b).
Tmetoceras scissum (m)
auctorum specimens
U/D% = 2.3 Ln(D) + 39.9
L/H% = -9.3 Ln(D) + 116.1
K/H% = 17.2 Ln(D) + 20.5
Tmetoceras scissum (M)
auctorum specimens
U/D% = 3.8 Ln(D) + 34.4
L/H% = -2.2 Ln(D) + 95.5
K/H% = 6.8 Ln(D) + 50.7
Tmetoceras scissum (M)
Catria Mts specimens
U/D% = 13.6 Ln(D) – 9.8
L/H% = -3.3 Ln(x) + 88.7
K/H% = -6.4 Ln(D) + 102.4

Family Graphoceratidae Buckman, 1905
Subfamily Leioceratinae Spath, 1936
Genus *Leioceras* Hyatt, 1867
Type species: *Nautilus opalinus* Reinecke, 1818

***Leioceras* sp. ind.**

Material: Specimen: AU 34.
Occurrence: In the faunal level AU 9 (Opalinum Zone) I have collected a middling fragment of *Leioceras* sp. ind.

Subfamily Graphoceratinae Buckman, 1905

Ludwigia murchisonae (Sowerby, 1829), *Brasilia bradfordensis* (Buckman, 1887), *Graphoceras concavum* (Sowerby, 1815).

Material: *L. murchisonae*: AU 32; RN 20; XN 14-XN 15. *B. bradfordensis*: RX 44-RX 50. *G. concavum*: AU 33.

Description: Few Catria Mts sections specimens of the subfamily Graphoceratinae belong to the species *L. murchisonae* (Pl. I, fig. 6), *B. bradfordensis* (Pl. I, figs 7-8; Pl. II, fig. 1) and *G. concavum* (Pl. I, fig. 9) that are the markers of Murchisonae Zone, Bradfordensis Zone and Concavum Zone respectively.

L. murchisonae has always L/H% > 50%, *B. bradfordensis* has, more or less, L/H% = 50% and *G. concavum* L/H% < 50% for D > 50 mm (Fig. 12). The shell involution often pointed out as a criterion to divide the species, is only slightly different. The bifurcated ribs are more discriminant: falcoid and finer in *B. bradfordensis* than in *L. murchisonae* and very angular in *G. concavum*.

Remarks: Parisch & Viale (1906) have established *Harpoceras buranense* and *Harpoceras (Polyplectus) pietralatae* for two specimens, one collected in the Burano gorge, the other in a stone quarry of M. Pietralata: it is the oldest quarry of M. Pietralata in Marche Apennins, a parallel chain to Catria Mts. The shell morphology of these specimens are comparable with *G. concavum* and the septal suture line of *buranense* (visible on the figured specimen) is like *G. concavum* in Géczy (1967, Pl. 65).

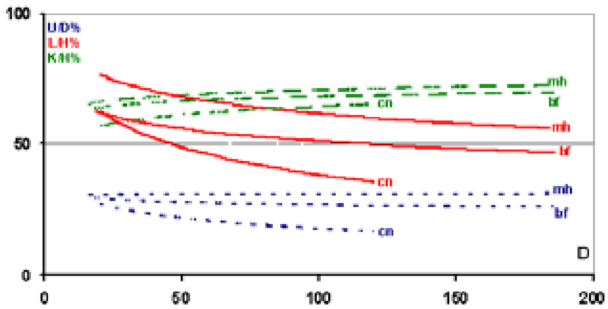


Fig. 12: *Ludwigia murchisonae* (mh), *Brasilia bradfordensis* (bf) and *Graphoceras concavum* (cn). Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from El Hammichi *et al.*, 2008; Géczy, 1967; Guerin-Franiatte & Weis, 2010; Komalarjun & Sato, 1964; Myczynski, 2004; Ramaccioni, 1939; Rulleau *et al.*, 2001; Schlegelmilch, 1995; Seyed-Emami *et al.*, 2006; Wierzbowski *et al.*, 2012.

Ludwigia murchisonae
auctorum specimens
U/D% = 0.24 Ln(D) +29.7
L/H% = -9.3 Ln(D) + 104.5
K/H% = 2.9 Ln(D) +57.2

Brasilia bradfordensis
auctorum specimens
U/D% = -1.6 Ln(D) + 34.1
L/H% = -6.9 Ln(D) + 82.7
K/H% = 2.6 Ln(D) + 56.1

Graphoceras concavum
auctorum specimens
U/D% = -5.9 Ln(D) + 44.9
L/H% = -15.3 Ln(D) + 108.5
K/H% = 4.7 Ln(D) + 42.4

Family Hammatoceratidae Buckman, 1887
Subfamily Hammatoceratinae Buckman, 1887
Genus *Bredyia* Buckman, 1910

Type species: *Burtonia crassornata* Buckman, 1910

Bredyia mouterdei (Elmi, 1963)

1963. *Pseudammatoceras mouterdei* Elmi, p. 20, pl. 2, fig. 1; text-figs 3-5.
2009. *Pseudammatoceras mouterdei* Elmi.– Rulleau, p. 54, pl. 43, fig. 2.

Material: Specimen RX 51.

Description: A single specimen (Pl. III, fig. 1) rather reworked. The whorl section varies throughout the ontogeny, the inner whorls are slightly depressed, progressively the coiling becomes evolute, the whorls are more compressed and the umbilicus wider and shallower. The venter has a keel without sulci. Three to four secondaries branch from midflank tubercles. The ribs last towards D = 60 mm, becoming weak. The whorls cover the secondary ribs as far as the tubercles at the furcation points. The primary ribs are always weaker than the tubercles.

Dimensions of the specimen RX-51:
D = 98.5 mm, H = 32 mm, L = 24 mm, U = 44 mm, K = 22.5 mm;
D = 84.5 mm, H = 26.6 mm, L = 22.8 mm, U = 37 mm, K = 20.9 mm.

Discussion: Elmi (1963, p. 92) puts in evidence that "*Pseudammatoceras mouterdei* [...] est un des rares individus à montrer, de façon complète et sur une pièce unique, comment se déroule le développement ontogénique des *Pseudammatoceras*. Sur l'holotype, on observe le passage d'une forme tuberculée et déprimée à un stade morphologique à costulation atténuée et à section comprimée et ogivale". Martínez-Gutiérrez (1992, pp. 137-139) has synthesized a long discussion about *Bredyia* vs *Pseudammatoceras* and has confirmed the occurrence of *Bredyia* in the Concavum Zone.

Bredyia sp. ind.

Material: Specimen AU 37.

Occurrence: A fragment of a specimen collected in the faunal level AU 9, Opalinum Zone.

Genus *Planammatoceras* Buckman, 1922

Type species: *Planammatoceras planiforme* Buckman, 1922

Planammatoceras metellii (Gemmellaro, 1886)

1886. *Hammatoceras metellii* Gemmellaro, p. 8, n. 32.
2002. *Planammatoceras metellii* Gemmellaro.– Cresta, p. 179, text-fig. 117 (cum syn.).

Material: Specimen RX 54.

Description: The coiling is evolute, the whorl section compressed and the venter narrow, keeled, without sulci. The ribs are branched; dense, straight, long primaries bifurcate beyond the midflank and secondaries are projected forwardly. The suture is not visible.
Dimensions: D = 92.5 mm, H = 33 mm, L = 24? mm, U = 37 mm, K = 22.5 mm.
Occurrence: This specimen (Pl. II, fig. 4) has been collected in the Burano gorge (faunal level RX 49s).

Genus *Euaptetoceras* Buckman, 1922
Type species: *Euaptetoceras euaptetum* Buckman, 1922

***Euaptetoceras dorsatum* (Merla, 1933)**

1933. *Hammatoceras dorsatum* Merla, p. 17, pl. 3, fig. 1; text-fig. 2.
1963. *Euaptetoceras dorsatum* Merla.– Elmi, p. 80, pl. 10, fig. 3; text-fig. 29 (cum syn.).

Material: Specimens AU 35, RX 52, XN 16.
Remarks: It is possible to identify the present specimens as *Euaptetoceras dorsatum* for the shell morphology, shape of whorl section, and the straight, large but weak primary ribs that furcate at midflank in stronger secondaries, well projected on the ventral area.
Occurrence: The specimens, rather reworked, have been collected in the Catria Mts faunal levels AU 13-14, RX 51 b and XN 6-7.

Subfamily Erycitinae Spath, 1928
Genus *Erycites* Gemmellaro, 1886
Type species: *Erycites fallifax* Arkell, 1957

***Erycites fallifax* Arkell, 1957, *Erycites intermedius* Hantken in Prinz, 1904 and *Erycites* sp. ind.**

Material: *E. fallifax*: AU 38-AU 95. *E. intermedius*: RX 57-RX 60. *Erycites* sp. ind.: RN 21; RX 55-RX 56.
Description and discussion: *Erycites* includes about twenty nominal species and many subspecies. The shell has two ontogenetic stages, the first (inner whorls) involute with depressed whorl section (L > H), the second (outer whorls) evolute with compressed whorl section (L < H), there is a short transition showing isodimensional whorl section (L = H).
The venter has a scarcely developed or weak keel: “les vestiges de la carène sont représentés sur le moule interne par une bande mince, lisse” (Géczy, 1966, p. 107). The primary ribs are strong, a little arched, without tubercles, and at midflank they branch into secondary ribs that join the keel or the ventral band. The septal suture line has a short ventral lobe, a narrow ventral saddle, a first lateral lobe asymmetric and many branched; a large lateral saddle, and umbilical lobes retracted.
In *Erycites* the whorl compression L/H% has a wide variation (Fig. 13). The value L/H% = 100% is very important because it indicates isodimensional whorl section. The boundary sizes (diameters) of the specimens (respectively *Erycites* sp. Er 12 in Rulleau, 1992, pl. 37, figs 5-6 and *Erycites subquadratus* Géczy, 1966, pl. 27, fig. 1) with L/H% = 100% (Fig. 13) are D = 39 mm and D = 131.5 mm, i.e. this special whorl section condition corresponds to very different sizes in different *Erycites*. The curves in Figs. 14-16 have been obtained from the

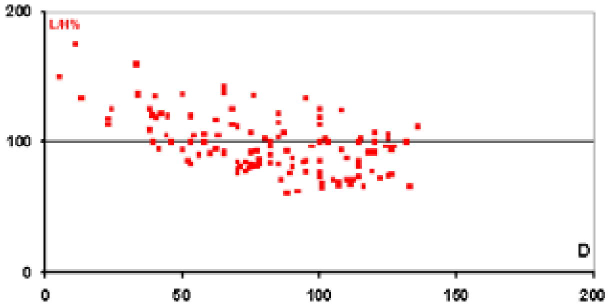


Fig. 13: Scatter diagram L/H% vs D (in mm) of *Erycites*; sets of measurements from Benecke (1865), Callomon & Chandler (1994), Cresta (2002), Dumortier (1874), Elmi & Rulleau (1993), Géczy (1966), Géczy *et al.* (2008), Kovacs & Géczy (2008), Rulleau (1992, 2009), Sandoval *et al.* (2015), Vacek (1886).

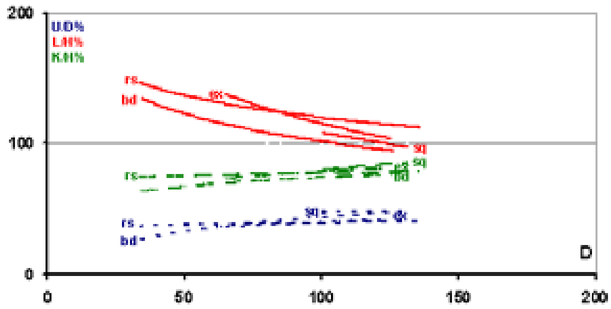


Fig. 14: *Erycites*. Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Benecke (1865), Callomon & Chandler (1994), Cresta (2002), Dumortier (1874), Elmi & Rulleau (1993), Géczy (1966), Géczy *et al.* (2008), Kovacs & Géczy (2008), Rulleau (1992, 2009), Sandoval *et al.* (2015), Vacek (1886).

Erycites barodiscus (bd)
$U/D\% = 16 \ln(D) - 30.1$
$L/H\% = -30.7 \ln(D) + 242.7$
$K/H\% = 10.2 \ln(D) + 27$

Erycites exulatus (ex)
$U/D\% = 8.4 \ln(D) + 0.9$
$L/H\% = -51.6 \ln(D) + 352.9$
$K/H\% = 12.3 \ln(D) + 21.9$

Erycites reussi (rs)
$U/D\% = 2.4 \ln(D) + 28.2$
$L/H\% = -24.4 \ln(D) + 231.8$
$K/H\% = 3.1 \ln(D) + 63.3$

Erycites subquadratus (sq)
$U/D\% = 3.3 \ln(D) + 32.4$
$L/H\% = -40.7 \ln(D) + 295.8$
$K/H\% = 23.9 \ln(D) - 31.1$

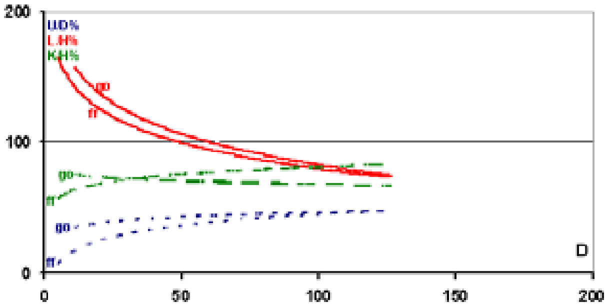


Fig. 15: *Erycites*. Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Benecke (1865), Callomon & Chandler (1994), Cresta (2002), Dumortier (1874), Elmi & Rulleau (1993), Géczy (1966), Géczy *et al.* (2008), Kovacs & Géczy (2008), Rulleau (1992, 2009), Sandoval *et al.* (2015), Vacek (1886).

Erycites fallifax (ff)

U/D% = 12.8 Ln(D) – 14.2

L/H% = -28.6 Ln(D) + 211.5

K/H% = 8 Ln(D) + 43.9

Erycites gonionotus (go)

U/D% = 5.2 Ln(D) + 22.2

L/H% = -34.2 Ln(D) + 240.1

K/H% = -3.3 Ln(D) + 83.2

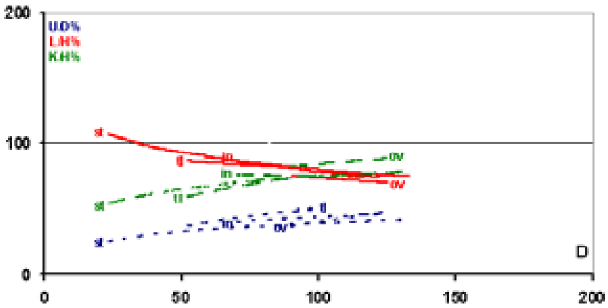


Fig. 16: *Erycites*. Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Benecke (1865), Callomon & Chandler (1994), Cresta (2002), Dumortier (1874), Elmi & Rulleau (1993), Géczy (1966), Géczy *et al.* (2008), Kovacs & Géczy (2008), Rulleau (1992, 2009), Sandoval *et al.* (2015), Vacek (1886).

Erycites intermedius (in)

U/D% = 10.9 Ln(D) – 6.4

L/H% = -21.6 Ln(D) + 177.7

K/H% = -4.2 Ln(D) + 93.9

Erycites ovatus (ov)

U/D% = 33 Ln(D) – 111.7

L/H% = -16.2 Ln(D) + 148

K/H% = 19.5 Ln(D) – 5.9

Erycites sutneri (st)

U/D% = 9.6 Ln(D) – 5.4

L/H% = -18,6 Ln(D) + 165,5

K/H% = 14.3 Ln(D) + 8.8

Erycites telegdirothi (tl)

U/D% = 20.1 Ln(D) – 42.3

L/H% = -9.4 Ln(D) + 123.6

K/H% = 25.4 Ln(D) – 41.3

Table 1: Diameters (D) of the isodimensional whorl sections of *Erycites* species.

Erycites reussi (Hauer, 1856)	221.8 mm
Erycites exulatus Callomon & Chandler, 1994	134.4 mm
Erycites subquadratus Géczy, 1966	122.8 mm
Erycites barodiscus (Gemmellaro, 1886)	104.4 mm
Erycites gonionotus (Benecke, 1865)	60.1 mm
Erycites fallifax Arkell, 1957	49.3 mm
Erycites intermedius Hantken in Prinz, 1904	36.5 mm
Erycites sutneri (Gemmellaro, 1886)	33.8 mm
Erycites ovatus Géczy, 1966	19.4 mm
Erycites telegdirothi Prinz, 1904	12.3 mm

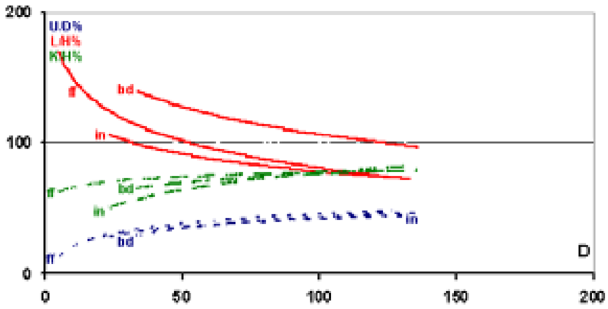


Fig. 17: *Erycites*. Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Benecke (1865), Callomon & Chandler (1994), Cresta (2002), Dumortier (1874), Elmi & Rulleau (1993), Géczy (1966), Géczy *et al.* (2008), Kovacs & Géczy (2008), Rulleau (1992, 2009), Sandoval *et al.* (2015), Vacek (1886).

group barodiscus (bd)

auctorum specimens

U/D% = 12.5 Ln(D) – 14.8

L/H% = -30.4 Ln(D) + 246.2

K/H% = 9.8 Ln(D) + 31.1

group fallifax (ff)

auctorum specimens

U/D% = 10.9 Ln(D) – 4.9

L/H% = -30 Ln(D) + 218.7

K/H% = 5.1 Ln(D) + 53.9

group intermedius (in)

auctorum specimens

U/D% = 9.3 Ln(D) – 0.9

L/H% = -19.3 Ln(D) + 166.7

K/H% = 18.5 Ln(D) – 8.5

sets of measurements of *Erycites* in the literature. The diameters (Tab. 1) of the isodimensional whorl section have been obtained from the equations of these curves.

By means of D it is possible to separate three groups of *Erycites*, named respectively (from the alphabetical order of the group): 1) the barodiscus group includes *E. barodiscus* Gemmellaro, 1886, *E. exulatus* Callomon & Chandler, 1994, *E. reussi* (Hauer, 1856) and *E. subquadratus* Géczy, 1966; 2) the fallifax group

Table 2: Mean values of the shell parameters of *Erycites* (data from the literature, see Figs 19-21).

group barodiscus	D	H	L	U	K	U/D%	L/H%	K/H%
specimens	62.0	62.0	62.0	62.0	62.0	62	62	62
min. value	33.2	11.0	16.2	8.0	9.1	20	84	53
max. value	136	42.5	46.0	65.0	35.0	52	159	93
mean value	87.0	29.0	32.0	36.0	22.0	40	112	74
st. deviation	28.0	7.0	7.0	16.0	7.0	7	16	10
coeff. of var. CV%	32.0	24.0	22.0	44.0	32.0	18	14	14
correlation coefficient						0.72	-0.69	0.43

group fallifax	D	H	L	U	K	U/D%	L/H%	K/H%
specimens	77.0	77.0	77.0	77.0	77.0	77	77	77
min. value imo	5.0	2.0	3.0	1.5	1.5	17	66	47
max. value	127.0	40.6	39.4	63.5	31.0	52	175	96
mean value	58.0	20.0	19.0	24.0	15.0	38	101	74
st. deviation	26.0	7.0	5.0	14.0	6.0	9	20	11
coeff. of var. CV%	45.0	35.0	26.0	58.0	40.0	24	20	15
correlation coefficient						0.72	-0.79	0.29

group intermedius	D	H	L	U	K	U/D%	L/H%	K/H%
specimens	42.0	42.0	42.0	42.0	42.0	42	42	42
min. value	23.0	11.0	13.0	7.0	5.0	23	64	45
max. value	133.0	47.0	37.0	59.0	35.0	49	118	97
mean value	91.0	31.0	24.0	38.0	23.0	40	81	74
st. deviation	25.0	7.0	5.0	12.0	7.0	6	11	11
coeff. of var. CV%	27.0	23.0	21.0	32.0	30.0	15	14	15
correlation coefficient						0.53	-0.59	0.58

includes *E. fallifax* Arkell, 1957 and *E. gonionotus* (Benecke, 1865); 3) the intermedius group includes *E. intermedius* Hantken in Prinz, 1904, *E. ovatus* Géczy, 1966, *E. sutneri* (Gemmellaro, 1886) and *E. telegdirothi* Prinz, 1904. In Tab. 2 the mean values of the shell parameters of these three groups are given, and in Fig. 17 the corresponding curves.

In addition to the species considered in this analysis, there are about twenty specimens that can be classified by the three-groups-division proposed (cfr. synonymies in Rulleau, 2009 and Sandoval *et al.,* 2015).

Biostratigraphic researches in some regions have described the distribution of *Erycites* from the Upper Toarcian to the Upper Aalenian. Nevertheless Cresta (2002) cast some doubts about *E. barodiscus* and *E. sutneri*: “the biochronological meaning of the *Erycites barodiscus* and *E. sutneri* series-type is vague, as the fossil assemblage mixes taphonomically reworked ammonites spanning from latest Toarcian to middle Aalenian. In the Middle Jurassic successions of Apennines, the species is typical of the Toarcian-Aalenian boundary and its vertical range is restricted to the *L. opalinum* Subzone. Rulleau *et al.* (2001) quoted the species in the uppermost Toarcian *P. lugdunensis* Subzone… *Erycites sutneri* is a marker species within the Lower Aalenian successions of the Apennines.”

Rulleau *et al.* (2001) states “les *Erycites* s.s. apparaissent au sommet de la zone à Aalensis avec quelques représentants de l’espèce *E. barodiscus* Gemmellaro et deviennent plus fréquents à partir de la zone à Opalinum (Aalénien inférieur), avec le groupe de *E. fallifax* Arkell.” Kovacs & Géczy (2008) assigned *E. barodiscus* and *E. subquadratus* to the Opalinum Zone, and *E. fallifax, E. intermedius* and *E. ovatus* to the Opalinum and Murchisonae zones.

By means of different considerations Rulleau (2009) describes a group *E. barodiscus* with *E. exulatus* and *E. subquadratus* that “occupent une même position stratigraphique […] zone à Aalensis […] base de la zone à Opalinum”. Moreover Rulleau (2009) specifies the biostratigraphic distribution of *E. fallifax* “sous-zone à Comptum et sous-zone à Opalinoides (?)”, of *E. sutneri* (with *E. ovatus*) “base de la zone à Murchisonae”, of *E. intermedius* “Aalénien moyen” and of *E. gonionotus* “Aalénien moyen”. Sandoval *et al.* (2015) confirm the position of *E. barodiscus*, *E. fallifax*, *E. gonionotus* and *E. intermedius*, but they assign *E. sutneri* to the Aalensis Zone.

Despite some discordances our groups barodiscus, fallifax and intermedius are arranged in chronological order. Therefore, in *Erycites* it is possible assuming a progressive reduction of the first stage of the shell, which is put in evidence by the transition of the isodimensional whorl section from the large diameters to the smaller diameters.

The small-sized *Abbasitoides* (microconchs) developed morphologically in parallel to the changes in the larger sized *Erycites* (macroconchs). In the Catria sections I have collected small-sized specimens with ribs crossing the venter, but the classification is doubtful because of the fragmentary condition of the material.

In many outcrops of the Betic Cordillera, Sandoval *et al.* (2015) have collected abundant *Abbasitoides compressus* (Hantken in Prinz, 1904) from Opalinum Zone, and *A. modestus* (Vacek, 1886) from the Murchisonae and Bradfordensis zones, and from their sets of measurements I have obtained the curves L/H% vs D (Fig. 18). The diameters of the isodimensional whorl sections of the two species are D = 65 mm and D = 29 mm respectively, i.e. the transition from large to small size occurs in *Abbasitoides* at the same time that in *Erycites*.

Many specimens from the Catria Mts sections are fragmentary. For this reason their L/H% are plotted (Fig. 19) as ratios of R (ventral radius). Two or more sets of the parameters R, H, L, at intervals of about a 90° angle distance, have been measured on complete specimens and fragmentary ones. The ventral radius R (Tab. 3) of the isodimensional whorl section has been obtained by means of the allometric curve L/H% vs R.

In most ammonites the ratio R/D is not constant: it can be a little different in the inner whorls from those of the outer whorls (Fig. 20). Nevertheless, this ratio has a good approximation to a constant value (Fradin, 1947). The measurements of R and D of the Catria Mts sections complete specimens allowed to obtain the equation of direct proportion R = 0.573 D (Fig. 20) and then D of the isodimensional whorl section (Tab. 3).

The *Erycites* from the faunal levels AU 10 and AU 11 show growth patterns comparable to *E. fallifax* and the *Erycites* of the faunal level RX 46 are comparable to *E. intermedius*. The distribution of *Erycites* in the faunal levels of Catria sections shows a gradual transition of the isodimensional whorl section from large to small sizes.

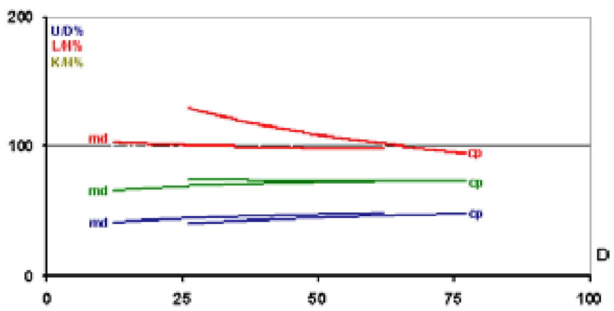


Fig. 18: *Abbasitoides*. Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Sandoval *et al.* (2015):

Abbasitoides compressus (cp)

U/D% = 8 Ln(D) + 13.6

L/H% = -32.5 Ln(D) + 235.8

K/H% = -Ln(D) + 77.3

Abbasitoides modestus (md)

U/D% = 5 Ln(D) + 27.9

L/H% = -2.9 Ln(D) + 109.8

K/H% = 4.3 Ln(D) + 55.1

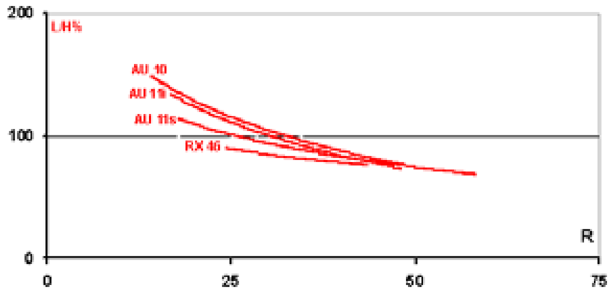


Fig. 19: *Erycites*. Curves L/H% vs R (in mm); sets of measurements from Catria Mts specimens.

Faunal level RX 46	L/H% = -24.2 Ln(R) + 167
Faunal level AU 11s	L/H% = -36.4 Ln(R) + 217.9
Faunal level AU 11i	L/H% = -58 Ln (R) + 297.4
Faunal level AU 10	L/H% = -59.4 Ln(R) + 306.3

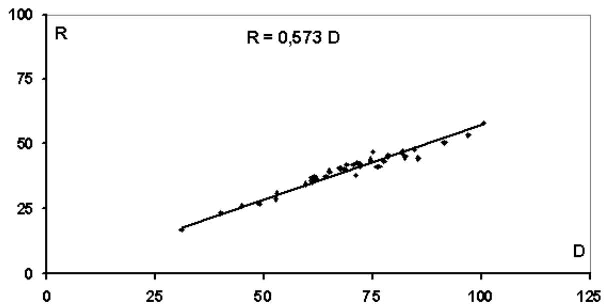


Fig. 20: Straight line running among the point of the scatter diagram R (in mm) vs D (in mm) and its equation of direct proportion.

Subfamily Zurcheriinae Hyatt, 1900

Genus *Zurcheria* Douvillé, 1885

Type species: *Zurcheria ubaldi* Douvillé, 1885

***Zurcheria* sp. ind.**

Material: Specimen RX 53.

Description: An incomplete specimen (Pl. II, fig. 3), about a quarter of shell. Approximate dimensions: D =

Table 3: Ventral radius R and diameter D of the isodimensional whorl section in *Erycites* from the Catria Mts.

Faunal level RX 46	R = 15.9 mm	D = 27.7 mm	Bradfordensis Zone
Faunal level AU 11s	R = 25.5 mm	D = 44.5 mm	Murchisonae Zone
Faunal level AU 11i	R = 30.1 mm	D = 52.5 mm	Murchisonae Zone
Faunal level AU 10	R = 32.2 mm	D = 56.2 mm	Opalinum Zone

41 mm, H = 11.4 mm, L = 9.5 mm, U = 20.5 mm. Slightly trapezoidal whorl section, rounded venter without keel or sulci, adorally convex ribs on the middle of the flank and prominent on the ventro-lateral margin; in the inner whorls the ribs seem relatively stronger than in the outer whorl. The ribs cross the venter curved adorally.
Occurrence: The specimen has been collected in the faunal level RX 47b, Concavum Zone.

Family Sonniniidae Buckman, 1892
Subfamily Witchelliinae Callomon & Chandler, 2006
Genus *Fontannesia* Buckman, 1902
Type species: *Dumortieria grammoceroides* Haug, 1887

***Fontannesia caterinae* (Parish & Viale, 1906)**

1906. *Hildoceras (Arieticeras) caterinae* Parish & Viale, p. 16, pl. 8, figs 7-9.

Material: Specimens AU 36 and XN 17.
Description: From the faunal levels XN 7i and AU 13 come the two specimens (Pl. II, fig. 2) which are comparable to *Hildoceras caterinae* Parish & Viale, 1906. Coiling evolute, whorl section square with rounded margins, slightly convex flanks, shallow umbilical wall, flat venter with keel and sulci. Simple ribs, a little sigmoid, rursiradiate, stronger in the ventro-lateral portion of the flanks, projected and truncated on the ventral sulci.
Dimensions: D = 44.4 mm, H = 12.8 mm, L = 13.2 mm, U = 20.9 mm, N = 32.
Remarks: *H. caterinae* Parish & Viale, 1906 comes from an undefined site near Rocchetta d'Arcevia, a place in San Vicino Mts, Marche Apennins. According to the original diagnosis, there is a "nodo spinoso" on the ribs (Parish & Viale, 1906, p. 16) that seems to be a typical characteristic of the inner whorls of representatives of the Sonniniidae, and the suture has the characters of *Harpoceras*, but this is not evident in the present specimens. Fucini (1908, p. 56), says *H. caterinae* has "un'importante e ben strana caratteristica delle coste, che sono munite a metà del loro decorso di una prominenza spinosa. L'*Hild. caterinae* sembra essere poi di Lias superiore". Ramaccioni (1939) collected *Sonninia italica* Ramaccioni, 1939 (Aalenian) and a fragment of *Sonninia* in Passo della Porraia, Cucco Mts (Catria chain). The morphology and the stratigraphic position of *H. caterinae* Parish & Viale, 1906 are comparable to those of *Fontannesia*.

Superfamily Stephanoceratoidea Neumayr, 1875
Family Stephanoceratidae Neumayr, 1875
Genus *Riccardiceras* Westermann, 1995
Type species: *Coeloceras longalvum* Vacek, 1886

***Riccardiceras longalvum* (Vacek, 1886)**

1886. *Coeloceras longalvum* Vacek, p. 99, pl. 17, figs 1-2.
1964a. *Docidoceras longalvum* Vacek.– Westermann, p. 48, pl. 6, fig. 1-2.
1983. *Docidoceras (Docidoceras)* sp. cf. *D. (D.) longalvum*, Vacek.– Sandoval, p. 177, pl. 4, fig. 1; text-fig. 90c.
1990. *Docidoceras* sp. ex gr. *longalvum* Vacek.– Cresta & Galácz, p. 170, pl. 8, fig. 1.
2000. *Riccardiceras longalvum* Vacek.– Sandoval *et al.,* p. 32, pl. 1, figs 1-2; pl. 2, fig. 1 (cum syn.).
2001. *Riccardiceras longalvum* Vacek.– Dietze *et al.,* p. 9, text-fig. 6.

Material: Specimens AU 96-AU 103; RN 22-RN 24; XN 18-XN 20.
Description: Present specimens (Pl. III, figs 2-3) are comparable to *R. longalvum* in terms of ontogenetic development (Fig. 21), rounded venter without keel and sulci, density of the primary ribs that branch in three secondaries crossing the venter uninterruptedly.
Remarks: In *Riccardiceras* the curves L/H% vs D have a rather horizontal trend and it is difficult to recognize the transition from depressed to compressed sections (Fig. 22). Specimens of *Riccardiceras longalvum* and *R. telegdirothi* (Géczy, 1967) have been mentioned from collections from M. Nerone (Cresta & Gálacz, 1990). Callomon & Chandler (1990) have collected *Abbasitoides modestus* (Vacek, 1886) assumed as the microconch of *Stephanoceras longalvum* (Vacek) and *Abbasitoides* aff. *modestus* in the Murchisonae Zone and Concavum Zone respectively. The curve L/H% vs D of *Abbasitoides modestus* (Fig. 18) is rather horizontal and it is also characteristic of *Riccardiceras* (Fig. 22). Thus, it is possible that the contemporary trend from a large-sized and depressed stage to a small-sized and compressed stage in *Erycites/Abbasitoides* went on *Riccardiceras*.

BIOSTRATIGRAPHY

The high diversity and abundance of the Jurassic fauna, in particular ammonites, and the good exposures have made the Umbria-Marche Apennines one of the most valuable geologic archives of the Mediterranean countries.
Aalenian ammonites of Furlo and Nerone Mts are well

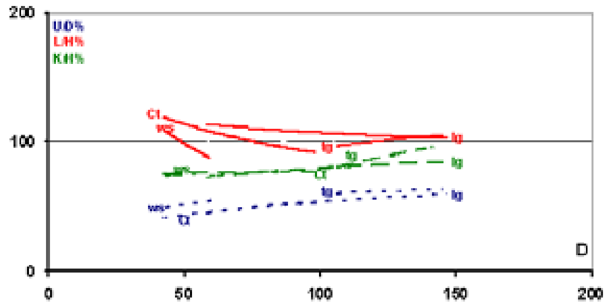


Fig. 21: *Riccardiceras*. Curves U/D%, L/H% and K/H% vs D (in mm); sets of measurements from Cresta & Galácz (1990), Dietze *et al.* (2001), Géczy (1967), Linares & Sandoval (1990: pl. 2, fig. 6), Sandoval *et al.* (2000), Sandoval (1983).
Riccardiceras longalvum (lg)
auctorum specimens
U/D% = 15.8 Ln(D) – 19.5
L/H% = -11.6 Ln (D) + 160.4
K/H% = 12.9 Ln(D) + 20
Catria Mts specimens (Ct)
U/D% = 14.9 Ln(D) -15.2
L/H% = -32.7 Ln(D) +241.3
K/H% = 1.7 Ln(D) +68.7
Riccardiceras telegdirothi (tg)
auctorum specimens
U/D% = 9.3 Ln(D) + 16.8
L/H% = 26.4 Ln(D) – 26.3
K/H% = 54.5 Ln(D) – 174.4
Riccardiceras westermanni (ws)
auctorum specimens
U/D% = 15.3 Ln(D) – 8.7
L/H% = -63.6 Ln(D) + 347.3
K/H% = 9.2 Ln(D) + 38.9

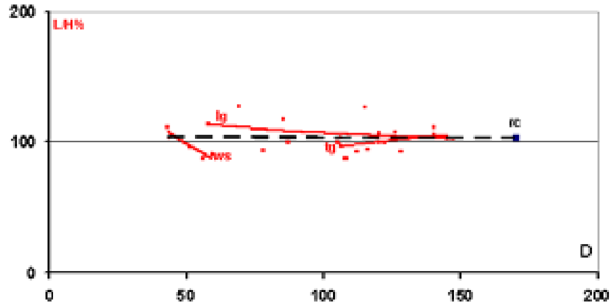


Fig. 22: Same caption as Fig. 21
Riccardiceras
dashes line: auctorum specimens
L/H% = -0.6 Ln (D) + 106
Riccardiceras richardsoni (in Dietze *et al.,* 2001, p. 8): black square "rc"

known. Within the last three decades, several papers deal with Aalenian ammonites of M. Nerone (Kälin & Ureta, 1987; Cecca *et al.,* 1990; Cresta, 1988; Cresta & Galácz, 1990; Cresta *et al.,* 1995, 2002; Cresta & Ureta, 2002).
On the contrary, the Aalenian biostratigraphy has not been adequately investigated in the Catria group. My researches have been done in the summit of M. Acuto (section AU) where the beds of a Jurassic seamount crop out at a height of 1490 m and the ammonites are abundant (Figs 1B, 23), the others in the Burano gorge (Fig. 1A) where some beds deposited in a Jurassic basin crop out at different heights (Fig. 24, section RN at a height of 470 m; Fig. 25, section XN at a height of 520 m; Fig. 26, section RX at a height of 565 m). In some levels of the Burano sections the ammonites are reworked. In these sections the beds are gray or reddish limestones with marl intercalations.
The faunal levels of M. Acuto and Burano gorge sections are distributed in the Aalenian zones. Their compositions are comparable with those of M. Nerone sections: 1) Gorgo a Cerbara section (Kälin & Ureta, 1987; Cresta & Ureta, 2002); 2) Bugarone Querry section (Cresta *et al.,* 2002) (Table 4).

The Phylloceratinae and the Lytoceratinae are more or less abundant in these faunal levels and particularly *Alocolytoceras ophioneum* is constant. Some genera of Gorgo a Cerbara, not recorded in the Catria sections, have been omitted, these are *Calliphylloceras, Catulloceras, Ancolioceras, Accardia, Spinammatoceras* and *Abbasitoides*.

CONCLUSION

This work is a contribution to refine the Aalenian biostratigraphy of the Catria Mts. This biostratigraphy has been neglected if compared with the advances made for the Nerone Mts, where a rich ammonite fauna has been collected in some well known quarries (such as Bugarone and Gorgo a Cerbara). Moreover, it has been possible to update the taxonomy and age of some species collected by Bonarelli from unknown sites of the Umbria-Marche Apennines which were described for first time by Parisch & Viale (1906), e.g. *Fontannesia caterinae*, that had been classified under different names of Domerian or Toarcian taxa.
From data in the literature, regarding the evolution of the genus *Erycites*, a hypothesis has been formulated, which is linked to the progressive transition of the isodimensional whorl section from large to small sizes during the Aalenian. Afterwards this hypothesis has been corroborated and proved by the independent analysis based on the Catria specimens of *Erycites* collected in stratigraphic succession in the Catria Mts sections. Hence, it has been possible to demonstrate that this morphological result is not casual in the *Erycites* species; rather, this trend went on during the Aalenian. It is possible that this trend continued in *Riccardiceras*, a genus diffused in the Catria sections above the genus *Erycites*.

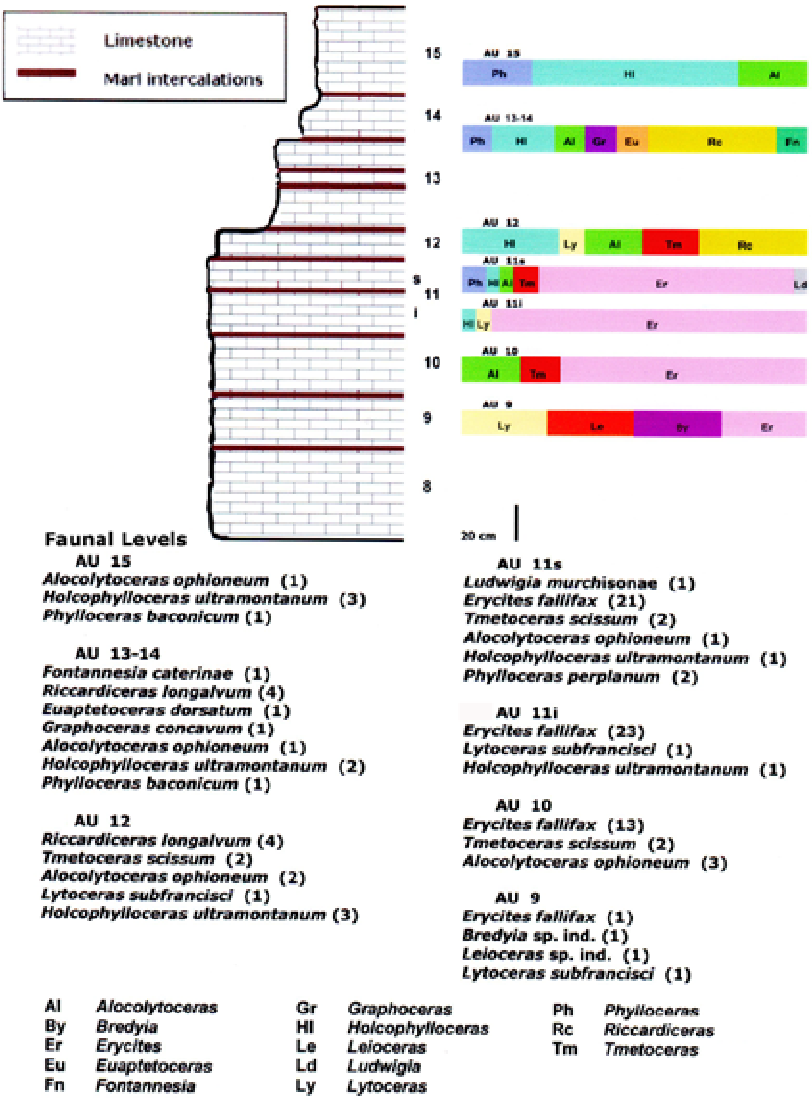


Fig. 23: M. Acuto, section AU, h. 1490 m.

Table 4: From above (Fig. 27):

IV) The Concavum Zone is represented	AU 13-14 – AU 15
by *Graphoceras concavum* with *Planammatoceras, Euaptetoceras, Bredyia, Fontannesia, Zurcheria* and *Riccardiceras*.	RN 13-14 – XN 6-7 RX 47b – RX 48-49 – RX 49s RX 50-51a-51b
III) In the Bradfordensis Zone in addition to the zonal marker *Brasilia bradfordensis* with *Tmetoceras* and *Erycites* appears *Riccardiceras*.	AU 12 – RN 12 RX 45 – RX 46
II) The Murchisonae Zone is identified by the zonal marker *Ludwigia murchisonae* with *Tmetoceras* and *Erycites*.	AU 11i – AU 11s RN 10 – XN 1-3
I) The Opalinum Zone is characterized by the association of *Leioceras, Tmetoceras, Bredyia, Erycites*.	AU 9 – AU 10

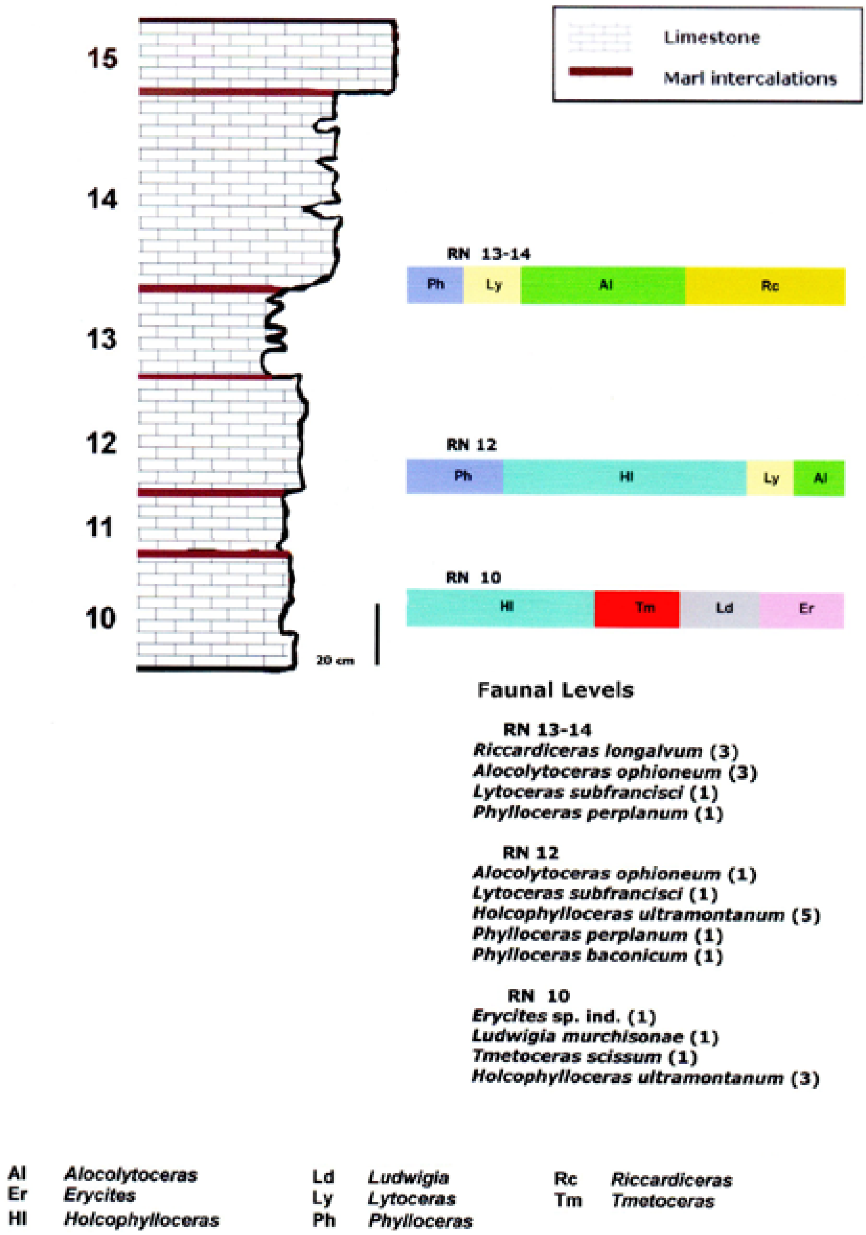


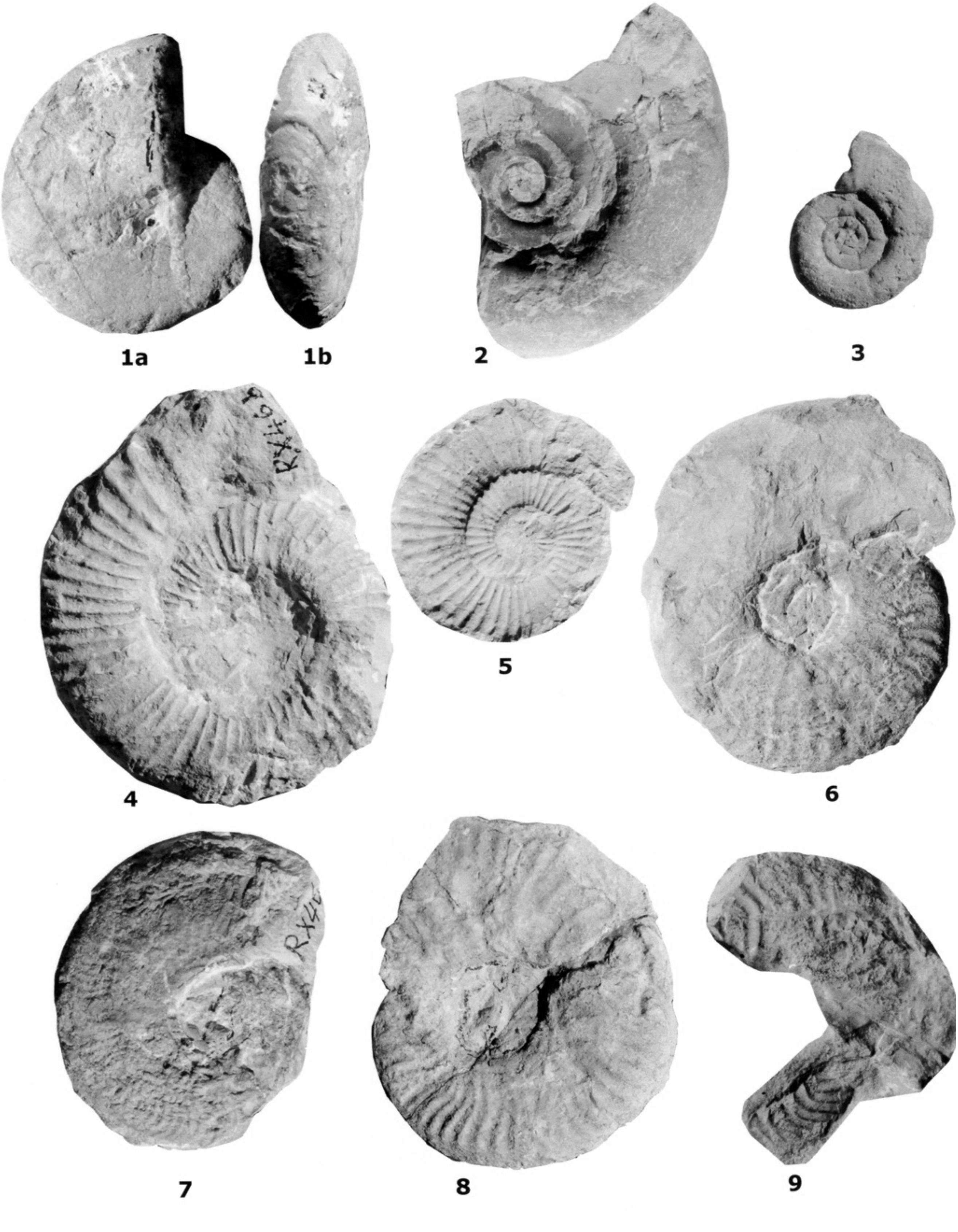
Fig. 24: Burano gorge, section RN, h. 470 m.

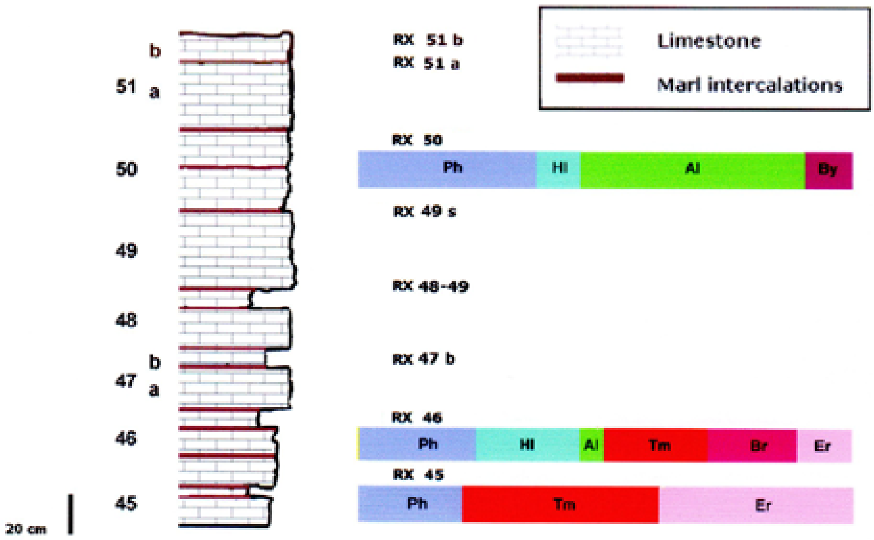
Plate I

All natural size.

Fig. 1: *Holcophylloceras ultramontanum* (Zittel, 1869), a: lateral view, b: ventral view; faunal level AU 13-14.
Fig. 2: *Lytoceras subfrancisci* Sturani, 1964; faunal level AU 11i.
Fig. 3: *Alocolytoceras ophioneum* (Benecke, 1865); faunal level RX 48-49.
Fig. 4: *Tmetoceras scissum* (Benecke, 1865); faunal level RX 46.
Fig. 5: *Tmetoceras scissum* (Benecke, 1865); faunal level RX 45.
Fig. 6: *Ludwigia murchisonae* (Sowerby, 1829); faunal level RN 10.
Fig. 7: *Brasilia bradfordensis* (Buckman, 1887); faunal level RX 46.
Fig. 8: *Brasilia bradfordensis* (Buckman, 1887); faunal level RX 46.
Fig. 9: *Graphoceras concavum* (Sowerby, 1815); faunal level AU 13-14.

Plate I





Faunal Levels

RX 51 b
Euaptetoceras dorsatum **(1)**
RX 51 a
Phylloceras baconicum **(1)**

RX 50
Bredyia mouterdei **(1)**
Alocolytoceras ophioneum **(5)**
Holcophylloceras ultramontanum **(1)**
Phylloceras trifoliatum **(1)**
Phylloceras baconicum **(3)**

RX 49 s
Planammatoceras metellii **(1)**
RX 48-49
Alocolytoceras ophioneum **(2)**
RX 47 b
Zurcheria **sp. ind. (1)**

RX 46
Erycites intermedius **(4)**
Brasilia bradfordensis **(7)**
Tmetoceras scissum **(8)**
Alocolytoceras ophioneum **(2)**
Holcophylloceras ultramontanum **(8)**
Phylloceras trifoliatum **(1)**
Phylloceras perplanum **(4)**
Phylloceras baconicum **(4)**

RX 45
Erycites **sp. ind. (2)**
Tmetoceras scissum **(2)**
Phylloceras perplanum **(1)**

Al	*Alocolytoceras*
Br	*Brasilia*
By	*Bredyia*
Er	*Erycites*
Eu	*Euaptetoceras*
Hl	*Holcophylloceras*
Ph	*Phylloceras*
Pl	*Planammatoceras*
Tm	*Tmetoceras*
Zr	*Zurcheria*

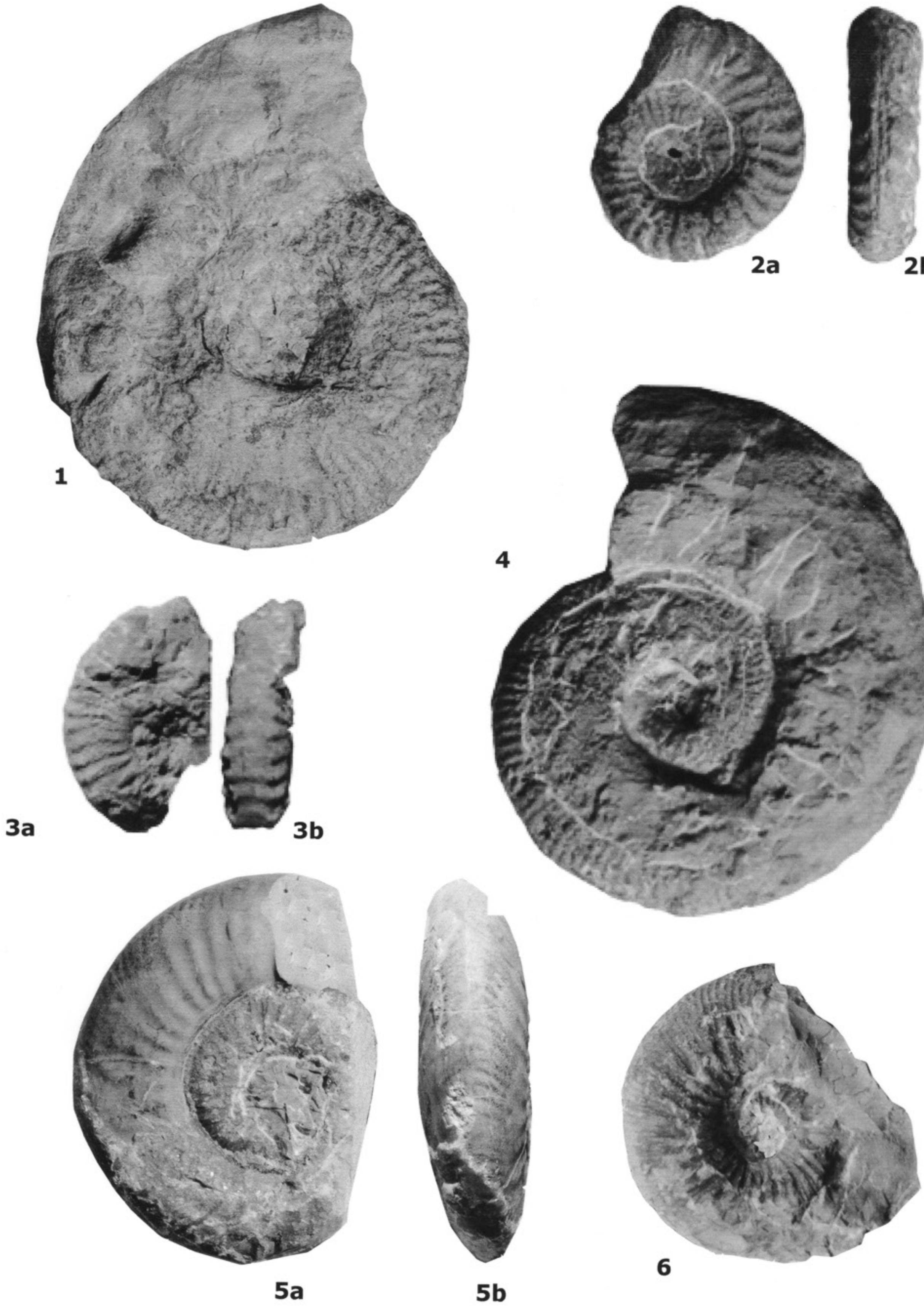
Fig. 25: Burano gorge, section RX, h. 565 m.

Plate II

All natural size.

Fig. 1: *Brasilia bradfordensis* (Buckman, 1887); faunal level RX 46.
Fig. 2: *Fontannesia caterinae* (Parish & Viale, 1906), a: lateral view, b: ventral view; faunal level XN 6-7.
Fig. 3: *Zurcheria* sp. ind., a: lateral view, b: ventral view; faunal level RX 47b.
Fig. 4: *Planammatoceras metellii* (Gemmellaro, 1886): inner whorls (D 92,5 mm) of a larger specimen (D max 120 mm); faunal level RX 49s.
Fig. 5: *Erycites fallifax* Arkell, 1957; a: lateral view, b: ventral view; faunal level AU 11i.
Fig. 6: *Erycites fallifax* Arkell, 1957; faunal level AU 11s.

Plate II



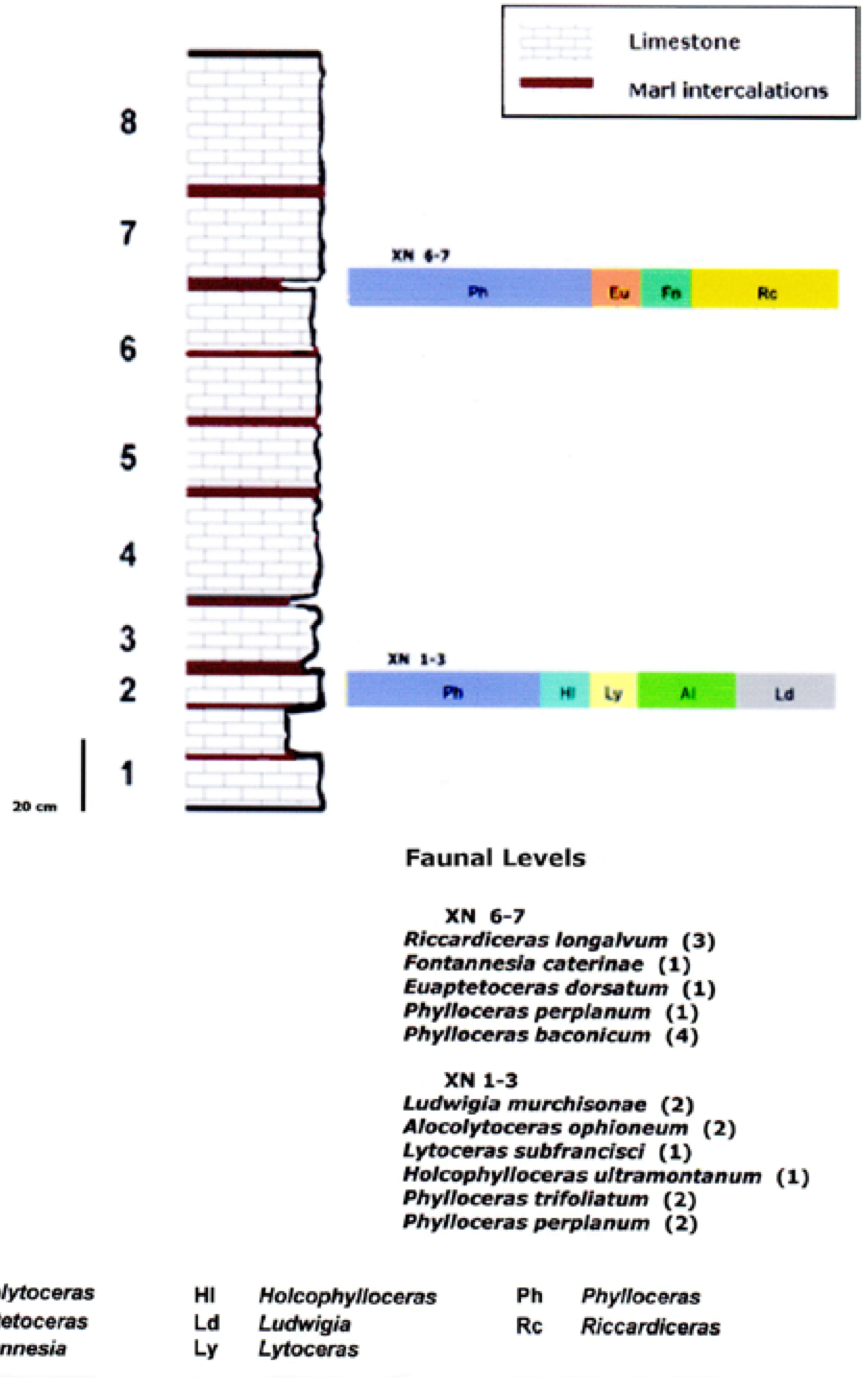


Fig. 26: Burano gorge, section XN, h. 520 m.

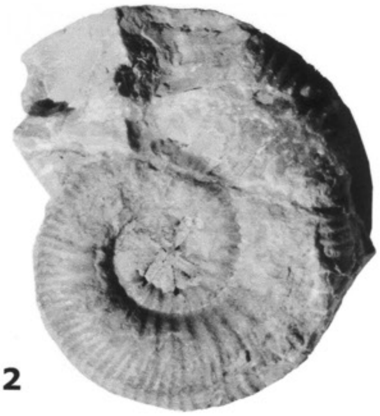
Plate III

All natural size.

Fig. 1: *Bredyia mouterdei* (Elmi, 1963), a: lateral view, b: ventral view; faunal level RX 50.
Fig. 2: *Riccardiceras longalvum* (Vacek, 1886); faunal level AU 13-14.
Fig. 3: *Riccardiceras longalvum* (Vacek, 1886); faunal level XN 6-7.

1a

1b



2

3

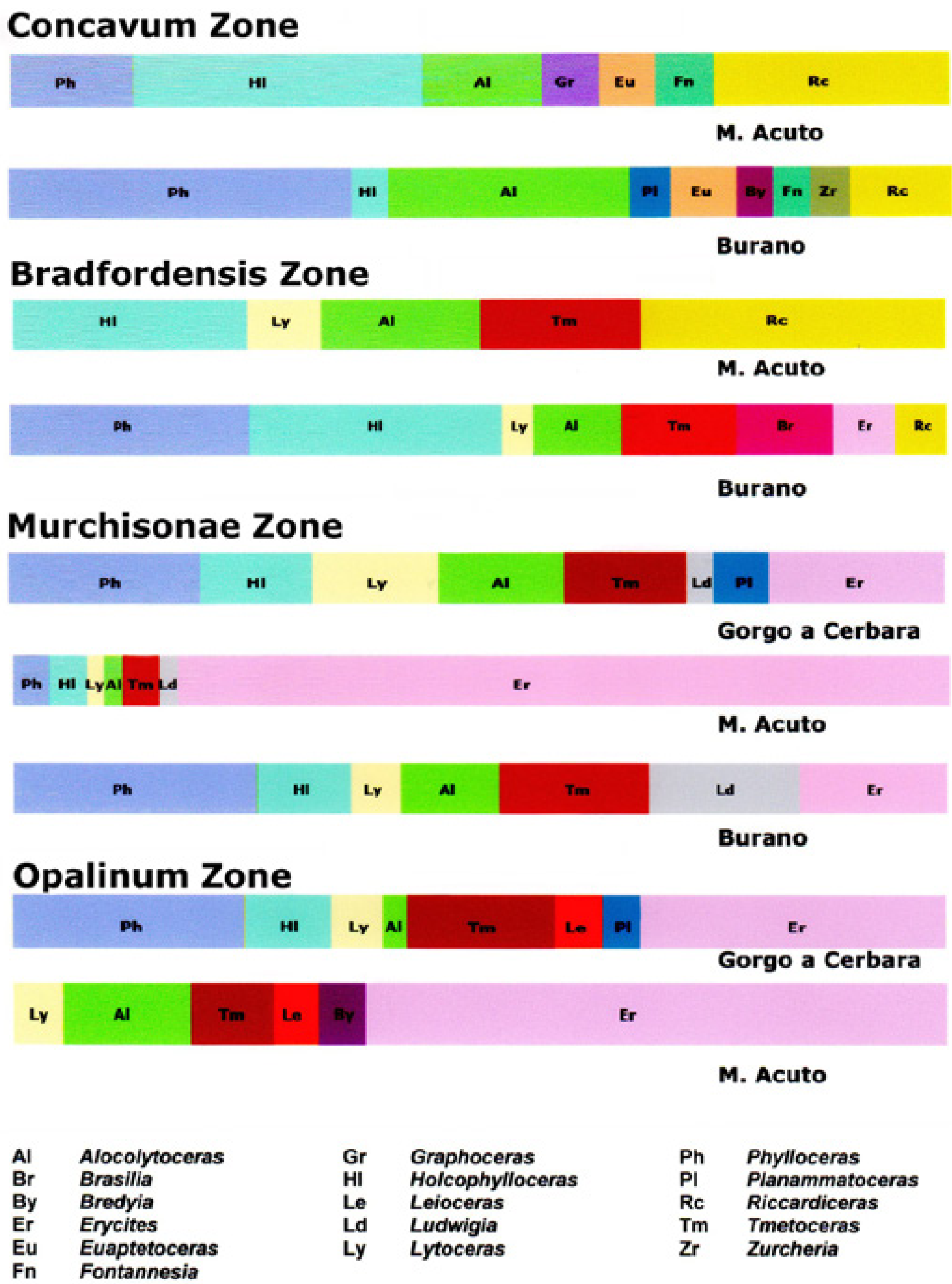


Fig. 27: Comparison of the taxonomic compositions of the faunae of the corresponding faunal levels and biohorizons of M. Acuto, Burano gorge and Gorgo a Cerbara sections.

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APPENDIX

Shell parameters of the examined species and the correlation coefficient of their graphs are reported. Note that the set of values here are different from those in the text since some specimens were measured at successive diameters and/or some are fragmentary.

	D	H	L	U	K	U/D%	L/H%	K/H%
Phylloceras baconicum **auct., Figs 2-3**								
specimens	16	16	16	16	16		16	16
min value	44	28	19	1	14,5		61	52
max value	98	59	41	4	36		77	68
mean value	71	43	29	2	25		67	58
standard deviation	17	10	7	1	6		4	5
CV%	24	23	24	50	24		6	9
correlation coefficient							-0.05	0.16
Phylloceras baconicum **Catria Mts, Figs 2-3**								
specimens	19	19	19	19	19		19	19
min value	22	11	7	3	8		62	58
max value	73	40.2	27.6	6.1	29		78	77
mean value	50	28	19	4	18		69	67
standard deviation	13	7	5	1	5		5	7
coeff. of var. CV%	26	25	26	25	28		7	10
correlation coefficient							0.05	-0.03
Phylloceras trifoliatum **Catria Mts, Figs 2-3**								
specimens	8	8	8	8	8		8	8
min value	31.5	16.5	11	2.5	12		54	49
max value	79	42.5	25.2	6.8	30.3		70	76
mean value	52	29	18	5	18		62	61
standard deviation	15	8	5	2	6		7	9
coeff. of var. CV%	29	28	28	40	33		11	15
correlation coefficient							-0.16	0.14
Phylloceras perplanum **Catria Mts, Figs 2-3**								
specimens	21	21	21	21	21		21	21
min value	23	12.5	6.8	2	7.3		40	43
max value	94	51	29.5	8	36		61	75
mean value	51	29	15	4	18		53	63
standard deviation	17	10	5	2	7		5	7
coeff. of var. CV%	33	34	33	50	39		9	11
correlation coefficient							-0.10	0.26

	D	H	L	U	K	U/D%	L/H%	K/H%
***Holcophylloceras ultramontanum* auct., Fig. 4**								
specimens	22	22	22	22	22		22	22
min value	29	15	9	3	10		44	57
max value	122	68	38	13	41		64	84
mean value	69	38	22	6	24		56	65
standard deviation	24	14	8	3	9		4	6
coeff. of var. CV%	35	37	36	50	38		7	9
correlation coefficient							-0.21	-0.29
***Holcophylloceras ultramontanum* Catria Mts, Fig. 4**								
specimens	23	23	23	23	23		23	23
min value	25	13	6.5	2	9.5		44	55
max value	84	46.5	23	10	27.5		80	85
mean value	45	24	14	5	16		58	69
standard deviation	14	8	4	2	5		10	9
coeff. of var. CV%	31	33	29	40	31		17	13
correlation coefficient							-0.34	-0.33
***Lytoceras amplum* auct., Fig. 5**								
specimens	5	5	5	5	5	5	5	5
min value	59	23	26.7	23	11.2	33	106	44
max value	115	47.5	59	44.5	23	42	143	57
mean value	82	34	42	32	17	39	122	50
standard deviation	24	11	14	8	6	3	15	6
coeff. of var. CV%	29	32	33	25	35	8	12	12
correlation coefficient						-0.45	0.005	-0.11
***Lytoceras rasile* auct., Fig. 5**								
specimens	12	12	12	12	12	12	12	12
min value	16	5	5.5	8	3	42	96	53
max value	120	41	49	54	26	50	135	76
mean value	86	29	33	39	18	46	114	62
standard deviation	29	10	12	12	6	2	10	5
coeff. of var. CV%	34	34	36	31	33	4	9	8
correlation coefficient						-0.70	0.02	-0.17
***Lytoceras subfrancisci* auct., Figs 5-7**								
specimens	9	9	9	9	9	9	9	9
min value	36	12	11	15	9	33	67	46
max value	200	90	67	69	41	42	92	75
mean value	105	44	33	38	24	37	79	58
standard deviation	57	27	18	18	12	3	8	10
coeff. of var. CV%	54	61	55	47	50	8	10	17
correlation coefficient						-0.72	-0.66	-0.66

	D	H	L	U	K	U/D%	L/H%	K/H%
***Lytoceras* (Fig. 6)**								
***Lytoceras gubernator* in Géczy (1967)**	100	41	36	30.5	28.5	31	88	70
***Lytoceras liocyclum* in Géczy (1967)**	50	19	15	19	12	38	79	63
***Lytoceras rubescens* in Dumortier (1874)**	56	17.9	16.8	26.3	11.8	47	94	66
***Lytoceras rubescens* in Vacek (1886)**	59	19	17	26	14	44	89	74
***Lytoceras rubescens* in Géczy (1967)**	70	24	21	30	16	43	88	67
***Lytoceras wrighti* in Géczy (1967)**	97	51	33	18	28	19	65	55
***Lytoceras rugulosum* in Vacek (1886)**	43	18	17	14	11	33	94	61
***Lytoceras rugulosum* in Vacek (1886)**	51	22	20	16	13	31	91	59
***Lytoceras subfrancisci* Catria Mts, Fig. 7**								
specimens	9	9	9	9	9	9	9	9
min value	25.8	7.6	8	11.2	6	37	74	45
max value	127.5	51.3	38.5	47	29.2	45	105	79
mean value	67	24	21	27	15	41	90	64
standard deviation	31	13	9	11	7	2	12	12
coeff. of var. CV%	46	54	43	41	47	5	13	19
correlation coefficient						-0.72	-0.53	-0.37
***Alocolytoceras ophioneum* auct., Fig. 8**								
specimens	19	19	19	19	19	19	19	19
min value	23	9.3	7	8.8	4.9	28	52	51
max value	150	52	37	64	35	44	83	76
mean value	65	24	16	26	16	39	69	63
standard deviation	34	11	7	15	8	4	7	7
coeff. var. CV%	52	46	44	58	50	10	10	11
correlation coefficient						0.40	-0.24	0.35
***Alocolytoceras ophioneum* Catria Mts, Fig. 8**								
specimens	19	19	19	19	19	19	19	19
min value	26	7.5	6	10	4.6	35	58	39
max value	102	41.5	25	37	24.5	50	80	83
mean value	48	17	12	20	11	43	71	64
standard deviation	21	8	4	8	5	4	7	10
coeff. of var. CV%	44	47	33	40	45	9	10	16
correlation coefficient						-0.48	-0.83	0.04
***Ludwigia murchisonae* auct., Fig. 12**								
specimens	18	18	16	18	18	18	16	18
min value	16	7.5	4.9	4.5	4	27	53	53
max value	184	70	37	59	55	36	83	81
mean value	85	35	21	26	24	31	64	70
standard deviation	47	18	8	15	14	2	9	8
coeff. of var. CV%	55	51	38	58	58	6	14	11
correlation coefficient						0.08	-0.63	0.30

	D	H	L	U	K	U/D%	L/H%	K/H%
***Brasilia bradfordensis* auct., Fig. 12**								
specimens	39	39	33	39	39	39	33	39
min value	18.3	7.3	5	5.2	4.6	20	41	49
max value	186	74.5	41	55.5	56	33	71	85
mean value	76	33	18	21	23	27	54	67
standard deviation	37	16	8	10	12	3	8	8
coeff.of var. CV%	49	48	44	48	52	11	15	12
correlation coefficient						-0.28	-0.46	0.24
***Graphoceras concavum* auct., Fig. 12**								
specimens	14	14	11	14	14	14	11	14
min value	20	8.6	5.5	6.4	5	16	33	48
max value	120	61.2	26.8	21	39.6	32	64	70
mean value	63	31	14	13	19	21	46	62
standard deviation	27	14	5	5	9	4	9	6
coeff. of var. CV%	43	45	36	38	47	19	20	10
correlation coefficient						-0.52	-0.80	0.34
***Erycites barodiscus* auct., Fig. 14**								
specimens	38	38	38	38	38	38	38	38
min value	34	13.5	19	8	10.3	20	84	53
max value	126	37.3	44	65	32	52	150	90
mean value	83	28	30	35	20	40	109	71
standard deviation	27	7	6	15	6	7	15	10
coeff. of var. CV%	33	25	20	43	30	18	14	14
correlation coefficient						0.80	-0.72	0.45
***Erycites exulatus* auct., Fig. 14**								
specimens	9	9	9	9	9	9	9	9
min value	65	23,4	33,2	23,4	15,6	31	103	67
max value	125	42,5	45	56,4	33,7	47	142	67
mean value	97	33	38	38	26	39	118	78
standard deviation	24	7	4	12	6	4	14	6
coeff. of var. CV%	25	21	11	32	23	10	12	8
correlation coefficient						0.50	-0.94	0.47
***Erycites reussi* auct., Fig. 14**								
specimens	8	8	8	8	8	8	8	8
min value	33.2	11	16.2	12.5	9.1	32	112	56
max value	136	41	46	60	35	44	159	88
mean value	72	25	31	28	19	38	130	76
standard deviation	36	11	11	16	10	4	16	11
coeff. of var. CV%	50	44	35	57	53	11	12	14
correlation coefficient						0.44	-0.74	0.26
***Erycites subquadratus* auct., Fig. 14**								
specimens	7	7	7	7	7	7	7	7
min value	100	28	29	46	21	46	100	64
max value	131.5	37	37	63	31,5	50	125	93

	D	H	L	U	K	U/D%	L/H%	K/H%
mean value	112	32	33	54	26	48	104	81
standard deviation	12	3	3	6	4	2	9	10
coeff. of var. CV%	11	9	9	11	15	4	9	12
correlation coefficient						0.21	-0.44	0.23
***Erycites fallifax* auct., Fig. 15**								
specimens	55	55	55	55	55	55	55	55
min value	5	2	3	1.5	1.5	17	66	47
max value	126	38	27	63	31	50	150	96
mean value	58	20	19	23	15	36	99	75
standard deviation	26	7	4	14	6	10	19	11
coeff. of var. CV%	45	35	21	61	40	28	19	15
correlation coefficient						0.82	-0.83	0.46
***Erycites gonionotus* auct., Fig. 15**								
specimens	22	22	22	22	22	22	22	22
min value	11	4	7	4	3	36	82	54
max value	127	40.6	39.4	63.5	22.9	52	175	90
mean value	58	19	19	26	13	43	105	70
standard deviation	27	8	6	14	5	5	21	9
coeff. of var. CV%	47	42	32	54	38	12	20	13
correlation coefficient						0.67	-0.74	-0.23
***Erycites intermedius* auct., Fig. 16**								
specimens	8	8	8	8	8	8	8	8
min value	70	24	19	27	19	39	67	57
max value	122	36	30	51	35	47	100	97
mean value	94	31	24	40	23	43	80	75
standard deviation	18	5	4	10	5	3	12	13
coeff. of var. CV%	19	16	17	25	22	7	15	17
correlation coefficient						0.66	-0.40	-0.01
***Erycites ovatus* auct., Fig. 16**								
specimens	8	8	8	8	8	8	8	8
min value	90	31	20	31	26	34	65	73
max value	125	37	26	59	32	47	81	94
mean value	108	33	24	46	28	43	72	85
standard deviation	11	2	2	8	3	4	5	8
coeff. of var. CV%	10	6	8	17	11	9	7	9
correlation coefficient						0.81	-0.30	0.27
***Erycites sutneri* auct., Fig. 16**								
specimens	18	18	18	18	18	18	18	18
min value	23	11	13	7	5	23	64	45
max value	133	47	37	53	33	49	118	91
mean value	93	33	26	36	24	38	83	72
standard deviation	30	9	7	14	8	6	12	9
coeff. of var. CV%	32	27	27	39	33	16	14	13
correlation coefficient						0.71	-0.64	0.63

	D	H	L	U	K	U/D%	L/H%	K/H%
***Erycites telegdirothi* auct., Fig. 16**								
specimens	8	8	8	8	8	8	8	8
min value	52	21	18	19	12	37	76	57
max value	100	29	25	48	23	48	91	79
mean value	70	24	20	30	16	43	84	66
standard deviation	15	3	2	9	3	5	5	6
coeff. of var. CV%	21	13	10	30	19	12	6	9
correlation coefficient						0.84	-0.28	0.83
***Abbasitoides compressus* auct., Fig. 18**								
specimens	24	24	24	24	24	24	24	24
min value	26	9.1	11.5	9	5.7	35	75	58
max value	77	26.5	22	35.2	19.5	50	134	91
mean value	47	15	17	21	11	44	112	73
standard deviation	14	4	3	7	3	4	15	10
coeff. of var. CV%	30	27	18	33	27	9	13	14
correlation coefficient						0.55	-0.66	-0.04
***Abbasitoides modestus* auct., Fig. 18**								
specimens	48	48	48	48	48	48	48	48
min value	12	4.5	4.6	4.6	2.8	33	80	52
max value	62	19	19	29.4	13.6	52	129	89
mean value	30	10	10	14	7	45	100	69
standard deviation	12	4	4	6	3	4	11	9
coeff. of var. CV%	40	40	40	43	43	9	11	13
correlation coefficient						0.52	-0.03	0.18
***Riccardiceras longalvum* auct., Fig. 21**								
specimens	15	15	15	15	15	15	15	15
min value	58	18.5	21	26.5	13	46	93	65
max value	147	34	37	91	26	62	128	92
mean value	106	27	28	58	21	54	107	80
standard deviation	28	4	5	20	5	5	11	9
coeff. of var. CV%	26	15	18	34	24	9	10	11
correlation coefficient						0.90	-0.26	0.36
***Riccardiceras telegdirothi* auct., Figs 21**								
specimens	7	7	7	7	7	7	7	7
min value	106	22	21	60	15,5	57	88	66
max value	145	29	30	90	26	65	108	104
mean value	118	25	25	72	21	61	99	86
standard deviation	14	2	3	10	4	3	7	12
coeff. of var. CV%	12	8	12	14	19	5	7	14
correlation coefficient						0.34	0.45	0.50
***Riccardiceras westermanni* auct., Fig. 21**								
specimens	8	8	5	8	8	8	5	8
min value	43	12.5	13.5	21	9	48	88	60

	D	H	L	U	K	U/D%	L/H%	K/H%
max value	61	16	14.5	34	12.5	56	112	86
mean value	51	14	14	26	11	52	98	75
standard deviation	7.1	1.5	0.4	4.7	1.4	2.5	9.8	7.8
coeff. of var. CV%	14	11	3	18	13	5	10	10
correlation coefficient						0.84	-0.93	0.19
***Riccardiceras richardsoni* in Dietze *et al.* (2001), Fig. 22**								
	170	34	35	114	22	67	103	65
***Riccardiceras* auct., Fig. 22, dashed line**								
specimens	28	28	28	28	28	28	28	28
min value	43	12.5	13.5	21	9	46	88	60
max value	170	34	37	114	26	67	128	104
mean value	101	24	25	58	19	55	103	79
standard deviation	34	6	7	24	6	6	10	11
coeff. of var. CV%	34	25	28	41	32	11	10	14
correlation coefficient							-0.01	
***Riccardiceras* Catria Mts, Fig. 21**								
specimens	17	17	17	17	17	17	17	17
min value	42	13	16	16.6	10.5	40	84	60
max value	98	23	24	56.5	22.6	58	133	103
mean value	62	19	20	29	14	46	108	76
standard deviation	17	3	3	11	3	5	13	11
coeff. of var. CV%	27	16	15	38	21	11	12	14
correlation coefficient						0.77	-0.60	0.09

	D	R	H	L	U	L/H%
***Erycites* Catria Mts, AU 10, Fig. 19**						
specimens	8	32	32	32	13	32
min value	31	14	7,5	11,3	5,5	67
max value	82.5	48.3	30.5	26	32,5	154
mean value	64	30	20	20	20	107
standard deviation	19	10	5	3	10	27
coeff. of var. CV%	30	33	25	15	50	25
correlation coefficient						-0.82
***Erycites* Catria Mts, AU 11i, Fig. 19**						
specimens	7	23	23	23	13	23
min value	49	16.6	13	15.6	9	75
max value	85.4	48	28	24	37.6	163
mean value	76	34	21	19	25	96
standard deviation	12	10	4	2	11	22
coeff. of var. CV%	16	29	19	11	44	23
correlation coefficient						-0.85

	D	R	H	L	U	L/H%
***Erycites* Catria Mts, AU 11s, Fig. 19**						
specimens	11	30	30	30	12	30
min value	52.7	17.8	13	13	8.5	68
max value	100.6	58.2	29.7	24	37.5	127
mean value	70	35	22	19	21	90
standard deviation	15	10	5	2	9	15
coeff. of var. CV%	21	29	23	11	43	17
correlation coefficient						-0.74
***Erycites* Catria Mts, RX 46, Fig. 19**						
specimens	6	13	13	13	6	13
min value	61	24	16.5	13.5	24.4	64
max value	74.5	43.5	24	19	36	106
mean value	67	34	20	16	29	82
standard deviation	6	7	2	2	4	11
coeff. of var. CV%	9	21	10	13	14	13
correlation coefficient						-0.46
***Erycites* Catria Mts, Fig. 20**						
specimens	36	36	36	36	31	
min value	31	17	13.5	13.5	6	
max value	100.6	58.2	30.3	23.5	37.6	
mean value	70	40	23	19	28	
standard deviation	15	8	4	2	8	
coeff. of var. CV%	21	20	17	11	29	
correlation coefficient		0.98				

	D	H	L	U	K	U/D%	L/H%	K/H%	N	Rd%
***Tmetoceras* (m) auct., Figs 9-11**										
specimens	33	21	19	21	17	21	19	17	33	33
min.value	4.8	1.8	1.9	2.8	1.7	40	64	45	8	50
max value	30	9	8	14,5	9	50	143	100	21	271
mean value	16	5	5	9	4	47	90	70	14	107
standard deviation	7	2	2	3	2	3	17	13	3	58
coeff. of var. CV%	44	40	40	33	50	6	19	19	21	54
correlation coefficient						0.16	-0.18	0.54	0.50	-0.79
***Tmetoceras* (M) auct., Figs 9-11**										
specimens	39	39	35	39	38	39	35	38	39	39
min value	14.5	4.9	3.9	5.8	3.8	39	67	56	14	34
max value	76	21	18	39	19	56	103	90	32	97
mean value	47	14	12	23	11	49	87	77	24	55
standard deviation	16	4	4	8	4	5	9	8	4	14
coeff. of var. CV%	34	29	33	35	36	10	10	10	17	25
correlation coefficient						0.24	-0.16	0.31	0.71	-0.87

	D	H	L	U	K	U/D%	L/H%	K/H%	N	Rd%
***Tmetoceras* Catria Mts, Figs 9-11**										
specimens	14	14	8	14	14	14	8	14	10	10
min value	32.7	10.9	8.5	13.2	8	36	68	56	20	36
max value	71.6	21.3	15.4	33.5	16.8	51	90	99	31	61
mean value	50	16	12	22	12	43	76	78	25	51
standard deviation	11	3	3	7	2	4	7	11	4	8
coeff. of var. CV%	22	19	25	32	17	9	9	14	16	16
correlation coefficient						0.73	-0.14	-0.14	0.78	-0.84