

Three new species of *Buchotrigonia* Dietrich, 1938 (Bivalvia; Trigonioida), from the Lower Cretaceous of Colombia

Tomás Villamil

Department of Geological Sciences, CB-250, University of Colorado, Boulder, CO, 80309-0250, U. S. A.

ABSTRACT

This paper describes three new Berriasian species of the genus *Buchotrigonia* Dietrich, 1938 from Colombia: *Buchotrigonia etayoi* sp. nov., *B. perezi* sp. nov., and *B. kauffmanii* sp. nov. They are the oldest known species of the genus *Buchotrigonia* in the world.

Key words: Systematics, Bivalvia, Trigonioida, *Buchotrigonia*, Lower Cretaceous, Berriasian, Colombia.

RESUMEN

Tres nuevas especies de *Buchotrigonia* Dietrich, 1938 (Bivalvia; Trigonioida) del Cretácico Inferior de Colombia. En el presente artículo se describen tres nuevas especies del género *Buchotrigonia* Dietrich, 1938, del Berriásico de Colombia: *Buchotrigonia etayoi* sp. nov., *B. perezi* sp. nov. y *B. kauffmanii* sp. nov. Las especies propuestas son las más antiguas conocidas de este género en el mundo.

Palabras claves: Sistemática, Bivalvia, Trigonioida, *Buchotrigonia*, Cretácico Inferior, Berriásico, Colombia.

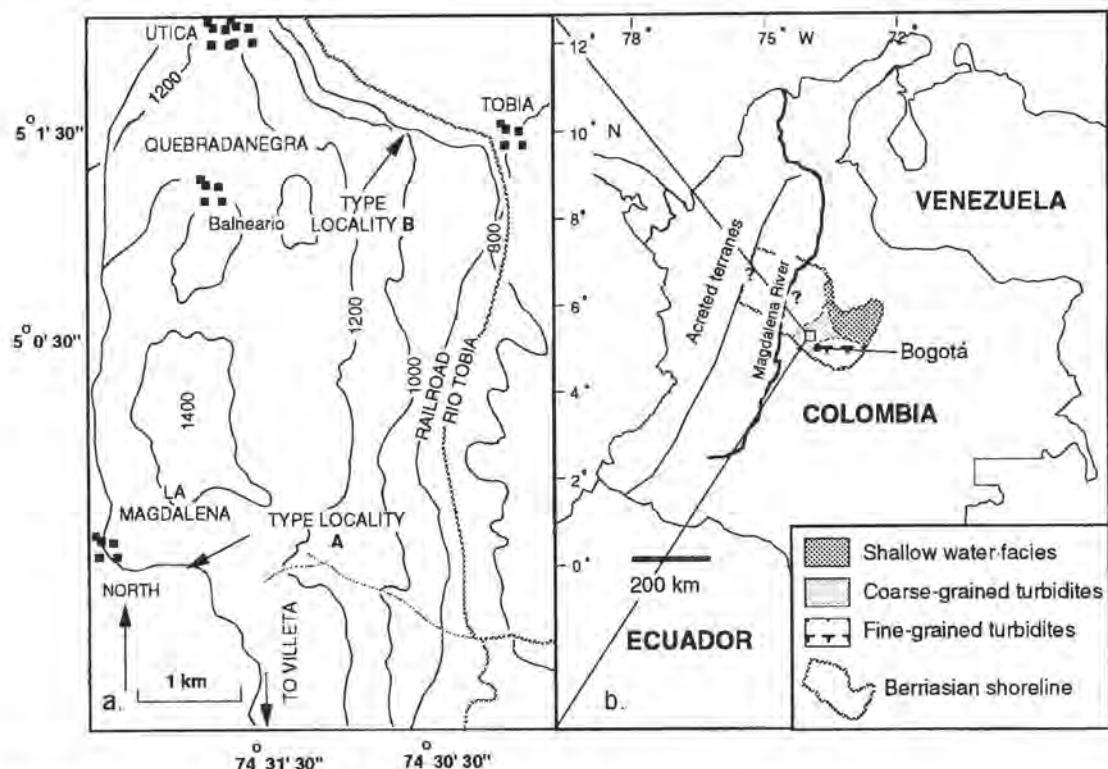
INTRODUCTION

Leopold von Buch (1839) first described the bivalve *Trigonia abrupta* in his work on South American fossils collected by the naturalist Alexander von Humboldt in 1836. One hundred years later, Dietrich (1938) assigned this species to *Buchotrigonia*, a new subgenus. Subsequently, Cox (1952) elevated *Buchotrigonia* to generic status and divided it into the nominal subgenera *Buchotrigonia*, and *Syrotrigonia*. The record of *Buchotrigonia* s. str. in the Americas is extensive with several species that have been described from the United States, Venezuela, Colombia, Perú and Chile in strata ranging in age from Berriasian (new species described herein) to late

Campanian (*Buchotrigonia topocalmensis* Pérez y Reyes, 1980, from Chile).

The three new species described herein are the oldest known members of *Buchotrigonia*. These fossils were collected by the author in 1987 in the area west of Departamento de Cundinamarca, Colombia, from coarse turbiditic sandstones and conglomerates of the middle Cáqueza Group (Villamil, 1990) (text-Figs. 1, 2).

The Cáqueza Group, originally defined by Hubach (1945), represents the first transgressive-regressive cycle of the Colombian Cretaceous (cycle 1 of Macellari, 1988). The lower unit of the Cáqueza



Text-FIG. 1. a- Index map showing the type localities of *Buchotrigonia etayo* sp. nov. and *B. kauffmani* sp.nov. (locality A), and *B. perezi* sp. nov. (locality B), located about 50 km northwest of Bogotá; b- the map on the right shows the Berriasian deposits in Colombia, modified from Etayo-Serna *et al.*, 1976.

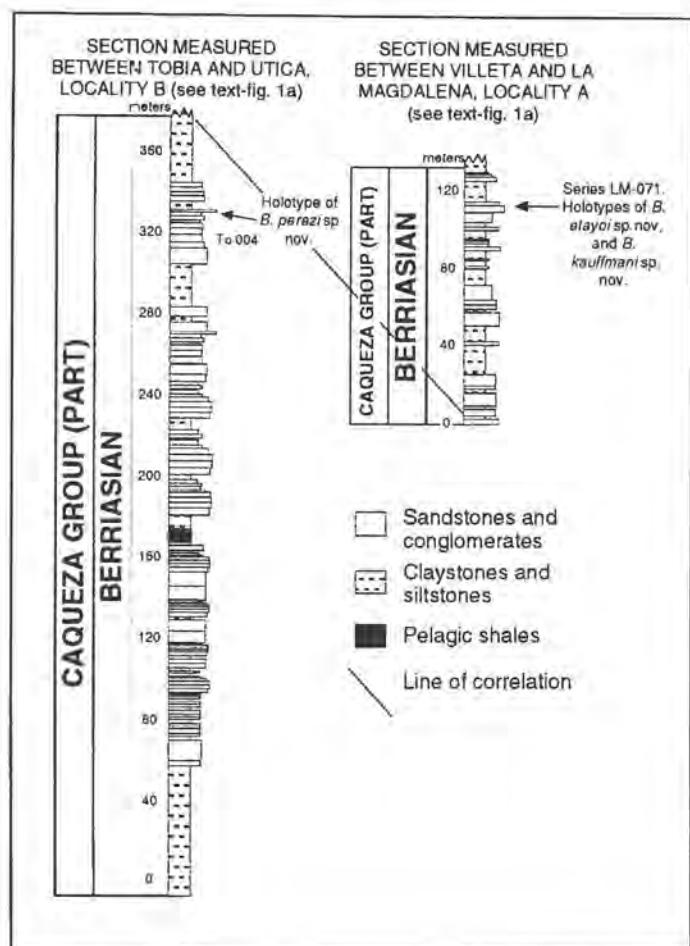
Group is composed of dark siliceous shales interbedded partly with turbidite sandstones. The middle portion of this group shows many more turbidite beds; this unit shallows upward into the upper part of the Cáqueza Group which is composed of shallow marine sandstones. A marked transgressive surface overlays the upper unit of the Cáqueza Group; marine black shales of the Villeta Group rest abruptly above the upper Cáqueza unit; these facies persist then for long in the Cretaceous. The lower boundary of the Cáqueza Group does not crop out in the region studied; east of Bogotá, it overlies a Tithonian conglomerate.

The type section of the Cáqueza Group is located near the village of the same name, 40 km east of Bogotá. The facies, however, are markedly different. They are composed of thinly bedded and fine-grained turbidite deposits interbedded with organic-rich shales. In the area studied in the present work, the Cáqueza Group is composed of thick, coarse-grained turbidite deposits interbedded with pelagic shales (text-Fig. 1,

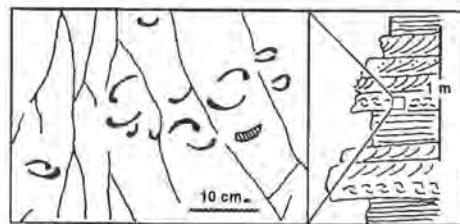
facies distribution; text-Fig. 2). The type Cáqueza represents more distal deposits, compared to the Cáqueza Group near the Villeta - Utica region.

Two detailed stratigraphic sections of the Cáqueza Group were measured in the western part of Departamento de Cundinamarca, Colombia, where the sequence is composed of turbiditic sandstones interbedded with hemipelagic shales (text-Fig. 2). The tritoniids occur as transported specimens within coarse sandstone beds representing the 'A' interval of the Bouma turbidite model. The shells occur in consistent orientations within different parts of the turbidite beds; tritoniids generally occur as single valves which are concave up in the lower part of the 'A' turbidite layers, and concave down in the upper part (text-Fig. 3).

The upper Cáqueza Group contains tritoniids of the genus *Mediterraneotrigonia* Nakano, 1974, in life position; however, no *Buchotrigonia* were found in this upper unit.



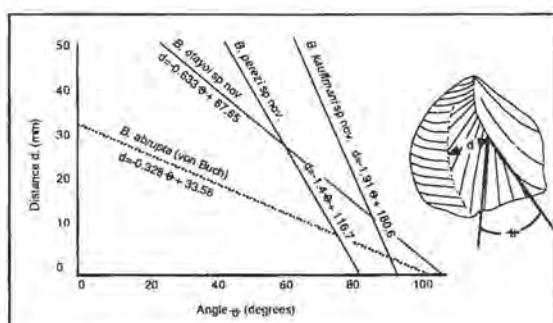
Text-FIG. 2. Sections of the Cáqueza Group, lower and intermediate unit. The section on the left was measured on the railroad Utica - Tobia. The section on the right was measured between Villeta and La Magdalena.



Text-FIG. 3. Simplified portion of a stratigraphic column of the Cáqueza Group, lower interval, measured in the railroad that leads to Tobia from Utica. This figure shows the coarse sandstones from where the fossils were collected, and a sketch of the arrangement of valves in the outcrop.

The type Cáqueza Group is composed of more distal facies and does not contain abundant *Buchotrigonia* spp. probably because the energy of the turbidite flow was not enough to carry fragments that large. Only scattered *Buchotrigonia* and *Pterotrigoria* van Hoepen, 1929 have been collected by the author from the type Cáqueza Group; smaller fossils are more common.

Verification of the differences between the three new species here described, in comparison with *B. abrupta* (type species) and *B. topocalmensis*, was performed using two independent biometrical methods. One of them utilized two external ornamentation characteristics, each of which can be measured several times in one shell. These are the angle that the marginal carina forms with each subvertical flank costae, and the perpendicular distance from the subvertical flank costae to the carina (text-FIG. 4). After plotting all the data for ϕ



Text-FIG. 4. Schematic *Buchotrigonia* showing the two measured features; d = distance between any given point in the carina and the anterior flank; ϕ = angle formed by the marginal carina and the costae that cross that same point. Comparison of the regression lines of d vs. ϕ for the type species of the genus (bold line) and for the three new species.

(carina - costae angle) and d (distance to carina) regression lines were calculated and drawn (text-Fig. 4). Regression equations and correlation coefficients are shown in text-figure 4. The other method was by means of two relatively independent measurements.

Three-dimensional graphs using independent measured characters support the separation of morphologic clusters (species). The following characteristics were measured on the external surface of each shell or mold: a- the distance from the umbo

to the point where the flank costae begin to break (dh); b- a distance perpendicular to dh from the point where the flank costae begin to break to the marginal carina (dl); c- the number of costae per centimeter on the anterior flank (text-Fig. 6). The graph in text-figure 6 shows morphologic clusters, each representing one species.

The main advantage of these two methods is that juvenile specimens, fossil fragments, and impressions can all be measured and analyzed.

SYSTEMATIC DESCRIPTIONS

Order Trigonioida Dall, 1889
Superfamily Trioniacea Lamarck, 1819
Family Trioniidae Lamarck, 1819

Genus *Buchotrigonia* Dietrich, 1938

Type species: *Buchotrigonia abrupta* (von Buch, 1839). Aptian of Colombia.

Diagnosis (emend.): Medium to large shells (5-8 cm long) with trigonal to elongate-elliptical outline. Wide area with oblique costae in early growth stages, which diverges in chevron-like manner from those of the flank, then smooth. Flank with three different types of costae: eccentric in early growth stages, and subsequently subvertical and transverse. Flank costae in late growth stages are not continuous.

Distribution. *Buchotrigonia* is distributed in America, Spain and France.

Buchotrigonia etayoi sp. nov.

Pl. 1, Figs. 1-4,7

Etymology: Named in honor of Fernando Etayo-Serna, paleontologist of the Universidad Nacional de Colombia.

Material: 130 specimens were studied. Most of them are very well preserved external molds; the rest are replaced with black calcium carbonate. Latex and silicone casts of the molds were made for taxonomic and biometric studies.

Holotype: The holotype is a well preserved right valve of a medium size specimen (LM 071 - s9; Pl. 1, Fig. 4), found in locality A, text-Fig. 1.

Paratypes: LM 071 - s2, a right valve (Pl. 1, Fig. 1);

LM 071 - s2', a left valve; LM 071 - s8, a left valve; LM 071 - 9, a left valve (Pl 1, Fig. 7); LM 071 - 10, fragment of a well preserved anterior region of a shell (Pl. 1, Fig. 2), LM 071 - s19, a left valve internal mold, that shows the adductor and pedal retractor muscle scar (Pl. 1, Fig. 3).

Repository: Laboratorio de Estratigrafía, Departamento de Geociencias, Universidad Nacional de Colombia, Bogotá.

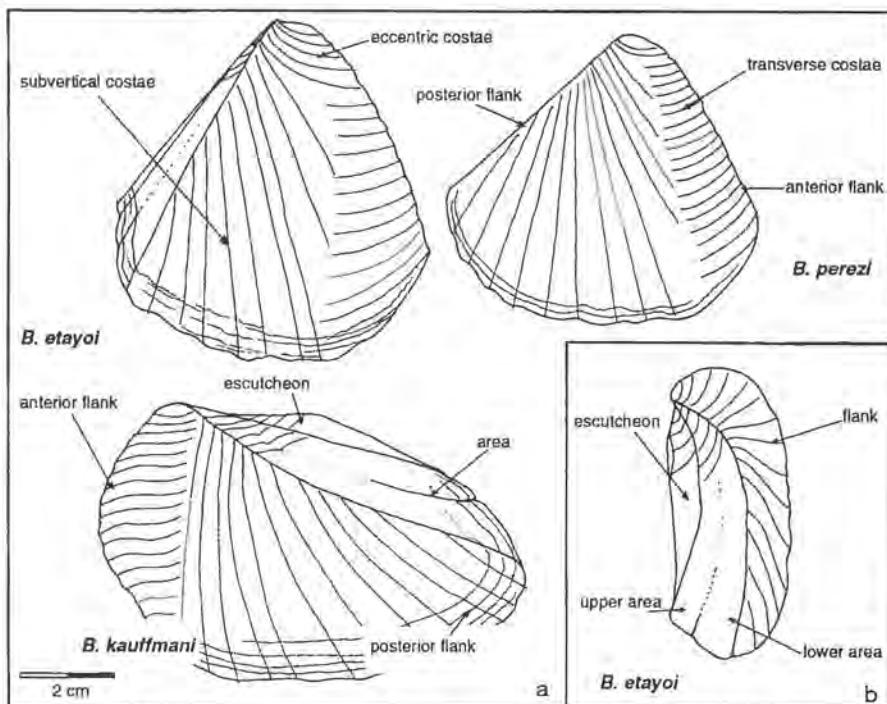
Type locality: The type locality is on the south side of the road between Villeta and La Magdalena (Cundinamarca, Colombia), 1 km east of La Magdalena ($4^{\circ} 59' 11.25''$ N; $74^{\circ} 32' 18.75''$ W), text-Fig. 1, loc.A; text-Fig. 2.

Other localities: The specimens were collected about 4 km north of type locality, 1 km west of Tobia on the south side of the railroad near type locality (text-Fig. 1); close to the town of Tobia (QNOIO-15), and from Tobia (F0081-b).

Stratigraphic occurrence: *Buchotrigonia etayoi* sp. nov. was collected from the coarse sandstones of a turbiditic sequence in the Cáqueza Group, intermediate unit (not formally named; text-Fig. 2).

Associate fauna: *Buchotrigonia etayoi* sp. nov., *B. kauffmani* sp. nov. and fragmentary echinoids, indeterminate gastropods, and bivalves such as *Protocardia* sp., *Exogyra* sp., and *Mediterraneotrigonia* sp.

Age: Berriasian, based on *Sarasinella cf. S. hondaana* Haas (late Berriasian) studied by F. Etayo-Serna



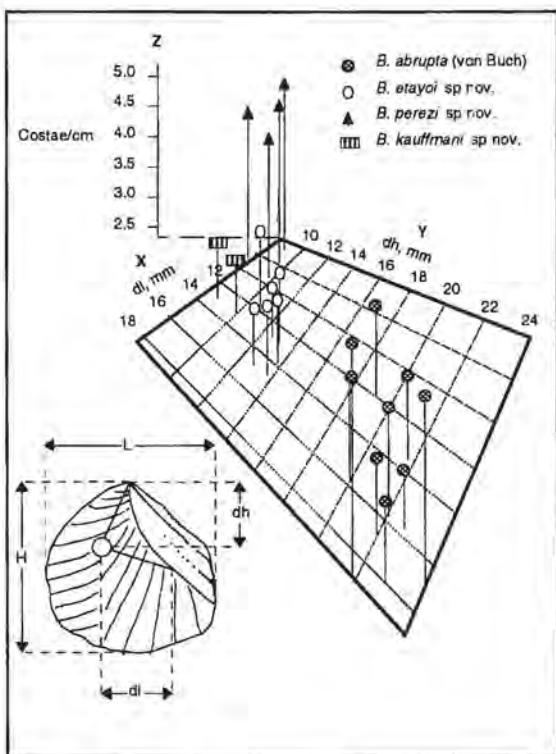
Text-FIG. 5.
a- Lateral view showing flank ornamentation. *Buchotrigonia etayoi* sp. nov., *B. perezi* sp. nov., and *B. kauffmani* sp. nov.; b- ornamentation of the area and escutcheon of the species *B. etayoi* sp. nov., dorsal view.

Text-FIG. 6. Schematic *Buchotrigonia* showing the point where the flank costae begin to divide (lower sketch) and the measured distances dh and dl (upper sketch). Plotted measurements differentiate *B. abrupta* (von Buch), *B. etayoi* sp. nov., *B. perezi*, and *B. kauffmani* sp. nov.

(1991, written communication), collected from the same stratigraphic interval as *Buchotrigonia etayoi* (sample number 21074, not illustrated).

Diagnosis: Species of *Buchotrigonia* that is slightly higher than long, large, with trigonal outline, and no more than 6 transverse costae per centimeter on the anterior zone of the flank. Non-tuberculate costae occur on the adumbonal region of the shell.

Description: Large shell with a maximum length of ca. 69 mm and rounded trigonal outline; slightly higher than long in most specimens (Pl. 1, Figs. 1-4; Fig. 7 shows a long rather than tall specimen). The anterior margin of the shell is broad, shows continuous flank ornamentation (Pl. 1, Fig. 2), and has a rounded outline. The posterior margin is slightly elongated, straight, and forms an angle of about 50° with the ventral margin. The umbones are wide, and slightly



opisthogyrus. The marginal carina is sharp in early growth stages, then obtuse and relatively wide (3-5 mm). The area comprises approximately 15% of the shell, and is divided by a weak ridge into an upper and a lower area, both of which are ornamented with oblique costae only in the early growth stages (text-Fig. 5b). The surface of the area and the flank form an angle of 110° in the adumbonal region and subsequently increases to 120° towards the ventral margin. The escutcheon comprises 6-8% of the valve surface, and is characterized by oblique costae in the very early growth stages, and growth lines in the late adult stages (text-Fig. 5b).

The flank is divided into three regions: a- the adumbonal one-tenth of the valve is ornamented with continuous eccentric costae; b- the anterior flank contains transverse straight costae that are subhorizontal, 6 per centimeter, and comprises 30% of the valve surface; c- the central posterior flank (45% of the shell) contains subvertical costae, that are thinner than the intercostal spaces (Pl. 1, Fig. 4).

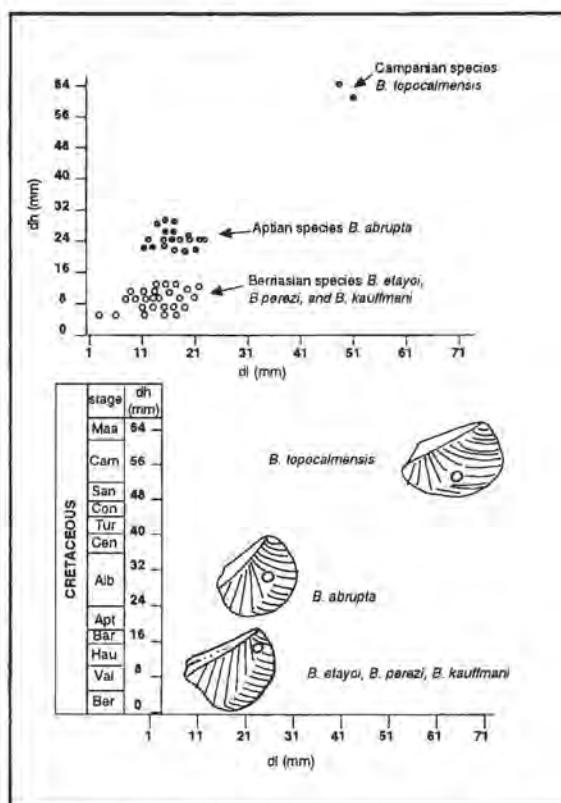
Measurements, mm

Fossil number	L	H	W	H/L	2W/L
Holotype					
LM 071-s9 (rv)	54	57	20	1.05	0.74
Paratypes					
LM 071-s2 (rv)	50	51	20	1.02	0.80
LM 071-s2' (lv)	44	51	21	1.16	0.95
LM 071-s8 (lv)	48	52	21	1.08	0.87
LM 071-9 (lv)	69	65	24	0.94	0.70

L= length; H= height; W= width of one valve; rv= right valve; lv= left valve.

Discussion. *Buchotrigonia etayoi* sp. nov. differs from *B. abrupta* (von Buch, 1839), the type species of the genus, mainly in the following aspects: *B. etayoi* sp. nov. is larger and its average ratio H/L is greater than the type species (1.05 average in *B. etayoi* sp. nov. and 0.85 average for *B. abrupta* (von Buch)). *B. etayoi* sp. nov. has non-tuberculate costae in the adumbonal region (Table 1). The point where the flank costae separate is located closer to the umbo in the species *B. etayoi* sp. nov. than in the type species *B. abrupta* (von Buch) (text-Figs. 6, 7). Consequently, the percentage of the shell ornamented with eccentric costae is relatively less in *B. etayoi* sp. nov. (10%) than in *B. abrupta* (von Buch) (25%).

Buchotrigonia etayoi sp. nov. is wider and larger than *B. reesidei* (Stoyanow, 1949); the latter



Text-FIG. 7. Graph of dh versus dl showing discrete species groupings. Each circle represents a measured specimen. The lower group comprises Berriasian species; the middle group Barremian-Aptian species, and the upper group represents Campanian species. The lower diagram shows Cretaceous stages and dh versus dl. Flank ornamentation is shown in schematic drawings which represent the morphologic groups. The point where the costae divide moves away from the umbo through time, and the amount of surface area ornamented with eccentric costae becomes larger with time.

commonly has zigzag costae (Stoyanow, 1949), a feature that never appears in the new species of Colombia. *Buchotrigonia etayoi* sp. nov. differs from *B. ?forti* (Lisson, 1930) in that it is shorter, has thinner costae, and the flank ornamentation is not continuous. *Buchotrigonia etayoi* sp. nov. is smaller than *B. topocalmensis* Pérez and Reyes; the area is divided, and the escutcheon is ornamented; in addition, the point where the flank costae separate is closer to the umbo in *B. etayoi* sp. nov. The new species does not exhibit thick concentric costae like *B. (Buchotrigonia?)*

TABLE 1. COMPARISON BETWEEN THE THREE NEW SPECIES AND *BUCHOTRIGONIA (B.) ABRUPTA* (VON BUCH, 1939)

TAXON SPECIES	OUTLINE	H/L MEAN	W MEAN	SIZE	% ECCENTRIC COSTAE	TRANSVERSE COSTAE DENSITY (MIDDLE REGION)
<i>B. abrupta</i>	trigonal	0.85	17	medium	25 %	5
<i>B. etayoi</i>	trigonal	1.05	21	large	10 %	6
<i>B. perezi</i>	trigonal	0.87	16	medium	10 %	7-8
<i>B. kauffmani</i>	elongate- elliptical	0.65	19	large	5 %	4

H = height; L = length; W = width one valve

inca (Fritzsche, 1923); this characteristic and the vaugonic costae toward the ventral margin suggests that the taxonomic position of *B. (B.) inca* (Fritzsche) is doubtful. Perhaps it will fit better in the genus *Syrotrigonia* Cox, 1952.

Some dissimilarities between *Buchotrigonia etayoi* sp. nov., *B. perezi* sp. nov., and *B. kauffmani* sp. nov. are shown in text-figures 5a, 6-7. *B. etayoi* sp. nov. is generally higher than long, whereas the other new species are relatively long (text-Fig. 5a). Transverse costae density per centimeter is greater in *B. etayoi* sp. nov. than in *B. kauffmani* sp. nov. (6.0 in *B. etayoi* sp. nov.; 4.0 in *B. kauffmani* sp. nov.), and lesser than in *B. perezi* sp. nov. (8.0 costae/cm) (Table 1).

Buchotrigonia perezii sp. nov.

Plate 1, Figs. 6,8

Etymology: Named in honor of Ernesto Pérez, paleontologist of the Servicio Nacional de Geología y Minería, Chile (SERNAGEOMIN).

Material: Four well preserved external molds from which latex casts were made.

Holotype: The holotype is a well preserved external mold of the right valve catalogued as To. 004. This specimen was found at locality B (text-Figs. 1, 2; Pl. 1, Fig. 8).

Paratype: A well preserved but incomplete external mold of a right valve found in Quebradanegra (QN 010-18; Pl. 1, Fig. 6).

Repository: Laboratorio de Estratigrafía, Departamento de Geociencias, Universidad Nacional de Colombia, Bogotá.

Type locality: One km west of Tobia (Cundinamarca, Colombia), on the south side of the railroad that leads to Utica ($5^{\circ} 1' 39''$ N; $74^{\circ} 31'$ W (text-Fig. 1, loc. B).

Other locality: Between Villegas and La Magdalena (text-Fig. 1), 1 km east from La Magdalena. Two external molds come from this locality: L M071-S13, right valve; LM 071-S32, left valve; this last specimen was not collected *in situ*.

Stratigraphic occurrence: The holotype of *Buchotrigonia perezii* sp. nov. was collected from the coarse sandstones of a turbiditic sequence in the Cáqueza Group, intermediate unit (not formally named; text-Fig. 2).

Associated fauna: This species was found together with *Buchotrigonia etayoi* sp. nov. Nearby strata yielded *Ptychomyia* sp. and *Mediterraneotrigonia* sp.

Age: Berriasian, based on *Sarasinella* cf. *S. hondaana* Haas (late Berriasian) studied by F. Etayo-Serna (1991, written communication). These ammonites were collected from a stratigraphic interval 100 m above *Buchotrigonia perezii* sp. nov. The sample number of the ammonites is 21074, not illustrated.

Diagnosis: Species of *Buchotrigonia* of medium size that are slightly longer than high, with trigonal outline, with no more than 8 transverse costae per linear centimeter on the anterior zone of the flank. Non-tuberculate costae occur in the adumbonal region of the shell.

Description: Medium size *Buchotrigonia* (approximately 5 cm in length). Outline trigonal, slightly longer than high (Pl. 1, Figs. 6-8). The umbones are slightly opisthogyrous. The area comprises 10% of the valve surface, it is bisected by a ridge, and ornamented with oblique costae in early growth stages (Pl. 1, Fig. 8). The marginal carina is sharp in early growth stages, then wide and rounded. The surfaces of the area and the flank form an angle of 120° in early growth stages and subsequently about 130°. The escutcheon is wide, depressed, with oblique costae in the very early growth stages.

The outline of the anterior margin of the shell is wide and straight whereas the posterior margin ends in an elongated and rounded manner. The ventral margin is crenulated and has a rounded outline.

The flank is divided as in *Buchotrigonia etayoi* sp. nov. into three regions (text-Fig. 5a; Pl. 1, Figs. 6, 8): the adumbonal region is ornamented with continuous eccentric costae; the anterior one is ornamented with transverse straight costae, 7 per centimeter (text-Fig. 6, Z axis) increasing to 8 towards the ventral margin and comprises 30% of the valve surface; the central posterior flank (50% of the total surface) has subvertical, relatively fine costae that are inclined towards the posterior margin.

Measurements, mm

Fossil number	L	H	W	H/L	2WL
Holotype					
To. 004 (rv)	52	48	18	0.92	0.69
Paratype					
QN. 010-18 (rv)	35	29	12	0.82	0.68

L= length; H= height; W= width of one valve; rv= right valve; lv= left valve.

Discussion: *Buchotrigonia perezi* sp. nov. differs from *B. abrupta* (von Buch) in having non-tuberculate costae in the adumbonal region. The percentage of eccentric costae is relatively low (<10%) compared to *B. abrupta* (von Buch) (about 25%; Table 1). This difference is represented by the plots in text-figures 5 and 6. *B. perezi* sp. nov. does not have the zigzag pattern of ornamentation and is slightly larger than *B. reesidei* (Stoyanow). The new species is relatively shorter and has thinner costae than *B. ?forti* (Lisson, 1930). Lisson's species has continuous costae in the flank (Lisson, 1930, Pl. 1, Fig. 1) whereas *B. perezi* sp. nov. shows clear discontinuous costae. *B. perezi*

sp. nov. is smaller than *B. topocalmensis* Pérez and Reyes, 1980, and has a bisected area and an ornamented escutcheon. *B. perezi* sp. nov. differs from *B. etayoi* sp. nov. in being smaller and having greater density of costae per centimeter in the anterior region of the shell (text-Fig. 6, Z axis). The point where the flank costae begin to divide is located closer to the umbo in *B. perezi* sp. nov. than in *B. abrupta* (von Buch) and in *B. topocalmensis* Pérez and Reyes (text-Figs. 6,7). *Buchotrigonia perezi* sp. nov. is smaller, less elongated and has straighter costae ornamenting the anterior flank than does *B. kauffmanii* sp. nov. (text-Fig. 5a).

Buchotrigonia kauffmanni sp. nov.

Plate 1, Figs. 5,9-10

Etymology: Named in honor of Erle G. Kauffman, paleontologist of the University of Colorado at Boulder.

Material: Three specimens, two are well preserved external molds; the third is an internal mold.

Holotype: LM-071 s3, a well preserved specimen (Pl. 1, Figs. 9-10)

Paratypes: LM-071 s1, a well preserved internal mold of a left valve (Pl. 1, Fig. 5), and LM-071 s7, the posteroventral region of a large specimen.

Repository: Laboratorio de Estratigrafía, Departamento de Geociencias, Universidad Nacional de Colombia, Bogotá.

Type locality: The type locality is between Villota and La Magdalena (Cundinamarca, Colombia), 1 km east of La Magdalena on the south side of the road (4°59'11.25"N; 74°32'18.75"W), Fig. 1, loc.A.

Stratigraphic occurrence: *Buchotrigonia kauffmanni* sp. nov. was collected from the coarse turbiditic sandstones of the intermediate unit of the Cáqueza Group (not formally named, text-Fig. 2).

Associated fauna: This species was found together with *Buchotrigonia etayoi* sp. nov., small echinoid fragments and other undetermined bivalves.

Age: Berriasian, based on *Sarasinella* cf. *S. hondaana* Hass (late Berriasian; F. Etayo-Serna, 1991, written communication).

Diagnosis: A very elongated, large species of *Buchotrigonia*. Shell with no more than 4 transverse costae per linear centimeter on the anterior flank, which form an elongated reclining 'S' pattern (Pl. 1, Fig. 9). Non tuberculate costae occur on the adumbonal region of the shell.

Description: Large forms with elongate and elliptical outline; opisthogyrous umbones (Pl. 1, Figs. 9, 10). The area comprises 10% of the valve surface; it is bisected by a ridge and ornamented, only in the adumbonal region, with oblique costae concave towards the umbo. The escutcheon is wide, elongated and shows the same ornamentation as the area (Pl. 1, Fig. 9). The marginal carina is broad towards the ventral margin, rounded in cross section, it generates an angle of 135° between the flank and the area. The anterior margin has a rounded contour, whereas the posterior one terminates in an acute angle. The ventral margin is crenulated. The flank is divided into three regions: the adumbonal flank (<5% of the total surface) is ornamented with eccentric costae; the anterior one is ornamented with transverse costae that form an elongated reclining «S» pattern (4 per centimeter); the posterior central region (60% of the valve surface) has subvertical costae.

Measurements, mm

Fossil number	L	H	W	H/L	2W/L
Holotype					
LM 071-s3	62	-	19	-	0.61
Paratype					
LM 071-s7	60	39*	18*	0.65*	0.60

L=length; H=height; W=width of one valve. *=approximate values.

Discussion. *Buchotrigonia kauffmani* sp. nov. is the most elongated and one of the largest species of the genus *Buchotrigonia*. It differs from *B. abrupta* (von Buch) in being larger and having non-tuberculate costae in the adumbonal region (Table 1). The point where the flank costae begin to break is closer to the umbo in *B. kauffmani* sp. nov. than in *B. abrupta* (von Buch) and *B. topocalmensis* Pérez and Reyes (text-Figs. 6, 7). This new species differs from all the other taxa of the genus mainly in its elongate-elliptical outline and in the curved costae on the anterior flank.

MORPHOLOGIC-STRATIGRAPHIC TRENDS IN THE SOUTHERN AMERICAN *BUCHOTRIGONIA* SPECIES

The strongly ornamented flank of *Buchotrigonia* shows a point where the eccentric costae divide (text-Figs. 6, 7); the distance from this point to the umbo (dh) parallel to the shell height (h) was measured in 44 specimens of the 5 South-American species. The distance is parallel to the valve length from the point where the costae divide to the marginal carina (dl in text-Fig. 6) was also measured. These two distances were chosen because they represent the amount of pre-adult shell, they vary between diachronous taxa and are constant within contemporary species. This is demonstrated herein by the similar values for the three Berriasian

species (text-Fig. 7). The selected criterion is therefore not valid for biometrical separation of all species; its chronological value seems to be significant, however.

Three statistical groups are clearly separated when plotting all measurements (text-Fig. 7). The lower cluster represents the Lower Cretaceous (Berriasian) species *Buchotrigonia etayoi* sp. nov., *B. perezi* sp. nov., and *B. kauffmani* sp. nov. The intermediate cluster belongs to the Aptian species *B. abrupta* (von Buch), and the upper group to the Campanian species *B. topocalmensis* Pérez and Reyes (text-Fig. 7).

CONCLUSIONS

The three new species of *Buchotrigonia* here described occur in the Berriasian stage of Colombia based on their association with *Sarasinella* cf. *S. hondaana* Haas. These are the oldest known species of this genus in the world.

The point where the eccentric costae divide is

close to the umbo in the Berriasian species (*B. etayoi*, *B. perezi* and *B. kauffmani*) in opposition to the Aptian and Campanian species (*B. abrupta* and *B. topocalmensis*) where it happens in the central and lower zones respectively.

ACKNOWLEDGEMENTS

This paper is part of the author's undergraduate thesis at the Universidad Nacional de Colombia; the work was supervised by Professors Fernando Etayo-Serna (Universidad Nacional de Colombia) and Ernesto Pérez d'Angello (Servicio Nacional de Geología y Minería, Santiago, Chile). Sincere thanks are offered to them. Professors Erle Kauffman, Héctor

Leanza, and Bradley B. Sageman (University of Colorado), José Corvalán, Ernesto Pérez, Vladimir Covacevich and Renato Reyes (Servicio Nacional de Geología y Minería, Santiago, Chile) critically reviewed the manuscript and helped improve it considerably. Thanks also to Oscar Alfaro who did the photographic work.

REFERENCES

- Buch, L. von. 1839. Petrifications recueillies en Amérique par Mr. Alexandre de Humboldt et par Mr. Charles Degenhardt. *Academie Royale des Sciences*, 22 p. Berlin.
- Cox, L. R. 1952. Notes on the Trigoniidae with outlines of a classification of the family. *Malacological Society of London, Proceedings*, Vol. 29, Nos. 2-3, p. 45-70.
- Dietrich, W.O. 1938. Lamelibranquios cretácicos de la Cordillera Oriental. *Estudios geológicos y paleontológicos sobre la Cordillera Oriental de Colombia* 1934, No. 3, p. 81-108.
- Etayo-Serna, F.; Renzoni, G.; Barrero, D. 1976. Contornos sucesivos del mar Cretácico en Colombia. In *Congreso Colombiano de Geología*, No. 1, Memoria, p. 217-252.
- Hubach, E. 1945. La Formación 'Cáqueza', región de Cáqueza (oriente de Cundinamarca). *Servicio Geológico Nacional, Compilación de Estudios Geológicos Oficiales, Colombia*. Vol. 6, p. 23-26.
- Macellari, C. 1988. Cretaceous paleogeography and depositional cycles of western South America. *Journal of South American Earth Sciences*, Vol. 1, No. 4, p. 373-418.
- Pérez, E.; Reyes, R. 1980. *Buchotrigonia topocalmensis* sp. nov. (Trigoniidae; Bivalvia) del Cretácico Superior de Chile. *Revista Geológica de Chile*, No. 9, p. 37-55.
- Stoyanow, A. 1949. Lower Cretaceous stratigraphy in Southern Arizona. *Geological Society of America, Memoire*, No. 38, p. 169 p.
- Villamil, T. 1990. Consideraciones tafonómicas de una concentración de bivalvos en una secuencia turbidítica del Cretácico basal de Colombia. *Universidad Nacional de Colombia, Revista Facies*, No. 1, p. 26-31.

Manuscript received: November 23, 1990; accepted: July 21, 1992.

PLATE 1

PLATE 1

(All photographs taken of latex casts, figures in natural size)

Figures

Figs. 1-4,7 *Buchotrigonia etayoi* sp. nov.
p. 230

South side of the road between Villeta and La Magdalena (Cundinamarca, Colombia), 1 km east of La Magdalena (text-Fig. 1, location A). Cáqueza Group, intermediate unit. Berriasian.

- 1 Specimen LM 071-s2 (paratype). Right valve.
Internal features view.
- 2 Specimen LM 071-10 (paratype). Both valves.
Anterior view which shows transverse flank costae.
- 3 Specimen LM 071-s19 (paratype). Left valve.
Internal mold. Note adductors and pedal retractor muscle insertion areas.
- 4 Specimen LM 071-s9 (holotype). Right valve.
Lateral view. Note the different density between subvertical and transverse flank costae.
- 7 Specimen LM 071-9 (paratype). Left valve.
Internal region view. It shows a long rather than tall specimen.

Figs. 6, 8 *Buchotrigonia perezi* sp. nov.
p. 233

One km west of Tobia (Cundinamarca, Colombia) on the south side of the railroad that leads to Utica (text-Fig. 1, location B). Cáqueza Group, intermediate unit. Berriasian.

- 6 Specimen QN 010-18 (paratype). Right valve.
Lateral view. Note that the point where the flank costae begin to divide is located close to the umbo.
- 8 Specimen To. oo4 (holotype). Right valve.
Lateral view. Note the great density of transverse flank (8 costae per centimeter)

Figs. 5,9-10 *Buchotrigonia kauffmani* sp. nov.
p. 234

South side of the road between Villeta and La Magdalena (Cundinamarca, Colombia), 1 km east of La Magdalena (text-Fig. 1, location A). Cáqueza Group, intermediate unit. Berriasian.

- 5 Specimen LM 071-s1 (paratype). Left valve.
Internal mold. Note muscle insertion area and the integripalliate line.
- 9 Specimen LM 071-s3 (holotype). Both valves.
Dorsal view. Note the area bisected by a ridge and ornamented with oblique costae concave towards the umbo.
- 10 Lateral view which shows transverse flank costae that form an elongated reclining 'S' pattern.

PLATE 1

