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FIRST REPORT OF *CLARAIA* (BIVALVIA) IN THE SERVINO FORMATION (LOWER TRIASSIC) OF THE WESTERN OROBIC ALPS, ITALY

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Key-words: Bivalvia, *Claraia*, bio- and chronostratigraphy, Lower Triassic, Lombardy, Southern Alps, Italy.

Riassunto. Viene per la prima volta segnalata la presenza di un orizzonte a *Claraia* nel Servino della Valsassina (Alpi Orobie occidentali), situato a circa 8 m dalla base formazionale. Gli esemplari presentano un'ampia variabilità morfologica che interessa principalmente l'ornamentazione. Questo ha portato a distinguerli in vari morfogruppi riferibili alle seguenti morfospecie: *C.* cf. *aurita* (Hauer, 1850), *C.* cf. *bittneri* Ichikawa, 1958, *C. tesidea* (Leonardi, 1929), *C. intermedia* (Bittner, 1901), *C. radialis* (Leonardi, 1929) and *C.* cf. *clarai* (Emmrich, 1844). Applicando il concetto di specie-popolazione, la maggior parte degli esemplari è riconducibile a *C. intermedia* mentre i rimanenti, per la conservazione non ottimale, vengono classificati in nomenclatura aperta (*C.* cf. *aurita*).

L'orizzonte a *Claraia* delle Alpi Orobie viene correlato ai livelli di transizione tra le subzone a *C. clarai* e *C. aurita* della Fm. di Werfen (Membro di Siusi) delle Dolomiti, dove le coeve popolazioni a *Claraia* registrano, parimenti a quella investigata, un'ampia variabilità intraspecifica. Significativa è la presenza, in questi livelli a *C. intermedia*, di esemplari a prevalente scultura radiale riferibili a *C. radialis* (Gruppo *C. stachei*). L'orizzonte a *Claraia*, che documenta nel Servino delle Alpi Orobiche il primo evento trasgressivo triassico contenente fossili marini significativi dal punto di vista cronostratigrafico, è riferibile ad un'età posta tra il Griesbachiano finale ed il Dieneriano inferiore.

Abstract. A fossiliferous horizon containing *Claraia* is reported for the first time 8 m above the base of the Servino Fm. in the western Orobic Alps (Lecco, Lombardy). The specimens have a broad morphological variability which mostly concerns the sculpture, and thus several morphospecies can be recognized [*C.* cf. *aurita* (Hauer, 1850), *C.* cf. *bittneri* Ichikawa, 1958, *C. tesidea* (Leonardi, 1929), *C. intermedia* (Bittner, 1901), *C. radialis* (Leonardi, 1929), *C.* cf. *clarai* (Emmrich, 1844)]. These taxa have mostly been classified into *C. intermedia* by applying a species-population concept.

The *Claraia* horizon of the Orobic Alps can be correlated with the transitional layers between the *C. clarai* and *C. aurita* subzones of the Werfen Fm. (Siusi Member) in the Dolomites. Thus, in this area, the first Triassic marine transgression with age-diagnostic fossils of the Servino Fm. may have an age ranging from the latest Griesbachian to the early Dienerian.

Introduction.

The cosmopolitan genus *Claraia* is an important tool from both a stratigraphical and a paleogeographical point of view for the Early Triassic (Nakazawa, 1977; Yin, 1985). In particular, it has a great chronological value for marine successions lacking ammonoids, as it occurs in the Western Tethys. *Claraia* is very abundant in the eastern Southern Alps (east of the Adige valley), where discoveries have been made since the first half of the last century (Dolomites, Carnia, Valsugana, Recoaro; Fig. 1). Here *Claraia* occurs in the lower members (Mazzin and Siusi) of the Werfen Fm. (Broglio Loriga et al., 1983). To the west of the Adige valley quotations are so far rare, with the last and uncommon discoveries being in the Servino Fm. of the Giudicarie area (Lepsius, 1878; Fig. 1). The Dolomites were submerged beneath a shallow sea while the sedimentary environment passed westward to mud-flat conditions (Assereto et al., 1973).

The Servino Fm. (Brocchi, 1808; Assereto & Casati, 1965) represents the Lower Triassic in Lombardy. It rests paraconformably on the Permian Verrucano Lombardo continental red beds. A regional westward encroachment onto Permian highlands (Assereto at al., 1973) suggests the occurrence of a hiatus at the formational boundary. In the western Southern Alps, the duration of this hiatus is unknown since marine age-diagnostic fossils in the lower Servino Fm. are generally lacking due to adverse ecological factors. So far, in central Lombardy (west of the Camonica valley), Early Triassic marine biomarkers are only known in the upper Servino Fm. (Olenekian) (Gaetani et al., 1987). The first report of *Claraia* in the arenaceous middle part of the Servino Fm. in the Valsassina (western Orobic Alps; Fig. 1) thus represents a significant step forward in the understanding of the Induan chronostratigraphic framework of this area.

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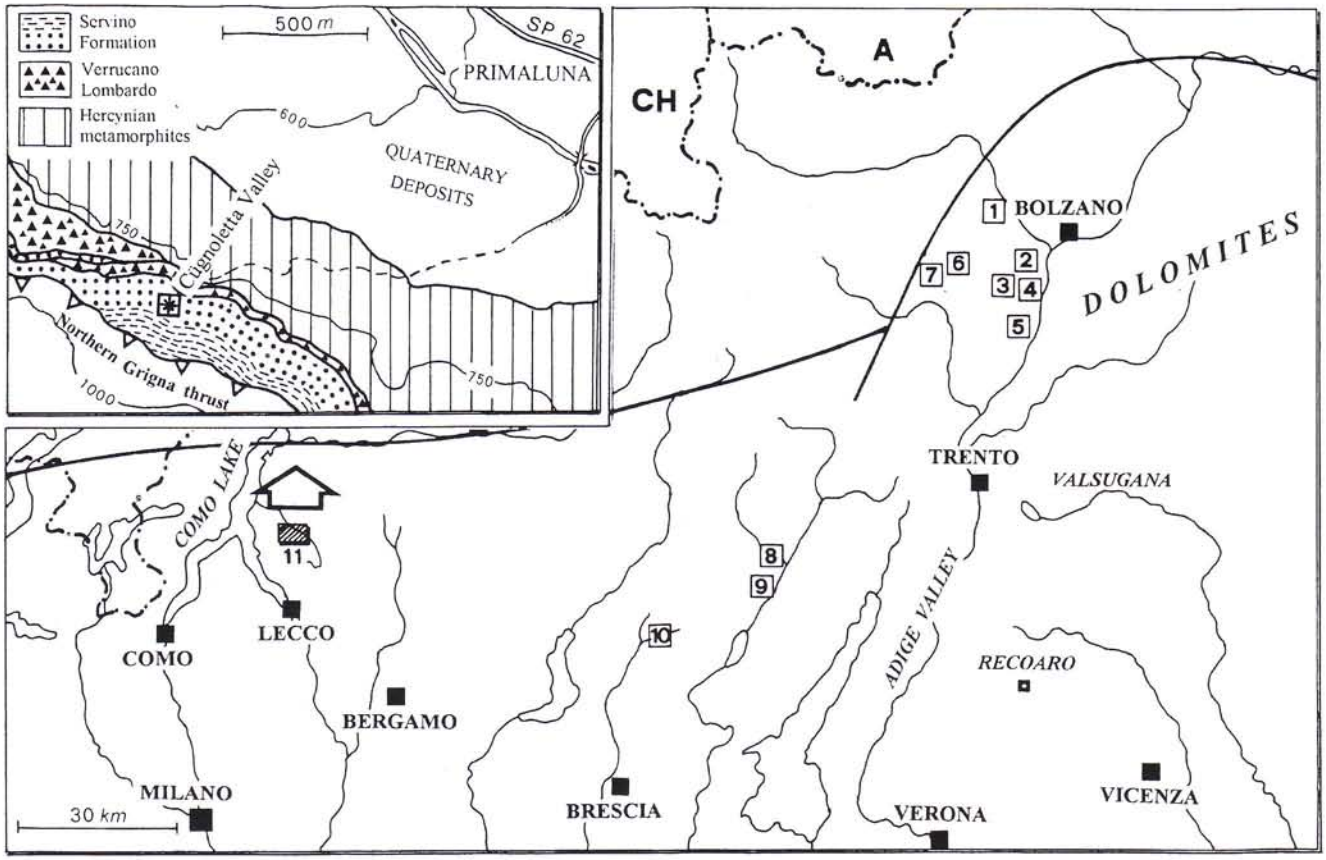


Fig. 1 - Geographical distribution of *Claraia* in the western Southern Alps (west of the Adige river; after Lepsius, 1878) and location of the fossiliferous locality in the Valsassina (upper left corner). 1) Tisens; 2) Eppan; 3) Mendel; 4) Kaltern; 5) Tramin; 6) Casteldolfo; 7) Val di Rumo; 8) Val di Daone; 9) Castello di Condino; 10) Collio di Val Trompia; 11) Valsassina, first finding reported here.

Stratigraphic setting and sedimentary environment of the *Claraia* beds in the western Orobic Alps.

The fossil locality is located in the Cügnoletta valley, a stream channel on the northern slope of the Grigna Group near the small town of Primaluna (Valsassina, Lecco; Fig. 1). In the Cügnoletta valley a complete section of the southern limb of the Orobic Anticline and the overlying Northern Grigna thrust sheet is exposed (Fig. 2). In the lower part (750 m a.s.l.) biotite paragneisses of Hercynian age ("Gneiss minuti a biotite" Auct.) are tectonically overlain by the Upper Permian continental red beds of the Verrucano Lombardo (13÷17 m-thick).

The Servino Fm. rests paraconformably on the Verrucano Lombardo. The lithostratigraphy adopted here for the Servino Fm. in the western Orobic Alps is based on that proposed by Sciunnach et al. (1996), who recognize three different intervals from the top of the Verrucano Lombardo: Prato Solaro Member, middle part of the Servino Fm. and upper part of the Servino Fm. In the Cügnoletta valley, the Prato Solaro Member is 0.7 m-thick (Fig. 2). It is represented by texturally mature quartzose conglomerates and sandstones largely deposited in fan-delta setting, the thickness of which ranges from less than 1 m to 50 m in the western Orobic Alps.

The middle part of the Servino Fm., 62 m thick, consists of mature, fine-grained quartzarenites and medium- to coarse-grained sublitharenites with abundant interstitial ferroan dolomite in 5 to 40 cm-thick beds. Grey, micaceous calcareous siltstones in 1 to 5 cm-thick beds and thin veils of black organic-rich to deep red mudrocks are intercalated. This interval was deposited in a high-energy coastal setting influenced by both tides and waves. *Claraia* beds are found in this interval about 8 m above the base of the formation. These bivalves occur in two distinct levels (Fig. 2) which belong to a horizon, 45 cm-thick, of medium- to coarse-grained sandstones with current ripples passing upwards to medium-scale cross- and trough-lamination; the topmost festooned layer displays parting lineation at the base and winnowed granules at the top. A high-energy upper shoreface environment is thus indicated for the *Claraia* beds.

The upper part of the Servino Fm. consists of yellow dolostones and greenish to deep red siltstones, and is over 50 m-thick in this section with faults at the top.

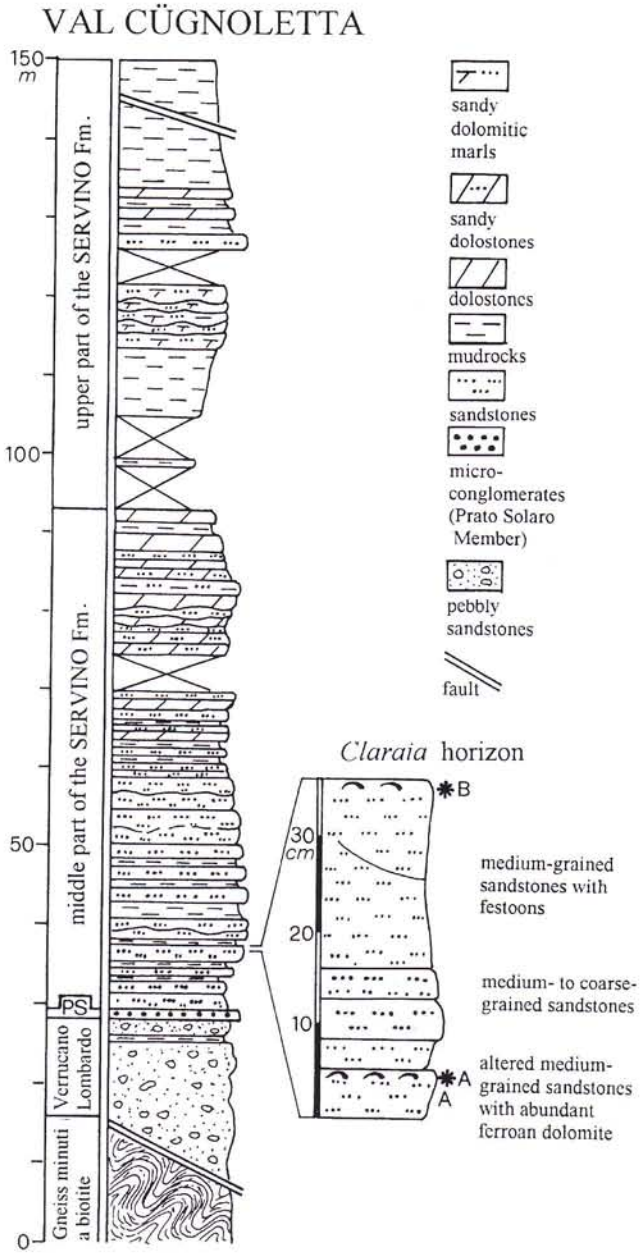


Fig. 2 - Stratigraphic column of the Cügnoletta valley (Valsassina, Lecco) and detail of the *Claraia* horizon in the lower part of the Servino Fm. Symbol: PS) Prato Solaro Member.

N	V	H	L	G	N	V	H	L	G	N	V	H	L	G
1	R	24.0	31.0	A3	23	L	27.0	32.0	A2	46	L	37.0	45.0	B1
2	L	30.2	27.0+	A2	24	?	-	-	A2	47	R	28.0	29.0	A3
3	R	13.4+	17.8	A3	25	L	15.5+	18.0+	A2	48	L	36.5	-	A2
4	L	33.2	39.0+	B2	26	R	13.8	14.8	A2	49	L	28.2+	36.2	A1
5	R	28.0	36.5	B3	27	L	39.5	-	B3	52	L	33.5	42.0+	A1
6	L	35.0	32.5+	B2	28	L	-	-	B3	53	L	39.0	-	B2
7	R	15.5	16.5+	A2	29	L	40.0	-	B1	54	L	44.0	47.0	B2
8	L	35.5	34.0+	B2	30	R	32.0	37.0	A1	55	R	31.5	39.0	B1
9	L	34.0	38.0	B1	31	R	21.0	23.8	A1	56	L	27.5	33.0	B3
10	L	38.5	-	B1	32	L	33.0+	36.0+	B1	57	R	21.5+	22.0	A2
11	L	26.0+	30.0	B3	33	L	29.0+	32.5	A2	58	R	-	28.5+	A2
12	L	39.5	44.0	B1	34	L	29.5	37.5	A2	59	R	18.0	23.0	A2
13	L	22.5+	27.0	A1	35	L	32.5	37.0	B1	60	L	-	33.0	B3
14	L	22.5+	24.0	B1	36	L	32.5+	39.0+	B1	61	R	21.0	24.5	B2
15	L	29.5	32.0	A1	37	R	32.5+	41.0	B2	62	L	35.0	39.5	A2
16	L	31.5	33.5	B2	38	R	32.2	38.5	A2	63	L	34.0	-	B1
18	L	37.0	48.5	B1	39	L	-	-	A1	64	L	31.5	-	A1
19	L	26.0	28.5+	B3	40	L	33.4	37.5+	A2	65	R	-	45.0	A1
20	R	18.0	23.0	A3	41	R	-	-	B2					
21	L	25.5+	35.0	B2	43	L	33.5+	39.9+	A2					
22	R	24.0	27.0	A2	45	R	16.5+	21.5	A2					

Tab. 1 - Measurements, in mm, and classification into subgroups on the basis of the sculpture pattern of the Claraias collected in the Cügnoletta valley. Only specimens no. 54 and 55 (MPUM 8017, 8018) come from bed B, while all the others come from bed A of the *Claraia* horizon (see Fig. 2). Symbols: N) number of specimen; V) valve: (R) right valve, (L) left valve; H) height; L) length; G) subgroups; +) real measurements of specimens with broken margins.

Material and Taphonomy.

The collection consists of about sixty specimens represented by disarticulated left and right valves (Tab. 1). All studied material is deposited at the "Museo di Paleontologia dell'Università di Milano" with the numbers MPUM 8002-8066. The specimens mostly come from the lower level (A). In the upper level (B) only a few specimens have been collected (no. 54, 55, MPUM 8017, 8018). The fossils are preserved as composite moulds, although the state of preservation is not always good. The majority of the specimens are in sandstone and thus the fine sculpture is often smothered and obscured, especially that occurring in the middle and umbonal regions. Well-preserved specimens are rare; their moulds are found in thin siltstone interlayers. Deformation of the outline and reduction of inflation caused by sediment compaction are lacking or slight for the valves lying in the sandstone with the commissure plane placed horizontally to the layer surface, whereas those occurring in the siltstone are more flattened. Outline deformation occurs in specimens lying obliquely to the stratification.

Morphology.

Outline and inflation. All the valves are longer than higher, whereas the outline ranges from nearly suborbicular (e.g. no. 38, MPUM 8003, Pl. 1, fig. 3) to posteriorly elongated and strongly inequilateral (e. g. no. 5, MPUM 8004, Pl. 1, fig. 12). Left valves are quite inflated; right valves are weakly inflated. The degree of inflation is higher with respect to the specimens collected in the Dolomites, but this character may depend on the different lithotype, which is sandstone in the Valsassina and prevailing marly limestone and siltstone in the Dolomites.

Auricles. Posterior auricle obtuse, flattened, clearly differentiated from the body by an auricular sulcus and by a quite distinct obtuse, smoothed angle along the posterodorsal margin. Left anterior auricle preserved in only one specimen (no. 4, MPUM 8002, Pl. 1, fig. 10): it is obtuse and slightly differentiated from the body. Right anterior ear occurs in rare valves, but the bad sta-

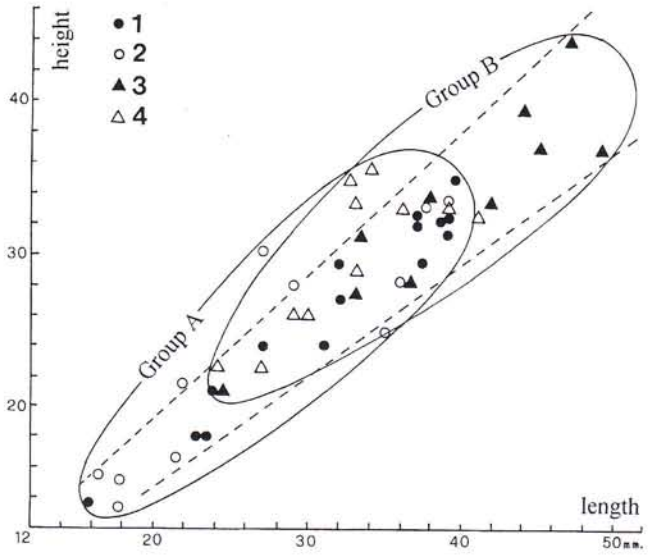


Fig. 3 - Scatter diagram of measurements of the length and height of the valve distinguished into two groups on the basis of sculpture pattern: group A with only concentric elements, group B with concentric and radial elements. If both groups belong to a single bio-species then it has an early growth stage with only concentric sculpture (small-sized specimens of group A), a polytypic middle stage (area of superimposition between the two groups) and a late ontogenetic stage (large-sized specimens of group B) with specimens all radially-ornamented. Legend: 1, 2) specimens of group A with complete (1) or broken (2) margins; 3, 4) specimens of group B with complete (3) or broken (4) margins. Broken lines delimit the specimens with a complete outline so that they show the real scattering of the sample. Measurements and groups are in Tab 1.

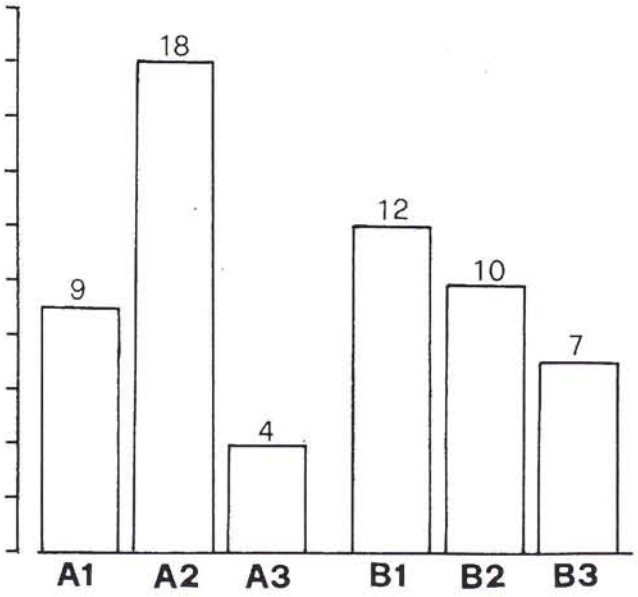


Fig. 4 - Histogram of the subgroups based on the sculpture patterns described in text. Specimens of subgroup A3 are interpreted as being early growth stages of subgroup B2; frequencies of A1 and A2 are overestimated because many of the small size specimens have to be considered as early stages of subgroup B1.

te of preservation has not permitted us to detect its morphology and that of the byssal notch.

Sculpture. This feature is highly variable in the specimens collected. Umbones are smooth. The degree and type of ornamentation varies both during ontogeny and among specimens of the same dimension. Small-sized specimens, less of 20 mm in diameter, have only fine growth lines or concentric folds. Middle-sized valves, 20 to 40 mm in diameter, are polytypic, because some specimens have again only concentric elements, while in others the radial elements appear (Fig. 3). The largest specimens are all radially ornamented with ribs and costellae developed to a variable extent. In some specimens, the radial elements occur only on the ventral region (no. 18, MPUM 8005, Pl. 1, fig. 7) whereas in others they extend in the middle and prevail over the concentric ones (no. 11, MPUM 8006, Pl. 1, fig. 11). On the basis of the strength, extension and kind of sculpture, the following classification can be applied to the specimens examined: group A with only concentric sculpture; group B with concentric and radial sculpture (Tab. 1; Fig. 3). Each group is further subdivided into three subgroups (Fig. 4):

A1 - smooth or with fine growth lines.

A2 - concentric lines and irregular, weak concentric folds.

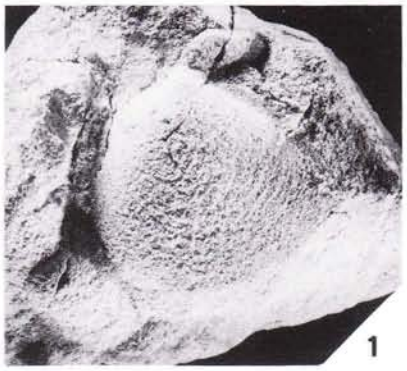
A3 - rather regular concentric folds.

PLATE 1

Claraia from the *Claraia intermedia* horizon (bed A), lower part of the Servino Fm. of the Cügnoletta valley, Valsassina (western Orobic Alps), Lecco Province. All specimens are natural size and whitened with magnesium fumes.

Fig. 1-3, 4b, 5b - *Claraia* cf. *aurita* (Hauer, 1850). Morphospecies: *Claraia* cf. *aurita* (Hauer, 1850), fig. 1 (no. 15, MPUM 8013, left valve) and 5b (no. 52, MPUM 8012, left valve) (subgroup A1); *Claraia* cf. *bittneri* Ichikawa, 1958, fig. 2 (no. 48, MPUM 8007, left valve), 3 (no. 38, MPUM 8003, right valve) and 4b (no. 2, MPUM 8014, left valve) (subgroup A2).

Fig. 4a, 5a, 6-13 - *Claraia intermedia* (Bittner, 1901). Morphospecies: *Claraia tesidea* (Leonardi, 1929), fig. 4a (no. 1, MPUM 8015, right valve) and 6 (no. 47, MPUM 8008, right valve) (subgroup A3); *C. intermedia* (Bittner, 1901), fig. 7 (no. 18, MPUM 8005, left valve) and 8 (no. 12, MPUM 8009, left valve) (subgroup B1); *C.* cf. *clarai* (Emmrich, 1844) (transitional forms between *C. clarai* and *C. intermedia*), fig. 5a (no. 53, MPUM 8016, left valve), 9 (no. 16, MPUM 8010, left valve with acute concentric folds) and 10 (no. 4, MPUM 8002, left valve with rounded concentric folds) (subgroup B2); *C. intermedia* (Bittner, 1901), fig. 12 (no. 5, MPUM 8004, right valve) and *C. radialis* (Leonardi, 1929), fig. 11 (no. 11, MPUM 8006, left valve) and 13 (no. 27, MPUM 8011, left valve) (subgroup B3).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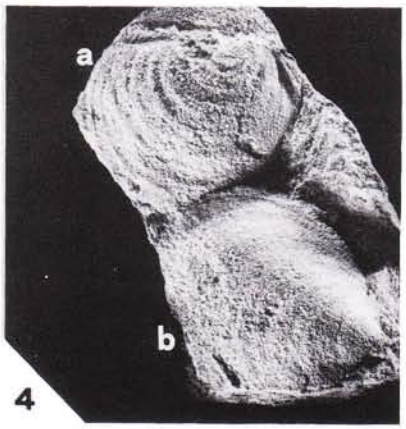

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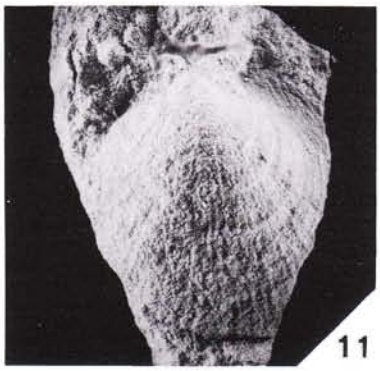
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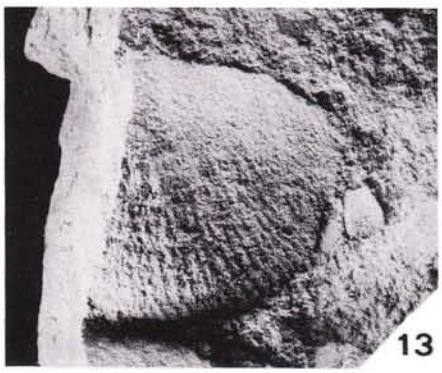
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B1 - weak radial ribs and riblets with concentric lines and low folds occurring on the ventral region in adult stage; middle and umbonal parts smooth.

B2 - concentric folds or wrinkles arising in the middle part of the body with radial ribs and riblets; marginal region in adult stage reticulate, lacking concentric folds.

B3 - radial sculpture prevailing over concentric sculpture, mostly restricted to anterior and posterior regions.

Classification.

The genus *Claraia* currently consists of more than sixty species and subspecies. This excessive splitting and "taxonomic provincialism" (Assereto at al., 1973, p. 189) arises both from taphonomic and genetic factors. Lower Triassic formations frequently consist of terrigenous sediments to various degrees, and thus fossils are affected by deformation to different extent. Furthermore, *Claraia* can display a very high genetic plasticity (Broglio Loriga et al., 1983) which mostly affects the sculpture. Many of the past authors did not consider such sources of variability and applied a rigid morphological concept of species thus creating a rather confused taxonomy. Therefore for a chronological and biogeographical use of *Claraia*, as pointed out by Broglio Loriga et al. (1983) and Newell & Boyd (1995), a modern classification of species based on the population analysis becomes necessary.

The *Claraia* classification proposed by Ichikawa (1958) is mostly based on the sculpture pattern, on the basis of which he gathered the species into four informal groups: *C. clarai, C. aurita, C. stachei* and *C. decidens*. Later, Nakazawa (1977) split each of the former three species-groups into two subgroups, named A and B on the basis of the occurrence (A) or absence (B) of the posterior auricle differentiated from the body. Such a classification has a pure morphological value since species-groups "are not sharply defined from each other" (Nakazawa, 1977, p. 193), with transitional morphotypes connecting them. Besides, such a classification has no chronological value as each species-group yields species with different chronological distributions. Nakazawa (1977) noted that only the *C. decidens* group could be treated as a subgenus because it has a strongly inflated left valve with a dorsoventrally elongated outline (H>L). For this species-group, Newell & Boyd (1995) have introduced the new genus *Crittendenia*.

Morphospecies. Claraias from the Valsassina are longer than higher and posteriorly auriculate, and therefore they do not belong to the *C. decidens* group and fall within subgroups A (posteriorly auriculate) of the other three groups of Ichikawa (1958) and Nakazawa (1977). By applying a typological concept of species, the subgroups distinguished within the Orobic material can be classified into different morphospecies belonging to the *C. clarai*, *C. stachei* and *C. aurita* groups. Such a classification has been carried mostly on the basis of comparisons with the species erected in the Southern Alps, and thus the classical paleontological works on the Werfen Formation (Hauer, 1850; Tommasi, 1895; Bittner, 1901; Wittenburg, 1908; Ogilvie Gordon, 1927; Leonardi, 1935; etc.) have been used. Of particular interest is Leonardi's (1960) paper, in which most of the known Alpine species and their transitional forms are illustrated. This paper also provides a picture of the broad variability of this genus. However, a precise species determination for each subgroup proposed is not always possible because many of the known morphospecies have been erected on the basis of a few (or single) specimens representing the extreme morphotypes of populations with a broad variability and numerically dominated by intermediate forms.

Subgroups A1, A2: *C.* cf. *aurita* (Hauer, 1850) and *C.* cf. *bittneri* Ichikawa, 1958. On the basis of sculpture, subgroups A1 and A2 belong to the *C. aurita* group of Ichikawa (1958). However, typical forms of *C. aurita* are absent because the concentric lines are not regular and raised (e.g. no. 52, MPUM 8012, Pl. 1, fig. 5b), even though lack of this character could be linked to the bad state of preservation. Some of subgroup A2 (no. 48, 38, MPUM 8007, 8003, Pl. 1, fig. 2, 3) can be compared with *C. bittneri* [ex *C. tridentina* (Bittner, 1901)]. However, this species does not have a very differentiated posterior ear. Some specimens closely related, which are ovoidal and posteriorly elongated with irregular concentric folds and lines and a differentiated posterior ear, similar to those of subgroup A2, were classified by Ogilvie Gordon (1927, pl. 1, fig. 3) as *C. intermedia* (Bittner, 1901).

Subgroup A3: *C. tesidea* (Leonardi, 1929). These specimens, with only rounded concentric folds (e.g. no. 47, MPUM 8008, Pl. 1, fig. 6), should be considered to be an early growth stage of *C. tesidea*, which was originally erected as a variety of *C. clarai*. *C. tesidea* was originally described as having acute folds or wrinkles with radial riblets in some cases occurring on the ventral region of mature individuals, which makes the adult stage very similar to *C. intermedia*. However, Leonardi (1960, pl. 6, fig. 6) attributed a right valve of middle size, with rounded concentric folds lacking radial elements to *C. tesidea*. Therefore, subgroup A3 which yields small to middle-sized specimens can be attributed to *C. tesidea* (*C. clarai* group). This species is here considered as a possible juvenile morphotype of *C. intermedia*.

Subgroup B1: *C. intermedia* (Bittner, 1901). It belongs to *C. intermedia* (*C. stachei* group of Ichikawa,

1958) because such specimens (e.g. no. 18, 12, MPUM 8005, 8009, Pl. 1, fig. 7, 8) have sculpture and outline similar to the types illustrated by Hauer (1850, pl. 3, fig. 6, 9) and Leonardi (1960, pl. 7, fig. 3).

Subgroup B2: *C.* cf. *clarai* (Emmrich, 1844). These specimens show transitional features between *C. clarai* and *C. intermedia* (no. 16, 4, MPUM 8010, 8002, Pl. 1, fig. 9, 10), since the middle body has a *clarai*-type sculpture whereas the marginal region has a reticulate ornamentation of *intermedia*-type. Concentric folds are both rounded (Pl. 1, fig. 5a, 10) and acute (Pl. 1, fig. 9).

Subgroup B3: *C. intermedia* (Bittner, 1901) and *C. radialis* (Leonardi, 1929). These specimens fall within the *C. radialis - C. intermedia* group of Leonardi (1960), which was later considered by Nakazawa (1977) as *C. intermedia*. Some specimens (e.g. no. 11, 27, MPUM 8006, 8011, Pl. 1, fig. 11, 13) can be ascribed to *C. radialis* (Leonardi, 1929).

Species based on population analysis. As already recorded, various authors pointed out that the recognition of *Claraia* species needs a population analysis. *Claraia* belongs to the order Pectinoida Newell & Boyd, 1995 (Fam. Pterinopectinidae Newell, 1938), which yields many polytypic species with "strikingly variable" (Newell & Boyd, 1995, p. 22) populations.

The *Claraia* collection from the Cügnoletta valley mostly comes from a single bed (A), thus the sample is nearly composed of coeval individuals. They have been previously gathered into six different subgroups, the extreme morphotypes of which are generally connected by intermediate forms. The occurrence of these transitional forms suggests the possibility that the majority of the morphopecies already recognized can be treated as morphotypes of a single (or few) species. The name assigned to this (or these) species will be that of the most abundant morphotype.

Subgroups B1 and B3 have been referred to *C. intermedia*, B2 yields transitional forms between *C. clarai* and *C. intermedia*, whereas A3 (*C. tesidea*) can be considered to be an early growth stage of subgroup B2; therefore *C. intermedia* and its transitional forms are predominant and characterize the *Claraia* horizon of the Cügnoletta valley.

C. intermedia was erected by Bittner (1901) on the basis of specimens with transitional characters between *C. clarai* and *C. aurita* previously illustrated by Hauer (1850, pl. 3, fig. 6, 9). The type-specimens illustrated by Hauer (1850) have a prevailing concentric ornamentation made of irregularly-spaced folds and lines, while the radial ribs appear in the middle body (fig. 6) or in the ventral region (fig. 9) as also occurs in subgroup B1. Bittner (1901) named the specimens with an equal development of radial and concentric sculpture (reticulate pattern) as var. *cancellata* (Bittner, 1901, p. 28, pl. 24, fig. 12). In the same paper, Bittner noted that some specimens of the *clarai* group have a radial sculpture prevailing over the concentric one; for these forms he erected "*Pseudomonotis (Claraia) stachei* n. sp." (Bittner, 1901, p. 29, unfigured). According to Bittner, *C. stachei* has the greatest size of shell with respect to the other Alpine Claraias. On the basis of the same sculpture pattern, Leonardi (1929, p. 63, illustrated in Leonardi, 1932, pl. 1, fig. 8) proposed "*Pseudomonotis Clarai* Emm. var. *radialis* n. var.", which was elevated to specific level by Nakazawa (1977). [For discussion on the nomenclatural question about these two probably synonymous species, see Nakazawa (1977) and Yin (1985). The present authors accept the reasons expressed by Nakazawa (1977) for considering both species valid and for using *C. stachei* according to the meaning of Spath (1930) and Newell & Boyd (1995)].

Bittner (1901) erected *C. intermedia* and *C. stachei* on the basis of material coming from different localities and perhaps from different stratigraphic settings but he described them as if no morphological break existed among them. The coeval specimens collected in the *Claraia* horizon of the Valsassina have a very high morphological variability. They display all the possible intermediate and extreme morphotypes of a *Claraia* population which could correspond with the transition between the *C. clarai* and *C. aurita* stages recognized in the Dolomites. Therefore the absence of the typical forms of these species may be related to the evolutionary stage recorded in the Valsassina, even if other causes can not be ruled out such as diagenesis which, in particular, could have obscured the *aurita*-like pattern sculpture.

In conclusion, the majority of the *Claraia* specimens of the Valsassina (A3, B1, B2, B3 subgroups) can be considered to belong to *C. intermedia* which, besides the typical forms, yields morphotypes with transitional characters towards *C. clarai* and *C. radialis*, with *C. radialis* as a possible adult extreme morphotype and with *C. tesidea* among the juvenile morphotypes.

As to the specimens ascribed to subgroups A1 and A2 (*C. aurita* group), many of those of small and middle sizes probably have to be considered as juvenile stages of subgroup B1, and thus the frequency of the *C. aurita* group (Fig. 4) is overestimated. For the large-sized specimens of subgroup A1 (e.g. no. 52, MPUM 8012, Pl. 1, fig. 5b) and A2 (e.g. no. 38, MPUM 8003, Pl. 1, fig. 3) there are two different possibilities: they can be considered either as belonging to a species distinct from *C. intermedia* and comparable to *C. aurita* or else as another extreme morphotype of *C. intermedia*, as is suggested by the scatter diagram of Fig. 3 and by the original meaning given to *C. intermedia*. Because of the bad state of preservation of the present material, we prefer to classify them as *C.* cf. *aurita* for the moment.

Among the specimens assigned to the *C. aurita* group, a further distinction could be made on the basis of the shape and obliquity (i.e. nearly suborbicular, acline morphotypes and ovoidal, prosocline morphotypes). However, specimens of the present material of which the outline is well-preserved enough to make an objective recognition of the obliquity possible are too few for a population analysis. Besides, at the moment, there is no data in the literature on the stratigraphical distribution in the Southern Alps of the different morphotypes of *C. aurita* group based on these features, which are frequently affected by diagenetic deformation in marly lithotypes. Further stratigraphical and taxonomical research within the *C. aurita* beds needs to assess the biostratigraphical meaning of these taxonomical features.

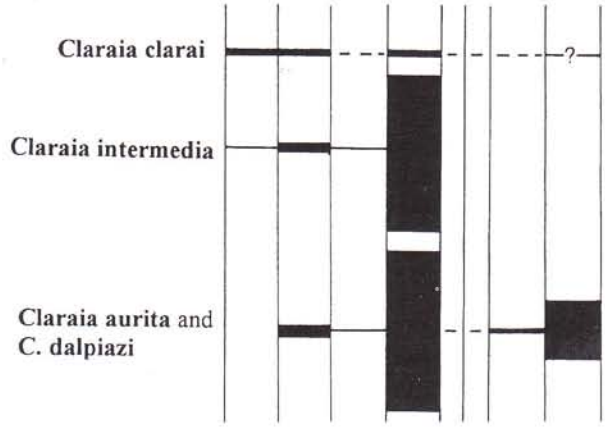
Correlation with the *Claraia* subzones in the Dolomites.

The *Claraia* Zone has been divided in the Dolomites into three subzones: *C. wangi-griesbachi, C. clarai* and *C. aurita*, with *C. dalpiazi* beds at the top of this youngest subzone (Broglio Loriga et al., 1983, 1990). These subzones correspond to the upper Mazzin Member, the lower Siusi Member and the middle Siusi Member of the Werfen Formation respectively. The *Claraia* beds of the Valsassina do not yield any of the index-species of the Dolomites, and thus only an indirect correlation is possible. The large size of the shell and the occurrence of specimens with radial sculpture rule out their correlation with the *C. wangi-griesbachi* subzone.

The occurrence of specimens with transitional features towards *C. clarai* (subgroup B2) could be used for a tentative correlation with the *C. clarai* subzone of the western Dolomites, which is about 20÷25 m-thick (Broglio Loriga et al., 1983). Such a hypothesis is supported by the absence of specimens with a strong radial sculpture in the *C. aurita* subzone (about 20 m-thick) and by the report of *C. radialis* and *C. intermedia* in the *C. clarai* subzone of the Dolomites (Broglio Loriga et al., 1983, p. 559). However, the occurrence in the Valsassina sample of *C.* cf. *aurita* seems to exclude the possibility of a direct correlation with this subzone. Therefore the *Claraia* horizon of the Cügnoletta valley can be correlated with the transitional beds between the *clarai* and *aurita* subzones of the Dolomites. Leonardi (1960) recorded *C. intermedia* at Tesero (Dolomites), where it is reported from the upper *C. clarai* beds (? last 10 m of the *C. clarai* subzone of Broglio Loriga et al., 1983) to the lower *C. aurita* beds, where its acme occurs (Tab. 2). At Tesero, *C. aurita* is predominant over *C. clarai* (185 versus 8 specimens) and all the morphospecies recognized in the Valsassina also occur. In the next fossiliferous horizons at Tesero, characterized by *C. aurita* and *C. dalpiazi* (*C. aurita* subzone of Broglio Loriga et al., 1983), *C. intermedia* disappears.

SIUSI MEMBER P.P. (TESERO, VAL DI FIEMME)

thickness in m	10		1.3	0.5	0.3	2.3	1.5	4.0
units	A1	A2	B	C	D	E	F	G
Claraia clarai								
clarai		8	8		8			2 (1)
catharinae					1			
Claraia intermedia								
intermedia	1		9	1	182			
clarai radialis (2)					6			
clarai tesidea			3		15			
clarai - clarai tesidea					2			
clarai - intermedia					30			
radialis - intermedia					24			
Claraia aurita and **C. dalpiazi**								
aurita			3	1 cf.	187		1 cf.	4
orbicularis				1 cf.	35		1	3
tridentina			4		25		2	1
dalpiazi			9		1			72
aurita haueri					11			
aurita gibba					1			
aurita costulata								10
aurita flemmensis			2					
aurita flemmensis -dalpiazi								1
dalpiazi - aurita					6			
aurita haueri - dalpiazi								1



Tab. 2 - Vertical distribution and abundance of *Claraia* in the middle Siusi Member of Passeggiata Merisol section (Tesero, Dolomites) after Leonardi (1960). The names of the taxa inside the tables are those used by Leonardi (1960) while those outside, in boldface, have the meaning of species based on population analysis used in this paper; *C. aurita* has not been distinguished from *C. dalpiazi* because of lack of data on their variability. Some discrepancies of occurrences and classification occur between the text and table of the paper by Leonardi; of which the most important are: (1) in the text, *C. clarai* is not recorded in bed G, while two specimens are quoted in the table; (2) in the text *C. clarai radialis* is indicated as being a transitional form between *clarai* and *radialis*. The *Claraia* horizon of the Valsassina can be correlated with the interval ranging from unit A2 and unit C of this section, which roughly corresponds with the transitional beds between the *C. clarai* and *C. aurita* subzones of Broglio Loriga et al. (1983).

In conclusion, the *Claraia* beds of the Valsassina can be correlated with the transitional beds between the *C. clarai* and *C. aurita* subzones of the Dolomites, where typical forms of *C. aurita* are already present. In such a way the absence of the typical *C. aurita* specimens in the Valsassina may depend on diagenetic factors, which smoothed and obscured these sculptures in the specimens of subgroups A1 and A2.

Age.

The ages assigned to the *Claraia* subzones of the Dolomites have been obtained by means of the associated conodonts and by correlations with sequences bearing ammonoid and Claraias, of which the nearest occur in Iran (Julfa and Abadeh). The lower limit of the *C. wangi-griesbachi* subzone roughly coincides with the appearance of the conodont *Isarcicella isarcica* (Huckriede, 1958), and thus it marks the beginning of the upper Griesbachian (Broglio Loriga et al., 1988). The *C. clarai* and *C. aurita* subzones have been tentatively considered to be latest Griesbachian and Dienerian respectively, mostly on the basis of correlations with the Iranian sequences. Therefore the Griesbachian/ Dienerian boundary in the Dolomites has been tentatively drawn at the limit between these two subzones (Broglio Loriga et al., 1983, 1990). According to the finding of *Neospathodus dieneri* Sweet, 1970 in the topmost part of the Mazzin Member (Perri, 1991), the age assignment of the *C. clarai* subzone should be Dienerian, excluding the topmost Griesbachian. Further research seems to be necessary to definitely assess this point.

In Iran, *C. intermedia* is reported in the upper *Isarcicella isarcica* Zone (upper Griesbachian) of Unit a in the Abadeh region (Iranian-Japanese Research Group, 1981). It appears earlier than *C. aurita* as at Julfa (Nakazawa, 1977), where both species fall within the *Gyronites* Zone (lower Dienerian). Therefore the Iranian *C. intermedia* beds have an age ranging from the uppermost Griesbachian to the lower Dienerian, and thus the *Claraia intermedia* horizon of the Valsassina would fall within such a time-interval.

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