Cynodont Teeth from the Carnian (Late Triassic) of Northern Italy

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Cynodont teeth from the Carnian (Late Triassic) of northern Italy

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A jaw fragment with three teeth preserved, collected from the Gorno Formation (Carnian, Upper Triassic) of Lombardy (Italy) is described. The teeth are transversely elongated, three-cusped and bear anterior and posterior cingula. Their overall morphology supports their identification as postcanines of a "eucynodontian". The unique tooth morphology of the new specimen supports its attribution to a new genus and species, while at the same time precluding positive assignment to already known gomphodont families. There is a fairly small record of gomphodont cynodonts in Europe, so that the described specimen adds to the knowledge of the distribution and diversity of European gomphodonts and it also represents the first ever collected in Italy.

Introduction and geological setting

The Triassic diversification of cynodonts is well documented in Lower and Middle Triassic strata, especially from the Gondwanan region of Pangaea. However, the Late Triassic record is much more limited, especially from the Laurussian portion of Triassic Pangaea. Thus, any discovery of a late Triassic cynodont from northern Pangaea is a significant addition to the distribution and diversity of the Cynodontia. We document such an addition here.

The cynodont specimen documented here was collected from a marly limestone of Carnian age belonging to the Gorno Formation, which crops out in Val Riso, in the municipality of Gorno (Bergamo, Lombardy, Italy; see Fig. 1). According to Gnaccolini (1988) and Gnaccolini and Jadoul (1988, 1990), the Gorno Formation is Middle Carnian in age, based on its fossil content, especially bivalves characterized by the presence of the species *Myophoria kefersteini* and *Curionia curionii* (Allasinaz 1966). The Gorno Formation was deposited in shallow lagoons close to a deltaic system, in an anoxic environment (Assereto and Casati 1965; Brusca et al. 1981; Garzanti 1985; Garzanti and Jadoul 1985). During the Middle to Late Carnian, the lagoonal environment was replaced by alluvial plains, which formed the San Giovanni Bianco Formation.

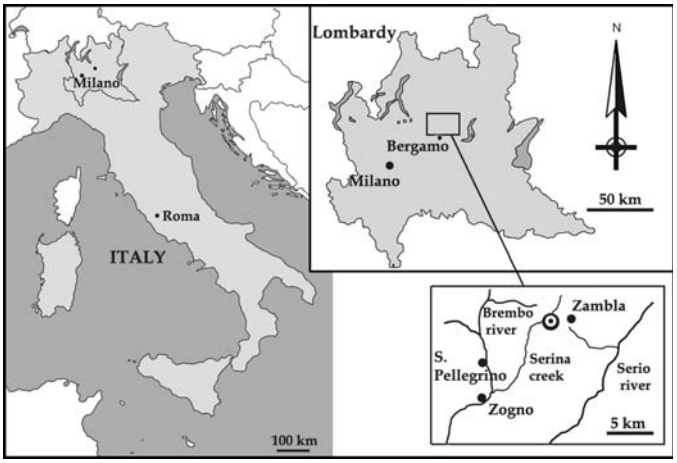

Fig. 1. Sketch map of Italy and Lombardy; bulls eye in inset, right center, indicates fossil locality.

The lithofacies present in the locality at which the cynodont specimen was found is typical of the Gorno Formation, and consist of marly, micritic and marly sandstone-limestones with a thin lamination, dark gray in color and in decimetre-thick beds alternating with lighter colored pelitic beds. A gradual transition to thin gray/greenish sandstone levels in alternation with green pelites that testify to the transition to the overlying San Giovanni Bianco Formation, allowing us to place the fossiliferous outcrop at the top of the Gorno Formation.

In the upper part of the sequence there is an abundance of plant remains and also vertebrates remains are frequent, represented by isolated bones and teeth, belonging to sauropterygians and to terrestrial archosaurs (Renesto et al. 2003; Renesto Gozzi and Tintori 2005).

Institutional abbreviation.—MCSNB, Museo Civico di Scienze Naturali "E. Caffi", Bergamo, Italy.

Systematic paleontology

Synapsida Osborn, 1903
Eucynodontia Kemp, 1982
Genus *Gornogomphodon* nov.

Etymology: After the Gorno Formation, which yielded the fossil.

Type and only species: *Gornogomphodon caffii* sp. nov.

Diagnosis.—A gomphodont cynodont primarily distinguished from traversodontids by the lack of an occlusal basin on the upper postcanines and primarily distinguished from trirachodontids by the tall labial cusp and lack of cuspules on the anterior and posterior cingula of the upper postcanines. Among gomphodonts, unique features of the upper postcanines of *Gornogomphodon* are a tall, single labial cusp that does not join a second labial cusp to form an "ectoloph"; anterior and posterior cingula confluent with the lingual cusp so that they form a complete cingular ridge around the anterior, lingual and posterior margins of the crown; and the bucco-lingually expanded tooth crown. Tooth implantation similar to the protothecodont condition, (teeth with deep, open roots with no alveolar space) but with divided roots.

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Gornogomphodon caffii sp. nov.

Figs. 2, 3.

Etymology: For Enrico Caffi, the first director of the Museo Civico di Scienze Naturali "E. Caffi" Bergamo.

Holotype: MCSNB 5863 (Figs. 2, 3), consisting of a fragment of maxilla bearing three partially preserved teeth.

Type locality: Zambla Alta, Bergamo (Italy).

Type horizon: Upper part of the Gorno Formation, Middle Carnian (Late Triassic).

Diagnosis.—As for the genus, being the only known species.

Measurements.—Of the most complete tooth: crown height 5.6 mm, crown transverse width 9.3 mm, crown anteroposterior width 4.5 mm, transverse width of the central cusp 6 mm.

Description.—The specimen (Figs. 2, 3) consists of a bone fragment bearing three transversely elongate teeth, each with an elliptic outline in occlusal view. The maxillary bone remains partially embedded in matrix, and the exposed portion is broken and weathered; the teeth are better preserved, however, allowing a detailed description. The three teeth show the same overall shape and all lack their labial end; the most posterior tooth is the best preserved, lacking only a small fragment of the labial cusp and of the labial edge of the crown. The crown is stout and transversely broadened, its transverse axis being twice the dimension of the anteroposterior one. The maximum width of the tooth crown is reached just below the occlusal surface. The teeth are three-cusped with a transversely broadened central cusp and two subconical cusps with rounded apices, one labial and the other lingual. The central cusp is rather worn and low, with a smooth, rounded occlusal surface. The central cusp is also surrounded by a distinct groove bounded by a convex, rounded cingular ridge. The overall morphology of these teeth is consistent with their identification as upper postcanines of gomphodont cynodonts (Abdala and Ribeiro 2003) so that the specimen can be considered as a fragment of a right maxilla. The labial cusp is much higher than the central cusp, whereas the lingual cusp is low, reaching only half the height of the labial cusp, and its apex is more blunt. The crown surface is smooth, with no traces of striations or fluting.

On the labial side the teeth and the maxilla are broken, showing details of internal tooth structure (Figs. 2B, 3C). The enamel layer is very thin, with a thick dentine layer underneath. The pulp cavity is large and deep, the roots are deep and seem to be divided and open, so that the inner alveolar bone that surrounds the teeth seems to bulge into the middle of the pulp cavity. It is difficult to interpret this structure: A mammal-like multiple rooted tooth seems rather implausible due to the absence of an alveolar space. An alternative explanation might be that the spongy bone invades the pulp cavity as in the ankylosed thecodont (Benton 1984) or the protothecodont (Gow 1977; Ivakhnenko 1979) condition, which can be found in most early reptile groups including procolophonids, and probably also basal therapsids according to Benton (1984), Edmund (1969), and Small (1997).

Comparisons.—The peculiar morphology rendered the taxonomic assignment of MCSNB 5863 very difficult. At first we were uncertain if it represented a tetrapod or a fish, because some overall resemblances to pycnodont fishes, such as the general shape of the crown and their arrangement forming a row, were suggested by some researchers. However, several characters allowed us to discard the pycnodont hypothesis.

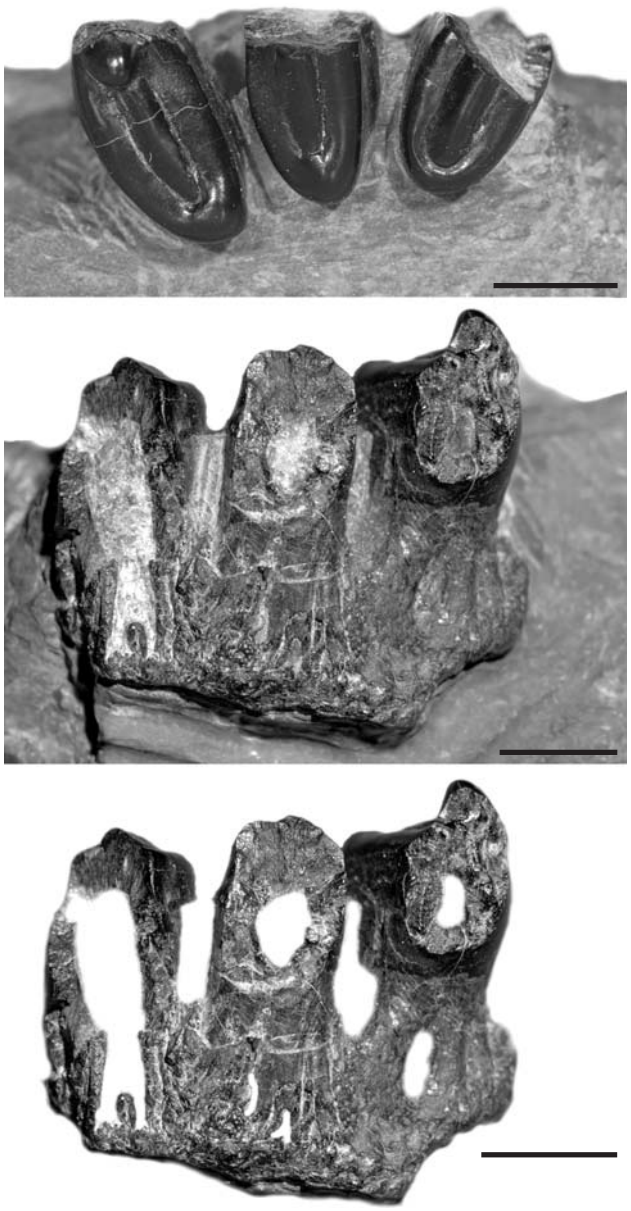

Fig. 2. Gomphodont cynodont *Gornogomphodon caffii*, the holotype and only known specimen. MCSNB 5863, from Zambla Alta, Bergamo (Italy), upper part of the Gorno Formation, Middle Carnian (Late Triassic). Maxilla with three teeth in occlusal (**A**) and labial (**B**) views. **C**. Labial view with embedding rock digitally deleted. Scale bars 5 mm.

According to Francisco José Poyato Ariza (personal communication to SR 2008) the lateral walls of the "roots" of MCSNB 5863 are too thick for a pycnodont, thus the "roots" have the same width as the crown, whereas in pycnodonts the "roots" are narrower than the crowns (for comparison see Nursall 1996: 132, fig. 3). In pycnodonts, the teeth are arranged parallel to each other, but in MCSNB 5863 they are arranged in a convergent fan pattern, never seen in pycnodonts. Finally

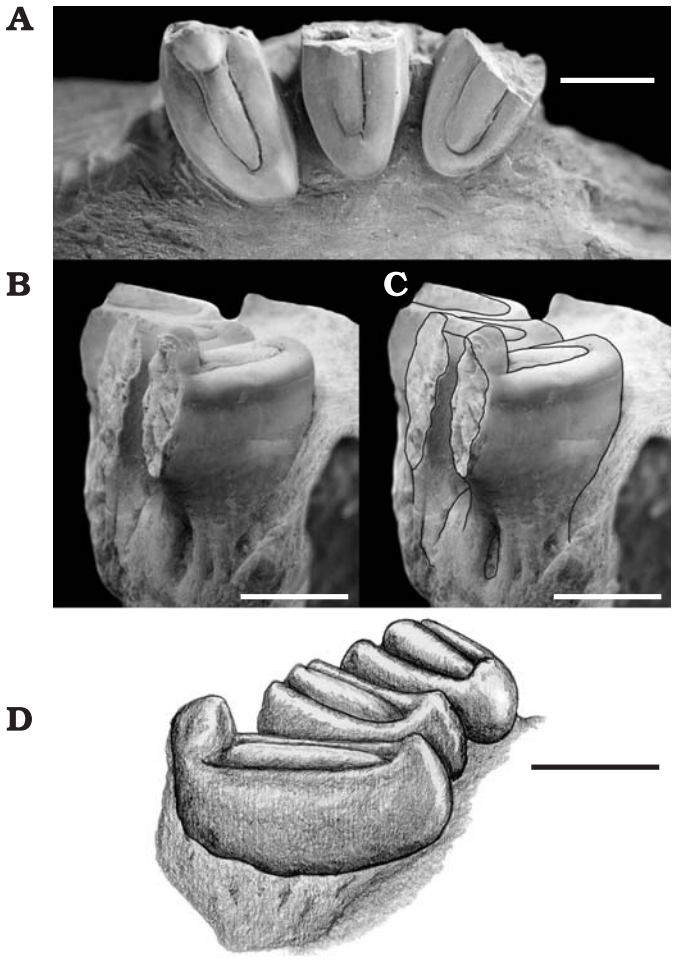

Fig. 3. Gomphodont cynodont *Gornogomphodon caffii*, holotype MCSNB 5863, from Zambla Alta, Bergamo (Italy), upper part of the Gorno Formation, Middle Carnian (Late Triassic). The specimen has been whitened with ammonium chloride to enhance tooth morphology. **A**. Occlusal view. **B**. Anterior view. **C**. Anterior view with outlines and relevant morphology traced in black. **D**. Sketch drawing (restoration) of the anterior view. Scale bars 5 mm.

pycnodont teeth never have a lateral cusp like that seen in *Gornogomphodon*; in fact there are never distinct cusps on pycnodont teeth. There may be crenulations, ridges, small elevations or papillae, but never real cusps. Thus the assignment of MCSNB 5863 to pycnodonts fishes can be ruled out.

Among tetrapods, detailed analysis and crown morphology of the postcanine teeth of *Gornogomphodon* differs from that of molariform teeth of procolophonids (e.g., Colbert1946; Carroll and Lindsay 1985) in being distinctly three cusped with a cingular ridge and a distinct neck. Trilophosaurids also have transversely wide, tricuspid molariform teeth, but unlike *Gornogomphodon*, these cusps are on a raised loph and the central cusp is the largest (tallest) (e.g., Spielmann et al. 2007: figs. 2, 3).

We identify MCSNB 5863 as a gomphodont cynodont (sensu Abdala and Ribeiro 2003; Abdala et al. 2006) primarily because the postcanine tooth crowns are transversely expanded and there are detailed similarities to the upper postcanine teeth of trirachodontids and traversodontids, the two main gomphodont families. Thus, as in trirachodontids, MSCNB 5863 has upper postcanine tooth crowns composed of three principal cusps aligned transversely, prominent anterior and posterior cingula and lacks shearing surfaces on the medial surfaces of the main cusps. However, unlike trirachodontids (compare Crompton 1955; Abdala et al. 2006), the cingula are not cuspidate and the labial, instead of the central cusp, is tallest in MSCNB 5863. The postcanine tooth crowns of diademodontids (*Diademodon*) also differ from those of *Gornogomphodon* in being nearly round in occlusal view and dominated by a large labial cusp and a broad lingual basin (Crompton 1972).

Unlike traversodontids, *Gornogomphodon* lacks a deep occlusal basin on the central portion of the tooth crown. In some traversodontids, such as *Menadon* from the Upper Triassic of Madagascar (Flynn et al. 2000), there is a low transverse ridge within the occlusal basin of the upper postcanines. However, this ridge is only a small part of the surface area of the occlusal basin in such traversodontids. In contrast, in *Gornogomphodon* a low ridge cusp is the dominant feature of the center of the occlusal surface, and the little basinal area that does exist is very narrow, forming slit-like valleys between the central ridge and the anterior and posterior cingula.

In addition to the differences from trirachodontids and traversodontids just listed, *Gornogomphodon* also has unique dental features not seen in other gomphodonts: a tall, single labial cusp that does not join a second labial cusp to form the "ectoloph" typical of most traversodontid upper postcanines; anterior and posterior cingula confluent with the lingual cusp so that they form a complete cingular ridge around the anterior, lingual and posterior margins of the crown; and the extremely transverse (antero-posteriorly short, and labio-lingually broad) tooth crown. These three features distinguish MSCNB 5863 from all known gomphodonts and justify its recognition as a new taxon. Assignment of MSCNB 5863 to either the Diademodontidae, Trirachodontidae or Traversodontidae as currently defined (Abdala et al. 2006) is debatable, owing to the differences between it and diademodontids, trirachodontids and traversodontids listed above. We thus regard *Gornogomphodon* as Eucynodontia family uncertain.

Discussion.—Most gomphodont cynodont fossils come from Lower–Middle Triassic strata in Gondwana (e.g., Crompton 1955; Bonaparte 1966; Kemp 1980; Lucas and Hunt 1994; Abdala et al. 2006). Traversodontids also have a significant Late Triassic record in Gondwana, especially in Argentina and Brazil. However, there is a small but growing record of traversodontids from the Upper Triassic of North America and Europe (e.g., Hopson 1984; Godefroit and Battail 1997; Hahn et al. 1988; Sues and Olsen 1990; Hopson and Sues 2006). There is also a possible trirachodontid record from the Upper Triassic of North America (Lucas et al. 1999) though its assignment to the Trirachodontidae has been questioned (Abdala et al. 2006). The discovery of *Gornogomphodon* thus adds to this record of gomphodonts in the Upper Triassic of northern Pangaea. The unique dental features of *Gornogomphodon* also indicate greater dental diversity among the gomphodonts than previously known and suggest that not all gomphodonts are readily assigned to either the Diademodontidae, Traversodontidae or Trirachodontidae.

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