

Supplementary Information for

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3 Central nervous system and muscular bundles preserved in 240 million year old giant
4 bristletail (Archaeognatha, Machilidae)

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Supplementary Note 1. Geology and Stratigraphy of Middle Triassic succession at Monte San Giorgio.

1.1 Geology

Monte San Giorgio (split by the boundary across Italy and Switzerland) is one of the most renowned among the Middle Triassic sites in the world, since it concentrates several marine vertebrate levels in a small area of approximately 20 square km (45). The Swiss side of Monte San Giorgio has been inscribed in the UNESCO World Heritage List in 2003, joined by the Italian side in 2010, for the global significance of its fossil marine fauna.

The Monte San Giorgio basin is located at the western termination of the South-Alpine domain situated on a passive continental margin open to the tropical western Neo-Tethys (46), which was progressively submerged by a long-term transgression from the east. Its location resulted in a peculiar sedimentary succession, showing the onsetting, at least temporarily, of severe dysoxic to anoxic bottom water conditions (33, 47). The marine ingression reached the eastern South-Alpine domain in the Late Permian and the westernmost (i.e. west of Lake Como) South-Alpine domain in the Late Anisian times.

The intensive Middle Triassic tectonics made the palaeogeographic scenario more complex, resulting in a structural compartmentalization of the area (48).

The east–west extension of the Monte San Giorgio basin is estimated to have been about 10 km or up to 20 km if it was located in the same basin as the Perledo–Varenna Formation outcropping to the east of Lake Como (49-50). Basin depths in MSG are regarded as varying between 30 and 130 m and 160–260 m for the Perledo–Varenna Formation (47, 48, 51-53).

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41 *1.2 Stratigraphy*

42 The Triassic succession at Monte San Giorgio spans from the Olenekian-Middle Anisian
43 to the Norian, possibly the Rhaetian beds being eroded at the end of the Triassic -
44 beginning of Jurassic. The sequence starts with fluvio-deltaic deposits dated possibly to
45 the Lower Triassic Servino Formation and surely to the Middle Anisian Bellano
46 Formation, unconformably overlying a Lower Permian volcanic basement (54).

47 The Bellano Formation Middle Anisian sediments testify the progressive transgression of
48 a shallow sea from the east and the initiation of carbonate platform growth (San Salvatore
49 Dolomite/Esino Limestone). Dolomitized microbial limestones, characterized by
50 stromatolitic lamination, were deposited in a shallow subtidal to intertidal environment
51 (Lower Salvatore Dolomite). The overlying Besano Formation, San Giorgio Dolomite
52 and Meride Limestone, forming an approximately 600 m thick sequence, were deposited
53 from the Late Anisian through most of the Ladinian during the formation of an
54 intraplatform basin with restricted circulation (47, 50, 55).

55 The Kalkschieferzone (KSZ) is the uppermost part of the Meride Limestone. It forms a
56 120 m thick level of thin-bedded, mostly laminated, limestones and marlstones. It
57 represents the latest stage of the intraplatform basin, recording strong seasonal variations
58 of precipitations leading to sudden changes in salinity (32), which was progressively
59 buried by an increasing input of siliciclastic material from the nearby small islands and
60 large emerged land (56).

61 The KSZ has been recently dated (54) to 239.51 ± 0.15 Ma, somewhat older than
62 previously thought.

Besides providing new radionuclide dating for the Meride Limestone, Stockar (54) also highlighted how sedimentation rates in that area can be estimated around 180-200 m/Ma, much higher than in surrounding areas (estimated 8 m/Ma for the Buchenstein facies of the Bagolino section in the Brescia area).

The depositional environment of the KSZ was that of a shallow lagoon, adjacent to a carbonate platform (S. Salvatore Dolomite). Toward East-Northeast it faced a deeper basin (Perledo-Varenna Formation) and the complex system of carbonate platforms of the Esino Formation further to the East (Grigna Mountain), with somewhat limited connection to the open and deeper sea (32, 33, 56). Sedimentation took place below wave base and with an often anoxic bottom, as indicated by common laminated limestone or marly-limestone layers and the almost general absence of bioturbation (32, 33, 56, 57). Quite common are also clay-chips beds, often rich also in dark algal-film fragments, probably related to storms affecting the shallower part of the basin or the threshold toward the open waters (32, 33).

During the deposition of the uppermost Meride Limestone (the Kalkschieferzone Member), the fresh water influence became stronger and stronger: conchostracans and insects point to a quite close land with superficial fresh-water ponds, permanent or seasonal, as suggested by the number of conchostracan-rich surfaces (32, 58).

Supplementary Note 2. The fossil assemblages and the paleoenvironment in the Late Ladinian of Monte San Giorgio

2.1 General information

85 During about 25 years of excavations in the Lower and Middle KSZ, a number of species
86 have been reported from this upper Member of the Calcare di Meride. However, the
87 general biodiversity of this Member is quite low, as apart from about 20 fish species
88 actually subdivided in at least two different assemblages (32, 56, 59-63), among the
89 macroremains, apart from the insects, we recorded only the nothosaurid *Lariosaurus*
90 *valceresii* (57, 64), possibly three crustacean taxa (the mysidiacean *Schimperella* sp. n.,
91 the conchostracan *Laxitextella* sp. n. (58) and one very rare decapods) and a few
92 terrestrial plant remains. On the other hand, if we compare the fossil assemblages in the
93 KSZ with those from the lower Calcare di Meride Cava Inferiore, Cava Superiore and
94 Cassina, we do not see many differences in the number of marine vertebrate and
95 invertebrate species found in each single level (65; 66). Thus, the only major difference is
96 related to the presence of the insects and fresh-water conchostracans in the KSZ.
97 Actually, during the deposition of the Calcare di Meride, the fresh water influence
98 became stronger and stronger and in the KSZ no sure stenohaline organism has been
99 found, leaving apart the nothosaurid *Lariosaurus* and most of the fishes. In fact, many
100 fish genera have been found also in other localities that can be considered surely marine,
101 such as Luoping, in southern China (67, 68) (and A.T. pers. obs.) or Perledo along the
102 eastern coast of the Lario Lake (56, 67) or just the Besano-Formation in this same Monte
103 San Giorgio area (69).
104 Conchostracans and insects point to a quite close land with superficial fresh-water ponds,
105 permanent or seasonal, as suggested by the number of conchostracan-rich surfaces.
106 Tintori (32) and Tintori and Brambilla (56) proposed an alternation between dry and very

rainy season, a monsoonal-like climate where heavy rains could suddenly affect the KSZ salted basin causing mass mortality events in the marine fauna, mainly fishes (32, 33). A further support to the fresh water causing mass mortality in a marine basin after flooding the nearby land is given by the assemblage yielding *Dasyleptus triassicus* even if Bechly and Stockar (28) did not interpret correctly what was the taphonomic history of the surface yielding the three specimens of *D. triassicus*. It is clear that having a surface of only two square meters yielding three specimens of this terrestrial insect together with ‘diffuse small land plant remains’ and five fish specimens (28), this must be considered as a mass mortality one, owing to the flooding that brought the insects and the plant remains in the basin and also killed the small fishes. Other than these uncommon peculiar surfaces, the number of fish specimens by square meter is actually very low (32, 33). Actually, Bechly and Stockar (28) did not find any other fossil in the excavation site yielding *D. triassicus* and the small fishes, even if the investigated sequence is over two meters thick, proving that the fossiliferous surface in the whole is strictly related to a flooding that caused also the death of marine fishes. Thus, it is evident that we can consider a mass mortality surface in the KSZ when we have just only one specimen per square meter of a single surface, especially if all are about the same size and they belong mostly to a single species. As already pointed out (32, 33, 56), the major mortality of marine dwellers was concentrated possibly in a single season of the year, possibly the rainy one. Stormy heavy rains could help in bringing insects to the basin from the nearby-emerged land by both running waters and winds.

2.2 The insect assemblages

During the fieldwork carried out between 1997 and 2003 in the Lower KSZ at the Val Mara site D near Meride, on the Swiss side of Monte San Giorgio, a remarkably diverse assemblage of 19 insect specimens were collected. They include whole individuals and fragments, adult specimens and larval stages. Some of the specimens have been described to the genus or species level, namely: the ephemeropteran (mayfly) (70) *Tintorina meridensis* Krzeminski and Lombardo 2001, two coleopterans (beetles) (13, 70) (*Praedodromeus sangiorgensis*, Strada et al., 2014; *Notocupes* sp., Krzeminski and Lombardo 2001); the archaeognathans (28) *Dasyleptus triassicus* Bechly and Stockar 2011 and *Gigamachilis triassicus* (this paper). The remaining specimens are still under study to confirm their assignment to eight different lineages (“orders”) (13). Noteworthy, the entomofauna of Monte San Giorgio includes terrestrial groups, with both phytophagous and predatory habits, and aquatic groups, collected both as larvae (?Plecoptera) and as adults (Ephemeroptera, ?Coptoclavidae). Coleoptera are the most common group with six specimens, both whole individuals and fragments.

Supplementary Note 3. Description of paratype specimen MCSN8466

Specimen will be deposited at Museo Cantonale di Storia Naturale di Lugano (MCSN) – Switzerland.

Habitus (Supplementary Fig. S1 online). Total length ~27.7 mm. Preserved only the thorax (meso- and meta-) and the first six abdominal metameres, specimen visible in ventral view.

Thorax. Light impressions of meso- and metathorax preserved. Structures attributable to

metatrochanters visible.

Abdomen. Abdominal metameres from I to VI visible, coxopodites I and II well preserved, bearing eversible vesicles and styli on the right side. A styli-like appendage presents on the right side of metamere V.

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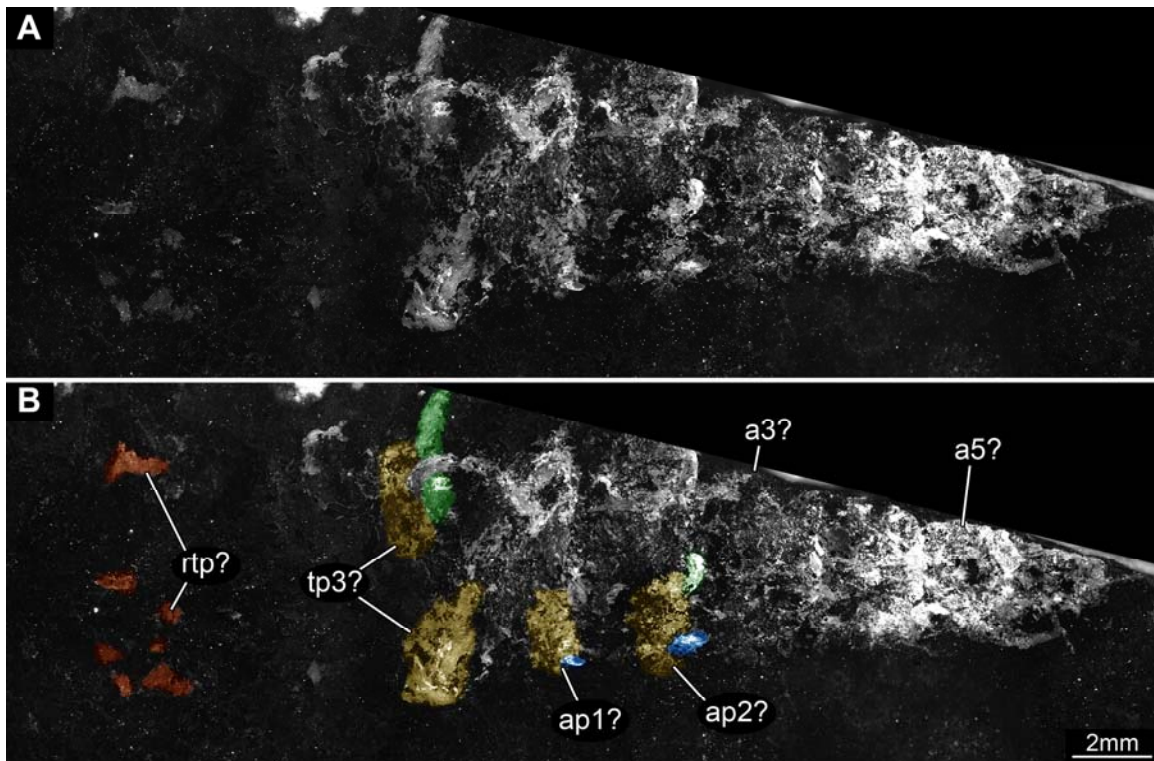
Supplementary Figures

Supplementary Figure 1. *Gigamachilis triassicus* paratype. (A) Overview. (B) Colour-marked version of A; remains of thoracopods in red; coxae and coxopodites in yellow;

245 derivatives of endopod in green; derivatives of exopod in blue. Abbreviations: a3? =
246 possible third abdominal segment; a5? = possible fifth abdominal segment; ap1? =
247 possible first abdominal appendage; ap2? = possible second abdominal appendage; rtp? =
248 possible remains of anterior thoracopods; tp3? = possible third thoracopod.

249

250 **Figure Supplementary 1.**



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