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The Carnic Alps: a treasure trove of extraordinary fossil arthropods

Introduction

Arthropods are the most diverse and abundant animals on Earth today. It is not surprising, therefore, that they can be abundant in certain fossil horizons. Fossil arthropods can be common in rocks if their cuticles are calcified (e.g. trilobites, ostracodes) or they are plentiful within the ecosystem (e.g. insects in lacustrine deposits). However, most arthropods have neither calcified cuticles nor are especially abundant in most sedimentary systems. For example, the most numerous multicellular organisms on Earth today are the copepod crustaceans, yet their fossil record is extremely meagre (SELDEN et al., 2010). The Friulian Carnic Alps and Prealps are exceptional in having produced a number of rare and unusual fossil arthropods, from the late Carboniferous (upper Moscovian-lower Kasimovian; c. 305-310 Ma) Meledis Formation and the Triassic (Norian; c. 210-215 Ma) Dolomia di Forni Formation. Five examples of such extraordinary finds are described here, and our dearly missed friend Luca Simonetto was involved in the research for all of these.

From the Carboniferous Meledis Formation, three exceptional arthropods have been described: a most unusual horseshoe crab (Chelicerata: Xiphosura) which is strongly effaced (SELDEN et al., 2019); a eurypterid (Chelicerata: Euryoterida), the first described from Italy (LAMSDELL et al., 2013); and a terrestrial whip-scorpion (Chelicerata: Arachnida) (SELDEN et al., 2016). From the Triassic Dolomia di Forni Formation, there are two unusual arthropods described: the first known fossil asellote crustacean (Crustacea: Isopoda) (SELDEN et al., 2016); and one of only four spiders known from the Triassic period (Chelicerata: Arachnida: Araneae: Mygalomorphae) (DALLA VECCHIA & SELDEN, 2013).

Arthropods of the Carboniferous Meledis Formation

The Meledis Formation (upper Moscovian-lower Kasimovian) is the oldest of the five formations of the Pramollo Group (upper Moscovian-Gzhelian, Upper

Carboniferous). It consists of arenitic and pelitic facies and rarer dolomitic algal limestones, which correspond to fluvio-deltaic and shallow-water marine environments (VENTURINI, 1990). As well as typical marine fossils like brachiopods and trilobites, non-marine and terrestrial fossils also occur (VENTURINI, 2006), including plant and insect remains. In addition, horseshoe-crab trackways have been described from the formation (CONTI et al., 1991).

A remarkable specimen of a horseshoe crab carapace was discovered by Giordano Marsiglio in a loose block in the bank of the Rio degli Uccelli (Vogelbach), north-east of Pontebba (Fig. 1A). The lithology of the matrix suggested it came from the Meledis Formation. It was named as *Stilpnocephalus pontebbanus*, and placed in the family Belinuridae by SELDEN et al. (2019). The large (>8 cm width) carapace is strongly effaced and appears to lack eyes (Fig. 2A). *Stilpnocephalus* was the first fossil horseshoe crab to be described from Italy and the largest known belinurid.

Related to the Xiphosura within the Chelicerata are the eurypterids. The common genus in Upper Carboniferous strata is *Adelophthalmus*. Hence, the specimen discovered by Stefano Piussi in the gravel bank of a tributary of Bombaso creek near the SP110 (Fig. 1), also belongs to this genus, and was named as *Adelophthalmus piussii* by LAMSDELL et al. (2013). The specimen was described as a new species on account of its possession of a carapace median furrow and the lack of expanded posterolateral corners of the carapace, which are features of other *Adelophthalmus* species. It is the first eurypterid to be described from Italy, although distinctive eurypterid fragments are known from the Silurian of Sardinia (GNOLI, 1992; CORRADINI et al., 2009).

Whilst both eurypterids and xiphosurans are primarily aquatic (but likely amphibious in part, in the late Carboniferous), arachnids are primarily terrestrial. Clues to the proximity to land occurred in the black

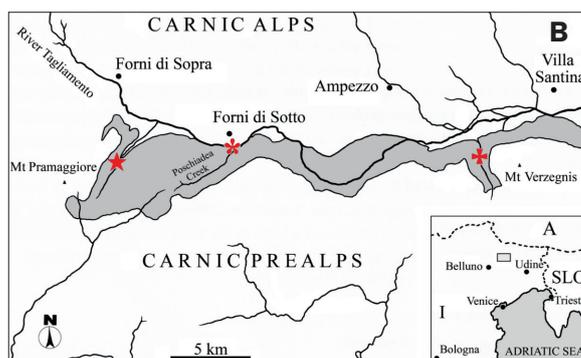
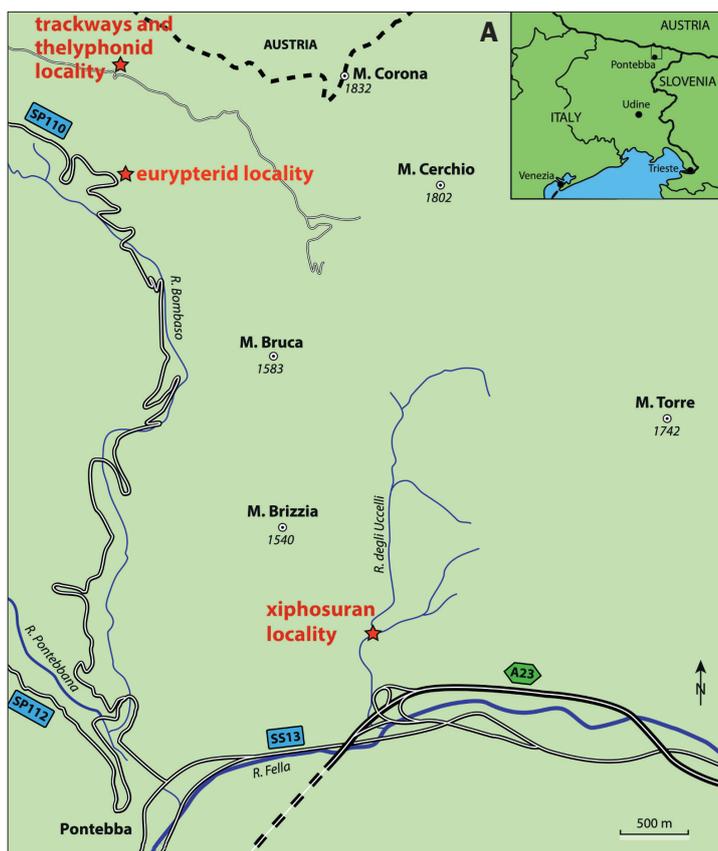


Fig. 1 - Maps showing the localities of the fossil arthropods described here. A) Area of the Carnic Alps in northeastern Friuli showing the localities of the fossil xiphosuran on the bank of the Rio degli Uccelli (Vogelbach), north-east of the village of Pontebba; the eurypterid in the Meledis Formation near the SP110 road from Pontebba to Passo Pramollo; and the landslide locality Frana Vecchia where the horseshoe-crab trackways and the thelyphonid were found. Spot heights in metres. Inset: location map. B) Map of the Tagliamento Valley showing the extent of the Triassic Dolomia di Forni Formation (grey), and the localities of the isopod in the bed of the Tagliamento River below the village of Forni di Sotto (asterisk); the spider, along the Rovadia Brook valley (star), and the main locality in the Seazza Brook near Preone village where the majority of other fossils from this formation have been collected (cross). Inset: location map.

bearing the eurypterid, which also bore land plant remains (LAMSDALL et al., 2013); so, it was of little surprise when a truly terrestrial arachnid, a thelyphonid (whip-scorpion) turned up in the Meledis Formation (SELDEN et al., 2016). The specimen came from a locality known as Frana Vecchia (the old landslide), not far from that which produced the eurypterid (Fig. 1A). Thelyphonids are known from Upper Carboniferous strata around the world. The Friuli example was named *Parageralinura marsiglioi* after its discoverer Giordano Marsiglio (Fig. 2C). It was the first Carboniferous arachnid to be described from mainland Italy and possibly the youngest Palaeozoic thelyphonid.

Arthropods of the Triassic Dolomia di Forni Formation

The Dolomia di Forni Formation is Triassic (Norian) in age, and the fossils date from approximately 210-215 Ma. The formation represents deposition in an anoxic marine basin of maximum depth ~400 m, and was surrounded by a shallow-water carbonate platform, the Dolomia Principale Formation (CARULLI et al., 1997). The Dolomia di Forni Formation has yielded a peculiar fossil assemblage composed of arthropods, a polychaete worm, ophiuroids, possible coleoid remains, gastropods, bivalves, marine fish, terrestrial tetrapods, and terrestrial plants (see DALLA VECCHIA, 2012 for more information).

Two specimens of a bizarre crustacean were found in debris in the bed of the Tagliamento River, close to the town of Forni di Sotto (Fig. 1B). They turned out to be the first known examples of asellote isopods (sea lice) in the fossil record. The specimens were named *Fornicaris calligaris* Wilson & Selden, 2016 (SELDEN et al., 2016), in memory of their collector, Claudio Calligaris. Characters such as narrow, elongate eye stalks, tiny uropods, and enlarged first pereonite (found in adult males) placed the fossil within the family Paramunnidae (Fig. 2D).

Like the Carboniferous Meledis Formation, the Triassic Dolomia di Forni Formation includes both marine and terrestrial fossils. *Fornicaris* is a marine arthropod, but another specimen discovered in the same river bed belonged to a terrestrial arachnid: a spider (DALLA VECCHIA & SELDEN, 2014; Fig. 2E). The specimen was described as *Friularachne rigoi*, in honour of the the finder, Roberto Rigo. The discovery brought the number of known Triassic spiders to four. The specimen is an adult male, and was identified as a possible member of the mygalomorph superfamily Atypoidea, and extended the geological record of the superfamily ~98-115 Ma.

Discussion

From this short survey of just five arthropod species from the Carnic Alps of Friuli, all of which represent first, oldest, and other records, it is clear that the region

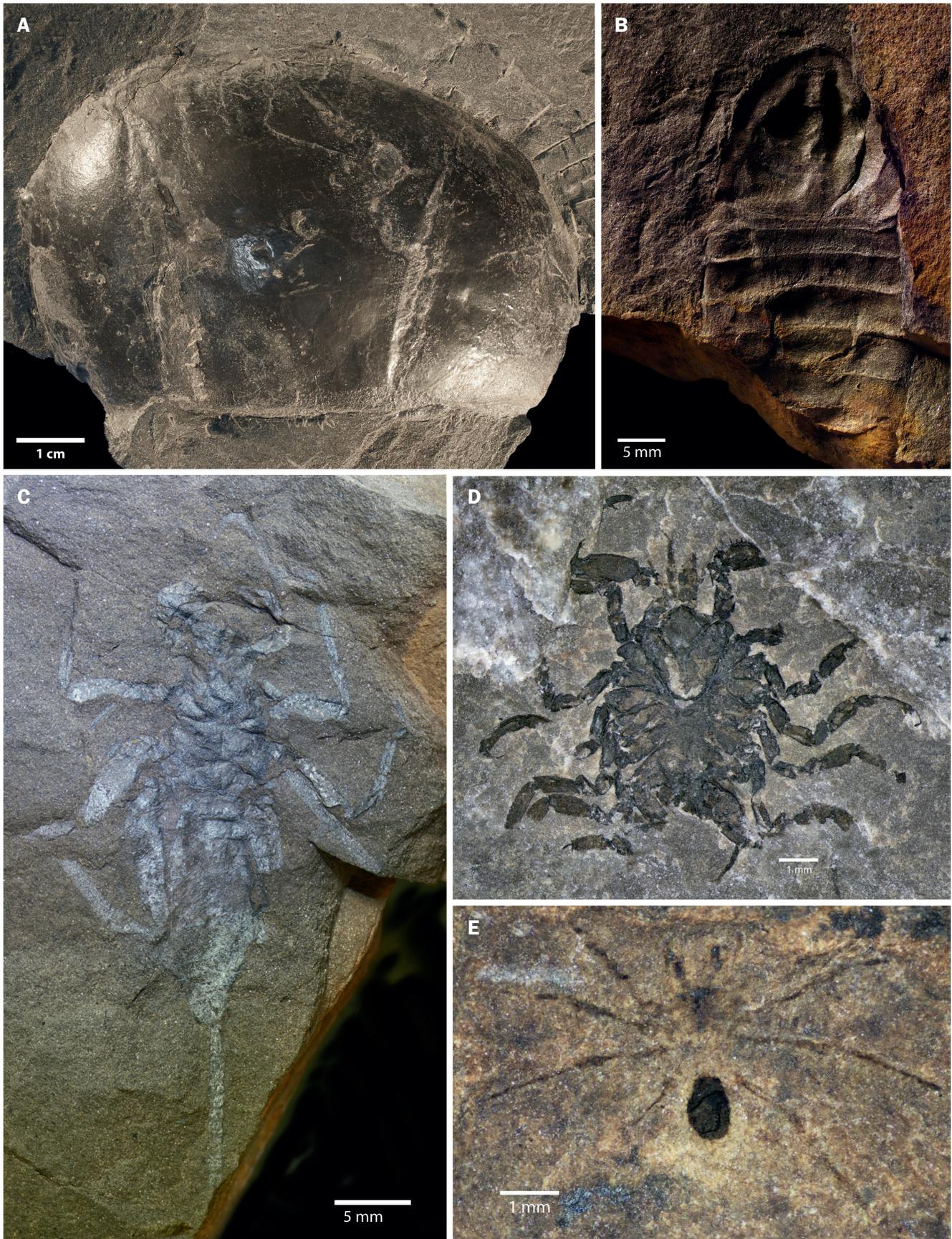


Fig. 2 - Fossil arthropods from the Carboniferous Meledis Formation (A-C) and Triassic Dolomia di Forni Formation (D-E) of the Carnic Alps and Prealps, Friuli.

- A) Large, effaced, eyeless carapace of the belinurid xiphosuran *Stilpnocephalus pontebbanus*;
- B) The eurypterid *Adelophthalmus piussii*;
- C) Thelyphonid arachnid *Parageralinura marsiglioi*;
- D) Asellote isopod *Fornicaris calligarisi*;
- E) Mygalomorph spider *Friularachne rigoi*.

of Friuli is an exceptional hotspot for amazing finds of fossil arthropods. Our dearly departed friend Luca Simonetto was instrumental in the description of all of these remarkable fossils.

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