

## **Dragonflies preserved in transparent gypsum crystals from the Messinian (Upper Miocene) of Alba, northern Italy**

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**Abstract.** From the Upper Miocene (Messinian) of the Alba area in Piedmont, northern Italy, are fossil dragonflies (mainly larvae) described, which were preserved in transparent gypsum crystals. The specimens belong probably to a single species (*Oryctodiplax gypsorum*), but occur in various pre-imaginal stages. This individual-rich but species-poor palaeontomofauna appears to be almost autochthonous in origin and may have developed under hypersalinar conditions in a lagoonal environment during the Messinian salinar event.

**Key words:** Odonata, Messinian, Upper Miocene, taphonomy, palaeobiology.

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### I. INTRODUCTION

Non-marine fossil arthropods preserved three-dimensionally are known from only a few deposits in the world. The most famous of this kind of preservation is represented by the various deposits of fossiliferous resins (known as amber and copal), ranging in age from Lower Cretaceous to Holocene, which have also yielded by far the greatest number of fossils. Other examples of three-dimensionally preserved non-marine arthropods are specimens including spiders, ants and caterpillars from Miocene volcanoclastic rocks of Mfangano and Rusinga Islands, Lake Victoria, Kenya (LEAKEY 1952; WILSON & TAYLOR 1964; HAY 1986), pyritized beetles from the Eocene London Clay of Bognor Regis in Sussex (BRITTON 1960; JARZEMBOWSKI 1992), various crustaceans, arachnids and insects from Miocene calcareous nodules of the Mojave Desert, California (PALMER 1957), beetles from Pleistocene tar deposits (MILLER & PECK 1979) and a few Pleistocene and Holocene ice-preserved arthropods mostly from the perma-frozen Siberian tundra (MÜLLER 1978).

The present paper is concerned with dragonflies (mostly larvae) observed in more or less transparent gypsum crystals, the latter irregularly baked together into nodules. The nodules were found

in the Alba area in Piedmont, northern Italy (Fig. 1), and are of Messinian age (Upper Miocene). In a general review of taphonomy, this deposit may therefore also be referred to as a Conservat Lagerstätte, or a fossiliferous deposit of exceptional preservation (ALLISON & BRIGGS 1991).

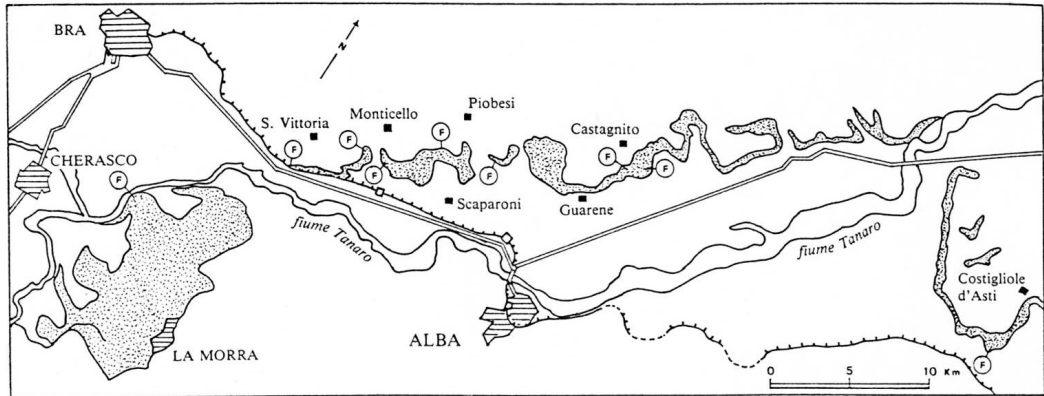


Fig. 1. Alba area, southern Piedmont in northern Italy, showing outcrops.

## II. GEOLOGICAL SETTING

Thousands of compression fossils (mostly dragonfly larvae) were collected since many years in bedding planes of gypsiferous marls and well-bedded gypsum deposits (so-called "Balatino") at outcrops of the Alba area in southern Piedmont (northern Italy). The stratigraphic age of these fossils (Fig. 4) was assigned to the Middle Messinian (STURANI 1973, 1976). Generally, the palaeoenvironment of the strata of the Middle Messinian in the Alba area is characterized by an extreme high salinity due to a dramatic salinity crisis in the Palaeo-Mediterranean Sea, the so-called "Messinian event". During the suggested desiccation of the Mediterranean Sea diatomites, carbonates, gypsum and halite as well as sulphur were deposited. A simplified profile of the Neogene in the Alba area ranging from the Upper Tortonian to the Lower Pliocene is given in Fig. 2 (modified after STURANI 1973).

Pre-imaginal stages of dragonflies occur in almost every layer of the evenly laminated marls and marly silts of Bed 3b, but were also recorded in strata containing transparent gypsum crystals of irregularly baked gypsum nodules underneath of Bed 3b in Bed 3a, which have been named as "banco de gesso coltivato" (CAVALLO & GALLETI 1987). The paleoenvironment has been suggested as being part of the former "lagune messiniane dell'Albese" (CAVALLO & GALLETI 1987: 176).

## III. MATERIAL AND METHODS

The here described material of dragonfly larvae embedded in transparent gypsum crystals was collected by one of us (H.-J. G.) and is housed at the Palaeontological Institute of the Free University of Berlin. The gypsum nodules below Bed 3a range from 5 to 20 cm in diameter. Their external form is irregular to spherical, sometimes subconical, hemispherical, or disk-shaped. From these nodules transparent platy gypsum crystals with an exposure of up to 30 cm can be extracted, which contain the enclosed dragonfly larvae. These are three-dimensionally preserved, but apparently only representing hollow spaces, therefore resembling in their mode of preservation the inclusions of amber, which are predominantly only cavities. All the studied dragonfly specimens are characterized by thin, tube-like extensions that preferably arise from sclerites of the body and occasionally

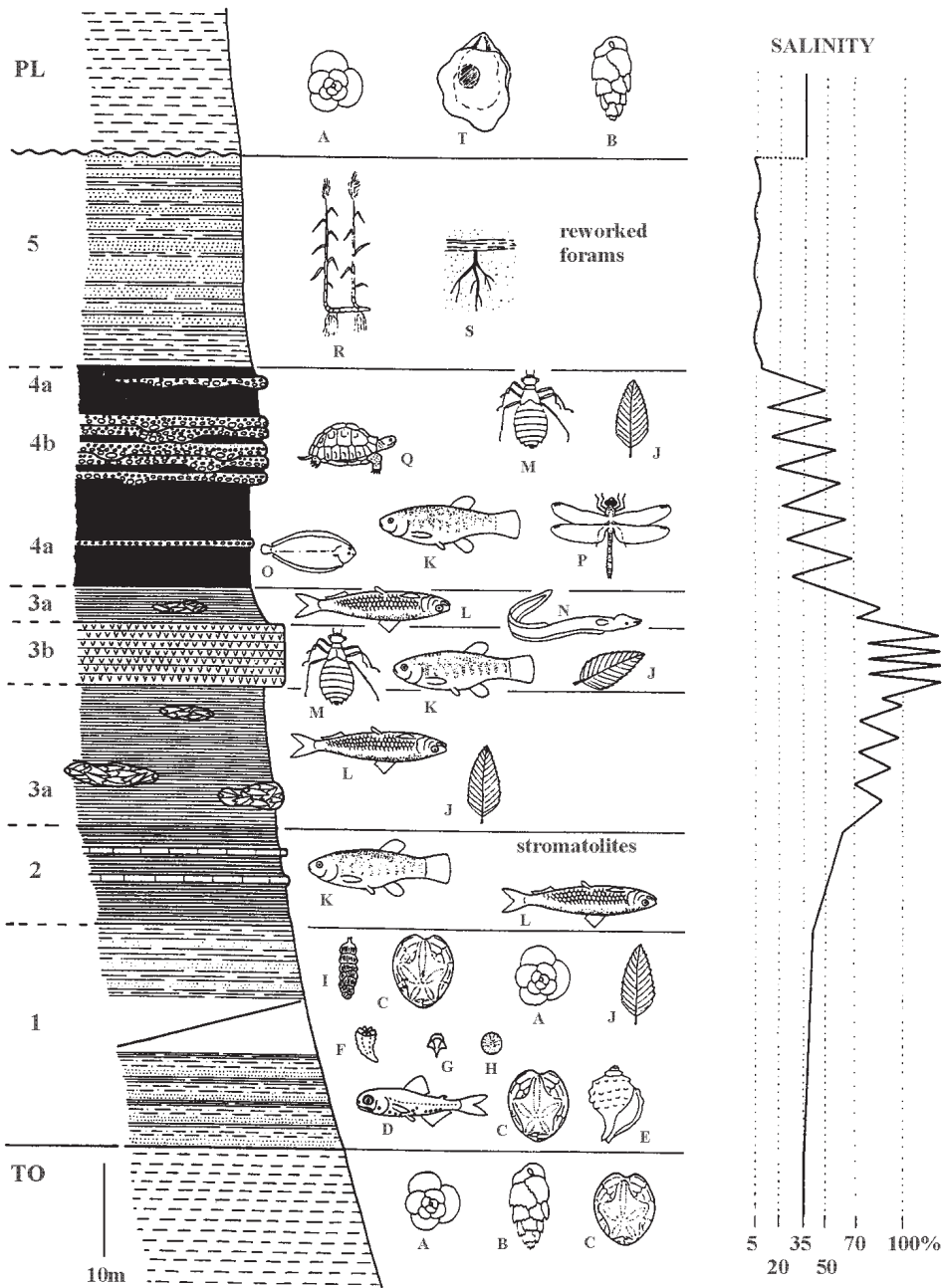


Fig. 2. Generalized cross section of outcrops in the Alba area ranging in age from the Tortonian to the Pliocene (from CAVALLO & GALLETI 1987).

branch off. These appear to be fungiform phenomena that possibly came into existence before entombment. This may be an indicator that these fossils represent only exuviae of the former larvae, which, after having been left by the next stage during their development and successive drying out, had been infected by fungus. Due to various impurities within the transparent gypsum crystals it was, however, difficult to produce photographs of the enclosed larvae.

#### IV. SYSTEMATICS

##### ORDER: ODONATA

##### Family: **Libellulidae**

##### ***Oryctodiplax gypsorum*** CAVALLO & GALLETTI 1987

(Fig. 3a-c, Fig. 4a-b)

1986 "dragonfly larvae" CITA & MCKENZIE, p. 129 (without fig.)

1987 *Oryctodiplax gypsorum* n. sp. CAVALLO & GALLETTI, p. 166 (Fig. 5, Tav. 8.1) adult specimen (Holotype) and larvae assigned to the new genus (Fig. 2, Tav. 2)

1995 "gipskonservierte Libellenlarven" KOHRING & SCHLÜTER, p. 474, Fig. 12.

**D e s c r i p t i o n** of the pre-imaginal stages. Length of specimens ranging 0.5-1.5 cm. Head relatively small, wider than long and elliptical in shape. Antennae filiform. Mask concave and elliptical. Abdomen broad and oval. Minute spines occur on 8<sup>th</sup> and 9<sup>th</sup> abdominal segments. Legs rather long, compared to fossilized compression larvae of Bed 3b.

**S y s t e m a t i c a f f i n i t i e s.** As already pointed out by CAVALLO & GALLETTI (1987), the dragonfly larvae preserved as compression fossils from the Messinian of the Alba area may belong to more than only a single species. Earlier authors had these fossils always assigned to "*Libellula doris*", a species described and named by HEER (1849) from the Late Miocene of Oeningen in Bavaria, and based only on pre-imaginal stages. CAVALLO & GALLETTI (1987) considered this identification as being incorrect, since the specimens from the Alba area possess a shorter and broader abdomen than *Libellula doris*, and have occasionally short lateral spines on their 8<sup>th</sup> and 9<sup>th</sup> segments, which are completely missing in *Libellula doris*. Additionally, in contrast to *Libellula doris* the fossil compression larvae from the Alba area possess a shorter 10<sup>th</sup> segment, the anal appendages are much smaller, the legs are slightly larger and the size of the mature larvae is apparently a bit smaller (Fig. 5). The bulk of larvae preserved as compression fossils from the Alba area, which exhibit quite some morphological variety, have therefore only been assigned for practical reasons to a single extinct genus and species under the collective name *Oryctodiplax gypsorum* of the family Libellulidae. From the observable morphological characters it appears reasonable to include the fossil specimens embedded in gypsum crystals also into the same systematic unit.

#### V. PALEOENVIRONMENTAL CONDITIONS

The Mediterranean salinity crisis, the so-called Messinian event, occurred during the latest stage of the Miocene. After initial restriction and euxinification an intensive sedimentation of evaporites (limestone, gypsum and halite) took place. Among the evaporites both marine and non-marine fossils have been found. Surprisingly, from the fossil inventory recorded from some of these evaporitic deposits a former non-marine ecosystem is indicated, documented by the assemblage of angiosperm leaves, insects and vertebrates (STURANI 1973; SORBINI & RANCAN-TIRAPELLE 1979).

The here reported dragonfly larvae have been found in laminated gypsum layers. This type of gypsum deposition is characterized by a succession of thin laminae of fine-grained gypsiltites alternating with carbonatitic layers (HARDIE & EUGSTER 1971). The presence of filamentous algae and/or bacteria in several gypsum layers may have led to the development of extensive deposits containing stromatolites (CIARANFI et al. 1976).

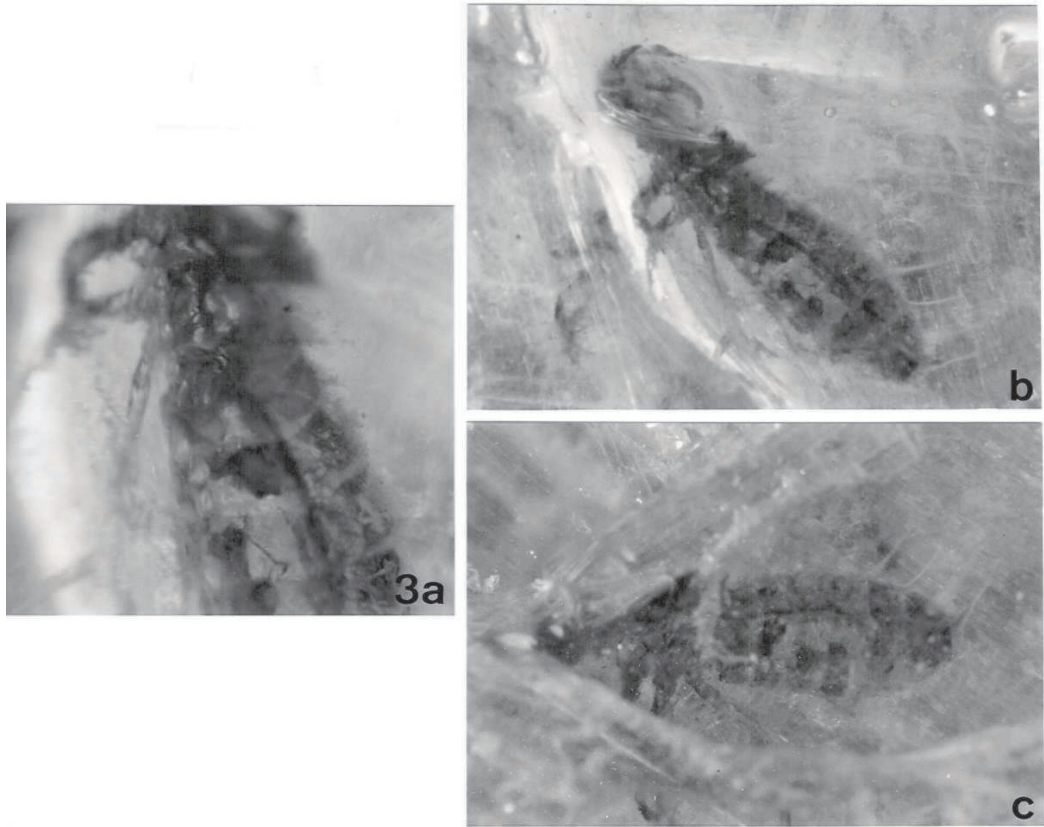


Fig. 3a-c. Photographs of dragonfly larvae preserved in transparent gypsum crystals.

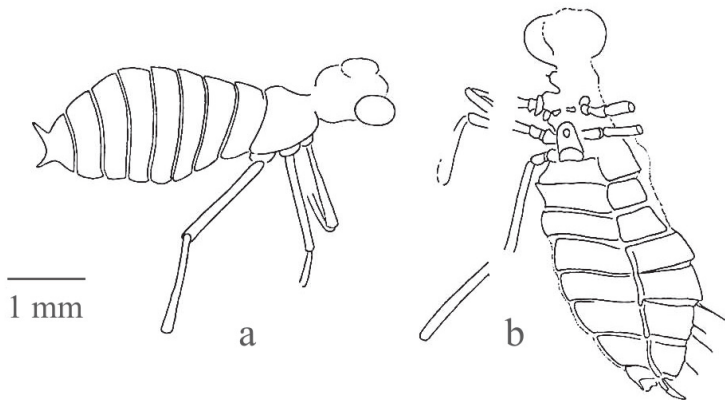


Fig. 4a and b. Drawing of two dragonfly larvae preserved in gypsum crystals.

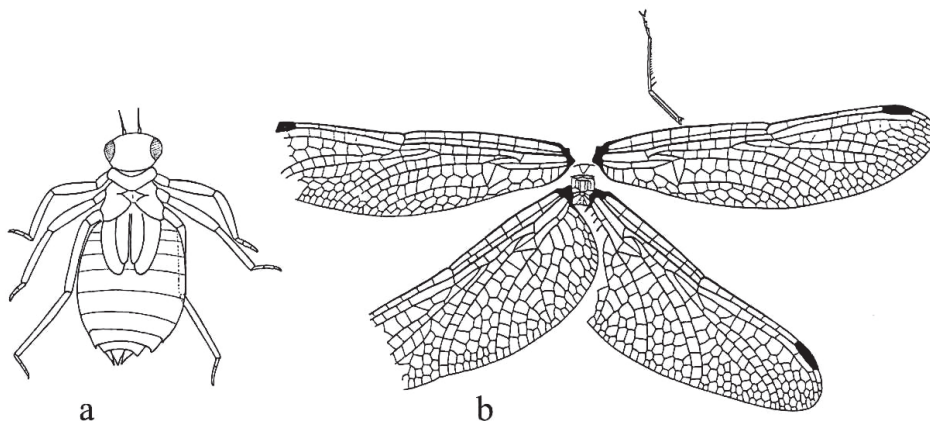


Fig. 5. Dragonfly larva and wings of an adult specimen of *Oryctodiplax gypsorum* from the platy marls of Bed 3b of the Alba area (after CAVALLO & GALLETTI 1987). Note the slit in the middle of the thorax of the larva indicating an exuvia.

HARDIE & EUGSTER (1976) suggested the deposition of fine-laminated gypsum in temporarily restricted environments on the lagoonal side of the levees, therefore in a very shallow water or even under temporarily sub-aerial conditions similar to modern sabkhas. The supply of solutes is suggested to have come from storm surges.

## VI. TAPHONOMY AND PALAEOBIOLOGY

From the compression fossils of dragonfly larvae in Bed 3b CAVALLO & GALLETTI (1987) concluded that many of them had died and were fossilized before reaching adulthood, but as shown by the open slit along the middle of the thorax in several of the compression fossil specimens (Fig. 4), these represent molten exuviae, which after drying out due to their extreme light weight had possibly been drifted away by wind to their place of sedimentation. In the dragonfly larvae preserved in the gypsum crystals such an open slit in the thorax is not recognizable, but may be observed in additional specimens not yet available. On the other hand it has to be considered that the size of the fossil dragonfly larvae preserved in the gypsum crystals varies widely, and that even remains of a few adult specimens (however in poor condition) are also recorded.

Due to the high amount of individuals of one or probably only a few species of dragonflies (the bulk of it representing pre-imaginal stages), this type of preservation in gypsum crystals supports the idea of an autochthonous character of the fauna, meaning that the specimens were buried where they had once lived. KOHRING & SCHLÜTER (1995) pointed out that some modern Odonata develop successfully in brackish waters or even in brines with a salt content of up to more than 1% (WESENBERG-LUND 1943: 99).

On the other hand, it is known that in allochthonous palaeontological deposits, caused by wind or stream-drifting, often a large variety of taxa from the surrounding environments is also included (e. g. Messel, Rott, Fur etc.). MURSCH & STEFFAN (1997) described an actualistic example from a modern saline lake shore in northern Namibia with an arthropod assemblage containing about 90 different species, mainly insects. Similarly, T. S. has observed on the surface of the trona crust ( $\text{Na}_2\text{CO}_3\text{NaHCO}_3\cdot 2\text{H}_2\text{O}$ ) of the recent Lake Magadi in southern Kenya a variety of well-preserved, secondarily salted, but mostly larger insect bodies, which have probably arrived there by wind floating.

Therefore the here described dragonfly larvae of the Alba area represent obviously a former community of a species-poor but individual-rich extreme palaeobiocenosis living near the shores of a largely saline aquatic environment with lagoonal character.

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