Quaderno di Studi e Notizie di Storia Naturale della Romagna
Quad. Studi Nat. Romagna, 19: 17-44, giugno 2004 ISSN 1123-6787

Giuseppe Gentilini & Loris Bagli

FOSSIL ZYGOPTERA AND ANISOPTERA FROM THE UPPER MIOCENE OF MONTE CASTELLARO (PESARO, MARCHES, CENTRAL ITALY)

(Insecta Odonata Coenagrionidae, Lestidae, Sieblosiidae, Calopterygidae, Libellulidae)

Riassunto

[*Zigotteri e Anisotteri fossili del Miocene superiore di Monte Castellaro, Pesaro, Marche, Italia centrale (Insecta Odonata Coenagrionidae, Lestidae, Sieblosiidae, Calopterygidae, Libellulidae)*]
Vengono discusse e figurate sette ali fossili di Odonata Zygoptera e descritte due nuove specie di Odonata Anisoptera appartenenti alla famiglia Libellulidae, scoperte nel giacimento miocenico di Monte Castellaro, Pesaro.Viene inoltre esaminata un'ala posteriore di libellula attribuita alla sottofamiglia Pantalinae e al genere *Trapezostigma*, proveniente dalla stessa località fossilifera.

Abstract

Seven fossil wings of Odonata Zygoptera from the Upper Miocene of Monte Castellaro, Pesaro, are discussed and figured, and two new species of Odonata Anisoptera belonging to the family Libellulidae, are described. A dragonfly hindwing attributed to the subfamily Pantalinae and genus *Trapezostigma* from the same fossiliferous locality, is also examined.

Key words: Insecta, Odonata, Coenagrionidae, Lestidae, Sieblosiidae, Calopterygidae, Libellulidae, Taxonomy, Upper Miocene, Monte Castellaro, Pesaro, Marches, Central Italy.

Introduction

New fossil damselflies and dragonflies from the Upper Miocene of Monte Castellaro, have been examined. The Odonata fauna consists of separate wing remains, preserved as compressions in fine-grained, bituminous marls, exposed in two fossiliferous sections developed along the Adriatic coast, in the lower part of a cliff about 3 km north-west of Pesaro (Marches, Central Italy) and included in the Gessoso-solfifera Formation of Lower Messinian age. Most of the dragonflies have been discovered by the senior author in the "Strato degli insetti" (GENTILINI, 1989, 1992, 1993; BAGLI & GENTILINI, 2003), a well cemented insect bed about 140

mm thick, located near the top of the Formation and consisting of very thin, dark-grey and light-grey evaporitic laminae probably related to a seasonal deposition. In this layer several insect orders have been discovered, often associated with fish and leaf remains. These fossil assemblages may indicate both deep off-shore and shallow, near-shore paleoenvironments: the presence of varved shales normally occurring in quiet basins, the predominance of articulated fish remains and complete insects preserved as adults (especially Hemiptera-Homoptera, Diptera Bibionidae, Mycetophilidae, Limoniidae and insects with strong flying ability as Diptera Syrphidae, Hymenoptera and Odonata), may indicate a relatively deep-water/off-shore paleoenvironment, while abundant remains of evergreen needles and taxodiaceous leaves and the presence of insects with weak flying ability (Coleoptera, Trichoptera, terrestrial Hemiptera), may represent a near-shore paleoenvironment (WILSON, 1980). Moreover, the scarcity of marine taxa among the ichthyofauna of the "Strato degli insetti"(only few specimens of *Lates* sp. and *Harengula* sp. have been found) and the predominance of the hypereuryhaline species *Aphanius crassicaudus* (Agassiz,1832), indicate highly saline water conditions (SORBINI,1988), with a normal salinity marine environment, present at least in certain periods.The majority of the terrestrial plant assemblages collected in this insect bed, suggest vegetational belts characterized by a great diversity of habitats with the presence of *Taxodium* in the warm, humid and swampy coastal plains, a belt of thermophyle plants with prevailing *Quercus*, *Acer*, *Populus* and probable mountain slopes with predominance of xerophile forests of *Pinus*, *Sequoia* and *Thuja*. However, the occurrence of Diptera Trichoceridae in the insect assemblages and the high proportion of Nearctic and Palearctic genera among the Odonata fauna, might suggest also climatic fluctuations including a possible cooling phase, correlated with the salinity crisis in the Mediterranean Sea during the Late Miocene, with a vegetational belt of conifers lowered towards the depositional basin (BERTOLANI MARCHETTI & MARIOTTI LIPPI, 1989); anyway, further collecting and comparative study will increase our knowledge of this Lower Messinian paleoenvironment.

Fossil Anisoptera (adults and larvae) from Monte Castellaro are relatively common, while fossil Zygoptera are extremely rare: only eight specimens (about 3.5% of the total number of Odonata) have been found up to now. It is interesting to note that species belonging to the subfamily Ischnurinae (Odonata Coenagrionidae) and the family Calopterygidae are infrequent in Tertiary insect localities and only one record of the genus *Ischnura* is known from the Eocene/Miocene amber inclusions of the Dominican Republic; on the contrary, the families Lestidae and Sieblosiidae are well known from Cenozoic deposits. Moreover, the finding of the genera *Deielia* and *Trapezostigma* (Odonata Libellulidae) is also of considerable interest: the wing of *Deielia* discovered at Monte Castellaro, represents the first fossil record of this genus, while well preserved species belonging to the genus *Trapezostigma* are poorly known from European Neogene deposits.

Fortunately, a Nature Reserve (Parco Naturale di Monte San Bartolo, including

the Monte Castellaro outcrop, considered as insects deposit of exceptional preservation), was established in 1994 and now the protected area may be used for research, education and organized visits. The most extensive fossil insect collections from the Monte Castellaro site, included the specimens described in this paper, are deposited in the Museo del Territorio of Riccione (Rimini, Emilia Romagna, Northern Italy).

The venation abbreviations are based on RIEK & KUKALOVÁ-PECK (1984) with modifications by NEL et al. (1993) and BECHLY (1996).The classification of fossil and extant Odonata, follows BECHLY (1996, 2000) and the principles of phylogenetic systematics (sensu HENNIG 1966,1969).

Systematic palaeontology

Order	Odonata	Fabricius,1793
Suborder	Zygoptera	Selys, 1854
Superfamily	Coenagrionoidea	Kirby,1890
Family	Coenagrionidae	Kirby, 1890
Subfamily	Ischnurinae	Fraser,1957
Genus	*Ischnura*	Charpentier, 1840

Ischnura sp. (Species A - Fig. 1)

Material - Specimen no.1289 and 1289a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

1

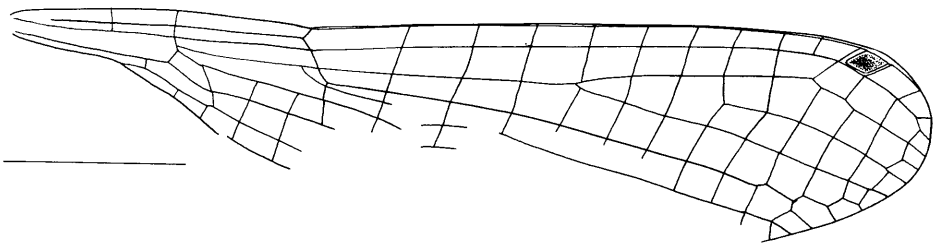

Fig. 1 - Venation of *Ischnura* sp. (Species A): right forewing of male. Scale: 3 mm.

Description

The species is known from an isolated right forewing of male with part of the posterior wing margin missing.Wing membrane hyaline; venation not dense with relatively large cells; veins brown; base narrow and well petiolate; wing apex wide and rounded; longitudinal veins long and straight. Wing length, 15.2 mm; width at nodus, 2.4 mm; width at wing base, 0.5 mm; petiole about 2 mm long; distance from base to nodus, 5 mm; distance from base to arculus, 2.3 mm; distance from arculus to nodus, 2.2 mm; distance from nodus to pterostigma, 8.6 mm; distance from pterostigma to apex, 1.8 mm; nodus situated at about 32.8 % of the wing length. Primary antenodal crossveins Ax1 and Ax2 aligned and bracket-like; Ax2 in line with the arculus and situated at 1.1 mm distal of Ax1; absence of secondary antenodal and antesubnodal crossveins. Arculus kinked; sectors of arculus distinctly separated from their origin; nodal crossvein in line with subnodus; nine postnodal crossveins between costal margin and RA all aligned with the postsubnodal crossveins below them excluding the most distal incomplete. Pterostigma short with margins thickened, bicoloured (brown to white yellowish), as long as wide and covering only one cell; pterostigmal brace vein oblique and in line with the proximal side of the pterostigma; there are three single cells beyond the pterostigma between the anterior wing margin and vein RA. Discoidal cell trapezoidal in shape, closed basally and with distal angle acute: length of basal side, 0.3 mm; length of ventral side, 0.9 mm; length of dorsal side, 0.5 mm; length of distal side, 0.5 mm. Vein MAb strongly oblique; subdiscoidal cell relatively wide (length, 1.3 mm; width, 0.25 mm), with distal side angulated; cell situated below the subdiscoidal cell, unusually crossed. Basal area free; cubital cell with only CuP-crossing situated 2.3 mm distal of the wing base; basal portion of CuA, straight. Postdiscoidal field with one row of cells; vein MA and MP basally straight with one row of cells between them; vein CuA straight at base. First branching of RP, 0.2 mm basal of the subnodus; base of IR2 aligned with subnodus; lestine oblique vein "O", absent; area between IR2 and RP3-4, very narrow basally. Fork of RP1 at about four cells and 4.3 mm distal of the subnodus; vein RP1 kinked below the pterostigmal brace vein and slightly zigzagging. Vein IR1 separates from RP1, 2.5 mm distal of the fork of RP1 and two cells basal of the pterostigma; vein RP2 separates from RP1 three cells basal of IR1 and four cells beyond the nodus. One row of cells distally between RA and RP1, between RP1 and IR1 (only a double cell is present on the wing margin), and IR1 and RP2. Distal portion of IR2 zigzagged; double cells between veins RP2 and IR2, and IR2 and RP3-4 on the hind margin; the vein RP3-4 reaches the posterior wing border well before the proximal side of the pterostigma.

Discussion

The fossil damselfly wing described above can be attributed to the extant genus *Ischnura* because of the following venational characters: small size of the wing, distinctly petiolate; venation rather open; wing apex fairly rounded in forewing; anal vein separating from the posterior wing border before the CuP-crossing; arculus

situated at the level of the distal antenodal; discoidal cell basally closed with distal angle acute; area between the bases of IR2 and RP3-4, narrowed; pterostigma bicoloured in male species of the genus, especially on the forewing; fork of RP generally situated about four cells distal of the nodus in forewings and three cells in hindwings. Moreover, this fossil species shows an unusual feature: the cell situated below the subdiscoidal cell is crossed nearly in the middle; this character is usually not present in Coenagrionoidea and probably may be considered as an aberration rather than a diagnostic feature.The genus *Enallagma* resembles *Ischnura* in many characters, but it differs in having five-eight cells instead of three-four, between subnodus and fork of RP1; moreover, the wing apex of *Enallagma* is slightly pointed and more densely reticulated. The fossil *Ischnura* (Species A) shares synapomorphies with the following taxa introduced by BECHLY (1996): Euzygoptera (longitudinal veins straight and long; one row of cells between CuA and posterior wing margin; only primary antenodals Ax1 and Ax2 present basal of the nodus; antesubnodal area without crossveins as well as area between RP and MA, from arculus to midfork); Coenagrionomorpha (postnodal and postsubnodal crossveins in alignment, with the most distal sometimes incomplete; oblique vein "O" secondarily absent; discoidal cell closed at base in forewings); Coenagrioniformia (pterostigma rather short with two crossveins below it; subnodus in line with the base of IR2; number of exagonal and pentagonal cells strongly reduced; area between RP1 and RP2 with two rows of cells separated by the vein IR1; postnodal crossveins in alignment with crossveins situated below; intercalary veins lacking, except IR1 and IR2); Coenagrionida (RP1 kinked below the pterostigmal brace vein); Cenagrionodea (proximal,ventral and distal margins of pterostigma, thickened and forming a U-shaped structure); Coenagrionidae (Kirby, 1890), (vein MAb very oblique so that the dorsal side of the discoidal cell is shorter than the ventral side). The fossil record for the genus *Ischnura* is poor: only one species certainly belonging to this genus, has been described by BECHLY (2000a) from Dominican amber inclusions (Eocene to Miocene), while species of Coenagrionidae or Ischnurinae incertae sedis, have been reported by NEL & PAPAZIAN (1990) and by NEL, MARTÍNEZ-DELCLÒS, PAPIER & OUDARD (1997), from the Upper Oligocene of Aix-en-Provence and the Upper Miocene of Sainte-Reine, France. *Ischnura* (Species A) differs from the Dominican amber species *Ischnura velteni* (Bechly, 2000), in the longer and wider wing, the longer petiole and the cell below the subquadrangle, crossed. Moreover, it is distinguishable from the French species by the shorter and narrower wing (the wing of the specimen no.IPM-R07706 from Aix- en Provence, France, has the same length (15.2 mm) but it is wider), by the shape of the pterostigma not rhomboidal, the crossed cell below the subquadrangle and the higher or lower number of postsubnodal crossveins.

At the present day the genus *Ischnura* is a cosmopolitan, widespread genus and it is represented in continental Europe and western Mediterranean basin by seven species.

Ischnurinae (Species B - Fig. 2)

(Genus and species undetermined)

Material - Specimen no. 1288 and 1288a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

Description

The species is represented by an isolated left hindwing with a small portion of the posterior wing margin, missing. Wing hyaline with base narrow and distinctly petiolate; veins brown; wing length, 14 mm; width at nodus, 2 mm; width at wing base, 0.4 mm; petiole, 2 mm long; distance from base to nodus, 5.1 mm; distance from base to arculus, 2.7 mm; distance from arculus to nodus, 2.5 mm; distance from nodus to pterostigma, 7.3 mm; distance from pterostigma to apex, 1.8 mm; nodus situated at about 36.4 % of the wing length. Primary antenodals Ax1 and Ax2 aligned and bracket-like; Ax2 in line with the arculus and situated 1 mm distal of Ax1; absence of secondary antenodal and antesubnodal crossveins. Arculus kinked and sectors of arculus separated from their origin; seven postnodal crossveins in line with the corresponding postsubnodal crossveins, excluding the most distal, incomplete. Pterostigma (length, 0.5 mm; width, 0.3 mm) rhomboidal in shape with proximal and ventral sides thickened: some traces of pale brown colour pattern are preserved on the membrane. The pterostigma is well braced (its oblique basal side is aligned with the brace) and covers about three quarters of a cell; there are four single cells with the first well elongate, beyond the pterostigma between the anterior wing margin and vein RA. Discoidal cell closed basally and with distal angle acute: length of basal side, 0.25 mm; length of ventral side, 0.8 mm; length of dorsal side, 0.4 mm; length of distal side .0.4 mm. Subdiscoidal cell moderately elongate with distal side angulated; cell situated below the subdiscoidal cell free of crossveins. Vein MAb oblique and aligned with subdiscoidal veinlet; basal space free; cubital cell

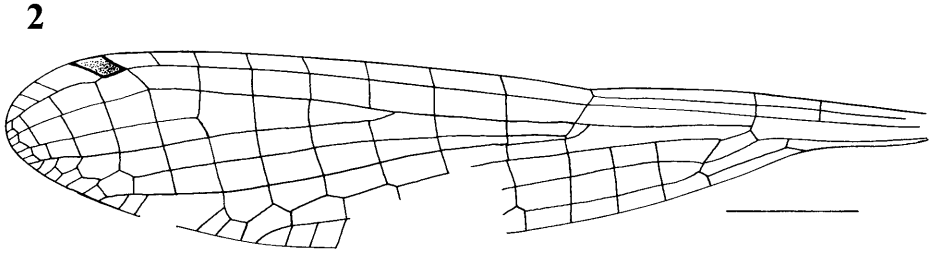

Fig. 2 - Venation of Ischnurinae (Species B): left hindwing. Scale: 5 mm.

with CuP-crossing strongly oblique and situated at about 2.2 mm distal of the wing base; anal vein separating from the wing margin, 0.25 mm basal of CuP-crossing. Discoidal field narrow with only one row of cells; vein MA and CuA straight in the first portion and zigzagged distally; one row of cells basally between veins MP and CuA, and between CuA and posterior wing margin. First branching of RP at 0.2 mm basal of the subnodus; base of IR2 in line with subnodus and basal area between IR2 and RP3-4, very narrow. Vein RP2 separates from RP1 three cells basal of IR1 and two and a half cells beyond the nodus.Vein RP1 kinked below the pterostigmal brace vein; origin of IR1, 3 mm distal of the origin of RP2 and one cell basal of the pterostigma; there are double cells between RA and RP1, RP1 and IR1, IR1 and RP2, on the wing apex. Lestine oblique vein "O" absent; vein IR2 strongly zigzagged distally with double cells on the hind margin; vein RP3-4 slightly sinuous and reaching the posterior wing border opposite the distal side of the pterostigma.

Discussion

The species shows venational features of the extant subfamily Ischnurinae (wings petiolate to level of CuP-crossing and anal vein separating from posterior wing border close to CuP-crossing; arculus situated at level of Ax2; discoidal cell closed basally and with distal angle acute; area between the bases of IR2 and RP3-4 very narrow), but the reliable attribution to a genus is difficult for the lack of body characters. This specimen of Ischnurinae (Species B) differs from *Ischnura* (Species A) described above, in the shorter and narrower wing, the apex smaller and pointed and the pterostigma scarcely coloured and rhomboidal in shape. Moreover, the cell situated below the subquadrangle is free of crossveins and there are seven postnodals instead of nine between the costal margin and vein RA; the fork of RP is at about two and a half cells distal of the subnodus instead of four cells and the origin of IR1 is only one cell basal of the pterostigmal brace vein, instead of two cells. The Ischnurinae (Species B) differs from the amber species *Ischnura velteni* (Bechly, 2000), in the longer and wider wing and the longer petiole and wider discoidal cell; moreover, it is quite distinct from Coenagrionidae or Ischnurinae incertae sedis from France, discussed in the description of *Ischnura* (Species A), in the shorter and narrower wing, in the less numerous postnodal and postsubnodal crossveins and in having two and a half cells in the basal area between RP1 and IR2, instead of four or five cells. According to NEL & PAICHELER (1993a), fossil Coenagrionoidea are difficult to recognize only by wing remains and several determinations are uncertain.

Family	Lestidae	Calvert, 1901
Subfamily	Lestinae	Calvert, 1901
Genus	*Lestes*	Leach, 1815

Lestes sp. (Species C - Fig. 3)

Material - Specimen no. 1287 and 1287a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

Description

The species is represented by a single, hyaline left wing with the distal half of the membrane strongly folded towards the costal margin.The wing venation of the specimen has been reconstructed by part and counterpart.Veins brown; wing length, 17 mm; width at nodus, 1.2 mm; width at base, 0.5 mm; petiole about 1.9 mm long; distance from base to nodus, 5 mm; distance from base to arculus, 2.4 mm; distance from base to midfork, 2.9 mm; distance from arculus to nodus, 2.5 mm; distance from nodus to pterostigma, 8.5 mm; distance from nodus to apex, 12.3 mm; distance from nodus to origin of RP2, 2.6 mm; distance from nodus to origin of IR2, 1.8 mm; distance from nodus to origin of RP3-4, 1.9 mm; nodus situated at about 29 % of the wing length. Primary antenodals Ax1 and Ax2 aligned and bracket-like; Ax2 in line with the arculus and 1.1 mm distal of Ax1. No secondary antenodal and antesubnodal crossveins; basal area between RP1 and IR2, free of crossveins. Sectors of arculus separated at the base; nine postnodal crossveins more or less aligned with the postsubnodal crossveins situated between RA and RP1, except for the last two incomplete. Pterostigma coloured pale yellowish, elongate and braced, with the oblique basal side aligned with the brace.The pterostigma is 1.4 mm long and 0.35 mm wide; there are two crossveins preserved below the pterostigma and six single cells beyond it, between the anterior wing margin and vein RA.Discoidal cell narrow, elongate, basally closed with distal angle strongly acute: length of basal side, 0.2 mm; length of ventral side, 1 mm; length of dorsal side, 0.6 mm; length of distal side, 0.4 mm. Basal space free; cubital cell with CuP-crossing situated at 1.7 mm distal of the wing base; anal vein separating from ving margin at the level of CuP-crossing. Only one row of cells in the cubito-anal area; vein CuA strongly zigzagged distally and vein MP straight with distal end distinctly bent towards the hind margin. Basal and distal portion of vein MA zigzagged; one row of cells between MA and MP; vein RP3-4 straight and reaching the posterior wing margin well beyond the distal side of the pterostigma; area between RP3-4 and MA widened distally; a long and straight intercalary longitudinal vein subtending two rows of cells, present between veins RP3-4 and MA. Space between bases of IR2 and RP3-4 very narrow: first branching of RP situated 1.8 mm basal of the subnodus; distance between origin of IR2 and subnodus, 1.7 mm; nodal crossvein and subnodus well oblique in position. Lestine oblique vein "O" between RP2 and IR2, situated 4.5 mm distal of the subnodus. Vein RP2 originates from RP1, 2.4 mm distal of the subnodus; course of vein IR1 strongly zigzagged basally; most of distal area between RP1 and IR2 missing. One row of cells between veins RA and RP1 and two-three rows of cells between IR2 and RP3-4 towards the wing apex.

Discussion

This fossil lestid can be attributed to the extant genus *Lestes* because of the following venational features: wing hyaline and well petiolated; sectors of arculus arising near the upper part of the arculus; discoidal cell with distal angle well acute; origin of RP3-4 nearer to arculus than to subnodus; pterostigma elongate, rectangular in shape and as long as the two cells under it; oblique vein "O" situated between veins RP2 and IR2; anal vein separating from posterior wing margin at level of CuP-crossing; area between RP3-4 and MA widened distally, with secondary longitudinal veins present. The species shares synapomorphies with the following taxa introduced by Bechly (1996): Euzygoptera (longitudinal veins straight and long; end of vein RP3-4 situated beyond the pterostigna; vein MA more or less reaching the pterostigma; vein CuA ending distal of the midwing; one row of cells between CuA and the posterior wing margin; only Ax1 and Ax2 present in the antesubnodal area); Eulestiformia (vein MP curved after its origin on the distal angle of the discoidal cell); Lestodea (arculus shifted towards the wing base, beneath the primary Ax2); Lestinoidea (Calvert,1901), (midfork recessed basally and situated at about 20-26% of the wing length; vein MA zigzagged distally); Lestidae (dorsal arcular bracket reduced; distal discoidal vein MAb very oblique and discoidal cell with distal angle well acute; three rows of cells between IR2 and RP3-4 on the hind margin); Lestinae (lower portion of the arculus formed by the basal side of the discoidal cell, so that it is very close to vein RA). Several species belonging to the genus *Lestes* have been discovered in Eocene, Oligocene, Miocene and Pliocene deposits of Europe: the species from the Monte Castellaro site, may be placed in the fossil *Lestes* group B (Nel & Paicheler, 1994), a group characterized by more modern venational characters, because of the absence of a supplementary row of cells between vein MP and the posterior wing margin. In the Palaeogene species of *Lestes* group A, found in western Europe localities, three-four rows of cells are present between vein MP and the hind margin. Concerning Italian fossil lestids, a forewing and a hindwing belonging to the subfamily Sympecmatinae and genus *Sympecma* (Selys, 1840), have been figured but not described by Cavallo & Galletti (1987), from the Upper Miocene (Lower Messinian) of the Scaparoni and Piobesi sites, near Alba (Piedmont, Northern Italy).

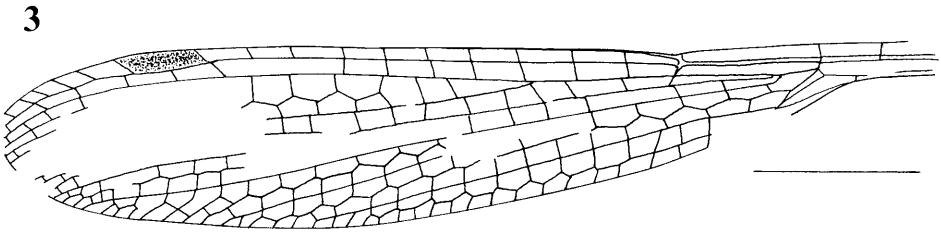

Fig. 3 - Reconstruction of left wing of *Lestes* sp. (Species C) by part and counterpart. Scale: 3 mm.

At the present day the genus *Lestes* is cosmopolite and occurs in vegetated areas with still, sluggish or moving water and in cool temperate to tropical climate. Six species of *Lestes* are represented in Europe.

Lestidae (Species D - Fig. 4)

(Genus and species undetermined)

Material - Specimen no. 1290 and 1290a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

Description

The species is known from head, thorax and abdomen fragments and from the basal areas of fore and hindwings. Head in poor condition; thorax dark brown to black coloured: mesepisternum about 4.3 mm long and 1 mm wide; mesepimeron 3.5 mm long and about 0.7 mm wide; preserved length of dark brown abdomen, 13.7 mm;

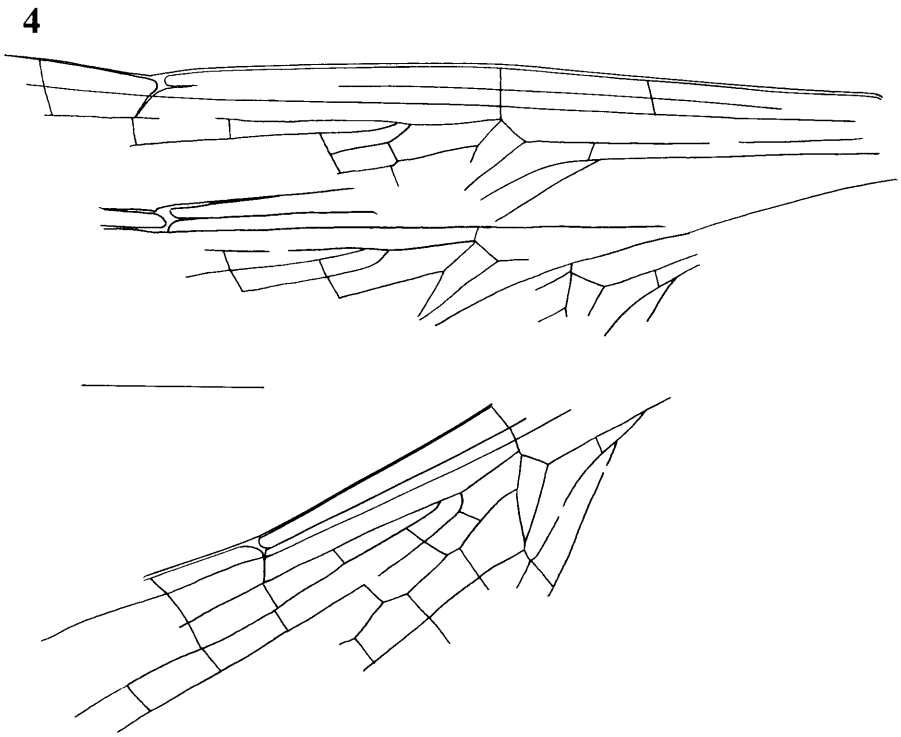

Fig. 4 - Venation of fore and hindwing bases of Lestidae (Species D). Scale: 2 mm.

width about 1 mm. Left forewing: preserved length of wing, 10 mm (right forewing, about 9 mm); width at base 0.7 mm; length of petiole 3.1 mm; distance from base to nodus, 8 mm (right forewing, 8 mm); distance from base to arculus, 4.1 mm (right forewing, 4.8 mm); distance from arculus to nodus, 3.7 mm (right forewing, 3.5 mm); distance from base to midfork, 5.2 mm (right forewing, 5.5 mm). Primary antenodals Ax1 and Ax2 aligned; Ax2 in line with the arculus and situated 1.6 mm distal of Ax1. Basal space without crossveins and cubital cell free, except for CuP-crossing situated 3.3 mm distal of the wing base. Anal vein separating from hind margin 0.5 mm basal of CuP-crossing. Sectors of arculus separated at origin; discoidal cell trapezoidal in shape with distal angle not preserved. Discoidal cell of left forewing: length of basal side, 0.4 mm (right forewing, 0.3 mm); preserved length of ventral side, 0.9 mm (right forewing, 1 mm); length of dorsal side, 0.4 mm (right forewing, 0.5 mm); preserved length of distal side, 0.4 mm (right forewing, 0.5 mm). Two single cells present basally between veins RP and IR2, before the subnodus. Left hindwing in poor condition. Right hindwing: preserved length, 8.5 mm; distance from arculus to nodus, 3.1 mm; Ax2 aligned with arculus; cubital cell with only CuP-crossing, present; anal vein separating from posterior wing margin 0.1 mm basal of CuP-crossing; sectors of arculus separated at origin. Discoidal cell trapezoidal in shape with distal angle acute: length of basal side, 0.35 mm (left hindwing, 0.35 mm); length of ventral side, 1 mm (ventral side of left hindwing incomplete); length of dorsal side, 0.45 mm (left hindwing, 0.35 mm); length of distal side, 0.7 mm (distal side of left hindwing not preserved).Vein MAb aligned with subdiscoidal veinlet; basal portion of MA, zigzagged; one row of cells between veins RP3-4 and MA and between MA and MP, basally.

Discussion

The fossil wings described above belong to the family Lestidae because of the following venational characters: anal vein separating from hind margin slightly basal of CuP-crossing; distal discoidal vein MAb strongly oblique and distal angle of discoidal cell well acute; vein MA zigzagged; vein RP3-4 with origin nearer to arculus than to subnodus.The size of the discoidal cell slightly smaller in forewings than in hindwings is a venational character present in the genus *Lestes*, but the area between nodus and apex is missing and it is very difficult to determine the genus only by the wing base venation, because of the similarities present in allied genera as *Chalcolestes* (Kennedy,1920), *Paralestes* (Schmidt, 1951) and *Platylestes* (Selys,1862).

Lestidae (Species E - Fig. 5)

(Genus and species undetermined)

Material - Specimen no. 1291; coll.Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte

Castellaro (Pesaro, Marches, Central Italy).

Description

The species is known only from a right wing base.Veins brown; preserved length of wing, 8 mm; width at base,1 mm; petiole about 1.9 mm long; distance from base to nodus, 5.1 mm; distance from base to arculus, 2.9 mm; distance from arculus to nodus, 2.2 mm; distance from nodus to origin of RP2, 2.4 mm. Primary antenodals Ax1 and Ax2 aligned: Ax2 in line with the arculus and about 0.7 mm distal of Ax1; sectors of arculus separated at origin. Discoidal cell basally closed, trapezoidal in shape, narrow and elongate: length of basal side 0.2 mm; length of ventral side1.2 mm; length of dorsal side 0.6 mm; length of distal side 0.7 mm.Basal discoidal field with one row of cells; basal space free; cubital cell with only CuP-crossing situated 2.4 mm distal of the wing base and nearer to Ax1 than to Ax2.

Discussion

The species is placed in the extant family Lestidae because of the following venational characters: wing well petiolated; arculus at level of Ax2; distal discoidal vein MAb very oblique; discoidal cell trapezoidal in shape with well acute distal angle. The lower portion of the arculus is formed by the basal side of the discoidal cell, situated near the base of the vein RP. Unfortunately, the specimen is too incomplete for genus placing.

Taxon	Caloptera	Belyshev & Haritonov, 1983
Family	Sieblosiidae	Handlirsch, 1907
Subfamily	Ischnurinae	Fraser,1957
Genus	*Italolestes* (?)	Nel, Petrulevicius, Gentilini & Martínez-Delclòs (in press)

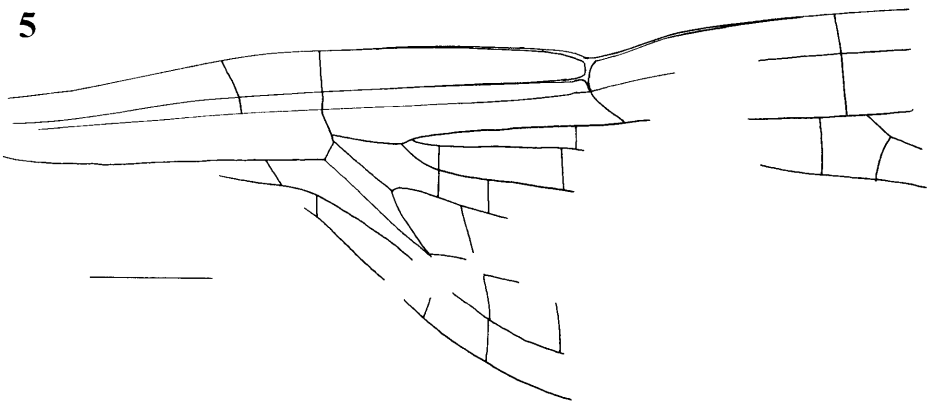

Fig. 5 - Venation of wing base of Lestidae (Species E). Scale 1 mm.

Italolestes (?) sp. (Species F - Fig. 6)

(Species undetermined)

Material - Specimen no.1292a (counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

Description

The species is known from a hyaline, rounded wing apex in good condition; the venation is fairly dense, consisting of numerous rectangular, pentagonal or hexagonal small cells. Preserved length of wing, 11.2 mm; maximum width, 7.3 mm; distance from proximal side of pterostigma to apex, 6.5 mm. There are six postnodal crossveins preserved before the pterostigma, not in line with the four postsubnodals situated between veins RA and RP1; pterostigma (length, 3.8 mm; width,1 mm) very elongated, pale brown coloured and with upper and lower margins thickened. Pterostigmal brace vein in line with the proximal side of the pterostigma. There are about seven and a half cells under the pterostigma and ten single cells beyond it, between the costal margin and vein RA. Area between RA and RP1 below the pterostigma, narrowed; veins RP1 and IR1 gently curved under the distal side of the pterostigma with only one row of cells between them.Three rows of cells are present between veins IR1 and RP2 and between RP2 and IR2, before the pterostigma; area between RP2 and IR2 widened distally, with nine rows of cells; end of veins IR2 and RP3-4 strongly curved towards the posterior wing margin with only one row of cells between them.Vein RP3-4 reaching the hind margin

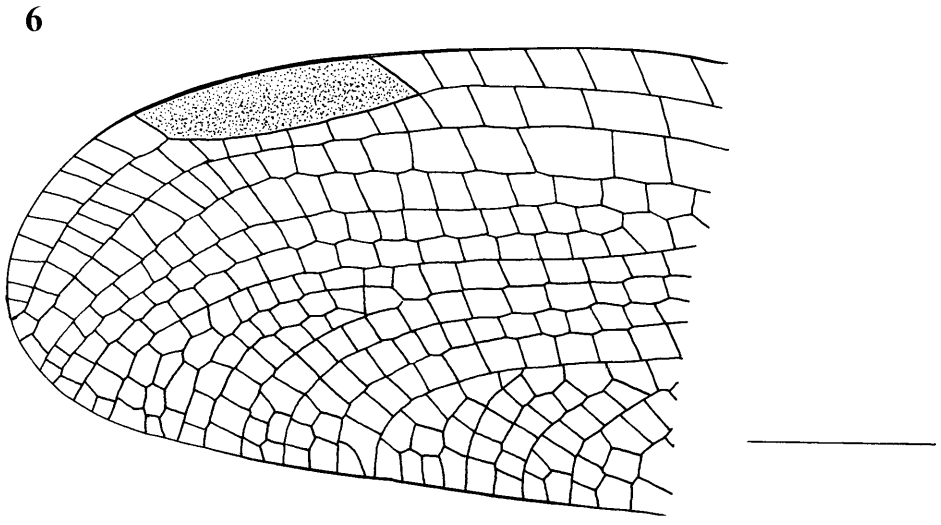

Fig. 6 - Venation of *Italolestes* (?) sp. (Species F): counterpart of a right wing apex. Scale: 3 mm.

opposite the proximal side of the pterostigma. Distal portion of veins RP1, IR1, RP2 and IR2, slightly zigzagged.

Discussion

This damselfly is placed in the fossil family Sieblosiidae because of the following venational characters: wing relatively broad and densely reticulated; pterostigma elongate and fairly wide so that the area below the pterostigma between RA and RP1 is very narrow. Veins RP1 and IR1 curved below the distal part of the pterostigma; area between RP2 and IR2 widened distally; one row of cells between IR2 and RP3-4. The specimen much resembles the new genus *Italolestes* (NEL et al., in press) recently discovered in the eastern fossiliferous section of the Monte Castellaro site, especially in the shape and size of the pterostigma and the numerous crossveins below and beyond it. Moreover, it is quite similar to *Italolestes* in the following features: the veins RP1 and IR1 are not strongly curved under the distal side of the pterostigma and include only one row of cells between them; there are three rows of cells between veins IR1 and RP2 and the distal end of RP3-4 is strongly bent towards the posterior wing margin.Unfortunately, the lack of the first half of the wing with important venational characters, does not permit a sure attribution.

Fossil damselflies belonging to the family Sieblosiidae are especially known from eastern and western deposits of the Oligocene and Miocene of Europe, with six genera described up to now: *Stenolestes* (Scudder, 1895); *Oligolestes* (Schmidt, 1958); *Paraoligolestes* (Nel & Escuillié, 1993); *Parastenolestes* (Nel & Paicheler, 1994); *Italolestes* and *Miostenolestes* (Nel, Petrulevicius, Gentilini & Martínez-Delclòs, in press).

Taxon	Caloptera	Belyshev & Haritonov, 1983
Taxon	Calopterygoidea	Selys, 1850
Family	Calopterygidae (?)	Selys,1853

Calopterygidae (?) (Species G - Fig. 7)

(Genus and species undetermined)

Material - Specimen no. 1735 and 1735a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

Description

The species is known from a wing fragment with the base and apex missing. Preserved wing length, 19 mm; maximum width, 8 mm; wing membrane entirely brown coloured and densely reticulated; veins brown; antenodal crossveins in poor

condition. There are 32 postnodal crossveins preserved rarely coinciding with the crossveins below them, between veins RA and RP1.Vein IR1 with origin about eight cells distal to nodus; first one row of cells, then two rows are present between RP1 and IR1; course of vein RP2 fairly straight; vein IR2 sinuous; one row of cells between RP2 and IR2 with two cell rows in the median/distal portion; three rows of cells preserved between veins IR2 and RP3-4 and between RP3-4 and MA; end of vein MP curved towards the hind margin; three rows of cells present between veins MA and MP.The cubital and anal area are poorly preserved.

Discussion

The specimen is too incomplete for an accurate attribution, therefore the fossil wing has been placed in the taxon Calopterygoidea and provisionally in the family Calopterygidae, because of the following venational characters: wing broad, densely reticulated (venation fine and close) and brown coloured; longitudinal veins curved towards the posterior wing margin; postnodal crossveins not always aligned with crossveins situated below them, between veins RA and RP1; origin of IR1 relatively close to the nodus; vein IR2 sinuous.

Fossil Calopterygoidea are rare in Cenozoic and Neozoic deposits and only the following genera and species are known, until now: *Eucalopteryx atavina* (Cockerell, 1920) from the Middle Eocene of the Green River Formation,Wyoming (U.S.A.), may be placed in the taxon Calopterygoidea (family uncertain); *Calopteryx atrata* (Selys, 1853), (sensu ESAKI & ASAHINA, 1957) from the Upper Pliocene of the Oya-Formation, Kazusa (Japon), has to be considered as undetermined species of the genus *Calopteryx*; *Sapho armissani* (Nel, 1987) is known from the Oligocene-Miocene deposit of Armissan (France); *Umma* sp. incertae sedis and Calopterygoidea (family, genus and species incertae sedis),

Fig. 7 - Venation of Calopterygidae (?) (Species G): left wing. Scale: 3 mm.

have been described by NEL & PAICHELER (1992), from the Upper Oligocene of Aix-en Provence and from the Mio-Pliocene of Sainte-Reine (France); two specimens of Calopterygoidea (family, genus and species incertae sedis), are known from the Eocene of the Green River Formation, Wyoming (U.S.A.); *Calopteryx andancensis* has been described by NEL & BRISAC (1994a), from the Upper Miocene of Saint-Bauzile, Ardèche (France). Concerning the Italian Calopterygiformia, an Eocene Zygoptera belonging to the fossil family Bolcathoridae and the genus *Bolcathore*, has been described by GENTILINI (2002) from the Monte Bolca site (Verona, Northern Italy) and a hindwing belonging to the family Epallagidae and genus *Epallage* (Charpentier, 1840), has been figured but not described by CAVALLO & GALLETTI (1987), from the Upper Miocene of Costigliole d'Asti (Piedmont, Northern Italy).
Extant Calopterygoidea occur in temperate, warm temperate habitats and even in torrid zones. The taxon is represented in Western Europe by two families, two genera and six species: the family Calopterygidae with the genus *Calopteryx* (Leach, 1815) and five species and the family Epallagidae, with the genus *Epallage* (Charpentier, 1840) and only one species.

Suborder	Anisoptera	Selys, 1854
Family	Libellulidae	Leach, 1815
Subfamily	Sympetrinae	Tillyard, 1917
Genus	*Deielia*	Kirby, 1889

Deielia sarae n. sp. (Fig. 8)

Holotype - Specimen no.1293, 1293a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy).

Type locality - Monte Castellaro (Pesaro, Marches, Central Italy).

Type horizon - Upper Miocene, Lower Messinian, Gessoso - solfifera Formation, Marne bituminose unit, "Strato degli insetti" level.

Etymology – This species is dedicated to Sara, granddaughter of the senior author.

Diagnosis
The new species can be distinguished by the following venational characters: wing relatively short, broad, densely reticulated and crossed by a brown band. Arculus situated between the first and second antenodals; sectors of arculus stalked; discoidal triangle two-celled; vein MP short, curved and reaching the posterior wing margin opposite the level of the nodus. Vein CuA zigzagged and strongly bent towards the hind margin; pseudo-IR1 originates beneath the middle of the pterostigma; RP2 sinuous; Rspl subtending two rows of cells. Pterostigma pale brown to yellowish, unbraced, elongate and surmounting two crossveins.

Description

The species is known from a left forewing characterized by a brown crossband between the nodus and the proximal side of the pterostigma: the colour pattern covers the area between vein RP1 and branches of Mspl and it does not reach rearward the hind margin.

Length of forewing, 23 mm; width at nodus, 8.5 mm; distance from base to nodus, 11 mm (the nodus is situated at about 48% of the wing length); distance from nodus to pterostigma, 6.7 mm; distance from nodus to wing apex, 11.7 mm; distance from base to arculus, 2.8 mm.There are eight antenodal crossveins between costal margin and ScP, all aligned with the corresponding crossveins between ScP and RA. Seven antesubnodal crossveins are present basal of the subnodus, with a moderately short "cordulegastrid gap" (sensu BECHLY, 1996); there are seven postnodal crossveins between costal margin and RA and only three postsubnodals between RA and RP1, with the first two not in line with the corresponding crossveins situated above; a long " libellulid gap" present directly distal of the subnodus. Pterostigma (length, 2.7 mm; width, 0.7 mm) elongate, with upper and lower margins thickened; there are one and two half cells below the pterostigma and five crossveins beyond it, between vein RA and the anterior wing margin. Arculus nearer to first antenodal crossvein than to second; sectors of arculus rising from a very short stalk, situated near the base of MP; hypertriangle free of crossveins and with costal side (MA) weakly curved; discoidal triangle transverse, narrow, pointed and divided into two cells by a crossvein: length of its basal side, 2.1 mm; length of its costal side, 1 mm; length of its distal side, 2.6 mm. Subdiscoidal triangle three-celled with costal side (pseudo-anal vein PsA) slightly concave: four paranal cells are present out of the subtriangle. Basal space free and cubital cell with CuP-crossing situated about 1 mm basal of arculus; anal area with two-three rows of cells; vein CuA strongly bent towards the wing margin and with five posterior branches: three-four rows of cells are present between CuA and the hind margin. Vein MP relatively short and ending on the

8

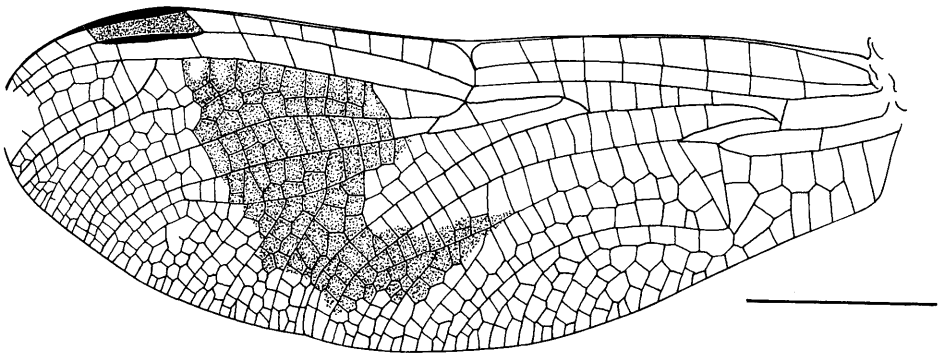

Fig. 8 - *Deielia sarae* n. sp., holotype no. 1293: venation of left forewing. Scale: 5 mm.

posterior wing margin, opposite the level of the nodus. Basal postdiscoidal area with three rows of cells and postdiscoidal field slightly widened distally. Vein Mspl subtending two rows of cells in the median portion; there are three branches of Mspl reaching the wing border. RP3-4 and MA run parallel with one row of cells present in the proximal and median area and two rows, distally. First branching of RP (midfork), situated 3.2 mm basal of the subnodus and origin of IR2 at about 2.5 mm. Vein RP2 aligned with subnodus; one lestine oblique vein "O" between veins RP2 and IR2, situated 0.6 mm distal of the subnodus; only one bridge crossvein basal of the oblique vein; course of vein IR2 straight excluding the distal portion moderately curved; Rspl long, gently arched, ending on vein IR2 and subtending a maximum of two rows of cells; about five secondary longitudinal veins distinctly originating on Rspl and reaching the hind margin.Vein RP2 well undulate: one row of cells in the basal area between RP2 and IR2 and two rows of cells in the median and distal portion. Vein RP1 and RP2 divergent with three single cells basally and two-three rows of cells before the pterostigma; "libellulid oblique vein" (sensu BECHLY, 1996), strongly bent and moderately sinuous.Vein IR1 zigzagged and forked below the distal side of the pterostigma; pseudo-IR1 originates on RP1 beneath the middle of the pterostigma; three rows of cells between RP1 and pseudo-IR1 and about seven cell rows between IR1 and RP2 distally.

Discussion

Within Anisoptera the new species shares synapomorphies with the following taxa introduced by BECHLY (1996): Cavilabiata (distal part of antesubnodal area, free of crossveins); Brachystigmata (pterostigma covering only 1-3 complete cells; pterostigmal brace vein absent; RP3-4 and MA parallel up to the hind margin); Paucipostnodalia (BECHLY, 2002), (basal part of postsubnodal area free of crossveins); Italoansida (forewing discoidal triangle divided into two cells; forewing subdiscoidal triangle three-celled with posterior margin angulated); Anauriculida (a "libellulid oblique vein" present in the basal area between RP1 and RP2; Rspl more or less curved and rejoining IR2, distally; vein Mspl well distinct and ending on MA); Libellulida (primary antenodals indistinct in the forewing; basal area between RA and RP1 unicellular for 2-5 cells); Eulibellulida (sectors of arculus stalked; a concave supplementary sector present between veins RP1 and RP2).
The specimen shows venational characters of the subfamily Sympetrinae (arculus situated between the first and second antenodals; sectors of arculus joined for some distance from origin; costal side of forewing discoidal triangle, narrow) and the wing venation mostly resembles that of the genus *Deielia*. The new species is placed in this genus because of the following features: wing densely reticulated and crossed by a brown band; last antenodal crossvein complete; sectors of arculus rising from a short stalk; discoidal triangle narrow, pointed and two-celled; postdiscoidal field with three rows of cells; vein CuA zigzagged; Rspl subtending two rows of cells; pterostigma elongate, covering more than one cell and with upper and lower margins moderately thickened. *Deielia sarae* n. sp. can be

distinguished from the only extant species, *Deielia phaon* (Selys, 1883), by the shorter and broader forewing, the higher number of cells, the subdiscoidal triangle less elongated towards the wing base and with the posterior margin angulated. Moreover, it differs in the less numerous double cells between RP3-4 and MA distally, the vein MP relatively short and ending opposite the level of the nodus and the brown marking situated between nodus and pterostigma, that does not extend forward to touch the costa and rearward to touch the posterior wing margin. It is interesting to note that most of the venational characters listed above are also present in the genus *Brachythemis* (mainly the wing crossed by a coloured band, the sectors of arculus stalked, the discoidal triangle and the subdiscoidal triangle free or two/three-celled and the vein Rspl subtending two rows of cells), but in the extant species of this genus the last antenodal crossvein is usually incomplete.
At the present day, the genus *Deielia* is represented by a single species limited to specific areas of the Far East: Japan, from Hokkaido to the Ryukyus, Taiwan, Korea, Manchuria and North and South China.The female specimens of *Deielia phaon*, often show pale yellowish body and banded wings: in northern Japan species, crossbands are broad and deeply coloured while in southern areas (Taiwan, Ryukyus and Cina), the wing colour pattern is much degenerated and often absent. The species is usually found in quiet, shallow water environments, where reed maces normally grow.
The discovery of a fossil dragonfly belonging to the genus *Deièlia* in the Monte Castellaro site, indicates that this genus already existed during the Lower Messinian in western Europe and the present distribution in Eastern Asia is probably related to climatic changes occurred during the Pliocene and Pleistocene times.

Subfamily	Pantalinae	Jacobson & Bianchi, 1905
Tribe	Trameini	Tillyard, 1917
Genus	*Trapezostigma*	Hagen, 1849

Trapezostigma barbaresii n. sp. (Fig. 9)

Holotype - Specimen no. 1295, 1295a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy).

Type locality - Monte Castellaro (Pesaro, Marches, Central Italy).

Type horizon - Upper Miocene, Lower Messinian, Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level.

Etymology - This species is dedicated to a friend of ours, Dr. Fabrizio Barbaresi amateur palaeontologist of Rimini.

Diagnosis
The new species is characterized by the following venational characters: wing

venation fairly dense; pterostigma short and pointed distally; discoidal triangle narrow, crossed and bent towards the anal area; postdiscoidal field with five rows of cells; vein Rspl subtending a maximum of four cell rows and vein Mspl a maximum of three rows of cells; vein MP reaches the hind margin before the level of the nodus.

Description

The species is represented by a left, hyaline forewing with the apex and most of the posterior margin missing. Preserved wing length, 43 mm; width at nodus, 8.8 mm; distance from base to nodus, 23 mm; nodus situated at about 50% of the wing length; distance from nodus to pterostigma, 17 mm; distance from base to arculus, 5.4 mm. There are fifteen antenodal crossveins between costal margin and ScP with the first seven crossveins in line with the corresponding crossveins situated beneath them. Only twelve crossveins present between ScP and RA; eleven antesubnodal crossveins with a long "cordulegastrid gap", preserved basal of the subnodus. There are ten postnodal crossveins (the first moderately slanted towards the nodus) between costal margin and RA and nine postsubnodal crossveins between RA and RP1 more or less aligned with the crossveins situated above, except for the last two. A distinct "libellulid gap" is present distal of the subnodus. Pterostigma (length 2.7 mm; width, 0.8 mm) short, brown, moderately thickened on upper and lower margins and with proximal and distal sides not parallel: the distal side is fairly concave and pointed towards the costal margin. Arculus oblique, slightly concave and nearer to the first than to the second antenodal crossvein; sectors of arculus rising from a relatively short stalk situated near the lower part of the arculus. Hypertriangle (length, 6.3 mm; width, 0.5 mm) free of crossveins and strongly elongated with costal side gently curved near the arculus. Discoidal triangle narrow, pointed, oblique in position and four-celled: length of the basal side, 3.3 mm; length of the costal side, 1.2 mm; length of the distal side, 4.1 mm. Subdiscoidal triangle eight-celled and very irregular (strongly zigzagged) on its inner side; pseudo-anal vein PsA, slightly curved only at the distal end. There are ten paranal cells and a

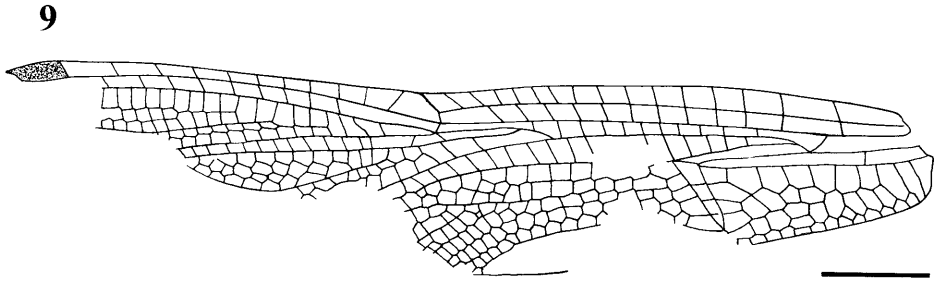

Fig. 9 - *Trapezostigma barbaresii* n. sp., holotype no. 1295: venation of left forewing. Scale: 5 mm.

maximum of four-five rows of cells in the anal area; basal space free; cubital cell with CuP-crossing situated 1.9 mm basal of the arculus. Postdiscoidal area with five rows of cells; Mspl well distinct and subtending three rows of cells in the median part; veins RP3-4 and MA running parallel in the portion preserved, with only one rows of cells between them; distal part of MP zigzagged and ending opposite the level of the nodus. The first branching of RP is situated 5.2 mm basal of the subnodus and the second branching (origin of IR2), at about 3.7 mm. Oblique vein "O" between RP2 and IR2 situated 1mm and one cell distal of the subnodus; only one bridge crossvein strongly bent present below the subnodus; veins RP2 and IR2 parallel sided and with only one row of cells between them; Rspl well arched and subtending a maximum of four rows of cells. Basal area between RP1 and RP2 including four single cells: the second crossvein, is developed as "libellulid oblique vein". The apical planate (vein IR1) is weakly concave and subtends three rows of cells before the pterostigma.

Discussion

The new species shares synapomorphies with the following taxa introduced by BECHLY (1996): Cavilabiata (distal part of antesubnodal area, free of crossveins); Cristotibiata (pterostigma with distal side more oblique than proximal side and with length less than 8 times width); Brachystigmata (pterostigma short and covering only 1-3 complete cells; RP3-4 and RA parallel up to the hind margin); Paucipostnodalia (BECHLY, 2002), (basal part of the postsubnodal area free of crossveins); Neobrachystigmata (posterior part of the arculus shorter than the anterior part); Paneurypalpidomorpha (anterior margin of hypertriangle distinctly convex , vein MA being more or less arched basally; oblique vein "O" situated only 1-2 cells distal of the subnodus); Eurypalpida (forewing pseudo-anal vein PsA, hypertrophied); Anauriculida (vein Rspl curved and rejoining the vein IR2 distally; Mspl well distinct); Libellulida (second crossveins between RP1 and RP2 developed as "libellulid oblique vein"; basal area between RA and RP1 unicellular for 2-5 cells); Eulibellulida (sectors of the arculus stalked; primary antenodal crossveins Ax1 and Ax2, indistinguishable from the secondaries; a supplementary sector present between RP1 and RP2; the most distal antenodal crossvein between costal margin and ScP developed as antenodal oblique vein); Pantalinae (Jacobson & Bianchi, 1905), (Rspl and Mspl similar to a primary longitudinal vein, with 2-3 rows of cells between, in forewings and/or hindwings).

Trapezostigma barbaresii n. sp. belongs to the subfamily Pantalinae and genus *Trapezostigma* (Hagen, 1849), because of the following venational characters: pterostigma with ends not parallell and longer in forewing than in hindwing; numerous antenodal and postnodal crossveins not completely in line with crossveins below them; forewing triangle narrow, elongate and with costal side relatively short; postdiscoidal area generally with four cell rows; Rspl and Mspl subtending two-three rows of cells (the type genus *Tramea* (Hagen, 1861) has to be rejected since junior objective synonym of *Trapezostigma* (Hagen, 1849).

The genus *Trapezostigma* has a relatively poor fossil record up to now: only the species *Trapezostigma miocenica* (Gentilini, 1989) has been previously described from the Upper Miocene of Monte Castellaro and the base of a hindwing is known from the Upper Miocene of Alba (Piedmont, Northern Italy). On the contrary, the fossil genus *Paleotramea* (NEL & PAPAZIAN, 1985), a genus showing a wing venation relatively similar to *Trapezostigma*, is known from the Upper Oligocene of Aix - en Provence and the Oligo - Miocene fossiliferous locality of Bes-Konak (Turkey), where numerous specimens have been found. The new species *Trapezostigma barbaresii* differs from *Trapezostigma miocenica* in the following characters: the first half of the wing is narrower and more densely reticulated; the antenodal crossveins are more numerous (15/12 instead of 12/11), the pterostigma is pointed distally and shorter, the postdiscoidal field has five cell rows instead of four, the vein Mspl subtends three rows of cells instead of two and Rspl four rows of cells, instead of three.
At the present day, species belonging to the genus *Trapezostigma* occur in the Temperate and Torrid zones of the whole earth (NEEDHAM & WESTFALL, 1975).
Five other specimens belonging to the genus *Trapezostigma* have been discovered in the Upper Miocene of the Monte Castellaro locality (Gessoso-solfifera Formation, "Strato degli insetti" level), but the attribution to a species is difficult because the material is too incomplete. A fairly well preserved hindwing is described and figured below. Available material: specimen no.208 (distal half of a right forewing); no.189, 189a (distal half of a hindwing); no.202, 202a (basal half of a right hindwing, brown coloured; this species has been tentatively placed in the genus *Trapezostigma,* but important venational characters of the distal part of the wing are missing and the attribution is problematical); no.1296, 1296a (right hindwing in quite good condition, with wing venation fairly similar to that of the specimen no.1297: the dragonflies might be conspecific); no.1297,1297a (a left hindwing).

Trapezostigma sp. (Species H - Fig. 10)

Material - Specimen no. 1297, 1297a (part and counterpart); coll. Gentilini; Museo del Territorio, Riccione (Rimini, Emilia Romagna, Northern Italy); Gessoso-solfifera Formation, Marne bituminose unit, "Strato degli insetti" level; Upper Miocene (Lower Messinian) of Monte Castellaro (Pesaro, Marches, Central Italy).

Description
The specimen is known from a single left hindwing characterized by three brown spots on the wing base, covering the basal half of the cubital cell, the hypertriangle, the discoidal triangle, the first three cells of the postdiscoidal area and a small portion of the membrane between the fork of Cuspl and some cell rows of the anal field. Hindwing length, 50.4 mm; width at nodus,11.7 mm; distance from base to nodus, 19.7 mm; nodus situated at 39% of the wing length; distance from nodus to

pterostigma, 30.5 mm; distance from base to arculus, 5 mm. There are seven antenodal crossveins between costal margin and ScP, all aligned with the corresponding antenodals situated between ScP and RA. Five antesubnodal crossveins are present between RA and RP/RP1-2, with a relatively long "cordulegastrid gap" basal of the subnodus; eleven postnodal crossveins not in line with the ten corresponding crossveins between veins RA and RP1; a long "libellulid gap" of the postsubnodal crossveins is present distal of the subnodus. Pterostigma (length, 2.8 mm; width, 0.7 mm) short, brown coloured, unbraced and covering one and a half cells. There are five crossveins between the costal margin and vein RA beyond the pterostigma. The arculus is slightly sinuous and in line with the basal side of the triangle; sectors of arculus stalked. Hypertriangle (length 4.1 mm; width, 0.6 mm) free of crossveins and with costal side strongly curved; discoidal triangle free: length of the basal side, 1.5 mm; length of the costal side, 3.9 mm; length of the distal side, 3.4 mm; vein MAb straight. Basal space free, cubital cell with only the CuP-crossing situated about 2.2 mm, basal of the arculus. Anal loop well developed, boot-shaped and including thirty-five cells; vein Cuspl (midrib) forked, strongly angulated and with a toe fairly straight. Anal area greatly expanded with numerous cell rows between the anal loop and the hind, rounded angle of the wing. Vein CuA sigmoidally curved and forked into CuAa and CuAb; one row of cells between veins MP and CuA. Basal postdiscoidal area with three rows of cells and discoidal field strongly widened distally. Mspl well distinct and subtending only one row of cells; distal part of Mspl zigzagged. Veins RP3-4 and MA running parallel with one row of cells between them: distal area between RP3-4 and MA, narrowed; RP3-4 and MA reaching the posterior wing margin, opposite the origin of vein IR1. First branching of RP at 5.8 mm basal of the subnodus; IR2 originates on RP1-2 about below the most distal antesubnodal crossvein; vein RP2 aligned with the subnodus; oblique vein "O" situated between RP2 and IR2, 1.7 mm distal of the subnodus. No extra bridge crossveins between RP1-2 and IR2. Veins RP2 and IR2 parallel with only one row of cells between them; vein Rspl elongate, gently arched, ending on IR2 and subtending a maximum of three cell rows; seven-eight

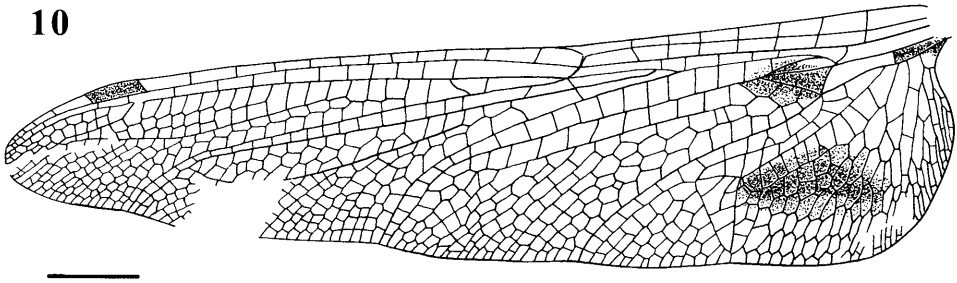

Fig. 10 - Venation of *Trapezostigma* sp. (Species H): left hindwing. Scale: 5 mm.

rows of cells are present between Rspl and the posterior wing margin in the narrowest part. Basal area between RP1 and RP2 with four single cells: the second crossvein, developed as "libellulid oblique vein" is sinuous in shape. Vein IR1 elongate, moderately concave in the median part and subtending three rows of cells before the pterostigma; pseudo-IR1 with origin on RP1 near the proximal end of the pterostigma.

Discussion

The fossil wing described above belongs to the genus *Trapezostigma* because of the following venational characters: hindwing long, pointed, very broad and spotted towards the base; pterostigma relatively short; anal loop elongate, boot-shaped, including numerous cells and with a midrib (vein Cuspl) well angulated; vein CuA sigmoidally curved at base; RP3-4 and MA strongly bent towards the posterior wing margin, distally. Vein IR1 weakly concave: first one row and then two-three rows of cells before the pterostigma between RP1 and IR1; vein Rspl subtending a maximum of three cell rows and rejoining vein IR2 distally.

The base of a hindwing belonging to the genus *Trapezostigma*, figured by CAVALLO & GALLETTI (1987), from the Upper Miocene of Alba (Piedmont, Northern Italy), has been described by NEL & PAICHELER (1993b) in an account of the tribe Trameini. This wing fragment much resembles the hindwing described above, in the venation and even in the position of the three brown spots preserved on the wing base, therefore the two specimens might belong to the same species. Moreover, a new genus and a new species of Pantalinae (*Pisaurum coloratum* Gentilini, 1989), are known from the Upper Miocene of Monte Castellaro. This species is based on a single right hindwing and it is quite distinct from the fossil hindwing of *Trapezostigma* examined above, by the following venational characters: the wing of *Pisaurum* is relatively short and greatly expanded towards the wing base; most of the first half of the wing is brown coloured; there are five antenodal crossveins, ten postnodals and six postsubnodals instead of seven antenodals, eleven postnodals and ten postsubnodals present in *Trapezostigma*. The pterostigma of *Pisaurum* is short, dilated and has the distal side weakly oblique: in *Trapezostigma* the pterostigma is narrow with the distal end well oblique. Moreover, the genus *Pisaurum* differs from *Trapezostigma* in having the anal loop foot-shaped, strongly elongate and entirely developed between the discoidal triangle and the distal half of the cubital cell, instead of an anal loop with a long gaff and the heel cells shifted distal of the discoidal triangle. In *Pisaurum* the vein IR1 subtends only one-two cell rows before the pterostigma, instead of two-three; the vein RP2 is sinuous rather than straight and the vein Rspl is shorter and subtends only one-two rows of cells instead of three.

List of the known fossil Odonata from the Upper Miocene of Monte Castellaro

Currently 225 specimens (135 adults and 90 larvae) in 7 families, 12 genera and 18 species are known from this fossiliferous locality, as follows: four families of Zygoptera with three genera and a new species and three families of Anisoptera with nine genera and seventeen new species.

Suborder Zygoptera
Family Lestidae
Genus *Lestes* (species undetermined): a left wing. Family Lestidae (genus and species undetermined): body and wing remains and a basal right wing fragment (this paper).

Family Coenagrionidae
Genus *Ischnura* (species undetermined): a right forewing. Subfamily Ischnurinae (genus and species undetermined): a left hindwing (this paper).

Family Sieblosiidae
Genus *Italolestes*. *Italolestes stroppai* (Nel, Petrulevièius, Gentilini & Martínez-Delclòs, in press): a complete specimen. *Italolestes* (?) (species undetermined): a wing apex (this paper).

Taxon Calopterygoidea
Family Calopterygidae (?) (genus and species undetermined): the median portion of a wing (this paper).

Suborder Anisoptera
Family Libellulidae
Genus *Sympetrum*. *Sympetrum italicum* (Gentilini, 1989): twelve forewings and ten hindwings. *Sympetrum elongatum* (Gentilini, 1989): fourteen forewings and nine hindwings. *Sympetrum krzeminskii* (Gentilini, 1989): a right forewing. *Sympetrum marinum* (Bagli & Gentilini, 2003): the distal half of a left forewing. *Sympetrum* sp.: four specimens. Libellulidae (genus and species undetermined): twenty eight specimens.
Genus *Deielia*. *Deielia sarae* n. sp. (this paper): a left forewing.
Genus *Celithemis*. *Celithemis zavattinii* (Bagli & Gentilini, 2003): a right hindwing.
Genus *Libellula*. *Libellula mediterranea* (Gentilini, 1989): a right forewing. *Libellula adriatica* (Bagli & Gentilini, 2003): distal half of a left hindwing.
Genus *Pisaurum*. *Pisaurum coloratum* (Gentilini, 1989): a right hindwing.
Genus *Trapezostigma*. *Trapezostigma miocenica* (Gentilini, 1989): a left forewing previously described by the author as *Tramea miocenica* (*Tramea* has to be regarded as junior synonym of *Trapezostigma*). *Trapezostigma barbaresii* n. sp. (this paper). *Trapezostigma* sp.: two forewings and three hindwings (this paper).

Family Corduliidae

Genus *Epitheca*. *Epitheca miocenica* (Gentilini,1992): a right hindwing. *Epitheca annae* (Gentilini, 1992): a left hindwing. Subfamily Corduliinae: a left forewing.

Family Aeshnidae
Genus *Anax*. *Anax cryptus* (Gentilini & Peters, 1993): four forewings and three hindwings. *Anax* cf. *imperator* (Leach, 1815): three forewings, two hindwings and two abdomen remains. *Anax* cf. *parthenope* (Selys, 1839):a left hindwing. *Anax* sp.: seven forewings and three hindwings.
Genus *Aeshna*. *Aeshna messiniana* (Gentilini & Peters, 1993): a right hindwing. *Aeshna ghiandonii* (Gentilini & Peters, 1993): a right hindwing. *Aeshna multicellulata* (Gentilini & Peters, 1993): a left hindwing. *Aeshna* sp.: a left forewing, a wing apex, the basal part of a hindwing and a female abdomen. Family Aeshnidae: a wing fragment and a forewing.
Odonata larvae (family, genus and species undetermined): 90 specimens.

Conclusions

The recent finding of the fossil family Sieblosiidae and the discovery of the genera *Ischnura* and *Lestes* as well as the occurrence of several genera and species of dragonflies, suggest an interesting biodiversity in the Monte Castellaro paleoenvironment, with the presence of four families of Odonata Zygoptera and three families of Odonata Anisoptera at least. Finds of damselflies and dragonflies now living in different habitats (temperate to subtropical or tropical areas) might be related to climatic changes of the Late Miocene in the Mediterranean basin, as suggested also by the lithostratigraphic characters of the Monte Castellaro section and by the fauna and flora found in the bituminous marls of the Gessoso-solfifera Formation. However, there is much to be done and further collecting of fossils as well as studies on other insect orders, which have not yet been investigated, will be necessary for increasing our knowledge of this Messinian environment.

Acknowledgements

We are grateful to Dr. Günter Peters of Berlin and Dr. Syoziro Asahina of Tokyo, for comments on some fossil damselflies and dragonflies. Our sincere thanks to Dr. Günter Bechly of the Staatliches Museum für Naturkunde, Stuttgart, for helpful suggestions and Dr. Daniela Grossi, director of the Museo del Territorio of Riccione, for access to palaeoentomological collections.

References

BAGLI L. & GENTILINI G., 2003 - Nuove libellule fossili del Miocene superiore di Monte Castellaro (Pesaro, Marches, Central Italy) (Odonata Libellulidae). *Quaderno di Studi e Notizie di Storia Naturale della Romagna,* 18: 37-50.

BECHLY G., 1996 - Morphologische Untersuchungen am Flügelgeäder der rezenten Libellen und deren Stammgruppenvertreter (Insecta; Pterygota; Odonata), unter besonderer Berücksichtigung der Phylogenetischen Systematik und der Grundplanes der Odonata. *Petalura*, 2: 1-402.

BECHLY G., 2000 - Phylogenetic Systematics of Odonata. *Website on the Internet*: www. bechly.de/phylosys.htm.

BECHLY G., 2000a - A new fossil damselfly species (Insecta: Odonata: Zygoptera: Coenagrionidae:Ischnurinae) from Dominican amber. *Stuttgarter Beiträge zur Naturkunde, Serie B (Geologie und Paläontologie)*, 299: 1-9.

BECHLY G., 2002 - The first fossil record and first New World record for the dragonfly clade Chlorogomphida (Insecta: Odonata: Anisoptera: Araripechlorogomphidae n. fam.) from the Crato Limestone (Lower Cretaceous, Brazil). *Stuttgarter Beiträge zur Naturkunde Serie B (Geologie und Paläontologie)*, 328: 1-11.

BERTOLANI MARCHETTI D. & MARIOTTI LIPPI M., 1989 - Le Messinien d'Italie du point de vue palynologique. *Bollettino della Società Paleontologica Italiana*, 28 (2-3): 183-188.

CAVALLO O. & GALLETTI A., 1987 - Studi di Carlo Sturani su Odonati e altri insetti fossili del Messiniano albese (Piemonte) con descrizione di *Oryctodiplax gypsorum* n. gen. n. sp. (Odonata Libellulidae). *Bollettino della Società Paleontologica Italiana*, 26 (1-2): 151-176.

ESAKI T. & ASAHINA S., 1957 - On two Tertiary dragonflies species from the Oya-Formation in Kazusa-Nagasaki Prefecture. *Kontyu*, 25: 82-86.

GENTILINI G., 1989 - The Upper Miocene dragonflies of Monte Castellaro (Marches, Central Italy) (Odonata Libellulidae). *Memorie della Società Entomologica Italiana*, 67 (2): 251-271.

GENTILINI G., 1992 - Two new species of *Epitheca* from the Lower Messinian of Central Italy (Odonata Corduliidae). *Bollettino della Società Entomologica Italiana*,123 (3): 201-208.

GENTILINI G. & PETERS G., 1993 - The Upper Miocene aeshnids of Monte Castellaro, Central Italy, and their relationships to extant species (Anisoptera: Aeshnidae). *Odonatologica*, 22 (2): 147-178.

GENTILINI G., 2002 - Fossil damselflies and dragonflies from the Eocene of Monte Bolca, Italy (Insecta: Odonata). *Studi e Ricerche sui Giacimenti Terziari di Bolca, Miscellanea Paleontologica,* 9: 7-22.

HENNIG W., 1966 - Phylogenetic systematics. *University of Illinois Press*, Urbana: 263 pp.

HENNIG W., 1969 - Die Stammesgeschichte der Insekten. *Kramer*, Frankfurt: 436 pp.

NEEDHAM J. G. & WESTFALL M. J., 1975 - A manual of the Dragonflies of North America (Anisoptera) including the Greater Antilles and the Provinces of the Mexican Border. *University of California Press*, Berkeley and Los Angeles: 615 pp.

NEL A. & PAPAZIAN M.,1985 - Une nouvelle espèce d'Odonate fossile du stampien d'Aix-en-Provence (B.d.R.) (Odonata Libellulidae). *L'Entomologiste*, 41 (2) .55-59.

NEL A. & PAPAZIAN M., 1990 - Les Coenagrionoidea fossiles de l'Oligocène du sud-est de la France (Zygoptera: Platycnemididae, Coenagrionidae). *Odonatologica*, 19 (3) : 251-262.

NEL A. & PAICHELER J. C., 1992 - Les Odonata fossiles: état actuel des connaissances. Huitième partie : Les Calopterygoidea fossiles (Odonata, Zygoptera). *Bulletin de la Société entomologique de France,* 97 (4) : 381-396.

NEL A., MARTÍNEZ-DELCLÒS X., PAICHELER J.C. & HENROTAY M., 1993 - Les Anisozygoptera fossiles. Phylogénie et classification. (Odonata). *Martinia*, 3: 1-311.

NEL A. & PAICHELER J. C., 1993a - Les Odonata fossiles: état actuel des connaissances. 7. Les Coenagrionoidea (Odon., Zygoptera). *Entomologica gallica*, 4 (2-3): 59-63.

NEL A. & PAICHELER J.C., 1993b - Les Libellulidae fossiles. Un inventaire critique (Odon., Anisoptera, Libelluloidea). *Entomologica gallica*, 4 (4): 166-190.

NEL A. & PAICHELER J.C., 1994 - Les Lestoidea (Odonata, Zygoptera) fossiles: un inventaire critique. *Annales de Paléontologie (Vert.-Invert.)*, 80 (1):1-59.

NEL A . & BRISAC P., 1994a - Découverte du premier *Calopteryx* fossile du Miocène de l'Ardèche (Odonata, Calopterygidae). *Bulletin de la Société entomologique de France*, 99 (1):27-30.

NEL A., MARTÍNEZ-DELCLÒS X., PAPIER F. & OUDARD J., 1997 - New Tertiary fossil Odonata from France (Sieblosiidae, Lestidae, Coenagrionidae, Megapodagrionidae, Libellulidae). *Deutsch entomologische Zeitschrift*, 44 (2): 231-258.

NEL A., PETRULEVIČIUS J. F., GENTILINI G. & MARTÍNEZ-DELCLÒS X. (in press) – Phylogenetic analysis of the Cenozoic family Sieblosiidae with description of new taxa from Russia, Italy and France (Odonata). *Geobios.*

RIEK E.F. & KUKALOVÁ-PECK J., 1984 - A new interpretation of dragonfly wing venation based upon early Carboniferous fossils from Argentina (Insecta: Odonatoidea) and basic character states in pterygote wings. *Canadian Journal of Zoology*, 62: 1150-1166.

SORBINI L., 1988 - Biogeography and climatology of Pliocene and Messinian fossil fish of Eastern-Central Italy. *Bollettino del Museo Civico di Storia Naturale di Verona*, 14: 1-85.

WILSON M. V. H., 1980 - Eocene lake environments: depth and distance-from-shore variation in fish, insect, and plant assemblages. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 32: 21-44.

Authors' addresses:

Giuseppe Gentilini
via Adriatica, 78 I - 47843 Misano Adriatico (RN)
e-mail: g_gentilini.adsl2003@libero.it

Loris Bagli
Museo del Territorio
via Lazio, 10 I - 47036 Riccione (RN)
e-mail: bagliloris@libero.it