

New paleopteran and polyneopteran insects from the Carboniferous of Northern France

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Two paleopteran and four polyneopteran insects are described from the Moscovian, Pennsylvanian, of coal slag heaps of Avion and Bruay-la-Bussière, Pas-de-Calais, Northern France, namely the spilapterid paleodictyopteran *Spilaptera* sp., Megasecoptera indet., a new caloneurodean *Fusiogramma minuta* gen. et sp. nov., an Archaeorthoptera indet., a new paoliid *Avionpaolia amansfossilia* gen. et sp. nov., and a Paoliida gen. et sp. indet. These new taxa confirm the important paleodiversity of the late Carboniferous insect assemblage from this area. Small insects are especially diverse and abundant in materials from Avion. Unfortunately, these coal slag heaps are now closed. We postulate that more efficient policy of field research should be applied to save the important insect assemblages of the area.

Key words: Megasecoptera, Palaeodictyoptera, Archaeorthoptera, Caloneurodea, Paoliida, Paleoptera, Polyneoptera, diversity, Carboniferous.

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Introduction

The Pennsylvanian (upper Carboniferous) coal slag heaps in the Nord and Pas-de-Calais departments are well known as indicators of the past of coal mining activity in the area. Some are preserved as such, though others are considered as natural biodiversity reserves. But no active scientific research is currently conducted by professional researchers to collect fossil plants and arthropods in these coal heaps. Some are exploited by industry to produce gravel. It is the case of the coal slag heap N°7, close to the town of Avion. Fortunately, a team of amateurs has conducted field and laboratory research in this place for the last 20 years. Their collaboration with our group of professional paleontologists has resulted in an impressive quantity of important discoveries of this Moscovian entomofauna, namely the oldest described Holometabola, Hemiptera, Thripida, Psocodea (Nel et al. 2013), several new families, new genera, and new species (e.g., Prokop et al. 2013, 2014a; Nel et al. 2019, 2020; Schubnel et al. 2019, 2020; Nel and Roques 2021a, b, 2022; Peng et al. 2023).

Unfortunately, this coal slag heap is now closed and it is no longer possible to find fossils. Nevertheless, additional materials are available to study due to the past collection efforts of one of us (PR). Here we describe two new Paleoptera and three new Polyneoptera from Avion and another closed coal slag heap near to Bruay-la-Bussière. These new fossils provide additional evidence of the high insect diversity during the Moscovian, Pennsylvanian, in this area. Unfortunately, some fossils are only partially preserved, a frequent case among Paleozoic insects (Prokop et al. 2023). Thus we refrain from proposing new names for these forms even though they represent most certainly some new taxa.

Nomenclatural acts.—This published work and the nomenclatural acts it contains have been registered in ZooBank: urn:lsid:zoobank.org:pub:B0CE2660-7912-4833-A8BC-8A8CC1228AEA

Institutional abbreviations.—MNHN, Muséum national d'Histoire naturelle, Paris, France.

Other abbreviations.—C, costa; CuA, cubitus anterior; CuP, cubitus posterior; CuPa, anterior branch of CuP; CuPa ante-

rior branch of CuPa; CuPa posterior branch of CuPa; MA, median anterior vein; MP, median posterior vein; RA, radius anterior; RP, radius posterior; ScP, subcosta posterior.

Material and methods

The fossils were collected by one of us (PR) during field works in the coal slag heap N°7, now closed, close to the town of Avion, with the authorization of the society Eiffage Route Nord Est during the twenty last years, and from the coal slag heap N°5bis, near Bruay-la-Bussière, ca. 30 years ago. It is extremely difficult to detect so tiny fossils on the very dark pieces of rock, mixed with numerous plants. Such discoveries are due to the very careful searches by amateur collectors Jacques Oudard, Hervé Duquesne, and Bruno Vallois (France) during the last twenty years. These efforts contribute to the many oldest records of insect orders, new families and genera, especially in the coal heap N°7 of Avion. Unfortunately, this coal heap is now closed and for now unavailable for further prospecting.

The fossils were prepared using a pneumatic needle under a binocular lens. The specimens were photographed with a Canon EOS 6D camera equipped with a Canon MP-E 65 mm f/2.8 1–5× Macro Photo lens. The camera was mounted on a semi-automatic Cognises Rail macro Stack Shot controlled by Helicon Remote software. Photographs were digitally stacked using Helicon Focus 6.7 software, exported in TIF format, cropped and enhanced using Pixelmator Pro 3.3.6 Mosaic software. All measurements were performed with ImageJ software and recorded in millimeters. Drawing lines were made under a camera lucida mounted on a binocular lens Nikon SMZ1500, digitally processed using Pixelmator Pro 3.3.6 Mosaic software.

For the Archaeoptera, we follow the wing venation terminology of Béthoux and Nel (2002) and the classification of Béthoux et al. (2004). For the Palaeodictyoptera and Megasecoptera we follow the general venation terminology of Kukalová-Peck (1991).

Systematic palaeontology

Insecta Linnaeus, 1758

Infraclass Paleoptera Martynov, 1924

Superorder Palaeodictyoptera Grimaldi & Engel, 2005

Order Palaeodictyoptera Goldenberg, 1877

Family Spilapteridae Brongniart, 1893

Genus *Spilaptera* Brongniart, 1885

Type species: Spilaptera packardi Brongniart, 1885; Commentry, France; Gzhelian, Upper Pennsylvanian, Carboniferous.

Spilaptera sp.

Fig. 1.

Material.—MNHN.F.A95110, a forewing obliquely broken into two fragments, with median part partly missing; from coal slag heap N°7, Avion, Pas-de-Calais, France; Moscovian, (Westphalian C/D equivalent to Bolsovian/Asturian), Middle Pennsylvanian, Carboniferous.

Description.—Forewing rather elongate, pointed, broadest in basal third, estimated maximum width ca. 9.0 mm, estimated length ca. 25.5 mm; anterior costal margin weakly serrate, concave in midwing; concave ScP nearly straight, ending in wing apex; costal area basally broad, markedly narrowing in midwing; RA+RP basally connected, convex RA nearly straight, ending in wing apex, RP diverging from RA about 7.5 mm from wing base, distally pectinate, ending with five simple main branches covering wing apex; simple straight or oblique crossveins present in area between RA and RP; division MA and MP ca. 1.0 mm distad of separation RA and RP; convex MA ending with two branches on posterior wing margin; concave MP ending with four branches on wing posterior margin; division of CuA and CuP close to wing base; CuA ending with four branches, concave CuP probably with two or three branches; anal area consisting of six branches.

Remarks.—This fossil is a forewing of Palaeodictyoptera attributable to the Spilapteroidea because the presence of the branched MA and CuA, ScP separated from the radius and ending close to the wing apex and the archeodictyon (dense pattern of crossveins) being absent (Riek 1976; Prokop et al. 2014a). Li et al. (2013) provided a matrix of characters for the separation of families and genera within the Spilapteroidea supporting the placement of the new fossil within Spilapteridae and *Spilaptera* or *Homaloneura* Brongniart, 1885. The fossil is attributable to *Spilaptera* because of: anterior wing margin more or less concave; long oblique sigmoidal crossveins between RA and RP, RP pectinate, with five main posterior branches and area between RA and RP with numerous oblique crossveins; stem of M and MA free from RP; MA and MP ending with long branches; CuA with four terminal branches. *Spilaptera splendens* Prokop et al., 2014a, is already described from Avion. The new fossil differs from this species in the distinctly smaller wing (25.5 mm long vs. ca. 43 mm long), and longer stem of RP, 7.1 mm long vs. 5.6 mm in the type of *S. splendens*.

Spilaptera americana Carpenter & Richardson, 1971, known from Westphalian C/D (Moscovian, Middle Pennsylvanian) of Mazon Creek (Illinois, USA), shares with the new fossil a long stem of RP, but differs from it by the MA having four branches instead of two, and by its longer wing, 38 mm long vs. 25.5 mm (Carpenter and Richardson 1971). *Spilaptera libelluloides* Brongniart, 1885, *S. packardi* Brongniart, 1885, and *S. vetusta* Brongniart, 1885, are all known from the Gzhelian (Stephanian) of Commentry (France). *Spilaptera libelluloides* has CuA with five branches, *S. packardi* also has a MA with four branches, *S. vetusta* and *S. tanaica* Sharov & Sinitshenkova, 1977, from the

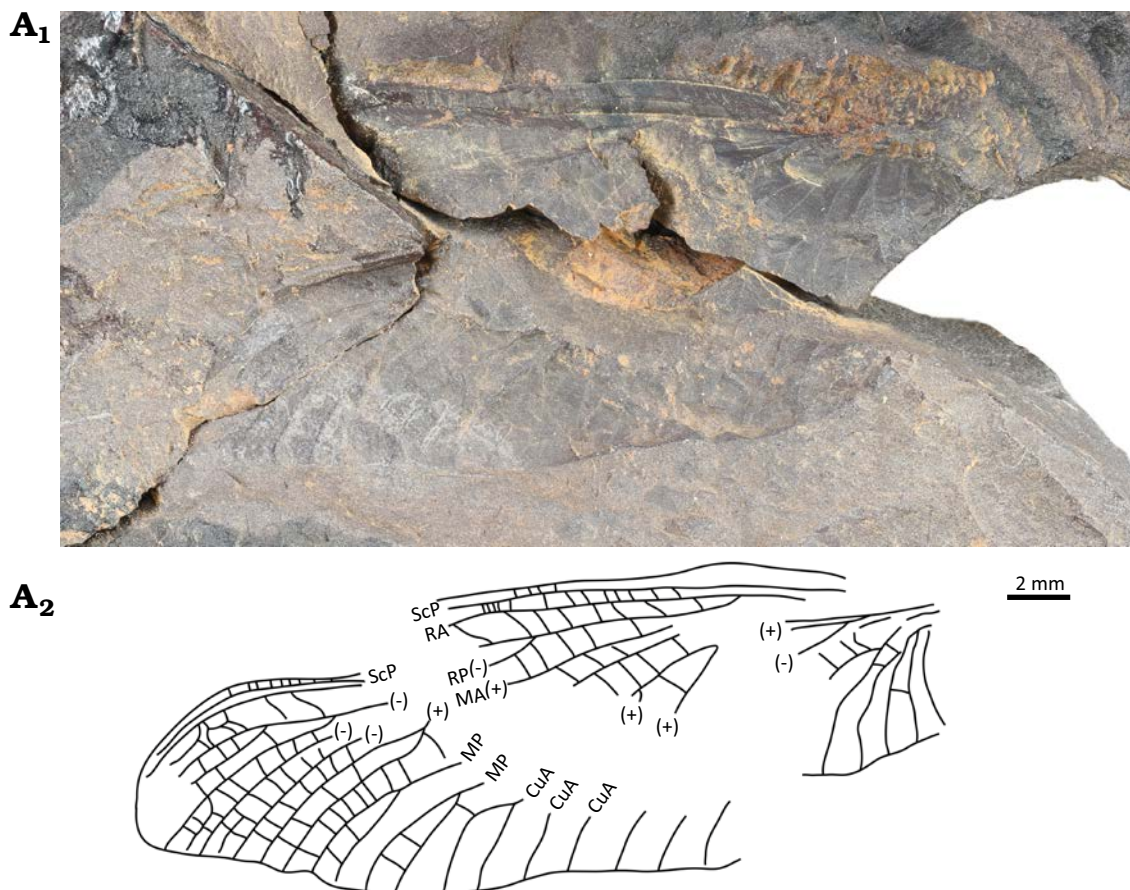


Fig. 1. Spilapterid paleopteran *Spilaptera* sp. (MNHN.F.A95110) from Avion, France; Moscovian, Middle Pennsylvanian, Carboniferous. Photograph (A₁), explanatory drawing (A₂). CuA, cubitus anterior; MA, media anterior; MP, media posterior; RA, radius anterior; RP, radius posterior; ScP, subcosta posterior.

Kasimovian of Lomovatka River, Alymznaya, Ukraine, have no sigmoidal veinlets in area between RA and RP. *Spilaptera peckae* Rosová et al., 2022, from Moscovian of Germany is based on a longer wing than the new fossil (34.5 mm vs. 24.5 mm long) and it has a three-branched MA (Rosová et al. 2022). Lastly, an undescribed *Spilaptera* species from the Moscovian of the Northern France has a wing more than 32.0 mm long (AN unpublished data). The new fossil strongly resembles *S. peckae* except in its smaller size.

Order Megasecoptera Brongniart, 1885

Megasecoptera indet.

Fig. 2.

Material.—MNHN.F.A.95114, distal half of a wing; from coal slag heap N°7, Avion, Pas-de-Calais, France; Moscovian, (Westphalian C/D equivalent to Bolsovian/Asturian), Middle Pennsylvanian, Carboniferous.

Description.—Length of fragment 6.9 mm, probable wing length ca. 14.0 mm; concave ScP ending on costa close to wing apex, 1.4 mm apart; costal area very narrow, without visible crossvein; area between R/RA and ScP 0.4 mm wide, with a series of straight crossveins; convex RA weakly curved, ending near wing apex; base of concave RP 6.0 mm from wing apex; RP posteriorly pectinate, with four simple

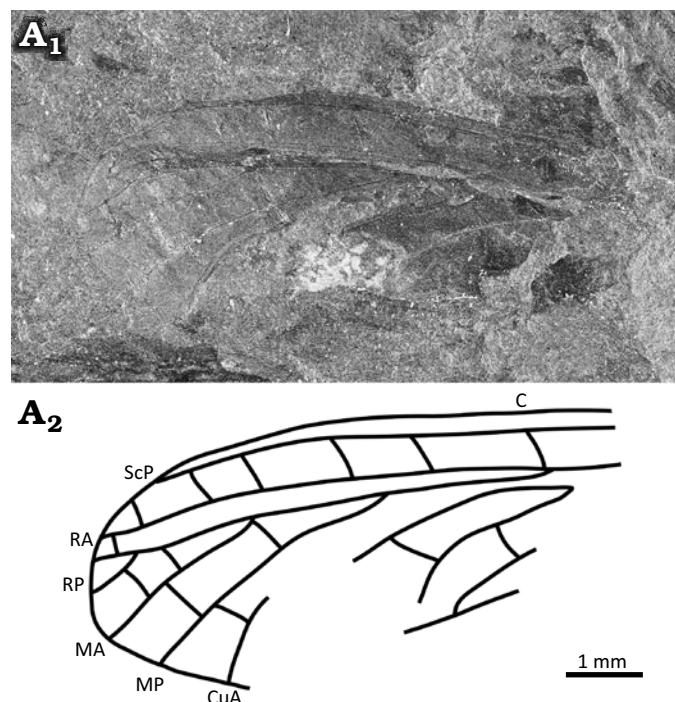


Fig. 2. Paleopteran Megasecoptera indet. (MNHN.F.A95114) from Avion, France; Moscovian, Middle Pennsylvanian, Carboniferous. Photograph (A₁), explanatory drawing (A₂). MA, media anterior; MP, media posterior; RA, radius anterior; RP, radius posterior; ScP, subcosta posterior.

branches and few crossveins in-between; M fork slightly basad base of RP, convex MA simple, curved, strongly approximating RP but not touching it; Concave MP also curved and simple; apex of convex CuA visible.

Remarks.—The pronounced corrugation of the main longitudinal veins, the vein ScP nearly reaching the wing apex, veins ScP and R very close together and usually close to costal margin; the presence of few simple and straight crossveins between the main veins, the vein M simply forked, the veins RP and M strongly approximating near their bases but without any crossveins in-between at this level support an attribution to the Megasecoptera (Santos et al. 2023). The Palaeodictyoptera have much more crossveins and branches of M. The Diaphanopteroidea have a distinct crossvein between RP and MA near base of RP, a shorter ScP, and generally much more branches of RP. This fossil is remarkable in its small size (probable wing length ca. 14.0 mm). Its main interest is that it is the first record of the Megasecoptera from the Moscovian of Avion. Therefore, its incomplete state of preservation prevents us to attribute it to a precise family nor to formally name it.

Infraclass Neoptera Martynov, 1924

Cohort Polyneoptera Martynov, 1924

Superorder Archaeorthoptera Béthoux & Nel, 2002

Order Caloneuroidea Handlirsch, 1937

Family uncertain

Genus *Fusiogramma* nov.

Zoobank LSID: urn:lsid:zoobank.org:act:76FD194F-214E-4A72-BF8A-7487700E0E53

Type species: *Fusiogramma minuta* sp. nov., by monotypy; see below.

Etymology: In reference to the basal fusion of vein MA with RP and the suffix *gramma*, identical, employed for the Caloneuroidea. Gender feminine.

Diagnosis.—As for the type species, by monotypy.

Remarks.—*Fusiogramma* gen. nov. is attributed to Caloneuroidea due to the presence of the following diagnostic characters (Béthoux et al. 2004): fusion of CuP α with MP+CuA as a short anterior branch CuP α between MP+CuA and CuPa, the latter character is typical of the Panorthoptera; a vein MP+CuA+CuP α with at most a short terminal twig; convex vein MP+CuA+CuP α and concave

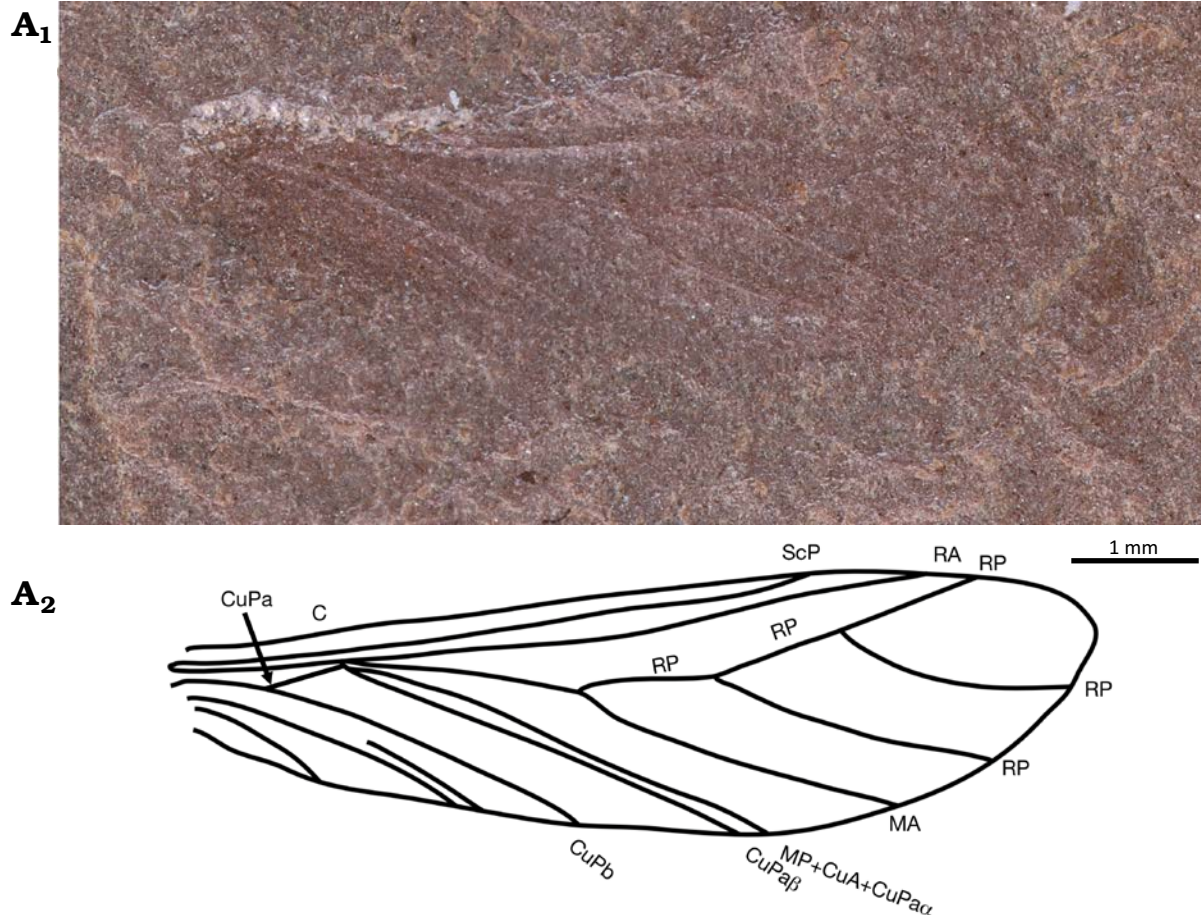


Fig. 3. Caloneurodean nolyneopteran *Fusiogramma minuta* gen. et sp. nov. holotype (MNHN.F.A95115) from Avion, France; Moscovian, Middle Pennsylvanian, Carboniferous. Photograph (A₁), explanatory drawing (A₂). C, costa; CuP β , second branch of anterior branch of cubitus posterior; CuP α , posterior branch of cubitus posterior; MA, media anterior; MP+CuA+CuP α , media posterior + cubitus anterior + first branch of anterior branch of cubitus posterior; RA, radius anterior; RP, radius posterior; ScP, subcosta posterior.

vein CuPa β running close, parallel and straight; MP running fused with CuA+CuPa α ; anal area considerably reduced. Due to the weakness of the current familial classification within the Caloneurodea, we can only compare *Fusiogramma* gen. nov. with the various genera currently attributed to this order (Béthoux et al. 2004).

Fusiogramma gen. nov. differs from *Aviogramma* Prokop et al., 2014a, from the same coal slag heap of Avion in its much smaller size (7.9 mm long vs. 32.0 mm), main stem of RP anteriorly curved vs. nearly straight, and MA basally fused with the stem of RP (Prokop et al. 2014a). The length of its wing is comparable to that of *Oudardgramma* Nel & Roques, 2021a, from the lower Langsettian (Moscovian) of Bruay-en-Artois (also from the Pas-de-Calais), but it differs from MA basally fused with RP vs. only touching it, and the long stem of RP (Nel and Roques 2021a). All the other Caloneurodea strongly differ from *Fusiogramma* gen. nov. in the MA not fused with RP and running separately to wing margin (Béthoux et al. 2004; Loureiro et al. 2010; Garrouste et al. 2018; Huang et al. 2020; Dvořák et al. 2021; Nel and Roques 2021b; Santos et al. 2024). The partial fusion of MA with RP is not sufficient at this stage of knowledge to define a new family because such fusions are frequent in Archaeorthoptera (Sharov 1968; Béthoux and Nel 2002).

Stratigraphic and geographic range.—Moscovian, Northern France.

Fusiogramma minuta sp. nov.

Fig. 3.

Zoobank LSID: urn:lsid:zoobank.org:act:55B8A246-4E60-4D41-9AE7-D1E713677BA1

Etymology: Named after the minute size of the species.

Holotype: MNHN.F.A.95115, part of a nearly complete wing, with only extreme base missing

Type locality: Coal heap N°7, Avion, Pas-de-Calais, France.

Type horizon: Moscovian (Westphalian C/D equivalent to Bolssovian/Asturian), Middle Pennsylvanian, Carboniferous.

Diagnosis.—Wing characters only. Vein MA basally fused with RP and re-emerging distally as a simple vein; stem of RP anteriorly curved; only three branches of RP.

Description.—Wing 7.9 mm long, 2.2 mm wide; costal area very narrow; ScP and R/RA straight and closely parallel; ScP ending on costa 5.4 mm from wing base; RA ending 1.2 mm distally; RP and M+CuA separating from R at the same point, 1.5 mm from wing base; vein MA not separated from RP and re-emerging from RP+MA 1.9 mm distally; MA simple; RP with three simple branches; area between RA and RP broad, 0.5 mm wide; anterior-most branch of RP ending on costa close to apex of RA; main stem of RP anteriorly curved; convex MP+CuA+CuPa α closely parallel to concave CuPa β , both straight; CuPb weakly curved; two veins in area posterior to CuPb.

Stratigraphic and geographic range.—Moscovian, Northern France.

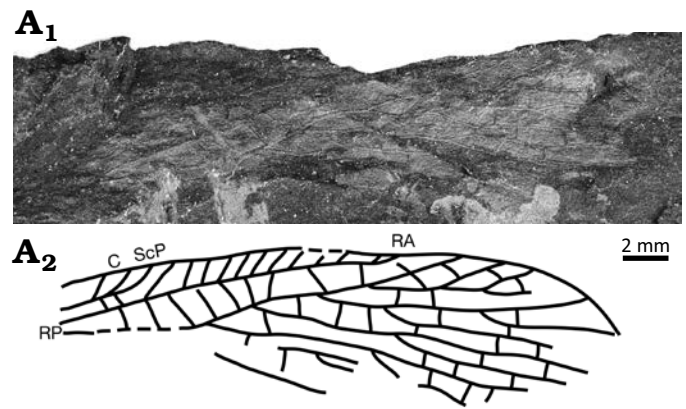


Fig. 4. Polyneopteran Archaeorthoptera indet. (MNHN.F.A.95113) from Bruay-la-Bussière, France; Bashkirian, Lower Pennsylvanian, Carboniferous. Photograph (A₁), explanatory drawing (A₂). C, costa; RA, radius anterior; RP, radius posterior; ScP, subcosta posterior.

Archaeorthoptera indet.

Fig. 4.

Material.—MNHN.F.A.95113, a well preserved costo-apical part of a wing, from coal slag heap N°5bis, “Faisceau de Modeste”, “Veine Maroc” (Corsin 1932), Bruay-la-Bussière, Pas-de-Calais, France; Vicoigne Series, lower Langsettian (= lower Westphalian A, Bashkirian), Lower Pennsylvanian, Carboniferous.

Description.—Fragment 12.2 mm long, 3.4 mm wide; wing apex rounded; ScP straight, rather short, ending in C well basad wing apex, 10.3 mm apart, at least three simple veinlets between C and ScP; RA and RP separating 12.2 mm from wing apex; RA weakly curved, ending into C 5.2 mm from wing apex; a series of 11 simple, oblique and short veinlets in area between C and RA; area between RA and RP rather broad, 0.8 mm wide, with 10 long and simple veinlets in-between; RP posteriorly pectinate, with four main branches, anterior-most one being anteriorly pectinate, other branches forked one or two times; RP covering all apical part of wing; a fragment of median vein preserved; CuA and CuP missing.

Remarks.—Although incomplete, this wing fits well into the Archaeorthoptera in the presence of a posteriorly pectinate RP, presence of numerous veinlets between C and RA and between C and ScP, numerous straight crossveins between branches of main veins and a rather pronounced corrugation of the main veins. This fossil is remarkable for the rather short RA ending into C well basad wing apex, branches of RP covering all apical part of wing, and short ScP. Unfortunately it is too incomplete to determine its exact affinities in the Archaeorthoptera as the veins CuA and CuP are missing. Nevertheless it corresponds to a taxon different from all the Archaeorthoptera already described from Bruay-la-Bussière and Avion.

Order Paoliida Handlirsch, 1906

Family Paoliidae Handlirsch, 1906

Genus *Avionpaolia* nov.

Zoobank LSID: urn:lsid:zoobank.org:act:D0742810-EE81-44B0-95ED-62E9221B7708

Type species: *Avionpaolia amansfossilia* sp. nov., by monotypy; see below.

Etymology: After the outcrop of Avion and the genus name *Paolia*. Gender feminine.

Diagnosis.—As for the type species, by monotypy.

Remarks.—This wing is attributable to the order Paoliida because it shows the diagnostic characters (Prokop et al. 2014b): crossveins simple or reticulate often forming a net of irregular cells; concave ScP ending in C or RA in distal half of wing; strongly convex RA simple or with weak, short but distinct anterior branches, unusually prominent steep elevation from ScP to RA forming a characteristic wing profile; costal area between ScP and costal margin with series of rather irregular, simple or branching, sigmoidal or oblique veinlets; RP rather concave with numerous branches; M rather concave; convex CuA and concave CuP separating from a basal stem Cu; CuA not in contact with stem R+M; a short, more or less distinct, but generally relatively convex arcus brace (crossvein) between M and CuA; area between CuP and CuA broad compared to the median and radial areas (autapomorphy), a general course of CuA making a double curve (autapomorphy); CuA has convex posterior branches, more or less developed (depending on the species), plus some weaker concave anterior branches (synapo-

morphy with Dictyoptera, see below); CuP simple or with a short terminal twig, straight or more or less sigmoidal, not posteriorly curved; anal fan strongly reduced on both wing pairs. Furthermore the extremely broad area between CuA and CuP, much broader than the other areas in the wing, and with distinct veinlets, and RP with only four-five branches are typical of the Paoliidae. “*Paolia* sp.” is already known from the same outcrop of Avion (Prokop et al. 2014a), but the new fossil differs from it in the presence of regular simple crossveins in subcostal area, the much longer stem of M and base of RP much distad base of M. Indeed, these three characters allow to differentiate the new fossil from all the other Paoliidae in which the base of RP is closer to the base of M and to the “arcus” and/or first fork of M basad the base of RP (Prokop et al. 2014b; Rasnitsyn and Aristov 2016; Poschmann and Nel 2020, Nel and Poschmann 2021; Santos et al. 2023).

Stratigraphic and geographic range.—Moscovian, Northern France.

Avionpaolia amansfossilia sp. nov.

Fig. 5.

Zoobank LSID: urn:lsid:zoobank.org:act:2643E738-0AAF-4154-86D0-A9155659238B

Etymology: From Latin *amans fossilia*, those who love fossils; named in recognition of the tremendous work done by the team of amateurs on the slag heaps of Northern France.

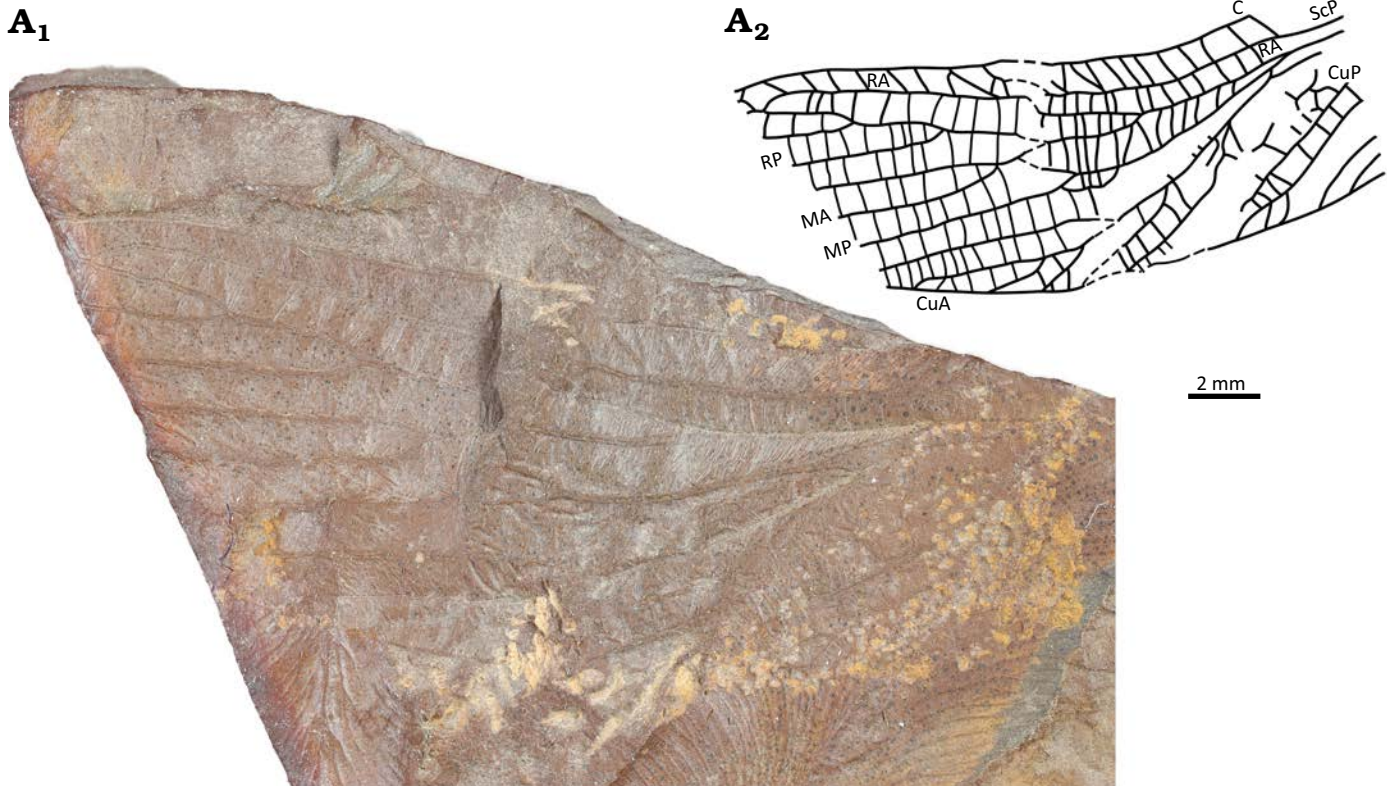


Fig. 5. Paoliid polyneopteran *Avionpaolia amansfossilia* gen. et sp. nov. holotype (MNHN.F.A95111) from Avion, Pas-de-Calais, France; Moscovian, Middle Pennsylvanian, Carboniferous. Photograph (A₁), explanatory drawing (A₂). C, costa; CuA, cubitus anterior; CuP, cubitus posterior; MA, media anterior; MP, media posterior; RA, radius anterior; RP, radius posterior; ScP, subcosta posterior.

Holotype: MNHN.F.A.95111, median part of a wing with apex and base missing.

Type locality: Coal heap N°7, Avion, Pas-de-Calais, France.

Type horizon: Moscovian (Westphalian C/D equivalent to Bolsovian/Asturian), Middle Pennsylvanian, Carboniferous.

Diagnosis.—Wing characters only. ScP rather short; presence of regular simple crossveins in subcostal area; base of RP well distad that of M; fork of M distad base of RP; stem of M very long; CuA nearly straight, with one anterior and six posterior branches.

Description.—Preserved part of wing 20.0 mm long, wing probably ca. 35.0 mm long, 7.0 mm wide; costal area 1.0 mm wide, with a series of simple oblique veinlets; ScP nearly straight, ending in costa well basad wing apex; area between ScP and RA 0.8 mm wide, with regular simple crossveins; RA nearly straight and curved at apex, emitting a series of simple veinlets towards C and apically fused with RP; base of RP very far distad base of M, 4.5 mm apart; RP with four branches, all simple in preserved part; MA directed towards RP and shortly fused with it, separating again distally, and simple in preserved part; stem of M 7.4 mm long, very long before fork into MA and MP; MP simple in preserved part; areas between RP and

M and between M and CuA broad, but distinctly less than between CuA and CuP; a basal oblique crossvein between M and CuA “arculus” situated near base of M from R, base of CuA not preserved, but this vein clearly not basally fused with R or M and coming from a common stem with CuP; CuA nearly straight, with six simple posterior branches and a distal anterior branch; area between CuA and CuP very broad, 2.0 mm wide, with an irregular net of large cells in between; CuP nearly straight, but with distal part not preserved; three long straight and parallel veins and a net of cells in cubito-anal area.

Remarks.—This fossil is probably a forewing because of the rather narrow cubito-anal area and general shape of the wing not triangular.

Stratigraphic and geographic range.—Moscovian, Northern France.

Paoliidae gen. et sp. indet.

Fig. 6.

Material.—MNHN.F.A.95112, distal two-third of a wing overlapping the apex of a second wing, from coal slag heap N°7, Avion, Pas-de-Calais, France; Moscovian (Westpha-

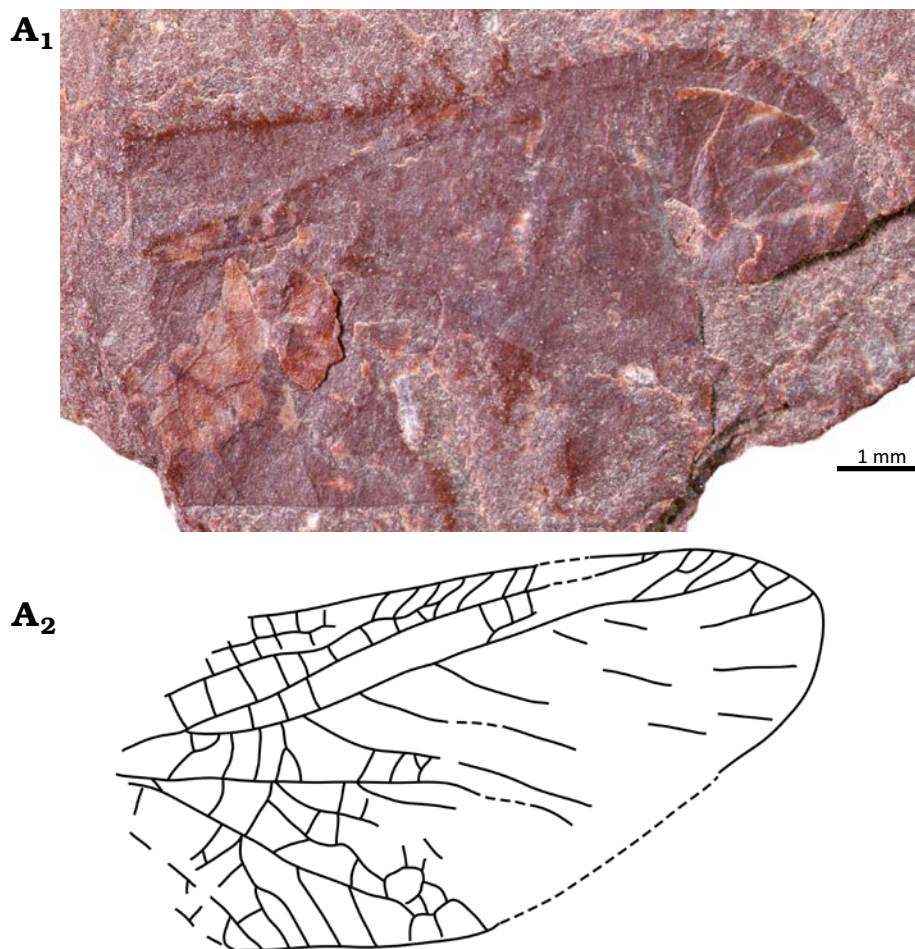


Fig. 6. Paoliid polyneopteran Paoliidae gen. et sp. indet. (MNHN.F.A.95112) from Avion, France; Moscovian, Middle Pennsylvanian, Carboniferous. Photograph (A₁), explanatory drawing (A₂).

lian C/D equivalent to Bolsovian/Asturian), Middle Pennsylvanian, Carboniferous.

Description.—No trace of coloration; preserved part of wing 9.7 mm long, wing 4.9 mm wide; an irregular net of cells all over wing; three rows of cells between C and ScP and two longitudinal intercalary veins in-between; apex of ScP 9.7 mm of wing apex; R/RA nearly straight; base of RP 8.7 mm of wing apex; apex of RA 2.2 mm of wing apex; RP covering a large area and emitting at least six posterior branches; stem of M rather straight, with two posterior branches; a broad area between M and CuA; an “arculus” between M and CuA, slightly basad base of RP; CuA weakly undulate; a broad area between CuA and CuP with three posterior branches of CuA, but no distinct anterior branch; CuP poorly preserved but apparently straight; a vein posterior to CuA partly preserved.

Remarks.—This fossil is more poorly preserved than the other Paoliidae studied herein, but it is probably also a forewing because of its general shape. The very broad area between CuA and CuP, presence of several posterior branches of CuA, basal separation of M from CuA, with an “arculus” in-between, presence of anterior short veinlets between C and RA near its apex and the rather irregular reticulation suggest an attribution to the Paoliidae. It is quite different from *Avionpaolia amansfossilia* gen. et sp. nov. in the much broader area between CuA and M, but it is hardly comparable to the “*Paolia* sp.” already known from the same coal slag heap of Avion.

Concluding remarks

The descriptions of the first French specimen of *Spilaptera* sp., of an undetermined but new megasecopteran, an undetermined but new archaeorthopteran, of the new caloneurodean genus and species *Fusiogramma minuta*, and of the new paoliid genus and species *Avionpaolia amansfossilia*, confirm the high diversity of the insect fauna during the Moscovian in Northern France. These new insect taxa recovered in this area are generally small to very small (wing lengths ca. 1–2 cm). The late Carboniferous is crucial to study the diversification of insects and the example of Avion outcrop emphasize that our knowledge of the early diversification of insects is still incomplete and requires further intensive fieldwork.

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