

VI. *An Inquiry into the Zoölogical Relations of the first discovered traces of Fossil Neuropterous Insects in North America; with Remarks on the difference of structure on the Wings of living Neuroptera.* By SAMUEL H. SCUDDER.

Read January 18, 1865.

IN the January number of Silliman's "American Journal of Science" for 1864, (vol. xxxvii., page 34,) Prof. J. D. Dana announced the discovery for the first time in North America of the fossil remains of Neuropterous insects. They were found in flattened iron-stone concretions, which occurred in the carboniferous beds at Morris, Illinois, in company with various coal-plants and amphipod crustaceans. Two specimens only had fallen under his observation, which, in the Journal referred to, in an article entitled "On Fossil Insects from the Carboniferous Formation in Illinois," he has figured upon wood and briefly described under the names of *Miamia Bronsoni*, and *Hemeristia occidentalis*, the former after the name of the original discoverer of these important remains.

Through the repeated courtesy of Professor Dana, I have been permitted as long an examination as I desired of these interesting fossils, the results of which, and the comparisons I have incidentally instituted with allied groups of living insects,<sup>1</sup> I have now the honor to lay before the Society.

The specimens imbedded in these stones exhibit the insects in the natural attitude of repose, which, as in many other Neuroptera, is with the wings overlapping one another above the abdomen; in those Neuroptera which close their wings in this manner the right upper wing overlaps the left upper wing (or the left overlaps the right), while that again overlaps the right under wing, and this the left under wing; the result is that in certain places we have actually in a cross-section four thicknesses of wing with their accompanying nervures, which last, if of sufficient thickness and strength to give an impression through these four thicknesses, when compressed between layers of mud, would in a case like that of *Hemeristia*, where the cross-veins are quite heavy and numerous, present an almost inextricable network of veins, and render it a very difficult task to determine the neuration of any one of them. In *Miamia* the nervures are feeble, though the wing-tissue is apparently correspondingly delicate; and the wings not overlapping one another so completely as in *Hemeristia*, it is not so difficult a task to determine to which wing different nervures belong; yet were it not for the general similarity of the neuration in the upper and under wings in this sub-order, it would even here be a perplexing matter. In *Miamia* the abdomen is preserved, and the nervures crossing it leave no room for doubt that the insect is viewed from above; but in the specimen of *Hemeristia* we have the additional disadvantage that we cannot tell which surface we view otherwise than by the structure and relations of the wings themselves, which besides are but fragmentary, and exhibit in continuity but a small portion of the outer margin of a single wing and the inner border of none at all, the base and apex also being absent. We have then in *Hemeristia* — given the central portion only of four wings, completely overlapping one another, unusually charged with cross-veins reuniting the branches in every part, with no external means of deciding whether the upper or under surface is presented to the eye, to determine what is the exact structure of each wing.

<sup>1</sup> I would here express my obligations to my friend Mr. P. R. Uhler, for the kindness with which he has permitted me to use freely his extensive and varied collection of Neuroptera, containing many forms otherwise quite unknown to me.

Looking at the right side as being in this case more complete, and following the course of the vein which appears at the margin next the base, we see that at a little distance out it sends forth a prominent branch which has a peculiar curve. Now as we know that among Neuroptera neither the *vena marginalis*<sup>1</sup> or *mediastina* sends off branches in this way, we necessarily conclude that this cannot be either of those veins; and as it is quite what we might expect in the *v. scapularis* and is just so important a vein as that is, and as at one side we find two veins outside of this running parallel to one another and to this, closely connected by and frequently charged with cross-veins, which in this part of the wing is often characteristic of the *v. marginalis* and *mediastina*, we conclude that these three veins belong to one and the same wing, and are those of the outer margin. Glancing at the opposite side we see the same peculiar curved vein, which here also is quite prominent, though there are no veins outside of it, and we naturally conclude that this belongs to the corresponding wing on the other side, the outer veins of which have been destroyed. We may notice next that on the right side between the peculiar curved branch and the vein from which it springs there lies a vein running midway between the two and apparently connected with either by frequent cross-veins, which being quite an anomalous feature among Neuroptera, if our previous views were right, excites our suspicions; but knowing that it would be quite as great an anomaly were there to be four parallel veins along the costal-border thickly beset with cross-veins and similar in every respect, we look more closely to see if these may not belong to another wing, either above or below that to which the curved branch belongs. We notice, in confirmation of this supposition, that on the left side this dividing vein does not run midway, but considerably at one side; and observing the right side more carefully, we see that the cross-veins between the *v. scapularis* and its branch override the vein which runs midway between these two, which has also itself separate and less distinct cross-veins, connecting it with a vein which must be directly beneath the *v. scapularis*; and we therefore conclude, that the space thus covered by these less prominent cross-veins must be either the *area marginalis* or *scapularis* of the wing lying beneath; to determine which of these it is, we look for the homologue of the peculiar curved branch and find it taking its rise from this vein at a point similar in position to what we found in the wing above, and less conspicuous than there, not only as it naturally would be from lying beneath but proportionally less so, as is also the *v. scapularis* of the lower, as compared with that of the upper, wing. The area referred to is then the *area scapularis*, corresponding to the inner of the two narrow ones which lie outside the *v. scapularis* of the wing above. Now, as in Neuroptera, not to speak of other insects, the anterior half of the wing is more specialized, and contains stronger veins in the anterior wing than the corresponding portion of the posterior wing, which in its turn is generally more specialized in its posterior half, we conclude from the prominence of the *v. scapularis*, and its branch and cross-nervures in the wing which lie above, that they belong to the anterior wing, and that we view the insect from above. In very strong confirmation of this view is the fact that the *v. scapularis* of the wing above lies outside of, and yet parallel to, the *v. scapularis* of the wing below, proving, beyond a doubt, that the upper is the anterior wing; for the *v. scapularis* of the posterior wing could not lie outside of that of the anterior in any part of its course without crossing it or at least being divergent from it.

Pursuing, then, the same method of inquiry in regard to the other principal veins,

<sup>1</sup> See note 3 on p. 175, where these names are explained.

we discover that those of the right anterior wing cut across the principal veins on the left side which correspond to those of the right anterior wing, and therefore that the right wing overlaps the left. The position of each of the wings being then satisfactorily made out, it requires only patient examination and studied comparisons to determine of every one of the principal veins, or even detached<sup>1</sup> branches and cross-veins, to which of the four wings it belongs;<sup>2</sup> and being able thus to delineate the remnants of each of the four wings, and making up from one, so far as is proper, the deficiencies of another, and carrying our point somewhat farther into what is partly conjectural, but guided principally by our knowledge of the relations of this insect to the Neuroptera in general, we are able to reconstruct, more or less accurately, the complete structure of all the wings of this insect as partially figured in our plate.

But this is only one step; it is indeed but the starting-point. We have now merely a basis, but a firm one, upon which to stand in making our most essential inquiry as to the relation of these ancient types to the other members of the sub-order to which we saw at first they were allied. We need to investigate something of their more intimate relationship, and to know how much kinship these forms, which flitted through the oozy marshes of the carboniferous forests, had with the living realities of our own day.

To determine this point we have in the Hemeristia only the wings to guide us (except a fragment of a leg which is here of but little value), and must therefore inquire whether the different families of Neuroptera have anything in the structure of these parts which shall enable us by their aid alone to distinguish them from one another, and to determine of any wing-form presented to our eye, to which of these groups it belongs. If we can do so, we can ask of course, in reference to the fragments in question, whether they belong to any one of the hitherto described family groups, and to which,—or whether they must form another akin to them, but belonging to the same sub-order of Neuroptera. Inquiries made with a view to determine this point have convinced me that this is quite possible, and I have therefore embodied the results of my inquiry in the following statement of the distinction in wing-neruration among the families of Neuroptera.<sup>3</sup>

#### TERMITINA.

The *v. marginalis* and *mediastina* run parallel to the very tip of the wing and in close junction, apparently with no connection between them; the *v. scapularis* also runs parallel to the *v. mediastina*, though a little more distant from it, and is sometimes connected with it irregularly by many cross-veins, directed from the *v. scapularis* upwards and outwards; generally it forks beyond the middle though sometimes close to the base. The *v. externo-media*

<sup>1</sup> Detached by the incompleteness of preservation, for there appear to be none independent.

<sup>2</sup> It was only at the very last moment of examination that I discovered also the remnants of the *v. marginalis* and *mediastina* separated from the basal portion of the right anterior wing, but otherwise unbroken, lying entirely removed from the wing; and what is rather remarkable, an exactly similar fragment of the left anterior wing also entirely detached and lying at right angles to it; at the outer extremities of the first we can see faint indications of fragments of a femur and tibia at their union, which correspond pretty well, so far as can be determined, with what we find in *Miamia*.

<sup>3</sup> I have made use here of the terminology employed by Heer, in his memoirs on the fossil insects of (Euingen, etc., as

being more true than any other known to me, though I am not quite sure that the names are fitly chosen, to suit the homologies of wings of insects in general. He enumerates six under the following names: the first, counting from the upper border, the *vena marginalis*; second, *vena mediastina*; third, *vena scapularis*; fourth, *vena externo-media*; fifth, *vena interno-media*; sixth, *vena analis*. The spaces between the margin and the *vena marginalis* he denominates *area extra-marginalis*; that between the first and second veins, *area marginalis*; between the second and third, *area scapularis*; between the third and fourth, *area externo-media*; between the fourth and fifth, *area interno-media*; between the fifth and sixth, *area analis*; and that between the *vena analis* and the hind-border the *area externo-analis*.

is as distant from the *v. scapularis* as that is from the *v. mediastina*, and runs parallel to it, sending out many branches downwards and outwards, which fork indefinitely, the forks being never united by cross-veins; these fill up the remainder of the wing. The *area externo-media* is occupied by an independent vein, which is connected with the veins on either side by irregular cross-veins; both wings are alike. This is substantially the same account as is given of them by Heer, only that he considers what I have called the *v. mediastina* as the *scapularis*, the *v. scapularis* as the *externo-media*, and the *v. externo-media* as the *interno-media*, in which he may be correct.

#### EMBIDINA.

In the *Embidina* the *v. marginalis* forms the anterior margin. The *v. mediastina* runs parallel and near to it till quite near the tip, when it is deflected downward and terminates at the *v. scapularis*, which in like manner, running parallel to the *v. mediastina*, turns abruptly downwards just at or beyond where the *v. mediastina* strikes it, and strikes the upper branch of the *v. externo-media*. The *v. externo-media* forks at a distance of one third or more from its origin to the tip of the wing, the upper branch running parallel to the *v. scapularis* till it strikes it, and then continues on in the same course to the tip; the lower fork is generally dichotomous. The *v. interno-media* is a simple vein running in quite a direct course to the margin; the *v. analis* is sometimes forked at the base, in which case the lower branch forms the hind margin of the wing, and the upper is generally simple and straight; cross-veins, very few in number, connect the *v. externo-media* with the *interno-media*, the branches of the *v. externo-media* with one another, the *v. externo-media* with the *scapularis*, and are found in the *area marginalis*.

#### PSOCINA.

*Vena marginalis* continuous; *v. mediastina* in the upper wing broken, in the under wing reaching the *v. marginalis*, a short distance from the base; *v. scapularis* occupying the greater part of the wing, being the only forked vein in the wing; near the base it sends out a branch abruptly downwards, which immediately turns and runs parallel to the main stem; the main stem, running in a straight course, reaches the margin beyond the middle, then deflects from it, and either strikes one of the branches of the other portion of the vein, or just before reaching it again turns abruptly upwards and strikes the margin; the main branch, running parallel to the main stem, sends out a branch at a wide angle just before the middle of the wing, which running in a straight line strikes the lower margin near the middle. Just below where the main stem reaches the upper margin, the main branch sends out another branch sub-parallel to the first, but sinuous, from which more than half way to the margin a widely spreading fork proceeds, the upper branch again and again forking widely. The main branch just beyond the origin of this second branch is itself deflected suddenly and sinuously downwards, running sub-parallel to the upper forks of the second branch, till it reaches the margin at the apex of the wing, but from the middle of its downward curve sending off a branch at right angles which forks and fills the space between the termination of the main stem and the main branch of this *v. scapularis*; at the middle of the wing a stout cross-vein unites the main branch and stem, and this is the only cross-vein in the wing. The *v. externo-media*, curving slightly with a convexity toward the apex of the wing, strikes the lower margin just behind the first branch of the main branch of the previous vein. The *v. interno-media* is but little separated from the *v. analis*, which simply forms

the lower margin of the wing. In the under wing the variation is so great from this that the main branch of the *v. scapularis* separates as a widely branching fork from the main stem some little distance from the base, and continues straight on to the margin as the first branch did in the upper wing, the main branch being then a fork from this straight one, and branching as the main one did in the upper wing, except that it wants altogether the second branch.

#### PERLINA.

The *v. mediastina* runs parallel and pretty near to the *v. marginalis* until somewhat beyond the middle of the wing, when it turns suddenly at right angles and strikes the *v. scapularis*, which has been running nearly parallel to it, though at a less distance from it, than the *v. marginalis*. The *v. scapularis* continues on parallel to the *v. marginalis*, and runs into it a little before it reaches the tip of the wing. The *area marginalis* is traversed by frequent cross-veins; the *area scapularis* has none. The *v. scapularis* gives off a branch generally half way between the base and where the *v. mediastina* strikes it, which running sub-parallel to the main stem terminates at about the tip of the wing, crossed at some point in its course by another vein from the *v. scapularis* which generally (exc. *Teniopterix*, etc.) continues on and connects with the upper branch of the *v. externo-media*; the branch of the *v. scapularis* then divides into many branches, which are sometimes simple, sometimes again forked, and sometimes have, in connection with the branches of the *v. externo-media*, recurrent forks.<sup>1</sup> The *v. externo-media* runs in very close proximity to the *v. scapularis* a little distance, and then runs parallel to the branch, until it approaches the cross-vein from the *v. scapularis*, when it forks, the forks sometimes again re-forking. The *v. interno-media* has a very indistinct attachment at the base, being seen only from the under side, — is distant from the *v. externo-media*, — has a considerable curve at its commencement, and very soon forks, the upper fork running distant from, but nearly parallel to, the *v. externo-media*, gradually separating from it until near the forking of the latter, when it curves towards it and unites to its lower branch; it sends off rather distant cross-veins to its own lower branch, and beyond emits many branches to the margin. The *area interno-media* is traversed sparingly by cross-veins, sometimes in the fore wing only. The lower branch of the *v. interno-media* is simple, and diverges from the upper branch as that from the *v. externo-media*. The *v. analis* is stout and forks at its origin; the space between the forks enclosed near to the base by a thick cross-vein which extends to the internal margin, and from mid-way between the forks sends out a branch which runs between them, any or all of which branches and forks may branch again, which they do to considerable extent in the hind wing, where also there are more branches from the cross-veins.

#### EPHEMERINA.

*Fore Wing.* The *v. mediastina* runs near, and parallel to, the *v. marginalis*, extending to the tip of the wing. The *v. scapularis* bears the same relation to the *v. mediastina*. The *v. externo-media* runs parallel to the *v. scapularis* for a short distance, and is at the same distance from it as that is from the *v. mediastina*; close to the base it sends out a branch, which forks when it has reached two thirds of the distance to the margin, the lower branch striking the outer margin at about the middle; at less than one third the distance to the tip of the wing the vein forks, the upper fork remaining parallel to the *v. scapularis*, while

<sup>1</sup> But in *Capnia* we have a very remarkable difference in that the main branch of the *v. scapularis* has its origin beyond the cross-vein from the *v. scapularis* to the *v. externo-media*.

the lower branch diverges rather widely from it, the space between being divided into equal distances by several independent veins. The *v. interno-media* starts from the same point as the former, and is simple. The *v. analis* is widely separated at the base from the previous, is much curved, first upwards and then downwards, and sends out several branches which curve as they are directed towards the margin. The veins and their branches are traversed everywhere by rather frequent cross-veins, but the wing is nowhere reticulated except slightly around the margin.

*Hind Wing.* Either the *v. mediastina* or *scapularis* is wanting, very probably the latter, as the *area externo-media* is very wide. The branching of the *v. externo-media* is nearer the base than in the fore wing; the *v. interno-media* is apparently wanting, and the *v. analis* is more uniformly curved.

#### ODONATA.

Quite a characteristic feature of this group is that the *v. marginalis* extends but half way along the margin, and terminates abruptly; and that the *v. mediastina* runs nearly parallel to it, with a distinct space between them; when it reaches the point where the *v. marginalis* terminates it turns abruptly upwards, forming the "nodus," and protects the rest of the margin. The *v. scapularis* runs parallel to the *v. mediastina* as far as the nodus, is there connected by a strong cross-vein to the *v. mediastina*, and then continues on in a direct line to the tip of the wing. At a short distance from the origin this vein sends down a short abrupt branch, which meets a similar branch directed upwards from the *v. externo-media*; from the cross-vein thus formed, two veins take their rise; the upper I consider to belong to the *v. scapularis*, and to be properly a continuation of the short abrupt branch; it continues a short distance either parallel to the *v. scapularis* or adjacent to it (as in some Agrionina), and then branches; it generally branches twice before reaching the nodus, and once at or just beyond that point, with which it is connected by a continuation of the strong cross-vein before mentioned.<sup>1</sup> The *v. externo-media* runs quite directly to the margin, curving downwards more or less at the outer half, and running nearly parallel to the lowest branch of the *v. scapularis*; it sends upwards the short abrupt branch mentioned to meet that of the *v. scapularis*, which turns abruptly outwards at right angles again, sometimes joining the vein again a short distance on, sometimes continuing freely to the margin. The intricacies of the neuration are such that the *v. interno-media* can be traced definitely but a short distance, to a point below the cross-vein, uniting the *v. scapularis* and *externo-media*; here it sometimes forks, sometimes continues on single but contorted, and sometimes seems to stop altogether. The *v. analis* is frequently if not generally confluent with the preceding for a short distance, then diverges and forms the lower border of the wing. The *area marginalis*, *mediastina*, *scapularis* and *interno-media*, are traversed by numerous cross-veins; the *area externo-media* is free from them as far as the cross-vein; beyond this they are present; the spaces enclosed by the branches of the *v. scapularis*, and all the wing below the upper branch of the *v. externo-media*, are reticulated. That the space between what I have here considered as the lower branch of the *v. scapularis* and the upper branch of the *v. externo-media*, has cross-veins and no reticulations, except in a few cases close to the margin (*Æschmideæ*) is one reason for my conclusion concerning the meaning of the cross-vein and its branches.

#### SIALINA.

The *v. mediastina* starts at considerable distance from the *v. marginalis*, approaching it

<sup>1</sup> In *Lestes*, however, it is somewhat different; it sends out a branch once before the nodus and once beyond.

gradually till it is in close proximity, when it terminates near the tip of the wing by striking the *v. scapularis*; this last runs close alongside of the *v. mediastina* and very nearly parallel to it, striking the *v. marginalis* at just about the tip of the wing. At about one quarter of the distance from its origin it sends forth a branch downwards and outwards, which having passed a distance about equal to that of the undivided parent stem, forks, the upper branch again forking, the upper branch of this fork again forking, and so on, the upper branches in their course gradually approaching nearer to the main stem, connected to it by a single cross-vein or two, and finally reaching the tip of the wing in close proximity; the various lower branches are connected together by a few scattered cross-veins, as are those of the rest of the wing. The *v. externo-media* starting and continuing in close proximity to the *v. scapularis*, diverges from it at about half the distance to the branch of the former; from here it runs parallel to the branch of the *v. scapularis* and not far from the middle of its whole course, and just below the divarication of the *v. scapularis*, forks, the upper fork sometimes forking again. The *v. interno-media* forks from its very origin, the upper fork turning sharply upwards against the *v. externo-media*. One examining these veins without great care would consider the former a branch of the latter, were it not that the branching does not occur in the lower wing of *Chauliodes* until a very little past the origin; beyond its collision with the *v. externo-media* the upper branch runs sub-parallel with the lower branch of that vein, and sends out branches from the under side more or less. The under branch, with a slight curve, runs directly to the margin, forking once a little before reaching it. The *v. analis* forks at its origin, the forks being connected close to the base by a cross-vein; each of the forks again divaricates, and their proximate forks are connected by a cross-vein.

#### HEMEROBINA.

This family includes a greater variety of forms than any other, even after we have excluded from it many of the lesser families with which they are erroneously associated (as I believe) by Hagen. To comprise the genera *Ascalaphus*, *Nemoptera*, *Acanthaelisis*, *Polystoechotes*, *Chrysopa*, *Sisyra*, and *Drepanopteryx* in one group and show a uniformity of character in the venation of the wings as great as they exhibit in other features, which shall also distinguish them from the other families, and especially from some of those included within it by Hagen, is certainly more difficult than the definition of many other of the families, including as it does the more aberrant forms of the sub-order. The lower wing of *Polystoechotes* is perhaps as fair an example as any of the family.

The *v. marginalis* is continuous and regular, except in *Drepanopteryx*, etc., where it is very much curved abruptly forward next the base. The *v. mediastina* is straight, and except where the *v. marginalis* is swollen, as in *Drepanopteryx* and *Chrysopa*, is parallel to the *v. marginalis*, terminating near the tip of the wing by striking either the *v. marginalis* (e. g. *Chrysopa*, *Drepanopteryx*,) or the *v. scapularis* (e. g. *Acanthaelisis*, *Polystoechotes*, *Neuroptera*, *Ascalaphus*, *Sisyra*). The *v. scapularis* runs parallel to the *v. mediastina* most of the way from the base to the tip, where it terminates, generally just at the tip. It sends down a branch, either quite near the base (*Polystoechotes*, *Drepanopteryx*, *Sisyra*), or at about one third the distance from the base (*Ascalaphus*, *Acanthaelisis*, *Chrysopa*), or even so far as the middle of the wing (*Nemoptera*), which strikes the border so as to include above it seldom less than half of the wing, and often (especially *Polystoechotes*) much more. From near the origin of this branch it sends forth another branch parallel to the main

stem, which runs equidistant from it to the outer border, or reunites with the main stem, sending off continually branches parallel to the first-mentioned branch. These latter branches are either united by frequent or infrequent cross-bars, or they may fork to an indefinite extent, or only near the border, or the space between the first branch and its branchlet, parallel to the main nervure, may be filled with a net-work of veins. The main stem and the branch parallel to it may be united by few or many cross-veins. The *v. externo-media* may be either perfectly simple (Nemoptera, Acanthaelisis), or it may fork once from near where it leaves its close conjunction with the previous nervure, generally diverging narrowly, and have its forks continually united by cross-veins, while the spaces on either side are differently characterized, or in some other way show more or less distinction from the surrounding spaces, or it may so fork without such distinction (Drepanopteryx, Chrysopa, Polystoechotes), or it may fork farther from the base, and re-fork once or twice (Sisyra); at all events, it occupies quite an unimportant part, Chrysopa alone excepted. The *v. interno-media* extends generally some little distance from the base before forking, though sometimes it forks quite near to it, and generally occupies considerable space, in which the character of venation is similar in nearly every case to that seen in the space occupied by the *v. scapularis*. In Drepanopteryx, Nemoptera, Ascalaphus, and Acanthaelisis, they are especially prominent, while in Chrysopa the large extent of the *v. externo-media* seems to be balanced by the slight development of this vein, for it simply forks once, curving downwards and meeting the border. The branches proceed downwards toward the border mainly parallel to one another, and thrown off from the upper branch of the original fork, which itself runs in close proximity to the *v. externo-media*. The *v. analis* generally occupies but a small space, forking at least once, sometimes its forks uniting and from their union sending forth new forks. In one instance at least (Polystoechotes) it occupies a larger space, and forks indefinitely.

In that abnormal genus of Hemerobina, Nemoptera, where the hind wing is reduced to a long, ribbon-like appendage, the *v. externo-media* alone is wanting; all the rest are perfectly simple and parallel.

#### CONIOPTERYGIDÆ.

In this family the venation is very simple. The *v. marginalis* (if it exists) is continuous. The *v. mediastina* is simple, parallel to *v. marginalis*, and extends to the tip of the wing. The *v. scapularis* forks near the middle of the basal half of the wing, the lower branch forking widely shortly before it reaches the lower angle, the upper continuing parallel to the *v. mediastina*, sending out a branch sub-parallel to the lower branch, which forks widely before reaching the border. The *v. externo-media* is simple, runs sub-parallel to the *v. scapularis*, and is united to it by the only cross-vein that exists in the wing, just anterior to the branching of the former. The *v. interno-media* forks at its origin, the forks continuing sub-parallel to the former. The *v. analis* exists only on the border, if at all.

#### RHAPHIDIDÆ.

The *v. marginalis* is continuous. The *v. mediastina* runs parallel to the former and strikes it in the apical half of the wing. The *v. scapularis* runs parallel also to the *v. marginalis*, and terminates at the tip of the wing. It sends off a widely diverging branch near the middle of the wing, which forks widely before it has passed half way to the margin, the upper fork



running nearly parallel to the extension of the *v. scapularis*, and is united to it by several cross-veins, while the lower one keeps on nearly the original course. The two forks are reunited afterwards by a cross-vein which runs parallel to the border, and sends off several branches to it. The *v. externo-media*, running a short distance parallel to the last, soon diverges considerably from it and immediately forks, the lower fork reaching the border at the middle, or sometimes nearer the base. The upper fork, sometimes united to the *v. scapularis* by a cross-vein, soon forks again, its two forks continuing at about equal distances from each other, from the other fork, and from the branch of the *v. scapularis*. These three forks, half way from the original branching to the border, are reunited by cross-veins, which send forth borderwards other branches, which are sometimes simple, sometimes forked and sometimes united again by cross-veins, like the original branches which send forth others to the border. In a similar way are the outer upper ones united by cross-veins to the branches of the *v. scapularis*. The branches of this vein occupy more space and are generally more prominent than those of the *v. scapularis*. The *v. interno-media* forks close to its origin, is thereafter simple, or nearly so, but may have its forks united by an occasional cross-vein to one another, or to the veins on either side. The *v. analis* is unimportant and has but a single fork.

#### MANTISPADE.

The *v. marginalis* is continuous, curving upwards next the base. The *v. mediastina* runs sub-parallel to it, and terminates abruptly at the outer extremity of the pterostigma, on the apical half of the anterior margin, either by a cross-vein uniting the *v. marginalis* with the *v. scapularis*, or by abruptly bending upon the latter. The *v. scapularis* runs in a straight course to the apex of the wing, parallel and in close proximity to the *v. mediastina*, so long as that continues; it sends out two parallel branches near to one another at about the middle of the basal half of the wing, from the second of which springs a branch which runs parallel to the *v. scapularis* itself to the very tip of the wing, connected with it by an occasional cross-vein, and sending out equidistant branches parallel to one another and to the first branches mentioned. They fork once next the border, just before which they are united together by cross-veins or by recurrence. They are united in a similar way to the first branches of the *v. scapularis*, which latter are also united together by a cross-vein, which is a continuation of the parallel branch of the second branch but is placed at an angle to it. The *v. externo-media* forks widely at the very base, is almost immediately united again, from which union a short branch or cross-vein connects it with the *v. scapularis* anterior to its branching, while two others widely divergent at origin run sub-parallel to the branches of the *v. scapularis*, are again united not far from the margin by a cross-vein, from which springs another branch. The *v. interno-media* is simple, and is united by single cross-veins to the veins above and below. The *v. analis* forks but once.

#### PANORPINA.

The *v. marginalis* is continuous. The *v. mediastina* is unimportant, parallel to it, and terminates by striking it at about two thirds the distance from its origin. The *v. scapularis* runs in contiguity with the former for a short distance, then diverging a little distance forks, the upper branch running parallel to the *v. mediastina*, and at about the same distance from it, as it is from the *v. marginalis*, till it terminates by striking the *v. marginalis* a little way beyond where the *v. mediastina* strikes it, never forking except sometimes near the tip.

The lower branch forks and re forks again several times. This vein, with the two previous, occupy just about one half of the wing. The *v. externo-media* can with difficulty be distinguished from the *v. scapularis* next the base, since it runs for a short distance in very close contiguity to it, after which it diverges and runs sub-parallel to the lowermost branches of the previous veins, forking about the middle of its course, each of the forks dividing once more. The *v. interno-media*, taking its origin at a distance from the *v. externo-media*, curves directly up into close proximity to that, then diverging runs nearly parallel to it, forking once at no great distance from the base (but in *Bittacus* at the base), thereafter remaining simple. The *v. analis*, except where it is atrophied, as in *Bittacus*, forks at the base. The upper branch, curving like the *v. interno-media* and running parallel to it, remains simple. The lower branch forks again immediately, the lower fork (forming the margin) dividing once more, but with these exceptions remaining simple. All the areas, and the spaces between the branches, but especially those beyond the middle of the wing, have conspicuous but very infrequent cross-veins. There are none in the *area externo-media* previous to the forking of the *v. externo-media*.

#### PHRYGANINA.

The *v. marginalis* is continuous. The *v. mediastina* is straight and runs into the margin in the apical half of the wing. It is connected with the *v. marginalis* close to the base by a strong cross-vein. The *v. scapularis* branches very near the base. The upper branch simple, and running parallel to the *v. mediastina*, reaches the margin before the apex. The lower branch branches again before the middle of the wing, the branches connected half way to the outer border by a bent cross-vein, which sends out a branch parallel to and midway between these. The *v. externo-media* bends up towards the *v. scapularis*, then diverging from it forks not far from the origin, the branches united at half their distance to the border by a cross-vein, at which point they both fork, the upper fork of the upper branch again and again forking, each time approaching the lowermost branch of the *v. scapularis*, with which the last is joined by a cross-vein, which is continuous with the forks of this vein and the cross-vein of the *v. scapularis*. The *v. interno-media* is simple, and runs parallel to the lower branch of the *v. externo-media*. It terminates at the border or at a cross-vein which unites the lower branch of the *v. externo-media* with the border. The *v. analis* forks at the base, the upper branch running parallel to the *v. interno-media*, and united near the base to the other branches, one of which forms the internal margin and the other is short and unimportant.

Since form dependent on general structure is a characteristic of families, as Agassiz has well presented it, we might have properly anticipated what we now find from this review, viz.: that distinctions of a general nature in the neuration of the wings correspond with the family divisions; for it is upon the structure of the wings of insects that their form very much depends. Especially is this true in Neuroptera, where, as much as in any other group except Lepidoptera, the form is presented most obviously in the contour of the wings. No systematists, however, have used these characters in the Neuroptera to any extent so far as I am aware, except Burmeister, who has treated of them in a general way, but scarcely so as to allow of ready comparison between the families. Heer, also, in his work on the Fossil Insects of Ceningen, has given in detail — and differing scarcely at all from what I have here presented — the mode of this venation in the Termitina. Besides

these, I do not know that any authors have given any specific distinctions of families among Neuroptera drawn from these characteristics.<sup>1</sup>

To enable us more readily to inquire how the two fossil forms under discussion are related to living types, we will reproduce some of the more striking of these characters in epitome, and append a similar brief account of the venation of the wings in the fossils.

*Termitina.* Nearly the entire wing is taken up with the simple and parallel branches of the *v. externo-media*, the anal area being wanting.

*Embidina.* The *v. mediastina* terminates near the tip of the wing by impinging on the *v. scapularis*, which impinges in the same way on the *v. externo-media*. The *v. externo-media* occupies the middle half of the wing with a few straight, simple, or dichotomous branches, distantly united by straight cross-veins to one another and to the veins above and below; anal area considerable.

*Psocina.* *V. mediastina* insignificant. The *v. scapularis* occupies almost the entire wing and is the only forked vein in it. It sends out a branch not far from the base, from which arise most of the branches, which curve and refork in the freest manner (though the wing is less crowded with veins than ordinarily), united by only one or two cross-veins to one another. The anal area is more prominent than the costal.

*Pertina.* The *v. mediastina* is connected with the margin by numerous cross-veins, and terminates by impinging on the *v. scapularis*. The branches of this latter occupy the apex only of the wing. It sends out a slightly diverging branch, which remains simple about half its distance to the margin, then sends out simple branches from its under side, seldom united by cross-veins. The *v. externo-media* branches like the branch of the *v. scapularis*, at about the middle of the wing, is connected by a cross-vein to that branch at its divarication, while the branches of the *v. externo-media* are themselves connected here and there by cross-veins and recurrent nervules. The *v. interno-media* forks several times, the consecutive upper forks continually reforking, and connected by a cross-vein at last to the *v. externo-media* at its first divarication. By this continual connection of the principal veins, two large cells are formed in the middle of the wing, the upper open, the latter filled with cross-veins in one sex; the last three veins are of not far from equal importance.

*Ephemerina.* The first three veins are simple. The *v. externo-media* occupies the largest portion of the wing, though it forks and reorks but once or twice, the spaces being filled by many intercalary nervures proceeding from the outer border. The *v. interno-media* and *analís* are about equal in importance, and similar in character to the *v. externo-media*, though with fewer intercalary nervures. All the nervures are generally connected by frequent, straight cross-veins.

*Odonata.* The most peculiar in its venation of all the families. The *v. marginalis* extends only to the middle of the wing, the *v. mediastina* taking its place beyond. The *v. scapularis* and *externo-media* are connected close to the margin by a cross-vein, from which arise two veins which occupy the greater portion of the wing. The *arcæ marginalis*, *mediastina*, *scapularis*, and *interno-media* are traversed by numerous cross-veins. The most of the rest of the wing is filled with minute reticulations.

*Sialina.* The *v. scapularis* sends forth a branch in the basal half of the wing, which strikes

<sup>1</sup> When this was written I had not seen Goldenberg's paper on the carboniferous Insects of Saarbrück, (Die fossilen Insectea der Kohlenformation von Saarbrücken, aus den Palæontographien von Dunker und Meyer, Cassel 4°. 1854,) which must be excepted from this remark, for so far as was

necessary for the object he had in view, he has given detailed comparisons of the venation in some of the families of Neuroptera. I hope to revert at some future time to the relation which the species of the genus *Dictyonera* there described bear to the *Sialina* and other Neuroptera.

the border on the outer half, but near its origin sends out a branch which forks, its upper fork continually reforking (the lower remaining simple and connected irregularly by occasional cross-nervures) and remaining parallel to the main stem. The *v. externo-media* forks near the middle of its course, the upper fork sometimes reforking. The *v. interno-media* forks widely at its very base, the upper fork sending out branches from its under surface. It is of considerable importance, while the *v. analis* is of but slight significance.

*Hemerobina.* The *v. scapularis* is generally much as in *Sialina*, but forks generally near to the base, and the branches are straight instead of curved, seldom united by more than one or two cross-veins, and these generally very regularly disposed, frequently united close to the margin and immediately forking again. It occupies also almost the entire wing. The other veins are much as in *Sialina*, but quite insignificant.

*Coniopterygida.* The veins never reach the border, and are extremely simple, but they nevertheless do not seem to agree in character with those of any other family. The only branching vein is the *v. scapularis*, which occupies half the wing. It sends out from its under side distant from one another one or two branches which fork widely near the margin, sometimes connected by cross-veins. It is connected to the *v. externo-media* by a cross-vein.

*Raphidiidæ.* The *v. scapularis* does not branch until beyond the middle of the wing, then sends out a branch which forks and is reconnected, before reaching the border, by a cross-vein which sends out several branches to the border. This vein thus occupies the apex of the wing. The *v. externo-media* occupies the central and largest portion. It sends out branches connected by cross-veins which latter themselves send out towards the border offshoots, which are sometimes again reconnected.

*Mantispadæ.* The *v. mediastina* impinges on the *v. scapularis* in the outer half of the wing. The *v. scapularis* sends out near together, in the basal half of the wing, two branches, the outermost of which sends out a branch parallel to the main stem, which again emits branches towards the border parallel to and equidistant from one another. These unite next the border and then fork again as in *Hemerobina*. This vein occupies more than half of the wing. The *v. externo-media* is much as in *Raphidiidæ*, but branches nearer the base. The anal area is quite insignificant.

*Panorpina.* The *v. scapularis* forks near the middle of the wing, its lower branch repeatedly forking. It occupies about one third of the wing, taking in all the apical portion. The *v. externo-media* forks in a similar manner but altogether beyond the middle of its course. The branches of the veins in general are mainly confined to the outer half of the wing, and they are connected by distant, straight cross-veins.

*Phryganina.* The *v. scapularis* sends from its lower side close to the base a branch, which forks near the middle of the wing, the branches being connected together afterwards by a cross-vein, which continues on and connects the branches of the *v. externo-media*. From this continuous cross-vein a considerable number of branches are sent toward the apex. This is nearly or quite the only cross-vein in the wing.

*Hemeristina.*<sup>1</sup> The *v. scapularis* sends downwards a branch near the middle of the wing, which curves outwards so as to run nearly parallel to the main stem, and sends from its under surface several other branches, occupying about a third of the wing. The *v. externo-media* divides near the base, and its lower branch forks when about half way to the border

<sup>1</sup> These names *Hemeristina* and *Palæopterina* are proposed to be respectively members; fuller details, as a basis for a better comparison, are given beyond.

of the wing. The *v. interno-media* branches many times but at a very slight angle; and the *v. analis* is not unimportant. All the veins and their branches are intimately united by very frequent, straight, strong cross-veins.

*Palæopterina*.<sup>1</sup> Both the *v. scapularis* and *externo-media* fork not far from their origin very narrowly, the lower fork of the former and the upper fork of the latter sometimes re-forking near the margin. Together they occupy scarcely more room than the *v. interno-media*, which at a distance from the base sends downwards more diverging branches which are occasionally united to one another and to the previous vein by distant, straight, but oblique cross-veins, as are also the branches of the *v. scapularis* to one another. The *v. analis* occupies considerable space, sending out many narrowly diverging forked branches not dichotomizing.

Other important distinctions, drawn from or dependent upon the structure of the wings, will be found to be characteristic of the families of Neuroptera. They differ, for example, in the various positions assumed by the wings when in an attitude of repose.

In the *Termitina* the wings in their natural attitude when at rest are extended horizontally backwards, those of the opposite sides completely overlapping one another. There is no deflection of the costal area, and the anal area being absent there is no plication.

In the *Embidina*, according to Westwood, the wings are matted down upon the abdomen as in the orthopterous family Forficulariæ. From figures of them one would judge that there was no deflection of the costal area and no plication of the anal area, and that their position may be exactly as in *Termitina*.

In the *Psoeina* they are extended backwards, sloping obliquely from one another like the roof of a house, their inner edges meeting loosely, without plication of the anal area of the hind wings; anal area of fore wings with a slight horizontal deflection; no deflection of the costal area.

In the *Perlina* they are extended horizontally backwards, completely overlapping one another; the anal area of hind wings plicated; the costal area of fore wings slightly deflected.

In the *Ephemerina* they are extended perpendicularly upwards, the surfaces of the opposite wings approximate, or sometimes separated by a slight, seldom a considerable, angle; no deflection of the costal area; no plication of the anal area.

In the *Odonata* they are extended either laterally and horizontally, or (*Agrionina*) upwards, and, by the structure of the thorax, backwards, the surfaces of the opposite wings approximate; the anal area not plicated; no deflection of the costal area.

In the *Sialina* they are extended backwards, incompletely overlapping one another, arched over the abdomen; a single plication or none in the anal area of hind wings; a slight deflection in the costal area of the fore wings.

In the *Hemerobina* they are extended backwards, steeply sloping obliquely from one another like the roof of a house, their inner edges in close contact throughout; no plication of the anal area; the costal area not deflected.<sup>2</sup>

The *Coniopterygidae* and *Rhaphidiidae* I have never seen alive, but they probably do not differ essentially from *Hemerobina*. Neither have I seen the *Mantispuide*, but they are probably either as in *Perlina*, though without deflection or plication, or also without complete or any overlapping of the opposite pairs of wings as in *Panorpina*.

<sup>1</sup> See note on preceding page.

<sup>2</sup> But Savigny figures *Nemoptera* in an attitude like *Ephemera*.

In the *Panorpina* the wings are extended backwards horizontally or sloping slightly, the lower completely covered by the upper; the opposite pairs divaricate slightly, so as not to overlap one another at all, while the inner edges meet only along the basal half. The anal area is not plicated, nor the costal area deflected.

In the *Phryganina* they are extended backwards, steeply sloping from one another obliquely like a roof, at tip generally steeper, nearly vertical, and the opposite pairs appressed; the anal area of the fore wings deflected horizontally, those of the opposite pairs overlapping one another, the anal area of the hind wings plicated; the costal area not deflected.

In the *Hemeristina* the wings overlap one another horizontally very completely, even close to the base, probably arched over the abdomen, and probably with the sides protected near the base by the deflected costal area.

In the *Palæopterina* they overlap one another partially in a loose way horizontally over the abdomen, probably with no costal deflection, and in general as in the *Termitina*, though with not so complete an overlapping.

Some of the families of Neuroptera will also be found to differ in the position assumed by the wings of the pupa, as follows:—

*Termitina*. When developed more than as tubercles they are represented by Westwood as extended horizontally elongate over the abdomen, their inner edges touching at tip.

*Psocina*. Horizontally extended backwards in a level plane, not covering much of the abdomen, the posterior covered by the anterior.

*Perlina*. Same as in *Psocina*, but never covering any of the abdomen, the posterior being behind and not overlapped by the anterior.

*Ephemerina*. Curving backwards and upwards over the abdomen, the posterior covered by the anterior, the outer edges meeting along the median line.

*Odonata*. Projecting backwards in a level plane, somewhat deflected, the hinder edge downwards, those of either side parallel.

In the other families the wings are bent over, either curving over upon the breast or extended along the sides, the posterior partially or completely covered by the anterior, or with some modification of one or the other of these modes, so nearly the same as to make the distinctions valueless.

The families differ also from one another, but agree among themselves in the position of the head. In the *Termitina*, *Embidina*, *Perlina*, *Sialina*, and *Raphidiidæ*, the head is in the same horizontal plane with the body. In *Psocina*, *Ephemerina*, *Odonata*, *Hemerobina*,<sup>1</sup> *Panorpina*, *Phryganina*, *Mantispadæ*,<sup>2</sup> and *Coniopterygida*, it is in a plane vertical to that of the body. We do not know the position of the head in *Hemeristina*, but in *Palæopterina* it is horizontal.

From this review of the distinctions among the families we see that the *Hemeristina* are related to the *Hemerobina* and *Sialina* more than to any other, by the mode of branching of the *v. scapularis*; to the *Ephemerina* by the comparative importance of the *v. interno-media* and *analis*; to the *Odonata* by the character of the *v. marginalis* and *v. mediastina* in the basal half of the wing; to the *Ephemerina* again in the method of dispersion of the cross-veins;

<sup>1</sup> It may be noticed here that the larva of *Myrmelion* has the head horizontal.

<sup>2</sup> This is an additional reason why this should be separated as a family group from *Raphidiidæ*.

and to the Odonata in the strength and importance of the same; and once more to the Sialina in the form and manner of folding the wings; while it has distinctive characters, not only in the unusual combination of these peculiarities, but also in that the *v. marginalis*, *mediastina*, and the main stem of the *v. scapularis* are equidistant and parallel throughout, uniformly connected by straight cross-veins; in the peculiar curving of the principal branch of the *v. scapularis*; in the mode of branching of the *v. externo-media*; and in that the lower principal fork of the *v. interno-media* occupies more space with its branches, and is of more importance than the upper fork.

The *Palæopterina* show their relation to the Termitina in the character of the *v. mediastina* and the irregular cross-veins which run towards the margin; to the Termitina more than to any other, though not intimately in the mode of divarication of the branches of this same vein; to hardly any unless it be the Panorpina in the peculiarities of the *v. externo-media*; to the Hemerobina and still more to the Sialina in the structure (though in *Palæopterina* given with more precision and exaggeration) of the *v. interno-media*; to the Ephemera in the mode of branching, and to the Sialina in the important development, of the *v. analis*; to the Raphidiidæ more than to any other, though but slightly, in the infrequency and manner of dispersion of the cross-veins, excepting the marginal ones; and to the Termitina in the obliquity of all the cross-veins apart from those on the margin, and generally in the manner of folding the wings in repose. In the importance of the *v. interno-media* and *analis*, occupying as they do fully half the wing, we have characters which of themselves would clearly separate this family from the others; we also find distinctions of sufficient significance in every vein of the wing except the *v. marginalis* and *mediastina*.

We have thus far treated only of the structure of the wings. In the *Palæopterina*, however, we have other portions of the body to examine in addition to these, though their structure is generally scarcely as distinct as that of the wings, being crushed and displaced.

The contour of the abdomen is best preserved, though least so at the terminal segment, the most important part. It is apparently depressed; the roundness of the lateral edges of the segments indicate a membranous rather than a corneous, or even coriaceous integument, broad at the base, slightly increasing in breadth towards the middle and then tapering considerably to the apex, the terminal segment apparently furnished with a pair of short, stout, conical, anal stylets, — in all this corresponding in general to what we find in some Sialina. The meso- and meta-thorax are somewhat indefinite in their outlines, but the inequalities of the upper surface and the direction of the principal wing-nervures, which afford us an indication of the point of attachment of the wing, together with the faint sutural marks, show that it was similar in character in this part of the body also to the structure we find in *Corydalis*, one of the Sialina. The prothorax is quite remarkable for its diminutive size, its width being only half that of the mesothorax. We find similar abrupt changes in the Raphidiidæ, but in the *Palæopterina* the prothorax is not, as there, lengthened anteriorly as a compensation, but is formed much as in *Perlina*, depressed, quadrangular, with a slight median carina, but its anterior edge produced in the middle to quite a prominent tooth. The anterior legs are wanting,<sup>1</sup> but both the other pairs are present in fragments, enough to show that they were of moderate length and strongly compressed,

<sup>1</sup> It will be seen in our description of the anterior legs and reasons for this we have given elsewhere. See *Amer. Journ. Science*, (2) XL: 268. of the head, that we interpret these parts very differently from Professor Dana in his article in *Silliman's Journal*. The

recalling vividly the *Perlina*. The outline of the head is partly very distinct and partly very indistinct, and is docked posteriorly by what indistinctly resembles the posterior two segments of the abdomen of another insect. It is depressed like the other parts of the body, and regularly ovoid in outline. The eyes are rather large, elongate, lateral. The other appendages of the head cannot be made out distinctly enough for any characterization, the only possible indication of antennæ being slight linear depressions in the stone. In those points which can be seen the head closely resembles the *Perlina*.

The only portion of the body besides the wings which is preserved with any distinctness in the *Hemeristina* is a fragment of a femur, which from its position on the stone may be assumed to belong to the anterior pair of legs. It is compressed, with a slightly swollen median ridge, as the femora of *Palæopterina* are. There is also an apparent fragment of a middle femur and tibia at their union, very indistinctly preserved. The most that can be said about it is that it seems to agree with the same parts in *Palæopterina*.

Now what is most interesting in this connection is, that the Neuroptera have been divided by Erichson, in this being followed by at least the German Entomologists, into two groups, called respectively the Neuroptera (comprising the families *Sialina*, *Hemerobina*, *Coniopterygidae*, *Mantispadæ*, *Rhaphidiidae*, *Panorpina*, and *Phryganina*), and the Pseudo-neuroptera (which include the *Termitina*, *Embidina*, *Psocina*, *Perlina*, *Ephemerina*, and *Odonata*), founded principally upon one very essential characteristic, — the complete or incomplete metamorphosis, *i. e.*, whether the pupa be inactive or active; in which latter case the rudimentary wings of the pupa are mere pads protruding horizontally or more or less deflected from the thoracic segments, and in the other are more developed and wing-shaped, encircling the sides and folded over upon the breast like Coleopterous pupæ; and in support of the naturalness of this division it is urged that in no other sub-order of Insects do we find existing simultaneously two so distinct forms of metamorphosis.<sup>1</sup>

We have already seen, by the comparison of the wings alone, that these two families of fossil Neuroptera borrowed from one and another of the other families characteristics of wing-structure, which show their close affinity to them. These families from which they were borrowed, will now be seen to belong, some to one and others to the other of these larger groups, proving that we have in our newly discovered families a SYNTHETIC NEUROPTEROUS TYPE. And this is still more evident when we carry our comparisons into other parts of the body, as we may in the *Palæopterina*, where the meso- and meta-thorax and the abdomen remind us strongly of the *Sialina*, a Neuropteran, while the head and eyes, the prothorax and legs, quite as much bring the *Perlina*, a Pseudo-neuropteran, to our mind.

In the *Hemeristina* we have nothing of importance in this direction; but the femoral fragments agree so closely with the *Palæopterina* in its mimicry of *Perlina* as to lead us to suggest that in its other features it may also have followed somewhat the peculiarities of the *Palæopterina* in the equal distribution of its characteristics over a field embracing both the Neuroptera and Pseudo-neuroptera.

We shall have completed the task we have assumed when we have given in detail the

<sup>1</sup> I cannot, however, discover any one character common to the wing-structure of one of these two groups which is not found in the other as well, though the families of Pseudo-neuroptera are much more distinct from one another than in general are those of the Neuroptera among themselves; unless it be that the *Phryganina* are as widely separated from the more nearly related families as those of Pseudo-neuroptera are from one another.



characters of the families, genera, and species of the fossil insects referred to in the previous remarks.

#### Family PALÆOPTERINA Scudder.

Neuroptera of medium size. Body rather broad and flat; the head horizontal. Head oval, depressed; eyes rather large, elongate; thorax square and depressed; the prothorax and head much narrower than the rest of the body; legs compressed, not long; abdomen full, long, probably (like *Corydalis*) not corneous; the terminal segment probably with a pair of very short anal appendages.

Wings large and regularly rounded, very broad near the base, the two pairs nearly equal, extending beyond the abdomen, and when at rest both pairs reaching about the same point; with only a very few and slight cross-veins, except in the *area marginalis*, where they are numerous and irregular; when at rest, folded as in the *Sialina*.

The *v. mediastina* runs parallel to the *v. marginalis*, but not in close proximity to it. It terminates at about two thirds the distance to the apex by impinging on the *v. scapularis*, which runs parallel and quite near to the *v. mediastina*, reaching the margin just before the very extremity of the wing. The *v. scapularis* forks at about one fourth its distance from the base, the upper fork taking the direction mentioned and remaining simple, the lower diverging but little though with constant increment, forking at about three fourths the distance from the base, the forks reforking one or more times. The upper branch is connected by a few oblique cross-veins with the lower, which run outwards and downwards. The *v. externo-media* forks quite near the base, its branches but slightly divergent, sometimes forking again. The *v. interno-media* covers with its branches a wider space. It is at first about as divergent from the last as that is from the lower branch of the *v. scapularis*. It soon forks, the upper branch again forking twice, the forks remaining parallel but separated from one another at the start as widely as those of the previous vein at their termination. There are one or two cross-veins uniting these forks, and one or two uniting the upper branch to the lower branch of the previous vein, where it comes in close contiguity. Of the *v. analis* little can be said, except that it terminates in a large number of closely contiguous, parallel nervures, which arise from forks near the base, which seldom refork, the branches running parallel to the innermost branch of the *v. interno-media*. The *area marginalis* has a large number of irregular cross-veins curving outwards from the *v. mediastina* as in many *Termitina*. The wings are quite alike and weak. In the specimen they are in their natural attitude of repose, overlapping one another in a loose way upon the back, probably with no side support.

#### GENUS MIAMIA Dana.

Head ovate; eyes oblong-ovate, situated on the sides in the middle, slightly approximate anteriorly, prominent above and below but not protruding laterally beyond the general contour of the head; prothorax as wide as the head, quadrangular, broadest anteriorly, the anterior border very much produced forwards into a median projection, both anterior and posterior angles prominent but rounded, the posterior border square; meso- and meta-thorax much broader than prothorax, with large, slightly elevated tubercles just within the base of the wings, as in *Corydalis*; middle and hind femora and tibiae broad and not long, femora and tibiae of equal length; abdomen large and plump, as in *Corydalis*, the basal joints not quite so large as the central, tapering regularly, though but little, from the

middle to the tip; last joint considerably smaller than the penultimate, furnished apparently with a pair of very short, bluntly conical, anal appendages. The costal border of the wings is almost perfectly straight, till near the tip, at a point just before reaching the tip of the abdomen when the wings are at rest, where it begins to curve. The inner border begins to form an opposite curve at a corresponding point, and together they form a curve of perfect regularity with no angle whatever. The inner border is straight for some distance from this curve towards the base, the wing growing but slightly narrower till near the base, when it narrows suddenly, but (probably) with a regular curve.

The cross-veins connecting the branches of the *v. scapularis* are only two or three, running obliquely downwards and outwards from the upper to the lower branch at equal distances from one another, and the outer at a similar distance from the forking of the lower branch. The cross-veins, between the branches of the *v. interno-media*, run parallel to the inner margin between the extremities of those branches. The cross-veins are very slight, and in the case of those in the *area marginalis* are very irregular in direction and disposition, like the same space in the Termitina. In the other parts of the wing the two or three scattered ones in the places mentioned are regular and straight.

#### Miamia Bronsoni DANA.

*Measurements*: head, .10 in. broad; length of eye, .08 in.; length of prothorax, including front projection or tooth, .15 in.; breadth of meso-thorax, .25 in.; from the hinder edge of prothorax to the extremity of the abdomen, 1.12 in.; breadth of middle femora, .05 in.; length of hind femora (what is seen of them), .33 in.; breadth of same, .07 in.; length of hind tibiæ, .18 in.; breadth of same, .04 in.; expanse of fore wings, 2.16 in.; expanse of hind wings, 2 in.; extreme breadth of fore wing, .40 in.; length of the anal appendages, .05 in.

Head just twice as long as broad; prothorax of the same width as the head, the front border convex, produced considerably forward in the middle to a pointed and rather slender tooth, a very slightly impressed median carina extending the whole length of the prothorax, a scarcely perceptible linear impression crossing the hinder portion, starting from a little in front of the posterior angle and curving forward so much that the broad, straight, scarcely elevated ridge connecting its two extremities is equally distant from it and the hind border of prothorax; the sides of prothorax very slightly convex, the prothorax itself about five sixths as broad posteriorly as anteriorly. Femora (front legs wanting) broad, slightly swollen along the middle line, flat upon either side, the extremities docked, the angles slightly rounded. Tibiæ much narrower, with no median ridge except in the hind tibiæ, where it is slight in the middle. Wings in repose reaching the same point.

#### Family HEMERISTINA Scudder.

Neuroptera of large size. The prothorax is quadrangular, narrower than the meso- and meta-thorax, though not proportionally so much so as in the Palæopterina; the femora (probably the front pair) are as in the Palæopterina, but proportionally broader.

Wings large, long, about twice as broad beyond the middle as near the base, the costal border convex in its outer half, with numerous and prominent cross-veins, but no reticulations; when at rest, overlapping quite completely even close to the base, much as in the Perlina, and probably with the sides protected near the base by the deflected *area marginalis et scapularis*.

The *v. mediastina* and *v. scapularis* run nearly parallel to each other throughout their course. The *v. scapularis*, at about one third the distance from its origin to the apex, sends out a branch, which curves outwards and considerably downwards, again curving upwards, so that when about two thirds the distance from the base it is as far from the main stem as that is from the front margin; beyond this, it keeps apparently parallel with the main stem; at the deepest part of its curve it sends out a branch about as divergent from it as it was from its parent stem, which continues directly to the margin, and again, but a short distance further on, it sends forth another, which runs parallel to the former. The *v. externo-media* is found a short distance from the base in close contiguity with the *v. scapularis*, but forking as it separates from the former, the upper branch continues a short distance in close contiguity to it, and then passes unchanged to the border of the wing parallel to the lowermost branch of the *v. scapularis*; the lower branch runs in a direction parallel to the general course of the upper, and forks once a little more than half way to the border. The *v. interno-media* forks at its origin, both forks running very nearly parallel and in quite close contiguity to one another, and parallel to, but rather distant from, the lower branch of the *v. externo-media*. The upper fork again forks at a little distance from the origin, the forks keeping in close contiguity. The lower fork sends off from its lower side one or two slightly curving, rather divergent branches. Of the origin and branching of the *v. analis* little can be said; the branches are rather numerous and distant, and sub-parallel to the lower fork of the *v. interno-media* as continued in its first branch, and the area covered by it is large and well developed. All of these veins and branches are connected together by numerous cross-veins, which are quite prominent, equidistant, and equally distributed throughout the wing, much as in most Ephemera.

The lower wing differs from the upper, so far as can be determined, in that the branch of the *v. scapularis* does not curve towards the main stem, and that there are other branches to the *v. scapularis* beyond the first, parallel to that. The veins below this were not easily distinguishable.

#### Genus HEMERISTIA Dana.

Prothorax equally wide throughout; the sides straight; the anterior and posterior borders slightly if at all convex; (fore?) femora as in *Miamia*, but proportionally broader, though with the same flat surface on each side of a slightly swollen middle ridge.

Wings of large size, probably extending considerably beyond the body, the costal border probably quite straight during the first part of its course, curving broadly towards the extremity, probably with the extremities rounded and without a pointed apex, and with a full anal area and angle. The second branchlet of the principal branch of the *v. scapularis* in the upper wing, previous to the origin of the third, is connected with the principal branch by sinuate cross-veins as frequent as the cross-veins in other parts of the wing.

#### *Hemeristia occidentalis* DANA.

The prothorax here is so indistinct and poorly defined as to be incapable of specific description, or of measurements. Mesothorax, .25 in. broad; the fragment of the (fore?) femur is .10 in. broad. The wings, too, being but partially preserved, it is impossible to give accurate measurements, save of parts within a wing. The probable expanse is 5.15 in.; the distance, when the wings are at rest, between the first branching of the *v. scapularis* on one wing and that on the other upper wing, is .50 in. The estimated breadth of

each wing at its widest point, probably the same as that between the margins of the wings at rest at their widest point, is .85 in. ; the distance between the origin of the principal branch of the *v. scapularis* of the upper wing and that of its second branch is .53 in. ; the greatest width of the space between the *v. scapularis* and its principal branch in the upper wing is .11 in. ; and the distance between the *v. scapularis* and the margin at this same point is .09 in. The figure answers better than description.

In this specimen the right upper wing overlaps the left upper wing, and the insect is seen from above.

#### EXPLANATION OF PLATE VI.

Fig. 1. — The right upper wing of *Hemeristia occidentalis* restored, magnified  $1\frac{1}{2}$  diameters.

Fig. 2. — Restoration of *Miamia Bronsoni*, magnified 2 diameters.

The dotted lines in these two figures show the conjectural parts.

Fig. 3. — The four wings of *Hemeristia occidentalis* as seen in the fossil, magnified  $1\frac{1}{2}$  diameters.

Fig. 4. — The veins of the wings only of *Miamia Bronsoni*, as they appear in the fossil, magnified 2 diameters.

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Fig. 1

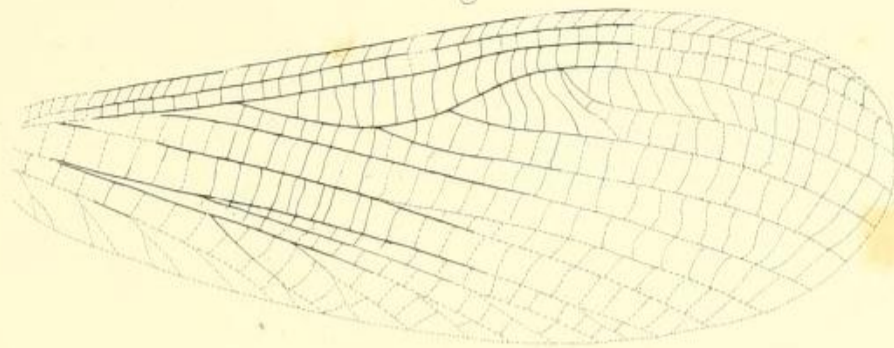


Fig. 2

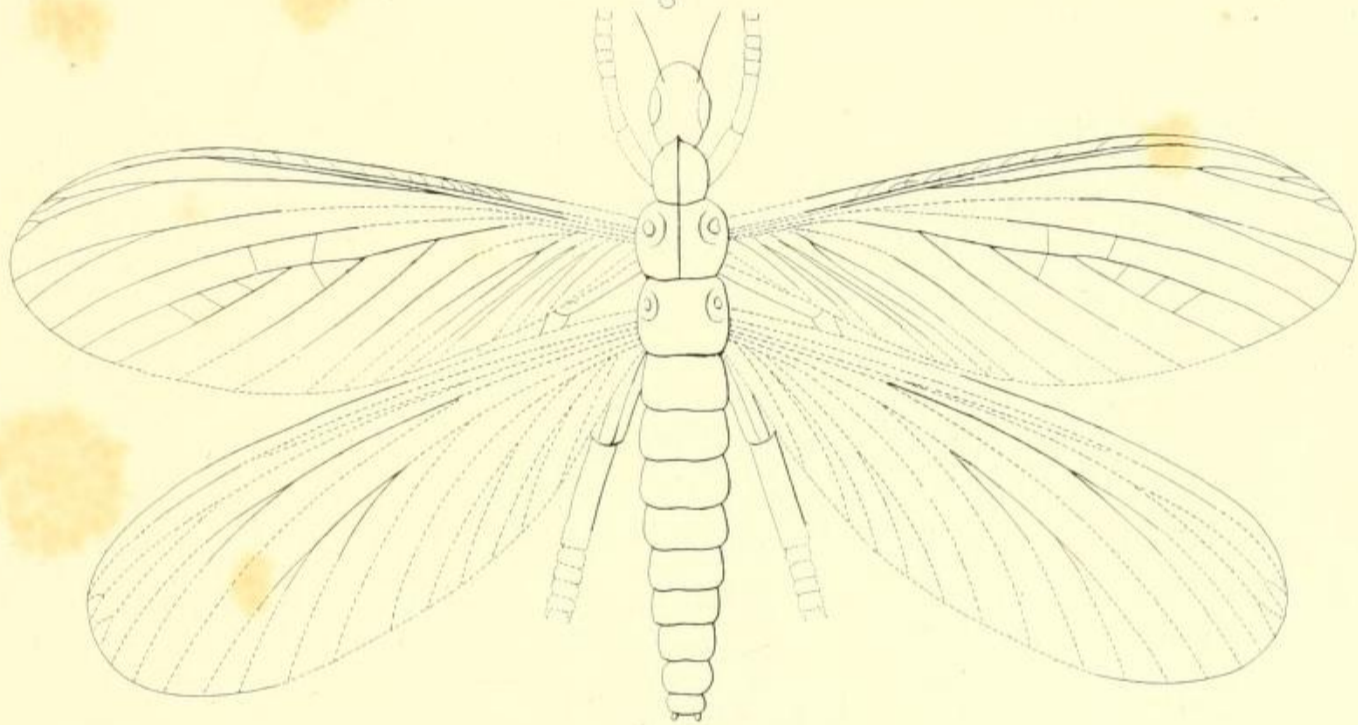


Fig. 3

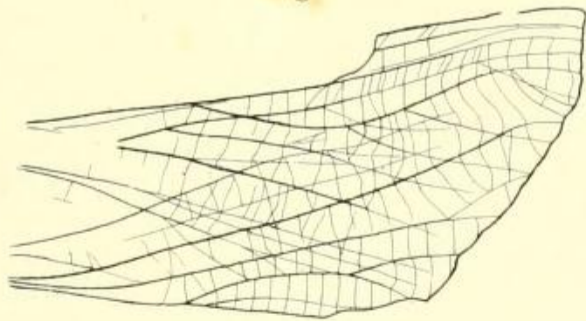
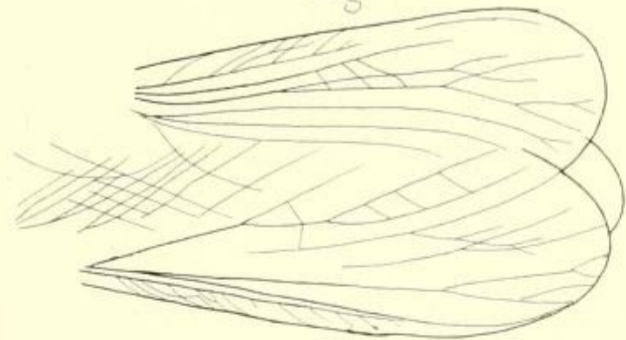


Fig. 4



L. Trouvelot, on stone