EXPLANATION OF PLATE I.

Fig. 1. Stage I of *Packardia*, dorsal view, enlarged.
" 2. Stage II, side view enlarged.
" 3. The subdorsal setæ of one tubercle, stage II, more enlarged.
" 4. Granules of *Packardia geminata*, stage III, enlarged.
" 5. Granules of *Packardia elegans*, stage III, enlarged.
" 6. Mature larva *P. geminata*, three-quarters view.
" 7. Moth of *P. geminata*.
" 8. The same, dark form, var. *albipunctata*.
" 9. Mature larva of *P. elegans*, three-quarters view, partially pigmented.
" 10. The same, dorsal view, fully pigmented form.
" 11. Moth of *P. elegans*.
" 12. The same, pale form, var. *fusca*.

AN ATTEMPT TO CLASSIFY THE HOLARCTIC LEPIDOPTERA FROM THE SPECIALIZATION OF THE WINGS.

PART II.—THE HAWK AND EMPEROR MOTHS.

By A. Radcliffe Grote, A.M.

C. Radius 5-branched; vein IV2 central or cubital; hindwings with intercostal crossvein.....**SPHINGIDES.**

c1. No costal vein (vein I) on primaries; vein III2 absorbed by Radius; crossvein degenerate; vein IV2 decidedly cubital.....ENDROMIDIDÆ.

c1. A costal vein (vein I) on primaries; vein III2 from Radius before extremity of cell; crossvein entire; vein IV2 not decidedly cubital SPHINGIDÆ.

D. Radius 3–4 branched; vein IV2 central or radial; hindwings with no intercostal crossvein.....**SATURNIADES.**

d1. Vein IV2 continuous with vein IV1.....SATURNIADÆ.

d2. Cell open.....ATTACINÆ.

d2. Cell closed.

d3. Hindwings without vein VIII.....SATURNIANÆ.

d3. Hindwings with vein VIII.....HEMILEUCINÆ.

d1. Vein IV2 from crossvein.....AGLIADÆ.

d4. Hindwings without vein VIII.

d5. Crossvein, between IV2 and IV1, directed obliquely outwardly AGLIANÆ.

d5. Crossvein transverse.....AUTOMERINÆ.

d4. Hindwings with vein VIII.....CITHERONIADÆ.*

* This table (*C*, *D*), and that of the Day-Butterflies (*A*, *B*), is compiled in accordance with the sequence in the Lepidoptera which I recommend, and not altering the Linnean arrangement upon opinionative grounds.

ENDROMIDIDÆ.

The subprimary tubercles of the larva (3 and 5) in stage I are wanting on the thoracic segments (I to III). On the abdominal segments the subprimary tubercle 6 is also wanting. In the "Saturniiden," page 6, I figure abdominal segment, but the bristles marked "6" are too low down for this and evidently belong to 7. I indicate this doubt in the text (p. 5). On the same segments the tubercles 5 and 4 are separate. There appears to me no insuperable objection to the view, that *Endromis* represents an isolated form of the Hawk Moth stem, separating soon after this stem had emerged from the Tineid trunk. The retention of the intercostal vein is then an independent survival of a character shared by both when the Endromid branch made its separate way. Dyar has enabled us to show that the type of the Endromid larva is opposed to the Saturnian and the latter to the Sphingoid type. The neuration excuses me in considering *Endromis* as an aberrant Sphingoid type. It is not improbable that the larva of an existing generalized Sphinx might throw some light on the matter through a comparison of parallel stages. When we turn from the larva to the pupa, we find that the segments of the abdomen are capable of movement in *Endromis* and by their aid the pupa is forced out of the cocoon before exclusion, as in *Anthrocera*, *Cossus* and the Tineides generally. Preparations before me of *Endromis* and *Anthrocera*, hatched in my breeding cages, show a striking similarity in this habit. The Sphingidæ seem to have the habit also, inasmuch as the naked pupa is stated to wriggle its way to the surface of the ground to allow the escape of the moth. Such species as transform on the surface within a slight cocoon have not, to my knowledge, been observed as to this point. This habit indicates a direct connection of the Sphingides with the Tineides. The links between *Endromis* and *Sphinx* appear to have dropped out; also those by which we might more surely trace the relationship between adult forms of the Sphingides and Tineides. Nevertheless, I call attention to the fact that the Anthroceridæ represent a Tineid branch possibly related to the stem which threw off the existing Sphingides.

Leaving these characters, we will consider the neuration. And first the shape of the wings is modified, and this probably in accordance with the method of flight. Disposed as I am to consider the Sphingides and Saturniades as parallel groups, each specialized in a different way, and the Saturniades unquestionably the more highly so, I would compare the Endromididæ with the Saturniadæ and the Sphingidæ with the

Agliadæ (the Citheroniadæ especially). For the moment we will consider and compare the Endromid and Sphingoid wing. The vein on costal edge of primaries (vein I) present in the Hawk Moths is absent in *Endromis*. This vein (or thickening, according to some of the costal edge) is found in the Hesperianæ but not, so far as I know, in the Pamphilinæ. The most striking difference between *Endromis* and *Sphinx*, is found in the evident effort in the former to get rid of vein III2. This springs from the Radius, near III1, in the Hawk Moths. In *Endromis* it is absorbed and appears as a short branch before apex.* This is a secondary character, belonging to the general direction of a diminution in the normal number of the radial veins. This direction has apparently been followed out and brought to a higher stage throughout the Saturniades. But the inequality of its expression is here no indication of the phylogeny, seeing that it is everywhere exhibited in different perfection and upon different lines of descent. It is my *second direction* in the general evolution of the lepidopterous wing.

In my *first direction*,† the suppression of the Media, *Endromis* has progressed further than *Sphinx*. For the cubital direction of vein IV2, often only indicated in the Hawk Moths, here becomes assured and evident. The crossvein already shows signs of degeneration. The wing, in broadening, has lost the strength requisite to sustain swift and prolonged flight. There is, in *Endromis*, a less crowding of the veins; they do not appear so like rigid and parallel rods. There is a larger space between the Cubitus and vein VII, so that VI there appears as a fold in the membrane. Both families retain VIII as a loop to VII on primaries, and there is no trace of other internal veins. On secondaries vein VIII is equally preserved. Looking at the two wings I am met with no character which renders it unlikely that they may have had a common origin. Here is where positive character may be said to end and where the tact and experience of the observer comes into play. But, on the threshold of this disputable region, I can yet point to the intercostal vein and throw the onus of proof on those who dispute the classification. As between *Endromis* and *Sphinx* there is no question which has submitted to most specialization in the neuration. In both

* In *Amphidasys betularia* the absorption of III2 by III1 is clearly seen to be in process of being carried out.

† Perhaps we should call this rather the "second direction," seeing that the suppression of the radial veins is used as a primary divisional character of the Suborder, but in the lepidoptera, as we find them now, the breaking up of the median system excites everywhere the chief interest.

main directions *Endromis* shows the most progress. Still, we shall have to discuss the relation between these specializations and habit, although here the matter may detain us no further.

It may be here remarked that it is not strictly correct to speak of the Cubitus "becoming three or four branched." The Cubitus is always two-branched. It is the movement of the lower branches of the Media, which become varyingly attached to the Cubitus, thereby giving the appearance of increasing the number of the cubital veins. In the opposite direction, it is the same way with the Radius.

SPHINGIDÆ.

The absence of homology between the anal horn of the Hawk Moths and the similarly situated hypertrophied tubercle of the Emperor Moths has been determined by Dyar and is illustrated by me in the "Saturniiden," pp. 7–8. The two groups have then no immediate connection and the correspondence with the Citheronians is illusory, the common habit of pupation of secondary acquirement. The venation, both of *Endromis* and *Sphinx*, entirely warrants this view of the case. We need not detain ourselves with these matters here but pass on to the venation. The mass of preparations I have made show me that this offers no characters of precision for a division into subfamilies. The wings appear cast, like iron, into the same mould. Still there is a play with the branches of the Media and it is often not difficult to decide, as between distinct forms, which is the more specialized. Harder to embrace these forms into groups. A form like *Cephonodes picus* seems specialized from the amount of absorption of vein IV1 by the Radius on primaries, the retreating, almost vanished cell on secondaries, the fusion of IV3 with V1. *Cephonodes* is more specialized than *Hemaris*. As between *Macroglossum* and *Aellopos* it is hard to distinguish; they seem practically identical. The obliquely transverse and rigid crossvein of primaries is the same and all goes to show that the position assigned by me to *Aëllopos* in 1865, among the Macroglossians, is correct and that its placement among the Chærocampians in the Philadelphia List is erroneous. A study of the neuration seems to favor the idea that the Macroglossians are really the more highly specialized of all the groups. On the other hand, that portion of the hind wing between Cubitus and the anal margin appears generally more lappet-like in the Macroglossians (shared by *Aëllopos*) as compared with the Elephant Hawk Moths. There is a decided indentation of the outer margin between V2 and VII. Almost does this character seem a probable test to distinguish the groups.

Still, it reappears more or less evidently and constantly not only in the Chærocampians but in the Eyed Hawk Moths; an indentation appears in *Sphinx ligustri* and *Hyloicus pinastri* and is replaced by a broad excision between VI and VII in *Dilina tiliæ*. It appears less evidently in *elpenor* and *lineata*. There seems then mainly the movement in the branches of the Media, which simply affords a criterion for the relative specialization. Judged by this, *Acherontia atropos* is more specialized than the majority of the Smerinthoid types, although it is overlapped by *tiliæ* and nearly reached by *Smerinthus populi*.* The shape of the secondaries in the Eyed Hawk Moths varies much. This differs even in *Calasymbolus astylus* and *Eusmerinthus geminatus*, while *Copismerinthus ocellata* and the allied North American species are distinguished by the tibial claw.

On the whole, then, the neuration of the Sphingidæ offers apparently no opposition to the general sequence of Kirby, which is that adopted by me in the Buffalo Catalogues, except that I gave the Eyed Hawk Moths a central position. But, for probably the true reason, viz., that I regarded the Smerinthinæ as nearer a more original Sphingoid type, from which the present groups have emerged in different directions. I was much struck by the resemblance of *Ambulyx* with Smerinthoid genera, and fancied that the Chærocampians might have had a separate and nearer connection with the stem which the Eyed Hawks represent. Hence I gave these a central position. The discovery of *Ambulyx sexoculata* Grote, strengthened this view of the case. But the arrangement of the genera adopted by Kirby is open to betterment in the light thrown by the details of the neuration. This is, however, a matter for the future student and need not to be here discussed.

From an examination of Siberian and European examples I would here simply correct Kirby's list of the species of *Smerinthus* and *Eusmerinthus* (Cat. pp. 711, 712). *Copismerinthus* is not a synomym of *Eusmerinthus* Kirby, as wrongly cited (p. 712) but of *Smerinthus* Kirby. This author has not understood the character and mixed the species. *Eusmerinthus* wants, *Copismerinthus* has, a tibial claw.

* From a note made by me when examining Latreille's works, *populi* is indicated as the type of *Smerinthus*, by being once solely cited. I regret that my note is not definite and that I have been unable, despite several efforts, to again consult all of Latreille's publications. Kirby prefers *Dilina* of Dalman, 1816, for *tiliæ*, and this is probably correct.

Eusmerinthus Grt., 1877.
Type: *E. geminatus.*

1. *kindermanni* Led.
2. *cæcus* Mén.
3. *planus* Walk.
   argus Mén.
4. *geminatus* Say.
   ? *jamaicensis* Dru.

Copismerinthus Grt., 1886.
Type: *C. cerisii.*

1. *ocellata* Linn.
   v. *atlanticus* Aust.
2. *cerisii* Kirb.
   opthalmicus Boisd.
   vancouverensis Butl.
3. ? *saliceti* Boisd.

The classificator must rely in great part on the body characters, the pattern of ornamentation, and, so far as I see, will run no great risk of being contradicted by the neurational features overturning his groupings. Nevertheless, when taking the question of specialization in hand, the neuration will afford him valuable hints which he will do well to respect. As to the name for the above genus (*Copismerinthus*) Kirby has adopted my former and original opinion that *ocellata* was the type of *Smerinthus*, an opinion I retained in my "Hawk Moths of North America." But, from my notes of Latreille, I believe *populi* may be really the true type of his genus. Whichever way the matter is settled, by reference to the original works, I have at least here sorted out the species accordingly as the front tibiæ are or are not armed. The North American genera *Paonias* (for *excæcatus*), *Calasymbolus* (*astylus*) seem to me on other grounds distinct from each other and from the above. (Consult an article on the frenulum of the British species of *Smerinthus*, by Geo. C. Griffiths, Ent. Record. VI, 250.)

SATURNIADES.

In the "Saturniiden," p. 6, I figured the first larval stage of the Silkworm, *Bombyx mori*, showing, from the arrangement of the tubercles, that this larva was related to the large group circumscribed by Dyar and which I had called Agrotides. The Silkworm has therefore to be excluded from the Emperor Moths. The Saturniades, cleared of this foreign element, have been taxonomically defined by Dyar by the presence in the larva of a system of subprimary tubercles, wanting in the Sphingides, as here accepted.* The pupa gives the moth within the cocoon. The Citheronian habit is not recorded. A nearer relationship, such as we can show for the Sphingides, with the Tineides is not yet indicated. There exists a temptation to regard the Ptochopsychidæ

* Mr. Grote has misunderstood me. I separate the Saturniides and Sphingides on the position of tubercle iv; neither group has distinguishable sub-primary tubercles. *Endromis* is a Bombycid except for the absence of sub-primary tubercles in stage I, which I do not regard as a strong character at present. I shall return to this point elsewhere.—H. G. DYAR.

and Psychidæ as standing in a connection with the ancestral line of the Emperor Moths, which may be merely noticed in passing.

Bearing in mind the two directions in which the evolution of the wing is chiefly displayed, we find in the Attacinæ their fullest development. In fact the wing of *Rothschildia jacobæa* represents almost the ideal apex of the movement. In the *first* direction, the Media and its system, as such, has completely disappeared. The crossvein has vanished. Veins IV2 and IV1 form part of the system of the Radius, vein IV3 forms part of that of the Cubitus. That portion of the crossvein, belonging to it morphologically, lying between IV2 and IV1, has become physiologically the base of vein IV2*. In the *second* direction, the radial branches are reduced to three from five. Added to this, the concave inner margin of the secondaries has lost vein VIII. By this latter character we are reminded of *Papilio*, and that the concave margin is a specialization is made clearer in this case by its more excessive development, attended by a shrinking in the length of vein VII, in the more specialized *Parnassius*.

There will come a time, to speak after the fashion of Mr. Strecker, and the ancient Greeks, when the uncritical classification which thrusts the Papilionides between the Blues and the Skippers (these latter two, as we believe, nearly related) will be read with amazement. The fable that the Papilionid wing is the most generalized must give way to the view that it is peculiarly specialized by the suppression of vein VIII of secondaries. Generalized it is, as compared with *Parnassius*, but it should not be compared with the other butterflies, since it has had a different line of development. Undoubtedly, the irritable defense of Mr. W. H. Edwards that *Papilio* has six walking legs and *Nymphalis* only four, was not sufficient to dispel the illusion clinging to the system of Bates. It was also felt that the more ideal championship of Wallace, that *Papilio* was so large and complete, could not excuse its being placed "at the head" of a phalanx in reality, a phalanx spreading over the plain of the present without a leader. All this was perceived, and other similar attacks upon a system adopted by my friend Dr. Scudder, and thus made part of the supreme cult of Boston, fell equally powerless. So that newcomers, rising from obscurity, felt themselves obliged to confess the creed as a matter of "my opinion," and to follow up the futile expression of *credo quia ineptum* by the statement that "the sequence is in accord with the more conservative modern classification." Where this more conservative modern classification leads to we may see

* Compare Mittheilungen aus d. Roemer-Museum, No. 8, p. 24.

in the case of Mr. Meyrick, who puts the Caradrinidæ "at the head." As matters stand Mr. Meyrick will undoubtedly be applauded to the echo by Mr. Hulst. Because, in the Lepidoptera, "students have specialized (!) and few collectors, even, go outside of the Macro-Lepidoptera." Prof. J. B. Smith has, "therefore (?) secured the co-operation of Dr. Henry Skinner in the Rhopalocera;" and Dr. Skinner warrants the endorsement of the Preface of the Philadelphia List by placing the Milkweed Butterfly "at the head" of the "Nymphalidæ." After this specimen of "modern classification" one may well put the List by with the feeling that whatever may be the cardinal error of the Boston creed, neither in Brooklyn or Philadelphia is there any salvation. The suppression of vein VIII of the secondaries, in the most specialized of the Emperor Moths, is a direct monition of the value of the character in the Papilionides. In this latter super-family the more specialized forms show clearly additional features of advancement, so that the lessons taught by the suppression of vein VIII is no longer needed to enable us to appreciate their development. The reason why this was not considered is, that the gauge for specialization offered by the wing was not understood, so that loose notions as to sequence and rank were not only permitted, but, the more bizarre they were the more they were thought "scientific," until at last we are landed in the anarchy offered us by Mr. Meyrick.

The Attacinæ have served us here for a text upon *Papilio*, and to the Emperor Moths we now return. The fact that the diminution of the radial veins in a secondary development, occurring in pursuance of evolutionary law, up and down throughout the more specialized groups (such as the Parnassinæ, Pierinæ, Lycæninæ, Saturniadæ and Agliadæ), is shown by a table published by me separating the genera of Attacinæ as the Radius is 3 or 4 branched. For a study of the whole insect leads me to regard the 3-branched *Philosamia* as a specialization of the 4-branched *Attacus* with which its phylogeny probably lies, rather than as nearly related to *Samia*; with which it has the suppression of III_3 in common.

Leaving the Attacinæ, with open cell, we come to the more generalized Saturnianæ* with the crossvein present and, so far as I can see, almost everywhere at least partially functional. Undoubtedly here is a

* It is more correct to commence with the more generalized forms, but I have become convinced that in the Lepidoptera it will always be more practical to adhere to the Linnean sequence, and this for a variety of reasons, among them this, that the contrary course will never be adopted by "collectors," who will thus be deprived of the light thrown or reflected by "scientists."

gap. The gradual stages of disintegration of the crossvein, such as I found in the Pierinæ and Nymphalinæ I have not so distinctly met with in the Emperor Moths. But the first step towards this stage is marked in the Saturnianæ and has already everywhere attained full expression. It is the conversion of the crossvein between IV2 and IV1 into the physiological base of IV2, so that the crossvein proper seems to lie merely between IV2 and IV3 and we can classify the Saturnianæ under the rubric: vein IV2 continuous or on a long stem with vein IV1. That the Saturnianæ have attained a high relative grade of specialization is seen by the loss of vein VIII on secondaries and the absorption of the radical veins on primaries. They have lagged behind the Attacinæ in the first direction: the suppression of the Media and its system. One point more and I have done with this typical subfamily. In the Saturniades vein VIII appears as a loop to VII on primaries. In *Actias* and *Telea* (proving the relationship of the dissimilar appearing imagos) this vein VIII has an outer inferior spur or prolongation. Is this a trace of the vein VIII in its former position as a parallel vein? Or is it a trace of an absorbed additional vein? Or is it a sporadic, or extra-growth? We notice it in *Castnia*. Its isolated appearance in two Saturnian genera makes it remarkable. Misled by Mr. Meyrick's figures of Geometridæ* I at one time thought the curved internal vein of *Papilio* might correspond to the internal vein figured by him in *Venilia macularia*. But it seems not, since the vein figured by Mr. Meyrick does not exist in the Geometrid form.

Next, we come to the Hemileucinæ, and here is a case of disputed classification, a matter I try here to uncover, with the help of the annexed diagrams of neuration obtained by photographic process. Both Professor Comstock and Dr. Dyar unite my Hemileucinæ with my Automerinæ under one "family," which they call Hemileucidæ after Packard. The origin of this notion may be traced back to Grote and Robinson, who, in 1866, established the group Hemileucini with the same contents.† A glance at the figure of the neuration of *Hemileuca maia*, which may also be found in Professor Comstock's beautiful Manual, p. 342 (a book I regret to have only recently become acquainted with), shows that its condition is what we might expect from a more generalized Saturnian. On the secondaries vein VIII is retained, and the retention of this vein is a generalization and repeated everywhere. This affords no proof of the want of relationship between *Hemileuca* and *Saturnia*; if it did, it would equally imply a want of consanguinity

* Consult: Ill. Wochenschrift für Entomologie, Band II, No. 38.

† Ann. Lyc. Nat. Hist. Vol. VIII, 376, October, 1866.

with *Automeris*. But here it is evidently vein VIII which is added to what is, in its total pattern, in its flowing venation, its wide interspacing, its treatment of the Media and its system, its position of vein IV2 —in all these points—the wing of a Saturnian, not the wing of an Aglian. What the addition of vein VIII makes to the wing of an Aglian we see in *Citheronia*. The student will follow me here better by a glance at the figures given, in this way complying with Hamlet's request to look first on this picture and then on this. How impossible does it not seem, that a classification can be correct (and a classification which represents even approximately the phylogeny) which would derive the Automerid from the Hemileucid wing, or the reverse! Is it conceivable that the malleable Hemileucid wing should have stiffened into the Automerid? Or that the rigid wing of *Citheronia* should have produced both? Or to believe with Dyar, that the wing of *Aglia* could have become transformed into the wing of *Saturnia* and *Attacus*, while the very wing of *Aglia*, its pendant, the wing of *Automeris*, should break out with *Hemileuca*? For those who believe in the "more conservative modern classification" it will be no argument to appeal to Hübner and that this writer considered *maia* to be a *Saturnia*; and, in fact, we see that Hübner was often mistaken, such as Professor Smith never is. But, in spite of all his mistakes, we believe that here Hübner is quite right; right also, in the "Tentamen" and in the "Verzeichniss," in recognizing two main groups of the Emperor Moths, which we call Saturniadæ and Agliadæ, and that *Hemileuca* belongs to the first and *Automeris* to the last. We shall try to make this clearer by our remarks on the next family.

AGLIADÆ.

It is to Dr. Packard that we are indebted for calling our attention to the fact that *Aglia* is a specialized Citheronian, and this from other grounds than the neuration, grounds we must here pass over. Before taking up the neuration of the Agliadæ, we will revert for an instant to *Hemileuca* again. The vein we call III1 + 2 in *Hemileuca* springs from the Radius above the cell. In the Agliadæ this is the normal condition of affairs. Its point of emergence travels upwards a little in *Aglia*, as compared with *Automeris*, and herein is the latter the more generalized. But in *Saturnia* it has already been absorbed to a point of issuance from III3 + 4, just before the apex. Now, this is just what we would expect in a generalized Saturnian, and it follows naturally the presence of vein VIII in *Hemileuca*. But the type of *Saturnia*, the long stem upon which IV1 and IV2 sit, is already fully developed in *Hemileuca*.

There remains, then, but the absorption of III1 + 2 on primaries, and the loss of VIII on secondaries to evolve out of *Hemileuca* the type of *Saturnia;* and this without violence and following the lines of evolution which we have shown to be followed by the lepidopterous wing. Now to form the Hemileucid wing out of the Citheronian or Automerid type we must have recourse to violence, and this violence is apparently not considered but committed by Professor Comstock and Dr. Dyar.

The neurational type of *Aglia* and *Automeris* is practically identical, so that their position is parallel to that of *Attacus* and *Saturnia.* We may consider them together. They differ exactly by characters on a line with the evolutionary advancement we have everywhere pointed out. In the *first* direction a hesitating and half-expressed step has been taken by *Aglia.* The cross-vein, *still uneven*, still distinctly reminiscent of its true character as a crossvein becomes oblique between IV2 and IV1. In all the Automerinæ from South America I have yet been able to study, the cross vein is transverse as in *Automeris io.* The point of issuance of III1 + 2 varies somewhat, but little. In this, the *second* direction, as we have above seen, *Aglia* is again more specialized. But otherwise the wings are identical. Neither express any of the distinguishing features of the Saturnian type. Inasmuch as the first direction, the suppression of the Media, is everywhere less progressed, both *Aglia* and *Automeris* are more generalized than the Hemileucid and Saturnian type. In their progression they have lost vein VIII of secondaries, here passing *Hemileuca* by, while the absorption of the radial veins would have rested at the Hemileucid stage. These are all secondary lines of advancement, unequally entered upon. We conclude that *Aglia* represents *Automeris* in the Old World and that it is the more specialized type. Both have sprung from the same near ancestors, the same stem, whether independently, or together, or whether *Aglia* may be looked upon as the outcome of an Automerid form, we can only surmise. But there they are and they belong together, their sundering, by any system of classification, from their common stem, is an act of violence and equivalent to a denial of any lessons to be derived from the neuration, at least so long as their common characters cannot be explained away. We are confident that it is impossible and that the classification we propose is natural and in accordance with the facts.

It does not diminish the difficulty to multiply the families; if we, out of the six subfamily groups originally proposed by me, make, instead of two, the whole six figures as families in our books. Always will *Hemileuca, Saturnia* and *Attacus* come together, always will *Citheronia, Automeris* and *Aglia* coalesce upon the type of wing. That

there is a difference in the closeness of contact we have urged. This difference is the measure of their nearness to a common ancestor. Thus *Attacus* and *Saturnia* are close together, while *Hemileuca* stands apart a little, still sharing the common type of wing which is indicated by the long stem of the two upper branches of the Media. And *Aglia* and *Automeris* are, in an opposite way, quite nearly related; while *Citheronia* stands still further off from these and is much more by itself, though still exhibiting the Aglian type of wing, the absence of stem to the upper branches of the Media, the transverse cross vein, the stiff, equal distanced, parallel veins. To a brief review of what we have published about *Citheronia* we devote the rest of this paper.

The student must study with this paper what Dr. Dyar has written in Can. Ent., 1896, 303, and the phylogeny there given. The drawing there given is correct, except that I suppose the original Aglian stem (assumed to be represented by the existing Citheronian branch) has given off both *Aglia* and *Automeris ;* whether together, or one after another, or whether *Aglia* be an outcome of Automerid-like ancestors, which I am now inclined to assume, I do not decide. My original view of the separation of the six into the two groups is here maintained. I placed *Hemileuca* parallel with *Citheronia*, or but slightly advanced from the difference in general type, from the common retention of vein VIII of secondaries. Above *Citheronia*, as having proceeded from the same stem I placed successively *Automeris* and *Aglia*, the latter being the most specialized. The antennal characters bear out this division. In the Aglian group the female antennæ are short and simple, with few exceptions in specialized forms. In *Attacus* and *Saturnia* they become pectinate. I consider *Citheronia* as specialized in peculiar directions, and as having lost much original character and added new ; still, by the retention of vein VIII, as being, rather, the representative in direct line of the original stem. But this view is, for the moment at least, subordinate in importance to the correct placing of *Hemileuca*, to the breaking up of the assemblage of *Automeris* and *Hemileuca* by Grote and Robinson, Packard, Comstock and Dyar. This is the main classificatory result which I believed to have attained in my recent studies of the Emperor Moths. For, whether *Citheronia* represents the main branch (in assuming which I am not a little influenced by Dr. Packard's paper), or whether *Automeris*, is clearly of inferior value to the main fact, that *Aglia*, *Automeris* and *Citheronia* belong together, while *Attacus*, *Saturnia* and *Hemileuca* represent another, and, on the whole, more advanced phylogenetic line upon the same stem. The student

may consult also my illustrated paper in the "Verhandlungen der Gesellschaft Deutscher Naturforscher und Aerzte" 1896, p. 197. In a linear series we would arrange the generic types thus: *Attacus*, *Saturnia*, *Hemileuca*, *Aglia*, *Automeris*, *Citheronia*.

In a foot-note, Journ. N. Y. Ent. Soc., VI, 46, I have written that the crossvein becomes oblique in *Aglia* and *Citheronia*. As I recollect, I had in my mind to write *Eacles*, but a fresh study of the latter genus, and all the Citheronians now accessible to me, has led me to the conclusion that everywhere in this group the crossvein remains transverse. No steps that I can now clearly recognize as such have been taken, as in *Aglia*, towards an independence of IV2. But even were my former statement correct, the argument supposed to be drawn from it is futile. For the movement is secondary in its nature and would not indicate any necessary nearer connection between *Aglia* and *Citheronia*. What we want is primary character, underlying the general type of the wing and this we have found in the long stem of IV2 and IV1 in *Saturnia*, together with the other comparative characters here discussed, as opposed to the issuance of IV2 from the crossvein in *Aglia*, together with the equally opposing features above summarized.

We have above admitted that the peculiarly Citheronian type of the Agliadæ, stands at a greater distance from *Aglia* and *Automeris* than these two from each other. It remains here to point out these differences and emphasize the conformity to a common type of wing. The wing in the Citheronians has pursued a slightly varying form of specialization of the Media from the other groups of Emperor Moths, one that we meet on occasion again in the Day-Butterflies and also the Hawk Moths. How far this variation is caused by the mechanics of the wing, I cannot now enter upon. Vein IV1 travels up the lower edge of the Radius, and the extent of its absorption by the Radius is the measure of the specialization of the genera. These stand, in ascending order, *Eacles*, *Citheronia*, *Anisota*. I do not know the neuration of *Sphingicampa*, nor whether it bears out my formerly expressed idea that it stood nearer to *Eacles* than to *Citheronia*. It is probably a specialized form. But although the wings of Citheronians are on the whole perhaps more specialized, as compared with *Automeris*, and in a different way, we have more than a reminder of the Aglian and Automerid pattern. The Radius is four-branched, and this is the natural precusory stage of the three-branched, here the Aglian and Automerid, wing. In *Anisota* vein III1+2 has traveled up the Radius and is given off beyond the cell. In the median system vein IV2 inclines to the Radius, and vein IV3

comes into near contact with the Cubitus, thus following the course of specialization in the entire group, by which the middle branch of the Media becomes radial in disintegration. But the pattern remains distinctly Aglian, the veins are stiff, tend, even in the most highly specialized forms, to remain equidistant, there is no effort to lead to the Saturnian pattern, indeed there seems no possibility of a progression in this direction, vein IV1 having taken quite a contrary course, a course entered upon already by the most generalized form, *Eacles*. But this course is possible from the Aglian, not possible from the Saturnian types. Vein VIII of the secondaries is retained, while it is shortening. Knowing, as we do from Dyar's studies, that the larva conforms to the Saturniades type, it becomes a matter of comparative less importance whether we confer upon the Citheronians family rank. Under this general view of the position of *Citheronia*, we consider the slighter correspondences in venation with the Hawk Moths to stand in relation to the narrowing of the wings and the habit of pupating in the ground to have been separately acquired. The Citheronians have pursued a peculiar path in evolution and one that stands in relation with their comparatively limited geographical distribution. They seem confined, as long ago pointed by me, to America, east of the rocky backbone of the two continents.

From the clear exposition of Dyar, Can. Ent., 28, 303, it seems impossible to reconcile a phylogeny based on the larval tubercles of the Saturniades with the one proposed by me on the neuration. Taking the latter as the final appeal we are obliged to suppose, that *Attacus* and *Saturnia* on the one hand and *Aglia* on the other have independently acquired the tubercles on anal plate. According to the value placed by Dyar on these organs, I must agree that this seems impossible. On the other hand, I cannot find it probable, indeed, it scarcely seems to me possible, that *Aglia* (which, in the same wing pattern of venation, clearly represents a more specialized type than *Automeris*) should belong to the Saturnian branch and wing pattern, as a generalized type. Nor does it seem to me within the range of probability, that *Automeris* or *Citheronia* could have produced the wing pattern of *Hemileuca*. On our respective trees, the groups represented by *Hemileuca* and *Aglia* change places. The female antennæ of *Aglia*, *Automeris* and *Citheronia* are of one type, so far as I can see; also those of *Attacus*, *Saturnia* and *Hemileuca* hold together, both types appearing distinctive. *Hemileuca* is just what one would expect of a generalized Saturnian; *Aglia*, just what one could agree that a specialized Automerid might

be. Vein VIII on secondaries has been retained by the two "lowest" groups on the respective branches, *Hemileuca* and *Citheronia*, exactly as appears most natural, in my tree, wheras in Dyar's *Hemileuca* goes to the top. The association of *Hemileuca* and *Automeris* as equivalent groups by Dyar seems, from this point of view, impossible. The whole wing pattern of the Agliid branch on my tree holds together, with *Citheronia* as its slightly dissenting feature, while the whole wing pattern of my Saturnian branch holds together without any discordant element whatever, unless the presence of VIII in *Hemileuca* is one, but this does not prevent Dyar placing it with *Automeris*. So that it is possible, from the neuration, to admit of three "families:" Saturniadæ, Agliadæ, Citheroniadæ. Further than this we cannot go, and the matter must be left for more light. If *Aglia* belongs to the Saturnian branch and *Hemileuca* to the Automerid, then Dyar is correct, if not, then I am justified.

The strength of Dyar's argument and his system in general lies in the indifferent nature of the position of the tubercles. Where such ornaments or their details can be proven to be useful to the organism, adaptive, they are clearly secondary and their importance fails. I cannot judge of the value of the tubercle on the anal plate, but must take Dyar's word for it that it is primary. So we are at a deadlock. The pattern of the wing venation, not the position of the movable veins, is for me primary. In this case *Hemileuca* displays the Saturnian pattern. The presence of vein VIII on secondaries is subordinate in value to this. *Hemileuca*, from the pattern of neuration, can not, by any reasonable process, have either been derived from *Automeris*, or alongside of it, or represent its ancestor—the rôle Dyar expects to fill, since it is less specialized. Its capabilities are exceeded by one and all of these demands. *Automeris*, on the other hand, may very well have thrown off *Aglia*, indeed I believe that *Aglia* sprang from Automerid-like forms. I can also clearly see, that *Saturnia* must have sprung from Hemileucid-like forms. So different are *Saturnia* and *Aglia* they are with difficulty compared. *Citheronia*, while at the bottom, showing the Castnia-like pattern of *Aglia* and *Automeris*, presents a modification in the movement of vein IV1, analogous to the Sphingidæ, Pierids and *Nemeobius*. *Attacus* and *Saturnia* show the Nymphalid movement of the meridian branches, but add to it the Pierid and Lycænid specialization of the radial branches. *Rothschildia iacobææ* has the most specialized neuration of any lepidopteron known to me. On another line, the common White butterfly competes with it.

Not only does *Rothschildia* carry the Nymphalid and Lycænid secondary movement of the veins to an extreme, but it shows also the subprimary Papilionid specialization of the hindwings, the inner margin hollowed out, and VIII vanished, characters evinced by the Attacinæ. No better proof can be offered to sustain the thesis, that rank is a relative conception and that corresponding specializations are worked out upon different phylogenetic lines. And we see that it is inevitable, that systematists like Mr. Scudder, who erect an imaginary sequence upon the fastening of the chrysalis, or other congruous class of facts, and finding some example, like *Oeneis*, which meets their fancied requirements, proceed to place this "at the head" of the lepidoptera, must be doomed to disappointment.

The arrangement for the new check list may be provisionally laid down here, so far as embraced, by the two parts of my revision now published. I may say, that, so far as my preliminary studies are concerned, I believe to recognize eight superfamilies in the Lepidoptera: Papilionides, Hesperiades, Sphingides, Saturniades, Bombycides (Agrotides), Tineides, Micropterygides and Hepialides. I would keep as near as may be to the Linnean sequence, transferring the Sesiadæ and Anthroceridæ from the Sphinges to the Tineides; and the Cossidæ, Apodidæ, Ptychopsychidæ and Psychidæ from the Bombyces to the Tineides.

To sum up: In *Hemileuca*, as in *Saturnia*, veins IV1 and IV2 are furcate at the extremity of a long stem. This stem is morphologically the extension of that piece of the cross-vein lying between IV1 and the Radius. Vein IV1 is thus prevented absolutely from ascending the Radius, as it can in *Aglia* and *Automeris*, where no such extension takes place or offers to take place, and does in *Citheronia*. The neuration here demands, in a positive manner, the classification advanced by me. No looking at the neuration "broadly," no trifling as to terms or the theoretical value of certain changes in the movable veins, can ever obscure this point, which proves that *Aglia* can never be brought into a connection, either as a derived or original representative form, with the typical Saturnians. The dichotomy proposed by me is borne out by all exotic Saturnians I have been able to study. On the other hand, the reference of *Endromis* to the Sphingides is not positively demanded by the neuration; a shorter vein, connecting II and III, and bending down II, near base of hindwings is present in *Bombyx mori*. From uncompleted studies in the Lachneidæ, this may not be homologous. The union is at most not contradicted strongly. It becomes

somewhat probable by the extension of the movable pupa from the web, a character not found in the Bombycides (Agrotides).

A. PAPILIONIDES.

Fam.	I.	PARNASSIIDÆ.	Type.	*P. apollo.*
"	II.	PAPILIONIDÆ.	"	*P. machaon.*

B. HESPERIADES.

Fam.	III.	PIERIDÆ.	Type.	*P. rapæ.*
"	IV.	NYMPHALIDÆ.	"	*N. lucilla.*
"	V.	AGAPETIDÆ.	"	*A. galathea.*
"	VI.	LIMNADIDÆ.	"	*L. chrysippus.*
"	VII.	LIBYTHEIDÆ.	"	*L. celtis.*
"	VIII.	NEMEOBIIDÆ.	"	*N. lucina.*
"	IX.	RIODINIDÆ	"	*R. lysippus.*
"	X.	LYCÆNIDÆ.	"	*L. endymion* (teste Scudder.)
"	XI.	MEGATHYMIDÆ.	"	*M. yuccæ.*
"	XII.	HESPERIADÆ.	"	*H. malvæ.*

C. SPHINGIDES.

Fam.	XIII.	ENDROMIDIDÆ.	Type.	*E. versicolor.*
"	XIV.	SPHINGIDÆ.	"	*S. ligustri.*

D. SATURNIADES.

Fam.	XV.	SATURNIADÆ.	Type.	*S. pavonia maior.*
"	XVI.	AGLIADÆ.	"	*A. tau.*
"	XVII.	CITHERONIADÆ	"	*C. regalis.*

EXPLANATIONS OF PLATES II AND III.

The accompanying figures of the neuration of Saturniades are obtained by photographic process and may thus be relied upon for exactness. The numbering of the veins is in accordance with the corrected Redtenbacher-Comstock system as applied to the Lepidoptera. III = Radial veins; IV = Median veins; V = Cubital veins.

Fig. 1.—*Saturnia pavonia maior.* This and the succeeding represent the Saturnian type, in which IV2 becomes continuous with IV1. The crossvein appears to obtain merely between IV2 and IV1 the middle branch of the Media becomes Radial. In the Attacinæ, here not represented, the crossvein vanishes.

Fig. 2.—*Hemileuca maia.*—The same Saturnian type is exhibited with the secondary distinctions that vein III1+2 springs from the Radius above the cell. In *Saturnia* it has travelled upwards to a point just before apex; by this character *Hemileuca* is more generalized. Also with the difference that vein VIII of hind wings, suppressed in *Attacus* and *Saturnia*, is here retained. Else it equals *Saturnia.*

Fig. 3.—*Aglia tau.* This and the succeeding figure represent the Aglian type of wing. Attention is called to the oblique outward direction of the still uneven portion of the crossvein between IV2 and IV1, the first indication of a secondary movement tending to the disintegration of the system of the Media.

Fig. 4.—*Automeris io.* The crossvein is transverse, and no indication of the secondary movement of the crossvein in *Aglia* is observed. The point of issue of III1+2 is removed further towards the base of the wing. In these two points the Automerid wing lags behind, or is more generalized, than the typical Aglian wing. Else it equals *Aglia.*

PROPOSED GENEALOGICAL TREES OF THE HAWK AND EMPEROR MOTHS WITH REFERENCE CHIEFLY TO THE NEURATION.