

The posterior margin of all the thoracic segments is edged with a row of small tubercles. The epimera are narrow, those of the second, third and fourth segments being rounded at the top, while those of the last three segments are more acute.

The first abdominal segment is entirely concealed by the last thoracic segment. The second, third, fourth and fifth segments are likewise edged with a row of small tubercles. The last segment is widely rounded. The outer branch of the uropods is somewhat narrower and shorter than the inner one and is rounded at its extremity. The inner one is bluntly rounded. Both are fringed with hairs, and on their exterior margins are armed with spines. The prehensile legs have three long, stout spines on the merus and two on the propodus. The gressorial legs are covered with spines.

Two individuals of this species were found in the southern part of the Gulf of California, at Station 2824, eight fathoms, type (U.S. Nat. Mus., No. 20652), and Station 2828, ten fathoms.

SPECIALIZATIONS OF THE LEPIDOPTEROUS WING ; THE PIERI-NYMPHALIDÆ.

(Plates I-III.)

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An immediate incentive to the present study is the statement, in *Evolution and Taxonomy*, that we find, in the Nymphalidæ, "an even greater specialization of the wings than exists in the Pieridæ." It may be premised that Prof. Comstock's classification unites in one family two seemingly distinct types under the term Nymphalidæ. Also that the neurational character given in the more recently issued "Manual" of the same author for the Pieridæ would exclude the Leptidianæ. The two wing types of the Nymphalidæ of Mr. Scudder and Prof. Comstock overlap. The Nymphalidæ proper, as I would limit the family, have vein iii_4 of the fore wings thrown off upon the external margin below apices throughout all the leading groups. But in the Fritillaries, which seems to be the most generalized group, there are genera, like *Euptoieta*, in which this vein reaches the apex, as in all the other brush-

footed butterflies. But, commonly, we can tell a Nymphalid from a Satyrid by this character. Again, on the hind wings, the Nymphalidæ proper show vein iv_3 entirely joined to the cubitus, and not issued from the cross-vein. In the Limnadidæ, Heliconidæ and Agapetidæ, which appear to form another branch of the "brush-footed" group of butterflies, this latter condition of vein iv_3 is only reached in a small group of specialized Satyrids, the Pararginæ. This character is plainly secondary, one which might occur independently in different groups not immediately phylogenetically connected.

The specializations of the lepidopterous wing, here chiefly considered, are visible among what I have called the "movable veins" and cannot be relied upon as decisive in general phylogeny. Their study leads to an arrangement of genera and species, in most cases upon a more positive basis, by supplying us with a gauge by which we may distinguish the younger from the older form. The norm by which these specializations are apprehended lies in the principle we have already set forth: the amount of the absorption is the measure of the specialization.

The two principal directions in which the specialization is manifested are: 1. the suppression of the media, common to both wings, and 2. the suppression of the branches of the radius, confined to the fore wings in most Lepidoptera and occurring sporadically. The latter is probably reminiscent of that action which has completed its task upon the hind wings of such Lepidoptera which have the radius already reduced to a single unbranched vein.¹

NOMENCLATURE.

The application of literary terms to structural groups, wider in extent than specific, has become uncertain through the publication of varying and subjective opinion. It has, therefore, become necessary to associate the generic title with a single specific type, ascertained by historical methods, in order to go safely. The failure to employ the name of the genus in this manner renders Mr. Reuter's recently published volume at times unintelligible. The same remark applies to Dr. Chapman's admirable paper on butterfly

¹ Consult, "Mittheilungen a. d. Roemer Museum," 8, February, 1897; "The Hind Wings of the Day Butterflies," Can. Ent., 29, 174; also several other papers more recently issued.

pupæ, where exactly what is meant by the terms "Satyrus, Epinephele, Hipparchia," does not appear (*Entom. Record*, vi, 152). So far as the diurnals are concerned the authority I recognize is Mr. Scudder's *Historical Sketch*, Salem, 1875. Since, in exceptional cases, this work has been seemingly properly corrected and even in one case by the author himself, a republication up to date would be one of the most grateful of literary helps to the systematist, to whom it is a matter of comparative indifference what term he uses so that it is correct and exactly conveys his meaning, while it should be one necessarily understood. Since the difference between genera and species is quantitative, the limitations of the former will be always more or less a matter of opinion. As matters are now and unless a standard is recognized, the object of nomenclature will be defeated so far as generic titles used by themselves are concerned. Both to give greater endurance to his work and to make it a useful addition to generic definitions extant in literature, the systematist might confine his studies to species used for generic types as far as possible and neglect those not yet so favored. To locate and compare genera their types need alone be considered; by clearly explaining the structure of these incidental help will be afforded to reach an approximative agreement as to the limitation of generic groups. Generic terms should always have the same meaning attached to them, and this meaning can only be derived from the structure of their types. I remember that Moeschler, disputing the validity of the genera allied to *Smerinthus* and wishing to discredit minute generic differentiation, asked triumphantly, To what genus, then, do the hybrids between species belonging to these different allied genera belong? A little reflection might have led him to ask the question also, And to what species? For although, to Moeschler, a genus would seem to have constituted a fixed quality, yet it is seen not to be so and that the genus idea is an extension of the species idea, and both ideal categories having a relative being without sharp outlines. In the formation of generic categories the idiosyncrasy of the describer comes easier to the surface, as in Mr. Scudder's genera; but for the purposes of the systematist these are as good as any, and better than most; all that is wanted being a certain name attached to a certain thing. The describers of species are the *avant couriers* of the systematists, one no more useful than the other, and any adverse criticism of the former class, who throw the first light upon our darkness, must be due to a lack of thought and considera-

tion. Nomenclature itself belongs to letters and is part of the machinery which biologists must use to work with. And we may remember here the fact that we possess no entire and satisfactory definition for the term *individual* as used in biology. So that it perhaps naturally follows that we are at a loss to define adequately groups or associations of which the individual forms the unit.

The following notes explain the changes made by me in

THE NOMENCLATURE OF THE PIERI-NYMPHALIDÆ.

Agapetidæ.—I use this term instead of Satyridæ because the generic title Satyrus Latreille is preoccupied (Scudder, *l. c.*, 265), and is properly replaced by the title Agapetes Bilberg, 1820 (*l. c.*, 104), with the same type, *A. galathea*. It is impossible to separate the name of a higher group from that of the genus upon which it is based. If Satyrus properly falls then Satyridæ must also go. But the type of Satyrus remains and the new generic title of this type by natural right replaces the old title in all its various modifications. It appears that the more modern title Satyridæ replaces the Satyri of older authors who antedate the Tentamen in the use of a plural form, thus in recognizing a group or family in our sense. In addition the term Oreas (Oreades) used by Hübner in 1806 is itself preoccupied. So that the claim of Agapetidæ to designate the family, with *Agapetes galathea* as its type, seems indisputable. Arge of Esper and also of Hübner would be preoccupied by Schrank (*l. c.*, 117).

Limnadidæ.—The earliest plural form applied particularly to a member of this group is Limnades of Hübner, 1806, based upon *Limnas chrysippus* as type. This must, therefore, replace the term Danaidæ of modern writers, a term based upon the later Danaus (*plexippus*) of Latreille, 1809, for which Scudder proposes to retain Danaida of the same author of 1805 (*l. c.*, 153), perhaps disputably, since Latreille's change seemed warranted at that time. Once a synonym always a synonym. In any case the modern Danaidæ cannot claim any connection directly with the *Danai festivi*, etc., of Linné, since that group had no legal standing; no genus of that name upon which it could be based having been published. Cuvier's similar use of "Danai" included also the Pieridæ (*l. c.*, 154), and, therefore, Limnadidæ has a clear right to recognition.

N. B.—I take the opportunity here to change my term Capis to Capisella since there is an earlier genus, Capys of Hewitson, which

interferes (PROC. AMER. PHILOS. SOC., xxxiv, 434). I also resume my name for *Lomanaltes lætulus*, since from the description it must be that Mr. Walker's species differs.

GENERAL DESCRIPTIONS.

These are limited to the holarctic fauna, of which the principal genera appear to have been examined. There remain, however, several types I have been unable to obtain.

Pieridæ. Pierinæ.—Primary wings, *specialization by suppression of the media*: Traces of the base of the media in the shape of scars I have found in *Eurymus* and *Callidryas*. In *Colias rhamni*, a mimetic form springing evidently from the same line, I fail to find the least impression. Backward spurs occur in *Aporia* and faint traces in *Callidryas*. The cell nowhere completely opens. The cross-vein becomes partially degenerate in a number of instances. In all the genera yet examined, vein iv_1 , the upper branch of the media, leaves the cross-vein and is given off, outside of median cell, from the lower branch of radius. This character I only find again on the hind wings of *Nemeobius*. The middle branch of media leaves cross-vein above the middle and is radially inclined.

Primary wings, *suppression of radial branches*: End forms of specialization in this direction are offered by *Mancipium*, *Pontia* and *Nathalis*, where the five branches are reduced to three. The bulk of the forms: *Pieris*, *Eurymus*, *Colias*, *Callidryas*, *Eurema*, etc., are four-branched. As yet I find only certain of the *Anthocharini*, therefore the more generalized group, five-branched.

Secondary wings, *suppression of media*: Taking the homologies as given, the vein iv_1 assumes function and position of iii_5 on primaries; usually the piece between its base and the issuance of iii_5 from radius must be reckoned to cross-vein. The inauguration of the movement of the movable veins appears to take place on secondaries generally, since in a number of *Lepidoptera* vein iv_2 remains central on primaries, while on secondaries of same wings it inclines radially or cubitally. As on primaries, the cross-vein nowhere disappears in the *Pierinæ* and the cell remains closed.

Other features of specialization by absorption of veins: On primaries, vein $viii$ is present, either as a scar or, in some instances, as an apparently functional, "tubular" vein. It takes the aspect of a short, oblique, more or less rigid piece, running from vein vii to internal angle. It has usually lost here the appearance of being

originally a longitudinal vein rooting in base of wing and, as in the Limnadiidæ, appears more as a supporting strap. However, in Terias, where it is reduced, it assumes nearly the loop-like shape. The minute study of this vein is a matter of some difficulty. The appearance of vein viii in the Hesperiadæ corresponds essentially with that in the Sphingidæ and Saturniades, where it has the loop-like shape. These quantitative changes are probably correlated with mechanical function. On the secondaries of the Pieridæ, there are but slight differences in the amount of absorption of veins ii and iii at base; on the whole, the absorption is small and herein is the wing generalized. Vein i, the so-called "præcostal spur," is usually present; it vanishes in the Eurymini and in Colias (*Gonepteryx*); it may be seen in *Callidryas*. There is no equality of specialization, no exact and equal step in all these instances and the position of a genus or group can here not be assigned with certainty from any one character. Better, as a guide, is the radial specialization on primaries, where it may be laid down as an axiom that the five-branched forms cannot possibly have been derived from the three or four-branched, and that they are consequently descendants of older types and clearly more generalized insects. But neither may we group all the three or four-branched species together, since these specializations are reached upon what are otherwise evidently independent phylogenetic lines, in all cases necessarily succeeding a five-branched ancestor. Thus the three-branched *Pontia* is clearly an offspring from the five-branched *Anthocharini*; the three-branched *Nathalis* is more immediately connected with the four-branched *Terias* and *Eurema*.

Leptidianæ.—So different is this butterfly and so isolated its present position, that we must almost leave it out of sight in discussing the specialization of the Whites. The suppression of the media is nearly limited to the extinction of the basal portion. The position of vein iv_2 is central, or very nearly so, on fore wings, cubital on hind wings; we have here an exceptional parallelism with *Papilio*. The radius is generalized, five-branched. No trace of vein viii appears on fore wings. The median cells are small, retreating; the veins long. In comparison with the other whites, the wings are in a generalized state, but the chances are that in *Leptidia* (*Leucophasia*) we have a survival of what was a more extended group at one period and that the generalization is strictly relative. The disappearance of vein viii points in this direction.

A feature of generalization is offered by ii and iii of secondaries which appear completely separate.

Nymphalidæ.—This term is used in a restricted sense, equivalent to the Nymphalinæ of Comstock, or typical Nymphalids, apparently taken from Scudder.

Nymphalinæ.—Characterized by the position of i, ii and iii, of hind wings, which spring from one point owing to the fact that ii and iii are absorbed or fused up to the origin of i, which remains nearly constant in all the butterflies examined. This character is secondary in its nature and I have not yet studied the phylogeny of the genera fully. In this subfamily the suppression of the media reaches its widest extent and is only paralleled again in the Attacinæ. In the most specialized forms the cell entirely opens, all trace of the cross-vein vanishes on both wings. Vein iv_2 becomes radial. Vein iv_1 leaves upper angle of cell and does not fuse with radius.

Argynninæ.—Characterized by the fusion of ii and iii on hind wings not attaining the point of origin of i. No taxonomical features of neurulation clearly define the minor groups, which are generally bound together by steps in the grade of specialization shown in the gradual suppression of the media. The "Goat Weed Butterflies" belong probably to the Charaxinæ, a specialized form having lost the "long fork" through absorption, but are not so specialized as the Nymphalinæ or "Purples," as might be inferred by their position in Comstock's *Manual*. In this work, as well as Mr. Scudder's, the sequence, as based on a specialization of the wings (and no other characters or class of characters allow of such fine distinction) is irregular. In the Check List of Dr. Skinner (1891) the disarrangement is nearly complete.

Agapetidæ (Satyridæ).—Wings (except in the Pararginæ) as in Pieridæ, but vein viii of fore wings entirely absent; vein iii_4 of fore wings to apex. The veins in many forms show a secondary sexual character in the enlargement of vein ii, the cubitus, or vii at base in male. This character is indicated in the Nymphalidæ, in Potamis and some Fritillaries and in the Ager.

Pararginæ.—The cross-vein of hind wings, or its traces, joins the cubitus; in other words the union of vein iv_3 with cubitus is complete, since this branch of the media has left the cross-vein. Here there is, in this apparently restricted group, a complete parallelism with the Nymphalidæ, from which the butterflies differ by

the position of vein iii_4 of fore wings. Cross-vein degenerate between iv_2 and iv_3 or cubitus, as might be expected, on hind wings, while on fore wings the specialization has not proceeded so far. Genera: Pararge and Lasiommata.

Agapetinae (Type: *Agapetes galathea*).—Vein iv_3 of hind wings springs from cross-vein as in Pieridæ and next two succeeding families. All the North American genera I have yet examined (but many remain), and most European Satyrids belong here. The cross-vein is partially degenerate, but as long as vein iv_3 keeps its position and does not fuse with cubitus this may not here disappear. Vein i of hind wings varies in expression and, almost vanishing in *Coenonympha*, is quite absorbed in *Pyronia*. It is diminished in *Cercyonis*. Probably its study may give us a better arrangement of the European forms. In *Eumenis* it terminates squarely as in the *Pararginae*, and again in *Nymphalis*. In the other genera it is pointed. Owing to the inequality and slight nature of the specializations in the *Agapetinae*, it will require a minute and patient comparison to straighten them out. Any rough classification or sequence attempted on "general principles" must be always nearly valueless. *Ceneis* is evidently a generalized form.

Heliconidæ.—Study of the type: *Heliconius antiochus*. As in all the "brush-footed" butterflies, the radius on fore wings is in a five-branched generalized state, while iv_1 springs from upper corner of median cell. Cells completely closed, the cross-vein merely thinning a little below iv_2 . No trace of vein $viii$, hence more specialized than *Limnadidæ* and agreeing with *Agapetidæ*. Vein iv_2 nearly central, a little radially inclined on fore wings and considerably more so on hind wings, where the cell is small, retreating, the veins long. Vein i determinate, pointed. The radius of fore wings is more specialized than in *Limnas*, where iii_2 leaves the stem opposite cross-vein. Here vein iii_2 arises beyond the cell. A more generalized wing than that of the *Agapetidæ*, more distinctly a *Limnad* type. All traces of the base of media disappeared; no trace of backward spurs from cross-vein.

Limnadidæ.—Study of the type: *Limnas chrysippus*. On the five-branched radius of primaries vein iii_2 springs from a point opposite cross-vein. Vein $viii$ on fore wings present strongly developed. Veins strong; cells closed; a backward spur from cross-vein on fore wings opposite iv_2 , the position of which is central. On hind wings this vein is slightly radial. Vein i of hind wings imperfectly

fused with radius at base ; cross-vein angulate. The curious stigma below v_2 is attended by a rounded retreat of the vein, which is here slightly swollen. On comparing this type with that of *Heliconius* it is seen to be the more generalized. To separate *Danaus* from *Limnas* we must encroach apparently upon specific characters.

Libytheidæ.—Vein iii_4 to costa before apex ; cross-vein partially degenerate ; vein iv_2 on primaries central, on secondaries radial ; vein $viii$ of fore wings strongly developed as in *Limnadidæ*. Outline similar to *Polygonia*. On secondaries the cross-vein reaches vein iv_3 just immediately before cubitus. Specialization here almost like the *Pararginæ*. This isolated group, with its strongly developed labial palpi, cannot be referred to the stem of the *Nymphalidæ* proper (in *sensu mihi*) on account of the position of iii_4 and the presence of $viii$ of primaries. It must be referred back on an independent line to the matrix from which the "brush-footed" butterflies originally sprang. It is now a specialized form as is seen by the extent of absorption of ii and iii , on hind wings, to the point of issuance of i , thus equaling the *Pararginæ*.

Nemeobiidæ.—Not a typical "brush-foot," but with the fore feet reduced in the male on the *Riodinid* type. Special examinations of this structure are needed to bring out the points clearly. Wings of the *Pieri-Nymphalid* pattern, not of the *Lycæni-Hesperid*. Radius five-branched, generalized. It is thus impossible to bring the butterfly into the *Lycæni-Riodinid* series in which the radius is specialized, three to four-branched, while the other neurational features contradict the supposition that it could represent a generalized type of the series. The neuration runs parallel with *Libythea* and the resemblances lie between this butterfly and *Pieris*. Vein iii_4 seems to join costa just before apex. Cross-vein entire, cells closed ; on fore wings vein iv_2 is central, on hind wings radial. Vein $viii$ of primaries seems to be degenerate and I represent it by dots in my original figure. Subsequent studies lead me to believe it wholly or partially tubular. Veins ii and iii of secondaries at base fused nearly to point of issuance of i , hence nearly as specialized as *Libythea*, much more so than in any *Riodinid* or *Lycænid* yet examined. When writing my original paper (in 1896) I failed to note that the family *Nemeobiidæ* had been recognized, though I have found no description and the study of the neuration seems to have been neglected. To unite this butterfly with the *Lycæni-Hesperid* branch appears to me a physiological impossibility. It

must rather be relegated to a distinct line, running parallel with the Libytheidæ and leading to the main stem of the Hesperiadæ. Its affinity with the Pieridæ is marked by the position of iv_1 , which, on secondaries, has left the upper angle of cell and is fused with the radius to a point much beyond the median cell, as in the Pierinæ. Since there is a parallelism in the specialization between the Lycænid group and the Pieridæ in the reduction of the radial branches, a further parallelism might be made to account for this, especially as on primaries vein iv_1 is fused with radius as in the Theclinae. But this will not explain the position of vein iii_5 on external margin, the radial position of iv_2 and the more unequal spacing. We might appeal to the imperfection of the geological record and conjure up extinct and intermediate series; but, independent of the fact that such flights of the imagination would lead us nowhere and would excuse even the arrangements proposed by Mr. Meyrick, we cannot do away with the main difficulty, that the wing of Nemeobius is developed upon the Pieri-Nymphalid pattern and that we should not logically graft it upon the Lycæni-Hesperid. The radius is also generalized, five-branched and cannot be derived from a three to four-branched group, which it should have preceded. But the five-branched Hesperiadæ are formed upon another pattern and could hardly have given rise to Nemeobius. The five-branched Hesperiadæ have most plainly produced the three to four-branched Riodinidæ and Lycænidæ. The wing of the latter is just what we might expect from a reduction of the radial branches of Hesperia. The conclusion we may come to is, that we should seek for the origin of Nemeobius in an independent line, and that the structure of the fore feet has been probably independently acquired. There is no difficulty in this, since aborted fore feet are also characteristic of certain moths belonging to the Hypeninae, notably of *Pallachira bivittata* Grt. There seems to be a latent tendency in this direction which has broken out strongly in the day butterflies.

GENERAL COMPARISONS.

Before entering upon any comparison as to the amount of specialization in the Pieridæ and the "brush-footed" butterflies (=Nymphalidæ of Scudder and Comstock) it will be well to get a mental picture of the neururation of the Pieri-Nymphalidæ as a whole. This can best be obtained by contrasting it with that of an allied wing group in the same structural series, the Lycæni-Hesperidæ. Inde-

pendent of relative breadth or shape of wing we have in the latter a simpler pattern, the veins more equidistant, an indisposition to fuse and furcate shown by the retention of a central position by vein iv_2 ; so that as the suppression of the media takes its course this branch tends to degeneration *in situ*, from resisting the attraction of either radius or cubitus. As opposed to this we have a willingness in the Pieri-Nymphalidæ to preserve vein iv_2 , which latter tends everywhere to become radial, except in the isolated case of Leptidia, where it becomes cubital. We have a spreading of the veins and abundant traces of unequal specialization. Except in the lycænid reduction of the radial branches, the Lycæni-Hesperiadæ offer few neurational changes to aid our formation of classificatory categories; the Pieri-Nymphalidæ plenty. United by the presence of the looping vein viii, or its traces unequally expressed and sometimes quite vanished, the Hesperiades offer in this way two groups characterized by the peculiar neurational wing pattern; giving us also an instance of parallelism in specialization, in that the Pieridæ sustain an analogous position with regard to the "brush-footed" butterflies (Nymphalidæ, etc.), to that the Riodinid-Lycænids show with respect to the Hesperids or "Skippers." In both these groups the reduction of the radius takes place; the Pierids still showing phases embracing and intermediate between the five and three-branched radius, while no five-branched Lycænid is yet known to me. Thus the gap in the Lycæni-Hesperiadæ between the subgroups is greater than that between the subgroups of the Pieri-Nymphalidæ. But the fact that the reduction of the radial branches has been independently taken up by the two main wing groups of the Hesperiades comes clearly out. I have been unable to find any characters which will always distinguish the neururation of the Hesperiades from the moths. Not so with the Parnassi-Papilionidæ, a distinct major division entirely left out of sight in the present studies.

Having thus endeavored to trace the outlines of the neururation of the Pieri-Nymphalidæ as a whole and to enable the reader to grasp more or less fully the wing structure of this waste of butterflies, we may more in detail compare the wings of the "Whites" with those of the other butterflies in their group. That the radius is specialized in the Pieridæ and generalized in all the other families is the first and obvious difference, one which strikingly throws the balance of specialization to the side of the "Whites." So that in this direction of secondary specialization, which the Pieridæ share with

the Parnassiinæ, the Riodini-Lycænidae, as well as the Saturniades among the moths, the "brush-footed" butterflies (Nymphalidae of Scudder and Comstock) as well as the Nemeobiidae have no share and are *hors de concours*.

We now come to the direction of the suppression of the media. Herein the Pieridae lag behind the Nymphalidae (*in sensu mihi*) with one remarkable exception in the position of vein iv_1 , the upper branch of the media, which ascends the radius (iii_5) to a point beyond the cell, a character repeated only on the hind wings of Nemeobius. In all the "brush-footed" butterflies this vein never leaves the cross-vein at the extreme upper corner of the median cell. Though the latter open and the disappearance of the media by the distribution of its branches between radius and cubitus become complete, still vein iv_1 never fuses directly with the radius. Did it do so its passage to a point beyond the cell in the process of specialization might be logically expected to follow. What power is it which keeps this vein apart, even in *Nymphalis* and *Potamis*, where, in the latter especially, the approximation is carried out so completely? Undoubtedly all these retained and abandoned positions for the veins indicate the action of the dynamical force which fits the wing for variations in the mode of flight. The field observations which are compared with the structure of the wings are as yet scanty in the extreme. I have only brought the opening of the cell and the radial position of iv_2 into a probable relation with a lofty and sailing flight, a tree life like that led by *Potamis iris* or *Philo-samia cynthia*. The passage of iv_1 along iii_5 does not seem to help the wing to extended flights. We find it again in the moths, in the Smerinthinæ and Citheroniadæ. The bunching of the two upper branches of the media near the radius at this point seems, on the other hand, to strengthen the primaries. As these veins are retired from the radius and retain their original generalized position on the cross-vein, closing the cell, so does a more modest terrestrial habit of flight seem to prevail; so that it seems probable that the Lepidoptera were not originally high flyers, and that those which now disport among the tree tops are the latest arrivals on their respective and differing lines of phylogenetic descent.

To return to our immediate subject, the comparison of the specializations of the Pieridae and Nymphalidae proper. So far as the suppression of the media is concerned, the advantage of the Nymphalidae is quite clear when the most specialized forms are compared, but

even when we descend to the "Fritillaries," where the cell of fore wings closes and vein iv_2 becomes quite central, the superiority is kept up. For everywhere on the hind wings of the Nymphalidæ does the lowest branch of the media, vein iv_3 , completely fuse with the cubitus. The cross-vein above it is always very weak, and even vanishes in *Araschnia*, *Melitæa* or *Euptoieta*.

Leaving the two principal directions in which the movable veins show the effects of specialization, we can compare the Pieridæ and Nymphalidæ upon other points. The most important of these is the fusion of ii and iii upon the hind wings at base. Here the Nymphalidæ continue their advantage. In the Nymphalinæ the absorption extends even to the point of issuance of i, and this measure is attained in the most specialized of the Agapetidæ or "Meadow Browns," the Pararginæ. In the mass of the Nymphalidæ this excess is not reached and the point of absorption falls varyingly short. But still it is always carried to a further point than in the Pieridæ, where the union is very brief and apparently quite wanting in Leptidia. This character is plainly secondary and cannot of itself determine the phylogeny. Again, the amount of absorption of i may be compared, a vein which is relatively constant in its position upon ii, from which it issues. It did not always probably do so, for I have observed in *Papilio*, *Zerynthia* (=Thais) and *Parnassius*, the process by which it has come to be fused with ii, and in the present group traces of its independence may be found in the Limnads or "Milk Weed" butterflies. In the Pieridæ this vein i, the so-called "præcostal spur," tends to be absorbed and disappears in *Eurymus* (*Colias*) and *Colias* (*Gonepteryx*). Here the parallelism in specialization with the "Blues" is continued. But in the Nymphalidæ it appears everywhere to be strong and well-developed; it is here more generalized. Evidently the strong flight continued to call for a strengthening of the shoulder of the secondary wings. In the flutterings of the "Whites," the "Meadow Browns," the "Blues," this need was not so felt and the vein would tend to disappear.

So much we may say in comparing the Pieridæ with the Nymphalidæ proper, and we may pass more quickly over our comparisons of the "Whites" with the remaining families of "brush-footed" butterflies, the "Nymphalidæ" of Scudder and Comstock. After we leave the Pararginæ, the scale of specialization comes to a standstill or turns gradually against the latter. In the Agapetinae, con-

taining the mass of holarctic forms of the "Meadow Browns," the lower branch of the media on the hind wings no longer fuses with the cubitus, but, as in the Pieridæ, springs from the cross-vein, the piece between this branch and the cubitus varying in length, and by so much marking here the grade of specialization. Except that vein viii of primaries seems to have been entirely absorbed in the Agapetidæ, it becomes difficult to distinguish their wings from the Whites. In both groups the position of the radial branches is similar. In the male sex the Agapetids show very frequently a bladder-like swelling at the base of ii, iii and vii of primaries, or the swelling may be confined more or less to the first-mentioned veins. In Agapetes it seems confined to ii; I do not find it in my preparations of *Oeneis ællo*, of which, however, I am uncertain as to the sex. It is a secondary sexual specialization, of which traces occur also in the Nymphalidæ. Like the Pierids, the Meadow Browns tend to lose vein i of secondaries by absorption; I believe, on the whole, that *Pyronia* represents the most specialized form. The amount of fusion of ii and iii at base still continues greater as against the Pieridæ, but hardly holds its own in comparison with the *Argyninæ*. In the *Morphinæ*, which appear to me to be specialized Agapetidæ, the cell opens on hind wings, but remains closed on primaries. They resemble thus the *Pararginæ* at present rather than the Agapetinæ, and have sprung apparently from the latter. Else, in our holarctic forms, the cell does not open on either wing, while it becomes, in the specialized forms, partially degenerate.

In the *Heliconidæ* and *Limnadidæ* the generalization makes itself more and more evident. The strong veining, closed cells, central position of iv_2 , all tell against them. *Heliconius* still lacks vein viii of primaries, but in *Limnas* it is stronger than in any Pierid. At the close *Libythea* recovers somewhat of the lost territory, but this isolated butterfly, difficult to intercalate in a sequence, cannot probably alter the average result. Taking this all in all, we must find I believe that the excess of specialization in the direction of the suppression of the media, and in the subsequent points here explained, on the part of the brush-footed butterflies, as a whole, cannot outweigh the absence of specialization by reduction of the branches of the radius; seeing also that only in one family, the typical Nymphalids, is that specialization of the media carried to an excess. We have also the difficulty of estimating the morphological value of the shifting of vein iv_1 in the Pieridæ. While we cannot

thus assent to the conclusion expressed by Prof. Comstock in *Evolution and Taxonomy*, that we find in the Nymphalidæ an even greater specialization of the wings than exists in the Pieridæ, we admit that the point of view from which this is regarded may influence any conclusion, while the unequal presentation of the changes in the wings renders a just weighing of the differences a matter of some difficulty. It will be sufficient for my present purpose if the impression left on the mind of the reader is that rank is a relative conception and that it is owing to the constitution of our minds that we are impelled to string one natural object after another, while we are apt to fortify a classificatory preference for a special group out of several lying nearly abreast, by reasons which, sufficiently telling as far as they go, are apt to reflect only one side of a complex subject. I think, then, we may believe that the specialization of the "brush-footed" butterflies is more apparent in the feet than in the wings, and that, if we are not inclined to give them pre-eminence on that account in our sequences, we shall not be induced to do it upon the statement of Prof. Comstock herein discussed and illustrated.

PHYLOGENETIC LINES AMONG PIERID GENERA.

I have previously shown that coincidence in the number of the radial branches in reduction does not determine common descent, but that a three-branched condition of the originally five-branched radius has been reached independently, not only in different families, but on different generic lines within the same group. It may be assumed that three-branched species, differing otherwise unessentially, are correctly associated by this character; but to use this character anywhere alone for taxonomic purposes, or to assign it a commanding value, would be plainly to go wrong. It is probable, for instance, that the three-branched radius correctly indicates that the species of *Thecla* (*in sensu mihi*, with the type given by Scudder) are monophyletic and that the four-branched Zephyrini stand, at least constructively, as representing the original condition of their ancestors.

Under these views we may sort out several different lines of probable descent in the holarctic Pieridæ, in which the examples of extreme reduction have been independently developed. It is clear, since nature does not proceed by jumps, that the missing stages between the five-branched ancestors and the three-branched de-

scendants have existed and that forms, which have retained the intermediate character and thus represent an earlier condition, may yet be found and correctly identified. So that we must seek out forms whose main disparity consists in their respective state of specialization of the wings.

Referring to the accompanying phylogenetic table, we may commence our brief study with the so-called "Yellows." In *Eurymus* (*Colias*) the second branch of the radius has passed from its normal position before to one removed beyond the cross-vein. In *Meganostoma* this branch has only progressed to a point opposite the cross-vein. Clearly, *Eurymus* is the more specialized and younger form since this passage of iii_2 along the main branch of the radius is one indicated on different phylogenetic lines and is evidently a phase of general process by which the radial branches are reduced in number. The normal five-branched radius has this branch, following iii_1 , before the cross-vein. Under this view *Meganostoma* is the representative of the primitive form of *Eurymus*. The "dog's head" pattern has probably yielded to the terminal band, straightly margined and the reappearance of the "dog's head" in species of *Eurymus* is due to "reversion." In other words, such species are the more generalized. But, while in the type, *hyale*, the distance which the vein iii_2 has traveled is a considerable one, it is much reduced in another species, *edusa*¹, which is more generalized in this way than *E. hyale*. From the multiplicity of species of *Eurymus*, especially in North America, it is not improbable that intermediate grades occur uniting the extremes *E. hyale* and *M. cæsonia*. I have not yet found them and *Eurymus* is yet separable from *Meganostoma* on this character. For purposes like the present study it is immaterial, so far as the use of the two generic names is concerned, whether such forms are found or not. The systematist needs both terms to designate different grades of specialization. The change in pattern involves a loss of black and not improbably does there exist a tendency, in the direction of specialization, to lose this and perhaps other darker colors upon the same immediate lines.

It is hardly probable that *Callidryas* is on the direct line of *Eurymus*, but it represents, in the holarctic fauna, an ancestral phase of development. It has the same four-branched radius, but vein

¹ Mr. Meyrick's figure of *edusa* (*Handbook*, 350) is too inaccurately drawn to be of service.

iii₂ has not moved at all from the original position within the cell. It is thus more generalized than either of its associates. From Callidryas-like ancestors may rather have sprung the curious form *Colias rhamni*, belonging to the genus Rhodocera, or again Gonepteryx of authors, but, according to Scudder, wrongly so referred.

In this genus in which the wings have probably been transformed by mimicry to copy the shape of a leaf, vein iii₂ keeps its original place of exit before the cross-vein; consequently it cannot have been derived from forms among which this vein was shifting. It must have been thrown off before Meganostoma-like forms appeared and probably Callidryas represents very nearly its direct line of descent. It is more specialized than Callidryas, not only in the remarkable shape of its wings, but because it has lost by absorption vein i of hind wings, the "præcostal spur" of some writers, which is still retained by Callidryas. The specialization runs in this respect parallel with the branch Eurymus-Meganostoma. In the latter genus a remainder of the vanishing vein i is to be seen which has become lost in Eurymus. The specialization on this phylogenetic line of the typical "Yellows" has not apparently developed a three-branched descendant, at least in the holarctic fauna, and so far as my studies now go. Nor have I yet found the five-branched generalized form, which might represent its more remote ancestry.

Turning to the next line of non-typical "Yellows," the Euremini, we find the three-branched descendant reached in Nathalis. This form has evidently emerged from four-branched ancestors, represented in America by Eurema and Terias, forms which so very nearly agree that I am even at a loss to distinguish them. I make out vein viii of primaries to be quite distinct and relatively strong in Terias, and conclude this may be the sub-specialized form of the two. I cannot now connect this line with the typical "Yellows," and its ancestry must be apparently sought for in more southern regions.

We will now take up the "typical Whites." The three-branched condition is attained by *Mancipium brassicæ*. Here the little remaining branchlet iii₃₊₄ of Pieris has at last vanished. But the vein iii₃₊₄₊₅ in which it has lost itself is a little bent at this place. I should not wonder if examples of the "large Cabbage White" might be found retaining some trace of this vanished veinlet. In Pieris I have examined *rapæ* and *napi*, while Prof. Comstock's beautiful figure of protodice appears to agree (*Evolution and Taxonomy*, Pl. ii, Fig. 3).

In all these the little vein iii_{3+4} remains distinct and has not been lost. Evidently *Pieris* represents the ancestral form of *Mancipium* and has perhaps been thrown off before the specialization of *Pieris* has progressed so far. Notwithstanding the similarity of the ornamentation I am not sure that *P. rapæ* is on the direct line of descent. As between *rapæ* and *napi* I incline to consider the latter at present the more specialized. *Aporia cratægi* is evidently a more generalized form, standing a little apart. Vein iii_{3+4} is quite a long furcation, and measures its distance from *Pieris*. The skeleton of the wing is more powerfully built and vein viii of primaries stronger than in *Pieris*, in which it seems little better than a scar. The gradation by which this vein, which appears usually like a loop, strap or support to vii at the base, passes into obliteration is so entire that the exact statement of its condition is often difficult either to correctly grasp or record. The "tubular" character disappears by minute gradations; the "scar" aspect and the "tubular" shape are easy to detect, but where the one commences and the other ends it is often hard for me to say. In the holarctic fauna I do not find any form to represent the probably actual five-branched condition of *Pieris*, but here several types are wanting to me which I should like to have examined. In the genealogical tree of the holarctic butterflies the more generalized *Anthocharini* must take the place of the common five-branched ancestor of the whole *Pierinæ*. But this seems to me to stand upon a separate immediate phylogenetic line of its own, notwithstanding some common features of color and marking. With this *Anthocharid* line we must now in concluding concern ourselves.

Among the *Anthocharini*, or what we may call the "non-typical Whites," we have, in *Pontia daphidice*, the attainment of the three-branched condition. This butterfly appears to me to have no immediate connection with the "typical Whites," but to be a descendant of *Anthocharid* ancestry. It is true that Mr. Meyrick refers it without comment to the genus *Pieris* (*Handbook*, 353), but it is also true that Mr. Meyrick, in the same publication, precedes *Pieris* by *Leptidia* (*Leucophasia*) and this again by *Euchloe*, and, to make the mixture complete, *Gonepteryx* (*Colias*). This sort of work appears to me to prove that Mr. Meyrick's studies are not yet sufficiently "correlated" with the actual facts of structure. If, indeed, the picture which Mr. Meyrick has received of the neurulation at all resembles the figures with which his publications are adorned,

no proper judgment could, in my opinion, be formed upon it, and this would perhaps account in part for the seemingly extraordinarily unnatural sequences adopted by him.

The coincidence between the neururation of *Pontia daplidice* and that of *Mancipium brassicæ* is so great, that I am at a loss to give good characters of distinction. But showing, as I do, that the three-branched character of the Pierid primary wing is attained upon obviously distinct lines (*e. g.*, Euremini), this coincidence will not of itself determine the phylogeny. The shape of the wings and the pattern of ornamentation of *Pontia* are both Anthocharid. It is not conceivable how either could have been derived from *Pieris* and the "typical Whites." We should have to suppose that the four-branched *Pieris* threw off the three-branched *Mancipium* and also the three-branched *Pontia*; an inference which, considering the want of any near resemblance in the shape and pattern of the wings between the two descendants, or between one of these (*Pontia*) and the supposed parent stem, must be set down as untenable. More than this, we have in *Pontia* a similar secondary sexual character in the shape and extent of the wings to that we find in the Anthocharini, no trace of which is evident in *Pieris* or *Mancipium*. This character has evidently been retained by *Pontia*, through an ancestry of which I find one existing representative form, extending back to the five-branched representative of a remote phase which is brought before us now in *Anthocharis* and *Euchloe*. I believe that these facts show, that the phylogenetic position heretofore assigned to *Pontia*, is a discordant one and should be corrected. We may now leave *Pontia* and look over the more generalized and the typical Anthocharini with their five-branched radius.

Mr. Scudder (*Historical Sketch*, 113) says, regarding the use of the generic term *Anthocharis*: "As *Euchloe* must be used for the European species, *genutia* should be considered the type of this genus." This would seem to imply that all the European species were generically distinct from all the American and that the latter should alone be referred to *Anthocharis*. I do not agree with this statement at all, and I can show grounds for referring American species, with orange blotch in the male, to *Euchloe*, and for considering that the white species of both continents are slightly more specialized and might be kept under the separate title of *Anthocharis*. I regret not to have *genutia* to examine and I use *Antho-*

charis for the type *belemia*, which is, perhaps, identical. The subjective question of whether there are two "genera" to be considered is not of any importance to me at all. I recognize two five-branched types: the one specialized, which I seem warranted in calling Anthocharis under Boisduval's original use of that term; the other, relatively generalized, which I call Euchloe, with the type given by Mr. Scudder of *cardamines*.

The white Anthocharids differ from the type of *Euchloe cardamines* in that vein iii_2 has moved from the original position and is given off opposite, or even beyond the cross-vein. In *A. ausonides*, which is slightly the more specialized of the three examined, it has even passed the extremity of the cell for a considerable distance. Therefore the specialization runs here upon the same line as in the case of *Meganostoma* and *Eurymus*. The generic title Anthocharis should have, I believe, the type *belemia*, in case *genutia* does not share these essential characters and is not, in the sense here proposed, an Anthocharis. It is clear from the above citation from the *Historical Sketch*, that Mr. Scudder has misapprehended the state of affairs in this group; for I am quite unable to find any neuration differences between the North American *E. stella* and the European type of Euchloe. In both insects vein iii_2 retains its original position above the cell. And the chances seem to be that this will be the case with most of the species, carrying an orange blotch on the male primary, irrespective of locality. In any case, that which interests us here especially is the development of a specializing movement tending generally in the direction of a reduction in the number of the radial branches, but here taking a special and, looking through the day butterflies, perhaps an unusual direction. I find it, besides in these two instances, in the Pieridæ, in Euptoieta, Melitæa, Euphydryas, Araschnia and Heliconius. But when we examine Pontia, we find that, although the five-branched radius has become a three-branched, still vein iii_2 has not changed its place. The reduction has been effected by other means than the shifting of iii_2 in the direction of the apex of the wing. Into the details of the physiological process of absorption I cannot now enter, sufficient for my present purpose is the fact, that Pontia represents a clean descent from Euchloe-like forms and that it has not passed through Anthocharid-like forms upon its way. The absorption of iii_4 has proceeded to a varying extent in these species of Anthocharis. The little branch remaining has

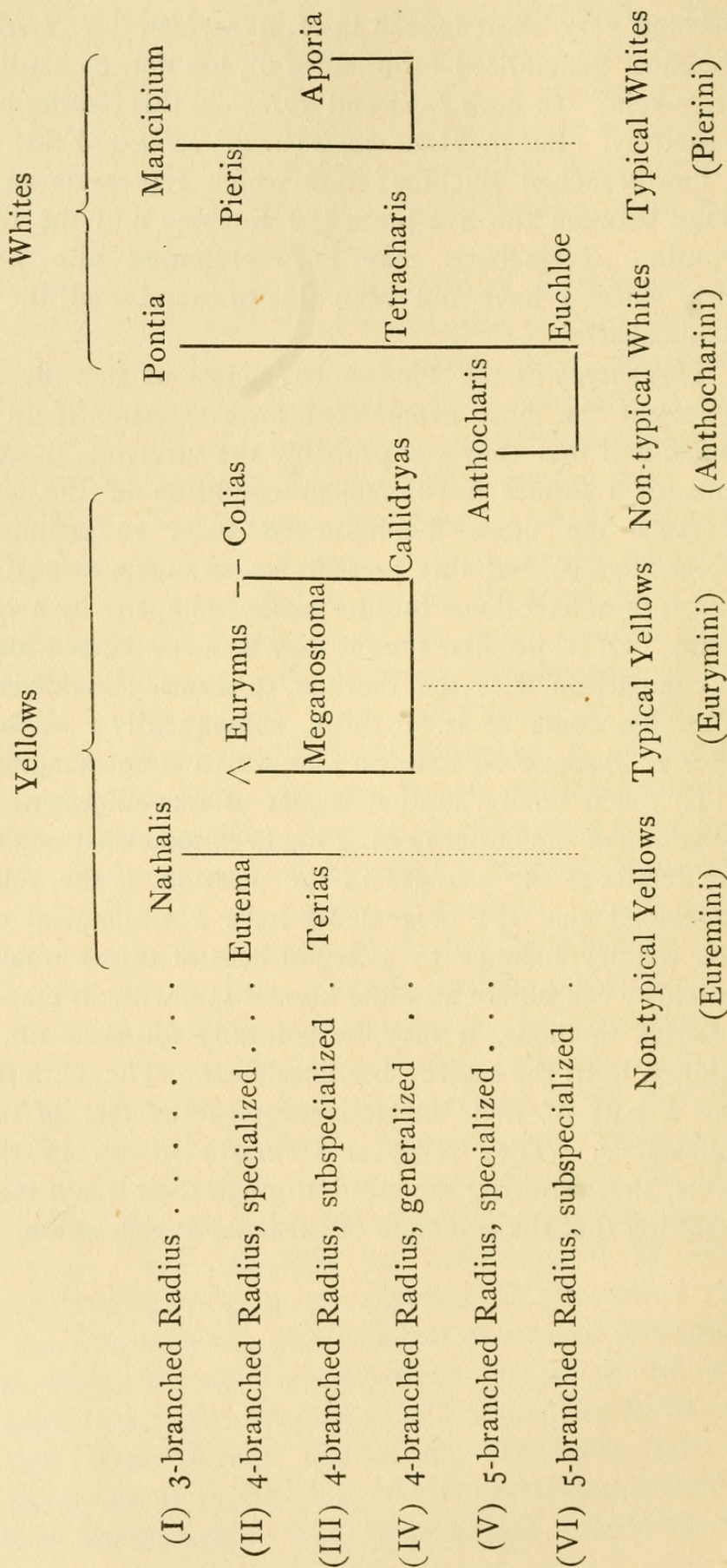
become very short indeed in *A. ausonides*. *A. belemia* would be the most generalized form, since iii_2 has not, or hardly, passed the cross-vein. In both *belia* and *ausonides* this halting place has been passed by. But in *Tetracharis* (n. g.) *cethura* Feld., sp., we have a four-branched Euchloe; one which represents an intermediate stage between the five-branched Euchloe and the three-branched Pontia. *Tetracharis* may be represented also by other species, since I have not been able to examine all the forms of the Anthocharini.

This survey of the Pierinæ has shown us that the Anthocharini represent the most generalized forms apparently in the holarctic fauna, and that they are probably the survivors, not on the direct line, of a former five-branched condition of the family. There remains one more five-branched form to examine: *Leptidia* (*Leucophasia*), but this presents so strange a neurational pattern, that it must have come into its present company by a vastly different route. Of its peculiar type it may be a specialized form, although, in comparison with the Pierinæ, it seems generalized. Its white color has come to it, I think, subsequently; as to its origin—*unde et quomodo*—I have no idea which is not imaginary.

To touch finally another aspect of our subject—a study of the dynamics of the butterfly wing has been somewhat neglected. From the details of the changes in the position of the veins, it may be concluded that the movements have a mechanical cause. Since this inquiry belongs to a department of direct observation upon which we can obtain absolute knowledge, without employing reconstructive methods, it may be painfully followed up, in field and cabinet, until the subject becomes clear. The butterflies certainly owe a part of their attractiveness to the fact of their seasonal appearance. They recur at a certain niveau in the biological circle, thus relieving the mind through their plain testimony from doubting that the principle of existence is succession.

TABLE OF PROBABLE TERMINAL PHYLOGENETIC LINES IN THE HOLARCTIC PIERINÆ.

(The differences in specialization are relative and unequal.)



THE CHARAXINÆ.

The Nymphalidæ proper appear dichotomous. The main ascending branch is represented by the Argynninæ, running up into the Nymphalinæ. This branch is characterized by a short furcation of iii_4 with iii_5 , and the genera may be called the "short forks." The second branch represents an earlier condition of the Nymphalids in which this furcation is more or less extended and the genera may be known as "long forks." Just as the passage from the Argynninæ to the Nymphalinæ by the continued greater absorption of ii and iii of hind wings may be considered to have gradually occurred, so the transformation of the "long forks" into "short forks" is inevitable by the progress of iii_4 toward the outer margin of the wing. But, other characters considered, the existing "long forks" seem to hold together on a distinct phylogenetic line. In Anæa we have an existing "long fork" which has lost its taxonomic character in this direction. In Euschatzia (type *morvus*) we have an allied Charaxid which still retains the character. Mr. Scudder having in 1875 (*l. c.*, III) fixed the type of Anæa as *troglydyta*, this action could not be properly subverted by Schatz, who subsequently made the same species the type of his genus "Pyrrhandra," which name must fall. For *morvus*, more generalized than the species of Anæa, I choose the generic name *Euschatzia*. Genera like Aganisthos, Kallima and Anæa appear to represent in succession Consul, Charaxes, Hypna, Prepona, typical "long forks."

In Charaxes veins iii_4 and iii_5 fuse at base for a short space, only about one-sixth of the length of iii_5 . If this short fusion were absent we should have a wing agreeing so far with that of Hesperia, that all the veins are separate, and no furcation, consequent upon the absorption of iii_4 by iii_5 , has taken place. Thus in the primitive Nymphalidæ, represented more nearly by the Charaxinæ, the veins were probably all separate. And probably also in the whole group Hesperiadæ. In fact the hypothesis suggests itself that the lepidopterous wing may have originally shown a series of longitudinal and independent veins, connected by a system of cross veins and without furcations. The disappearance of the cross veins would allow of the contact of the longitudinal veins. This state of affairs would in turn lead to their partial absorption and consequent furcation. We may have in the Hesperiadæ and Tortricidæ existing stages of this evolutionary change in the lepidopterous wing.

To resume: Butterflies like *Athyma* and even *Adelpha* seem to find their natural place in the *Nymphalinae*. But, when we come to the west coast of South America, we find in *Megalura* a form which shares the taxonomic character of the secondaries with the *Nymphalinae*, while iii_4 of primaries reaches apex. Perhaps here we come upon a fresh phylogenetic line, and the meeting of *i*, *ii* and *iii* of the hind wings at one point is no longer a reliable index of a nearer blood relationship.

A STRANGE AFRICAN PIERID.

A genus which has reached the grade of specialization of *Nathalis*, *Mancipium* and *Pontia*, and even gone beyond it, is represented by the strange little African butterfly *Gonophlebia paradoxa*. In his recent work Mr. Reuter has classified this butterfly as follows: "Papiliones: Pierididae: Pseudopontiinae: Pseudopontiidi: Pseudopontia." The major clamp in this declensional series—Papiliones—we can at once discard, since no proof has, nor apparently can ever be offered, that the Whites are phylogenetically connected with the Swallowtails. Further, if we may trust Mr. Scudder, the whole series of etymological changes must go by the board, since *Pseudopontia* is a synonym of *Gonophlebia*.

Two common butterflies will help us in understanding the venation of *Gonophlebia*: *rhamni* and *sinapis*. How the veins may be twisted to sustain the new shape of the wing, here assumed very probably under the influence of mimicry, is certainly taught us by *rhamni*, in which the branches of the radius are bent upward to sustain the expanded costa of primaries. Our strange African butterfly has the veins still more strongly bent out of their normal course to meet the required shape of its funny round wings. In *Gonophlebia* veins iv_1 and iv_2 have left the cross vein and spring, one following the other, from the main branch of the radius, vein $iii_3 + 4 + 5$, outside of the closed cell. This is an amplification of the usual Pierine movement of the upper branches of the median system of veins. This, not the whitish color, stamps *Gonophlebia* as an offshoot of the Pierid stem. *Gonophlebia* is even more easily recognized as a Pierid than *Leptidia sinapsis*, in which iv_1 has not left the cross vein. But, despite the contrasted shape of their wings, it is not impossible that *Leptidia* and *Gonophlebia* are isolated survivors of the same phylum.

The extraordinary movement of the middle branch of the median

series, vein iv_2 , in following the lead of iv_1 , proves *Gonophlebia* to be a highly specialized form. The neurulation shows us that there is no contradiction offered to the view that *Gonophlebia* is a specialized Pierid and, in order to make this still plainer, we will study it a little closer.

What gives the pattern of the veining its singularity, and affords a faint reminiscence of the *Pericopids*, is the tendency to run apart which the veins display in *Gonophlebia*. The veins are bent more or less out of their usual course, and this is especially the case with v_2 on both wings. But all this effort is clearly exerted in order to sustain the circular shape of the wings and keep the thin membrane taut. On the secondaries the expansion of the rounded costal margin has to be performed solely by the radius, in its single specialized condition, without branches. And how is this infrequent task accomplished? The simple vein is bent upwards, near the middle, at a nearly right angle, supporting and anastomosing with vein ii ; thence again, less abruptly descending, the radius runs outwardly to external margin below the apices, while vein ii itself is continued to the apex of the wing. Nature wished to make a spherical wing with no greater number of sustaining rods than go to support the longer wings of other butterflies, or even the narrow and extended wings of *Leptidia*. And thus, with the same economy of material, is the end attained. There arise no new veins, no complexity of machinery astonishes. We have the old veins in new position, but still showing the Pierine movement in specialization.

If *Gonophlebia* is the pattern of the veining so transformed, it is small wonder that Mr. Butler should deny and Mr. Scudder question its being a butterfly. Added to this the antennæ lack the regulation knob, which would allow Mr. Butler to place it among the "*Rhopalocera*." A puzzle to the classificators and a seduction to Mr. Reuter to a waste of category, this frail butterfly has evidently suffered many "vicissitudes of the voyage" along the road it has traveled and which may not be so very far now from its ending.

This strange butterfly is the only diurnal I have yet met with in which vein ix is retained on hind wings.

EXPLANATION OF PLATE I.

The figures are obtained by combined photographic process. The veins are numbered according to the system Redtenbacher-Comstock.

iii = radius, iv = media, v = cubitus.

- Fig. 1. *Pontia daplidice*. Type of genus. Attention is called to the three-branched radius. A specialized type. Vein iii₂ in original position.
- Fig. 2. *Tetracharis cethura*. Type of genus. Compare the four-branched radius with the five-branched radius of *Euchloe*. Vein iii₂ in original position.
- Fig. 3. *Anthocharis ausonides*. Vein iii₂ has moved forward to a point considerably beyond the cross-vein. Attention is called to the diminished extent of vein iii₄. A more specialized form than *A. belemia*. For this type Mr. Scudder uses *Synchloe*, but contrary to custom. The reason for rejecting *Midea* for *genutia* does not seem to me tenable.
- Fig. 4. *Euchloe cardamines*. Type of genus. The five-branched radius shows vein iii₂ in original position above the cell. *E. stella* agrees. A generalized type of the group.
- Fig. 5. *Nathalis iole*. Type of genus. A specialized type with three-branched radius.
- Fig. 6. *Terias hecabe*. Type of genus. A subspecialized type with four-branched radius. Vein viii of primaries fairly distinct. A mere rudiment of vein i of hind wings.
- Fig. 7. *Gonophlebia paradoxa*. Type of genus. Vein viii of primaries present, short, close to vii. On secondaries three internal veins. Type of subfamily *Gonophlebianue*. Compare text.

EXPLANATION OF PLATE II.

The figures are obtained by a combined photographic process. The veins are numbered according to the system Redtenbacher-Comstock.

iii = radius, iv = media, v = cubitus.

- Fig. 8. *Eurymus edusa*. Attention is called to the slipping forward of iii_2 . If a comparison is made with my figure of *Eurymus hyale* (l. c., Fig. 7) it will be found that in this type of the genus the distance traversed by this vein along radius is slightly greater than in *edusa*, which is so far the more generalized form. A specialized type.
- Fig. 9. *Meganostoma cæsonia*. Type of genus. Attention is called to the remains of i on secondary wings. On primary wing vein iii_2 halts opposite cross-vein. A subspecialized type on the direct line to *Eurymus*. Mr. Scudder prefers *zerene* for this genus.
- Fig. 10. *Callidryas eubule*. Type of genus. A generalized four-branched type. Vein iii_2 in original position.
- Fig. 11. *Nymphalis lucilla*. Type of family, subfamily and genus. Vein iii_4 given off upon external margin. Attention is called to the generalized state of the radius, common to all brush-footed butterflies. Also to the specialized condition of the median branches, which have joined the radial and cubital systems respectively. The cross-vein has vanished and the media, as a system, has virtually disappeared from the wing. Veins ii and iii on hind wings absorbed to point of issue of i.
- Fig. 12. *Pararge ægeria*. Type of genus and subfamily. Attention is called to position of cross-vein on hind wings and to the fact that iv_3 has joined cubitus. Compare with the following figure in this respect.
- Fig. 13. *Agapetes galathea* ♀. Type of genus, subfamily and family. A more generalized type than the preceding. The lower branch of media, vein iv_3 , arises from cross-vein and is not permanently joined to the cubital system.

EXPLANATION OF PLATE III.

The figures are obtained by combined photographic process. The veins are numbered according to the system Redtenbacher-Comstock.

iii = radius, iv = media, v = cubitus.

- Fig. 14. *Oeneis norna*. Type of genus. Attention is directed to the fact that this is a more generalized form, belonging to the Agapetinae with iv_3 from cross-vein, by the strongly closed cell and equidistance of the branches. The position assigned by Mr. Scudder, "at the head" of the brush-footed butterflies, cannot be a proper one. The genus seems related to *Erebia* (*l. c.*, Fig. 23).
- Fig. 15. *Heliconius antiochus*. Type of genus and family. From its total characters a more generalized type than that of the Agapetidae.
- Fig. 16. *Limnas chrysippus*. Type of genus and family. Still more generalized. Attention is drawn to the strong condition of vein viii on fore wings.
- Fig. 17. *Libythea celtis*. Type of genus and family. Outline of wings resembling *Polygonia*. Vein viii of primaries strong and position of iv_2 nearly central. In other characters specialized. ii and iii on hind wings fused to issue of i.
- Fig. 18. *Euschatzia morvus*. Type of genus. The radial branches have intersected with subcosta. A long fork; furcation of iii_4 and iii_5 long, but shorter than in *Charaxes*. Compare text.



Grote, Augustus Radcliffe. 1898. "Specializations of the Lepidopterous Wing; The Pieri-Nymphalidæ." *Proceedings of the American Philosophical Society held at Philadelphia for promoting useful knowledge* 37(157), 17-44.

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