

A COMBINATION OF TWO CLASSIFICATIONS OF LEPIDOPTERA.

By HARRISON G. DYAR, A. M.

The present article is the third in a series of papers on the classification of lepidopterous larvæ.* I believe that I have now brought out the characters exhibited by the larval tubercles sufficiently so that they may be considered to be known. The next thing in order is to combine the classification derived with this given set of characters with other classifications derived from other characters, in order to approximate to a natural classification. It so happens that the only classification sufficiently worked out for my purpose, is the old one founded upon the venation of the wings. That suggested by Mr. V. L. Kellogg on scale structure, as well as Prof. J. B. Smith's idea of using the general body structure or Dr. A. S. Packard's special head characters have never been completed, nor even well outlined with tangible points of contrast.

In the first place, I regard the suborders of the Lepidoptera, the Jugatæ and Frenatæ, to be established. All lines of research have tended to confirm this conclusion, with perhaps the exception of the pupal characters. But this is scarcely to be regarded as an insurmountable exception. In the following, then, we will confine our attention to the divisions of the Frenatæ.

The divisions which I propose to consider are of greater than family rank. The families of the Frenatæ are reasonably compact and well defined. A few intergrade, others are scarcely of family rank and again other genera may be entitled to a higher position than they now occupy. But these objections will right themselves as our knowledge of the complete life histories of all the species advances, for I believe the system of family classification and definition is not at fault.

To return to the higher divisions, the superfamilies or tribes. It is clearly the function of a natural classification, one founded by a synthesis of special classifications, to so expound the various characters used in the several classifications that they do not tend

* The first appeared in the *Annals of N. Y. Acad. Sciences*, Vol. VIII, p. 194 (1894); the second in *Transactions of N. Y. Acad. Sciences*, Vol. XIV, p. 49 (1895).

to produce conflicting results. It is scarcely possible in using one set of characters only, to adequately differentiate between the characters due to adaptation and those of real phylogenetic significance. Now it is hoped that the present attempt to combine two classifications founded on two very different sets of characters, may tend to show which of the characters in each set are reliable, or at least which are evidently unreliable; in other words parallel adaptations.

Before proceeding to the discussion, I will dispose of a few notes on larval tubercles, which extend my former observations to certain families not then examined.

Family ADELIDÆ.

On larval characters, the group represented by *Adela* must be given family rank. I have not studied the moth. I have examined the following species.

***Adela viridella*.**

A dorsal shield on each thoracic segment as in the Psychidæ. Setæ fine, pale, arising from large, diffuse, brown, corneous areas; i and ii remote, out of line; iii above the spiracle; iv and v from a single area close below and behind the spiracle (on joints 5 and 6 the areas of iii and iv+v are fused); vi subventral; vii without corneous area, represented by a very indistinct, small seta on the anterior outer side of the slight foot prominence. Feet represented by two transverse multiple rows of rudimentary hooks, grading off imperceptibly into the skin surface.

This is the most generalized larva of Frenatæ that I have seen. It should be placed at the bottom of the series and be followed by the Psychidæ.

Family TINEIDÆ.

Only a single dorsal (prothoracic) shield, rarely a mesothoracic one; abdominal feet more or less well developed, the crotchets in one or more circles or two transverse rows, but not grading off into the general surface; rarely entirely absent. The following species represent many of the "families" (= sub-families*) of the Tineidæ which I have not previously described. The descriptions are from beautifully prepared larvæ received from Staudinger & Haas, Blasewitz-Dresden, Germany.

***Simæthis pariana*.**

Cervical shield scarcely corneous, obscure. Setæ distinct, arising from large black areas, normal; i dorsad to ii; iv and v on a single area, consolidated; vi with

* Some of these may really be of family rank, but it is scarcely probable that they all are.

a small black area; vii without any black area, consisting of three setæ above base of foot; viii inside of base of foot next midventral line. Abdominal feet slender, well developed, the crotches in a single complete circle.

Gelechia rhombella.

A distinct corneous cervical shield. Setæ distinct, but without corneous areas; i dorsad to ii, remote; iv and v closely approximate, normal; feet moderate, the crotchets in a ring.

Endrosis lacteella.

Cervical shield well cornified, large; setæ long and fine, the tubercles scarcely perceptible; i dorsad to ii, iv and v closely approximate, all normal. Feet well developed, the crotchets in a single circle.

Plutella porrectella.

Cervical shield reduced to a series of dots. Setæ fine, short, but black and very distinct, arising from minute black tubercles; i dorsad to ii; iv and v in line, rather remote, entirely unconsolidated; other setæ normal; vii composed of three closely approximated setæ. Feet well developed, the crotchets in a circle but breaking down and incomplete on the outer side.

Hyponomeuta cognatellus.

Cervical shield distinct. Setæ fine but long, from minute obscure tubercles; ii slightly dorsad to i (compare *Psychidæ*), i being situated at the upper border of a subdorsal black patch; iii lateral; iv and v remote, iv being moved up out of line with v, almost on a level with lower border of spiracle; vi posteriorly subventral; vii of three setæ on base of leg, the upper one not closely approximated to the other two; viii next midventral line. Abdominal feet rather short, the crotchets three rows deep in a circle.

Acrolepia assectella.

Cervical shield sub-corneous. Setæ short, from minute tubercles surrounded by a diffuse sub-corneous area; i dorsad to ii, normal; iii close above the spiracle and slightly anterior; iv and v remote, iv moved up a little out of line; vi posteriorly subventral; vii of three setæ closely approximated; viii normal. Feet moderate, a single outer circle of crotchets and a second concentric inner row, represented only on the inner side of the foot (i. e. broadly broken outwardly).

Laverna phragmitella.

Cervical shield not distinguishable, the larval shape thicker than usual, slightly flattened approaching the shape of the *Anthrocerina*. Setæ fine, obscure, tubercles absent; i slightly dorsad to ii; iii above spiracle; iv and v greatly reduced, scarcely to be made out under a half-inch objective, apparently in line and rather remote; vi, vii and viii normal; feet well developed with a single circle of crotchets.

Tinea pellionella.

Cervical shield distinct. Setæ short, very fine, obscure, tubercles absent; dorsad to ii; iii lateral; iv and v not very closely approximate; iv dorsad to v, the

rest normal. Feet represented by a transverse ellipse of crotchets narrowly broken on the inner side.

Coleophora ochripennella.

Cervical shield (prothoracic) large, supplemented by a second (mesothoracic) one, small, widely bisected into two triangular halves. Setæ fine, short, greatly reduced, without tubercles; i small, dorsad to ii; iv and v apparently in line; v much shorter than iv, all very difficult to distinguish, and I cannot feel sure of their position. Feet nearly obsolete, represented by two transverse rows of very few crotchets.

Tischeria complanella.

Flattened, evidently a leaf miner; cervical shield sub-corneous. Setæ very obscure, rudimentary, no tubercles; iv and v appear on the lateral bulging outline of the segments, moderately approximate, iv a little dorsad to v. Legs absent, even the thoracic feet reduced to little rounded stumps.

Family ORNEODIDÆ.

Orneodes hexadactyla.

Cervical shield not corneous, practically absent. Setæ moderately distinct, single, from minute tubercles; i and ii remote, i dorsad to ii; iii lateral; iv and v closely approximate, iv slightly dorsad to v; vi sub-ventral; vii of three setæ on base of leg; viii normal. Feet moderate with a single circle of crotchets. An arrangement perfectly typical for the Cossina.

Family HETEROGYNIDÆ.

Heterogynis paradoxa.

Body robust, thickened, head retractile, resembling the Anthrocerina; setæ single, fine but distinct; iv and v approximate, almost in line transversely; vi represented by two setæ; the rest normal for the Cossina. Crotchets of abdominal feet forming a dense semicircle on the inner half of the planta.

Family PTEROPHORIDÆ.

I am now able to give some details for this family.

Lioptilus scarodactylus.

Setæ simple, coarse and distinct, arising from small cup-shaped tubercles; i and ii nearly in line, scarcely approximate, being separated by one-third the length of the segment; iii above and a little before the spiracle; iv and v closely approximate, sub-stigmatal, iv slightly dorsad to v; vi sub-ventral; vii of three setæ; viii present but small. Feet slender, small with only two or three crotchets like little claws curved inward, representing an inner segment of a circle. No secondary hairs, though the body is thickly clothed with small, round, brown, corneous areas.

Lioptilus microdactylus.

Setæ as in the preceding species, but finer and less distinct; the upper of the three setæ of vii is longer than the others. The minute corneous areas on the skin

are less numerous than in *scarodactylus*, and are more confined to the dorsal area, being also slightly more pointed and tubercular. The small, slender abdominal feet have no crotchets.

Platyptilus rhododactylus.

Setæ distinct, rather coarse, single, arising from somewhat enlarged conical tubercles, supplemented by a number of short secondary hairs with enlarged tips; i dorsad to ii, not approximate: iv and v closely approximate, all normal. Feet slender, the crotchets in a single row forming a semicircle on the inner side of the planta.

Oedematophorus lithodactylus.

Tubercles converted into small warts, each bearing some ten to twelve setæ; i and ii in line, closely approximate but not consolidated; iii lateral, behind it a little secondary wart with one small seta; iv+v also with a little secondary wart with three setæ behind; vi and vii each a distinct wart; viii represented by rather numerous hairs on the base and inside of the leg. Legs slender, the crotchets in a half circle on the inner side.

Oxyptilus periscelidactylus.

Tubercles converted into moderate sized warts with six to twelve long hairs; body also rather sparsely covered with short secondary hairs with enlarged tips: i and ii entirely consolidated into a single wart, a single long seta behind iv+v; viii a single seta; other warts normal. Legs slender, the crotchets forming two-thirds of a circle on inner side.

Family DIOPTIDÆ.

Phryganidia californica.

Mr. T. G. O. Mueller has kindly obtained the larvæ of this species for me in its home in California. The larvæ are referable to the Noctuina.

Setæ small and inconspicuous, but normal; a slight development of smaller secondary setæ consisting of one above and caudad to iii, another below and caudad to iii close above the spiracle; iv and v remote, iv moderately well moved up; many setæ on the leg plate. Larva otherwise naked, noctuiform; joint 12 enlarged and 13 small; anal feet slender, divergent and rather weaker than the others.

Family BREPHIDÆ.

I have before me the larvæ of three European species of *Brephos*. The setæ are greatly reduced, but the tubercles remain rather distinct, in the normal arrangement of the Noctuina, without secondary hairs. The interesting point is the structure of the legs. All the abdominal ones are present, but the three anterior pair are about half aborted. In the Geometridæ, these legs are

entirely aborted and in many Noctuidæ the first pair or first two pair are partly or completely aborted, so that the Brephidæ stand intermediate between these two families, but somewhat on the side of the Geometridæ.

Family NOLIDÆ.

On larval characters the genus *Nola* is deserving of family rank. These larvæ have been a great puzzle to me, and will probably remain so till I have the opportunity of observing the first stage. I have before me the larvæ of five European species of *Nola*. They correspond in all structural respects exactly with the American species. The arrangement of the warts is exactly that of the Anthrocerina as represented by the genera *Anthrocera*, *Adscita*, *Aglaope* and *Harrisina*, and less perfectly by *Megalopyge*; but with the important exception that, while in these Anthrocerina wart vii is distinctly situated on the anterior side of the slender abdominal feet, in *Nola*, the hairs of vii are scattered over a distinct corneous leg plate on the outer side of the foot. This leg plate is a typical noctuine structure, and it appears probable that the Nolidæ belong among the Noctuina where the moths are at present placed. But I am at a loss to conjecture what has happened to the tubercles.

Family EUPTEROTIDÆ.

This family has its stronghold in India, but is represented in Europe by at least one genus (according to Hampson). I have before me the larvæ of four species of this interesting genus. Not only do the tubercles show the position of the Eupterotidæ to be among the Noctuina, but their structure throws an unexpected light on the condition found in the Lasiocampidæ, which has been far from clear to me before seeing these larvæ.

Cnethocampa (Thaumetopea, Kirby*) **herculeana**.

Tubercles converted into large warts with many bristly hairs, also supplemented by scattered short and feeble secondary hairs from the skin and a development of short, finely branched hairs in close tufts, arising from the dorsal area enclosed by tubercles i and ii on joints 5—12. Some bristly hairs arise from the posterior part of these areas as if tubercle i had been stretched out in a longitudinal direction and the fine hairs developed from its central part; warts otherwise normal; iv and v rather near together; iv dorsad to v, v smaller than iv, considerably reduced; vi rather large; a distinct corneous but small leg plate.

* It does not appear from Kirby's catalogue why he has seen fit to propose a new name for this genus.

The arrangement is close to that of the bombycoid noctuids but differs in that tubercle v tends to become small instead of iv, while in the Noctuidæ iv is moved much farther up than in these Eupterotidæ. There is also a considerable resemblance to the hairy Notodontians.

Cnethocampa pinivora.

Primary hairs less abundant than in *C. herculeana*, the warts smaller and more reduced. Wart i is indistinct on account of its modification for the dorsal tufts which seem to be, in this species, partially replaced by a raised, somewhat eversible (?) area of skin which the stiff hair borders before and behind. Wart v very small, almost obsolete on account of the general reduction of all the warts. Secondary hairs more abundant, longer and stiffer than in *C. herculeana*.

Cnethocampa processionea.

Hairs and warts about as in the preceding, the secondary hairs not so well developed. Dorsal areas not eversible, covered with dense, fine and short down, the posterior stiff hairs scarcely developed at all. Warts iv and v very nearly in line. iv the larger and a very little dorsad to v, which has only one or two hairs and is really absent on some of the segments.

Cnethocampa pityocampa.

Dorsal areas eversible (?), downy, surrounded by a ring of soft reddish hairs. Warts greatly reduced, the hairs rather few and no stronger than the secondary hairs which are well developed. Wart iii is rather distinct; the position of iv and v can just be distinguished with a lens, iv the more distinct and dorsad to v.

Family LASIOCAMPIDÆ.

In the larvæ of this family the primitive first stage has disappeared. The mature warts are greatly reduced and obscured by secondary hairs, so that I could not obtain sufficiently positive evidence of their arrangement. The series of eupterotids described above shows beautifully the course which has been pursued in the development of the lasiocampid larva as we see it to-day. Derived from a bombycoid-noctuid, or lymantriid stock, by the suppression of the warts and development of secondary hairs in a manner parallel to that seen in the Eupterotidæ, the typical lasiocampid form has been evolved. Tubercles iv and v appear to have dropped back nearly into line in the first larval stage, probably by degeneracy toward the original primitive arrangement.

Clisiocampa fragilis.

Stage I. Wart i large, sub-dorsal; ii minute, a little caudad and below i; iii small, lateral; iv and v approximately in line, sub-ventral, very obscure; no others seen; no secondary hairs.

Clisiocampa neustria.

Mature larva. Several coarse black hairs arise from an area representing i, and a single hair from ii; other warts obsolete. Secondary hairs fine and soft, quite abundant sub-ventrally. Body scarcely flattened, a slight noctuiform dorsal enlargement on joint 12.

Lasiocampa quercus.

Secondary hairs abundant, thick, forming broad bands of dense hair absent only at the edges of the segmental incisures but becoming short and thin laterally and sub-ventrally. Primary hairs absent, the position of i and ii indicated by a disturbance in the uniformity of the dorsal hairy coat. Just below the spiracle and behind it an area can be distinguished which represents iv, and before and below this, another smaller one, rather a colored spot than a structural area, represents v. The area corresponding to vi, is well clothed with hairs and projects a little.

Gastropacha quercifolia.

Greatly flattened with well developed sub-ventral "lappets" and an unpaired dorsal prominence on joint 12. Hair rather abundant, but not long, all secondary. Patches of vivid white, short, dense hairs occur between the legs sub-ventrally. Seen at a distance a series of blackish patches seem to represent tubercles i and ii, but under the lens nothing appears but patches of dark pigment; a black pigment spot behind the spiracle. Sub-ventral area in the region of tubercle vi produced in two rounded confluent and hairy processes, forming the lappet.

CONCLUSION.

As regards the characters of wing structure, I believe the following are to be eliminated as unreliable.

1) *The frenulum.* This structure seems very flexible and readily subject to adaption. It is not reliable even for family definition in many cases. I have before me the European *Endromis versicolor* and the Australian *Chelepteryx collesi*. In all characters they approach each other very closely, even the peculiar pattern of maculation is identical, and they must belong to the same family (Endromidæ, Plötz 1885); yet the former is without frenulum with an expanded numeral lobe while the more primitive Australian form has a well developed frenulum. Other examples could easily be cited.

2) *The branches of cubital vein.* The apparent number of branches of the cubitus (three or four), which may be otherwise expressed as the direction of migration of 'vein 5', is insisted upon by Mr. G. F. Hampson as a character of super-family value. In comparison with the larval classification it is seen to be of family value only.

As regard the larval characters :

1) *The arrangement of crotchets on the feet.* The hooks on the abdominal feet are not very reliable characters, as their arrangement is quickly subject to modifications whenever the necessity arises for an exposed mode of life by the larva. The presence of the unmodified condition is of more value than its absence, inasmuch as no larva of the higher families possesses this typical structure even when returned to a concealed mode of life, whereas some of the lower ones may possess a considerably specialized foot structure.

2) *The tubercles.* The special modifications of the tubercles (warts, processes etc.) are not of more than family rank, often of only generic rank.

There remain, then, for primary divisions in the wing veins the presence of vein 1c; in the larvæ the approximation in position of tubercles iv and v. In the higher moths of the first division (Pyralidæ, the Saturnians above the Bombycidæ and a few others) there is a tendency, often complete, to the disappearance of vein 1c. In the larvæ of several genera of the lower families (Tineidæ) tubercles iv and v are scarcely approximated or even remote and out of line.* But taken together, the exceptions tend to eliminate themselves. As I am only combining two classifications, some gaps may occur.

In the second primary division vein 1c is absent from the wings and larval tubercles iv and v are remote. In some Dioptidæ there is a partial development of vein 1c on hind wings, but the larval characters are normal.

First division. I have divided this into three super-families on larval characters but, as there appears to be no corresponding character in the venation, my Cossina and Anthrocerina must be united. Further, the Pterophoridæ cannot be placed positively in the Cossina or Anthrocerina as different genera exhibit the characters of both divisions.

We have left, then, first, the Cossina (Microlepidoptera) with generalized wing veins and usually a frenulum, the larvæ with tubercle ii either present or disappearing by fusion with i; and,

* This is probably due to the generalized condition of these larvæ, which have retained the primitive arrangement of the setæ found also in stage I of the butterflies.

second, the *Saturnia* (*Bombyces*) with specialized wings, robust bodies and frenulum tending to disappear, the larvæ with tubercle ii disappearing by abortion by the first moult.

Second division. The super-families established on larval characters in this division seem to be quite corroborated by the imaginal ones.* It remains only to unite the *Noctuidæ*, *Geometridæ*, *Arctiidæ* and a few minor families under the term *Noctuina* to render the classifications identical. Indeed it will be seen that the only reason for giving such families as the *Noctuidæ* and *Geometridæ* greater than family rank has been the great number of species in each, and the consequent impression they have produced of a large and definite aggregation. Their differential characters do not warrant such a position.

We have then the super-families *Noctuina*, *Sphingina* and *Rhopalocera*, named in ascending order.

Antennæ filiform, pectinate, or rarely slightly thickened before the tip.

Larval tubercles iv dorsad to v except in a few instances when iv and v are in line.....**Noctuina.**

Antennæ fusiform, body robust, wings elongate, with distinct intercostal cell. Larval tubercles v dorsad to iv.....**Sphingina.**

Antennæ clubbed or knobbed at tip, or if simple, the anterior pair of feet partly aborted. Larval primary tubercles soon aborted, iv and v in line or iv dorsad to v when the mature armor is secondary.**Rhopalocera.**

I have not combined, as a third classification, Dr. T. A. Chapman's arrangement on pupal characters† because I have not undertaken to examine the subject personally and because I expect that Dr. Chapman will modify his arrangement somewhat before it is fully completed. As it stands, there are many things in correspondence with the views expressed here, but also many disagreements. I shall not attempt to analyze these at present.

* Contrary to the statement which I have formerly quoted from Weismann's "Studies in the Theory of Descent".

† Trans. Ent. Soc., London, 1893, pp. 97—119.





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