XVI. *On some Variations observed in* Bombyx Cynthia, *in* 1866. By Alexander Wallace, M.D., M.R.C.P.

[Read February 4, 1867.]

During the summer of 1866 I bred over 4,000 specimens of *Bombyx Cynthia*. My first specimen came out on May 30th when the weather was temperate, about 55°—60° F. during the day: the last one emerged on August 8th: there was thus a period of seventy-one days between the first and last emergence.

The cocoons were strung up in chaplets of fifty each, and suspended round the walls of a room which had an eastern aspect. Hence the sunshine fell during a portion of the day on some only of the cocoons. When the moths appeared, I noticed that the darkest and richest coloured specimens were invariably on the west wall, especially in the angle of the room which was the most remote from the light; one portion of cocoons, however, which had been allowed to retain their leafy covering produced the darkest specimens, whereas all the other cocoons had been denuded as far as possible of their leafy envelope. Hence I came to the conclusion that shade, during the pupa stage, is *cæteris paribus* most favourable to the production of the darker tints, whereas sunshine tends to diminish the intensity of coloration. The larvæ which had spun their cocoons were freely exposed to the sunshine in 1865, being fed in the open air on a plantation of Ailanthus trees on a railway bank near Colchester.

Another observation on coloration I was also able to make, that the earliest bred specimens were of a predominant olive-green ground-colour, whereas the later bred, and especially those that escaped from pupæ in September, not having passed a winter in cocoon, were of a predominant yellow tint. Specimens of these tints are brought for exhibition. The three first males in the box are of the dark summer hue, and the fourth is a later and lighter tinted specimen. Exceptions of course occur to this rule, but they are very few. It is hardly necessary to observe, that these tints closely resembled the shades of the Ailanthus leaflets,

which assume a yellower tint as the season advances and the leaflets grow older.

Some specimens, bred late in the season, were small and evidently weakly; their coloration was very deficient. No. 5 is a specimen. These were greatly deficient in vigour, and if able to effect copulation and fertilize eggs, their progeny would doubtless be a very feeble race, whereas the richly-coloured specimens were very vigorous and wild, and produced healthy and fine offspring.

There are two specimens fed one on plum and the other on laburnum, both defective in size and coloration, and evidently weakened by an unnatural diet.

But the most curious specimens are the dwarfs. These were from the cocoons of a second brood, which were fed later in the autumn, after the Ailanthus leaves had failed, on celery leaves, indoors. They are very diminutive in size, some only measuring 3 inches in expanse, whereas the finer specimens measure some 6 inches from tip to tip; the dwarfs are also deficient in depth of coloration, their markings are less clearly defined, the shape of the wings is rounder and blunter at the tip, and the abdomen is covered with white prominent tufts. But what seemed to me the most singular point about them is, that although they spun up several months after the first brood, they were the first to emerge. On the 30th May a ♂ emerged from the small cocoons strung up; this was so unexpected, that I had failed to examine for several days some baskets wherein other small cocoons of the second brood had been placed; on searching in them I found another ♂ out, rather worn. On June 1st two ♀ emerged of the first brood; on the 2nd, one ♂ emerged of the first brood and three of the second brood; and so on, the dwarfs coming out rapidly.

I believe this will throw some light on the question of the prior appearance of males or females. It seems to me that in proportion as the individual is finer, so the time required for its metamorphosis is longer; and for this reason the female, which is the larger and heavier insect, from having to carry her numerous eggs, will be preceded by the male, which is smaller and has less to mature. Thus the dwarfs, carrying few eggs and those small, required less time for their metamorphosis and appeared as early as their uncles and aunts. If this idea be correct, and it has been suggested to me by the observations made on *Bombyx Cynthia*, and also on *B. Yamamai*, it will follow that, though we may as a

rule expect the male to emerge first, there must be frequent exceptions, as, for instance, a half-starved female would precede a well-developed male, a stunted second brood would run a race with a full-fed first brood, and this will, to a certain extent, explain the difference in observations made on the same species by different observers.

This point, priority of appearance, is of considerable consequence in the culture of silkworms: the cultivators of *Bombyx Mori* use every endeavour to obtain the different moults and changes passed by all their stock on the same day. Hence if any linger behind they are thrown away, if any precede the others they are also got rid of; though it is confessed that they are the strongest and most vigorous worms. Hence as a result of this interference the cocoons are all spun up together, and the moths emerge on the same day; but this is the result of domestication and human manipulation, and the habit has been artificially induced by rejecting all those individuals that will not conform to it; but the same uniformity is not observed in the wild races. Thus in the case of *Bombyx Yamamai*, we find M. Personnat, in his book on that species, writing that the habit of the *Yamamai* is for the males to precede the females, so that males at the beginning of the season and females at the end are lost from want of mates. To prevent this, it is desirable to retard those which first change to pupæ, and to hasten the later ones, so as to equalize the interval; this is effected by placing the first cocoons in a cool, and the later ones in a warm place. M. Chavannes recommends only to retard the males, which have a propensity to emerge first: taking 100 cocoons and weighing them and dividing by 100 he ascertains the mean weight of a single cocoon; those that exceed the mean weight are females, those that fall short of it are males. Elsewhere M. Personnat declares that he can separate the male from the female larvæ after the last moult, by observing those which grow the fastest and eat the most; these he declares are males, and will spin up first; he proposes to retard these by giving them a somewhat scantier diet, and to hasten the others by supplying them with an abundance of fresh food; and thus he expects to equalize the time of spinning.

Now with regard to *B. Cynthia*, it must be borne in mind, that of the cocoons gathered in any year some at least give their moths in the autumn of the same year; these then are the earliest born of the brood. My first experience in the autumn of 1863 was with about twenty pupæ of *B. Cynthia*; of these two larvæ had been

left at a higher temperature than the rest; these both spun up on the same day and emerged on the same day, and being of different sexes paired together. A month later one ♀ emerged; the rest passed the winter in pupa. In 1864, June 4th, one ♂ emerged from the cocoons of a late brood obtained from eggs from Paris in the autumn of 1863; on the 10th, a ♀; the 11th, a ♂; the 12th, a ♀; the 13th, a ♀; the 14th, a ♀; the 15th, two ♀; the 16th, two ♀; the 17th, two ♀; the 18th, four out, some were males. It was not till the 11th July* that one ♂ and one ♀ of the first brood appeared. In that autumn (Oct. 8th) a ♂ emerged from a cocoon spun in the summer in the open air; on the 15th, a ♂ and a ♀ emerged; on the 20th, a ♀; the 21st a ♀; the 23rd, a ♂; the 26th, a ♀, and so on. In 1865 a ♂ emerged on the 22nd May, one out of some pupæ which had been taken out of their cocoons and put to force; on the 23rd, a ♀; the 29th, a ♀; the 30th, three ♂; the 31st, a ♂; and so on. The summer of 1865 was very warm, and so on the 20th August a ♀ emerged (the cocoon was spun July 15th, thirty-six days previously); on the 21st, a ♀; on the 24th, a ♂; on the 26th eight were out; these had all been forced under glass at a high temperature during the larval and pupal states, to obtain a second brood, and in consequence were of a medium size. Of the brood placed as larvæ on trees in the open air, one ♂ emerged September 24th; on the 26th, six emerged; on the 28th, six more emerged; and so on; but I have not noted when so many emerged whether the males or females preponderated. In 1866, as before stated, the first two emerged (both males) on May 30th, being stunted specimens of the second brood; on June 1st, two ♀ emerged of the first brood; on the 2nd, two ♂; and about the 10th they began to burst out in quantities. In the autumn, November 7th and 8th, one ♂ emerged on each day; both these were medium-sized specimens. The emergence therefore of the ♂ first is as four to two. I may add, that invariably at the commencement of the burst the males largely preponderated in number over the females, while towards the end the reverse was the case. The conclusion, therefore, from these observations that I have come to is, that

* The first brood were from eggs sent to me by Lady Dorothy Neville, and having been for several years acclimatized in England, had become accustomed to one generation annually, and were by far the largest insects; the Paris brood were accustomed to two or three generations annually, according to temperature, and produced a smaller insect. Hence it is not possible to compare these two races together, as their antecedents were widely different.

cæteris paribus the smallest individuals emerge first, and that these are generally males.

I proceed now to make a few remarks on the specimens exhibited. The first two are fine ♀, measuring a little over 6 inches in expanse. No. 3 is a not uncommon variety, partially variegated with a tawny tint. No. 4 is a very fine male, measuring over 5 inches. Nos. 5 and 6 are splendid dark ♂ varieties of early summer. No. 7 is a tawny autumnal tinted specimen. No. 8, a ♂, deficient in size, tint and coloration, and during life was weakly; it emerged late, and the larva had probably been injured or was unhealthy. Nos. 9, 10, 11, 12, are remarkable for the variation in the colour of the tufts on their bodies, the two latter having very large tufts, so as almost to be called woolly. No. 13 is a ♀, remarkable for the rich olive-brown ground-colour. In this variety the wings seldom attain the full size of specimens Nos. 1 and 2. Two dwarfs of the stunted half-starved second brood of 1865 complete the series in that half of the box. These are remarkable for their small size (3 inches expanse) and their deficiency in coloration.

In the lid of the box we have Nos. 1, 2, 3, three ♂, remarkable for their white-tufted bodies and small size; No. 4, a small ♀ fed on laburnum, deficient in size and ground coloration; No. 5, a ♀ fed on plum, rather larger and better coloured, but in both respects rather below the average. Nos. 6 and 7 are remarkable for a broad black band across the dorsum of the abdomen, near its junction with the thorax. In No. 7, as also in Nos. 8, 9 and 10, a spot, or an approach to a spot, occurs at the inner aspect of the lunule of the upper wing. In Nos. 11, 12, 14 and 15 a similar curiosity is seen, the most marked in the last; this is caused evidently by the white marks approximating somewhat more closely than in the normally marked specimens; hence the space between the white lines is smaller, and instead of a patch we get a spot, more or less small. Nos. 12 and 13 are remarkable for having their upper wings not fully developed, one being on the left, the other on the right: a great many specimens were noted as presenting this appearance, and it was found to proceed from a want of space to extend the wing: if any contiguous object, either a cocoon or the wing of another insect, prevented the expanding wing from attaining its full dimensions by the resistance which was offered, the wing so opposed remained imperfectly developed, whilst the other wings attained their natural size. Nos. 16 and 17 are two ♀ dwarfs. Nos. 19, 20, 21 and 22 are dwarfs, having bodies more or less tufted with white, and wings with the colora-

tion blurred, or less distinct than in the normal insect. Nos. 18 and 23 are specimens of the most vigorous and healthy dwarfs.

With these specimens before us, it is evident that great variation occurs in this species, dependent on food-plant, temperature, season of the year, and influence of light. It varies greatly in size and in coloration.

The question may be asked, Are *Bombyx Cynthia* and *B. Ricini* distinct species? There is also a third species or variety, *B. Guerinii*, described in Mr. Fred. Moore's Catalogue from a few specimens extant; but until we have many more examples of this insect sent over, with a description of the larva, showing that it differs from that of *B. Cynthia*, I should be inclined to believe it only a variety of that insect; for I can, I think, produce varieties of the latter, possessing some or all the traits of *B. Guerinii*, except the entire suppression of the lunule, and I expect some day to witness that among my dwarfs. Again, the differences recorded between *Ricini* and *Cynthia*, according to Mons. Guérin-Méneville, are as follows:—

1. "The egg of the true *Cynthia* is white, but its shell is covered with little brown or black particles of gum, which give it a spotted look. That of *Ricini* is entirely white, is smaller, and less heavy."

2. "The caterpillar of *Cynthia* has on each segment four black spots, and when full grown is of a beautiful emerald-green, with its head, claspers and the last segment beautifully marked with yellow. That of *Ricini* has no spots, and is uniformly of a pale azure."

3. "The cocoon of *Cynthia* is naturally of a hempen-grey colour; that of *Ricini* of a vivid red, and weighs less." (Yet I have had many cocoons of *Cynthia*, especially of the earlier and later growth, or if fed on other than Ailanthus leaves, and therefore not maturely developed, more or less of a rusty-red colour.)

4. "The imago of *Cynthia* is larger, its abdomen is yellow above, having little white separate tufts of scales. The large transverse white line beyond the middle of the wings is bordered externally by a broad rosy band. The transparent lunule in the four wings is greater, and the brown space above the lunules in the upper wings is much longer (often twice or thrice) than it is broad. In *Ricini* the belly is entirely white, instead of being rosy the transverse band is of a dull grey, the lunules are shorter, and the brown space above in the upper wings is shorter, hardly as long as it is broad. In order to complete the comparison, *Cynthia* has but

two generations in the year, and passes the winter inactive in cocoon: *Ricini* has from seven to twelve broods, and is in a state of constant reproduction, winter as well as summer."

All these differences summed up give to *Ricini* a smaller size than *Cynthia*, a suppression of coloration in the egg, larva and imago, some difference in the cocoon, an absence of spots in the larva of *Ricini* which are present in that of *Cynthia*, and a blurredness of marking in the imago, with the presence of numerous white woolly tufts on the abdomen. These two latter characteristics, together with a deficiency in size and an absence of coloration, have been exhibited in the varieties of *B. Cynthia* bred by me. Two other chief characteristics are, 1st, a difference in the cocoon, which is much more woolly in *Ricini*, harder and closer in *Cynthia;* but this is due to the presence of more gum (and that may be due to the influence of the food-plant) in the cocoon of *Cynthia*, which enables the larva to bind the threads down more closely; 2ndly, the absence of black dots in the larva of *Ricini* which are present in *Cynthia;* but unless some other stronger evidence is brought forward to show that the larvæ differ, I cannot admit that dermoid differences, which are the least of all to be depended upon in differentiating species, can alone constitute *Ricini* distinct from *Cynthia*.* As to the alleged habit of *B. Ricini* breeding five or eight times annually, or oftener, in Bengal, and *B. Cynthia* only once in Assam, England, &c, we have this fact, that in 1865, in Paris, there were four generations of *B. Cynthia*, which proved that under a suitable temperature that insect is, like *B. Ricini*, many-brooded. Looking to the habitat of *B. Ricini*, Bengal, and its food-plant, *Ricinus*, I see no ground for separating the species; I

* The more especially as, on referring to Mr. Moore's "Synopsis of Asiatic Silk-producing Moths," I find it stated, p. 32, that, according to Mr. Hugon, see "Journal A. S. Bengal," vi. pp. 23, 24, the caterpillar of the *Eria*, which is the local name for the *Bombyx Ricini*, "in a domesticated state in Assam, as it increases in size, becomes of an orange colour, with six black spots on each of the segments; after the second moult the colour of the body becomes lighter; in some approaching to white; in others to green, and the black spots gradually become of the colour of the body; after the fourth moult the colour is a dirty white or a dark-green; the white caterpillars invariably spin red silk, the green ones white. The *Eria* feeds on the *Ricinus communis*, and gives twelve broods in the year." If, then, we have a history of spots apparent at birth suppressed after an interval, the argument that *Cynthia* and *Ricini* larvæ are distinct, because the one has spots and the other has not, becomes considerably weakened. Again, M. Personnat states that larvæ of *B. Yamamai*, fresh from Japan, are flecked laterally with silver spots, whereas, when naturalized in France, they lose all metallic tint.

would rather, therefore, consider these as local varieties of *Cynthia*. Had the variety *Ricini*, perfecting its changes rapidly under a hot, moist climate, been larger and finer—had the coloration been more distinct, the markings more defined—I should have viewed the insect as a distinct species; but I regard size, intensity of coloration, distinctness of the markings, as clear evidence of abundant vitality—and this is corroborated by Capt. Hutton's views on the *B. Mori*, who states that the *vers zébrés*, or dark worms, are the healthiest and strongest individuals (*vide* Capt. Hutton on the Reversion and Restoration of the Silkworm, Trans. Ent. Soc. 3rd ser. vol. ii.) I must necessarily regard the converse, *i. e.*, smallness of size, blanched coloration, blurredness or indistinctness of markings, as indicative of diminished vitality; and these latter indications are precisely what I find in the specimens of *Ricini* and *Guerinii*.

Three other points I mention, in conclusion:—First. That in looking over the empty cocoons in the autumn of 1866, I found about twenty large living pupæ which had not hatched, and which, I suppose, are laying over to emerge in 1867.

Secondly. That a sound was frequently observed to proceed from the eggs, a sort of click, a single sound; this was generally in the second week, and I have been informed that a similar click had been observed to be emitted by the eggs of the Emperor moth. I attributed it to the parchment-like shell being pressed out with a spring by the effort of the larva within, and its returning to the concave form. This little creaking or clicking sound was very frequently heard by me, often daily every minute, while sitting writing at my desk in the same room with the eggs.

Thirdly. In two instances males at liberty paired with females put out to attract them at two miles distance from my house; and I found a worn female in my Ailanthery on the railway bank, resting by day on an Ailanthus tree.

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