THE AMERICAN SILK WORM.

BY L. TROUVELOT.

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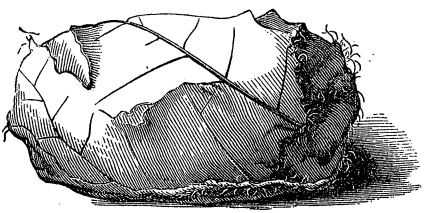
It is astonishing how rapidly the larva grows, and one who has no experience in the matter could hardly believe what an amount of food is devoured by these little creatures. One experiment which I made can give some idea of it: when the young silk worm hatches out, it weighs one-twentieth of a grain; when

10 days	old	it	weighs	½	a grain,	or	10	times	the	original weight.
20 "	"	"	"	3	grains	"	60	"	"	"	"
30 "	"	"	"	31	"	"	620	"	"	"	"
40 "	"	"	"	90	"	"	1800	"	"	"	"
56 "	"	"	"	207	"	"	4140	"	"	"	"

When a worm is thirty days old it will have consumed about ninety grains of food; but when fifty-six days old it is fully grown and has consumed not less than one hundred and twenty oak leaves weighing three-fourths of a pound; besides this it has drank not less than one-half an ounce of water. So the food taken by a single silk worm in fifty-six days equals in weight eighty-six thousand times the primitive weight of the worm. Of this, about one-fourth of a pound becomes excrementitious matter; two-hundred and seven grains are assimilated and over five ounces have evaporated. What a destruction of leaves this single species of insect could make if only a one-hundredth part of the eggs laid came to maturity! A few years would be sufficient for the propagation of a number large enough to devour all the leaves of our forests.



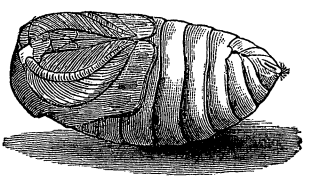
Cocoon of *Telea Polyphemus*.

When fully grown, the worm which has been devouring the leaves so voraciously, becomes restless and crawls about the branches in search of a suitable place to build up its cocoon; before this it is motionless for some time, holding on to the twig with its front legs, while the two hind pair are detached; in this position it remains for some time, evacuating the contents of the alimentary canal until finally a gelatinous, transparent, very caustic fluid, looking like albumen, or the white of an egg, is ejected; this is a preparation for the long catalepsy that the worm is about to fall into. It now feels with its head in all directions, to discover any leaves to which to attach the fibres that are to give form to the cocoon. If it finds the place suitable, it begins to wind a layer of silk around a twig, then a fibre is attached to a leaf near by, and by many times doubling this fibre and making it shorter every time, the leaf is made to approach the twig at the distance necessary to build the cocoon; two or three leaves are disposed like this one, and then fibres are spread between them in all directions, and soon the ovoid form of the cocoon distinctly appears. This seems to be the most difficult feat for the worm to accomplish, as after this the work is simply mechanical, the cocoon being made of regular layers of silk united by a gummy substance. The silk is distributed in zig-zag lines of about one-eighth of an inch long. When the cocoon is made, the worm will have moved his head to and fro, in order to distribute the silk, about two hundred and fifty-four thousand times.

After about half a day's work, the cocoon is so far completed that the worm can hardly be distinguished through the fine texture of the wall; then a gummy resinous substance, sometimes of a light brown color, is

spread over all the inside of the cocoon. The larva continues to work for four or five days, hardly taking a few minutes of rest, and finally another coating is spun in the interior, when the cocoon is all finished and completely air tight. The fibre diminishes in thickness as the completion of the cocoon advances, so that the last internal coating is not half so thick and so strong as the outside ones.

During the process of spinning, the worm contracts and diminishes in size, as the silk reservoirs empty. Six or eight days after the beginning of the cocoon, the worm casts its last larva-skin, and then appears under a very different form—a transitory one, which is neither worm nor moth; it is the chrysalis or pupa. When the chrysalis comes out of the larva skin, if observed closely, it will be seen that its resemblance to the perfect insect is striking; the antennæ, the head, the legs and abdomen resemble very much those of the moth. The wings only, are very small, but in a few minutes they grow to about half the size of the abdomen. The legs of the chrysalis, at least the tarsi, are enclosed in the articulated leg of the larva, the wings are folded under the skin of the second and third segments, and the antennæ are rolled up in the lobes of the cranium. When the chrysalis comes out, every part is detached and free, and if then put in alcohol they will remain so; but when left to its natural course it will soon be observed that a general envelope covers the whole chrysalis, and that any motion of the legs, wings and antennæ is impossible, since the insect is contained in the hard brownish envelope secreted by its tegument, and



Pupa of *Telea Polyphemus*.

now resembles an Egyptian mummy. If before the shell of the pupa has become hard, an antenna, a leg or a wing be changed from the position that the insect has given to it, that part of the body which would otherwise have been covered by the part removed out of place, will remain of a different color and of a thinner consistence, and an insect thus treated will not generally live to arrive at the imago state.

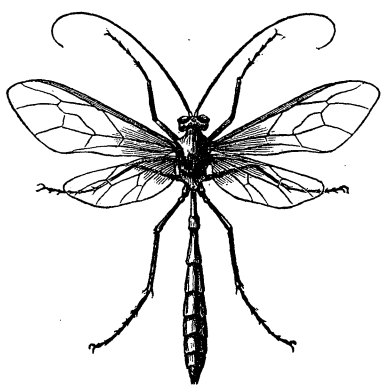
Before the last transformation is accomplished, the insect takes a long rest, and this period is the longest of its life; if it can be called an existence to live without eating, breathing, or even, probably, without having any distinct sensation. The pupa spends about nine months in this torpor, and braves the hardships of winter, notwithstanding all the changes of the temperature, being frozen as hard as a stone. It is only when the warm spring days come that life awakens, and the pupa is transformed into a perfect insect.

If a worm be opened longitudinally, even when half grown, there will be found in the female a vast number of little globular white bodies attached to a fine tube on each side of the stomach. These little bodies are the eggs of the future female moth, as yet in a rudimentary state. This is the only method of distinguishing the female from the male, while in the larva state. I have never been able to find any other character by which to distinguish the sexes. Again on making the same dissection of the larva, there will be found on each side of the stomach, and running from head to tail, two long secretory reservoirs, making a great many convolutions. These are the silk reservoirs. The transparent liquid they contain is the silk, as yet in a liquid state. If one of these vessels be taken out carefully and stretched, it will mea-

sure twenty five inches in length; these two reservoirs become very narrow as they approach the mouth, and unite together, terminating in a special contractile organ, attached beneath the mouth. When spinning, the silk is thrown out from the two reservoirs at the same time, and the thread is in reality composed of two distinct fibres which can be easily separated.

The silk in the reservoirs is sometimes used in commerce, being sold under the name of "gut." The process of obtaining the gut is very simple; it consists in preparing worms ready to spin by putting them in strong vinegar for eighteen hours; a transverse opening is then carefully made on the under side and about the middle of the body, taking care not to injure the silk reservoirs which are very distinct. The glands, or reservoirs, are then taken out and stretched parallel to each other on a board, and dried in the shade for several days.

The Enemies of the Silk Worm. Birds are the most formidable foes to the silk worm, especially the Thrushes, Cat-birds and Orioles. It is probable that ninety-five out of a hundred worms become the prey of these feathered insect-hunters. Toads and snakes also destroy some, and mice, rats, moles and squirrels eat the chrysalis enclosed within the cocoon. Among insects they have many enemies, such as various spiders, ants, bugs and wasps; but their most



Ophion macrurum Linn. Ichneumon Parasite on the larva of *Telea Polyphemus*.

dangerous foe is the Ichneumon fly. A Tachina-like fly also deposits its eggs in the body of the larva. The Ichneumon flies can be seen in summer flying about bushes in search of caterpillars in which to deposit their eggs, and I have observed them often flying for an hour among shrubs where no worms were feeding, for which they searched carefully, peering under almost every leaf. When an Ichneumon detects the presence of a worm, she flies around it for a few seconds, and then rests upon the leaf near her victim; moving her antennæ very rapidly above the body of the worm, but not touching it, and bending her abdomen under the breast, she seizes her ovipositor with the front legs, and waits for a favorable moment, when she quickly deposits a little oval white egg upon the skin of the larva. She remains quiet for sometime and then deposits another egg upon the larva, which only helplessly jerks its body every time an egg is laid on it. She thus lays some eight or ten eggs which adhere so firmly to the skin, that it is very difficult to take them off. After several days these eggs hatch out, and the small white larvæ may be seen at work as soon as they are out of the eggs, digging their way under the skin of the worm, on whose fatty portions they feed. The caterpillar, however, continues to eat and grow, and lives long enough to make its cocoon, but when once enclosed in it, the parasites which prey upon it have already eaten the fatty portions, and now attack the vital parts of the larva, which they speedily consume, and finally the one that outlives the others makes a cocoon within that of the Polyphemus larva. But it is a remarkable fact that here the maternal instinct of the Ichneumon fly makes a terrible mistake. Several of the Ichneumon larvæ have entered the worm, but only one

of them can find food enough to enable it to arrive at maturity; so probably the strongest one devours its weaker brethren when food becomes scarce, or else they die from hunger.

Description of the larva of Polyphemus. When fully grown this larva measures over three inches in length, and the body is very thick. The head is of a light chestnut brown color; the body of a handsome transparent light yellowish green, with seven oblique lines, of a pale yellowish color, on each side of the body; the segments are each adorned with six tubercles, giving rise to a few hairs, which are tinted sometimes with orange, with a silvery spot on the middle; there are six rows of protuberances, two on the back and two on each side, and the oblique lines run between the two rows of lateral tubercles uniting the lower one to the upper one by a yellowish line. The underside of the body is longitudinally striped with a faint yellowish band; the spiracles are of a pale orange color, and the feet are brown. The posterior part is bordered by a purplish brown angular line similar to the letter V.

Description of the Pupa. The pupa is much of the form and size of a robin's egg; the color is dark chestnut-brown, with a pale greenish spot at the base of the antennæ. The form of the legs, wings and antennæ are distinctly marked, while the posterior part is furnished with a brush of minute hooks.

For a description of the Moth (*Imago*) see the Synopsis of Lepidoptera, by Dr. J. G. Morris*, only observing that there are at least six varieties: the yellow, the ferruginous, the brown, the greenish, the pale cream color, and another variety with the black lunule on the secondaries replaced by a ferruginous spot. The male can be easily

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distinguished from the female by its lighter form, and by its smaller abdomen, which is not so highly coloured as that of the female; but the most striking difference is in the antennæ; those of the male are pectinated, broad, and like two feathers adorning the head, while those of the female are narrow and very much smaller.

Description of the Egg. The egg is about one-tenth of an inch in diameter, almost cylindrical, with the two ends convex. The cylindrical surface is brown, with a narrow white spot about one-half the width of the egg; the two convex parts are white. One hundred of them weigh on the day they are laid, eight grains, but an evaporation of the fluid contents of the body takes place, and on the day the young hatch out, the same number weigh only six and two-third grains. One hundred and ten empty shells weigh one grain; about six thousand worms are equivalent in weight to one ounce. I will now proceed to give some instructions as to the rearing of the worm. They will be easily understood, if I have been clear enough in explaining the natural history of the Polyphemus Silk Worm.

Selection and preservation of Cocoons intended for Stock. The cocoons' intended for the propagation of the species for the following year, should be carefully selected. As a general rule the female larva is larger than the male; so the cocoon of a female is also larger than the male cocoon. I estimate a cocoon to be a very good one, and the pupa within healthy, when it is heavy for its size, and resists well the pressure between the fingers, not being deformed by it. About one-half of the number intended for propagation should be selected from among the largest; very probably the majority will be females. The other half should be selected, not among the largest, nor

the smallest, but among the intermediate ones. When properly selected, they should be placed beyond the reach of rats or mice, in boxes, baskets or bags. The boxes should be stored in a cold, dry room, or cellar, where the temperature does not get above forty-five degrees, for if the temperature be higher, they will be liable to hatch before winter. While the temperature should not go above forty-five degrees, it can descend indefinitely without injury to the pupa.

Hatching out of the Moth. Towards the end of May, in the latitude of Boston, the temperature sometimes reaches seventy degrees. I have said above, that a heat of fifty or fifty-five degrees continued for some time, is sufficient to put in activity the causes which transform the pupa to perfect insects. So about the middle of May, the cocoons should be taken out of the cellar and put into the hatching room, as the time approaches when the perfect insect will appear out of its prison. Tables or shelves should be placed in the hatching-room to lay the cocoons upon. They should be spread out, and not piled one upon the other, as the insect in coming out would get to the surface with difficulty. Over the tables or shelves where the cocoons are placed, should be hung pieces of cloth, or net, to which the insect can easily attach its hooks, for the purpose of allowing its wings to develope. The perfect insect rarely comes out before noon, and very few after five o'clock in the afternoon. One should watch the process of exclusion, in order to help the insects when they do not readily find the net, or cloth to cling to, and also to remove those which disturb others whose wings are already expanding. The rays of the sun should not fall directly upon the cocoons, as the heat would cause a rapid evaporation, which would certainly kill the chrysalis.

Towards the evening of the day on which the moths leave their cocoon, an equal number of both sexes should be placed in the same cage, and after pairing, the females should be kept until they die, which will occur in four or five days after their union. The eggs which are stuck to the cage with gum, should be scraped off with a wooden, or whalebone knife, and then spread in a large pasteboard box to dry thoroughly. A ticket, with the date stating when the eggs have been laid, should be put upon the box, so as to indicate the day the worm will probably hatch.

The length of the period of incubation depends entirely on the temperature, but in June, the incubation generally lasts twelve or thirteen days, while in August the period is two days shorter. Eight or ten days after the eggs have been laid, they should be placed in the hatching box, which should be made of tin, and about three inches long, two inches broad, and one and a half inches deep. In the middle, a narrow longitudinal band of tin should be soldered, and bent so as to form a hook by which the box may be hung to some twig or branch. The box should be painted, and before it is dry sand should be sprinkled over it, so as to make a rough surface upon which the worm can crawl with ease.

The larvæ hatch out from five to ten o'clock in the morning, and the attendant should be ready at that time, to place the box upon a branch which has its extremity in the water. A thousand of the little worms can feed upon a branch of moderate size for four or five days, and when it is well covered with them the box may be removed to another branch. The larvæ feed equally well upon the different species of oaks, maples, willows, poplars, elms, hazels, birches, blueberry and other plants, without affecting the quality of the silk.—*Concl. in May No.*