# SOME OBSERVATIONS ON THE TELEA POLYPHEMUS LARVA

Early last June, while working on a bird photography project near Jackson, Michigan, I found two polyphemus cocoons on spiraea bushes in a marsh. They were heavy with unhatched pupae. Motivated by childhood feelings -- a mixture of discovery and acquisitiveness - I collected and carried them around with me in my car. Being a non-smoker I kept them in the open ash tray on the dashboard. From time to time I vaguely wondered what I would do when the moths emerged but never reached any decision about it until one morning around the first of July in a little cross-roads town in the Upper Peninsula where I had gone in pursuit of birds. I discovered that one of the cocoons was very light and saw that the moth had hatched and flown away through the open car window during the night. I was more disappointed than I imagined I would be to have missed this event. I would have liked to have seen the fat adult emerge through the silk walls of its cocoon and to have witnessed the enormous expansion of its limp wings. I resolved then and there not to miss these happenings - at least not to miss all of them - when the second cocoon hatched. So from then on, when I was not in it, I kept the windows of my car shut.

A few days later I left Michigan for my home in Santa Fe, New Mexico. On the second day while driving up the valley of the Platte River in Nebraska, I noticed something moving in the ash tray. The other moth had come out and was struggling to escape into the open. She, for it proved to be a female, was not the beautiful creature I

had anticipated. Her wings were crumpled and deformed by the confined space. She must have hatched several hours earlier and, being unable to crawl free, her wings, useless now for flight, had not been able to expand properly. Had she been perfect, I probably would have released her and the sequel to these initial events would never have taken place - at least not under my observation. But being the poor, deformed creature she was, I felt compassion and responsibility for her and gave her a twig, which I hung over the rear-view mirror, to cling to for the rest of the trip. Slowly as I drove along, a plan began to evolve in my mind; I would guard her virginity until I got home and then I would offer her at night as a lure to indigenous males of her kind. Since I had never seen polyphemus moths in New Mexico, although they are supposed to occur there, I was curious to see if she would attract a mate.

Arriving in Santa Fe in the afternoon of the third day, the first thing I did was to place the moth on a small potted oleander in the patio. There she made her way to the top of a slender branch and clung motionless as day faded slowly into evening and evening into a warm, still night. The next morning I arose, not very early, and remembering my moth while drinking my breakfast coffee, hurried out to see how she had passed the night. I confess that I had little confidence in the success of my experiment, expecting that she would cling unrequited for days to her oleander branch until she died. Therefore, I was somewhat taken aback when I saw that she was not alone. With her - coupled to her - was a tattered, weather-beaten male. Where had he come from - how far - in response to her emanations? Judging from his appearance one would be tempted to say that it was a great distance. Perhaps it was, or perhaps he

had been searching nearby for days for a mate until my moth was fortuitously transplanted into the radius of his senses. They stayed together all day and during the following night he disappeared.

I placed the now fertilized female in a cage and gave her branches and leaves on which to deposit her eggs. She crawled restlessly from twig to twig in a continuous search, the motivation for which I did not understand. It may have been that she was looking for a more suitable food plant for the offspring she would never know. I had provided her with willow, cottonwood and elm. The book I consulted said that polyphemus larvae could subsist on a great variety of vegetation including hickory, basswood, elm, oak, birch, dogwood and wildrose. My choices did not seem to meet her requirements, however, and not being able to use her wings effectively, she kept falling to the floor from which she was unable to rise again. I finally gave up helping her back and after several days she glued quantities of small, disc-shaped eggs to the bottom and walls of her cage. When she was through laying I scraped the eggs into a jar. There were more than one hundred of them. From then on, because I could not bring myself to destroy her, her life slowly faded out, although she lived distressingly longer than I would have considered possible.

The hard, grain-like eggs remained, to all appearances, inert in the jar for over ten days. Then one day within the lapse of a few hours they all split open on one side like the opening of the hinged lid of a round box and tiny, hairy, green caterpillars crawled out. It seemed impossible that they could survive very long without food or water, but they are in fact remarkably hardy creatures and spend

a good time wandering around before they at last settle down to feeding. This behavior serves to disperse them and probably has important survival value. I divided them into ten groups which Iplaced in separate petri dishes with moistened filter paper and different kinds of leaves. Among the plants used to test their preference, all available nearby, were elm, willow, woodbine, wildrose and black locust. After a day those that had been given elm, black locuts and rose leaves began to eat, but all the others ignored their food. Elm and black locuts were the most favored plants so I put them all on these two varieties. However, after several days, many of the young caterpillars died and I was forced to conclude that their food was not proper. Going back to the recommendations in the literature I found that oak was the only easily available and abundant tree in this area common to them all. Gambel's oak occurs plentifully in the mountains at a slightly higher elevation than Santa Fe. I gathered some leaves of this tree and was relieved to see that they were quickly accepted by the surviving caterpillars. From then on they settled down to a steady diet of oak leaves on which they subsisted and thrived throughout their larval lives.

My stock of polyphemus larvae had shrunk during these first critical days to about a fifth their original number, but they were now growing rapidly and acquired a sparsely hairy, healthy, translucent green complexion with rows of pinkish dots along their sides. Every two or three days I provided them with fresh food, transferring them gently from the old to the new supply. This process took over an hour and during it I had ample opportunity to observe the differences in appearance and posture between individual caterpillars.

Some would be eating steadily when the transfer was started, whereas others would be found inactively clinging by their five pairs of prolegs - the false feet at the rear end of a caterpillar - to a twig or petiole. In this position the body was arched back away from its support and the head curved forward and tucked under the first few, bulging thoracic segments in the shape of a question mark. Seen from the front with its three pairs of true legs gathered together under its chin, so to speak, like three pairs of hands palm to palm it presents an aspect of most devout prayer. This I call a resting position which the larva assumes periodically between times of feeding. It lasts maybe for an hour and is always followed by a resumption of eating. What the significance of this attitude is, I was unable to determine although it might be the result of temporary glutting.

There is another resting attitude, quite similar in some respects to the first, which proved to be related to and to presage a sequence of events of the utmost importance to the animal. Every time I changed the caterpillars' food I had been on the lookout for signs of molting. One day I did find a caterpillar in the act of shedding its skin. It had just begun to peel back and I saw that the skin broke loose at the head end first. The brown, horny chitin covering the head separates and is pushed forward revealing under it the nearly white new head; then the transparent skin on the flanks of the first four or five segments splits longtitudinally as the larva rears back and frees its legs. After this the shed skin which forms a strap along the larva's back separates and falls away carrying with it backwards the old head piece, which often at this moment becomes detached and falls to the ground. I had observed previously

that sometimes in its resting stage the caterpillar's head was not always neatly tucked under in the question mark position but seemed to be protruding and showing a white wedge at its base. This appearance, I suspected and subsequent observations confirmed, was the first indication that molting was about to begin or had already begun.

It was now possible to recognize and to observe and photograph the complete process of molting from beginning to end. The pre-molting resting stage, as I call it, to distinguish it from the glutted resting stage, always starts with the caterpillar hanging from its support, whereas in the other it may be either above or below it. Furthermore, in pre-molt resting all five pairs of prolegs are attached to the support which is not necessarily so in glutted resting when the forward pair are often held free and opposed. It will be seen later that these details of position are necessary for the larva to free itself with least difficulty from its old skin. Pre-molt resting, indicated by the forward-thrust head, may continue for hours before active shedding sets in, the first sign of which is a loss of the inflated, rubbery look of the larva's body segments as the skin becomes wrinkled and loose. A band of compression forward of the first pair of prolegs appears, the beginning of a series of contractions that occur at increasingly frequent intervals and gradually develop into slow peristaltic waves passing down the animal's body to die out near the caudal end. As the tempo of contractions rises, the skin becomes streaked with white lines and blotched with shiny areas of separation. Then, as it begins to slip back and the head chitin drops forward, the linings of the breathing tubes, the tracheae, two for each segment one on either sideof the body, begin to pull out

through their exterior openings called spiracles and show as white bands. This is a critical moment for the insect because if molting is disburted or progresses abnormally, its respiratory system may be permanently damaged. The caterpillar has by now become quite active, rearing, bending back and stretching to split the old skin and pull free its legs. Several things happen more or less simultaneously; the skin on the sides of the larva near its front end splits; the true legs are pulled out of their old integuments; and the first pair of prolegs begin to emerge leaving behind, still attached to the support, their old sheaths like a thin pair of flexible gloves being pulled off right side out. Splitting continues rapidly and as noted above the front half of the skin drops down over the insect's back carrying with it the shed head chitin. By continued peristaltic contractions as well as by pulling itself along its support, the caterpillar rolls the posterior half of the old skin down over its body into a shrunken, wrinkled mass. One set of appendages after another are withdrawn as the skin slips over them. A final act of grooming in the anal region is performed by the insect with its mouth after the skin is completely shed. Following these exhausting labors, it rests for several hours but before resuming feeding the larva turns around as a seeming afterthought and deliberately consumes, holding it meanwhile by its legs, the entire discarded slough with the exception of the horny head piece.

The sequence of photographs showing molting were made when the larvae were four to five weeks old and nearly full grown. The molts at this age were probably the last they underwent before entering the cocoon spinning and pupation period in their lives. This is not

to say, however, that they did not continue to feed and to grow still larger in preparation for these terminal larval events. Their appetites became prodigious and they devoured more and more food, stripping whole branches of leaves in a day. But at last when they were six to seven weeks old, one by one they stopped eating and began to encase themselves in silk. The way in which they spun their cocoons and protected them against mishap is the subject of the next period of observation of the caterpillar's life history.

The basic spinning process is the formation of a mat of silk fibers glued together with saliva. Both these substances are secreted by glands within the caterpillar's body and exuded through its mouth parts. The silk, which starts as a liquid, is drawn out in a fine filament that sets into an insoluble material on exposure to air. Saliva, the binding material, also sets or dries into an extremely adherent consistency immediately on excretion. The larva draws the silk fiber, which is usually invisible except for an occasional glint of reflection, from its mouth, either with its lega or by virtue of the motion of its head after sticking it down. The two substances are probably excreted by the larva simultaneously, coming in contact as soon as they leave its mouth. It is possible, however, that it produces a fiber already wetted with saliva as it is drawn out. But in either case the fibers would stick together or to any support they came in contact with and the results would be the same.

Cocoon spinning starts with the caterpillar selecting a group of leaves that it can gather together to establish a foundation for the first layers of silk. The procedure followed is to deposit a mixture of silk and saliva on a leaf or twig covering a small area

by a back and forth weaving motion of its head. From this anchor fibers are led to another similar connection on an adjacent leaf and pulled tight to draw the two attachments together. Astonishing as the strength of the fiber is to sustain this strain, it is not less remarkable than that of the salivary attachment to which it adheres. In this way spaces between leaves are narrowed. The gaps are filled in later with silk that is woven between the leaf edges and their silk covered surfaces.

The caterpillar works on the whole cocoon at once, turning around frequently to do it, and does not carry progress on one part far in advance of any other. It attempts to make a complete leafy enclosure as an outer support for its cocoon. To this end it goes to a great deal of trouble, pulling in leaves on all sides and fastening them together. After the first two have been secured, other leaves are sought but they are not always within easy reach. The caterpillar, in its effort to find a leaf, will crawl out of one end of its cocoon space to the full length of its body - holding on only with its posterior prolegs - and grope around in space, waving this way and that in its search. It usually succeeds in finding one which it hauls down over itself by a silk filament and secures firmly in place. To see what the caterpillar would do, I have broken these fastenings repeatedly, but they were persistently re-established until the leaf was removed altogether. Observations of the caterpillar's behavior becomes increasingly difficult as its leafy covering is completed. In some cocoons, however, wide spaces between leaves are filled with silk instead of being covered over, and the actions of the larva can be observed for some time through the mesh. Under these circumstances

it is seen working away on the inside surface, swinging from side to side, laying down silk all around over the surfaces of the leaves and the silk bridges between them, and often turning around to build the wall first at one end and then at the other.

Before the cocoon is closed in at the end where the leaf petioles attach to the twig, the caterpillar makes sure that the cocoon will not drop to the wet ground with the falling of leaves in autumn. It weaves silk around the stalks of several leaves, up to the twig and around it many times. It reaches far out of the cocoon and around the woody part of the twig, moving its head first around in one direction and then the other to spin a very strong, visible band of silk which becomes an integral part of the outer layers of the cocoon itself, and anchors it securely in all weather.

The last stages of spinning, which occupies altogether four or five days, can only be observed by cutting open the cocoon. When this is done, the larva is seen, somewhat shrunken from loss of material that has been transformed into the large quantities of silk and saliva used, still laying down silk on the smooth interior wall. Opening the cocoon will stimulate the larva to increased activity and it will seal the cut if the edges are kept opposed. Eventually, however, spinning ceases and the larva lies in its neatly fitting space, fat and shortened, semidormant, able to wriggle but not to turn around, and still bright green, although it has lost its translucent larval quality.

Dormancy continues for a week or ten days as pupal transformations take place within the body of the caterpillar. They are reflected in a slow change in its exterior appearance. Gradually the bright green color fades to a pale greenish yellow. The skin becomes wrinkled and ill-fitting and blackened at the tail end. The prolegs

change to two rows of dried black knobs along the ventral side. To all intents and purposes the creature looks as though it had died and were falling into decay, but if it is stimulated by touching or stroking, it may give a violent jerk, belying its appearance. At this juncture the final pupal changes take place rapidly without warning signs. Suddenly the animal bends from side to side, swinging its abdomen first one way and then the other. During these convulsive movements its body rotates in the cocoon and the skin loosens and begins to slip off caudally. Then a split appears at the head, traveling down the center of the back, allowing the skin to peel down ventrally as the wriggling movements continue. The linings of the tracheae are shed as in molting by being pulled out through the spiracles and appear in pupal shedding also as white bands along the sides. In an unopened cocoon the larval skin is compressed into a pad on which the posterior end of the pupa rests, but in one that has been opened without confining walls it tends to remain more expanded.

The pupa that emerges from the necrotic-looking caterpillar skin is a beautiful, translucent, yellow-green creature with all the features of the adult moth neatly folded over the ventral thorax. Most prominent among them are the antenae, from the size of which the sex of the adult can be recognized, and the vestigal wings with all the veining visible. Slowly the color of the newly born pupa changes. First the lighter, yellowish abdomen turns to a yellow-brown, while more gradually the thoracic end darkens to a richer brown and deeper green. The last parts of the pupa's body to lose their green color are the appendages - the wings and antenae. This color transformation

is part and parcel of a profound change that takes place in the integument of the creature.

When the metamorphosed pupa first emerges its tender, soft body could be easily injured. To afford it more protection against the vicissitudes of weather, perhaps, as well as mechanical damage, the ectodermal layers harden into a touch chitinous shell in which the animal can live through the winter and emerge the following summer, after completing its metamorphosis, a fully developed adult.

The cycle is now closed. The original polyphemus cocoon from Michigan produced a female moth which after fertilization by an indigenous New Mexico male, deposited a large number of eggs. These hatched and grew, by undergoing a series of moltings, into large larvae. They, in turn, spun cocoons and pupated and are now waiting to reemerge as winged adults. Thus, the continuity of the life substance is assured.

I have observed closely and photographed only parts of this life history. To continue with the rest of it: The emergence of the adult, fertilization, egg laying and the early larval stages, I must wait for warm weather to return. Although I have made no new observations nor added to entomological knowledge, I have discovered for myself things that I did not know before and that I could not have learned so well in any other way. I feel that I have acquired a speaking acquaintance with Telea Polyphemus, one of the entities of our living environment, and that all the hours devoted to this association were well spent.