CARNIVOROUS MOTHS AND BUTTERFLIES

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Moths and butterflies, because of their beauty and the ease with which their larvae may be reared, have long attracted much popular interest. We have a larger body of knowledge today concerning the members of this order than for any other group of insects. As a consequence, it has been conclusively established that the chief food of caterpillars is living plant tissue, but it is not so fully appreciated that large numbers of the Lepidoptera feed upon other animals, primarily other insects. The outstanding examples of carnivorous moths and butterflies now known occur in the tropical portions of the earth, but many exist in our own country. The habits of the carnivorous minority are characterized by a greater degree of specialization than is exhibited by their phytophagous relatives. A series of instances will serve to illustrate the nature of these habits.

A small number of cases has been recorded indicating that adult Lepidoptera may take the products of animals as food. Numerous moths, the most of which were Geometridae, were observed by Shannon [1] sucking the eye secretions of a horse in Argentina, and also visiting other parts of the body and endeavoring to feed on the perspiration. Their need for moisture is abundantly met by rainfall, hence it is considered more likely that the moths craved salt. Several observers in the tropics report seeing adult butterflies of the family Lycaenidae probing aphids and tree hoppers with their beaks to obtain the sweet secretion commonly produced by these Homoptera. The tropical hawk moth, *Acherontia atropos,* enters the nests of both wild and domesticated honey bees and with its relatively short beak sucks the honey from the cells. Although not carnivorous, these species have departed somewhat from the usual nectar sipping habit of their stage, and depend more or less on materials provided by other animals. In a similar way, the common clothes moths represent a divergent habit in the larval stage in their attack upon animal products. An African species, *Tinea vastella* Zell, is known to have constructed brown, fingerlike tubes of silk and debris on the horns of a dead water antelope. The tubes connect at the base with galleries in the horn, where the larvae feed. It

is considered possible that the tubes may occur also on the horns of the living animal.

Truly carnivorous Lepidoptera are invariably caterpillars, and may be divided into two groups, according to the regularity of their feeding habits, (1) occasional predators, and (2) habitual predators or parasites. Students of insects not infrequently observe a habitually phytophagous caterpillar turn carnivorous upon occasion. In control experiments, small codling worms in artificially infested apples become cannibalistic when the fruit is overpopulated. It is rare to find more than one corn earworm at a time on the tip of a corn ear, but when two or more occur, they are invariably distinctly separated from one another. The presence of a single larva on the ear is explained by the fact that the larger or more aggressive individual seizes the other and at least breaks the body wall of the victim, causing its death. This habit may simply indicate a pugnacious temper rather than a desire to feed, but it suggests one way in which carnivorous tendencies may begin. A similar viciousness exists in other common caterpillars, notably some species of Papilionidae and the monarch butterfly, but here the tendency has gone beyond the level of pugnacity. When plant food is inadequate these larvae attack their own kind, often individuals which have transformed to the pupa state, and consume them more or less entirely. Often the attack is limited only to what chances to be at hand. A tiger moth larva, ordinarily a plant eater, fed upon a noctuid caterpillar, and an Orthosid larva, placed in a cage as food for a predaceous Pentatomid, reversed the expected procedure and devoured the stink bug instead. *Heliothis dispaceus* seems [2] to eat the chrysalis of the imported cabbage butterfly *(Pieris rapae)* even when its food plant is available in the cage. However, in most instances of occasional predatism, the attack appears to be induced by hunger. Proximity, due to overpopulation or cage conditions, or factors such as a vicious nature, or the stimulus of hunger, or all of these in conjunction, may be responsible for this radical change in kind of food taken.

A small pryalid moth *Cryptoses choloepi* Dyar, possesses the remarkable habit of existing, perhaps in all its stages, in the fur of the living sloth. The gray pelt takes on a green color due to the presence of algae growing in large quantities on the hairs. Although the caterpillars may eat the algae, the insect is responsible for matting the fur, and we have the unique phenomenon of a phytophagous insect which, in a sense, owes its existence to a vertebrate host.

In the majority of carnivorous Lepidoptera, the practice of eating other insects has become mostly habitual. The handsome little pyralid moth, *Dicymolomia julianalis* Wlk., has been reared [3] from the bag

of the common bagworm. The larva is known to eat the eggs deposited in the bag in the fall by the wingless female moth. In each case, where a full grown larva was found, the eggs of the bagworm had been entirely consumed. The full-grown predator larva spins a cocoon on the outside of the free end of the bag. This species had been formerly reared from the heads of cat-tail. The adults probably issue in April or May, and the eggs of the bagworm hatch in spring, so that the progeny of the predaceous species must have another host to carry them through the summer.

Several moths belonging to widely separated taxonomic groups have become specialized to live at the expense of scale insects. Some of these may properly be designated as parasitic in habit, the entire larval life being spent within a single scale, but the larvae of other species crawl about and consume one coccid after the other. *Erastria scitula* Ramb. [4], a small Noctuid moth, deposits her eggs on leaves and young buds of plants infested with black olive scale and others, or directly upon the back of the bark-lice. The young larva at once enters its host, devouring all the internal organs, then seeks another scale, hastening to bury itself in the new victim. After ten days the larva begins to make a silk covering which enlarges the case previously formed of debris and the shells of consumed coccids. This case, which resembles smut-covered scales, is carried by the last instar larva. Openings are left for the head and venter. Under this armour, the predator crawls about devouring several scale insects each day. The case is finally enlarged, and when it has been attached to the bark of the tree, the larva spins a cocoon for pupation. Several generations occur in a year in Europe, all developing on scales.

Another Noctuid species, *Eublemma rubra* (Hampson), feeds on *Lecanium* scales in Central Java [7], and always carries a shield which is believed to protect the larva from the fierce red tree-ants, *Oecophylla smaragdina* which tend the scales. That the covering has a protective function is suggested also by the caution with which the larvae use it. As in the instance of *Erastria,* it is composed of pieces of scales intimately spun together, but remains open below. The basal rim of the shield is securely fastened by means of silk threads to the branch or leaf on which the caterpillar lives. When ready to move, the larva drags the shield a little forward, cuts off the anchoring threads, and at the same time fastening it again with new silk. In this way the shield is never loose from the branch and the caterpillar moves its house along slowly, until it comes upon a scale insect. If the prey is still young and flat, the shield has to be raised to get the victim partly underneath it, whereupon the insterstices between the lower rim of

the shield and the branch are closed with a dense web of silken threads. The caterpillar then gnaws a large hole in the back of the scale and devours its contents. The larvae of *Catoblemma sumbavensis* Hamp. carry a similar shield and destroy the Coccids, *Tachardia aurantiaca* Cock., which are also tended by the tree-ant.

The carnivorous habit of *Eublemma amabilis,* on the other hand, makes this species an enemy of man because it feeds extensively upon *Tachardia,* the lac insect, which is the source of the valuable commercial product known as shellac. In some tracts of India [8], 20 to 25 per cent of the lac scales are destroyed each year by this moth. The larva chews its way through the heavy covering of resin present over the lac insects and penetrates down into the lac cell. It devours both sexes of the scales, and makes galleries through the encrustation of scales as it goes. The insect pupates in these galleries. Two to three generations occur in a year. Several other species of noctuid moths also attack the lac insects in this way.

On the other hand a small pyralid, *Laetilia (Dakruma) coccidivora* Comst., a species widely distributed in the United States, does not form a portable case, yet like *Erastria* it consumes many scales during its larval growth. It feeds [5] on the eggs and young of our larger scales, *Dactylopius, Lecanium,* and the cottony maple scale, *Pulvinaria innumerabilis.* The larva works beneath the bodies of the scale insects [6], eating them out, one after another, from below. When the scales are crowded upon a twig or branch, the predator larva passes directly from one to the other without showing any indication of its presence but where the scales are more scattered and some distance intervenes between them, the *Laetilia* larva traverses the open spaces within a delicate silken tube which it spins as it goes.

If any carnivorous Lepidoptera may be said to be truly parasitic, this habit has been developed in the families Blastobasidae, and Heliodinidae. The prominent gall-like insects of the scale genus *Kermes* are the hosts of two species, the oak-coccid Blastobasid, *Zenodochium coccivorella,* and the more common Heliodinid *Kermes* parasite, *Euclemensia bassettella.* Comstock [5, p. 629] found the *Zenodochium* larva common as an internal parasite at Cedar Keys, Florida. *Euclemensia* is widely distributed in this country, being known from Connecticut, Florida, Minnesota, Texas, and intervening states. The larva makes its entire growth within a single individual of various *Kermes* species, and seems [9] to confine its activities to a V-shaped retreat or burrow which occupies the lower half of all the infested hosts, instead of working at large throughout the body of the scale. The larva, which is grub-like, possesses poorly developed thoracic and abdominal legs,

exhibiting the type of reduction of locomotor appendages and form of body generally associated with parasitic holometabolous insects. The full-grown larva cuts a small hole through the hard body wall of the host, and then closes it again with a thin, tough mesh of silken threads. The pupal stage is therefore passed within the shell of the host.

A unique instance of a small pyralid larva of the genus *Sthenauge* living as an external parasite on the caterpillar of several species of Saturniid moths of the group *Automeris* is reported [10] from Brazil. The parasite larvae spin a web across the back of the host caterpillar from spiracle to spiracle between two rows of spines, forming a loose transparent retreat open at each end. They eat the spines of the *Automeris* which sickens and finally succumbs. As many as six of these very active pyralid caterpillars may live on a single *Automeris* larva. The full-grown parasites pupate in a tough, blackish cocoon in the ground.

The tineoid family Epipyropidae includes a number of genera and species well known as parasites. These have become specialized to live at the expense of some members of the homopterous families Fulgoridae, Cicadellidae, or leaf-hoppers, and Cicadidae. Hawaiian entomologists contributed much of the present knowledge because the larvae are of economic benefit through their attack upon destructive leaf-hoppers, but reports of the interesting habits of these parasites have come also from South America and Australia. *Agamopsyche threnodes* is parasitic on the sugar cane leaf-hopper and allied hoppers in Hawaii. Perkins [11] gives a fairly complete life-history of this species, which is somewhat typical of the habits of other members reported in literature. The sluggish, parthenogenetic female begins oviposition very soon after emergence. The eggs are deposited in masses on dead grass leaves. The larval stage is passed on the back beneath the wings of either short winged or long winged adult hoppers. The larva, which has been aptly described as a "coccus-like insect," moults on the hopper's back, and in most instances the parasite has the head turned toward the tip of the abdomen of the host. Some Homoptera that serve as hosts of Epipyropidae excrete a mealy covering, which, it was sometimes believed, constitutes the food of the caterpillars. However, other hosts lack the waxy excretion. It is probable that the food consists of the honey-dew which is commonly produced by Homoptera affected by these larvae. The fact that the parasite's body is headed cauded suggests that this sweet liquid is taken as food. The effect of parasitism of this type on the host is not fully understood, but death not infrequently results, and usually the host's abdomen becomes shrunken and depressed.

According to observations of Dodd [12], the larva of the Queensland form *Epipyrops doddi* acquire a light, waxy, white cover, which is presumably a secretion of its own. Upon moulting, the entire white covering is shed, and a new one is formed in a few days. The larva is capable of dropping on a thread, as many caterpillars do, and when thus suspended, looks like a spider's egg case. The full-grown larva of known parasitic Epipyropidae leaves the hopper and makes a cocoon on grass blades.

Perhaps the most surprising examples of carnivorous Lepidoptera are to be found among the butterflies. Furthermore, all butterflies whose carnivorous habit is known to be habitual belong to the family Lycaenidae. In view of the delicate and beautiful forms of our native coppers and blues, one scarcely would have expected to find the aggressive and fine structural adaptations necessary to a predaceous habit, in the larvae of these butterflies. Yet, in this family occurs a relatively large number of species that eat other insects, and more remarkable still, the phenomenon of predatism has assumed a diversity of type exceeding that of any other groups of carnivorous Lepidoptera. However, the various exhibitions of this predatism are fundamentally related and probably derived from a common ancestral type of habit.

Of the eight subfamilies composing the Lycaenidae [15] only two, the Gerydinae and the Liphyrinae, so far as known are exclusively carnivorous, but the larvae of several others are carnivorous in the last instar.

The caterpillars of all the Lycaenidae are more or less slug-like, or for the most part shaped like sowbugs. Those of certain species are attended by ants. This attention [17] is due to the excretion by the larva of a liquid agreeable to the ants. The liquid is produced from a slit-like opening on the seventh abdominal segment. On the eighth segment is a pair of evaginable organs believed by some observers to yield an odor that serves to attract the ants. The larvae of some sixty-five species are reported to be attended by ants, and these organs have been found in a large number of species. However, not all ant-attended species are carnivorous.

A few examples will illustrate the trend of development of the lycaenid carnivorous habit and the bearing of association with ants and Homoptera upon that habit. Even among the phytophagous species, which predominate numerically in the family Lycaenidae, there exists a strong tendency toward occasional cannibalism.

The next step in lycaenid predatism is exemplified by *Lycaena alcon*. The young larvae [18] feed in the autumn on the flowers and other portions of *Gentiana pneumonantha*. When it reaches the third

instar it leaves the plant, and the rest of its development is completed in nests of ants. Here it feeds on both the larvae and the pupae of the ants. Other English species, *Lycaena arion,* and *L. euphemus* have similar life cycles, the last larval instar turning carnivorous upon ant brood.

Liphyra brassolis [15], an Australian species, places her eggs on the branches of a tree that bears several large nests of the tree ant, *Oecophylla smaragdina.* In this grade of predatism, the caterpillars, during all their growth, live in the nests of the ants and devour ant larvae. There is evidence that they pass from one domicile to another, presumably when their food is exhausted in one. They are evidently so tough skinned that the mandibles of the ants can make little or no impression upon them. Pupation takes place in the ant's nest, and the emerging adult, although attacked by the fierce ants, escapes unharmed. The scales covering the body of the butterfly adhere to the antennae and mandibles of the ant, so annoying the assailant that it retreats from the attack.

Lamborn [14] found *Aslauga lamborni* associated with *Cremastogaster buchneri* var. on a Euphorbiaceous plant bearing a scale, *Stictococcus sjöstedti* Cock., which are almost invariably attended by ants. In this animal complex, the Lycaenid larvae consumed the Coccidae. No dorsal gland was found on them. Their skin was hard, tough, and covered with coarse, rough tubercles, evidently protective in function, and it extended down as a fold on all sides in carapace fashion so as to protect the soft lateral and ventral surfaces. The lower margin of this fold bore a fringe of very fine hairs such as would efficiently prevent small insects from crawling underneath. Only the presence of spiracles gave evidence of body segmentation. On account of the long neck, the larva is able to thrust the head out and retract it in a tortoise-like manner. Such a protective covering suggests hostility from the ants, and the absence of the honey-dew gland indicates that the ants have no incentive to be on friendly terms with the caterpillars that destroy their food-producing coccids. A special development in method of attack for the sake of securing food is shown by the African *Megalopalpus zyma* [14]. The associated ant was *Pheidole aurivillii* which attends certain leaf-hoppers and tree hoppers. Again, the ants obtain no food from the Lycaenid larva, which, like the one described above, is equipped with a hard, defensive skin, and in addition is studded with tubercles surmounted with coarse hairs. The caterpillar has the ability to capture the Homoptera. The larva was often seen crawling slowly in the direction of the leaf hopper, *Nehela ornata,* stopping frequently and vibrating all three pairs of thoracic legs. Upon reaching the hopper,

the caterpillar caused its vibrating legs to play on the closed wings of the prey, in such a way, so Lamborn thought, as to simulate the caresses of the usual attending ants. Still advancing, it gradually raised the fore-part of its body so as to overhang the insect, and, when well above it, suddenly dropped and seized its prey with all its legs, immediately devouring the victim. Our own *Feniseca tarquinius* exhibits a similar relation to ant-tended Homoptera. This species, like many other Lycaenidae, seems to occur rather locally, being present only in the neighborhood of water where alder grows. However, it is widely distributed in the eastern half of the United States and Canada [15]. It appears to have three to five generations in a year from the northern to the southern limits of its range in the United States. The female usually deposits her eggs in the mass of aphids infesting the alder. There may be a dozen or more in a single colony of plant lice. Most often the alder aphis, *Schizoneura tessellata,* has been found to be the food of this caterpillar, but other plant lice are known to be consumed by them. The exact place of pupation has not been satisfactorily determined. Clark feels sure that the mature caterpillar drops to the ground to pupate on any convenient support.

Perhaps the most specialized food habit among Lycaenidae is that of *Euliphyra mirifica* Holl., another African form, associated with the ant, *Oecophylla smaragdina* var., which weaves leaves together composing its tent. The larvae of *Euliphyra* live in the nests of *Oecophylla.* Lamborn [14] observed this caterpillar thrust its little proboscis into the jaws of a large ant and keep it there while the ant made movements as if feeding it. Sometimes, when a large ant was feeding a smaller one, the latter retired in favor of a caterpillar waiting with proboscis extended to be fed. These caterpillars have neither dorsal gland nor tubercles, and it has not been discovered how they can benefit the ants. In fact, the larva is sometimes assailed by the ants, but its hard, carapace-like shield is at once drawn down to the supporting surface, effectively protecting the caterpillar.

Clark [15] summarizes the evolution of the food habits of carnivorous lycaenid larvae, saying that they are merely an extension of the intimate association with ants. This association is eminently characteristic of the carnivorous Lycaenidae, for they all feed either upon the brood of ants, upon material regurgitated by ants, or upon ant-tended insects. From the habit of feeding on ants or on ant-tended insects there is the natural transition, seen in *Euliphyra,* into a form which induces ants to feed it.

Some of the Lycaenidae in the warmer latitudes of our country may prove to have interesting carnivorous habits. A study of such

species would perhaps reveal additional intermediate steps showing the nature of the transition from the phytophagous to the carnivorous habit of feeding in this family. Some light could perhaps also be thrown on the origin of predatism as a phenomenon by a study of the conditions that induce normally plant-eating caterpillars to turn cannibal or predator on some occasions. Any attempt to answer these questions by an extensive investigation should yield much interesting information as well as keen enjoyment.

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