Biological Control Possibility

One phase of integrated fly control studies on poultry ranches in northern California involves research on several natural enemies of the house fly, Musca domestica **L., the little house fly,** Fannia canicularis **(L.), and other nuisance flies. The black garbage fly,** Ophyra leucostoma **(Wied.), is one promising, and otherwise harmless, biological control agent. Its predaceous larvae kill and feed on house fly maggots and other fly larvae which commonly inhabit chicken droppings. Recent studies have shown that one** Ophyra **larva during its development may kill from 2 to 20** M. domestica **maggots per day.**

A FRENCH SCIENTIST first reported in 1923 that *O. leucostoma* larvae were carnivorous, and a Russian worker published some additional field observations on their carnivorous nature in 1940. However, no one had studied the feeding habits of these larvae since then and no determination had been made of how many prey larvae are killed or consumed by each developing *O. leucostoma* larva. The 1963 tests reported here verified the voraciousness with which these predaceous larvae killed and fed on house fly maggots, and analyzed the biology and larval feeding habits of the black garbage fly under experimental laboratory conditions. As several previous workers had reported the larvae of another common fly inhabitant of chicken manure, *Muscina stabulans* Fall., (the false stable fly) were also predaceous on house fly larvae, this species was also included in the study.

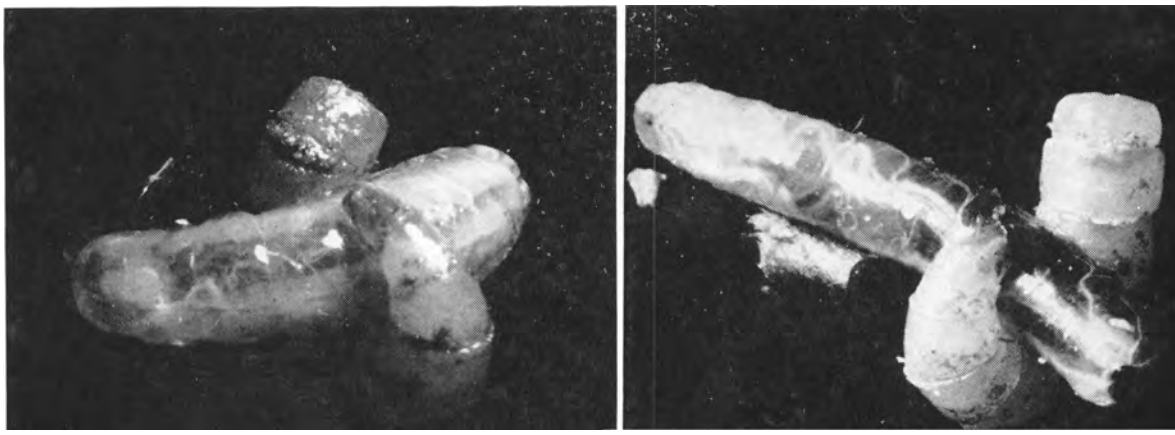
To determine the number of prey larvae killed per *O. leucostoma* or *M. stabulans* larvae, replicate groups of different numbers of predator and prey larvae were placed together either in standard, commercial fly larval rearing medium, or in moist vermiculite (an inert micaceous material in which the added prey larvae served as the only food source). Seven-ounce capacity jars half-filled (about 50 grams) with the nutrient medium or vermiculite were used to hold and rear 10 or more predator larvae and 25 to 200 prey larvae. The size, weight and age of both predators and prey were recorded for each experiment, and control jars containing different numbers of predators or prey alone were set up with each experiment. All jars were covered with a double layer of fine mesh nylon cloth, and tightly sealed at the top with a rubber band to prevent larvae from escaping. The jars were then placed in 5-inch deep enameled pans so that if any larvae escaped from individual jars they would be trapped and accounted for.

After initiating an experiment, all jars were checked for escaped larvae at periodic intervals during a 24-hour period. Prior preliminary feeding experiments had shown that the escape precautions were necessary because placing the predaceous *O. leucostoma* in the same jar caused the house fly larvae to rapidly attempt escape. Black garbage fly maggots forced almost all house fly maggots out of the rearing medium and up the bare sides of the jars within 10 to 30 minutes. If jar tops were not sealed tightly some house fly maggots would succeed in squeezing under or through a single layer of mesh. Whenever house fly larvae later re-entered the medium (presumably to feed), they were either killed or driven out again by the *O. leucostoma* larvae.

M. stabulans rarely predaceous

Although several previous workers had commented on the voraciousness of *M. stabulans* larvae as predators of other fly larvae, the specimens studied in these tests were rarely predaceous. In 260 jars containing from 10 to 50 *Muscina* larvae per jar in combination with varying numbers (usually 25 to 100) of *Musca domestica, Fannia canicularis* or *Ophyra leucostoma* larvae, *M. stabulans* larvae were predaceous on house fly larvae in only eight of 160 replicate jars containing larvae in nutrient rearing medium and in one of 40 jars containing larvae held in vermiculite. In like experiments, *M. stabulans* larvae did not feed on either *F. canicularis* or *O. leucostoma* larvae. However, when *M. stabulans* larvae did feed on house fly maggots, the resulting *Muscina* pupae were larger than the comparable controls which had developed on only the nutrient rearing medium. At this time, no explanation is available as to why the results with *M. stabulans* varied from previous reports on its voraciousness as a predator. However, even if other geographical races or genetic strains are con-

Coiling is the frequent manner of attack by Ophyra larvae. The house fly prey maggot is grasped and held by the predator as it injects a paralytic toxin, left photo. The paralyzed house fly maggot being penetrated by the feeding Ophyra larva, right photo.



For House Flies

J. R. ANDERSON
J. H. POORBAUGH

siderably more rapacious than the one studied, the encouragement of *M. stabulans* as a biological control agent for house flies appears highly undesirable because false stable fly adults can often be as much of a nuisance to man as the house fly—and robust *M. stabulans* adults are almost twice as large!

O. leucostoma highly voracious

Although *M. stabulans* larvae did not feed on *O. leucostoma* maggots in these experiments, *O. leucostoma* larvae attacked and fed voraciously on *Muscina* maggots. Other fly larvae killed and fed on by *O. leucostoma* in the laboratory included: *M. domestica, F. canicularis,* and the blow fly, *Aldrichina grahami* Aldrich. In control jars, pure cultures of *O. leucostoma* larvae developed as rapidly on nutrient rearing medium alone as when they were supplied with prey larvae. There was no difference in the weight of *Ophyra* pupae between those larvae fed on other larvae and those reared only in nutrient rearing medium. *O. leucostoma* larvae, however, always attacked and fed on other fly larvae whenever the prey were present, regardless of whether they were held in nutrient rearing medium or in moist vermiculite. When held in nutrient medium, *Ophyra* larvae killed as many house fly maggots as when held in moist vermiculite, thus indicating an attraction to or preference for house fly larvae over other components in the nutrient rearing medium. Groups of 50 to 200 *O. leucostoma* larvae held in moist vermiculite or crowded in the nutrient rearing medium were not found to be cannibalistic.

Attacking *O. leucostoma* larvae kill their prey by injecting a paralytic toxin into the body cavity via their needle-like mouthparts, and it appears that the speed with which the attacked prey die depends on the amount of toxin injected. Almost all attacked prey are eventually paralyzed and killed by the toxin, but not all attacked maggots are caught and eaten by their attackers. When struck at or seized by *Ophyra* larvae, house fly maggots squirm about vigorously and rapidly attempt to escape. Prey apparently injected with a large dose of toxin are paralyzed within seconds, whereas those receiving smaller doses may be only partially paralyzed and manage to crawl to the surface of the rearing medium where they eventually die. Although *Ophyra* larvae strike out at passing prey larvae or those contacted head to head, they appear most efficient in injecting immediately paralyzing doses of toxin when they coil around and hold their squirming victims as shown in photos. As paralysis sets in, the *Ophyra* larvae bore into the dead victims and begin to feed. A typical sequence of attack and subsequent feeding by the venomous snake-like *O. leucostoma* larvae is illustrated in the photo series.

Starved *O. leucostoma* larvae occasionally attacked and ate pupae of *F. canicularis* and *M. domestica,* but on the whole, such feeding was rare. Although the soft-integumented first- and second-instar larvae of *F. canicularis* were commonly consumed, *Ophyra* larvae did not usually kill or eat large numbers of the "leathery-like" older larvae of *F. canicularis,* apparently because their thicker integument served as a barrier to penetration.

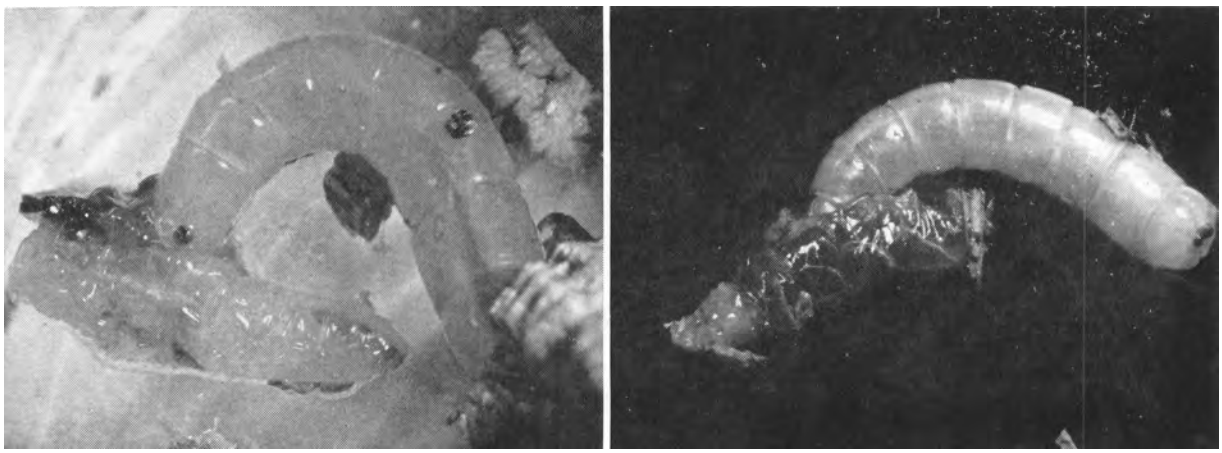
Quantitative studies

In quantitative studies, the number of prey larvae killed by an *Ophyra* varied with the age and size of both predator and prey at the time an experimental jar was set up, and upon the size of prey larvae subsequently added each day until the *Ophyra* ceased feeding. In beginning experiments with small (5 or 6 mm.) *O. leucostoma* larvae, the active feeding stage on other larvae lasted for seven to 10 days, after which the *Ophyra* larvae passed into the nonfeeding pre-pupal stage.

When supplied daily with only small house fly maggots (5 to 8 mg) the maximum number killed per *Ophyra* per day was 20, and when continuously supplied with 15 mgm *M. stabulans* larvae, each *Ophyra* killed 10 prey per day during five-day feeding periods. If supplied daily with large house fly maggots (20 to 30 mg) or large *M. stabulans* larvae (20 to 40 mg), the developing *O. leucostoma* larvae killed only two to three *M. domestica* and one to two *M. stabulans* larvae per day.

When a victim is punctured and invaded by an *Ophyra,* much of its body contents flow into and are absorbed by the rearing medium. As an *Ophyra* larva does not eat its prey's integument, the feeding larva actually obtains only about 10 to 20% of its prey's total weight. Be-

The meal in progress. Note body contents of prey which have spilled out around penetrating Ophyra and are beginning to spread over the bottom of glass dish, left photo. A half-eaten house fly maggot. Note wrinkled integument of the shrinking house fly larva, right photo.



cause killed prey are not efficiently utilized by these predators a medium-sized, growing larva must kill and feed on numerous small *M. domestica* maggots per day to obtain enough food. On the other hand, should such an *Ophyra* larva kill a *M. stabulans* or *M. domestica* maggot larger than itself, the feeding predator may become fully gorged before consuming all the remains of its victim. When this occurs, and if no other living prey are present after its first meal is digested, an *Ophyra* will return to a previously killed cadaver to feed on it again. However, if living prey are present, an *Ophyra* will kill and feed on them instead of feeding on the remains of a previously killed maggot.

When the total number of missing prey larvae per experimental jar is considered (after adjusting for natural mortality in control jars), it is apparent that *Ophyra* larvae kill many more prey per day than they can possibly eat. Superfluous prey larvae killed and left (or not found) by the *Ophyra* are subsequently eaten by the remaining living prey species. House fly maggots, for example, in preference to other food in the rearing medium, are rapidly attracted to and devour members of their own kind which have been killed and left by *Ophyra*. As no prey larval cadavers remain when the *Ophyra* are ready to feed again, they kill and feed on the remaining living prey larvae.

In addition to the voraciousness of the larvae, another aspect which makes *O. leucostoma* particularly attractive as a potentially favored biological control agent of house flies and related nuisance flies is that we have found that the adults rest at different sites about poultry ranches than do those flies on which its larvae feed. Current field studies are being conducted to determine whether the various insecticides recommended for fly control can be applied in a selective manner to kill a maximum number of house flies and other nuisance flies while sparing maximum numbers of the black garbage fly.

The black garbage fly is not considered a nuisance fly about poultry ranches because the adults do not, like house flies and other nuisance species, congregate about houses and other buildings. Instead, *O. leucostoma* adults gather about trees and shrubs and are not usually noticed.

John R. Anderson is Assistant Professor of Parasitology; and John H. Poorbaugh is Research Assistant, Department of Entomology and Parasitology, University of California, Berkeley.

Plant Rooting Studies Indicate Sclerenchyma A Restricting Factor

Brighter-walled cells running through center of micro-photos below are sclerenchyma tissue of Ascolano, top photo, easiest-to-root olive variety in these tests; Sevillano, center photo; and Moraiolo, bottom photo, the two most difficult to root varieties. Many holes appear to exist in continuity of sclerenchyma tissue of both Ascolano and Sevillano as compared with Moraiolo which is nearly continuous in this photo.