Billions of Insects to Fight Man's Battles

Entomology

By Frank Thone

Meet *Trichogramma minutum.*

And give the little lady a big hand. For she's a friend of yours, though you may not have known it. She's hardly big enough to see without a magnifying glass, but she packs a knockout wallop for many a one of the insect thugs that are constantly threatening man's property and peace of mind. She's been scrapping 'em on her own for a long time—how long, we shall never know—but at last we have come round to a realization of the help she can give us, and scientists are now busily engaged in providing training quarters for her, and arranging bouts with insect "push-overs," so that she can go out the more effectively after the real "bad eggs" that she has to put down for the long count.

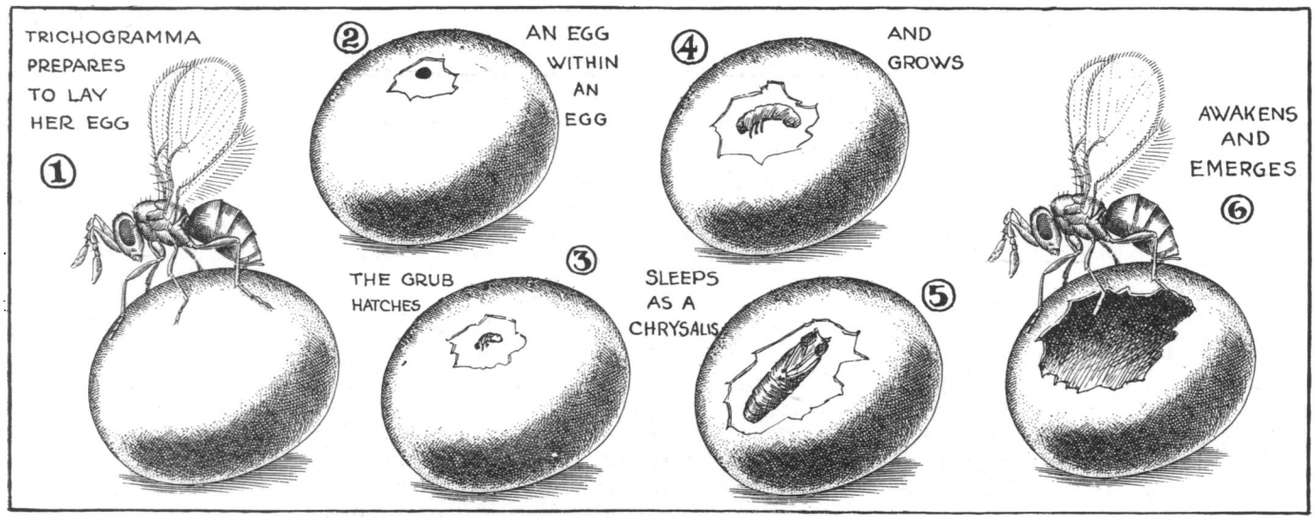
Trichogramma minutum is a lady all right, but she is an insect also, and nothing invidious intended. You'd say she was a rather pretty little lady, if you could see her. But if by any chance you do happen to catch a glimpse of her, you will pass her up as just another undersized gnat. For the ordinary midge or gnat is a pretty big insect alongside of Trichogramma. She's so tiny she can roost on the end of an ordinary sewing needle, like a cat on a fencepost, and not feel particularly crowded for foot-room. On the egg of an ordinary moth, which is about as big as the head of a pin, she walks around comfortably, as a Plymouth Rock hen might walk on Plymouth Rock. This little insect is very fond of

DR. STANLEY E. FLANDERS, field marshal of the Trichogramma armies

taking little walks on the eggs of other and larger insects. She isn't walking just for fun, either. She has eggs of her own to lay, and to her the larger egg represents both nest and a food supply for her young ones when they hatch. She takes a few nervous steps around on the smooth oval surface, selects a suitable spot. Thrust—in goes the sharp, dagger-like ovipositor she carries aft, right through the shell. In a moment the moth egg has company—unwelcome company—within itself. One Trichogramma egg, if the moth or insect was only a little one; more, if the food supply inside will rear a larger family of Trichogramma grubs. The mother insect has been known to deposit as many as seventeen of her eggs inside the egg of a large tiger-moth.

Having deposited her eggs, Trichogramma goes on to the next victim and gives no further thought to the matter. The little grubs that hatch out in a few days, finding a rich food supply right in their mouths the moment they emerge from the shell, feed greedily and grow rapidly. Soon they fold themselves up into pupae, that strange transition form most insects go through, and after a little time emerge as full-grown Trichogrammas. These crawl out through a hole in the egg-shell that has served as their nursery, and are ready to mate and seek new eggs to puncture.

The whole life story of Trichogramma reminds you of that of the hunting wasps, that carry home sting-stunned caterpillars, spiders or other prey, to seal into their clay cells along with their eggs. The resemblance is not superficial, either, for in spite of the vast difference in size between a black wasp and the tiny Trichogramma, they are sisters under their skin. Trichogramma is a member of the wasp family, and her basic instinct, to find rich meat for her offspring (*Turn to next page*)



TRICHOGRAMMA MINUTUM, friend of man—how she grows and works

Billions of Insects—*Continued*

to grow on, simply expresses itself on something she is big enough to tackle.

This business of providing for the future of the race by laying an egg within another egg is by no means uncommon among insects. Many species of minute wasps do it; "egg parasitism" is the learned name the entomologists have given the phenomenon.

But the egg parasitism of Trichogramma is different from that of most of her sister wasplets. These other egg parasites are very choosy as a rule; they will lay their eggs in only one kind of a "host" egg, and hence they are valuable only against one kind of insect pest, or at best against a relatively small group of related insects. But Trichogramma is not fussy. She will lay her eggs in any other eggs she can get at. She will not crawl through a crack to reach the eggs of insects that hide them, nor will she push her way through a silken web such as protects the egg masses of certain other insects. But woe to any kind of insect that lays its eggs unprotected in the open, if this nearly-microscopic wasp happens to be around. She will parasitize any egg into which she can stab that sharp ovipositor of hers. Codling moth, sawfly, European corn borer, sugar cane borer, gipsy moth, brown-tail moth, satin moth, tussock moth, spruce budworm, even the harmless dragonflies—these and a host of others besides are all just so many omelet providers for the insatiable little Trichogramma. Houseflies and mosquitoes are among the comparatively few insects whose eggs she will not touch. Even though one lives by assassinating pests, one must draw the line somewhere.

This universality of appetite is at once the benefit and the bane of Trichogramma, from the human point of view. She will conduct a sweeping campaign against a swarming, multiplying insect pest species in one season, and all but wipe it off the map, but the following year, having herself reduced that particular shelf in the cupboard nearly to Hubbardian bareness, she blithely disregards that pest and turns to the eggs of some other kind of insect. Thus, in one year nine-tenths of the eggs of the cotton caterpillar moth, one of the worst enemies of the cotton crop, were parasitized by Trichogramma in one part of the South, but the following year the shortage of eggs of this species drove the little wasp elsewhere to lay her eggs. Similarly, during one year, Trichogramma killed forty per cent. of the eggs of the European corn borer in Massachusetts. But she did not repeat the performance, so the hopes of the entomologists fell again.

This, then, was the problem that fronted the applied entomologists, those warriors against the chitin-armored hordes that perennially threaten man and all his works. When there were plenty of insect pests, and hence plenty of eggs to be parasitized, there were not enough Trichogramma to take care of all the business. In the years when Trichogramma abounded, there was not always a serious pest situation to handle. How could the matter be brought under human control? How could man guide the processes of nature for his own benefit here, as he has learned to do elsewhere? How arrange things so that billions of moth or sawfly eggs could be met with counter billions of Trichogramma eggs?

When man wants a lot of a thing that grows irregularly and often sparsely in nature, he deliberately cultivates it. He puts out a whole row of apple trees, instead of seeking one chance-planted wild crab bush in the woods. He sows a grain-field, instead of depending on random handsful of grass seed. He coaxes bees to live in hives which he provides (and will subsequently loot) instead of wandering the forest hunting for a bee tree. Why could not some way be devised of hiving these useful little insects also? To this problem entomologists addressed themselves.

There was one precedent, already well established, besides the ancient one of the bees. Ladybird beetles, which are very useful to California citrus fruit growers as devourers of the destructive mealybug pest, have for some time been reared successfully by the agricultural workers of that state. Potatoes are allowed to sprout indoors. Mealybugs are pastured on the sprouts and allowed to increase and multiply. Then ladybird beetles are turned loose to pasture on the mealybugs, and they in their turn increase and multiply. Finally the millions of new ladybirds are gathered up, kept dormant in cold storage until wanted, and then released to clean up the pest-ridden orchards.

There was a young entomologist, named S. E. Flanders, who pondered these things in his heart. He was at the time working for a California walnut growers' association, and the thing that was threatening him with premature gray hair was the common codling moth. The same pest that is responsible for most of our "wormy" apples was playing hob with the highly valuable California walnut crop, and costing the growers endless money and labor in spraying and dusting campaigns. Mr. Flanders knew that Trichogramma parasitizes codling-moth eggs, but here as elsewhere she cannot be depended upon to be present in large enough numbers when the codling moth outbreaks are at their worst. Could not some way be found to produce Trichogramma in quantity, as the ladybird beetles were already being produced? Mr. Flanders thought it worth a try.

So he methodically set about building a Trichogramma nursery. It might well be called a Trichogramma factory, for in the end he developed a method that would produce a million of these insects a day, in a building only 25 by 36 feet in floor size. These can then be distributed to the growers at a very small expense—a package of 100,000 eggs goes by airmail for 35 cents, most of the weight being in the container itself. Released from their mailing-tube prison, the newly-emerged insects wing their way through the walnut groves, seeking codling-moth eggs to conquer.

Mr. Flanders based his mass rearing of Trichogramma on the same principle that had already proved successful in the production of ladybird beetles by the million — the deliberate encouragement of a pest under controlled indoors conditions. He arranged trays of common white corn in racks, spreading out corn by the ton, and then turned one of the worst of granary pests, the grain moth, loose to do her worst. Before long the rearing cages were swarming with moths, anxious to lay their eggs.

Now a grain moth has one reaction at egg-laying time that is almost mechanical. When she comes to a crack she wants to drop an egg into it. Mr. Flanders provided cracks, most generously. He let the moths crawl on screen cloth, which is almost all cracks, and, finding that a gentle current (*Turn to next page*)

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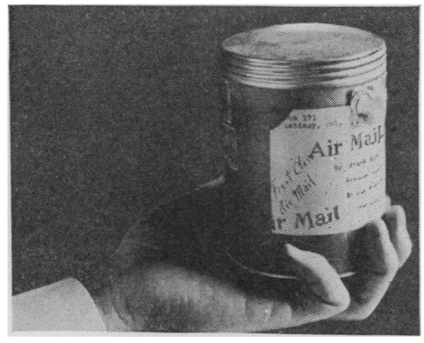
of air would hasten the egg-laying process, provided that, too, by means of an electric fan. So the moths laid their eggs through the screen, and the eggs dropped down into a trough, whence they were gathered up by the laboratory assistants.

Here then was a fine mess of nursing bottles for potential Trichogramma babies. How arrange their nursery to best advantage? Simplicity itself. A piece of stiff paper about 4 by 10 inches, is thinly coated with sticky shellac. Over this the moth eggs are dusted, adhering to the shellac, and giving the general effect of a coarse piece of sandpaper. Approximately 100,000 moth eggs can be stuck to one of these strips. Then the strip is bent around end to end and slipped inside a tin-bottomed cardboard mailing tube, about the size of a common tomato can. This is the maternity ward for the female Trichogramma, the nursery of the babies, and finally the travelling carriage when the new crop of insects journeys to the pest-threatened orchards to do battle with the codling moth.

The cylinders with the egg-laden strips within then are turned upside



A HUNDRED THOUSAND EGGS of Trichogramma are sent across the country by air mail in this container

down on glass shelves, and female Trichogramma, eager to lay their eggs, are liberated inside them. The little insects clamber over the thousands of moth eggs, stabbing and laving, stabbing and laying. Soon every one of the hundred thousand moth eggs harbors its Trichogramma egg.

Then the lids are screwed down on the mailing tubes, and the hecatombs of assassinated moth eggs, loaded with trouble for the orchard pests, are "ready to roll," as they say in the Artillery. If there is a war going on at the moment, they are mailed out to the beleaguered orchardists. In a few days the eggs within the eggs have hatched, the grubs have completed their development, and the adult Trichogramma are ready to go to work in the open. But if all is peaceful along the orchard front, the potential flying armies are put on the reserve list by the simple expedient of piling their containers in a refrigerator. This holds them *in statu quo* until the codling moth is injudicious enough to open hostilities somewhere; then they are brought out into a warmer room and allowed to emerge, armed for battle.

Mr. Flanders has left his walnut growers' laboratory, and this fall will join the staff of the Riverside Laboratories of the University of California. But his work will be carried on by his successors; and he considers his method to be developed now to a point of commercial practicability. For this reason many of his colleagues in the ranks of economic entomology are studying it with concentrated interest. In some other places the use of Trichogramma has been considered (*Turn to next page*)

Crops Must Contain Minerals

Chemistry

If the human race is to continue healthy, the animals on whose meat they feed must be in best condition. And to achieve this, the food they eat must contain the proper supply of minerals and vitamins—a condition to which the farmer must see.

This was the message brought to the American Chemical Society in session at Columbus, Ohio, by C. H. MacDowell, Chicago chemist. Mr. MacDowell told of the farm as a consumer of chemical products.

"The farm is a great bio-chemical factory," said Mr. MacDowell. "The farmer must concern himself with capital, labor, instruments of production and raw materials. The soil is his primary storehouse for raw materials. However, the supplies therein are seldom balanced or complete, and never illimitable. They must be augmented and replenished. Over large areas there are deficiencies of supply not only of the more common food elements such as nitrogen, phosphorus, potassium, calcium and sulphur, but also of the rarer tit-bits such as iodine, magnesium and manganese. The effect of total lack of any one of these latter is often as insidious and far-reaching as a poor supply of the former. If the crops are deficient there may result thinner and weaker livestock and poultry on the farm, milk lacking in vital minerals and vitamins, and so indirectly ill health and deficiency diseases in the city.

"Nor can the native supply of any of these elements in the soil be drawn on indefinitely, without replenishment, if economic stability and financial security are to be maintained on the farm. Inevitably with depletion of plant food supply comes decrease in both quality and quantity of yield. It doesn't rain minerals, and therefore mineral depletion must be counteracted from outside sources.

"Fertilizers undoubtedly comprise by far the largest tonnage of prepared chemicals used on the farm, but they are by no means the only ones. Plant life and animal life are subject to pests and parasites as well as disease and epidemics. These cause untold economic (*Turn to next page*)

Hoover as a Scientist

Metallurgy

Calling attention to the scientific work of President Hoover in the footnotes to his translation of Agricola's classic work, on metallurgy, "De Re Metallica," H. M. Elsey, of the Westinghouse Electric Manufacturing Co., expressed the hope that the President may eventually return to this work. He spoke before the meeting of the American Chemical Society.

Agricola's book was published in 1556. It was in 1912, while living in London, that Mr. and Mrs. Hoover collaborated on its translation. The latter was published privately.

"The footnotes are very readable and the longer ones might very well be published unchanged as chapters in a short history of the metals," said Mr. Elsey. "The evidence on a debated point is presented in lengthy quotations from the source books of early science and then the conclusions which may be drawn are given in a most logical manner. Where these conclusions are novel we must needs agree with the careful reasoning of one who approaches his problem as a metallurgist (*Turn to next page*)

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as of possible value in fighting insect pests. This is notably so in Louisiana, where the planters are even more worried over the wickedness of the cane borer than they are over the tariff. In Illinois the defenders of the corn belt hope to enlist the aid of Trichogramma against their arch-foe, the European corn borer. In New England, whose classic elms are threatened by the gipsy moth, the browntail moth and the tussock moth, this same little ally on wings will probably prove of value if California methods can be worked successfully in the latitude of Boston.

Like many another of our friends in this complex world, Trichogramma was doing her best to help us long before we ever took the trouble to get acquainted with her. She has been on the human list of insect acquaintances only 101 years. It was in 1818 that an English naturalist first observed her, and it was not until a half-century after that, more or less, that entomologists succeeded in finding out some of the details of her life history. A good deal still remains to be learned, in spite of the fact that we are now in position to cooperate with her in her job of destroying the eggs of other insects.

One very curious thing has been learned about her, that is probably of a good deal of help, is her peculiar way of living. Trichogramma is one of those peculiar females who doesn't need a mate in order to produce offspring. She just lays her eggs, and they hatch quite as efficiently as though there had been a paternal ancestor. And in some strains at least, they're all girls. Other females will produce nothing but male offspring; but surely this can't go on indefinitely. Still others have families nearer the ordinary fifty-fifty sex ratio. This is one of the things that entomologists are puzzling over at present, and the solution is not yet in sight.

One German entomologist has reported evolutionary changes in his rearing stocks, of the kind usually called mutations — sudden appearances of individuals quite unlike their parents, whose peculiarities continue to be inherited if the line is kept pure. One such mutation might prove practically valuable. This is a wingless form, which seems to be normal in other respects. If wingless Trichogramma could be got on the large-scale production basis, their use would be made independent of the wind, which, of course, always threatens to carry off the tiny winged insects. They could simply be turned loose on foot, to range over twigs and leaves like doughboys cleaning up a trench system.

But whether this suggestion should prove practicable or not, the practicability of the alliance between man and his tiny ally, Trichogramma, has already been demonstrated, and campaigns against the hordes of six-legged enemies will undoubtedly go on, with the economic entomologist in the role of liasion officer. Not long ago Dr. L. O. Howard, for many years generalissimo of the insect fighters of America, said that "hope could be held out for man in his war with the insects if he could make domestic animals out of these parasitic forms." It seems probable that Mr. Flanders' work will be the first step in making Dr. Howard's dream come true.

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Hoover as Scientist—*Cont'd*

rather than as a historian.

"For example, Mr. Hoover argues that the so-called 'bronze-age' followed rather than preceded the 'iron age' for the reduction of iron from its ores is a very simple process, whereas in making bronze two metals, copper and tin, must be prepared and then melted and cast together to prepare the alloy. Not only is the preparation of iron simpler but it can be carried out in the solid state and the iron worked at a temperature far below the melting point of copper, hence Mr. Hoover concludes that since the simpler and easier process would probably be developed first, the use of iron would precede or at least be developed along with the use of bronze.

"As a closing comment in several of the notes, Mr. Hoover expresses the hope of writing more fully on the subject in question at some time in the future. We all know how fully occupied his time has been since then but we join in wishing that his hopes may be fulfilled, for we are sure that any such papers will be delightful reading to students of science."

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Minerals in Crops—*Continued*

losses to the farmer. They are fought and controlled by chemicals, both inorganic and organic. The mine and smelter, the coke plant and the oil well, furnish their quota in fighting the farmer's foes."

It is getting the proper mineral constituents into the food of cattle that the farmer must take as his responsibility, the speaker stated.

"Agriculture must concern itself most definitely with the proposition of producing crops not only adequate in quantity but so supplied with minerals and vitamins that the animals feeding on them will be in prime physical condition," he declared. "Only in this way can human health be guarded. Food of proper composition is the greatest factor in the continued health of man. Entire civilizations have deteriorated and passed out, largely through diet deficiencies.

"Man is basically dependent on his food supply. The soil is its primal source. If the soil is deficient in nutrients for its benign bacterial inhabitants and for ample plant health and production, the crop suffers. Properly and adequately feed our plant crops to insure their well being, and they will in turn directly and indirectly assure us of our proper food supply.

"Chemical science and chemical products are destined to play an increasingly important and necessary role. Chemicals will continue increasingly to benefit crops, not only as direct plant foods, but by policing the crops from fungus and insect attack affecting quality as well as quantity of product. All for the good of Man."

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A California company is manufacturing paper from grape vine cuttings.

Anemia is a comparatively new and serious disease among pigs, affecting especially those raised in the confined quarters of apartment style hog houses.

Bear-proof garbage cans are an invention used in Sequoia National Park to prevent the nuisance of upset cans in public automobile camp grounds.