

In October, 1913, Mr. W. A. Ross, Field Officer of the Entomological Branch, conducted an experiment in a large feed-store at Dundas, Ont., which was badly infested with the Mediterranean flour-moth. Myriads of the moths were present and the meal and flour in the sacks were literally alive with caterpillars. The heating system consisted of five steam-pipes, which extended half-way around the walls, and four box stoves. Practically half of the second floor was occupied by a suite of offices heated by steam-radiators. In the unheated portion of this flat one box and two steam-gas stoves had been installed, and on the top flat four gas-stoves.

At 6 p.m. the steam was turned on and the stoves were lighted. At 1 a.m. the moths in the bins on the top flat commenced to succumb to the heat (114° Fahr.). At 10.30 p.m. the following day no living insects could be found on the second and third flats. The temperature on the third floor had reached 120° Fahr., and on the second floor 108° Fahr. in one place and 120° Fahr. in another. The thermometers available and used on these floors did not register higher than 120° Fahr. On the first floor five extra stoves were installed owing to the fact that the temperature in the immediate neighbourhood of the floor was not sufficiently high to prove fatal. The heating on this floor was begun at 9 a.m. and discontinued at 6 p.m. Better thermometers were obtained and these registered as high as 147.2°, 120°, and 150.8° Fahr. The one which registered 120° Fahr. was lying on the floor near a door. Two weeks later Mr. Ross again visited the store and no sign of the insect could be seen, nor had any been noticed by the owner of the warehouse or his men since the building was superheated.

One other experiment to which I will refer took place in a large seed-store at Victoria, B.C. The insects present in this instance were the two granary-weevils—namely, the grain-weevil (*Calandra granaria*) and the rice-weevil (*Calandra oryzae*). Both weevils had been found working freely in stored grain. Towards the end of April, 1914, we recommended to the proprietors of this store that they adopt superheating to destroy the insects. This they did, the temperature being raised to between 115° and 125° Fahr. and maintained for about eight hours, with the desired effect. Steel oil-barrels were used as stoves to raise the temperature. Holes were punched in these, near the bottom, so as to provide a draught, and coke was used as a fuel. Previous to the superheating, fumigation with bisulphide of carbon had been tested, the amount of bisulphide used being approximately 3½ lb. to every 1,000 cubic feet of space. The building consisted of four floors, of a size 30 x 110 feet, three being 10 feet high and one 14 feet high. The liquid was poured into tin vessels which were distributed throughout the building. This fumigation killed large numbers of the adults, but did not have any effect upon the eggs. Consequently, later, the superheating method was adopted with entire satisfaction.

As mentioned above, the heat from a high temperature of 125° Fahr. maintained for several hours penetrates into all cracks, etc., killing all stages of the insects present.

CONTROL OF CABBAGE-APHIS BY PARASITES IN WESTERN CANADA.

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The cabbage-aphis (*Aphis brassicae* Linn.), though a native of Europe, is now widely distributed in America, where it was first recorded in 1791. In Fletcher's report for 1895 it was stated that a "grey aphis (possibly *A. brassicae*)" had been very destructive on Vancouver Island, and that the worst year on record was 1876. There can be little doubt but that this note referred to *A. brassicae*, which has been recorded frequently from this locality since that date. It has therefore been present in British Columbia for at least forty years.

Very briefly the life-history of this aphis is as follows: The small shining black eggs are laid in the fall on cabbage stumps and leaves. They may be found also on

infested turnip, mustard, or rape leaves. They hatch in the spring into wingless female aphides, known as "stem mothers." These mature in about two weeks and begin giving birth to another generation of females, which in their turn mature rapidly and are soon actively producing a third generation. This rapid production of new generations of wingless females continues throughout the summer. Occasionally winged specimens appear, and fly to new plants, thus spreading the infestation. Males are not produced until the fall. These mate with the females, and as a result the latter produce eggs instead of living young. It is these eggs which pass the winter; no other stage of *A. brassicæ* is able to do so.



Egg of *Aphis brassicæ* as laid on cabbage.

The alarming rate at which these aphides increase might make one wonder how it is that all cabbages, wherever this pest is found, are not invariably and quickly destroyed. One, and perhaps the chief, reason is that the aphid has several natural enemies which are continually reducing their numbers.

These enemies are divided into two classes—viz., predators and parasites. Among the predators are found both the larvæ and adults of ladybirds (*Coccinellidæ*), the larvæ of hover-flies (*Syrphidæ*), and the larvæ of lace-wings (*Chrysopidæ*). These we can probably aid or harm but little. Several parasites have been bred from *Aphis brassicæ* in different parts of the continent, but from material studied in South Alberta during 1914 and 1915 one species only has been bred. This is a small Hymenopteron, named *Diaretus rapæ* Curt. Since this species parasitizes a large percentage of the aphides, and it is present in the fields and gardens from the time when the stem mothers hatch, it is very valuable for preventing outbreaks of cabbage-aphis.

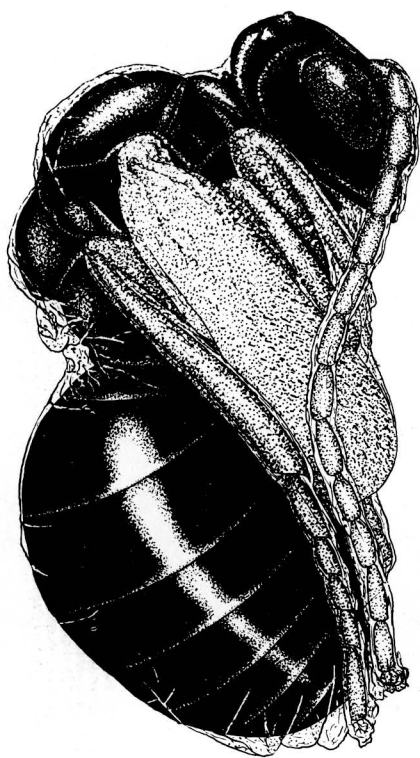
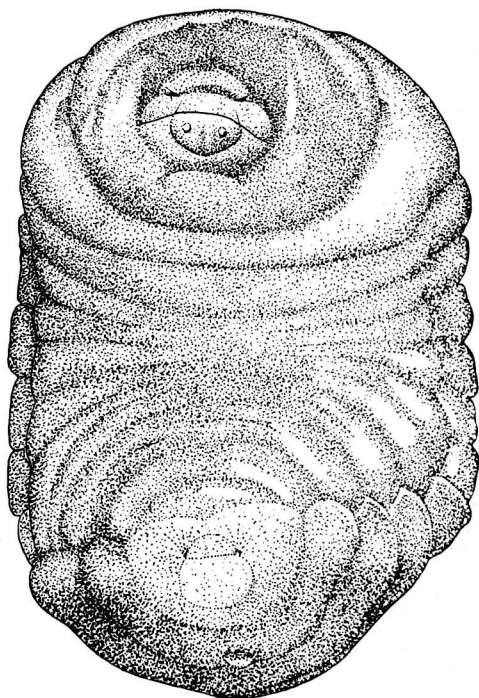
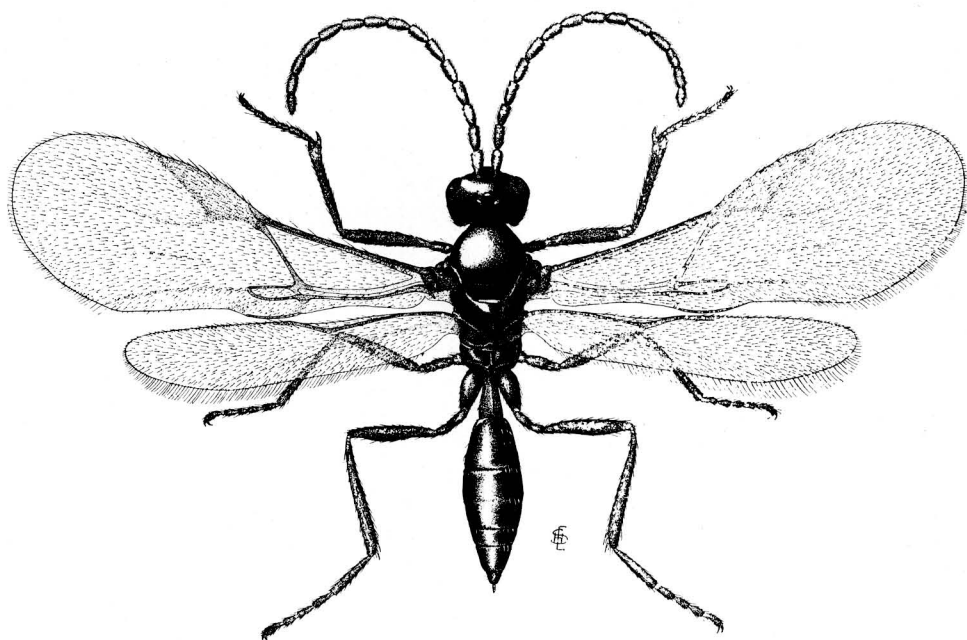
The life-history of this parasite is similar to that of most of the aphid parasites. The adult buries its egg inside an aphid with the aid of its ovipositor. From this egg hatches an orange-coloured larva, which develops rapidly at the expense of its host. By the time it is full-grown the body of the aphid has become much swollen, and is almost spherical, while its "skin" has changed from a dull-grey to a straw-yellow colour, and is of a parchment-like consistency. The parasitic larva by this time completely fills the dead aphid, which is firmly cemented to the cabbage-leaf upon which it was feeding. Within it the parasite pupates, and later the adult emerges through a circular hole. How many generations of this parasite there are in a year we do not know, but there must be several. The most important point for us to consider is the manner in which the winter is passed.

Late in the fall many of the aphides contain fully developed parasitic larvæ, pupæ, or occasionally adults which have not emerged. These aphides, with their contained parasites, are so firmly attached to the cabbage leaves and stumps that they remain on them throughout the winter. The first severe frosts kill off all normal aphides, leaving only the parasitized specimens and the small black eggs produced by the fertilized female aphides of the last generation.

If we examine some of the parasitized aphides in the early spring we find that in most cases where they contain a full-grown *Diaretus* larva this larva is alive and healthy. We find also that the pupæ of the species have passed the winter successfully, but that the few adults which we dissect out are in every case dead.

During the first week in April adults began to hatch from material collected at Lethbridge earlier in the spring. From this it is seen that both the aphid and its valuable parasite pass the winter on the cabbage stumps and leaves.

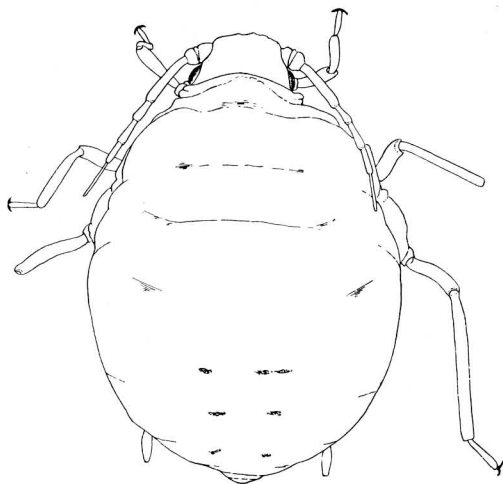
In passing, we might mention that in some of the parasitized aphides we found an unwelcome guest, which was passing the winter in the same stages of develop-



Life stages of the parasite of the cabbage-aphis.

ment as *Diaretus rapae*. This insect was determined for us by Mr. Girault, of the United States National Museum, as "near *Pachyneuron*." This small green Hymenopteron lays its egg on the ventral side of the orange-coloured *Diaretus* larva. From it hatches a white hyperparasitic grub, which slowly increases in size at the expense of its shrinking host, till we find, instead of a large orange larva with a small white grub on its ventral side, a large white larva with a small, shrunken, orange-coloured skin on *its* ventral side. Still later we find the pupa or adult of the hyperparasite. Since, however, we bred forty-three *Diaretus* adults to every *Pachyneuron*, the flies which we hatched from our parasitized aphides were decidedly beneficial.

The question which now arises is: Can we aid these parasites in any way without at the same time aiding their host, the cabbage-aphis? In dry, cold latitudes we certainly can, but it must be borne in mind that the following suggestion applies only to such places as the Interior of British Columbia and to the Prairie Provinces, where the cold is sufficiently intense to kill off all cabbage-growth with certainty before the spring.



Parasitized larva of *Aphis brassicae* containing the over-wintering parasite. (In nature it is very much swollen and enlarged.) (Del. E. H. S.)

A control measure advocated in the east and to the south of us is that of collecting and burning all old stumps and other refuse during the fall and winter. This is very beneficial since it destroys numerous aphid-eggs. Where there is much snow or where the winter is not severe, such stumps are not killed by the spring, and even though they are pulled they may have enough vitality to produce sufficient green growth for the young aphides that hatch from the eggs to mature and produce a winged generation.

Under our conditions, however, such growth is impossible, and we can obtain even better results from a modification of this method. The stumps and refuse must be collected during the fall or winter, and placed in a heap on an absolutely bare piece of land, at some little distance from any green growth, especially any such weeds as shepherd's-purse, mustard, or any of the plants belonging to the order Cruciferae, since *Aphis brassicae* can breed on almost any of these.

In the spring both the parasite adults and the aphid-eggs hatch. The parasites are strong-winged and can rapidly fly to more favourable locations, but the tender wingless aphides are too far removed from any food to stand a chance of crawling to it before they die of starvation. A few may possibly be blown or carried by birds to some cruciferous plant, but this number must be very small, whereas innumerable parasites are continually escaping.

From a large heap of badly infested stumps on the Experimental Farm at Lethbridge a constant flight of parasites was observed during April in 1915, while numerous minute aphides were seen crawling over the heap of well-frozen and lifeless stumps. Some of the aphides were hatched in captivity and lived for two or three days only. None was seen to attempt to feed upon the over-wintered cabbage-tissues.

The foregoing suggestion must not be considered as an excuse for leaving cabbage-stumps, etc., lying around in the fields during winter. It is just as essential that all refuse be collected and placed on a clean piece of land, which must not be allowed to grow up to weeds during April or early May, as it is to collect such refuse for burning. We would repeat, also, that this is applicable only to those localities in which the winter is always sufficiently severe to ensure that all refuse left over from cabbage or turnip crops is completely killed. In such localities we would recommend that some such arrangement be made so that we do not annually kill off a large percentage of our best friends, and then inadequately replace their rôle in nature with expensive spraying.

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