REARING THE COCCINELLID HIPPODAMIA CONVERGENS GUER. ON FROZEN APHIDS

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The ladybeetle *Hippodamia convergens* Guer. cannot be handled in the laboratory in quantity unless there is available at all times an abundance of aphid material for food. Field populations of aphids can be relied on only at intervals during the year. In the search for an all-year-around food, it was decided to determine the feasibility of freezing and storing aphids, collected during periods of abundance, for use during remaining parts of the year. The work was prompted by the need of an unfailing *convergens* egg supply for ovicide tests (2).

The first aphids were frozen in June, 1935. By the following fall it was noted that methods could be developed for freezing and storing them at subzero temperatures (C.) without loss of body fluids through dessication. Also it was evident that satisfactory egg production by *convergens* could be maintained at any time of the year on frozen aphids, but that very special methods and equipment would have to be used.

This equipment was developed (1). During the studies, attention was given almost exclusively to the production of eggs by adults. Larvae can be reared through to adults that produce fertile eggs. However, methods have not been studied for bringing them through in quantity. Frozen aphids proved especially valuable to the writer as food for first instar larvae during larval insecticide tests (2), at a time when field aphid populations failed. Furthermore, the dead, motionless, frozen aphids were much easier to handle than living, mobile forms.

METHODS

Species of Aphids Frozen. Species frozen in large quantity include the poplar gall aphid (*Pemphigus populi-transversus*, the false cabbage aphid (*Rhopalosiphum pseudobrassicae*), the pea aphid (*Illinoia pisi*), and the giant hickory aphid from sycamore (*Longistigma caryae*). Also, the aphid from willow (*Clavigerus smithiae*) and the bean aphid (*Aphis rumicis*) were frozen with success.

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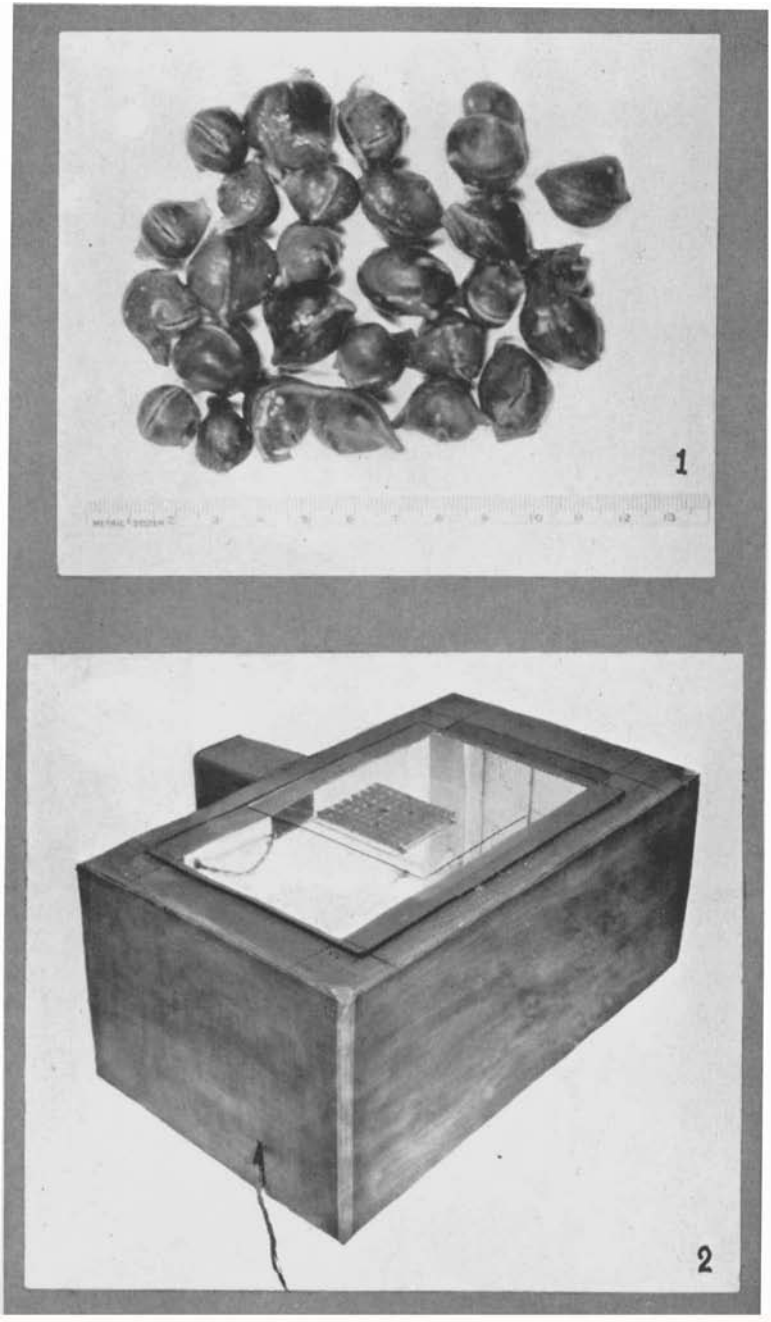

Fig. 1. Poplar galls (*Pemphigus populi-transversus*), prepared for freezing.
Fig. 2. Coccinellid cage in place on light-box.

Most of the above species have been in storage since October, 1935, and there is no apparent change in their condition.

Of all species experimented with, the poplar gall aphid has been the most satisfactory. On removal from a cold environment it decomposes and dessicates less rapidly than the other species, especially the pea aphid. This factor is very important.

Freezing Methods. Aphids are packed in air-tight glass containers and stored at —21 to —25 degrees C. Probably higher temperatures, yet below 0 degrees C., would be satisfactory. Rubber-stoppered shell vials, 22x65 mm., pint and quart wide-mouth fruit jars are used. Cellucotton saturated with water is placed in the top of the container to increase humidity before freezing.

Poplar galls are trimmed from the leaf petiole (fig. 1) and packed, about 260 per quart. Non-gall forms are packed loosely in the container.

Apparatus for Feeding Frozen Aphids to Convergens Adults. Flowerpot saucers, petri dishes, pill boxes with transparent bottoms for use with light from below, and other cages of a similar nature cannot be used for feeding frozen aphids to *convergens* adults. In the case of a petri dish, egg production is low, and eggs produced are eaten. In a petri dish, adults cling to one another several deep, do little stirring around. Though there is plenty of fresh (frozen) aphid material about them for several hours after it is introduced, the adults each may feed on only one or two aphids, this at the time they are disturbed when the aphids are being introduced into the cage.

Beetles must be separated from one another, and kept close to their food supply through the proper use of light. The aluminum, cellular cage described below (fig. 3) was developed. It has proved very satisfactory and is standard equipment in this work.

Description of Feeding and Oviposition Cage. It is made of ½ inch aluminum stripping, and consists of 70 cells, 10 long by 7 wide (fig. 3). Each cell is ⅝x¾x½ inch deep, the whole thing is 5½x6½x½ inch deep. The layer of cells is closed-in on the bottom side by 8-mesh hardware (metal) cloth. The top of the cage is a sheet of glass twice the area of the unit of cells. In the center of this plate a ¾ inch hole is bored. By sliding the plate glass, access may be had through the hole to any cell for removing eggs, without exposing any other cell. When not in use a small square of glass is placed over the hole, to prevent beetle escape. Four metal clamps, one in each corner, hold the cage tightly down on to a sheet of glass the same area as the unit of cells.

The clamps slide off or on into place easily. Frozen aphids are sprinkled lightly on this bottom glass piece, the cage is then clamped to it and the beetles (one per cell) feed on the aphids through the wire screen. The beetles are positively phototropic. Constant light from below keeps them close to the food.

The beetles are fed twice daily. At each feeding the bottom glass piece is washed with water before fresh (frozen) aphids are spread on it. The metal part of the cage is cleaned every two weeks by removing the beetles from it and washing it in hot paraffin.

Most of the egg clusters are deposited on the sides of the cells. They

are removed from a surface with a camel's hair brush and water, the adhesive material being soluble in water.

To keep the beetles next to their food supply, all light is directed from below. So that light used in this work would not affect other experiments in the same laboratory, a special light box was constructed. It has been used in all feeding work, whether living or frozen aphids were used as food.

Description of Light-box. It is a cardboard carton 21x35x15¼ inches. A wooden framework inside gives it support. An opening is cut in the top leaving a margin of 4 inches, and this opening is covered by a sheet of heavy plate glass. Feeding cages rest on this plate glass, and are furnished with light from below. To prevent heat accumulation from the source of light, a tin can is set off on the side of the box. Inside this tin the bulb is mounted (five watts). Most of the heat generated by the bulb is radiated off by the tin, there is no accumulation in the box. Figure 2 shows a frozen aphid feeding cage in place on the light-box.

Beetles become too active when they are disturbed at time of feeding, or when eggs are being removed. An extra light (60 watts) is turned on, therefore, during periods of examination. This extra light on the bottom of the box effectively keeps the beetles in the bottom of their cells.

Description of Humidifier. Frozen aphids dry out too rapidly at ordinary room humidity. The humidifier developed for this work is shown in position over the feeding cage on the light-box (fig. 4). The humidifier has been also a necessary part of the technique employed when living aphids are used as food.

It is a box 17½x18x5½ inches deep made of ¾ inch redwood, heavily impregnated with paraffin. It is open at the bottom, and covered across the top with canton cloth. In each of two opposite corners is strapped a jelly glass containing a saturated salt solution.

In the usual laboratory, where the air humidity is low, K_2SO_4 is used. If the humidity is high in the room, the K_2SO_4 may have to be replaced by NaCl.

From each of the two glasses a wick of cellu-cotton leads upward, through a hole in the cloth to the top of it, and diagonally across. At right angles to this strip another strip of cellu-cotton is placed on the cloth, reaching toward the other two corners. By capillary action these strips are kept saturated with salt solution, which in turn is fed to the tight cloth top. The tightly woven face of the canton cloth is downward, the loose fluffy surface upward. Spread of the salt solution is on the under surface where the humidity is wanted. The loose fluffy surface on the upper side remains dry, greatly reduces evaporation upward, outside of the humidifier. To further reduce evaporation upward, a paraffined piece of thin composition board, 18x19 inches is placed over it. This cover is not shown in the figure.

The two jelly glasses containing the salt solution should be paraffined to prevent the salt from "creeping" over the edges. The jelly glasses are refilled with salt solution through the holes above them, through which the cellu-cotton wick passes upward. The holes are covered by small flaps of canton cloth, which can be drawn back as desired.

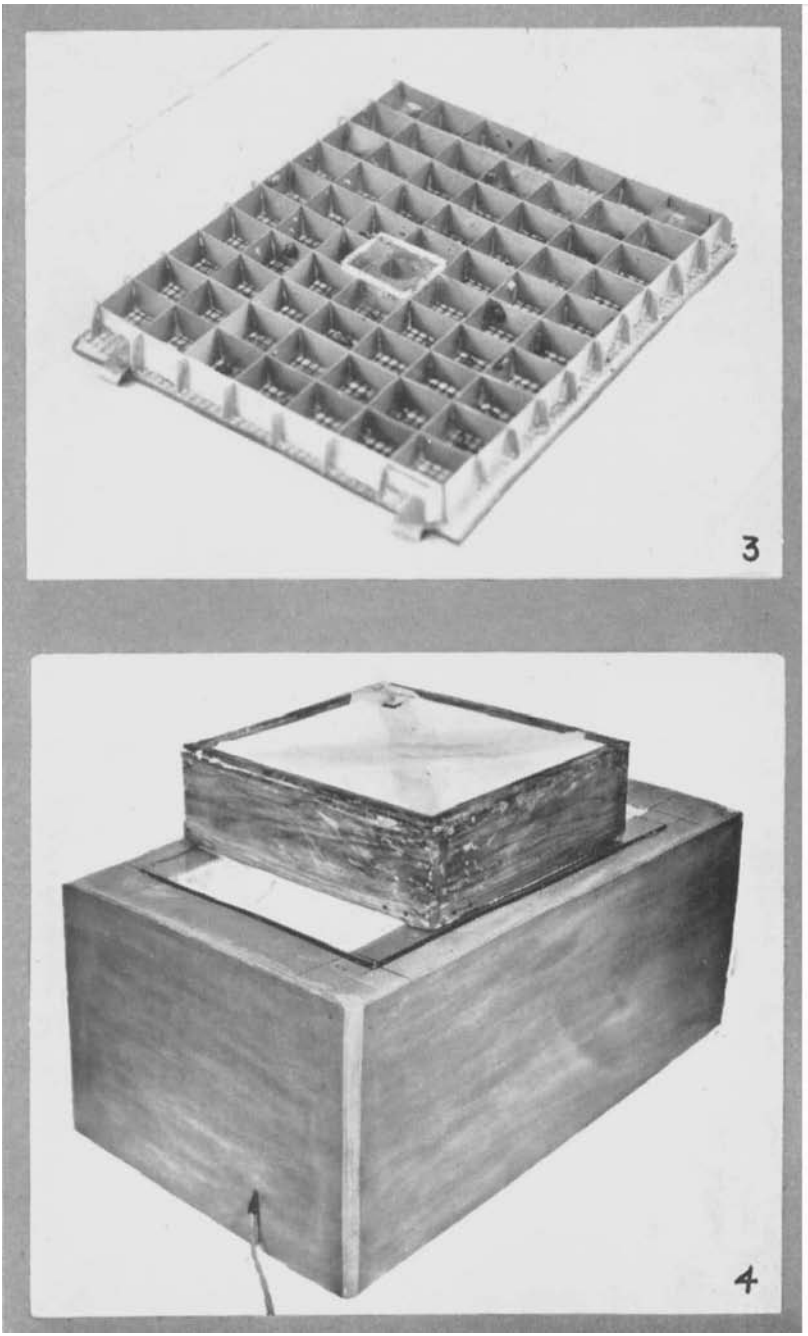

Fig. 3. Cage for coccinellids while feeding on frozen aphids and while ovipositing.
Fig. 4. Humidifier in place over feeding cage on light-box.

OVIPOSITION DATA

Two experiments are reported on. In each case, nothing but the frozen poplar gall aphid (*P. populi-transversus*) was used as food.

Using Old Adults. In the first experiment, complete egg records were kept for the winter period December 10, 1935, to March 12, 1936. The beetles used were old adults from California and Idaho with reduced egg-laying potentialities due to transportation, storage, and having already passed through a portion of their egg-laying activities. The California adults were first generation beetles that had gone into the mountains in June. They were collected July 4 in Placerville, had been kept in storage since that time. The Idaho adults were collected in December at Moscow. The latter were very inactive and weakened by a delay during shipment.

A total of 16,058 eggs was collected for the period. For the 94 days this averaged 170.8 eggs per day. A maximum of 525 eggs was collected on February 13. Altogether 241 beetles were used in the experiment. The number being fed each day varied. The average was 47, the maximum 66. Until the end of February the minimum was 17.

Only 92 beetles, or 38.2 per cent of the total, oviposited. Two factors account for this low proportion of producing females. First, they were old beetles, the Idaho individuals in particular, being extremely docile. But far more important than the age or previous history of the beetles, is the fact that they were kept on a semi-starvation diet during this experiment. At each feeding they were given a minimum amount of food. On 39 of the 94 days they were fed only once, and on 2 days not at all.

For maximum egg production beetles must be given an excess of food at least twice per day. Despite the starvation diet, however, female 49 deposited 898 eggs, female 40 deposited 882. Like several other individuals, female 40 was already laying eggs when records were begun December 10. Female 49 was not dead when the experiment was terminated.

Using Newly-emerged Adults. Twelve newly-emerged females were exposed to fertilization by 12 newly-emerged male beetles. All had developed from larvae that had been fed nothing but frozen poplar gall aphids. After fertilization the males were discarded, and the females fed frozen poplar gall aphids twice daily. The first 8 days of egg production was recorded.

Each of the 12 females produced eggs that hatched into normal larvae. Egg production was very gratifying. Though all beetles did not begin laying until the fifth day, 631 eggs were collected, averaging 80 per day for the 8 days of observation.

CONCLUSIONS

By the use of frozen aphids, egg production by *Hippodamia convergens* can be maintained throughout the year. Methods of freezing the aphids and feeding them to *convergens* adults have been worked out.

Of the various species of aphids tested, the poplar gall aphid (*Pemphigus populi-transversus*) has proved the most satisfactory.

If one were interested in large-scale egg production, it would be advisable to rear larvae through to adults, and work with newly-emerged adults exclusively. It would be necessary to feed them twice daily, preferably three times.

Individuals confined to a strict diet of frozen aphids through the larval and adult stages, produce fertile eggs.

Methods have not been studied for rearing *convergens* larvae in quantity on frozen aphids. During insecticidal work, frozen aphids have served well as food for the first instar (2).

The reactions of other coccinellids to frozen aphids have not been studied. From two incidental observations it was learned that *Coccinella trifasciata* and *Adalia bipunctata* feed readily on frozen poplar gall aphids. *A. bipunctata* was reared to the adult stage on them.

Technique for obtaining mass-egg production by *convergens* when living aphids are available as food will be reported in another paper.

LITERATURE

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