Results with Carbamates Alone.—Tests were conducted over a period of several months; therefore, all the carbamates were not tested against the same lots of house flies. The results are comparable, however, since the pyrethrins standard tested on each lot indicated very similar susceptibilities for all the lots of flies used. The average kills obtained with the 0.2, 0.4, and 0.8% concentrations of pyrethrins were 27, 64, and 91%, respectively. Dimetilan and MC-A 600, the most effective compounds tested, caused 50% and 52% kills, respectively, at the lowest concentration tested, 0.0156% (Table 1). Bayer 37344 and Bayer 39007, next in effectiveness, resulted in approximately 50% kills at the 0.0625% concentration. Carbaryl, dimetan, and UC-20047 resulted in less than 50% kills at the 1% concentration. In knockdown, Hercules 7522-H was only slightly effective and carbaryl was ineffective at the 0.25% concentration. All the other materials caused very high or complete knockdowns.

Results with Carbamates plus Piperonyl Butoxide.—The concentration causing approximately 50% kill for each carbamate alone (Table 1) was selected for use to determine synergism with piperonyl butoxide. However, with carbaryl, dimetan, and UC-20047 the 1% concentration, which caused less than 50% kill, was used. The ratios of carbamate and synergist tested for each material were 4:1, 2:1, 1:1, and 1:2. Each carbamate was retested alone at the concentration employed in the synergist mixtures. The average kills obtained with the 0.2, 0.4, and 0.8% concentrations of pyrethrins standards were 27, 60, and 87%, respectively.

Carbaryl at 1% concentration, although quite ineffective alone, was highly synergized by piperonyl butoxide (Table 2). The 4:1 ratio of carbaryl to synergist was less effective than the other ratios; but the 1:1 and 1:2 ratios caused kills in the range of effectiveness of the 0.8% pyrethrins standard. Synergism was shown with Isolan, but in this series of tests Isolan alone was much less effective than when it was tested alone in the 1st series (Table 1). Hercules 5727 and Bayer 39007 were only slightly synergized at the 1:2 ratio of carbamate and synergist. All the carbamate–piperonyl butoxide sprays caused high knockdowns except those with dimetilan, Hercules 7522-H, and UC-20047. None of the other compounds tested caused synergism. Antagonism was indicated in the tests with dimetilan, Geigy 35234, Hercules 7522-H, and Mobil MC-A 600.

Culture-Jar Modifications for Sampling Respiratory Environments[1]

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One-quart-capacity wide-mouth glass mason jars are widely used for rearing insects of stored products. The jars can be modified to permit studies of the respiratory environment of stored-product insects without affecting their physical environment.

Three holes 3/16 inch in diam, were drilled 1 in. apart in a vertical line beginning ¼ in. above the floor of the jar with a Dremel Model 2 high-speed drill using Dremel bits 8145, 977, and 945. The stone bits grind through glass satisfactorily. The large cone-shaped bit was used first to break the polished surface and to provide initial penetration into the glass wall. The smaller bits were used alternately to grind through the wall of the jar and to enlarge holes to 3/16 in. Three holes/jar were drilled in 20 min. A face mask, protective laboratory coat, and disposable plastic gloves protect the user from the resulting powdered glass.

The holes were fitted with rubber cap septums[3] to facilitate sampling respiratory gases. The septums were sealed with wax applied with a 1/8-in. brush at the juncture of the glass and septum. The outer lip of each septum was clipped off to facilitate centering the syringe needle when gas samples were drawn from the culture.

The introduction of a gas-tight syringe through the septum (Fig. 1) did not disturb the insect culture in any way. Sample sizes of 0.8 ml did not appear to upset the respiratory environment.

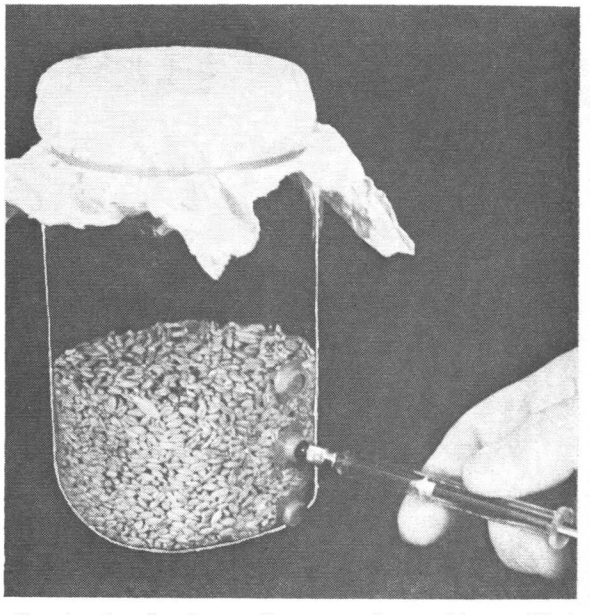

FIG. 1.—Detail of sampling procedure with modified culture jar. Samples are collected with a 1-ml Hamilton gas-tight syringe with Cheny adapter.

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Techniques for Mass-Producing *Coccinella septempunctata*[1]

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Research to determine the possible utility of 2 insect predators in controlling the potato-infesting species of aphids was begun at Presque Isle, Maine in 1964. One of these predators, *Chrysopa* spp., is commercially available; the other, *Coccinella septempunctata* L., was reared for us at the laboratory maintained by the Entomology Research Division, Moorestown, N. J., and the eggs sent to us at Presque Isle.

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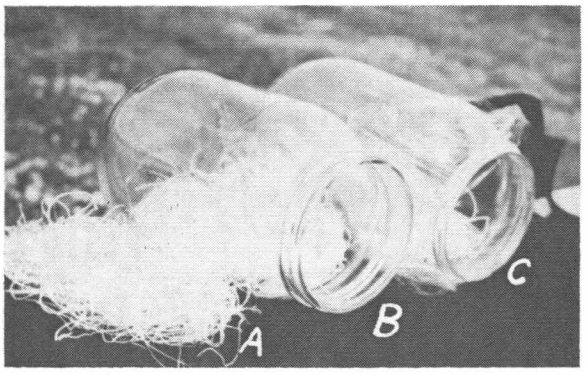

FIG. 1.—The excelsior (A) is placed in a 1-gal jar (B). After the larval-infested leaves are introduced the jar is sealed with clear plastic film (C).

In 1965, our expanded program necessitated that we mass produce 2nd-instar larvae as well as eggs of *C. septempunctata* for field tests. Three of the techniques we developed may be of interest to others working with this predator. These are the multiplication of breeding stocks of the beetle during winter, the use of quick-frozen aphids as food for rearing the beetle, and the mass-production of 2nd-instar larvae.

MULTIPLICATION OF BEETLE BREEDING STOCK IN WINTER.—As eggs hatched from masses deposited by caged, mated females, the larvae were placed on aphid-infested plants of Chinese cabbage, *Brassica chinensis* L., in specially constructed cages. Loss by escape of the 1st- and early 2nd-instar larvae from these cages was so great as to threaten failure for the undertaking. At this time about 200 larvae that remained were collected and placed on aphid-infested foliage of potato, *Solanum tuberosum* L., resting on excelsior in glass containers (1-gal size or larger) closed with waxed paper secured with rubber bands. Depending upon size of the container, from 25 to 40 larvae of the same age were placed in and allowed to develop to maturity in each. The larvae were fed through the 3rd instar by placing aphid-infested foliage in the containers once daily; they were fed similarly twice daily during the 4th instar. Every 2nd day the glass containers were scrubbed in water and rinsed and supplied with new excelsior. The excelsior provided the larvae with space in which to travel and rest without having to contact other larvae frequently. By this means the number that could be reared without cannibalism was increased and there was no detectable loss prior to emergence as adults. However, cannibalism caused considerable loss of pupae and deformity of emerging adults when 3rd- and 4th-instar larvae were caged together on aphid-infested foliage. Thus an important consideration in mass producing these beetles in glass containers is to confine together only larvae of the same age or stage of development.

QUICK-FROZEN APHIDS AS FOOD FOR THE BEETLE.—In Orono, Maine, live foxglove aphids and green peach aphids, *Acyrthosiphon solani* (Kaltenbach), and *Myzus persicae* (Sulzer), respectively, stored in a 0° to −5°F freezing unit proved adequate as food for the larval stages of the beetle; subsequently, maturing adults also were satisfactorily fed such frozen aphids, supplemented every 2nd day with feedings of a water mixture of pollen, honey, and a protein hydrolysate, for more than 5 weeks. Obligatory transfer of these beetles from Orono to Presque Isle necessitated a shift in diet from quick-frozen to living aphids. The percentage of ovipositing females 10 weeks old was about the same whether they were fed quick-frozen or living aphids throughout larval development and during early adulthood. The time required for development and the size of the larvae and adults were about the same as for those fed living aphids.

The newly hatched larvae were fed the thawing aphids manually with an artist's brush. Soon, however, the developing larvae began to search for food when their containers were opened at twice-a-day intervals to introduce the frozen aphids. The adult beetles appeared to search through their thawing food for aphid bodies still completely intact, but the larvae readily accepted aphid bodies partly macerated or ruptured in freezing. Containers loosely filled with aphids before freezing likely will result in more acceptable food after thawing, especially for adult beetles. There was some evidence that a beam or pinpoint of light might serve as an attractant and feeding stimulus to the adults. Haug (1938) successfully reared the convergent lady beetle, *Hippodamia convergens* Guérin-Méneville, on frozen aphids of several species including the poplar petiole gall aphid, *Pemphigus populitransversus* Riley; the turnip aphid, *Hyadaphis pseudobrassicae* (Davis); the pea aphid, *Acyrthosiphon pisum* (Harris); the giant bark aphid, *Longistigma caryae* (Harris); the aphid *Pterocomma smithiae* (Monell); and the bean aphid, *Aphis fabae* Scopoli. He also reared the two-spotted lady beetle, *Adalia bipunctata* (L.), on frozen poplar petiole gall aphids.

MASS-PRODUCTION OF SECOND-INSTAR LARVAE.—With an artist's brush, the newly hatched larvae were transferred from the egg masses to excised leaves of collards, *Brassica oleracea* var. *acephala* DeCandolle; radish, *Raphanus sativus* L., or Chinese cabbage heavily infested with the green peach aphid. Three small leaves holding a total of 200 larvae were placed on a layer of excelsior in a large-mouth, 1-gal glass jar lying on its side, which was then closed with a thin layer of clear plastic film held in place by a rubber band (Fig. 1). These leaves were replaced with fresh aphid-infested leaves each day until the larvae molted, which was in about 3 days at temperatures of 70–85°F. The yield of 2nd-instar larvae was 80% or more of the number initially introduced. Including the time for incubation of eggs, rearing the larvae to the 2nd instar at these temperatures took about 5 days. About ½ man-day was required to rear 1000 larvae to the 2nd instar. With more experience and improved procedure, a skilled technician likely can produce 8000–10,000 or more 2nd-instar larvae/week, and at the same time take care of enough ovipositing females to get the required number of eggs.

Several factors influence the degree of success with this procedure. The maximum "hatch" is obtained by removing the larvae from the egg masses before they can eat the unhatched eggs or one another. The larvae most likely to be eaten are those in the center of the hatched group bunched on top of the egg mass. Separating the newly hatched larvae on infested leaves prevents early loss from cannibalism. Maximum yields of 2nd-instar larvae depend upon maintaining a delicate balance among the number of newly hatched larvae per container, the amount of excelsior required, the amount and kind of excised, aphid-infested leaves with respect to relative humidity in and moisture accumulation on the inside surface of the jar, and the number of aphids needed as food for the developing larvae. Leaves of collards generally are more satisfactory than those of radish or Chinese cabbage; in fact, experience suggests the possibility of successfully rearing beetle larvae to the 2nd instar on excised, aphid-infested foliage of collards in glass containers without the necessity of replacing the leaves.

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