Live Insects in the Classroom and Laboratory

By E. C. MASTELLER

With a little knowledge of insect life-cycles, a teacher can make excellent instructional use of live insects. If the right techniques of maintenance are applied, insects of many kinds can be kept throughout the year. However, when one ventures into insect-rearing the choice of species should be carefully considered: even the well-trained entomologist has met with frustration in attempting to colonize an insect. For those who have had little experience with insects in the classroom or laboratory, certain insects are ideal. And for thorough understanding of insects, species that can be reared through their complete life cycle should be selected.

In rearing insects, important considerations are food, water, cages, and general sanitation. I shall discuss the latter two considerations first—they apply generally—and then discuss the nutritional and other requirements of several insects that lend themselves well to a beginner's efforts.

Cages

Some insects can be maintained in a dry environment; others need dampness. The kind of cage used can determine the humidity, in most instances. Shoe boxes, sandwich boxes, refrigerator storage containers, and utility boxes, all of clear polystyrene, make excellent cages (fig. 1 and 2). The refrigerator containers allow students to work individually or in pairs when maintaining a small number of insects. Lea (1953) described the adaptability of plastic boxes for entomology experiments: these containers can easily be altered with heat from an ordinary soldering iron. Melting will open holes for ventilation (which decreases humidity) and for watering devices. The ventilation holes are covered with 16-mesh aluminum or bronze screen or 60-mesh brass strainer cloth, depending on the size of the insects and their developmental stages. The edges of the screen can be bonded to the container by narrowly melting the plastic.

Openings for watering devices should be just large enough to insert a roll of dental cotton or a reservoir bottle. A 1-dram vial with 15-mm aperture, that will retain a roll of dental cotton without becoming "drippy," makes a reliable water source. A 3-inch cotton roll serves as a wick from the water bottle, which is inverted through the lid of the cage (fig. 1: A2, B2, C2).

Acetone can be used to produce a rough surface on which to paint a label. Acetone will also seal cracks. A thin film of vaseline applied to the upper inside rim of the plastic container prevents the insects from escaping when the lid is off.

Sanitation

Insect cages need to be cleaned from time to time. Most plastic boxes can be dipped in boiling water or mild acid for cleaning. Lysol is also a satisfactory disinfectant.

Sand used as a substrate should be sterilized by heating in an oven at 160° C for 1 to 1½ hours. Sawdust should be heated at 100° C for 4 hours for sterilization.

If insects are to be reared in a humid environment care must be taken to exclude molds, which thrive in damp places in the absence of sunlight.

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Avoid adding too much water to insect diets: it will enhance the growth of molds. A mold inhibitor, such as Moldex or polypropylene glycol, may need to be added.

Dental-cotton rolls should be replaced whenever they become fouled with excrement. (A clean water supply is extremely important.) Dead insects and molted skins should be removed from time to time; certainly they should not be left in the cage if they have become moldy. If possible, each new generation of insects should be started in a clean cage: for lack of cleanliness, mites may develop and soon deplete the colony.

Before disposing of equipment, destroying old or unwanted cultures, or discarding food and oviposition media, heat these things in an oven at 60° C for 1 hour. If the cages need to be opened before disposal, the insects can be immobilized by placing the cage in a refrigerator for at least 1 hour before opening.

Choosing the Insects

The first four insects described are typical of three of the four principal groups of winged insects: hemipteroid (milkweed bug), orthopteroid (cricket), and neuropteroid (wax moth and meal-

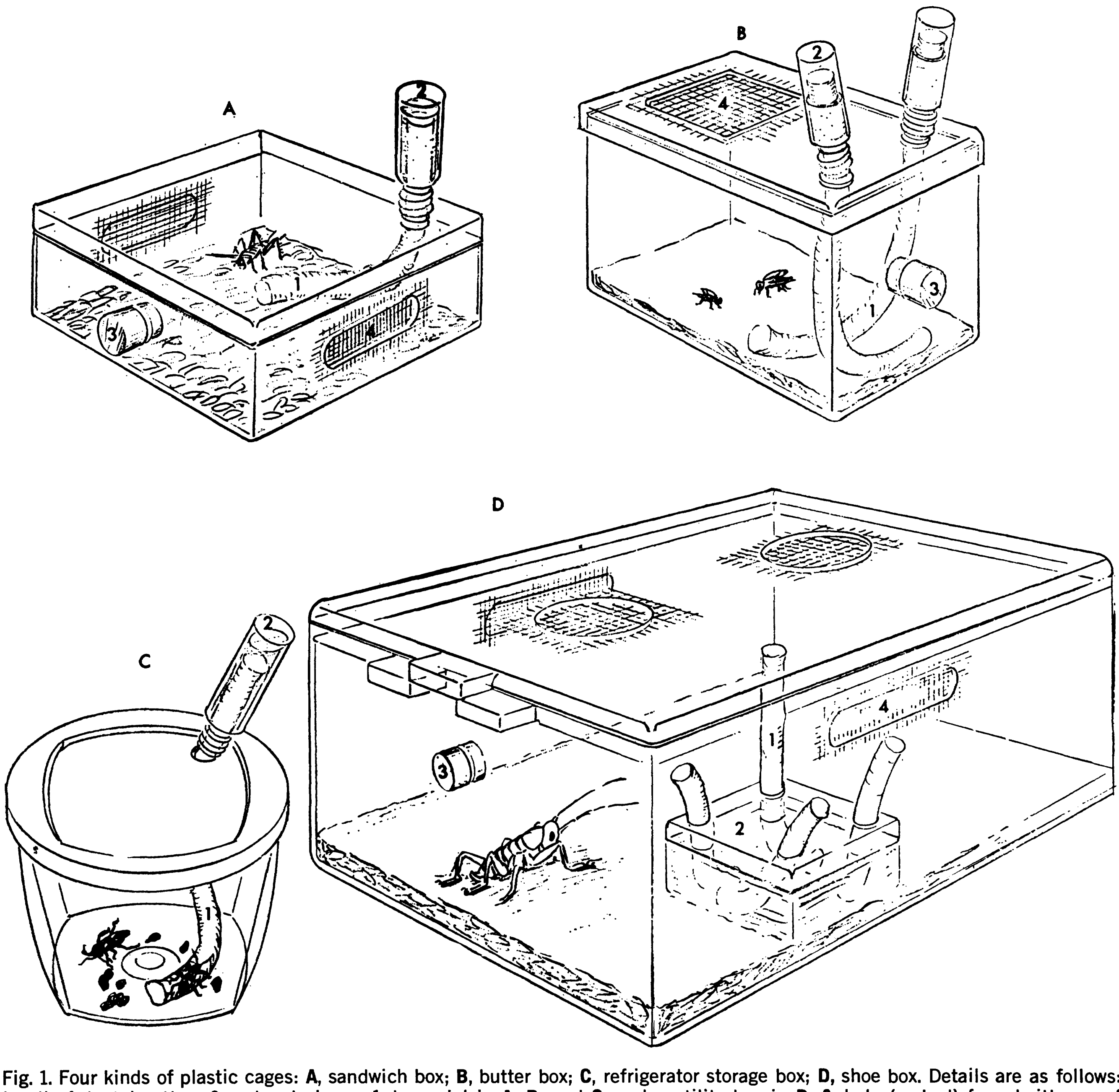

Fig. 1. Four kinds of plastic cages: **A**, sandwich box; **B**, butter box; **C**, refrigerator storage box; **D**, shoe box. Details are as follows: **1**, roll of dental cotton; **2**, water device—a 1-dram vial in **A**, **B**, and **C**, and a utility box in **D**; **3**, hole (corked) for admittance of tube from a carbon dioxide generator (Follansbee, 1962); **4**, screened aperture for ventilation.

worm beetle). Two prominent kinds of mouthparts—chewing and piercing-sucking—are represented by these insects. None requires a sophisticated diet and all the ingredients can be obtained locally.

Gradual Metamorphosis

The large milkweed bug, *Oncopeltus fasciatus,* is an excellent insect with which to start. This insect has a fairly short life-cycle and is large enough to be observed without magnification. It has clean habits and is relatively odorless. Peterson (1964) reported that the five nymphal instars require 33 to 37 days to reach the adult stage at temperatures of 29° C and relative humidity of 70%. Adults live 22 to 35 days. I have found that the same time-spans can be obtained in the laboratory without regulated temperature or humidity. Mating usually will take place 5 to 10 days after the adult stage is reached. Eggs are laid 4 to 8 days after mating. Eggs hatch in 4 or 5 days, and the first molt occurs 3 or 4 days later. Raising the temperature and humidity will increase the hatch.

Adult *Oncopeltus fasciatus* can be collected outdoors from July to October at latitude 42° N. (Most state universities also maintain colonies.) The insects are found on their food plants: common milkweed, *Asclepias syriaca* L.; showy milkweed, *A. speciosa* Torr.; and whorled milkweed, *A. verticilliata* L. When the milkweed pods begin to split (in early October at this latitude) the pods should be collected to obtain the seeds as food for the milkweed bugs. The seeds should be separated from the pods and spread to dry for several days. The dried seeds can be used for several years. One quart of seeds should support a colony for nine months, at the rate of approximately two or three seeds per insect per day (Siverly, 1962). The insect secretes enzymes into the seed through its piercing-sucking mouth and then sucks out the nutrients. Milkweed bugs have such strict requirements for water and food that they cannot become accidentally established in the home or school.

A plastic shoe box is adequate to maintain a colony of milkweed bugs. No substrate is required. Until the insects reach the adult stage a lid is not necessary if a thin film of vaseline is applied around the inner upper 5 cm of the cage. When adults appear the lid should be kept on, because the insects sometimes take flight. At this time an oviposition site should be provided. Squares of gauze or small pieces of cotton serve this purpose. If cotton is used the eggs need to be removed before hatching; otherwise the first-instar insects become entangled in the cotton. A good rearing procedure is to remove eggs to a clean cage so that the insects can be maintained in more uniform instars; too, this will prevent problems arising from infrequent cage-cleaning. Water is provided in small plastic utility boxes (fig. 1: D2). If fresh water is not available at all times the adults may become cannibalistic.

Because milkweed bugs do not require much space they are ideal for the use of students, each of whom can rear his own small group of insects. Much about insect life in general can be observed from this insect: growth, molting, feeding, mating, egg-laying, and the entire cycle of development, which takes only about 5 weeks. Sexes are readily discernible without magnification: the male has two black bands on the ventral surface of the third and fourth abdominal segments, and the female has two black spots on both the second and fourth ventral abdomen segment and a black band on the third segment.

The house cricket, *Acheta domestica,* is a good insect for behavioral studies as well as for studies of metamorphosis and of mouthparts. It was introduced into North America from Europe. Laboratory specimens may become established if they escape. The sexes are easily differentiated: the female has a needlelike ovipositor as an adult, and only the male produces sound. Behavior between and within sexes is most interesting.

At 25° C the adult stage is reached in five or six weeks; at 32° C, in a little over four weeks. Adults live about three months. A female may lay as many as 2,600 eggs in a three-month period (Stone, 1953). Eggs hatch in two to three weeks at 26° to 32° C. These insects thrive best at temperatures of 26° to 35° C.

House crickets can be purchased cheaply from

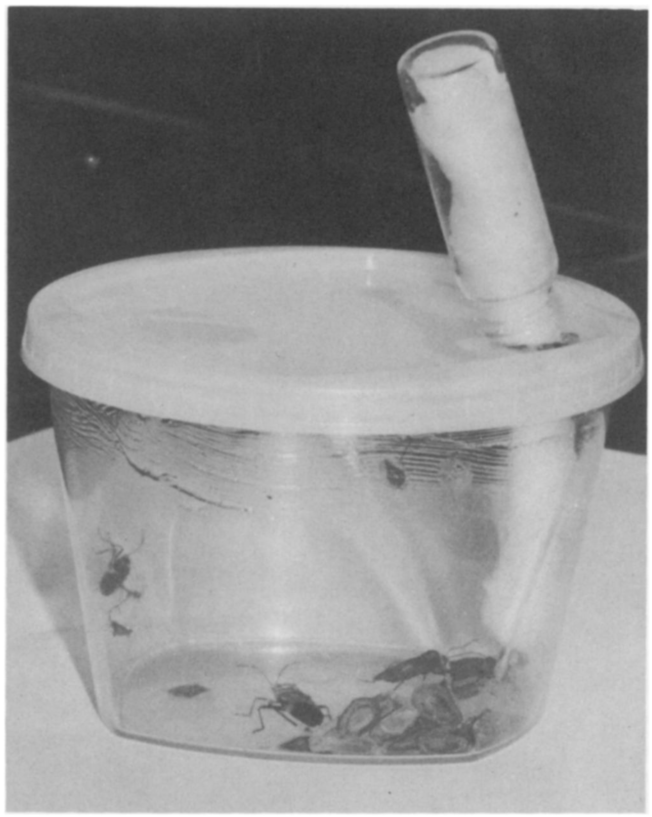

Fig. 2. Plastic refrigerator jar containing milkweed bugs.

local bait shops in season or from science supply houses. Crickets are omnivorous feeders on dry and fresh food. Young nymphs prefer soft food, such as bananas, apples, and lettuce. A satisfactory food for adults is a pulverized mixture of 3 parts dog food or lab chow, 2 parts skim milk, 1 part brewer's yeast, and a pinch of salt (Peterson, 1964). Once a week, fresh food should be provided for the adults.

A cage with sides at least 25 cm high does not require a lid; and an open cage is recommended, to avoid high humidity. For large colonies of crickets an aquarium is adequate. The floor of the cage should be covered with about 2 cm of sand or sawdust. The water container illustrated in fig. 1 (D2) is adequate. Resting places and shelters should be provided: pill boxes, rolls of screen, rolls of corrugated cardboard, or crumpled paper will serve this purpose. An oviposition jar (plastic cup or baby-food jar) 5 to 8 cm deep should be placed in the cage with adults. The oviposition jar should be filled with sand and kept moist. It is advisable to remove the oviposition jar every two or three weeks, lest the adults prey on the young nymphs.

Complete Metamorphosis

The common yellow and black mealworms, *Tenebrio molitor* and *T. obscurus,* require practically no care at all. A mealworm has a long life cycle: it takes four to six months to reach the adult stage at temperatures of 21 to 27° C. Eggs hatch in four to seven days; the 9 to 20 larval instars develop over three to five months; and pupation lasts 6 to 20 days (Peterson, 1964). The female pupa can be determined by the possession of a pair of small appendages on the terminal segment of the abdomen; in the male these are indistinct (Needham, 1959).

Mealworms can be purchased from local pet stores or bait dealers or from science supply houses. A plastic shoe box one-quarter full of wheat bran mixed with a small amount of brewer's yeast and cornmeal makes a satisfactory home and a food supply adequate for several months. An occasional slice of apple (or an apple core from your lunch), a carrot, a potato, or some lettuce or cabbage leaves will provide ample moisture. No water is required for these insects, and the food should be dry. Mealworms thrive in a relatively dark place and will move away from the light. Foam packing-material is also used by the larvae for burrowing and by the adults as a substrate for egg-laying. If this material is dyed a dark color the eggs can be seen more easily.

A plastic shoe box is adequate for a colony, but smaller groups are best raised in sandwich boxes. If late-instar larvae are used, the changes in complete metamorphosis become apparent with the formation of an exarate pupa (appendages free, not glued to the body; no pupa case) and finally the adult. These insects are relished as food by a number of animals that may be present in the classroom or laboratory: toads, frogs, salamanders, field mice, shrews, and certain birds.

The wax moth, *Galleria melonella,* is a member of the familiar order Lepidoptera, which contains about 10,000 species in North America (Teale, 1962). A starter culture may be obtained from a biology supply house. The larva is a typical caterpillar; that is, it has a segmented fleshy body and a well-defined head. Three pairs of jointed legs are present on the thorax, and there are four pairs of prolegs, equipped with hooks (crochets), on the third through sixth abdominal segments and a pair of prolegs on the terminal segment of the abdomen.

A colony will do well if kept at temperatures of 29° to 35° C and in the dark. Larvae in a culture are capable of raising the temperature of the colony 10° to 15° C above the ambient air temperature (Needham, 1959). A female moth will lay as many as 1,000 eggs, which hatch in about 7 to 10 days. Larvae molt eight times during a larval period of approximately 35 days. An obtect pupa (appendages closely appressed to the body; an enclosing pupa case) is formed, and this remains in this condition about 13 days before the adult emerges (Fremling, 1969).

Plastic shoe boxes with ventilation openings in the ends and the top or a quart jar with a screen lid will accommodate a colony. To discourage mold, the container should not be sealed and water should not be added. An artificial diet used by Dutky, Thompson, and Cantwell (1962) is adapted as follows: 1,200 ml dry pablum (baby cereal), 91 ml glycerine, 0.6 ml Deca-Vi-Sol vitamins, 77 ml Karo syrup, and 72 ml water.

Sexes can be distinguished with the naked eye: the posterior edge of the female's wings is straight and she is lighter in color than the male, which has notched wings. Corrugated paper is a good pupation site. As soon as adults appear they should be transferred to fresh food; or else the eggs, which are laid around the edges of the lid, should be transferred to fresh media. Mating occurs the first day after eclosion. The adults never feed or drink and will live only long enough to mate and lay eggs. This period, of about 10 days, clearly illustrates a common condition in insects: the adults' only function is to reproduce.

These insects do not require daily care, have no objectionable odor, and need very little space. Their diet is specific enough that they will not establish themselves in the classroom accidentally.

Insects for Special Studies

There are, of course, other insects that can add a great deal to one's knowledge of biology. Ants and honeybees are social insects offering hours of observation. Springtails, silverfish, and firebrats are examples of wingless insects having no external metamorphosis. Springtails are the most common insects in the soil and should be studied in more detail. Cockroaches, such as the American cockroach, *Periplaneta americana,* have many undesirable attributes but are good experimental animals; and several roaches from Central America are so used—among them *Blaberus giganteus* and *B. craniifer,* which are large and not offensively odiferous.

Benefits of Raising Insects

The study of insects in elementary and secondary schools is too often superficial—limited to a look at an insect collection, the hatching of cocoons, and genetics experiments. In these circumstances, only a superficial knowledge of insects is acquired. Furthermore, the dead insect in a collection usually represents only one phase in the life history of the species; and this form may differ greatly from the one found in competition with man for his very existence. Insects can and should be observed throughout the entire life cycle; when this is done, many biologic concepts become more than static terms to be memorized and promptly forgotten. Try rearing some of these insects: the incidental learning will amaze you.

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A MAN HAD A COW . . .

A man had a cow, a horse, and a few acres of land. He had a gun and a dog. When he wanted a pheasant or a rabbit he went out and shot it. He had a small stream flowing through his land where he could catch a trout if he wanted one. He thought he lived quite comfortably.

One rainy day he went to town. There he took himself a wife. He lived a little more comfortably now because he didn't have to carry the water, get his meals, and wash his clothes.

Then one day his wife said she was through carrying water from the spring and she wanted a pump in the house. She also was tired of cooking over an open fire. She said other women had stoves they could put wood into and cook on top of and inside of. The man finally got more cows so he could sell a little more milk, and when he did he bought his wife the things she wanted and had the pump installed.

Soon he found he could not produce enough food to feed the cattle through the winter without another horse and some more machinery. With more machinery and horses he cleared more land for planting crops. Now he produced more, so he added more cows.

He was getting along quite comfortably now.

A few years passed and electricity came through the country. The wife wanted lights in the house. By now they had four children. They needed a bigger house. He would have to build one. The wife was tired of the wood stove. Other women had stoves you could turn on with buttons. They had hot and cold water that came out of a faucet. Yes, these things would all be nice.

More cows were bought. Then a milking machine. The horses were worn out and had to be replaced with a tractor.

As time passed the flat lowlands where the pheasants used to be were plowed. The once bushy wooded hillsides were now bare and scarred with deep ditches. Ridges could be seen around the hillsides, caused by too many cattle walking. Overgrazing had left the steep slopes bare, with nothing to break the fall of the raindrops. The once beautiful clear stream was now an ugly deep ditch that ran brown with muddy water after each rain.

One day the man was seen at his table writing a letter. It was to the State Conservation Department. It read as follows: "I buy a hunting and fishing license every year and I think you guys should do more than you are doing to get good hunting and fishing. I can remember when . . ."

—*Dean Volenac,* Wisconsin
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