DEVELOPMENT AND MAINTENANCE OF INSECT COLLECTIONS

by

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INTRODUCTION AND SOURCES OF LITERATURE

This topic was selected for the subject of a Master's Report because the writer's government (Turkey) wishes for the writer to curate the national insect collection and to build it up for use in determining species of Turkish insects.

The development and maintenance of insect collections is a subject upon which a vast amount of knowledge has been acquired and many books, scientific papers, manuals, and bulletins have been written.

This report attempts to condense and bring together as much of this material as possible. The information may be useful to museum curators, technicians, amateur entomologists, students, and agriculturists.

Many of the books written on this subject are at the amateur naturalist's level, such as "How to make a home nature museum" by Vinson Brown. They show how to start a nature collection in a simple, easy way, but contain little technical information useful to more serious students. On the other hand, articles written for the use of amateur or professional entomologists, such as "Collecting, preparing, and preserving insects" by Bryan Beirne, contains a wealth of information describing standard methods of collecting, preparing, and preserving specimens, as well as the equipment and apparatus required.

Some books such as Harold Oldroyd's give information on how to learn more about the insects caught, and how to make known new discoveries that are certain to be made when insects are observed closely. Others, like "The preservation of natural history specimens" by Reginald Wagstaffe and J. Havelock Fidler, are written primarily for museums. They explain how to preserve permanently the most important taxonomic features of each group of insects.

There are several manuals written on this subject. In particular, "A manual of entomological equipment and methods" by Alvah Peterson contains a large number of plates with outline drawings of equipment, as well as explanations and references to the literature sources or the names of contributors. It also attempts a complete compilation of abstracts and original contributions on rearing techniques found in the English literature. In addition, it contains information on marking insects, shipping or transporting living and pinned specimens, and many miscellaneous notes on museum and laboratory methods.

Some articles are written as guides for farmers or other non-entomologists confronted with insect problems. These give general information regarding the methods of procuring and preserving specimens for identification. They also contain hints that may be useful to amateur collectors in caring for specimens in their collections.

WHERE AND WHEN TO COLLECT INSECTS

Insects can be found almost everywhere and usually in considerable numbers. However, in order to build a comprehensive insect collection it is necessary to sample as great a variety of habitats as possible. Different species may occur in the same macrohabitat, such as open forest but exhibit small or large differences in their particular location, i. e., their microhabitats which differ. (The term microhabitat is applied to special, limited habitats such as caves, crevices in rocks, under bark, soil, plants, etc.) For example, the habitat of the water "backswimmer", Notonecta is the shallow, vegetation-choked area of ponds and lakes. Many beginning collectors simply wander over the countryside collecting whatever insects they chance to meet, a technique which gives a very poor sample of the insects in a given area.

In building a comprehensive insect collection, collecting should be organized so that all macrohabitats are covered, and within each macrohabitat as many microhabitats as possible.

Many kinds of insects feed upon or frequent plants; hence plants provide one of the best places for collecting. Different species feed on different kinds of plants, e. g., grasses, flowers, weeds, shrubs, and trees. Every part of the plant may harbor insects. The majority will probably be on the foliage or flowers but others may be on or in the stem, fruit, or roots.

Some species can be found under stones, boards, decaying material of all sorts, such as fungi, decaying plants, or the bodies of dead animals, rotting fruits and dung.

A great many insects are found in aquatic situations. Different species can be found in different parts of any particular pond or stream. Some are found on the surface, others are free swimmers in the water, and others occur on aquatic vegetation.

The best time to collect most insects is in the summer, although they are active from early spring until late fall, particularly on warm days. Many insects can be found in hibernation during the winter. The adults of many species have a short seasonal range; hence one should collect throughout the year in order to get the greatest variety. At least some kinds of insects can be collected at any hour. During the night many insects may be taken at street or porch lights and windows or screens of lighted rooms.

There are several kinds of light traps especially designed to attract and collect night flying insects.

Bad weather conditions, such as rain or low temperature, will reduce the activity of many insects. Some others are little affected and can be collected in any kind of weather.

EQUIPMENT AND METHODS FOR COLLECTING INSECTS

Many different collecting methods utilizing a variety of equipment are used to collect insects. Beirne (1963:10) suggests that collecting may be merely a matter of picking up the insects with the fingers after field observations have revealed their habits and habitats. However, the necessity to obtain specimens rapidly or in quantity often precludes prior extensive field observations, and special collecting equipment must be used. Some kinds of equipment operate on the principle of extracting the insects manually or mechanically from the situations in which they occur; others concentrate on trapping the insects by taking advantage of their normal movements, or their reaction to light, gravity, heat, moisture, or odors.

Nets. Nets are generally used to catch flying and aquatic insects, and to sweep insects from vegetation. Differences in design for special uses consist of modifications of some or all of the three main parts: the ring, the bag, and the handle.

Beirne (1963:10) describes a simple net with a 15-inch ring of about one-eighth inch diameter, of iron or steel wire. The ends of the wire are straight and fit into grooves in the handle with their tips bent inward to fit into holes in the handle. The ends may be held firmly in place with insulating or adhesive tape or by a sliding metal sleeve. The latter enables the ring to be removed easily from the handle.

It is advisable to use a net with a detachable ring. This allows the bag to be replaced easily if it wears out, gets wet, torn, or dirty, or if it has to be changed for one of a different material. A folding ring is desirable as it is easy to carry.

A good net for general purposes may be a fisherman's landing net. The ring is of spring steel bands and is collapsible, and it measures about 13 to 15 inches when open. The ring screws into a ferrule at the top of the handle, so that it may be taken apart to change the bag by unscrewing a bolt in the ring.

The net handle should be both strong and light. A bamboo handle is suitable. A jointed wooden handle or one made from a telescopic aluminum pole has the advantage of being adaptable for different purposes, even though it may be rather heavy. For most purposes, a handle two or three feet long will be found most convenient (Beirne 1963:12).

Oldroyd (1958:29) states that the bag should be at least twice as long as the diameter of the frame, so that, with a twist of the wrist, it can be closed over the frame. The material used for the bag depends on the method and purpose of collecting. Materials such as mosquito netting, well washed to make it soft, or old lace curtains can be used. Rayon materials are liable to tear when they are wet. The traditional material for the making of insect nets is millers' bolting silk, but this is too expensive for general use. A closely woven material is unsuitable because, besides staying in stiff folds, it also holds a cushion of air inside it, which may prevent small insects from going into the net opening.

Borror and DeLong (1963:676) state that the best material for the net is marquisette, or scrim; cheese cloth is unsatisfactory because it snags too easily.

Each net bag should have the edge where it is attached to the ring, lined at point of greatest wear with strong cloth such as light canvas, or heavy muslin, or linen. This cloth forms a tube about an inch and a half in diameter through which the ring passes. This facilitates rapid changing of the bag (Beirne 1963:12).

Killing agents and killing bottles. A killing agent should kill the insects as rapidly as possible and should not affect their color or harden them unduly. The most satisfactory killing agent for general use is calcium cyanide, calcium cyanamide, sodium cyanide, or preferably, potassium cyanide. These are poisonous to man and domestic animals and must be used with great care. They must be used in a specially designed, properly labeled killing bottle for maximum safety.

According to Beirne (1963:39) preparation of a killing bottle may be done thus: a half-inch layer of broken potassium cyanide is placed in the bottom of a jar. Then, sawdust or dry plaster of paris is poured into the jar until it fills the space between the lumps of cyanide. Three or four drops of water are added. Over this is put either a layer of wet plaster of paris about half an inch deep or a tight plug of cotton wool, which may be covered by a tight-fitting circle of blotting paper or porous cardboard. If wet plaster is used the bottle should be left open for 12-24 hours, until the plaster dries (Fig. 1).

Various sizes and shapes of bottles may be used, depending on the type of insects to be collected, such as milk bottles, pint jars, small vials, or unbreakable, transparent plastic jars. The size and shape of the bottle used is a matter of personal preference. Corked bottles are usually preferable to screw-capped jars, and wide-mouthed bottles or jars are more easily used than narrow-necked ones.

When one goes to the field to collect insects one should have two or more bottles of different sizes for insects of different types. Insects such as beetles must not be put in the same bottle with small or fragile forms. Also, grasshoppers and some beetles expel juices which may damage the other specimens in the bottle. Lepidoptera must not be mixed with other insects since the other insects will become covered with scales and hairs. It is important that the collector place specimens from different microhabitats in separate vials or bottles with labels if he wants to have complete information about the place where the specimen were collected.

Cyanide has certain disadvantages because it leaves small specimens rather brittle. It also turns yellow colors to red, pink or orange, and some greens to yellowish when specimens are left too long in its fumes.

A cyanide bottle becomes gradually ineffective with constant use. Old bottles should be broken and buried in a deep hole where children and animals can not reach them.

Each killing bottle should be labeled "POISON" and all glass bottles should be reinforced with tape to reduce the hazards of breakage.

Other killing agents include laurel leaves (*Prunus lauro-cerasus* L.) which act as a slow killing agent, but have the advantage that they can be safely prepared at home and specimens remain relaxed. The leaves are picked and crushed. A layer is then put into a bottle. It is covered with a piece of blotting paper (Oldroyd 1958:78).

Many liquids can be used such as ethyl acetate, benzene, chloroform, ammonia, and carbon tetrachloride. Ethyl acetate is most frequently used. The others have some disadvantages, being more poisonous, flammable, or leaving the specimen dry. Ethyl acetate acts quickly and is not very poisonous to humans. Some collectors prefer ammonia especially for butterflies and moths, because specimens will be in good condition for pinning. However, it has the disadvantage of changing the color of the specimen. Chloroform and benzene are not good as general killing agents because they are very flammable.

An absorbent material is necessary to soak up and hold the liquid. A layer of plaster of paris is often used to absorb the killing agent. Another method is to hollow out the cork stopper of a bottle and fill the cavity with cotton wool, then moisten the cotton with a few drops of the killing agent, and seal the cavity with blotting paper (Oldroyd 1958:79).

Pill-boxes. Pill-boxes are small cylindrical boxes used for temporary storage of insects. They may be constructed of a variety of material. Some have glass bottoms and cardboard tops. They may be used like tubes for putting over insects when picking them off the ground or leaves. Others may be of metal, in which case they retain moisture inside, and for that reason they are less desirable. Strong cardboard boxes are very serviceable, will last longer if they are painted on the outside. Pill-boxes can be obtained in nests of graded sizes which fit into each other so that the whole nest when empty occupies only the space of the largest box (Oldroyd 1958:38).

Pill-boxes should contain some kind of absorbent material, such as cleansing tissue to absorb moisture and reduce the breakage of specimens during transportation (Borror and DeLong 1963:681).

Envelopes. Different kinds of envelopes may be used for temporary storage of insects, particularly butterflies, dragonflies and moths. "Glassine" envelopes are excellent for papering specimens and may be purchased from any biological supply house. Ordinary newsprint or pulp pages can be used also. In damp and hot areas, porous papers are preferable because specimens will dry out quickly and will not mold (Klots 1958:10).

To make a triangular paper envelope, a rectangular piece of paper about 1 1/2" by 2 1/2" to 5" by 8" is used. The paper is folded as shown in Figs. 32-37. Stiff paper is preferable since it reduces damage when envelopes are packed together. Only one specimen should be put in each envelope.

It may also be convenient to store smaller insects between layers of cellucotton in rectangular paper packets. The packet may be made as in Figs. 38-41. These are especially convenient on field trips where it is impossible to pin all specimens before they dry. Various sizes of pockets may be constructed to fit into cigar boxes or other sturdy boxes.

The specimens should be spread sparsely between two layers of the cellucotton which will prevent breakage from movement and will absorb moisture. When it is convenient to pin the specimens, the entire pocket may be placed in a relaxing jar since the cellucotton will absorb excess moisture.

Data should be written on the outside of the envelope or pocket before placing the specimen in it.

Vials for preservatives. Most soft-bodied or extremely fragile insects such as aphids, Collembola, or Trichoptera, as well as larva and nymphs, should be preserved in liquid. If they are dropped in alive, the preservative will enter their body readily through the spiracles and alimentary openings, but there may also be shrinkage and distortion of the body and contraction of the appendages.

The most common preservative is 75% ethyl alcohol. Beirne (1963:63) stated that alcohol discolors some specimens and tends to make tissue brittle if it is used higher than 75%. It is always advisable to add 2% glycerin to 75% alcohol since the glycerin will keep the specimens from drying if the alcohol evaporates.

Other solutions that are used to prevent hardening are the AGA solution and Pempel's fluid. The formulae for these solutions are given by Beirne (1963:126). AGA solution is used if the external anatomy is to be studied. It causes some distension of the specimens, so that tergal and sternal characters are revealed more clearly. Pempel's fluid also keeps specimens soft but reacts poorly to subsequent treatment in caustic solution.

Chloral hydrate keeps the specimens in good condition for a long time. According to Beirne (1963:64), an incision is made in the body of the specimen to permit penetration of the solution. Then the specimen is placed in a 5% solution of chloral hydrate in distilled water. This is warmed until it is near boiling. Then the specimen is removed and dried about 5 minutes, after which it is placed in a 5% solution of chloral hydrate for about a week. It is then dried again and stored in the solution permanently.

Peterson (1962:6) recommended some combinations of chemicals to kill and preserve the specimens well:

1. X.A. mixture.
   Xylene . . . . 1 part
   95% ethyl alcohol . . . 1 part

2. X.A.A.D. mixture
   Xylene . . . . 4 parts
   Commercial refined isopropyl alcohol . . 6 parts
   Glacial acetic acid . . . . 5 parts
   Dioxane . . . . 4 parts

3. K.A.A.D. mixture
   Kerosene . . . . 1 part
   95% ethyl alcohol or
   Refined commercial isopropyl alcohol . . 7-9 parts
   Glacial acetic acid . . . . 1 part
   Dioxane . . . . 1 part

4. Ketone mixture
   - Unsaturated 14 carbon ketone . . . . 2 parts
   - Glacial acetic acid . . . . 1 part
   - Refined methyl alcohol . . . . 4 parts

K.A. and K.A.A.D. mixture are good for Lepidoptera and Coleoptera larvae. K.A.A.D. mixture gives good results with Lepidoptera, Coleoptera, Hymenoptera, Diptera, and Siphonaptera larvae and adult Arachnida, but is not good for heavily sclerotized larvae such as wireworms and some aquatic insects like Ephemeroptera and Zygoptera. A ketone mixture is used for larvae of Coleoptera, Lepidoptera, non-aquatic Diptera and Hymenoptera but it is not good for Ephemeroptera and Odonata adults because it causes rupturing or ballooning of the gills.

Peterson (1962:8) stated that killing larvae in K.A.A.D. mixture and preserving them in 95% alcohol gives very satisfactory results.

A number of sizes of vials are available for storing specimens preserved in liquids. One-dram vials are convenient for most purposes. The vials must be filled completely with the liquid so that there are no air bubbles. This prevents breakage of the specimens when the vial is shaken. To cork a vial, a pin is held alongside the cork to allow the escape of air. When the cork has been inserted the pin is removed.

Forceps. Small metal forceps with curved, or straight, fine points are quite useful for picking up insects in the field. They may be purchased from any biological supply house. The types of forceps are shown in Figs. 2 and 3.

Hand lens. Every entomologist should have a hand lens when working in the field. The hand lens give very low magnification, but has an advantage in that it can be used at a safe distance from the specimen so that it will not be damaged. Some types can also be used on glass topped drawers without removing the lid.

There are many kinds and sizes of lenses such as watch maker's lens, folding pocket lens, etc. They may be purchased from any biological supply house. Banks (1909:50) stated that a half-inch lens is most useful for insect work, although for Lepidoptera a 3/4 or an inch lens is suitable and for small insects a 1/6 inch lens can be used.

Aspirators. Aspirators are used to collect small insects from foliage, walls, the ground, etc. In its simplest form it is a simple tube with both ends open. One end is the intake while the other end is a mouthpiece. A piece of gauze or cotton prevents the specimens from being drawn into the mouth. A more complex form, often called a suction-bottle, is made of a small collecting bottle or vial fitted with a cork through which two small tubes are placed. The two tubes are bent at right angles, one being used as an intake, the other as the mouthpiece. The inner end of the mouthpiece tube may be closed with a piece of muslin held by a rubber band. The outer end of the mouthpiece may be fitted with rubber tubing to allow maneuverability. Oldroyd (1958:42) states that suction tubes have advantages over the suction bottle because they can be opened at both ends for cleaning. Suction bottles can be carried easily, may accommodate more insects, and can be corked tightly. Suction bottles may be used with a vial containing a killing agent. In this case, a suction bulb must be placed at the mouthpiece.

Sifter. Many small insects in trash, soil, and leaf litter may be easily collected by the sifting method. The simplest method is to take a handful of material and sift it slowly onto a large piece of white cloth. The insects can then be easily picked up with an aspirator or a wet brush.

Another method is to use a container with a wire mesh bottom. The size of the mesh in the screen depending upon the size of the insects to be collected. Chu (1947:23) stated that eight meshes to the inch is generally most useful. Commercial sieves may be quite useful for separating insects from soil, grain, etc. They are generally made of aluminum, about 12 inches in diameter and 2 1/2 inches deep, and are grouped into a nest, each screen being made of a progressively smaller sized mesh. Each sieve can be used separately as well as in the nest (Fig. 4). Mechanical sifters have also been designed for specialized purposes such as separating insects from stored products (Fig. 5).

Aerial collecting. According to Oldroyd (1958:30) the most important features of nets for aerial collecting are a large aperture, a light weight frame, and an open mesh bag. If only large insects like butterflies and dragonflies are to be collected, the bag may be of very coarse netting. Dark nets are preferred by some collectors because the insects show up well against the net. Small Diptera and Hymenoptera are seen best against a white net, however, the length of the handle is a matter of individual preference and may depend upon the kind of insects being collected. A long handle is a great help in catching high-flying butterflies or day-flying or dusk-flying moths.

The depth of the bag should be about 2 or 2 1/2 times the diameter of the ring, or slightly shorter than the length of the collector's arm. The fabric of the bag should be light and more or less transparent. Woven material is unsuitable for aerial net bags as it is too stiff and damages the wings, especially of Lepidoptera. The standard material for aerial net is Brussels netting, brusselette, or bobbinet. Rayon bobbinet is too weak; organdy is an excellent material because it is cheap, easily obtainable, and does not scratch the wings of Lepidoptera. Light nylon curtain material may also be used for aerial net bags.

Another kind of aerial net has been designed for use by airplanes. One such sampling net was used at Kansas State University for collecting high-flying aphids by Taylor and Berry (1965). The net was cylindrical, 32 inches long and 21 inches in diameter. It was made of "fiber glass screening" on the outside and "fine mesh nylon cloth" on the inside. The bag was attached to the circular rod frame by heavy canvas. In operation, the net was attached to the airplane wing.

Water collecting. Nets used to collect insects from the water must be heavier and stronger. Oldroyd (1958:32) stated that the same frame may be used for water collecting and for sweeping but with different bags. But most entomologists feel that for water collecting it is better to have a square, or a diamond shaped frame since it can be pushed into water-plants or loose gravel more easily. Water nets need a long, strong handle like a broom stick in order to have enough reach and force for pushing aside plants. Water nets also have a more flexible bag, similar to an aerial net. The bag is made less deep than an aerial net, because it often fills with debris and needs to be cleared out. The bag material can be made of heavy marquisette or bolting cloth.

A screen made from wire mesh of about 12 standards to the inch also can be used for aquatic collecting. There are two fitted stakes at each end which are driven into the bed of the stream so that the screen stands vertically and at a right angle to the current. The bed of the stream above the net is then stirred with a stick, so that insects are disturbed and drift against the wire screen (Oldroyd 1958:34).

Sieves can be used to collect insects from mud. They appear as a coal-riddle, placed in a stand similar to the frame of a table. The stand can be placed in the stream. The mud is taken up with a ladle and poured onto the sieve. The insects may easily be picked from the sieve (Oldroyd 1958:34).

Sweeping. Sweeping is the most productive method of collecting insects that fly or crawl on herbage. Although such insects can be captured in large numbers, sweeping has definite limitations because it captures free-living insects only. Miners, borers, and leaf rollers escape. If the vegetation is dense, insects that live near its roots escape capture. Nevertheless, sweeping is the most efficient and one of the most rapid and simple methods of collecting insects in large numbers from vegetation (Beirne 1963:21).

The principle of sweeping is to dislodge the insects from the vegetation into a net. Herbage, flowers, or the foliage of trees are swept with rapid sidewise strokes. Strokes, too slow, may allow the insects to escape from the net and upward or downward strokes normally produce fewer captures. Sweeping should not be done when the vegetation is wet, as this causes "irreparable" damage to most insects.

Oldroyd (1958:32) states that both the frame and the bag of the sweeping net must be very strong. The bag should not be much deeper than the diameter of the ring, about 20 to 24 inches. If the bag is too deep it is difficult to pick insects out of the bottom. The material of a sweep net bag may be scrim or a heavy muslin since the resistance to air is not so important as in an aerial net. A small net with an 8 inch ring and an 18-inch handle is very useful to sweep individual plants growing in mixed vegetation, or bushes where a larger net may get snagged (Fig. 6).

Searching. Searching is a method of acquiring series of insects that are difficult to collect, such as insects that inhabit galls, or bore in stems or roots, or live under bark in beach drift or in debris.

Free-living and non-living species may be picked off vegetation, stones, etc., with forceps or the fingers. A moistened brush may be used for small species that do not have fragile wings or hairs of taxonomic importance. Usually, the most convenient way of picking up insects is with an aspirator or a collecting bottle.

Ross (1953:64) states that "All one needs besides collecting jars and vials are sharp eyes, tweezers, and a tool for prying, a stout screw driver or a geology hammer."

Beating. Beating may be the best method of collecting insects from foliage of trees and shrubs. It is particularly useful for collecting free living larvae. The principle of beating is to strike sharply a branch of a tree with a stout stick so that the insects fall on a tray or cloth beneath, where they are easily seen and captured. Though beating is best for collecting larvae, many active and flying insects may be captured as well. The branch should be struck with a downward stroke; a sidewise stroke may cause some specimens to fall to one side of the cloth. Some collectors give a branch two sharp strokes, so that the first one loosens the insects' hold and the second dislodges them.

The cloth onto which the insects fall may be a large tarpaulin, beating tray, a net, or an umbrella held in the hand (Beirne 1963:23).

A simple beating tray can be made from canvas spread by crossed strips of wood. It should be rectangular rather than diamond shaped (Oldroyd 1958:32).

According to Ross (1953:65) beating is best in the cool of the early morning or by lantern light at night when the insects are too sluggish to escape.

Rearing and holding. Among the purposes of rearing are to obtain specimens in good condition for taxonomic study, specimens never or rarely captured by normal collecting methods, or specimens with parasites. Also reared specimens allow observations or experimental studies on bionomics (Beirne 1963:34).

For rearing, living insects are carried into the laboratory from the field in metal, glass, or cardboard containers. Excessive moisture, excessive dryness, and lack of food can cause death. Moisture from the insects' bodies and from the food plant condenses on the inside of metal or glass containers and may kill or damage the insects. This can be avoided by keeping the container in a cool place, by not overcrowding the specimens, and by putting in a piece of dry blotting paper. Small holes or panels of wire screening in the wall of the container, or a muslin or cotton covering, permit some air circulation and help to prevent saturation of the air. The container should not be exposed directly to the sun or there may be rapid drying or condensation of moisture, either of which may result in death of the insects. The insect should also be supplied with adequate food. The food should be put into the container before the insects are introduced, to prevent crushing. Different species should be put in different containers in order to avoid confusing ecological data (Oldroyd 1958:65).

Field containers must be sufficiently small to be carried. For rearing, numerous types of specialized containers have been designed to fit the habits of the various insects to be reared. Peterson (1937:141) figures and refers to more than 400 kinds of rearing, breeding, feeding, and hibernation cages.

The simplest cage can be made by using a glass jar covered on the top with a piece of muslin. A little sand or soil may be put on the bottom along with the plant from which the insects were taken. Moisture, temperature, and food are critical factors in rearing insects. Moisture can be provided in a cage by a piece of wet sponge or a small glass tube filled with water and with its mouth plugged with cotton. A tube should lie on its side, so that the cotton is kept wet. In larger cages, a small spirit lamp may be filled with water, so that the wick will supply moisture to the atmosphere (Oldroyd 1958:66).

Temperature will seldom be critical during a short period after capture, unless the insects have been sent from a tropical country. It is important to protect the insects against extreme temperatures that lie outside their normal ranges.

Food must be given during active stages. Oldroyd (1958:67) stated that caterpillars, bugs, and other plant feeders should have a supply of the plant on which they were caught. A leaf or small twig can be kept alive longer when held in water or planted in soil in the cage.

Insects that live in stored products such as flour and grain are adapted to dryness so can be kept in these materials. It is important that the containers be kept clean. Flour moths, for example, will breed in a jar of flour, but they soil it with their droppings and mat the food together with the webs that they spin before pupating. If nothing is done the culture will mould and the insects may die. To prevent this, the jar must be emptied, cleaned and dried carefully. Fresh food must be put in the jar and the insects may then be put in the same jar again.

Problems may arise with insects that hibernate or undergo diapause. The insect often cannot complete its development until it has been chilled or frozen. Diapause may occur in any stage of life cycle, especially in eggs or pupae.

Rearing adults from larvae is quite easy with insects infesting stored products or those living in dung or decaying vegetable matter. In a few cases it is not even essential to use the natural food material. West (1951:357) stated that different kinds of artificial foods can be used for rearing housefly larvae and some other insects. These may be made of bran, oats and powdered milk.

Different techniques are required for rearing almost every group of insects. Ford (1940:90) described techniques for rearing microlepidoptera. The breeding jars are covered with a sheet of plate glass and the rim of the jar is ground with silver sand and water until it makes complete contact with the glass. The insects are then placed on growing plants transplanted to flower pots which may be placed in the cage.

Many holometabolous insects pupate in the soil. For this reason it is better to put the larvae and their food in a large container standing on a layer of soil or sand. Pupae require a certain amount of moisture when emerging. The water can be sprayed into the soil from a fine nozzle.

Lights and light traps. Many insects are attracted to light at night and may be captured with a net or trap. Insects come to light in largest numbers during dark, cloudy nights when both temperature and humidity are high, but in lesser number on cold, windy, moonlit nights. Beirne (1963:14) mentioned that the higher the surface brilliance of the light source the larger the number of insects attracted. Light does not attract insects from long distances.

The results of many tests show that ultraviolet fluorescent type lamps (black light) are most suitable for insect attraction, especially in the 15 watt sizes. These lamps attract several kinds of insects, are low in cost, and have a long life. However, they have one disadvantage because they may be too attractive, drawing thousands of specimens of undesired species (Taylor, Altman, Hollingsworth, Stanley 1956:2).

Frost (1954:275-78) stated that black (ultraviolet) light attracts more of most groups of insects than white light, although species of Miridae and Chrysopidae apparently respond more freely to white light.

The simplest method for collecting night-flying insects is to use a white sheet. The sheet may be laid on the ground with a lamp in the middle, or hung vertically. Electric lights or gasoline or kerosene vapor lamps are effective light sources. The insects are picked off the sheet by hand or captured with a net. Several kinds of traps have been especially designed for efficient collecting of specimens and species in large number. Evans (1907:150) described a very simple but efficient trap. It consists of a funnel made of a half-sheet of heavy drawing paper with a light just below the top of the funnel and cyanide bottle placed at the small end of the funnel.

The Brooklyn light trap consists of a box larger in front than behind and attached behind to a lantern. Three panes of glass are placed into the box obliquely, and a cyanide jar is placed next to the lantern. The box is painted white inside and dark green or black outside, the dark color preventing the insects from resting on the outside of the trap (Banks 1909:47).

The Hiestand trap is a similar device, attracting moths from one direction. It has a light chamber that contains an electric or oil lamp and a killing chamber separated from the light chamber by a plate of glass. The killing chamber opens to the outside, around several panes of glass which are placed at an angle so that moths can enter easily but cannot escape. A killing bottle is placed at the bottom of this chamber. An improved model attracting insects from all directions consists of a funnel with the spout removed, and a mason jar with a circular hole cut in the lid and soldered to the bottom of the funnel. The funnel is hung by three or four wire rods to a circular iron disc which has a light in the middle. The cyanide may be placed in cheese cloth so that the jar can be cleaned frequently (Hiestand 1928:158-160).

According to Oldroyd (1958:48) the Robinson trap introduces a new principle, based on analyses of the behaviour of night-flying insects towards a light. A high illumination lamp causes such insects to cease flying, and settle, just as they do at day break. The trap is made of several vertical metal vanes arranged inside a drum-like container which is open at the top and attached to a cone and bottle at the bottom. The light is at the center of the vertical metal vanes and level with the top rim of the drum. When an insect flies toward the light, it hits one of the vanes and falls down the cone into the bottle beneath. The Robinson's used the vapour of tetrachlorethane as an anaesthetic in the collecting jar, so that insects were stupefied but not killed. They could then either be used for breeding purposes, or released. A mercury vapour lamp was the light source although the design may be easily modified to use ultraviolet light.

Frost (1952:13) described the New Jersey mosquito light trap which is especially designed for mosquito surveys. This trap consists of a galvanized iron cylinder 9 inches in diameter and 12 inches long, suspended beneath a conical roof 16 inches in diameter. At the bottom a 25 watt bulb is located inside the cone. The underside of the roof is painted white to reflect the light. A 5/16 mesh screen is placed over the upper end of the cylinder to keep out moths and other large insects. A small fan (8" diameter) is placed below the screen. A funnel-shaped screen fits into a cylinder below the fan blades and projects below the lower end of the cylinder where it opens into a collecting jar.

The light trap shown in Fig. 7, is the black light trap used at Kansas State University. It consists of a galvanized iron funnel, on ultraviolet fluorescent lamp and a collecting jar.

An underwater light trap was described by three American authors (Hungerford, Spangler, Walker 1955:387) for collecting water beetles, water bugs, and aquatic nymphs and larvae of flies, mayflies and dragonflies. The body of the trap is formed by a 21" length of galvanized iron flue-pipe that is held horizontally. A cone of copper gauze about 40 meshes per inch and 9 inches deep with a 1-inch hole at the apex is placed in one end of the flue-pipe. The other end is closed by a wooden plug, through which four short pipes about 1 inch in diameter are inserted. Each is closed by copper gauze. These allow water to drain out when the trap is lifted. The top of a water tight jar is fastened to the middle of the inner surface of the wooden plug with a fitting to hold the end of the flashlight. A lead sinker is attached to one side of the tube and a strong eye is bolted to the opposite side for the attachment of a length of window cord.

Bait and bait traps. Many adults, larvae, or nymphs can be collected by baits. Many different attractants, either natural or synthetic, can be used. Natural substances such as flowers, the aphid excretions known as honeydew, fermenting sap taken from wounds in trees, rotting or overripe fruit, rotting fungi, carrion, and animal excreta can be used (Beirne 1963:18). The insects may be collected with a net or forceps, or the baits may be placed in any of a variety of traps.

According to Oldroyd (1958:54) fermenting substances are always attractive to insects because of the alcohols, esters, and similar organic compounds produced. The technique known as sugaring takes advantage of this attraction. A bait may be composed of a fermenting mixture of sugar, treacle or molasses, rum or other types of alcohol, and beer. This mixture is boiled, then painted onto trees. This method is a particularly effective means of capturing moths.

There are several kinds of bait traps, but the general principle of most is the same. Bait is placed in a container to which the insects have ready access, as through a cone. After feeding they are unable to escape. In some designs the bait is placed under a wire enclosure. After feeding, the insects fly into the enclosure from which it is difficult to escape. Peterson (1937:82) describes and figures several kinds of traps. One for cave-inhabiting insects consists of a metal cylinder placed in a hole made in the floor of the cave. The bait is placed in a glass tube within the cylinder. The attracted insects fall into the cylinder.

A special bait trap for collecting cockroaches was devised by Graham. It contains a flat-bottomed water flask in which is placed the mouth of a paper cone. The cone is held in place with a little vaseline smeared around inside of the neck of the flask. A similar cone is glued in position within the larger one. Banana is smeared around the inside of the cone as bait. Several hairs were glued to the smaller end of the inner cone to prevent the insects from escaping (Washburn 1913:327).

Insecticides such as malathion may be mixed with the bait to kill the insects when they feed. An absorbent surface such as a corn cob may be dipped in the bait and suspended over a container into which the insects drop when they are killed by the bait.

Malaise trap. The malaise trap takes advantage of the fact that day-flying insects tend to move toward a light in a darkened container and upward on striking a barrier (Beirne 1963:20). The trap consists of a large, box-like tent which may be made from various materials. The tent may be suspended from a tree limb or an overhead frame, or may be supported by a pole. The top of the tent fits onto a wire screen which tapers into a funnel to which is attached a killing jar which may contain either alcohol or cyanide. The insects strike the walls of the trap, move upward into the screen, then go into the funnel where they are killed and drop into the bottle.

The tent may be of cloth, plastic, or netting. The original material used by Dr. Rene Malaise was black fishing net. Marston (1965:158) stated that visqueen polyethylene film is inexpensive but it is undesirable because of deterioration in the sunlight. Nylar film seems promising.

Locality is very important for collecting specific kinds of insects. For general collecting the margin of a woodland or field, a stream bed, a river bank, or a small gap in a range of hills is a good location. Figures 12 and 13 show a malaise trap that was used at Kansas State University by Marston (1965). The trap was placed in a dry stream bed along a high bank in a forested ravine. About 3,000 specimens constituting about 480 species were collected in one week.

Suction traps. Suction traps are used to sample airborne insects by drawing them into a tube with the aid of a fan. The original Vent-Axia design is a small suction trap about 6", 9", or 12" in diameter. It consists of an electric fan, mounted with the blades revolving in a horizontal plane through which air and insects are drawn. The air then passes through a fine screen cone suspended beneath the fan, leaving the insects in a terminal collecting tube. It is suitable in sheltered situations, such as in crops, or when located less than 10 feet off the ground.

Large suction traps (Fig. 8) have been designed for use on towers, on top of buildings, or in areas exposed to wind. These traps are more powerful with a much greater air delivery and are designed to take larger samples of insects from the air where winds may be above 15 m.p.h. and insect densities are low (Johnson and Taylor 1955:52).

Johnson-Taylor type suction trap (Fig. 9) is composed of a "trap unit" consisting of an air filtering cone of fine screen and a segregating mechanism within a collecting tube, all enclosed in a cylindrical duct; and a "fan unit" attached above the trap unit. Traps are designed so that their opening faces upward and the fan revolves in a horizontal plane. Thus, wind blowing across the top does not enter through the opening directly. Air is sucked in together with insects, which are sucked down the cone into the collecting tube at the lower, pointed end.

Large fan units must be constructed of material of minimum weight in order to facilitate moving. Since the air delivery depend on the fan diameter and on the air speed through it, both the size of the fan and its speed must be taken into consideration. The fan unit may be designed to be mounted either sideways or upright with the motor below the fan.

The collecting tubes in the early traps had no segregating mechanism and consisted of simply a glass tube with alcohol in it. Later models have been designed to segregate the catches at hourly intervals. The segregating mechanism is composed of a pile of 24 metal disks (Fig. 10). At each hour a time switch allows a current to pass through a transformer to a solenoid which, acting as a magnet, pulls a release and allows a disk to drop down a central rod which guides it to its resting place in the collecting tube. After a disk drops, the one above falls into its place on the release, ready to drop after another hour has passed. The time switch turns off the current after a few seconds. After 24 hours the screen collecting tube containing a pile of disks with the hourly catches of insects may be detached from the trap and the insects removed (Johnson 1950a:81).

Wind-vane trap. This trap is used to catch many kinds of weak-flying insects that drift with the wind. The insects are filtered from a column of air passing through the trap. There are several types of wind-vane traps, one of which is shown in Fig. 11. This design was developed by Shands and is used to collect the aphids. The trap is made of welded 1/8" metal rods covered with cotton scrim. It is shaped like a curved horn, with the plane of the large opening, 19 1/2" square, mounted in a vertical position. A metal shaft attached at right angles to the base of the square opening, acts as a swivel mounting which permits the trap to turn with the wind. The small circular opening at the end of the trap is attached to a "baker's cap" 6" to 8" in diameter. In operation, wind currents push the aphids upward toward the opening of the bag. The number of the insects caught depends on their density and the wind velocity (Wave and Shands 1965:11).

Aerial tow-net trap. This trap is used to collect insects which alight or fly onto them or are blown against them by the wind. The net is conical, 33" in diameter at the mouth, 42" long, and made of hand-spun, single thread cotton. The rim of the net is attached to a light bamboo hoop. The net is held stiff by a boom running along the top on the outside. There are two swivels at opposite points on the bamboo hoop which allow the net to rotate round a vertical wire (Johnson 1950b:

272).

Sticky traps. These traps capture insects when they alight on or are blown onto an adhesive surface. In one design, the trap is made of a cylinder of galvanized iron 12" long, 5" in diameter, and painted white. Around this is placed a sheet of stiff cellophane on which an adhesive preparation is smeared (Johnson 1950b:272).

Collecting insects from debris. Many small insects live in debris such as in decaying vegetation, rotten wood, humus, beach drift, flood debris, and birds' nests. Some insects can be collected with an aspirator or forceps by turning over the materials but several specialized collecting methods can be used to get a more representative sample.

Emergence cages. A wire cage, which has a small glass bottle or tube attached on the top, can be put down over a mass of debris so that any insects flying up from it will be trapped. This cage is most suitable for field work. When debris is brought to the laboratory, a separator can be used to collect the insects. A separator is a wooden box with a tube or a bottle attached to one face of the box. The insects are attracted to the light and collect in a bottle (Oldroyd 1958:61).

Berlese funnel. Only a small portion of the insect population can be collected with an emergence cage or separator.

Immatures and those forms which prefer dark and moist conditions will remain in the debris. A Berlese funnel (Fig. 14) consists of a metal funnel, an electric light and collecting bottle. The material is placed on a coarse-mesh screen in the funnel, and the electric light is placed over the funnel. As the heat from the light dries the debris, the insects move downward, falling down the funnel into the collecting bottle which contains alcohol.

EQUIPMENT AND METHODS FOR PRESERVING AND MOUNTING INSECTS

The majority of insects are pinned, either using regulation insect pins or for minute forms, on "points", or tiny "minuten" pins. Very small species are often mounted on microscope slides and soft bodied insects such as nymphs, larvae, and the adults of midges, mayflies and stoneflies can be preserved in fluids.

Pinning. Special pins are required. These are made of steel and do not rust. Pins vary in size from number 0 to 7, although the most useful sizes are 0 to 3. Pins may be purchased from any biological supply house. It is very important to insert the pin at the correct point in the body to prevent damage. Larger insects, such as butterflies and moths, should be pinned vertically through the thorax near the center of balance of the specimen. Other insects are pinned in the same manner but a little to the right of the median line. Beetles and many other insects such as mantids, roaches and crickets are pinned through the right wing cover near the base. Grasshoppers and katydids should be pinned through the base of the prothorax. True bugs are pinned through the scutellum slightly to the right of center (Figs. 18-26).

Pinning block. In order to position an insect and labels at uniform heights a pinning block is used (Fig. 15). This may be a rectangular piece of wood or a block shaped like a stair step with holes drilled to appropriate depths. The deepest hole is used to determine height of specimens on pin, the middle hole to determine height of locality label, and the last hole for any additional label such as the determination label.

Cardboard points. Very small insects can be mounted on cardboard points. Points are elongate, triangular pieces of cardboard, about 8-10 millimeters long and 3-4 millimeters wide at the base. A special type of punch may be purchased to cut points. The point is supported with an insect pin through the broad end and positioned at a uniform height with a pinning block. The tip of the point is then bent downward, touched with glue and applied to the side of the insect. The point should extend to the left of the pin, and the head of the insect should be pointed forward. If the specimen is mounted on its side the head should be directed to the left. When a specimen is mounted, care should be taken not to imbed the body in glue since this will obscure characters for identification. The glue must be clear, quick-drying and hard when it sets. Clear nail polish works well and may also be used for repairing broken specimens.

Minuten pins. Small flies and some other insects are often mounted on minute, extremely fine, short pins. The minuten is inserted horizontally into a square of soft material which is mounted on an ordinary insect pin. The specimen is then pinned with the minuten through the side of the thorax. The most satisfactory material for embedding minutens is polyporus, although strips of cork, pith, balsawood, etc., can be used.

Mounting on microscope slide. Many insects are too small to pin, especially soft-bodied forms. The specimens may be killed and preserved in fluids until they can be mounted. Techniques for mounting specimens vary, depending on the insect and type of mounting media. Some insects are very dark-colored and thick bodied, so that they must be cleared before mounting. A solution of potassium hydroxide can be used as a clearing agent. The duration depends upon nature of the pigment and the temperature and concentration of the clearing agent. Delicate parts may be destroyed if the specimen is left in a solution too long. After clearing it is transferred to water to wash out excess potassium hydroxide. Some specimens then have to be stained if some structures are otherwise too transparent for study. Specimens to be mounted may or may not require dehydration, depending upon the mounting medium to be used. Polyvinyl lacto-phenol, Hoyer's, de Faure's, Berlese's and glycerin jelly do not require dehydration of the specimen. Dehydration is necessary for mounting in canada balsam (Beirne 1963:70).

To mount the specimen, a drop of medium is placed on a slide and the specimen is placed in the drop. The appendages are arranged, then a cover glass is placed over it and left to dry. If Berlese's medium is used, the slide has to be warmed. To mount in glycerin jelly, a small piece of the jelly is put on the slide and heated until the jelly melts, then the coverglass is applied before the jelly solidifies (Beirne 1963:70).

Temporary storage of specimens. Insects such as Lepidoptera and Odonata may be stored in envelopes, made from rectangular piece of stiff paper. Some collectors prefer cellophane envelopes although they may allow bacterial decomposition in wet climates. Data should be written on the outside of the envelope before the insect is placed in it. In order to prevent the envelopes from opening, they may be folded and pressed.

Hard-bodied insects such as Coleoptera may be stored in paper tubes.

It is often convenient to store an entire collection of small insects together between layers of cellucotton. The insects should be spread thinly in a layer so that they do not touch. The data of the specimens may be written on the enclosing paper.

For further information of temporary storage of specimens see the section on collecting.

Relaxing. It is necessary to relax specimens which have been placed in temporary storage before they can be mounted. Specimens are placed in an atmosphere of high humidity which softens the tissues. Beirne (1955:44) stated that a relaxing box may be made from any metal or plastic container which can be tightly closed. The bottom of the box is covered with wet sand, absorbent cotton, soft paper or synthetic sponge, saturated with water. On top of this layer a tablespoon full of napthalene or paradichlorobenzene or a small quantity of phenol should be placed to inhibit the development of mold. Specimens may be placed in the box in their special envelopes. The length of time required to relax specimens depends on their size and the humidity and temperature within the box, but is usually one or two days. Specimens should not be left too long in the box or they will become wet, destroying delicate patterns, matting fine hairs and discoloring scales. Green insects are particularly liable to discoloration. This may be avoided by adding ammonia into the relaxing box.

Spreading. The wings of Lepidoptera and some other insects may have an important taxonomic character which may be seen only if the wings are spread. A spreading board consists of two flat, parallel pieces of soft wood with a cork-lined groove between their inner edges. The board can be made of redwood, pine, basswood, or other soft woods. Proper attention must be given to the selection of a board of a suitable size. The groove must be wide enough to fit the insect's body; otherwise it is difficult to get the wings into position. Also the board must be wide enough to keep the wings from projecting over the edges. The pin with the insect is thrust vertically into the groove until in the bases of the wings are level with the surface of the board. The wings are then advanced into the required position by inserting a fine pin behind a main longitudinal vein of the fore wings. In most insects the fore wings are pushed forward until their posterior margins are in a straight line and at right angles to the body. Then, the hind wings are brought forward in the same manner until their anterior margins are just underneath the posterior margins of the fore wings. A strip of paper is placed over the wings and secured with pins to prevent the wings from curling up and warping during the drying process. The antenna may be positioned with pins and the abdomen should be supported by pins crossed beneath it (Fig. 16). The data for the specimen must be written on a strip or on a label beside the specimen. After the insect is spread, the board must be put away to allow the specimen to dry for one to three weeks, depending on the size of the insect and temperature, and humidity of the atmosphere.

When removing insects from the board, care should be taken to avoid breaking the legs and antenna (Beirne 1963:55).

Dry preservation of soft-bodied insects. There are two methods of preserving soft-bodied insects in the dry state inflating the skins with air or wax, or replacing the natural moisture with a liquid that hardens the tissues.

Inflation can be used for caterpillars and other larvae. Inflated larvae retain their green colors better than specimens preserved in alcohol but often the setae are broken and the internal organs may be missing. Beirne (1963:66) states that the larva should be killed in hot water and stretched on blotting paper. Then, an incision is made around the anus with scissors after which the body contents are forced out by rolling a pencil along the length of the body. The empty skin is then inflated by blowing through a glass tube inserted in the anal opening. In an oven the skin quickly dries in the inflated position (Fig. 17). The oven should not be too hot or the skin may scorch and color will be lost. Alternatively, the skin may be inflated with melted beeswax or paraffin which will make the specimen less fragile. The skin may be mounted by attaching its feet with adhesive to a length of straw transfixed at one end by an insect pin, or by inserting into the anal opening a tiny sharpened cork.

Freeze drying. The freeze drying may be used to support the tissue of the insect against distortion. The method requires an oil pump that will give a pressure down to 0.02-0.01 mm. mercury, and a deepfreeze cabinet that will give a temperature of -12°C, and will accommodate an ordinary laboratory desiccator. The specimen is placed in a glass tube and immersed in a dish of acetone. Lumps of solid carbon-dioxide are then dropped into the acetone until they cease to melt. The specimen is then placed in its tube into a desiccator with phosphorous pentaoxide as a drying agent. The desiccator is left in the cabinet 3 or 4 days at -12°C, when the weight is about 30-40% of the original, drying has been completed (Oldroyd 1958:108).

Labels and labelling. The value of an insect collection depends on the accuracy and completeness of the specimen labels. The labels should be written on stiff, high-quality paper and should include all pertinent information placed with the specimen when it was collected. The labels should be small, preferably about 1/4 by 3/4 inches. Type printed labels are most convenient but they may be written in India ink. When written labels are used for specimens preserved in alcohol, the ink may dissolve. For this reason, the labels should first be soaked in acetic acid or alcohol, and allowed to dry before putting them into the vials. A soft lead pencil can also be used to write labels for the specimens preserved in alcohol. Some collectors prefer photographs of typewritten labels but they may fade soon, do not hold to the pin well, and cannot be used in alcohol. Labels for microscope slides must be written or printed in India ink and glued to the slides with a permanent adhesive (Beirne 1963:74).

Each specimen should have a label citing locality, collector's name, and the date of capture. The latter should include the day of the month, the month, and the year, with the month indicated by roman numerals. Additional labels may be attached giving additional ecological and biological data but, since only a limited amount of information can be placed on the label, it is often desirable to have some system for recording additional information.

Numerous forms have been devised for recording information but each individual will find it expedient to devise a form for his particular needs. One such form for general collecting is that given by Hogue (1966:231). A separate sheet is used for all specimens collected at a single site (Fig. 42). This information should be recorded in the field or as soon thereafter as possible in order to minimize inadvertent errors.

STORAGE, CARE AND ADMINISTRATION OF COLLECTION

Small collections may be kept in one or a few storage boxes. But in large research collections, such as those of museums where specimens are identified to species, it is most convenient to keep specimens in drawers in specially designed cabinets.

Storage of pinned insects. Pinned insects may be stored in display boxes, Schmitt boxes or in unit trays in drawers, but in any case the boxes must be lined with soft materials such as balsawood, cork, or synthetic preparations into which the pins may be easily inserted. If cork is used, it is best to cover the surface with white paper.

The simplest method of arranging a small collection is to place the specimens alphabetically by order and family. The order label may be put on a separate pin and the family label either on a separate pin or on the pin of the first insect in the row of specimens in that family.

In large collections the cabinets can be made of wood, but most modern ones are constructed of steel (Fig. 27). Their size depends on the size of the collection and the size of the drawers to be used.

Each cabinet contains a number of glass topped drawers. Each drawer may be lined with a pinning bottom, or, more conveniently, they may be filled with unit trays, small boxes varying in size from 1" x 2" to 8" x 8". Unit trays are an advantage because all specimens of one species may be kept together, and the collection can be easily expanded or rearranged. Arrangement is usually phylogenetic by orders, families, subfamilies andtribes, while the genera and species are usually arranged alphabetically although sometimes phylogenetically.

Labelling of boxes and drawers. The purpose of labelling boxes and drawers is different from that of labelling the specimens. The labels act only as a guide and an index to the collection. Oldroyd (1958:130) states that the order name should be in capitals, whereas on labels for lower categories on the pin the first letter is capitalized. Family, genera and intermediate category names such as subfamilies and tribes, should be placed before the specimen to which they refer. In the system employed at Kansas State University, order names are written in capitals and glued on the doors of the cabinets. Within each cabinet, each drawer has a bracket on the front which contains a card listing the families and genera within the drawer. Inside the drawers, the labelled specimens are arranged in unit trays. In each box, a label with the genus, species and describer's name is placed at the front of the box, at left corner, where it can be seen easily in the drawer without moving the lid. Another label is pinned on the bottom of the box at the upper left corner (Fig. 29). Labels for families and the lower categories are glued to the tops of strips of word which are inserted between the unit trays. Labels should be typed or printed.

Protection of stored specimens. Dried insects are subject to attack by several insects, especially dermestids, which may completely destroy a collection. Infestation may be prevented by placing naphthalene, or paradichlorobenzene in each box or other container. If naphthalene is in flake form, it may be enclosed in a muslin bag and pinned in one corner or, if in ball form, it may be attached to the head of a pin and pinned in one corner of the container. The balls may be attached by heating the head of the pin and pushing it into the ball. The heat melts the naphthalene which then solidifies around the pin.

Most drawers for use in cabinets are constructed with a double wall, between which is a space to be filled with naphthalene. This may effectively protect specimens for 2 or 3 years.

If a collection has become infested the best way is to kill the pests by fumigation. For this purpose, paradichlorobenzene may be put into the boxes. Care should be taken to close the lids tightly. Carbon tetrachloride and ethylene dichloride are also effective fumigants but are more dangerous to humans and should be used with great care.

Storage of liquid collections. Since the collecting unit for specimens preserved in alcohol is usually a small vial, the method of storage must protect the vials from breakage and still allow ready access to the specimens. Large collections are commonly stored in narrow racks (Fig. 30) which are stored on shelves in a cabinet (Fig. 28). The vials are held in place by a stiff wire, a thin lath or a strip of clear plastic such as plexiglass.

Glass vials can also be stored in a jar although this method allows less ready access to the specimens. The bottom of a jar is covered with blotting paper and covered with alcohol. The tubes are stopped with cotton and placed open end downwards into the jar which is then sealed to prevent evaporation of the alcohol. Oldroyd (1958:133) recommends the use of small round-ended tubes of about 1" x 1/8". He placed a small, round label written in pencil or ink into the bottom of each tube so that it could be read when the tubes are stored upside down in glass jars. Each label showed a number which corresponded to a number on an index card. Beirne (1963:65) suggests that vials may be attached to a vertical wire screen. One end of a copper wire is wound around the neck of the vial and the other end is hooked onto the screen. The screens may be fixed to the top or the bottom of a cabinet.

The vials should be checked regularly in order to maintain the level of alcohol in the vials.

Storage of microscope slides. Microscope slides must be stored flat in order to prevent movement of the coverslips. Slides should not be placed, one on top of the other, because the mounting medium may move to the slide above and scratching may occur. Special types of cabinets have been designed to store microscope slides (Fig. 31). These cabinets are constructed on the unit system with the slides being placed flat on their trays which slide into the cabinet. Their capacity ranges from 500 to 2000 slides.

Slides may also be kept in cardboard, plastic, or wood slide boxes of varying slide capacity. The boxes should be stored on end in order to keep the slides flat.

All slides must be protected from dust, light, and dampness.

Selecting specialists. Since the value of an insect collection depends on the accuracy of the identification of the specimens, it is important to select competent authorities to determine the various groups. If a competent specialist is not known, Blackwelder's (1961) "Directory of Zoological Taxonomists of the World" may be of help. After the specialist has been selected an official letter should be written, asking him if he is willing to work with the material. The letter should tell how many specimens are involved, what political reigns they are from, and how many, if any, have been determined by other specialists. Only then, should the specimens be sent to him. The specialist should be allowed to retain a reasonable number of specimens in compensation for his services. Include or send separately, a packing slip or list of specimens, to be returned upon his receipt of the specimens.

Packing insects for shipment. It is very important to take certain precautions in shipping specimens. Pinned specimens should first be pinned firmly and carefully into the bottom of the boxes. If the specimens are heavy the pin should be pushed into the box until it touches the bottom. Some insects have long appendages or long abdomen or swing on the pin. These should be braced by extra pins. Then a sheet of cardboard should be cut to fit the inside of the box. It is placed over the top of the pinned specimens and the space between it and the lid is filled with cotton.

Specimens preserved in liquid containers should be shipped completely filled, so that there is no air bubble. This will prevent rapid shifting of the specimens and consequent damage to the appendages. If the vials are placed in an open box, pins should be inserted in each and at each end to prevent the vial from moving.

Whenever possible, specimens in alcohol should be shipped separately. The vials should be wrapped individually or in small groups with cotton or soft tissue and the entire unit packed in the same material. If any vials break during the transit, the cotton will absorb the liquid.

Insects mounted on microscope slides should be shipped in special shipping boxes for slides. The slides are inserted into the groove of these boxes between two layers of soft material.

Dried specimens may also be shipped in envelopes or pill boxes. Specimens in pill boxes should be placed between layers of cellucotton. In this case they should be padded with cotton.

With any type of shipment, the specimen containers should be packed inside a larger box of wood or heavy cardboard. The inner container should be carefully wrapped to prevent dust from entering. All boxes containing insects should be marked "Fragile". When the material is shipped a letter should be sent to the same address giving information on the shipment.

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APPENDIX

EXPLANATION OF PLATE I

Fig. 1. Killing bottle.

Figs. 2-3. Types of forceps.

Fig. 4. Commercial sieves.

Fig. 5. Mechanical sifter.

Fig. 6. Sweeping net.

PLATE I

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EXPLANATION OF PLATE II

Fig. 7. General view of a black light trap.

Fig. 8. Large suction trap.

Fig. 9. Johnson-Taylor type suction trap.

Fig. 10. Segregating mechanism of Johnson-Taylor type suction trap.

Fig. 11. Wind-vane trap.

PLATE II

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EXPLANATION OF PLATE III

Fig. 12. General view of a malaise trap.

Fig. 13. Collecting assemblage of a malaise trap.

Fig. 14. Berlese funnels.

Fig. 15. Pinning blocks.

Fig. 16. Method of spreading Lepidoptera.

Fig. 17. Inflated Lepidoptera larvae.

PLATE III

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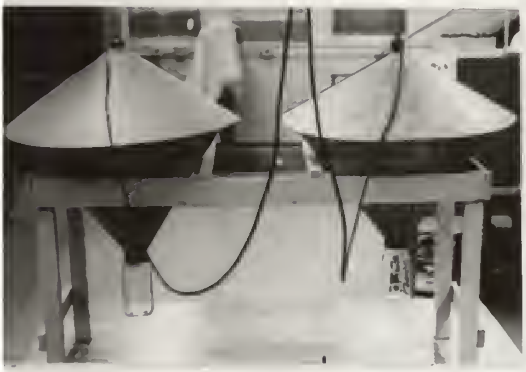

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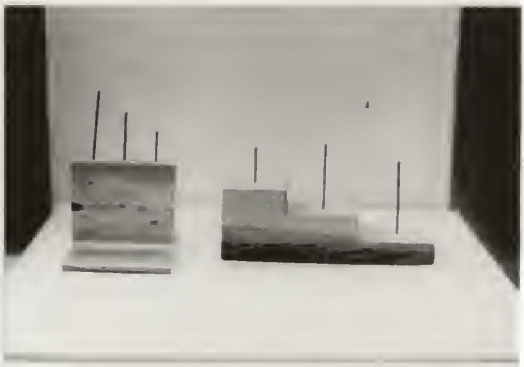

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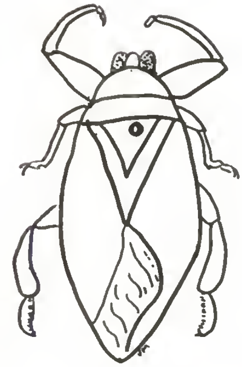
EXPLANATION OF PLATE IV

Figs. 18-26. Various examples of direct pinning.

PLATE IV



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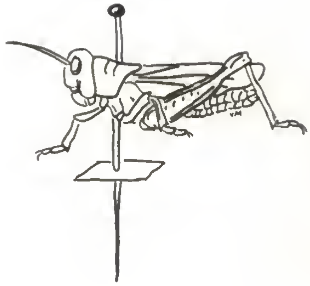

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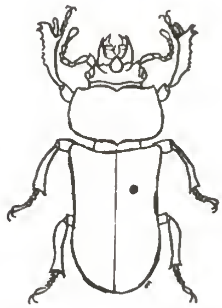

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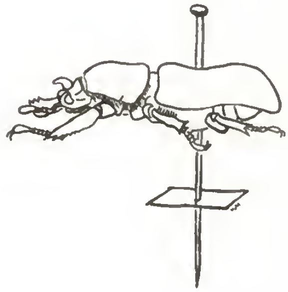

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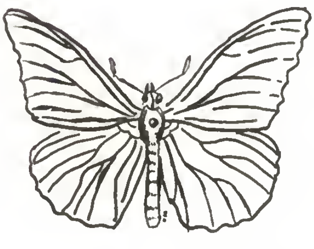

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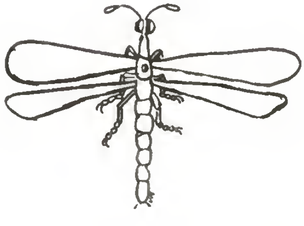

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EXPLANATION OF PLATE V

Fig. 27. A steel cabinet for storage of pinned insects.

Fig. 28. A steel cabinet for storage of liquid collections.

Fig. 29. Cabinet drawer.

Fig. 30. Narrow rack containing vials.

Fig. 31. Cabinet for storage of microscope slides.

PLATE V

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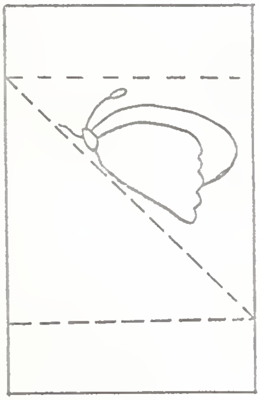
EXPLANATION OF PLATE VI

Figs. 32-37. Method of making triangular paper envelope.

Figs. 38-41. Method of making paper pocket.

PLATE VI



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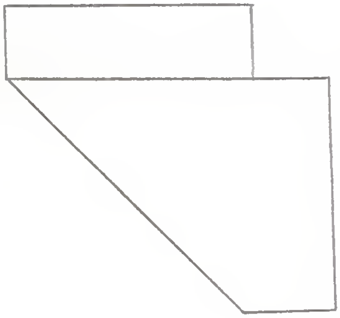

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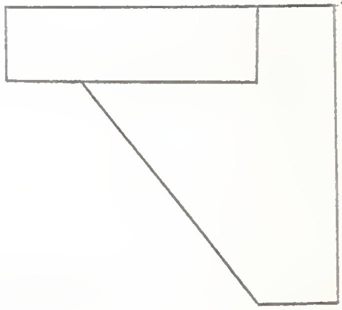

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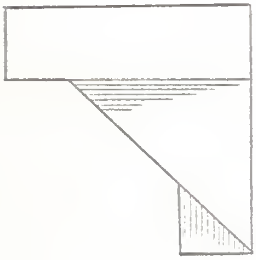

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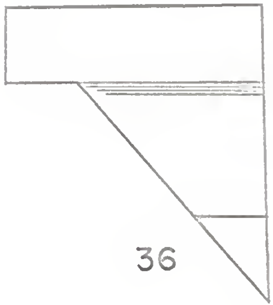

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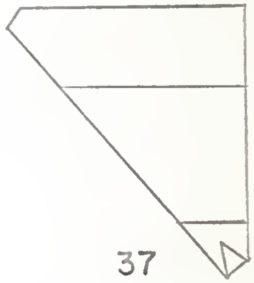

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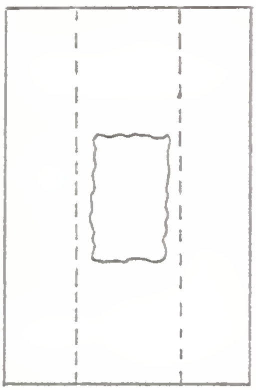

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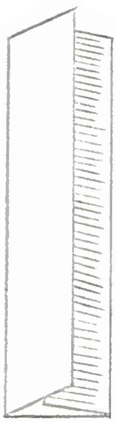

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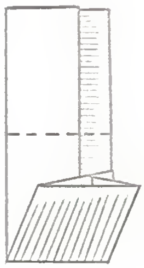

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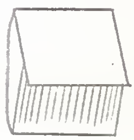

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EXPLANATION OF PLATE VII

Fig. 42. A field-note form.

PLATE VII

Charles L. Hogue — COLLECTING NOTES — No. CLH. 1649.

Locality 2 mi. S. Little Rock Dam (M), San Gabriel Mts. Coords. 118°1'-34°27'
District CALIFORNIA Sub. Los Angeles County Country U.S.A.
Date 15 May 1965 Time 1 P.M. Elevation 3800'
Collected by C. L. Hogue Method net

SITE

TERRESTRIAL: Visiting flowers of Salix sp. growing by small, sluggish stream.

Weather almost clear, hot day (third in a series of three following mild storm).
Temperature 85 deg. F. Humidity 16 rel. % Barometric pressure 29.6 rise ✓ fall
Clouds sparse, high Wind intmt. breezes force 0-10 mph. direction S - SSE
Terrain gravelly, boulder strewn wash slope level % direction

AQUATIC: Small ground pool in a shallow depression beneath edge of a large Baccharis shrub (P)

Size oval, 6' x 2' Flow none - stagnant
Salinity none (by taste) Other solutes not determined
Temperature 73 deg. F. Color clear Surface light bacterial scum
Bottom algae covered granite rocks Shade partial
Vegetation abundant & thick masses of Spirogyra; sparse grass near edge

ANIMAL HOST: wood rat
Species Neotoma fuscipes macrotis det. C. L. Hogue
Age adult Size 388-191-39-32 Sex ♂
Situs base of tail Preserved: yes ✓ no Museum LACM no. 28621.

OTHER

GENERAL ENVIRONMENT

Artificial
Natural Shadscale Scrub (Munz & Keck)

COLLECTIONS

No.	Identification	Remarks
A	Autographa californica	♀ - confined, laid 60 eggs (over)
B	blue megachilid bee	exhibited peculiar feeding behavior *
C	large tachinid	
D	Andrena sp.	
E	Culiseta incidens	2 blooded ♀♀; both confined, #1 laid 30 eggs, #2 " 40 "

<u>Some biological supply houses</u>.

Carolina Biological Supply Company,
Burlington, North Carolina 27216,
Catalog number 36, 1965-1966.

Ward's Natural Science Establishment, Inc.
P. O. Box 1712
Rochester, New York 14603
Catalog number 641, 1965.

Ward's Natural Science Establishment, Inc.
P. O. Box 1712
Rochester, New York 14603
Catalog for biology and The Earth Sciences,
1966-1967.

DEVELOPMENT AND MAINTENANCE OF INSECT COLLECTIONS

by

SUHEYLA GUL

B. S., Ege University, Izmir-Turkey, 1960

AN ABSTRACT OF A MASTER'S REPORT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Entomology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1966

This report attempts to condense and bring together as much as possible of the literature on methods of collecting and preserving insects, and management of insect collections.

The principal collecting methods of general application are discussed, such as the use of nets, light traps, and malaise traps, as well as the use of special techniques or equipment for collecting insects from particular habitats, such as water or debris. Techniques for preserving insects are reviewed, such as direct pinning, mounting on cardboard points or on a microscope slides, or preservation in liquids.

Information is also given on the various facilities required for housing an insect collection and the methods of arranging and caring for the specimens.