AUTHOR

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ACKNOWLEDGMENTS

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CONTENTS

Reared Insects as Projects

To conduct an insect rearing project, you may take two approaches: long-term or short-term rearing studies.

Long-term. Select one or more insect species and try to rear them through several generations. Here are some items that should be pat of your project:

Record notebook. Keep a journal of everything you did, the type of container or cage you used, the type and amount of food you fed the insects and the rearing conditions (temperature, humidity, light, etc.).

Reproduction rate. Count or estimate the number of individuals in your culture at regular intervals (weekly or monthly).

Problems. Describe any problems you encountered, whether solved or unsolved! Report the problems you ran into (like insect diseases, parasites, starvation or accidents) and tell how you handled these situations.

Life cycle. Collect and preserve representative specimens from each life stage to show the complete life cycle of the insect species you studied. Keep notes on the life cycle of your insects and how long it takes them to complete their development at certain temperatures.

Educational displays. Prepare a notebook, picture album, display or slide program so you can share what you learned from your project.

Short-term. Even if you are only able to observe insect cultures (either your own or someone else's) for a short period of time, you can still conduct a study project. Here are some of the items you may want to observe and report on.

Life stages. Which are present? Which are absent? How much time is spent in each stage? How active are the various stages?

Requirements for life. What are they, and what evidence do you see to support your conclusions?

Reproduction. How do the insects mate and reproduce?

Field Observations of Live Insects

You can discover many interesting facts about insect life cycles, behavior and ecology by observing insects in their natural habitat. Your observations could provide insight into some of the many unanswered questions about insects. The following information is intended to stimulate you to conduct your own field observations of living insects. Therefore, only basic information and a few examples are given. The rest is up to you!

KEEPING A FIELD NOTEBOOK

Every good field observer keeps a notebook. This is very important in preserving your observations. You should not rely on memory alone for an accurate accounting of your observations. You must train yourself to write everything down. Some observers write everything down while they are in the field. Others take notes and then write a full account of their observations once they are at their home, office or laboratory. The method you choose will depend on the complexity of the insect activity you are observing and your ability to recall facts. You may be able to use the **4-H Entomology Record and Report** (4-H 1393) to record some of your field observations.

To improve the accuracy of their recorded observations, some entomologists use tape recorders and even computers to record extremely complex, varied or abundant observations in the field. They can then transcribe their recorded observations at a later, more convenient time.

Not all observations are best recorded as words. Some observations are better recorded as photographs. You've no doubt heard the old saying, "A picture is worth a thousand words!" Well, there is a considerable amount of truth to this old saying, because many insect activities are best captured for later study with photographs. You may also be able to use sound recordings to gather information on those insects which "sing" or make other sounds.

No matter how you record your field observations, there are a few essential items you should always include.

Date month, day, year

Location state, county, city and specific location of your observations

Conditions day or night, temperature, weather, host plant or animal, traps or special techniques used, etc.

Observations species being observed, detailed account of your observations of insect activity

Observers list all observers

Date July 28, 1989

Location Crystal Falls, Iron Co., MI; on riverbank below Paint River dam.

Conditions 3:15 p.m., 83 °F, humid, sunny; using aerial net.

Observations Watched Eastern blue darner dragonflies skimming the river, one or two individuals at a time. Caught one male and two females. Some mating activity underway.

Observers Gary Dunn, Rebecca McKee and Susan Seitz

FIELD OBSERVATION PROJECTS

Insect development and life cycles. The following section contains suggestions for field observations on insect development and life cycles. Remember, these are just suggestions to get you started. There are many other projects you could conduct if you just use your imagination.

1. Keep a notebook of your observations on the life cycles of various insect species. What time of year do you see the various insect life stages? Are they more or less abundant than in previous years? What are the effects of natural enemies such as predators, parasites and diseases? What is each species' preferred food source? Do the habits of the adult and immature insects differ?
2. Photograph the life cycle of an insect species. You can also collect and preserve a representative specimen of each life stage and both adult sexes.
3. Construct and set out trap nests for bees and wasps. This technique is used to attract and study the species of solitary bees and wasps which normally nest in hollow twigs and branches.

   Most species have a single generation each year, but some have two or three. Bees stock their nests with pollen mixed with nectar. Wasps, however, use animal prey such as caterpillars, spiders, aphids, crickets and leafhoppers. The female finds the nest, makes the cells and provides food for each cell. She lays one egg on the food and makes a cell partition of mud or leaves. She continues laying eggs and building partitions until the nest is filled. The eggs hatch in 3 or 4 days and the larvae feed on the pollen or the insects until the food is gone. The larvae then spin cocoons and hibernate for the winter. The adults emerge the following season.

   Trap nests (fig. 8) can be made by cutting narrow strips of soft wood (6 inches by ¾ inch by ¾ inch). The long axis of the strip should be oriented with the grain, not across it. Cut a groove into each strip, then seal one end of each groove with wood filler (putty or caulking). Number each nest (using permanent ink), then wrap each one with a piece of clear plastic (cellophane). Put a cover strip in place to darken the nest; these can be held in place with elastic bands. The nests are usually bundled together in groups of 9 or 12. Place bundles of nests horizontally in different parts of a yard, farm, field or woodlot. You can remove the cover and look through the plastic without harming the inhabitants.

   Keep a notebook of your observations, recording information separately for each numbered nest. Inspect the nests frequently and record your observations of the bee or wasp activity. Record the dates for starting and finishing the cells. Check the position, size and shape of the eggs. Check for larvae, parasites and cocoons. After the larvae spin their cocoons, you can put them in an emergence cage and wait for the adults to appear.

Insect behavior. The following section contains suggestions for field observations on

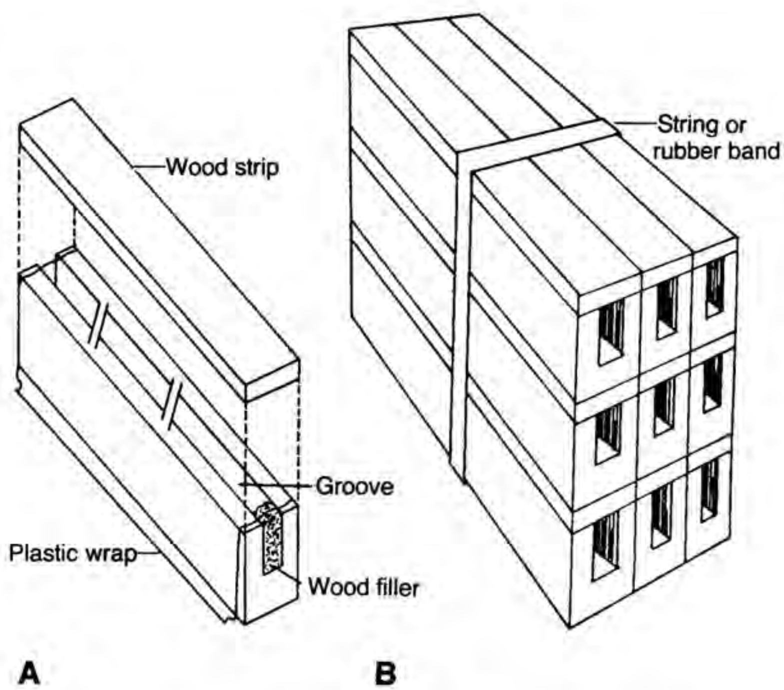


Figure 8. Trap nests for bees and wasps: a) individual trap nest, b) nine trap nests bundled together for placement in the field.

insect behavior. Remember, these are just suggestions to get you started. There are many other projects you could run if you just use your imagination.

1. Keep a notebook of your observations on the behavior and daily activities of various insects species. Here are some examples:
   Aphid colony. Record population increases. How does this effect the number of winged individuals? How do they react to their natural enemies? What is their relationship with various ants and leafhoppers?
   Ant nest. What happens when two ants meet? What type of food are they gathering? Do the workers cooperate when gathering food? Do they use pheromone (odor) trails? Is there any nocturnal activity? Are there different types of nest structures? How many individuals are there in the colony?
   Solitary bees. Can these ground nesting bees find their nests if you change nearby landmarks? How frequent are their foraging trips? What type of food do they gather?
   Bark beetles. What tree species do they attack? Do they attack healthy trees? What do the larval galleries look like? Are the patterns different for each species? Are they vertical or horizontal?
2. Take photographs to illustrate unique insect activity or behavior.
3. Record insect songs and other sounds. Capture specimens for matching a species to each song.
4. Use an ultraviolet (UV) blacklight to observe the behavior of nocturnal insects. What groups of insects are attracted to the light? What happens if you place the trap at different heights? What happens if you run the light at different times of the night (10 p.m. to midnight versus 3 to 5 a.m.)? Is the catch different in numbers and species in different months? How many pest versus nonpest species are attracted to the light?
5. Participate in a study of monarch butterfly migration. Contact the Xerces Society, 10 SW Ash Street, Portland, OR 97204, or the Lyman Research Lab, MacDonald College, McGill University, Ste. Anne de Bellevue, Quebec, H9G 3M1, Canada, for information on how you can get involved.
6. Set out various kinds of bait (such as sugaring bait, rotten fruit, spoiled meat or cheese) and observe what insects are attracted to it. Which insects arrive first? How soon after the bait is set out do they arrive? What insects arrive second, third, etc.? What time of day are the various insects active?
7. Obtain different insect pheromones (insect odors and sex attractants) from a garden shop or pesticide distributor and use them to observe insect behavior. How specific is the attraction? What are the effects of wind, temperature and humidity on the attraction? Can you make a population estimate from a pheromone trap?
8. Observe insect activity at a flowering shrub or in a flower garden. What insect species are attracted to the flowers? What time of the day or night do they come? Which species of insect is most abundant? Do marked individuals revisit the same flowers? What types of predators or parasites are present? Do all the flowers on the same plant get equal attention? Which plants are most attractive to the insects? (Hint: You can use this information to plan a butterfly garden!)
9. Observe the mating behavior of lightning bugs (fireflies). Can you determine the specific flash pattern for each species? Do the males and females of the same species use the same flash pattern? What are the effects of weather on this behavior? What time does the flashing begin? Does each species fly at the same height? Are there any lightning bugs that mimic other species' flash patterns? If so, why?

Insect populations and communities. The following section contains suggestions for field observations on insect populations and communities. Remember, these are just suggestions to get you started. There are many other projects you could undertake if you just use your imagination.

1. Estimate insect populations using a mark and recapture technique. Capture a representative sample of a selected insect species (preferably with some type of trap) over a measured amount of time. Mark the captured individuals with nail polish or enamel model paint, and release them back into the sample area. Repeat the capture process

over the same time period as before. Count the number of marked and unmarked individuals and use this information in the following formula (known as the Lincoln Index).

P = A × N ÷ R

P is the total population.

A is the number of marked individuals released from the first trapping period.

N is the total number of recaptured individuals.

R is the number of marked individuals recaptured.

2. Observe aquatic insect populations. You may want to make a simple waterscope to observe insect activity beneath the surface. Remove the top and bottom of a large waxed cardboard carton (a half-gallon milk carton will do). Stretch a piece of cellophane wrap across one end and hold it in place with elastic bands. To use your waterscope, put the cellophane end (the "lens") into the water and look through the scope.
3. Attract corn borers for study. Plant sweet corn early in the season, so that the corn plants are 24 inches tall in late June. Plant a second sweet corn crop so that it is about 24 inches tall by August 1. You should have no problem attracting significant numbers of corn borers to your unprotected corn. If you plant corn on the same land for several years on the same schedule, you should have an abundance of borers for study or harvesting. Don't plow the land (corn borers overwinter in corn stubble and soil), and don't collect all of the corn borers from any one crop. Corn borers also make good fish bait.
4. Observe nocturnal insects. Create an insect terrarium stocked with live insects collected at lights, from pitfall traps or by hand. Use an assortment of species, including both predators and plant feeders. To watch the insects without disturbing their night behavior or activity, illuminate the terrarium with red light (a flashlight covered with red acetate will do nicely). Record your observations.
5. Observe insect locomotion. How do insects move? How do they use their wings, legs and/or bodies to get from one place to another?
6. Observe insect distributions. What is the distribution pattern for selected species? Does the pattern bear any relationship to the habitat limitations? Is there evidence of a dispersal stage? What is the means of dispersal?

Experimenting With Live Insects

You can discover many interesting facts about insect life cycles, behavior and ecology by experimenting with live insects under carefully regulated artificial conditions. Your experiments could provide insight into some of the unanswered questions about insects.

The following information is intended to encourage you to conduct your own experiments with living insects, so only a little bit of background information and a few examples are given to get you started. The rest is up to you!

THE SCIENTIFIC METHOD

Science can be described as a methodical approach to seeking answers to questions about the world. The way people ask and answer these questions is called the scientific method. The purpose of the scientific method is to distinguish facts (things which can be proven) from beliefs (things which are only ideas or opinions, and may or may not be true). Complete honesty in the search for facts is an essential foundation for scientific investigation.

The scientific method uses five basic steps.

1. Clearly define your objectives. What is the specific question or problem you wish to address?
2. Collect preliminary information. What facts are already known about your question or problem? Ideas or opinions which are not necessarily established facts that you have gathered from other people may be helpful.
3. Form a hypothesis. This is your "best guess" about the outcome of your experiment.
4. Test your answer with a carefully designed experiment. Does the experiment reveal that your answer works under all conditions?
5. Revise the hypothesis and test again. If your hypothesis is still valid after repeated experimentation you may now consider it a scientific theory. When a theory is fully tested and proven through additional experimentation, it may then be raised to the rank of scientific law—the ultimate in scientific fact!

Conducting a scientific experiment requires good managerial skills. This means you must be able to make and carry out decisions in a manner that allows you to accomplish your objectives as quickly and accurately as possible. Set your goals and then conduct your work in an organized, thorough manner. Learn to be a keen observer. As you gain experience in conducting experiments your skills will improve.

Many scientific studies show that certain events happen as a result of something that occurred earlier. This idea is referred to as "cause and effect." In scientific studies, observations (data) may be collected on factors that lead to a certain result. These data can be used to predict quite accurately the results that might be expected in a future situation. For example, a farmer may be able to estimate rather closely the number of bushels of corn a certain field will produce using information (data) obtained previously on soil type, fertility, drainage, pests, weather and corn variety.

Sometimes coincidences occur which seem to be easily linked by a cause and effect relationship. You must be careful not to make assumptions which may not be true. Experimentation must be used to determine if a true cause and effect relationship actually exists. For example, you may go collecting insects along a stream and collect two specimens—a 10-spotted dragonfly and a monarch butterfly. Is it correct to assume that there is a cause and effect relationship between the stream and the appearance of these insect species there?

If you make such an assumption, you would predict that the best place to collect these two species is near streams. A study of the habits of these insects would show that only the dragonfly is attracted to water, and that the monarch must have been attracted to the area for some other reason. Additional observation is necessary to determine the true cause and effect relationship in the monarch's appearance at the stream, if there is any. It could be due to chance, the presence of the proper host plant, the weather or some other reason.

Using the scientific method. When you select an experimental project, be sure the topic really interests you. Would you really like to explore it in detail? Unless you're really interested in throughly exploring a particular topic, it is unlikely that you'll carry the project through to its conclusion. Do not, however, abandon an idea without seriously considering the possibilities and doing some initial research on the topic. Often as you learn more about the project, it becomes more appealing.

Try to think all the way through your project before you actually begin work. Consider the equipment and materials you will need. Will you be able to get everything you need? If not, are there any substitutes you can use? Although there will probably be some unexpected problems, try to anticipate as many of them as possible and decide how you could handle them. Plan carefully and keep in mind the time factor. Will you have time to complete the project and prepare your results before any deadline you have?

After you have selected your project, follow the scientific method. State your objectives clearly and concisely. Gather facts and background information on your project. Formulate your hypothesis. Gather data; be sure it is reliable and that you have adequate controls. If you have any doubts, see if you can duplicate your data in additional runs of your experiment (this is called replication). Keep a notebook that contains each procedure and the results. If possible, take pictures of the experiments as they progress.

The final step is to prepare a report on your experiment to share with other entomologists. If you took good notes as your experiment progressed, your job will be greatly simplified. Your data can be presented with words, tables, graphs, illustrations or photographs. Your report should be so complete that anyone reading it would be able to follow your directions and duplicate your results. You may want to consider publishing the results of your experiment in an entomological journal for others to read. One journal that specializes in publishing investigations by young entomologists is the **Y.E.S. Quarterly** of the Young Entomologists' Society (see "References," page 35).

You may want to inform other entomologists about your experiments in other ways, too. You could give an oral presentation or prepare an exhibit showing the highlights of your experimental design and your results. Such presentations and exhibits will be greatly enhanced by any photographs, scientific illustrations or other visuals you have.

SCIENTIFIC ILLUSTRATION

Illustrating your entomology reports, displays and posters yourself can be a very satisfying way to clarify important points and to add visually interesting details to your work. Doing your own illustrations can heighten your awareness of detail and improve your powers of observation of the natural world. This section could help you begin your career as an amateur, or even professional, scientific illustrator.

Materials. The equipment necessary to make pencil drawings is simple and inexpensive. You can purchase everything you need fairly inexpensively at a local stationary or art supply store.

Pencils are rated in degrees of hardness. The most common art pencils, and the ones you will probably use the most, range in hardness from 5B (very soft) to HB (medium) to 5H (very hard). There are several varieties of art erasers on the market. A standard "Artgum," or plastic or kneaded rubber erasers will handle most of your erasing needs. Try a variety of eraser types to determine which you like best.

Erasing will be less frustrating if you avoid using a common pink pen or pencil eraser, or one that comes on the end of a pencil. These erasers contain too much grit and will tear up the surface of your drawing paper.

For your rough sketches and preliminary drawings, you can use inexpensive sketching paper or typing paper. Graph paper is helpful for doing measured, scale drawings. For your final drawings, use a high quality 100 percent rag paper that is acid-free. This paper is a bit more expensive because it is "archival quality" and will preserve your drawings for years. Make sure the surface of the paper you use for your final drawings has a fine texture and is not perfectly smooth.

Other helpful items for your equipment list are dividers, straight edges (such as rulers, triangles, T-squares, etc.), french curves and correction fluid.

Drawing. Choose your first subjects carefully. Begin with large insects, either larvae or adults. The larvae of the Cecropia moth (or any other silkmoth species) or the tomato hornworm make excellent subjects. Grasshoppers, walkingsticks, moths, butterflies, cockroaches, scarab beetles, stink bugs and many other large insects are also good starting material. Stay away from subjects with complex structures or those that are highly colored or textured, they will be too frustrating for your first efforts.

You'll probably want to use preserved specimens for your first efforts in order to avoid the frustrations of dealing with live insects. If you are using specimens that have been preserved in alcohol, remember that they have probably shrunk and changed color. For that reason you may want to refer to photographs or live specimens as you work. This section will describe how to draw a monarch butterfly *(Danaus plexippus)* that is 3 inches wide and 2½ inches long.

Pose live caterpillars on twigs for observation. Adult insects should be killed and then positioned on lumps of modeling clay. The insect's claws can be pressed into the surface of the clay to hold the legs away from the body. The wings of butterflies and moths should be spread.

Select a clean sheet of paper and pin or tape it to a wooden drawing board or other smooth surface. For starters, lightly draw a 6-inch by 6-inch square in the center of your paper with a 3H pencil. These lines represent the extreme limits of the image you are drawing. Draw a vertical line through the center of the square. If you are drawing a butterfly or some other bilaterally symmetrical insect, the insect's body region should lie on this line (fig. 9c).

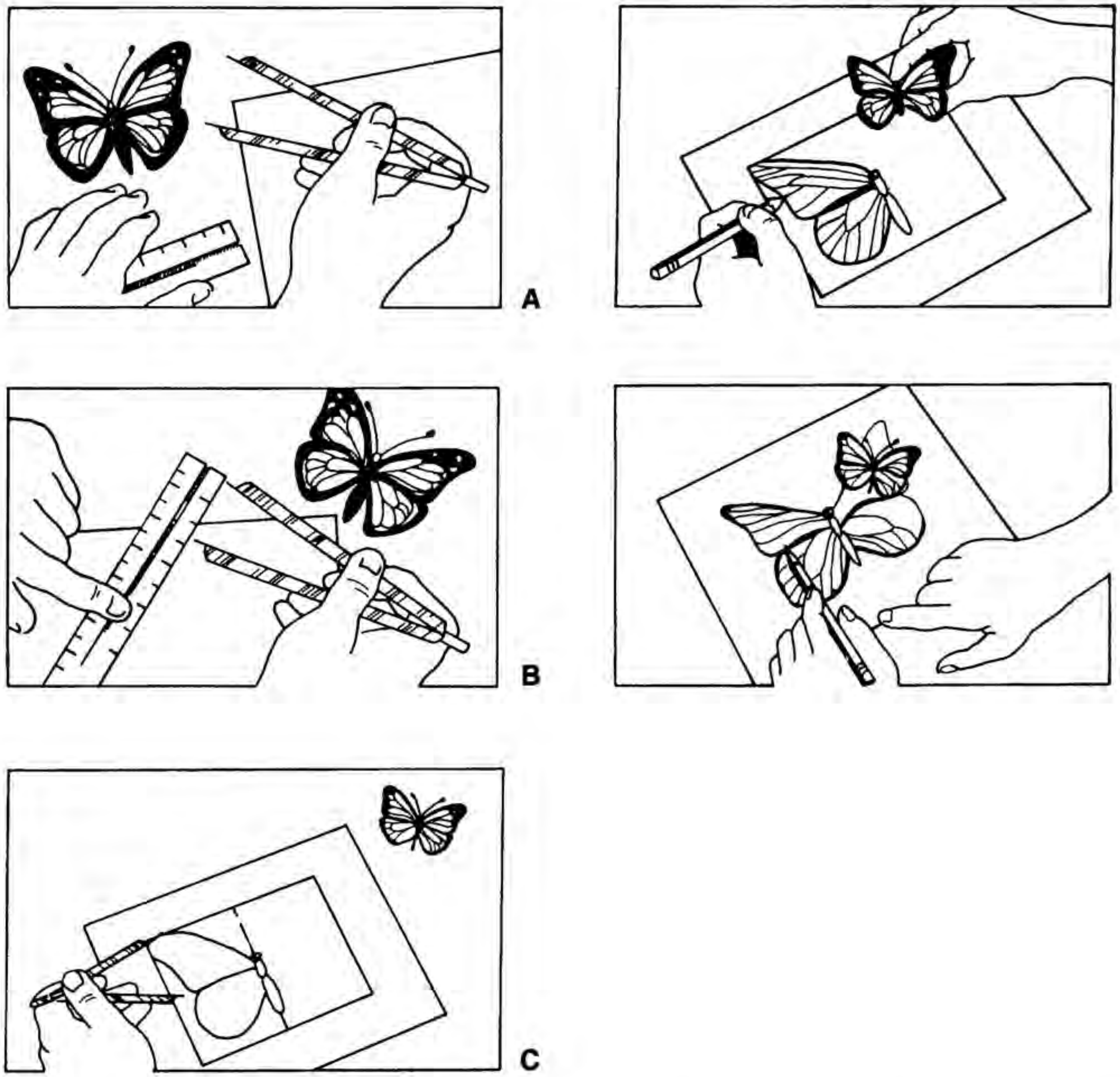
Your illustration probably won't be the same size as the insect you are observing. A life-size drawing of most insects would be too small to allow you to include much detail. Therefore your drawing should be proportionally larger than the subject. You may decide to make your drawing of that 3-inch wide by 2½-inch long butterfly twice the insect's normal size. That means the image will end up being 6 inches long by 5 inches wide. Indicate the proportional increase (2X) in the upper right-hand corner of your drawing. Some insects, such as the Cecropia moth, may be large enough that enlargement is not necessary. If so, indicate this by writing "actual size" in the upper right-hand corner. After you decide on the proportion of your drawing, all measurements must be adjusted to the same scale by multiplying by two, three, four or whatever proportion you are using.

Now that you have decided on the size of your drawing and laid out the pencil square, you can begin transferring the butterfly's image to the paper. Use a pair of dividers to find the distance between the front of the head and the tip of the abdomen; indicate these points on the central line of your paper (remember to double the figures). Next indicate the point at which the thorax and abdomen join. Do the same for the head and thorax. Now use a 3H pencil to lightly draw in the body region. Use the dividers to find the butterfly's wing size (fig. 9a), transfer the dividers to your ruler to find the actual size (fig. 9b), then double that figure on the drawing (fig. 9c). This "point of reference" technique helps you outline your drawing. By using body divisions, wing demarcations, etc., you should be able to make an outline of the insect.

Once the rough outline is completed, you can begin the final outline work. Bring the specimen close to your paper so you can clearly see the fine points you are adding. Add the outline and wing variations of your butterfly with a 2H pencil (fig. 9d).

After you have done the basic anatomy, indicate the color pattern. You can create a series of tones with your pencils to represent the butterfly's colors. The soft 4B pencil is good for dark colors; other pencil grades can indicate other shades. Use the side of your pencil point to begin to lay in the dark color pattern of the wing (fig. 9e). Continue to build up the detail of the colors.

After your drawing is completed (fig. 10, page 32), you can erase the points of reference and other pencil lines used to help indicate the butterfly's size. Make sure any smudges have been removed or covered with correction fluid.



A B C D E

Figure 9. Drawing a monarch butterfly *(Danaus plexippus):* a) using dividers to measure wing size of specimen, b) transferring measurement to ruler to determine size, c) using points of reference to lay out a rough outline, d) addition of detail (note that the specimen is nearby for referrals on fine points), e) applying color tones with a soft pencil.

Matting the drawing. You are now ready to mat your finished illustration of the monarch butterfly. Matting creates air space between the artwork and the glass of the frame to prevent water spotting from condensation, mold growth, etc. Matting also makes your work look more "finished" and professional. A list of suggested materials you will need to mat your illustration follow.

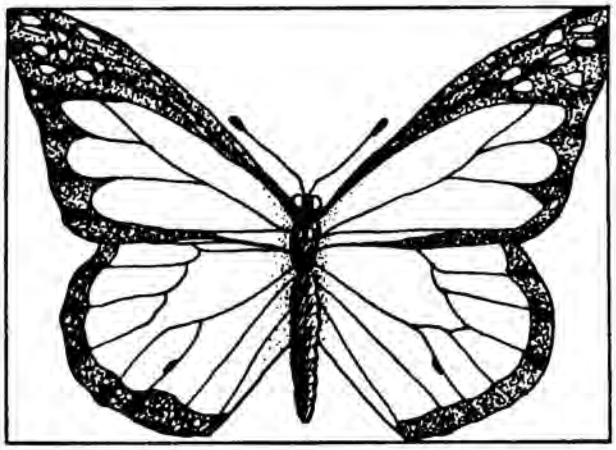


Figure 10. Final drawing of the monarch butterfly *(Danaus plexippus)*.

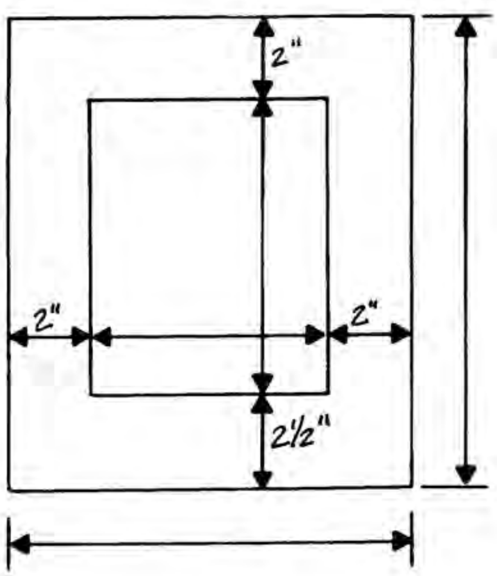


Figure 11. Measuring and cutting mats.

- Mat board
- Backing board
- Pencil and kneaded eraser
- Glue stick, library paste or homemade starch paste
- 10 percent rag or rice paper
- Linen or book tape
- Scrap board to cut on

You will also need the following tools:

- Mat cutter (Dexter, X-Acto or other brand)
- Metal-edge ruler, T-square
- Scissors

Measure the image area of your drawing to determine the size of the mat "window." Use two L-shaped pieces of cardboard to help you decide on the window size. Next decide on the width of the mat border. A typical mat width is 2½ inches on the top and sides, and 3 inches on the bottom. This can vary depending on the size of the artwork and your personal preference.

Calculate the outside measurements of the mat. It's best to make the measurements in even inches because most readymade frames are in even inches. Make a diagram of your mat showing all the measurements you have decided on. Transfer the measurements to the back of the mat board with a soft pencil (HB or 2B) (fig. 11, page 32).

Cut the mat window using an X-Acto knife, utility knife, Dexter mat cutter or other mat cutting tool. Make sure the cuts run exactly over your pencil marks. Cut just slightly past the corners of the mat window. Marking and cutting from the back side of the board prevents dirt and marks from getting on the good side. After you cut the window, cut the outside dimensions of the mat.

Cut another backing board the same size as the outside edge of the first board. (A backing board such as Fome-cor works well because it is light and relatively acid free.) Arrange the drawing on the backing so that it is straight when the mat board is laid over it.

Attach the drawing to the backing using linen tape hinges or other framer's acid-free tape, or use 100 percent rag paper hinges with starch paste (fig. 12). Tape in only a few spots along the top of the artwork, using 1- to 2-inch pieces of tape. Hinge the mat to the backing board either on the side or on the top. Your illustration is now ready for framing.

Helpful Hints

1. A pencil sharpener makes an excellent point for most drawing needs; however, to make fine lines, use a piece of sandpaper to create a sharp point. Be careful though, because if you press too hard with a very sharp pencil you may cut the paper. Sandpaper may be used to flatten a pencil lead for shading.
2. Small french curves are good for making smooth, curving lines. Practicing with these curves will make drawing much easier.
3. Your imaginary light source should come from the upper left-hand corner of the drawing paper when you are shading a three-dimensional scientific drawing, such as a dorsal (top) view of a grasshopper. This means that your highlights are in the upper left of the drawing and the shadows in the lower right. You can practice shadow techniques by outlining the subject, then constructing a cross section of the area to be shaded. With a cutaway section you can see where the light falls and where the shadows begin and end (fig. 13).
4. Practice using different grades of pencils to create a full range of tones (variations in shades of black) in your drawings. For dark colors or shades, use a 3B pencil; for light tones use a 2H pencil. Each degree of hardness will produce a different tone.
5. Don't try to put a soft pencil shading (such as a 3B) over a hard pencil shading (like 3H) to make it darker. The hard pencil produces a smooth surface and the soft pencil won't have much of an effect.
6. Make all outlines in light pencil first, then go over them again to make them darker if you have to.
7. You can create a uniform tone in a portion of your drawing by smudging your soft pencil (3B) shading. Use a piece of tissue paper over your finger tip or a smudging stick (available from art supply stores) to smear or smudge the soft pencil. Lay another sheet of paper over any portions of the paper you want to mask from being smudged.
8. Observe other people's work whenever possible. Use your public library to find books on insects, zoology, biological sciences and nature study. Such books contain drawings you can learn a great deal from.

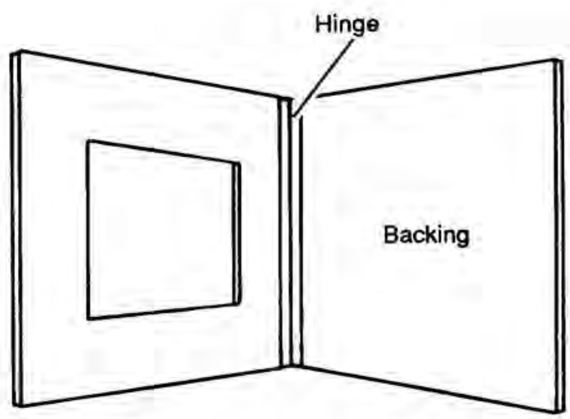


Figure 12. Hinging the mat to the backing.

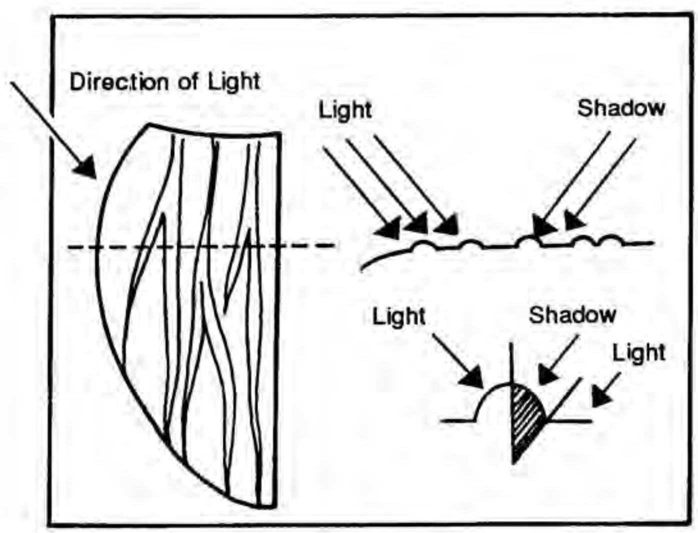


Figure 13. A method for determining shadow effects by constructing a cross section of the subject.

ENTOMOLOGY EXPERIMENTS

The following section contains suggestions for entomological experiments in insect development and behavior. Remember, these are just suggestions to get you started. There are many other experiments you could conduct; just use your imagination.

Insect Development

1. Determine the effects of temperature, relative humidity, food quality or quantity on the growth and development of various insect species. How quickly do the insects grow under each condition? Prepare a chart of growth rates (size or weight) under various conditions.
2. Determine the strength of an insect. How far can an insect jump? You can make an insect jumping arena by drawing a series of concentric circles (at measured distances) around a center point. Place an insect on the center point and record the distance of each jump. Compute the minimum, maximum and average jump for each individual of a species. Compare different species. How much weight can an insect lift? Prepare a weight lifting table (fig. 14, page 34). Test different insects (individuals and species) by adding weights to the container at the end of the string (and don't forget to add in the weight of the container). Does the table's surface affect the insects' ability to pull ("lift") the weight? Compute the average and maximum weight lifting ability for each species.

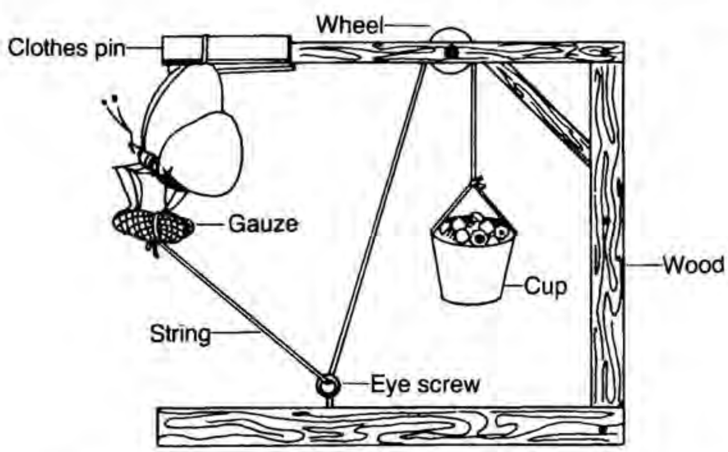


Figure 14. Weight lifting apparatus for testing the strength of insects.

Insect Behavior

1. Determine the effect of ultraviolet blacklight on the behavior of nocturnal insects. What is the relationship between insect activity at the blacklight and the temperature, the relative humidity or different intensities of moonlight? What happens if you run the light at different intensities? What happens if you change the color of the light?
2. Experiment with the trail making abilities of ants. What changes in ant behavior take place if you move their pheromone (odor) trail? (Hint: Allow ants to lay down a pheromone trail across a small piece of paper in a larger test chamber. Rotate the paper to break the trail and then make your observations.)

References

BOOKS

A few of these books are no longer in print. This means you will not be able to go to a local bookstore and order them. However, all these books are available at larger public libraries, so the information they contain is still accessible.

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PERIODICALS

Amateur Entomologists Society Bulletin. A.E.S. Registrar, 355 Hounslow Road, Hanworth, Feltham, Middlesex, TW13 5JH, England.

Y.E.S. Quarterly. Young Entomologists' Society, Department of Entomology, Michigan State University, East Lansing, MI 48824-1115.

APPENDIX A—COMPANIES THAT BUY LIVE ARTHROPODS

Carolina Biological Supply Co.
2700 York Rd.
Burlington, NC 27215

Sigma Chemical Co.
P.O. Box 14508
St. Louis, MO 63178
—fireflies only

Wards Natural Science Establishment, Inc.
P.O. Box 92912
Rochester, NY 14692-9012

APPENDIX B—CLASSIFICATION OF COMMONLY REARED ARTHROPODS

Common Name	Order	Family	Scientific Name
Large milkweed bug	Hemiptera	Lygaeidae	*Oncopeltus fasciatus*
Confused flour beetle	Coleoptera	Tenebrionidae	*Tribolium confusum*
Yellow mealworm	Coleoptera	Tenebrionidae	*Tenebrio molitor*
House cricket	Orthoptera	Gryllidae	*Acheta domestica*
House fly	Diptera	Muscidae	*Musca domestica*
Giant cockroach	Orthoptera	Blaberidae	*Blaberus gigantae* *Blaberus craniifer*
Greater wax moth	Lepidoptera	Pyralidae	*Galleria mellonella*
Tarantulas (USA)	Araneae	Theraphosidae	*Dugesiella* spp. *Aphonopelma* spp.
Chinese mantid	Orthoptera	Mantidae	*Tenodera aridifolia*

APPENDIX C—SOURCES OF LIVE ARTHROPODS

Orthoptera

American cockroach .... American, Carolina, Wards
Blaberus cockroach .... American, Carolina
German cockroach .... American, Carolina
Chinese mantid............... American, Wards
House crickets .... Carolina, Armstrong's, Wards
Grasshopper .... Carolina

Dermaptera

Earwigs .... Carolina

Isoptera

Subterranean termite .... Carolina, Wards

Hemiptera

Large milkweed bug .... Carolina, Wards

Lepidoptera

Miscellaneous butterflies	Carolina, Wards
Painted lady butterfly	Carolina, Insect Lore
Greater wax moth	Carolina
Silkworm	Carolina, Insect Lore

Coleoptera

Dermestid beetle	American, Carolina, Wards
Mealworm	Carolina, Lemberger, Rainbow, Wards
Ladybird beetles	Carolina, Natural Pest Controls
Bessbugs (passalids)	Carolina
Confused flour beetles	Carolina

Diptera

House fly	American
Blow flies	Wards
Mosquitoes	American
Drosophila fruit flies	Carolina, Wards

Hymenoptera

Ants	Carolina, Wards
Parasitic wasps..............	Carolina, Natural Pest Controls

Other arthropods

Tarantula	Carolina

Addresses for Firms Listed Above

American Biological Supply Co.
1330 Dillon Heights Ave.
Baltimore, MD 21228

Armstrong's Cricket Farm
P.O. Box 125
West Monroe, LA 71294-0125

Carolina Biological Supply Co.
2700 York Rd.
Burlington, NC 27215

Insect Lore Products
P.O. Box 1435
Shafter, CA 93263

William Lemberger Co.
P.O. Box 2482
Oshkosh, WI 54903

Natural Pest Controls
8864 Little Creek Dr.
Orangevale, CA 95662

Rainbow Mealworms
126 East Spruce St.
Compton, CA 90220

Wards Natural Science Establishment, Inc.
P.O. Box 92912
Rochester, NY 14692-9012

APPENDIX D—SOURCES OF REARING SUPPLIES AND EQUIPMENT

Albany International
P.O. Box 537
Buckeye, AZ 85326
—pheromones

American Biological Supply Co.
1330 Dillon Heights Ave.
Baltimore, MD 21228
—cages

BioQuip Products Inc.
P.O. Box 61
Santa Monica, CA 90406
—cages

BioServ, Inc.
P.O. Box 450
Frenchtown, NJ 08825
—artificial diets and rearing containers

Carolina Biological Supply Co.
2700 York Rd.
Burlington, NC 27215
—cages, containers and artificial diets

Wards Natural Science Establishment, Inc.
P.O. Box 92912
Rochester, NY 14692-9012
—cages, containers and artificial diets

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