# NOTES ON THE LIFE HISTORIES AND REARING AND HOLDING TECHNICS OF CERTAIN LIVE BAITS

By

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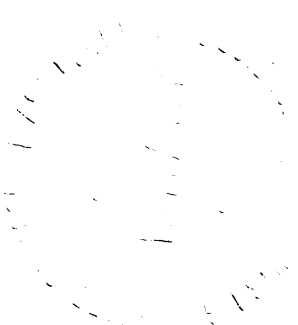

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# INTRODUCTION

With the exception of the war years there has been a steady increase in the number of fishermen that flock to the streams and lakes of Michigan. As a result there has been a greater demand for bait. In former years it was possible for bait dealers and fishermen to supply their needs from natural sources, but the increased number of fishermen coupled with modern agricultural and industrial practices has placed certain baits at a premium and rendered older methods of supplying bait inadequate. More efficient insecticides, crop rotation, and delayed planting practices have done much to reduce the supply of terrestrial insect baits while pollution has had the same effect on aquatic forms.

The bait industry of today has become one of enormous size and complexity. Lauff (1950) found that in Michigan alone there were over 2000 licensed live bait dealers and that the total gross sales of the industry was 3.8 million dollars, about half of which was derived from the sale of baits other than minnows. Lauff found that over 95 per cent of the wholesale dealers and 70 per cent of the retail dealers utilized natural live bait resources. With such a demand being placed

on natural bait supplies it is easy to see that an even greater increase in the number of fishermen in future years may cause more problems to arise in the bait industry.

As a result of this increasing shortage of natural baits a great deal of work has been done in an attempt to find more efficient methods of collecting and holding live baits and to make better use of those organisms already supplied by nature. In many cases artificial means of propagation have been worked out that give promise to an inexaustable and constant supply of certain species. The results of this work; however, are widely scattered throughout the literature and it is the purpose of this paper to bring together that literature dealing with problems related to the bait industry, adding to it some original data concerned with holding technics. To thoroughly understand problems involved in supplying bait, a knowledge of the natural history of the group or species is necessary and an account has been included for each bait considered. Some of the baits discussed have only recently appeared on the market and little is known about the technics involved in their propagation; in such cases what is known has been presented. The quality of each bait as far as its attractiveness to fish is concerned has been mentioned, however, this information is

based on the opinions of fishermen and bait dealers familiar with the bait and is not derived from scientific investigation.

## EARTHWORMS

Life History - Earthworms are primarily nocturnal animals living in good soils, rich in humus and moisture; they are usually scarce in poor, acid, sandy soils. Storer (1943) states that the burrows of earthworms are nearly vertical at the top but wind about in the soil to depths as much as six to eight feet. In soft soil, worms burrow by using their narrow anterior end as a wedge, forcing the soil outward by swelling the pharynx region. In heavier soil the worm moves about by actually eating its way. The soil is taken in through the mouth, passes through the alimentary canal, and is then deposited as feces or "castings". Burrows may be lined in their upper parts with slime, castings, leaves, or fine pebbles to produce a smooth interior. During the winter or periods of drought, earthworms go deep within the soil where they remain inactive until more favorable conditions present themselves. When the soil is moist and temperatures moderate, they come to the upper soil layers, where, according to Olson (1928), they lie in their tunnels with the

anterior end near the surface. At night they push out the plug of leafy material blocking the burrow and crawl to the surface. A small portion of the posterior end is left in the ground to aid in hasty retreats or to serve as an anchor while the anterior end is pulling up plants. The food of earthworms consists chiefly of organic matter in the soil, leaves and small plants. Fresh meat is eaten but never putrid meats. Prior to ingestion salivary fluid is poured on the food to soften and partially digest it. The soft parts are then injested leaving the veins of the leaf like fine lace. Frequently leaves are taken into the burrow to line the enlarged chamber at the bottom.

Olson (1928) found that in Ohio the most active part of the breeding season was from June to October but that some breeding took place even later in damp shady places and at considerable depth. Though each worm is a male-female (hermophrodite), containing both eggs and spermatozoa, they are not self-fertilizing, but mutually fertilize each others eggs. Olson describes the copulation of worms as follows:

> "The two worms meet and overlap one another for about one-third to one-fourth of their lengths, with the heads facing opposite directions and the ventral sides in contact. They then secrete quantities of viscous mucous,

> which forms a thick band about the clitellar regions of their bodies. These mucous bands surround both bodies and serve to bind the copulating individuals tightly together. Each worm acts as a male, giving off a quantity of seminal fluid that is conducted along the grooves to the seminal recepticals of the other where it is picked up and stored."

Upon separation, the slime tube of each worm closes about the body and is worked forward. As it passes the fourteenth segment it picks up a few eggs and continues to the ninth and tenth segment where spermatozoa is added from the seminal receptical. The ring is then slipped off the anterior end, closing up as it does so. This closed slime ring with its eggs and spermatozoa is known as the capsule. Size, shape, and color of capsules vary. Those of Eisenia caliginosus trapezoides are oval with pointed ends and a yellowish color. Only one egg, rarely two or three of the eight originals develops into an embryo in this species. Lumbricus terrestris has lemon-shaped capsules, olive in color, and four to twenty eggs, all of which hatch. Storer (1948) states that Eisenia foetida has 1 to 28 eggs of which 10 to 12 develop. He states that the young worms hatch in two to three weeks. According to Shepherd (1953), earthworms produce a capsule of 2 to 20 eggs every seven days or so, which, after hatching, require 60 to 90 days to mature.

As regards the regeneration of lost somites, Storer (1948) says:

> "The adult earthworm has some ability to regenerate somites removed at the ends of the body by accident or experiment. At the anterior end no more than 4 will form, and no 'head' will form if 15 or more are cut off; regeneration at the anal end often follows loss of somites there. Experiments in grafting have produced worms with two tail ends, short worms from two terminal portions, or extra-long worms by joining parts of three worms."

Earthworms have certain external characteristics, described by Storer (1948), that deserve attention. Their bodies are composed of 100 - 180 ring-like segments or somites separated by transverse grooves. Each somite with the exception of the first three and the last one, has four pairs of minute bristles or setae on the ventral and lateral surfaces. Setae can be moved in any direction and extended or withdrawn at will. They serve as hold-fast organs when the worm is moving in its burrow or over the ground. The clitellum or pack saddle, located over somites XXXI - XXXVII (in Lumbricus terrestris), is a glandular swelling which secretes the slime for cocoons. The entire body is covered with a thin moist cuticle through which oxygen is taken and carbon dioxide is expelled.

The genus Eisenia (Helodrilus) which includes the common earthworm and manure worm may be identified by the following

characteristics, according to Eddy and Hodson (1950): prostomium incompletely divides peristomium and anterior edge of clitellum is before segment 30. Lumbricus terrestris commonly known as night crawler, crawler, dewworm, and night walker has the clitellum included in segments 31 or 32 to 37 and the prostomium completely dividing the peristomium.

Rearing - Large quantities of earthworms can be raised in wash tubs, metal drums, fruit lugs, and other such containers. Metal containers should be painted with asphalt, acid proof paint, or a good house paint to prevent rust (Swingle and Sturkie, 1948). Wooden boxes should be of a rot resistant wood and have the bottom covered with two or three layers of burlap. Any of the soils used, according to Swingle and Sturkie, should be free of sand since the sharp grains are injurious to the digestive tracts of worms. Loam, clay loam, or porous clay may be used. Leaves, grass, moss, manure, or rotten straw should be mixed with the soil (one fourth its volume) to increase the organic content. Enough moisture is added to allow clumping when a handful of soil is squeezed. Swingle and Sturkie found that if the soil was too dry, the worms went to the bottom of the rearing bed; and if it was too wet they came to the surface. Moisture

should be regulated in such a manner that the worms will be found in the upper three to five inches of soil. A cover of burlap or boards will help retain the moisture.

Several types of food may be used. Swingle and Sturkie (1948) had their best results with a mixture of one half pound of vegetable shortening or lard to one pound of corn meal. This was mixed together and added to the upper two or three inches of soil. That quantity is enough for the first month in a tub two feet in diameter with eight inches of soil. After the first month, one-half pound of lard to one pound of corn meal should be added every two weeks. Using this food, worms of bait size may be produced for about five cents per hundred. Swingle and Sturkie (1948) state that contrary to popular opinion coffee grounds have no value. Foods used with success by Shepard (1953) are: chicken mash, rabbit food in pellet form, nut meal, grass cuttings, and garbage. These were added to the top of the worm bed as soon as the previous supply had been exhausted.

The number and size of the rearing containers used will, of course, depend on the needs of the individual. Swingle and Sturkie (1948) state that a tub two feet in diameter and ten

inches deep will produce from 3,500 to 5,000 worms of bait size. They recommend that no less than two tubs be used. This way worms may be taken from one tub for several months without disturbing the other tub. Tubs or other such containers may be kept in a cool basement where the worms will produce all year around; or they may be placed outdoors, in which case, the bed should be provided with good drainage, plenty of shade, and a cover for protection during periods of abundant rainfall.

The initial supply of worms placed in each rearing bed will depend on the size of the bed. About 100 worms are sufficient to stock a tub or fruit lug; more may be added proportionately to larger beds. From the time of stocking, three to four months are required before the young hatch and attain bait size. Large commercial beds may be constructed if desired. Shepherd (1953) states that a three by eight foot bed with twelve inches of soil will accommodate 100,000 worms. A bed of this type may be constructed with cement blocks or cinder blocks piled two deep and arranged in a rectangle. The bottom is lined with boards and burlap.

Hutchins describes an outdoor worm bed directly in contact with the earth. He says that such a bed also requires a shady

well drained area. A pit is dug 12 to 18 inches deep, 3 to 4 feet wide and 6 to 10 feet long. It is then filled with the mixture of soil and leaves described above. He says, "As the soil and leaf mixture is replaced, rake it out into layers three to five inches deep and sprinkle yellow cornmeal on each layer. Spray water on each layer to moisten the soil required. Fill the pit to the level of the surrounding area." Several hundred worms are sprinkled over the surface and after two hours the dead ones are removed. Food should be added once a week and only as much as will be consumed between feedings. Some of the better foods for this purpose are: yellow cornmeal, vegetable refuse, and old bread. After each feeding, a thin layer of dirt should be sprinkled over the food. This bed like the others is covered with straw or burlap to reduce evaporation. Manure worms may be cultured in the same type of pit if it is filled with rotted horse or cow manure.

Probably the simplest outdoor worm bed is that described by Swingle and Sturkie (1948) in which dish water is utilized. The water is either carried to the bed or piped to it from the kitchen sink. In the later case the water should be piped at least fifty feet from the house through tile or pipe and emptied

into a long shallow V-shaped ditch lined with boards. The 100 worms added to this bed usually require a year to produce sufficient numbers for harvest. When a supply of bait is needed, the boards are raised and the desired worms scooped from the surface soil.

Certain pests are likely to be found feeding upon the food in rearing beds. Mites may be killed by lightly dusting the top of the bed with sulfur dust. Concentrations high enough to kill mites are still safe to the worms. Ants are kept out of indoor tubs or boxes by either setting them on a chair which has the legs immersed in oil or by dusting the floor around the container with pyrethrum or chlordane powder. Screening is the only way to keep out rats and mice.

The removal of worms from tubs or fruit lugs may best be affected by throwing a quantity of soil and worms into a large bucket. If it is allowed to stand for thirty minutes and the top soil put back in the rearing container, the majority of the worms will have crawled through the loose soil and be concentrated in the bottom of the bucket where they may be easily removed. To take worms from a permanent bed the surface layers are turned over with a spading fork. Worms that are softer than desired

should be toughened in sand. In the Wise Fisherman's Encyclopedia it is stated that to do this a box is filled with sand the consistancy of brown sugar. A large ball of clean moss is placed in the center of the box and the worms are dug down into the sand. If they are left in the box for a week, the worms will pass back and forth from the sand to the moss, shrinking in size and becoming tough. When carrying worms on fishing trips, it is best to use two containers, one small enough to fit inside the other. The worms are placed in the smaller can with damp moss. The larger can is then lined with moss and the smaller one placed inside it. Worms will keep much better this way than they will in a single can.

Quality as a Bait - Worms are probably the most popular freshwater bait in the country. Great numbers of bass, bluegills, perch, trout, bullheads, wall-eyed pike and others are taken on this bait each year. All bait shops, regardless of size, handle worms. They charge from 35 to 50 cents a hundred for them early in the season and 75 cents a hundred in late July and August when they become scarce. The price of nightcrawlers ranges from 25 to 50 cents a dozen.

## LEECHES, HIRUDINEA

Life History - Several species of leeches are found in ponds, lakes, and streams, but only four interest the fisherman or bait dealer. One of the larger of the four is the American medicinal leech. Macrobdella decora, which was used in this country for blood letting in years past and is still being used to some extent. Moore (1923) states that this species reaches a length of 10 to 12 inches but more commonly is 3 to 6 inches. The body is flattened and the margins sharpened; its anterior sucker is powerful and has a wide, unsegmented, mobile border. The upper lips can be folded into the mouth cavity and are almost concealed by the lateral lobes that close beneath it. The jaws are prominent and possess 65 small teeth in each, arranged in a single series. All members of the family Hirudinidae have five pairs of eyes. In M. decora the eyes are large and arranged in a submarginal arch. Living specimens display rich colors. The dorsal surface varies from a light sage-green to dark olive-green with dark longitudinal lines or streaks faintly visable in the median area. A series of small but conspicuous cadmium-orange or light red spots are arranged along the median line, one on each segment. Near the

margin on either side is a similarly arranged row of small black spots. The ventral surface is rich orange varying in shade and intensity. Sometimes it is plain and sometimes spotted with black to a varying degree.

The American medicinal leech is more of a swamp inhabitant than of ponds and may be found in shallows or at the shoreline. They conceal themselves beneath stones and logs, particularly those that are partially emergent. A positive tropism is shown to any mechanical disturbance of the water, such as a wading person or animal. Their chemical senses are also affected by such activity. In collecting leeches advantage may be taken of this. If a collector stirs up the bottom mud with his foot, any leeches in the neighborhood will move slowly toward the commotion and become attached to the foot or leg of the individual.

Food of M. decora consists primarily of vertebrate blood derived from man or animals entering the water. In the absence of vertebrates leeches will feed on tadpoles, fishes, frogs, or turtles. Frogs' eggs, aquatic worms, and occasionally insect larvae also are consumed. Macrobdella are primarily nocturnal, but proper stimulus will induce them to go forth

freely in daylight. As with most aquatic invertebrates, metabolism is largely a function of temperature. A reduction of temperature induces quiescence. At 40°F. they become sluggish, and at 39°F. they seek winter quarters. Freezing is not lethal unless temperatures are reduced below 20°F. In the spring they make their appearance with the frogs and feed freely on both frogs and their eggs. If the pond drys up, leeches incase themselves in a mucous lined cell beneath a log or a stone, shrink in size and remain there until more favorable conditions present themselves.

After feeding voraciously in the spring, they copulate. This is done much after the fashion of earthworms. With aid of secretions from the copulatory gland these hermaphrodites become joined together and a transfer of spermatophores is made. Egg capsules may be found at the water's edge buried in the mud or turf during June or July. They are from 1/2 to 3/4 of an inch in length, broadly elliptical, and are pale straw in color. The period of incubation is about three weeks depending on the temperature.

Moore (1912) gives the distribution of M. decora as the northern half of the United States and into Canada.

The most widely distributed leech is Erpobdella punctata. According to Moore (1912), it may be found in every spring, brook and river, ditch, pond and lake regardless of how pure and cold, warm or foul. It is usually the most common species of leech present. Larger specimens are found in larger rivers, ponds, and the Great Lakes. They congregate on the shore of ponds having the richest food supply. During the day they conceal themselves under logs, stones, and leaves going forth at night in search of food. E. punctata feeds on aquatic insects and larvae, and aquatic oligochaetes, but will attach to fishes and frogs or warm blooded animals. They are sometimes cannibalistic. The breeding period is long, extending over most of the spring and summer. Their small, flat, amber-colored egg cases are attached beneath under-water objects. Moore (1912) states that this leech is of moderate size, slender and elongate, usually terite anteriorly and often depressed posteriorly. The sides are nearly parallel, rounded anteriorly, and have sharp, prominent edges posteriorly. Its firm, muscular body attains a length of about five inches. Of the three pairs of eyes, the first is the most prominent. The oral sucker is small consisting of little more than short lips overhanging the nearly

terminal mouth. Young Erpobdella punctata are nearly translucent; the blood showing through gives them a pinkish color. Ground color of adults is plumbeous, slate-color, brownish gray, olive, brown, fuscous, light brown, or chocolate. Ventrally they are lighter. Sometimes a golden green hue spreads over the entire dorsum. Brown is the most usual color and may be plain or marked with irregular black spots with light centers. These are arranged in two or four longitudinal lines leaving the middle of the back and margins clear.

The horse leech, Haemopis marmoratis, is described by Moore (1912) as possessing five pairs of eyes in a regular arch on somites II to VI. The fourth and fifth pairs are not as prominent. Its jaws are well developed, bearing a few coarse teeth arranged in paired series. There are 12 to 16 teeth on each jaw. Color varies, but it is marked more or less thickly with non-metameric black blotches. The body is soft and limp and seldom exceeds six inches in length or 1/3 of an inch in diameter. Ground color is usually some shade of green, olive, or greenish brown. Sometimes this leech is nearly plain, sometimes remotely spotted, but usually it is thickly and confluently blotched with irregular or intermixed

spots of lighter gray and darker browns or black. Sometimes the dark markings are so close together on the dorsal surface that the leech appears black.

Horse leeches are semi-aquatic, living in mud by the side of ponds, pools, and lakes, not actually in the water. They eat earthworms, aquatic insects and their larvae, aquatic oligochaetes, gastropods, pelecypods, and large quantities of mud with organic matter. Sometimes they attach themselves to man and cattle. They are found in all parts of the United States.

Haemopis grandis is the largest American leech. Moore (1912) states that a foot in length is not uncommon and that specimens 15 to 18 inches have been recorded. More commonly, however, they are 5 to 8 inches. The body is robust and heavy posteriorly but tapered anteriorly. Its large mouth is contracted, and its narrow lips prolonged. The five pairs of eyes characteristic of the family are small, the fourth and fifth being inconspicuous. On the dorsal surface ground color varies from tawny olive to green. Gray, yellow, or light brown covers the ventral surface making it more pale than the dorsum. A great range in degree of maculation is exibited. Most typical

are those in which the dorsum of each complete somite is marked by 8 or 10 irregular but somewhat quadrate black spots, most of which are confined to the limits of each annulus. Some are nearly free from spots. H. grandis is found on the shores of the Great Lakes and the lakes and ponds of Wisconsin, Minnesota, and Michigan. It extends east to New England and New York but is rare in the Middle States. This leech may be found at the borders of bodies of water concealed beneath stones. Food consists of earthworms, aquatic worms, other leeches, snails, insect larvae, and organic mud. It does not seem to be interested in fishes, frogs, or turtles.

Collecting - Moore (1923) devised and tested three traps in his study at Palisades Interstate Park. Since these traps at no time captured more than three leeches, their construction will not be discussed in this paper. Moore states that in the days of hirudiculture a bag containing a freshly killed, bleeding animal or slaughter house blood was placed in the water or dragged through it. The leeches were then either removed from the outside of the bag or caught with a dip net as they swam toward the bag. Large numbers of leeches have been captured in this manner.

Rearing - In the past leeches have been cultured on a large scale for blood letting purposes. Bullough (1950) says, "It (Hirudo) will live for years, and will breed in aquaria, or even in earthen jars, which are kept half full of fresh water in a cool shady place. The aquaria must have well-fitting lids, as the leeches leave the water and wander. They can be kept for at least a year without food, and in any case they need not be fed more often than once in six months. They will suck the blood of any mammal or, more conveniently, of a frog which can be added to the aquarium." Horse leeches Haemopis can be similarly cultured, but it is not a blood sucking species and should be fed on earthworms or tadpoles (Bullough, 1950).

Holding - From the above it is evident that leeches are not difficult to keep for extended periods of time. A quart jar half full of water is all that is needed. If placed in a cool basement, the only care that need be rendered is the replenishment of the water that evaporates.

Quality as a Bait - Leeches are a very good bait for bass, bullheads, and catfish. They have the advantage of being tough enough so that perch and other small fish cannot chew them off

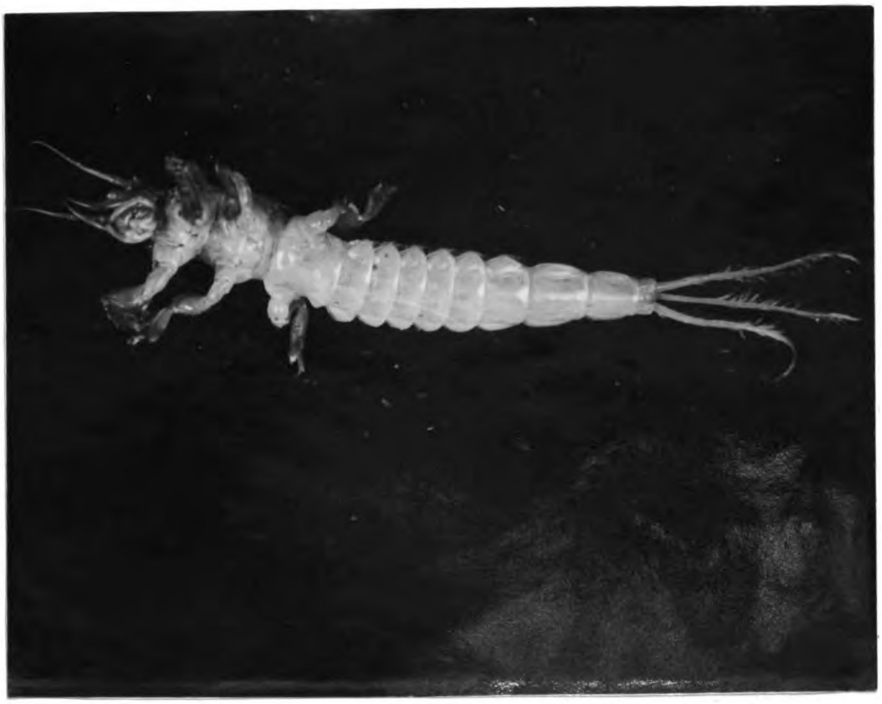
the hook. In parts of the state particularly the Upper Pennisula they are commonly in use, but in the Lansing area there is not enough call for them to induce bait dealers to stock them. They feel, however, that if they did collect leeches or bloodsuckers as they are called, the price would be about 75 cents a dozen.

## WIGGLERS, EPHEMERIDA

Life History - Mayfly nymphs or naiads are strictly aquatic; occurring in ponds, streams, and at lake margins. These nymphs belonging to the order Ephemerida have seven pairs of gills on the abdomen, a single claw on each foot, and two or three slender tail filaments or setae (Figures 1 and 2). Stonefly nymphs, with which they may be confused, have two claws on each foot and nearly all their gills on the thorax. Mayfly nymphs demonstrate three ecological forms. Species of the subfamily Baetinae are streamlined, agile, smooth-bodied, and fitted for darting about in ponds. The length when full grown is one half to three quarters of an inch. Heptageninae is found in swift water clinging to stones. Its body is dorso-ventrally depressed, and its eyes and antennae have moved to

Figure 1. Dorsal view of burrowing mayfly. X 1.25
Ephemerinae

Figure 2. Ventral view of burrowing mayfly. X 1.25
Ephemerinae



the dorsal surface. Ephemerinae or burrowing mayflies are commonly known to the fisherman as "wigglers". This is the only group of mayflies used as live bait (Dobie, Meehean, and Washburn 1948). Burrowers may be found in the muddy shallows of lakes and rivers. They are the largest of the mayfly nymphs, and are from one and a half to two inches long when full grown. The exact length of the life cycle of Ephemerinae is not known, but Dobie, Meehean, and Washburn (1948) believe it to be two years. Burrowers, as the name implies, live in U-shaped burrows in the mud. Both ends of this burrow are open, and the nymph by the action of its gills keeps a stream of water flowing through it. There is great variation in the depth at which they live, but most burrowers are found in water from two to ten feet deep. Bottom type is important to wigglers, for they cannot penetrate such hard materials as gravel and hard marl nor can they do well in soft muck and sand. Most wigglers are found in firm muck or soft marl where there is no or at least scanty vegetation.

The life cycle of mayflies is not completely known. According to Matheson (1948), the female may either drop her eggs on the surface of the water or crawl down into the water

and lay them in single layered, circular patches beneath stones. Eggs hatch immediately or may not hatch for some time, as is the case when ponds dry up in the summer. Winters are passed under water in the nympal stage. Mayfly nymphs are strict vegetarians. Most of their food consists of diatoms, desmids, and sometimes the soft tissue of larger plants. Although they do not feed on other aquatic organisms, wigglers , according to Morgan (1930), are eaten by "dragon-fly nymphs, water beetles, and young fishes in enormous numbers." Matheson (1948) states that the last nymphal skin contains within it the fully developed adult; the male and female organs and the eggs are all nearly developed. Having reached this stage, the nymph rises to the surface of the water, emerges through a slit in the back, and takes to the air. It is then that they are referred to as subimagos or "duns". A short time later they shed their skin again and become fully matured imagos or "spinners". The adult stage is short, lasting from a few hours to two days. They are delicate insects, soft gray and brown, or pale and translucent. The front wings are much larger than the hind wings, and like the nymph, two or three tail filaments project from the posterior end of the abdomen. Tail filaments

of the adult are much longer than the nymphs'. Their mouth parts are reduced and their legs too long and weak for walking. Immediately after emerging, the adult mayfly rises to nearby bushes or trees where it remains until the mating flight. Within a few hours to two days mating occurs. Morgan says,

> "The mating flight usually takes place in late afternoon or twilight. The hundreds of spinners, mostly males, swing up and down through the air in a rhythmic dancing flight over streams or lakes. With their rudder-like tails stiffly extended they drop downward in swift descents of thirty feet and more and then bound upward with the lightness of springing thistledown. Hundreds or even thousands of them move up and down together. In half an hour they have disappeared into the trees as suddenly as they came, or they are strewn upon the water to become the food of eager fishes. During this flight a dozen or so from the hundreds of males mate with the few females which almost immediately lay their eggs in the water and then die upon its surface."

At night in lake shore cities, the dead bodies of mayflies are found by the thousand, strewn upon the streets beneath the lights. They are commonly known as fish flies, shad flies, and mayflies.

Rearing - It may be seen from the life-history study, that rearing wigglers is not practical because of the time required to complete the life-cycle and because of the mating habits of the insect.

Collecting - The first step in collecting large numbers of mayfly nymphs is to locate the type of bottom in which they are likely to be found. Firm muck or soft marl lake bottoms, free or nearly free from vegetation, are the most likely places to look. In streams, eddies, backwashes, and silt bars often have large numbers. Wigglers may be dug from the bottom of lakes or streams with a long handled dip net made of 1/8 or 1/4 inch mesh screen. Part of the bottom is scooped up with the wigglers, but it may be washed free by jiggling the net up and down in the water. Nymphs too small for bait should be returned to the water for next year's crop. Operations of the type described above may be carried on from a boat in the spring or through the ice in the winter.

Holding - Various methods have been successfully employed to hold wigglers. Bait dealers usually keep them in the same tanks used for minnows. A large, screened basket is often slung between the walls of the tank to facilitate the removal of nymphs. When a supply is needed, the basket is raised and the desired number scooped from the squirming mass. Mayfly nymphs require cool water high in oxygen. The constant, fine spray of well water, usually used in minnow tanks, satisfies

this need. Chlorinated city waters should not be used. Bait dealers state that with the above arrangement wigglers will keep for about a week or more. If the bait is to be held for longer periods, the basket arrangement should be dispensed with. The wigglers are placed in the bottom of tanks with leaves, moss, or strips of burlap in the bottom for the insects to hide under. If this material is lacking they will swim about until exhausted, then die. Removal of bait from the tank is more difficult; but, according to bait dealers, mayfly nymphs will keep for nearly a month with this arrangement.

Several tests of technics for holding wigglers were tried. Four pint jars were treated in the following manner: Jar 1, containing one inch of water, was held at a temperature of 60°F.; Jar 2, with damp sphagnum, was held at 60°F.; Jar 3, with one inch of water, was held at 34°F.; and Jar 4, held at 34°F. contained one inch of water and several 1/2 inch strips of paper toweling. Ten mayfly nymphs of the burrowing type were placed in each jar and examined every four days. The results of these tests reveal that these organisms may be kept under refrigeration for more than a month if some material is furnished for them to hide under. Without refrigeration, all of the larvae died in less

than a week. Those that were refrigerated but had nothing to hide under, lived a little longer than two weeks, but not nearly as long as those supplied with cover, nine of which lived more than 36 days. The results of these tests are by no means conclusive. Since the larvae were purchased from a bait dealer, their condition before the tests was not known. Bait dealers state that wigglers will not keep longer than three days during the summer under any conditions, however, no tests were run at this time of the year to confirm these claims.

Quality as a Bait - Wigglers are considered one of the best winter bluegill baits. Some perch fishermen use them in the winter, and in certain areas both perch and bluegill fishermen find them a very effective summer bait. Most bait dealers handle wigglers. In the winter, when they are easiest to collect, the price is 35 cents for two dozen but in the summer 20 cents a dozen is charged.

## CADDIS LARVAE, TRICHOPTERA

Life History - Caddis larvae may be found in fresh water streams, lakes, and ponds. To the fisherman they are known as redammites,

Figure 3. "Stick caddis" within case. X 1.25
Trichoptera

Figure 4. "Stick caddis" removed from case. X 1.25
Trichoptera

Figure 5. "Stone caddis" within case. X 2
Trichoptera

Figure 6. "Stone caddis" removed from case. X 2
Trichoptera

caddis, stone caddis, and stick caddis. Usually they are caterpillar-like (eruciform) in shape (Figures 3, 4, 5, and 6), and have filamentous gills attached along the sides of the abdomen. All caddis larvae have a pair of short, curved, horny hooks at the end of the abdomen that serve to anchor the worms to their cases. Three tubercles keep the body away from the inside of the case allowing free circulation of water to the gills within. Caddis larvae have a peculiar undulatory motion that keeps water flowing over these gills. Their six legs enable caddis worms to drag their case-laden bodies over the bottom, however, not all of these larvae move about. A variety of substances are utilized in the construction of the case, each species having its own preference. Sand, bits of leaves, tiny twigs, or pebbles are cemented together with silk secreted from modified salivary glands to form cases of varying shapes. When a caddis worm outgrows its case, it may either wiggle out and build a new one or build on to the front of the old one. Larger species of caddis worms are popular as bait. According to Dobie, Meehean, and Washburn (1948), all bait species make tubular cases and may be collected from beds of vegetation, particularly water cress and cattails. The food of younger

larvae consists of algae and minute animal matter: later mayflies, water mites, midge larvae, small crustaceans and others are added to this diet. Morgan (1930) states that larvae continue eating up to the time of pupation, then seal the front of the case shut with building material or a silk net and continuing the undulatory movements of the larvae, they pupate. When the pupa living in swift streams are ready to hatch, they leave their cases, swim to the surface, shed the pupal skin, and immediately take to the air. Quiet water species climb out on the shore or projecting stones to shed their pupal skins. Adults of one species or another may hatch throughout the summer, but the majority are found in May and June. Morgan (1930) says,

> "Adult caddis flies look like moths but their bodies are more slender and they are more delicately built. They are soft brown, or gray, sometimes black, very rarely bright colored. Their four wings are folded like a tent over their backs, and their thread-like antennae, often longer than their bodies, are extending far out in front of them. As in the butterflies and moths their color lies mainly in the long silky hairs and scales which cover their wings and soft bodies."

With the exception of the palpi, mouth parts of adults are vestigial, and no food is eaten during this stage of their lives. Caddis flies are not found far from water and are seldom seen during the day. At night they are attracted in large numbers

to artificial lights near the water. Egg laying usually takes place in the summer at which time gelatinous masses of eggs are attached to submerged stones, twisted about aquatic vegetation, or sticks. In some species females go underwater to lay their eggs but others lay them on objects near the pond or stream, forcing the larvae to make its way to the water when it hatches. Eggs are round or slightly oval in shape; each species has its characteristic way of arranging the egg in the gelatinous mass. They hatch within a few weeks, after which the larvae spend the winter feeding and growing in the water.

Rearing - No technic has been devised.

Holding - Most bait dealers keep their caddis larvae under the same conditions that minnows are kept. The larvae within its case is placed in a tank of water oxygenated by a fine spray. Bait dealers agree that caddis larvae will live about a week this way before great losses are noticeable. Laboratory experiments indicate that this is not the most efficient method for holding baits of this type. Ten caddis larvae were placed in a pint jar with one inch of water. The jar was then held under refrigeration at a temperature of 34°F. Examinations were made

every four days to determine the loss during that length of time. Nearly a month passed before a single death was recorded; the last two were found dead after 44 days; the average length of time the ten larvae were held was 36 days. Since such a small number of larvae were tested, the results of this test are of value only as a prediction of what might be expected.

To determine how long caddis larvae will keep without reduced temperatures or the addition of oxygen, ten larvae were placed in a pint jar with one inch of water and were held at 60°F. Examinations made every day showed considerable loss as early as the second day and a total loss by the fourth day.

The caddis larvae used in both tests were purchased from a bait dealer; and although their condition was not known, all appeared to be quite lively.

Quality as a Bait - Caddis larvae are an excellent bait for bluegills and other panfish both winter and summer; but, by far the greatest demand is in the winter. A few people use them on trout with some success. The current price of caddis larvae in the Lansing area is 20 cents a dozen.

Figure 7. Dorsal view of "hellgrammite". X 1.25
Corydalis cornutus

Figure 8. Ventral view of "hellgrammite". X 1.25
Corydalis cornutus

## HELLGRAMMITES, Corydalis cornuta

Life History - Hellgrammites are the larval form of Dobsonflies (Corydalis cornuta). To the fisherman they are commonly known as crawlers, hellgrammites, dobsons, grampus, snipper, clipper, and bass bait. These larvae inhabit fast flowing streams where they are found in the swiftest part beneath stones. Morgan (1930) says,

> "When fullgrown they are two or three inches long with dark brown, rough looking skin, and large jaws which extend lustily at the slightest irritation. Their bodies are flattened and sprawling and there is a tuft of white hair-like gills at the base of each of the lateral appendages on the first seven abdominal segments." (Figures 7 and 8)

This voracious-looking, six-legged creature feeds on mayflies, stoneflies and other aquatic insect larvae. In May or June of their third year the hellgrammite reaches maturity and crawls out of the stream to pupate beneath a log or stone. After about ten days, the adult emerges. Its cinnamon brown body is covered dorsally by two pairs of wings lying flat across the back of the insect. These have a span of four to five inches and are spotted with grayish white markings. The mandibles of females are short and stubby; those of males are tusk-like, and are three times the length of the head. They are used during mating to hold the female. Adults are short-lived,

probably not living more than a week (Wickliff, 1937). Morgan (1930) states that although they have strong jaws adults eat no food. A short time after adults emerge egg laying occurs. Eggs are placed on stickes and stones just above the water in a single chalky white mass not more than an inch in diameter but often containing more than 2,000 eggs. Newly hatched larvae either fall or crawl to the water where they spend the next two years and eleven months.

This species may be found throughout Eastern United States and Southwest to the Rocky Mountains.

Collecting - To collect hellgrammites, a fine mesh net is placed in a stream known to have the species; and rocks are turned over upstream from the net; larvae, hiding under the stones, are then washed into the net by the current (Dobie, Meehean, and Washburn, 1948).

Rearing - The length of time required for Dobson-flies to complete their life cycle makes rearing impractical.

Holding - Bait dealers keep hellgrammites in tanks similar to those used for holding minnows. Oxygenation is necessary and may be supplied by a spray of water or by bubbling air into the tank. Food is usually supplied in the form of meat scraps or

chopped fish. Food scraps should not be allowed to accumulate because the products of their decomposition have a toxic affect on the larvae. Overcrowding induces cannibolism. Bait dealers state that hellgrammites held under the above conditions will live more than a month.

Fishermen wishing to keep a small supply on hand may do so by placing them under refrigeration in a small container of water or damp moss. To determine how long hellgrammites will keep under such conditions five larvae were placed in each of two pint jars and held at a temperature of 34°F. Jar 1 contained one inch of water, Jar 2 was two-thirds full of damp moss. The results of this test showed that both methods are suitable for holding hellgrammites and that the larvae may be kept for the same length of time under either condition. The minimum holding time was 31 days, the maximum 49 days, and the average for the ten larvae was 39 1/2 days.

Quality as a Bait - Hellgrammites are an excellent bass bait and often command a high price (60 to 85 cents a dozen in the Lansing area). Their only drawback is that when used in a lake or stream they cling to any debris on the bottom that they come in contact with.

Figure 9. Rat-tail maggot
Syrphidae

## RAT-TAIL MAGGOT, SYRPHIDAE

Life History - Several larvae of the family Syrphidae are refered to as rat-tail maggots because of their tail-like posterior breathing tube. To the ice fishermen they are known as mousies. For the most part this long-tailed type is found in liquid manure or the foul stagnant water of ditches and watering troughs. Mallota has been found by Metcalf (1913) in rotten wood. Adults of the rat-tail maggot like other Syrphidae may be found on sunny days buzzing like bees around flowers. They feed on nectar and pollen, and in the early spring may be seen mating in the air or on the leaves of flowers. Eristalis sp., according to Metcalf (1913), hovers over the surface of the liquid depositing her eggs side by side in large masses. The eggs of Eristalis tenax are 1.6 mm. long, .4 mm. in diameter, elongate and ovoid. They are chalk-white, slightly bent, and have rounding ends. Within 24 hours they hatch into larvae scarcely longer than the egg except for the posterior respiratory appendage. This larvae is sub-cylindrical but attenuated at the posterior end to the breathing tube (Figure 9). A prominent dorsal hump may be found in the posterior third of the body. Mature larvae are 20 mm. long and have antennae, prolegs,

tracheal trunks, and other larval structures. Metcalf (1913) says, "The mouth parts of the larva are located internal to a hood-like, striated, chitinous termination of the oesophageal framework." There is an absence of hard external parts, the opening being a soft fleshy buccal cavity with flaps or lips used to create a current of water toward the mouth. While crawling about on bottom, larvae obtain air through their telescopic "tails". Haland (1921) states that the three segmented, telescopic tail can be extended as much as five inches. At the tip of the tail is a circlet of bristles, wherein may be found the spiracles in communication with the maggots respiratory apparatus. Trying to keep the circlet of hair floating at the surface the larvae travels about the bottom lengthening or contracting the "tail" as water depth changes. Different species have different numbers of prolegs. According to Metcalf (1913), E. tenax has 8, E. aeneas 7, E. arbustorum 7, and genus Helophilus 6. Metcalf (1916) lists five genera as being of the long tail filth inhabiting type: Eristalis, Ringia, Tropidia, Syritta, and Helophilis. Generally speaking the color of these larvae is dirty, grayish-brown; the integument translucent and flexible. Food consists of

what decayed organic matter can be carried in by the stream of water created by the motion of the buccal flaps or lips. About the middle of September, the larvae buries itself in soft mud. It forms a small dome in the mud above it, then pupates for a period of 10 to 14 days. Length of the puparium is 8 to 10 mm., height 3 to 4.5 mm., and width 3.5 to 4.5 mm. The shape is elongate-ovoid, much like that of the larvae but shorter and dorsally inflated. Color of the puparium with the enclosed pupa is dark brown. Adult E. tenax are abundant from early spring to late autumn. The larvae may be found for only a slightly shorter period of time. It is not known in which stage they pass the winter. E. tenax is cosmopolitan, but other species are limited in distribution.

Collecting - Mousies can be collected with a fine mesh net or screen in any highly polluted, stagnant water. Bait dealers in the Lansing area buy their mousies from a wholesale concern in southern Ohio where they are collected from the slough of a canning factory. It would be possible for these local bait dealers to collect their own in the fall and hold them until the winter fishing season if they desired to do so; but it is more convenient to purchase them.

Rearing - A practical means of rearing mousies artificially is not known, but natural conditions may be set up in which eggs will be laid and larvae developed. These conditions, however, are far from sanitary. An abundance of manure or rotted vegetation placed in a pond or in an outdoor tank will soon be teeming with life among which will be found rat-tail maggots. Certain noxious flies and mosquitos are also fond of this type of habitat, however.

Holding - Bait dealers keep their mousies in saw dust usually in a damp basement, since they are prone to dry out. In an attempt to hold larvae beyond their natural hatching date, ten were placed under refrigeration at 34°F. on February 20. Ten others were held in a damp walkin locker at a constant temperature of 60°F. After six days, it was observed that five of the maggots held at 60°F. had pupated and two were already in the adult stage. Within the next two days, two more pupated and the remaining one was found dead. Only one more hatched out, the rest evidently died as pupa. Those held at 34°F. did not keep as well as most insect larvae do at that temperature. After two weeks, two of the larvae pupated and by April 22 signs of shriveling were observed. By May 4 all were dead.

Quality as a Bait - Mousies are considered a good winter bait for bluegills and other panfish. They sell for about 20 cents a dozen.

## WAXWORM, Gallaria mellonella

Life History - Waxworms are the larvae of a moth known as the beemoth or waxmoth(Gallaria mellonella). They were introduced to this country at the beginning of the 19th century and have spread wherever beekeeping is practiced. Any weak colony of bees is likely to have from a few to 2,000 of these waxworms or webworms gnawing at the comb. The adult moth may be seen only at dusk unless frightened from hiding during the day. Even then, only a short flight is taken before it settles to some object and remains still. This moth, according to Paddock (1918), is 15 mm. long and has a wing span of 30 to 32 mm. When the wings are folded, their general appearance is ash-gray. The back third of the fore wings is bronze, and the rear margin has a scanty row of short hairs. Hind wings are usually gray with traces of a few black lines extending from the outer margin inward toward the base. The outer and rear margins have a thick fringe of hairs with a dark line running parallel to the border of the wing. The body is brown. Males

are generally lighter colored than females, and the posterior edges of their fore wings are notched at the ends as opposed to the nearly straight ones of the female. Male palpi are rudimentary. During the mating season, males produce a low humming sound by drumming their wings. Mating takes place within a few hours after emergence and the eggs are laid one or two days later. When ready to oviposit, the female darts into the hive at dusk. If she is not seen and killed by the bees, she proceeds to lay her eggs in holes and crevises of the comb. One egg is laid per minute and each is assigned an individual place. Every 30 minutes a short rest is taken. In all, 200 to 300 eggs are laid. Females die just before oviposition is completed, some of the eggs being left in the body of the dead female. Males live about 21 days. No food is taken by either adult.

The egg is elliptical, nearly pearl white, and has a shell roughened by wavy lines running across it diagonally at regular intervals. Its length is .43 to .49 mm., the width .38 to .44 mm. A gradual color change occurs in which the eggs turn from white to yellow. Incubation time varies as much as 6 to 27 days depending on the temperature.

Figure 10. Dorsal view of waxworm. X 2
Gallaria mellonella

Figure 11. Ventral view of waxworm. X 2
Gallaria mellonella

Newly hatched larvae are one to three mm. long and have a dirty-white, waxy color, according to Paddock (1918). The head is yellowish and slightly smaller than the prominent prothoracic segment. Thoracic legs are well developed; and after three days, prolegs appear. The first part of the comb eaten by the larvae is the midrib or sheet of wax at the base of the cells; later the walls of the cells are devoured. Everywhere larvae go web is secreted, and soon the comb is a mass of web and piles of masticated wax. Mature larvae attain an average length of 20 mm. Paddock (1918) says,

> "The head is small and pointed, reddish brown in color, with a light V-shaped line on top, this "V" opening towards the front of the head. The body is larger than the head, long, cylindrical, smooth except for a few short hairs (Figures 10 and 11). The general color is a dirty gray with the prothoracic shield brown and having a broad band across it."

Average duration of the spring larval stage is 49 days, running from April 8 to May 26; the fall brood is 35 days, from August 25 to October 1. At room temperature Smith (1937) gives 35 days as the average.

When ready to pupate, the larvae seeks out a crack or corner in the hive or sometimes conceals itself beneath the mass of refuse and webs at the bottom of the comb. Often they burrow

into wood, paper, and other materials which may be handy. The cocoon is constructed of silk thread. Starting at the anterior end an outer layer is made, then inner layers are added to it. The outer surface is very tough while the inside remains soft and fluffy. Construction of the cocoon requires one to five days. Upon completion, a slit is made in the anterior end to expedite emergence. The time required for transformation is from three to seven days. Newly formed pupa are white; but after the first day, they assume a straw color; later, light brown; and by the time the adult emerges, they have deepened to dark brown. Male pupa average 14 mm. in length; females 16 mm. A row of spines extends from back of the head to the fifth abdominal segment and the body is slightly curved downward. Under natural conditions the length of the pupal stage varies greatly; sometimes they hatch in six days and sometimes not for 50 days depending on the temperature. Those reared by Smith in the laboratory emerged within 12 to 14 days. Paddock (1918) believed that in the South three generations a year were completed, but overlapping of generations made it difficult for him to confirm this. In the North there are probably only two a year.

Rearing - Often enough waxworms can be collected from the bee-hives of a local apiarist to satisfy the needs of fishermen; but if such a ready made supply is not available, they can easily be raised in a basement or spare room. Two rearing methods have been devised; the most convenient of which may be selected to fit the circumstances.

Smith (1937) suggests the regular milk bottle as used in rearing Drosophila. Cardboard bottle tops should be used instead of cotton plugs, however, since the larvae can crawl out between the plug and the bottle. A 1 5/8 to 1 3/4 inch hole is cut in the centers of each of two caps and a 40 mesh copper wire screen is stapled between them. This aerating cap provides a sufficient amount of air and prevents the worms from cutting their way through the carboard. About 1/2 to 2/3 of a pint of honey comb is placed in each bottle to serve as food. This may be obtained from an apiarist. The initial supply of larvae may be purchased from a bait dealer or removed from bee-hives, in which case, cocoons may be found and used with quicker results. Few worms are needed to start your own constant supply since one female moth may produce as high as 3,000 young. The length of time required for larvae to achieve adulthood

depends on the age of the larvae at the time they are placed in the bottles. If mature worms are used, it may be only a few days before they pupate, provided they are kept in a warm room with a fairly high humidity. After pupation, it is a matter of less than two weeks before adults emerge, then production can be started on a large scale. Three or four adults of each sex (see life history for identification of sexes) are placed in each bottle. An examination should be made every week or more to see how far the life cycle has progressed. When the newly hatched larvae are two weeks old, they should be placed in separate bottles so as to have forty or fifty to a bottle. If the food in the rearing bottles is used completely, more should be added. A stock supply of food may be kept in lard or pretzel cans equipped with tightly fitting covers to keep any stray or wild waxworms from contaminating the food supply.

Haydak (1936) developed a method of raising waxworms using pint mason jars filled up to 2/3 with food. The following formula was used:

| Ingredient | Parts by Weight |
|---|---|
| Fine corn meal | 4 |
| Whole wheat flour | 2 |
| Skim milk powder | 2 |
| Powdered dry yeast | 1 |
| Standard wheat middlings | 2 |

The above formula is added to a mixture of equal parts of honey and glycerine until the entire mixture has the consistancy of moderately wet sand. Two sticks are placed on top of the food and one is leaned against the side of the jar to provide a place for the moths to rest and deposite their eggs. A fine mesh, copper wire screen is placed over the mouth of each jar and a piece of cotton cloth over this to prevent the newly hatched larvae from escaping. The rest of the operation is the same as that described above.

For optimum results, a temperature of 30° to 35°C. (86°to 88°F.) and a humidity of 65 percent or more should be maintained at all times. These conditions may be approached in a simple home-made incubator. Smith (1937) recommends that this incubator be made of fibrous building board and suggests that its size be four feet wide, three and a half feet high, and fourteen inches deep. If two by two framework is covered both inside and out, a two inch dead air space will be left

for insulation. Shelves should be two inches narrower than the depth of the incubator to allow free circulation of air. A small fan, if available, aids in the aeration of the cultures. Heat is supplied by electric light bulbs; the number of bulbs needed and their size will depend upon the room temperature and the construction of the incubator. By using a thermometer and making the necessary bulb adjustments the optimum temperature may be approached. A pan of water should be placed in the incubator near one of the bulbs to increase the humidity. As noted in the life history of waxmoths, egg laying takes place at dusk; for this reason the author suggests placing a dark cloth over the culture bottles, at least during the oviposition period, to simulate natural conditions. The temperature and humidity of an incubator of this type will be found useful in rearing other types of bait, too; and what care is taken in its construction will be amply rewarded.

Holding - Waxworms are not a popular summer bait, however, there is no reason why they should not be. If it is desirable that they be used for such, those raised during the winter may be held in the refrigerator until that time. On February 20, a dozen larvae were placed in the refrigerator at 35°F. and

another dozen in a bottle which was held at room temperature. By April 25, one half of those held at room temperature had emerged. All of the waxworms in the refrigerator were still in the larval state on June 1. If artificial methods of propagation are used refrigeration will probably not be necessary for there will be a constant supply on hand in all stages of production.

Quality as a Bait - Judging from the numbers of waxworms sold by bait dealers, they are one of the better winter baits on the market. The retail price in Lansing at the present time is 40 cents a dozen.

## CATTLE GRUBS, Hypoderma bovis and H. lineatum

Life History - During the winter months the backs of cattle are often found to have swellings or lumps about twenty mm. long and six mm. high. These are produced by larvae of the ox-warble-flies, Hypoderma bovis and H. lineatum. The latter is widely distributed in the United States, but H. bovis is more northerly in occurrance. Both of these flies, which belong to the family Oestridae, have much the appearance of bumble-bees and are characterized by vestigial mouth parts and an

$M_{1\&2}$ vein so bent that cell $R_5$ is narrowed or closed at the wing margin. Hypoderma bovis, according to Comstock (1950), is about fourteen millimeters in length, has yellow hairs on the anterior part of the thorax, and orange-yellow hairs on the posterior of the abdomen. The alulae are bordered with reddish-brown. It is a clumsy fly that darts at the legs of cattle and attaches one egg per dive to the base of a hair. This method of oviposition has caused the insect to be known as the bomb-fly. Warburton (1922) states that no pain is inflicted at the time eggs are laid; but if cattle become aware of the presence of the fly, uneasiness and terror may insue, resulting in "gadding". "Wild-eyed with fright, and with tail horizontally outstretched, the animal gallops madly to escape its enemy and takes refuge in the nearest pond or river, where it stands trembling, knee-deep in the water. The terror is infectious, and often spreads to the whole herd." Bomb-flies will not cross water. Comstock (1950) describes the heel-fly, Hypoderma lineatum, as being 12.7 mm. in length, with the anterior part of the thorax black and shining, the alulae white, and the posterior end of the abdomen reddish-orange. While laying eggs, heel-flies rest on the ground and attach the

eggs to the hairs of recumbent animals, one to fourteen eggs being attached in a series to each hair. This method of oviposition does not induce the terror associated with bomb-flies.

Warburton (1922) states that the eggs of both flies are long, oval, white bodies about one mm. long with a bi-lobed foot or clasper for hair attachment. Eggs of H. lineatum are longer and the sides are more parallel than those of H. bovis. The foot of the latter is shorter and more broadened. Both flies lay about 800 eggs. In about four days, the eggs of H. bovis hatch into minute larvae 0.8 mm. long. Those of H. lineatum require a few more days. These larvae have a median piercing tooth, flanked by a pair of well-developed mouth-hooks. The body is white, somewhat transparent, and, each segment is armed with small spines. A short time after hatching, the larvae crawls down the hair and bores into the skin, a process requiring several hours and causing considerable uneasiness in stock. Skin lessions appear but do not last long. For about seven months no external sign of larvae is evident. At this time they are located in the oesophageal region, a position attained by burrowing through the connective tissue. While in this location, they grow to a length of six to

fourteen mm., are glassy and smooth, and have minute spines confined to the oral region and posterior spiracles. From the oesophagus, most grubs migrate directly to the back of the animal where in yearlings as high as several hundred have been found at one time. More than fifty, however, is uncommon. The first grubs to appear on cattle in Michigan are those of the heel-fly, which, according to Janes (1953), occur during January and last until the middle of March. Those of the bomb-fly reach the back about the middle of March and last until June. A few of the smaller grubs, according to Warburton (1922), do not go directly to the back but wander to the stomach region for a short time before going to the final location just beneath the hide. In the back, larvae lose their white, semi-transparent appearance to a white opaque form with the ventral surface minutely spined. Mouth-hooks are no longer present, but the size of the posterior stigmata has increased and the body has become posteriorly tapered. A cyst is formed and migration halted; but the larval movements within the cyst produces an inflamation of the surrounding tissue. A hole is pierced through the hide to the open air and the posterior end is inserted. As the larvae matures the size of this

Figure 12. Ventral view of cattle grub. X 1.5
*Hypoderma sp.*

Figure 13. Dorsal view of cattle grub. X 1.5
*Hypoderma sp.*

breathing orifice is increased. Another ecdysis brings the larvae to its final stage. This is a spindle-shaped form, convex ventrally, but flattened dorsally, with three rows of tubercular ridges on each side (Figures 12 and 13). It is white at first but gradually darkens. Mature larvae may be separated by the arrangement of spines on the ventral (convex) side. H. bovis has no spines on the last two segments, while in H. lineatum only the last segment lacks spines. The uniform spiracles of H. bovis are somewhat funnel-shaped, the central boss being depressed. Those of H. lineatum are level with the surface.

When maturity is reached, the larvae squeezes through the breathing orifice kept open during the larval stage and drops to the ground where its integument quickly hardens to form a dark brown or black puparium. About five weeks are spent in the pupal stage, after which, the adult emerges through a triangular operculum.

Collecting - Cattle grubs may be obtained in quantity from the inside surface of freshly skinned cattle at slaughter houses. Yearlings are more susceptable to infestation than are calves and mature cattle. Older cattle have the least infestation.

The grubs will be found enclosed in a cyst on the flesh side of the hide with its posterior end directed toward a small hole in the hide. The grub is removed from the cyst by making a small shallow slit near the breathing orifice and squeezing the worm out. It is difficult to make the incision shallow enough to keep from cutting the grub, and unless considerably more dexterity is developed than the author was able to, it will not be economically feasible for bait dealers to handle them.

Holding - On March 26, 10 grubs each were placed in three bottles. Bottle 1, was kept dry and placed under refrigeration at 34°F.; Bottle 2 was lined with damp paper towels and refrigerated with Bottle 1; Bottle 3 was lined with damp paper towels and held at room temperature. After three days, an examination was made. In Bottle 1, four grubs (the smaller ones) had turned brown and soft; those in Bottle 2 showed no change in condition, but in Bottle 3, all of the grubs were unfit for use as bait, the smaller ones having turned brown and dried out and the larger ones brown and mushy. The sixth day another examination was made of Bottles 1 and 2. All of those in Bottle 1 were brown, soft, and unfit for use; those in Bottle 2 remained unchanged. After 21 days the temperature in the refrigerator

dropped below freezing, thus terminating the test. Prior to this time, however, all of the cattle grubs in Bottle 2 remained in a usable condition, indicating that of the three methods tested, a damp, cool situation is the most satisfactory.

Quality as a Bait - In certain localities cattle grubs or magic honey bugs, as they are known, are quite popular as winter bait for bluegills and other panfish; but for the most part they are unknown. There is no reason why this would not make a good summer bait, too, however, it is doubtful that they are ever used as such.

## HORSE BOTS, Gastrophilus

Life History - According to Curran's classification, horse bots belong to the family Gastrophilidae, represented by the single genus Gastrophilus. Herms (1948) lists four North American species; 1) Gastrophilus intestinalis which as an adult may be recognized by the cloudy patches near the center and apex of the wings and the prominent spur on the trochanter; 2) G. inermis, which also has cloudy patches on the wings but lacks the spur on the trochanter; 3) G. haemorrhoidalis lacks cloudy patches on the wings, the anterior basal cell is markedly

shorter than the discoidal cell and the tip of the abdomen is reddish; and 4) G. nasalis also has hyaline wings, but the discoidal cell and anterior basal cell are nearly equal in length. Flies of this genus are smaller than honey bees; they have rudimentary mouth parts, small antennae sunken in pits, and bare arista. The squamae are small, the ovipositor of females large and protuberant. All of them are strong fliers and spend the larval stage in the intestines and stomachs of horses.

Chandler (1950) describes the larvae of the genus Gastrophilus as being leathery, somewhat flattened, and not tapered from the posterior end to the anterior end. The body has rings of large, dark spines and stigmal plates in contact, each with three bent slits.

Common horse botflies or nit flies, Gastrophilus intestinalis are widely distributed. Adults are commonly seen in the United States from June to September. The light yellow eggs are attached to hairs on the median surface of the knees, however, forelegs, belly, flanks, shoulders, and other parts accessible to the tongue, teeth and lips may be used. Hovering a few feet from the horse, the female darts in

repeatedly, each time attaching an egg to a hair. Nearly 1000 eggs may be deposited in less than three hours in this manner. Saliva seems necessary for the hatching of eggs. During warm weather, the incubation period is seven to fourteen days, but a cold season may extend this period to late autumn. Upon hatching, the larvae burrow into the tongue, then proceed rapidly to the left sac or oesophageal portion of the stomach where they remain until the following spring or early summer at which time they detach themselves and pass out with the feces. The mature larvae, which is 1.5 to 2 cm. in length, pupates soon after it is eliminated from the horse. Three to five weeks are passed in loose soil or dried droppings before the adult emerges.

Gastrophilus haemorrhoidalis is commonly known as the "nose fly" or "redtailed bot". The female of this species "strikes" the horse in the region of the nose, attaching her black eggs to the fine hairs of the lips or thrusting the screw-like stalk of the egg into the flesh. Mature larvae do not pass directly from the stomach to the ground as in the preceeding species but attach themselves close to the anus before finally dropping to the earth.

Gastrophilus nasalis is widely distributed, reaching considerable abundance in the Rocky Mountain Region. These chin flies or throat botflies are particularly annoying to horses because of their egg laying habits. The fly darts at the throat and attaches its eggs to the hairs beneath the jaws, causing the horse to throw back its head as though it were struck on the chin. Oviposition takes place in the spring or early summer. The eggs hatch in four to five days without moisture, and the newly hatched larvae crawl up the jaw and into the mouth between the lips. Without burrowing into the skin, they go directly to the pyloric portion of the stomach and the anterior end of the duodenum where they gather in groups and remain for the ten or eleven days required to mature. They are voided with the manure during early summer, and within a few hours begin the three week pupal period.

Gastrophilus inermis, a European species recently found in Illinois, lays its eggs on the cheek hairs of horses. The larvae penetrate the epidermis, molt once in the epethelial layer of the cheek, then migrate to the rectum where they stay until mature. They, then, drop to the ground and pupate like the species above.

Collecting - Horse bots may be obtained from fox farms, mink farms, and other places where horses are slaughtered for animal feeding. Sometimes a hundred or more are found in the stomach or intestine of one horse.

Holding - No tests were run on holding technics for horse bots but their body textures are so much like cattle grubs that there is little doubt but what the same holding method will apply in either case. Tests run on cattle grubs indicated that a damp, cool (34°F.) situation is the most desirable means of holding larvae of this type and that under such conditions they will keep for at least three weeks.

Quality as a Bait - Horse bots or "magic honey bugs" are an excellent winter bait for bluegills, however, they do not enjoy a widespread popularity. The few bait dealers that have introduced them sell large numbers.

## EUROPEAN CORN BORER, Pyrausta nubilalis

Life History - The European corn borer was first discovered in this country near Boston in 1917 and was probably introduced from Europe. The larvae of this moth feeds on various thick-stemmed grasses, weeds, ornamental plants, sorgham, teosinte,

celery, beans, potatoes, spinach, dahlias and similar plants. Corn, however, is the plant in which it is most frequently found. Herrick, (1925) describes the female as a small yellowish moth with a wing expanse from three-fifths of an inch to slightly over an inch. Reddish zig-zag lines are borne on the fore wings and wide reddish areas run along each outer margin. The hind wings are more pale. Full grown larvae are about one inch in length and dirty white or pink in color with a dark brown or black head. Brownish dots run along each side, and the entire body is sparsely clothed with hairs. According to Mosher (1919), the larvae has five pairs of prolegs, four abdominal, and one anal (Figure 14). These are armed with chitinous hooks or crochets. There are two setae in front of, or occasionally, slightly below the thoracic spiracle; one of these is small and difficult to locate. The crochets of the prolegs are arranged in nearly a complete circle. All thoracic segments are approximately the same width and the head is of normal size. The chitinized shield of the tenth abdominal segment is usually emarginated, and the anterior setae and punctures of the head are arranged in nearly a straight line. The pupa of P. nubilalis has an average length of 13 mm. in the

male and 15 mm. in the female. When young, they are yellow tinged with brown on the head and cremaster. The older pupa are quite brown on the dorsal surface.

Shortly after the moth emerges from the pupa, she mates, then deposites her small, flat, pale yellow eggs in masses of 15 to 20 on the undersides of leaves and on the stem of the plant. This takes place in the later part of April or early May at which time each female deposites 500 to 1000 eggs. The incubation period is from four to twelve days depending on the temperature. It takes 38 days for the young caterpillars to attain full growth, after which, they may pupate or pass the winter, depending on the strain of the corn borer. If the larvae pupates, it spends about 11 days in that stage, hatching out in August. It then lays a second batch of eggs and dies a few days to two weeks later. Upon hatching, the larvae bores a small hole in the stalk of the corn and proceeds to channel out the pith. The stem is so weakened that it often topples over just below the tassel or in the upper part. Larvae also tunnel through the ears of corn and cause damage similar to that of the corn ear worm.

The European corn borer up to the present time has extended

its range so that it now covers the northeastern quarter of the United States. They may be found west as far as the Dakotas and south to Tennessee.

Rearing - An attempt was made to propagate corn borers artificially, but it was met with negative results. Corn meal was placed in the bottom of a quart milk bottle and ten larvae added to it. Strips of corrugated cardboard were provided for the larvae to pupate in and the top of the bottle was kept stoppered with a wad of damp cotton batton. Seven of the larvae pupated within a period of two weeks but only two of these chose to make use of the corrugated cardboard. Three climbed to the top of the bottle and pupated between the glass and cotton; the other two formed cases between the corn meal and the side of the bottle. Only one male and one female attained adulthood but the female died two days before the male emerged. The rest of the corn borers either died as larvae or within the pupal case. Work done by Smith (1937) would indicate that the failure of this technic lies in the fact that the bottle was not supplied with sufficient aeration. Smith's method of propagation produced numerous larvae, but it is too complicated and requires too much attention to be practical for the purposes

of most fishermen or bait dealers. It requires the use of a rearing cage, an incubator, a cage for oviposition, and individual vials for each of the larvae.

Holding - Corn borer larvae can be collected from infested corn stalks during the winter when the bait is needed and held throughout the season. Bait dealers keep their corn borers in cans with perferated lids. Pith from corn is placed in the can with the larvae. Stock supplies should be kept in a cool damp place to prevent drying out. It is not known that corn borer larvae have ever been used as summer bait but tests indicate that it is not practical to attempt holding them that long. Ten of these larvae were placed under refrigeration at 34°F. on February 20. Examination on June 3 indicated that all but three were dead. Only two showed signs of shriveling that may have been caused by drying; the rest were plump but black in color.

Quality as a Bait - Corn borers are considered one of the top winter bluegill baits and are also taken by other panfish. A scarcity of them this year has put the price at 80 cents a dozen.

Figure 14. Corn Borer. X 2.5
*Pyrausta nubilalis*

Figure 15. "Sand grub". X 2
*Trox sp.*

## SAND GRUBS, TROGIDAE

Life History - Sand grubs belong to a small family of insects known as skin-beetles. Adults are 8 to 12 mm. long with rough, dark outer surfaces usually covered with dirt not easily removed. The head is withdrawn in the thorax up to the eyes, and flattened fore legs appear beneath the head. Trogids, according to Comstock (1950), feed upon dried, decomposing animal matter. They are found about tannery refuse, and upon the hoofs and hair of decaying animals. Eggs and larvae develop in the same situation. The larvae is a small dirty-white grub 15 to 17 mm. long and has a dark brown or black head (Figure 15).

Rearing - No literature has been published on the rearing of this insect; and the bait dealers consulted, are non-committal as to where they obtain them, though, some stock sand grubs in fairly large numbers. The answer most often given is that they collect them from dead animals. It is quite probable that an outdoor bed may be prepared that will produce sand grubs. Professor Morofsky (Personal communication) has told the author that such a bed may be prepared by placing a bunch of animal skins on a box of sand. He says the adults will gather there and lay their eggs. An attempt was made by the author to rear

sand grub larvae in a jar with a piece of squirrel hide on top of dirt. Within two weeks mold killed off the culture.

Holding - Bait dealers hold sand grubs in sawdust where they keep well for about three or four weeks without drying out. Those tested under refrigeration at 34°F. lasted about the same length of time.

Quality as a Bait - Sand grubs are a good winter bait for bluegills and perch, but fishermen consulted agree that other baits are superior. The price in the Lansing area is 30 cents a dozen.

## GOLDENROD GALLS, Eurosta solidagines and Gnorimoschema gallaesolidaginis

Life History - Goldenrods grow abundantly on flood plains, wet meadows, dry thickets, slopes, railroad grades and empty lots. On the stem of this plant may be found two types of gall. That of the small fly, Eurosta solidaginis, is rounded, with an average length of 28 mm. and an average width of 25 mm. (Figure 16). Two or three of these ball galls may be found on one stem. The gall of the moth Gnorimoschema gallaesolidaginis is somewhat spindle-shaped with a length of 30 to 50 mm. and a width that seldom exceeds 7 mm. (Figure 17). According to

Figure 16. "Ball gall". X 2
*Eurosta solidagines*

Figure 17. "Stick gall". X 1.5
*Gnorimoschema gallaesolidaginis*

Weigel and Dilks (1950), the cause of gall formation is not definitely known; but it is believed that this swelling is produced by growth stimulating substances secreted by the insect or by an irritation of the plant tissue by the insect.

In the spring Eurosta solidaginis, according to Matheson (1948), lays her eggs in the apical rosette of leaves of young plants. Upon hatching, the larvae burrows down the stem, and where it stops, a gall is formed about it. Here, the larvae continues to grow until mature, then, preparation is made for hibernation. A tunnel is cut to the surface of the gall, and a tiny cap, thin enough for the adult fly to push through when the time comes, is left for protection. Hughs (1934) states that pupation does not occur before March and that it is the middle of April before the adult emerges. Larvae are described by Phillips (1946) as "barrel-shaped, 8 mm. in length by 4 mm. in diameter; pearly white and with intersegmental lines running around the body in a changing zig-zag fashion." It has a small mouth hook which is widely arched on the dorsal margin and about as deep as it is long. The pupa is brownish-orange in color and has a small brown spot at the end through which the adult emerges. It is capsule-shaped and slightly

smaller than the larvae. Comstock (1950) separates the adults of this family (Trypetidae) by the subcostal vein which is turned abruptly forward and usually becomes very weak. It is a small fly much like the well known "fruit fly", Drosophila. Legs are moderately long; tibia lack preapical bristles; ovipositor flat and more or less projecting; and wings pictured.

The solidago gall-moth, Gnorimoschema gallaesolidaginis, belongs to the family Gelechiidae which is described by Comstock (1950) as a smooth headed or at most slightly ruffled moth with long, curved, ascending labial palpi. The hind wings are somewhat trapezoidal with the outer margin usually sinuate or emarginate below the apex. "In the fore wings the second anal vein is forked at the base, i.e., the tip of the third anal vein unites with it; and in some forms, veins $R_4$ and $R_5$ coalesce throughout their length, but they are usually stalked."

Comstock states that eggs of G. gallaesolidaginis are laid on the old plants in the fall and hatch in the spring. The newly hatched larvae crawls to a new shoot, bores down it a little way and starts a gall growth. Maturity is reached about the middle of July; but before pupating the larvae tunnels through the upper end as does E. solidaginis. In this case,

however, the outer opening is closed with a silk plug. There appears to be some variation in the life cycle as given above, since, at this latitude, mature larvae are found in the galls all winter. Possibly in the northern states two years are required to complete the life cycle. Mature larvae are over 12 mm. long and about 2 mm. wide. The body is yellowish except for two brown triangular patches just posterior to the head. The eyes are dark brown. Thoracic legs are present and prolegs appear as four pairs of tiny dots.

Hughes (1934) lists several insects found in goldenrod galls which may be parasites, predators, or just visitors: A stem-boring beetle, two chaliced wasps and a braconid wasp. Woodpeckers frequently remove gall inhabitants. E. solidaginis is absent from its gall more often than not, but G. gallaesolidaginis is usually present when its spindle-shaped cell is opened.

Little work has been done on G. gallaesolidaginis, and the distribution is not known. E. solidaginis, however, has a fairly wide distribution, being found throughout the range of the goldenrod, Solidago canadensis. Fernald (1950) gives the distribution of this plant as: Newfoundland to Manitoba, south

to Nova Scotia, New England, Virginia, West Virginia, Illinois, Minnesota, South Dakota, and Colorado.

Rearing - It is doubtful that artificial rearing of either gall insect is desirable although Leiby (1937) has described a technic for the stick gall. As many of these larvae as are needed can be collected at the time of year the demand is greatest.

Holding - Both species can be kept all winter in a cool damp basement; warm, dry rooms cause the larvae to dry out and die. If gall larvae are to be used for summer fishing, refrigeration is necessary to keep them from hatching out. On February 20 three pint jars of each species were exposed to the following conditions: Jar 1 was held at room temperature, Jar 2 was kept in a damp, cool basement, and Jar 3 was refrigerated at 34°F. Once a week a few galls from each jar were examined. After two weeks those in Jar 1 showed signs of drying out; and by the end of the third week, all were dead. By the middle of March, many larvae in Jar 2 had hatched; and by the end of March all that were not dead, had hatched out. On June 3 the gall larvae in Jar 3 were still alive and usable as bait.

Quality as a Bait - Both of these gall larvae are fairly good

bluegill baits according to those who use them, but the general opinion seems to be that there are better baits. Galls have the advantage of being very abundant during the winter fishing season when they are needed. The fact that galls are easy to collect coupled with the fact that most fishermen know where to collect them has kept the retail price down around 10 cents a dozen. Bait dealers do not like to handle the ball gall, E. solidaginis, because it is so frequently empty; but many dealers stock stick galls, G. gallaesolidaginis. Gall larvae are not used as a summer bait, probably because they are not available at this time of the year; but since it has been found that they can be collected in the winter and held until summer, fishermen would do well to at least try them this time of the year, too.

## NUT WEEVILS, Curculio

Life History - Species of the genus Curculio (Balanius) may be found abroad from early spring until late fall feeding on and laying their eggs in acorns, walnuts, hazelnuts, hickory nuts, and chestnuts. They also feed on all other parts of the plant. Craighead (1950) states that this beetle is a rich,

light brown, mottled and spotted with gray or yellowish brown hairs. All species look somewhat alike. They have stiff beaks bearing at the tip the mouth parts which, consist in part of a strong pair of jaws. Craighead says,

> "The body is robust, and in some species the beak of the female is much longer than the body; in others it is the same length or shorter. The beak of the male is always shorter than the body. The elbowed antennae are very long and slender, and in females are inserted well back of the middle of the beak; in the male they are usually inserted at or near the middle of the beak."

Mandibles move vertically instead of horizontally as in most Coleoptera. Brooks (1910) states that the head is rounded and fits into a concavity in front of the thorax like a ball and socket joint. This permits the head to revolve more than a fourth of its circumference. To pierce a nut the beetle presses the point of the beak against the surface and rotates the head until a hole is drilled to the desired depth. Shells one tenth of an inch in thickness and hard as bone can be pierced with this instrument. Upon completing the hole, the female with her telescopic ovipositor places the egg within. Some species are host specific, others are not. If nuts are scarce, less discrimination is shown in the selection of food and of nuts for oviposition. Some species deposit their eggs

in half grown nuts while others use those which are quite matured. The type of hole bored varies with species. Some make a single hole and place one egg in it; others make branched punctures containing a dozen eggs.

Eggs, larvae, and pupa of different species of curculios are much alike. The eggs are small, elongate, and translucent-white with a polished surface and fragile shell. Size and shape varies, but in most cases these variations are hardly noticeable. Within one to two weeks eggs hatch. The larvae stays in the shell until fully grown after which it cuts a circular hole in the shell, emerges, and goes into the ground to hibernate. Curculio larvae are all robust, white, creamy-white, or yellowish-white grubs with red or brown heads. Sizes vary somewhat. The pupal stage lasts for about two weeks; but after transforming to adults they remain in their earthen cells for several days; often until a warm rain softens the earth. They then emerge from the ground and go to the trees.

Species of Curculio may be found in one form or another throughout the country.

Rearing - Nothing is known regarding the rearing of this insect.

Holding and Quality as a Bait - This bait is not used in the

Lansing area; and the author is not familiar with it; but it is used in other parts of the state as a winter bait for panfish and was, therefore, included.

## OAK OR MAPLE TWIG PRUNER, *Hypermallus villosus*

*Life History* - Eggs of oak twig pruners, *Hypermallus villosus* (*Elaphidion villosum*) are deposited in July on the small twigs or leaf axils of apple, pear, plum, peach, grape, quince, orange, osage orange, hickory, chestnut, locust, sassifras, and sumac. Felt (1926) states that the grubs feed for a time under the bark, then, bore along the center of the twigs making oval channels in the wood. By late summer, the borer has eaten away much of the woody fiber and plugged the end of its burrow with castings. The next high wind blows the twig to the ground. Pupation occurs in the fall or early spring within the twig. Oak twig pruners may be located after mid-summer by the small clearly cut twigs one inch or less in diameter scattered about beneath the infested tree. Craighead (1950) describes the oak twig pruner as "an elongate, sub-cylindrical, brownish beetle from 10 to 17 mm. in length, having spines on the first few antennal joints and at the tip of the

elytra. . The thorax is nearly cylindrical." Forbes (1911) says it is "sparsely covered with coarse white or yellow hairs which show a tendency to collect in irregular clumps or spots." The posterior tip of each fore wing is concave between two stout, sharp spines of which the outer is usually larger. Larvae according to Craighead (1950) are elongate, slender forms of shining texture. The head is wider than long and has two ocelli on each side. The apex of the mandible is rounded, the pronotum shining, somewhat striated, and bears an X-shaped impression above. Legs are present.

Hypermallus villosus may be found throughout Eastern and Central United States.

Rearing - No work was done on a rearing technic for this species.

Holding - Oak twig pruners can be held in a damp cool basement or in a refrigerator the same as goldenrod galls. They should not be removed from the twig in which they are encased.

Quality as a Bait - This bait does not enjoy the widespread popularity of some baits. In this part of the state the fisherman or bait dealer who has heard of oak twig pruners is very rare, but good catches of bluegills have been reported further north on this bait in the winter. The price of them is about 35 cents a dozen.

## FLATHEADED WOODBORER, BUPRESTIDAE

Life History - Flatheaded woodborers are the larvae of a metallic colored beetle with a hard inflexible body produced by a ventral fusion of the first and second abdominal segments. This beetle may be found upon flowers and the bark of trees on sunny days. Some metallic woodborers fly off with a loud buzzing noise when disturbed; others drop to the ground feigning death (Comstock, 1950). Adults feed on foilage or the bark of twigs, but most larvae are borers, feeding beneath the bark or within the solid wood. The white, legless, hammerheaded or flatheaded larvae give this family its common name. This flattened portion, however, is not the head but the first two thoracic segments which are more widened and flattened than the succeeding segments. From the thorax back there is a gradual narrowing and rounding of the body producing a tadpole-like appearance.

The flatheaded apple-tree borer, Chrysobothris femorata is the woodborer larvae most used as bait and is probably the best known flatheaded borer in America. Adults, according to Doane, Van Dyke, Chamberlin and Burke (1936) are oval, flattened, dark grayish-bronze beetles about ten millimeters long and

five millimeters wide. The wing covers are marked with two wavy bands, light in color and slightly depressed. Several small teeth are mounted on the fore legs of males, but both adults have green heads. The eggs are pale yellow with a wrinkled disk-like form and a diameter of about one millimeter. They are laid in June and July in crevices, under flakes of bark, or at the edges of wounds of apple, pear, quince, maple, oak, hickory, chestnut, or other trees. From 12 to 20 days are required for the eggs to hatch. A young larvae upon emerging bores through the bark and into the wood. As it burrows, it grows; and as it grows it enlarges the tunnel to accomodate the increase in size. Full grown larvae are yellowish white and about 25 millimeters long. A "V" on the dorsum extends to the outer margin of the rugose area. At the end of the summer, after reaching full growth, the larvae forms a cell in the outer wood, sealing itself in by a plug of borings. In the spring there is a period of pupation which may last from two weeks to two months depending upon the temperature. The young adult spends one or two weeks in the pupal cell before emerging.

Flatheaded woodborers are found throughout the United States.

Rearing - The life cycle of woodborers is too long to make rearing practical.

Holding - No tests were run on holding technics for woodborers, but sportsmen usually keep them in sawdust in a cool, damp place.

Quality as a Bait - Bait dealers in the Lansing area claim that the demand for woodborers is not great enough for them to bother handling this bait. The author was unable to purchase any at bait stores in this area. They are used to some extent, however, as a winter bait for bluegills and other panfish.

## LONG-HORNED BORER, CERAMBYCIDAE

Life History - Cerambycid adults are usually elongate and cylindrical. The antennae exceed the length of the head and thorax combined and nearly always are as long as or longer than the entire body. All tarsi are five segmented and tibial spurs are present. They are medium to large sized beetles graceful in appearance, and often beautifully colored. The larvae are all wood borers with strongly sclerotized heads and powerful jaws, but soft, creamy-white bodies. Their cylindrical bodies are slightly flattened and generally lack true thoracic legs. Deep creases separate the body segments; and large,

flattened sucking discs may be found on the upper, lower, and lateral surfaces (Doane, Van Dyke, Chamberlin, and Burke, 1936). Toward the posterior end there is a gradual tapering of the body. This family infests orchard, shade, and forest trees.

The life history of the round-headed apple-tree borer, Saperda candids, as given by Matheson (1948), is fairly typical of other cerambycids. Adults emerge in May or June (April in the South) and live for a month or more. When ready to lay her eggs, the female cuts a slit in the bark of a tree with her mandibles, drives her ovipositor in as far as possible, and releases one egg. The process is repeated until 40 to 60 eggs have been laid. In about two weeks the larvae hatch out and start tunneling. By the end of the first summer, sap wood is reached; here the larvae hibernates at the end of its burrow until spring. During the second season, tunneling continues in the sap wood and extends up the trunk. Towards autumn the larvae burrows into the hard wood where it passes the second winter. All the following summer is spent tunneling in the hard wood; and by late fall, a mature length of 30 to 35 mm. is reached. The pupal chamber is directly under the bark at the end of the tunnel. In the spring the larvae passes through a

short pupal stage, then, as an adult, the insect cuts its way through the bark and emerges. Three years are required to complete this life cycle in the south and four years in the north. Cerambycids differ greatly in respect to length of life cycle; some are one year while others are as high as seven.

Rearing - The length of the life cycle makes rearing impractical.

Holding - No tests were run on holding technics for woodborers, but sportsmen usually keep them in sawdust in a cool, damp place.

Quality as a Bait - Bait dealers do not handle this bait in the Lansing area because there is little demand for it. In former years flatheaded woodborers were used to some extent as a winter bait for bluegills and other panfish.

## MEALWORMS, Tenebrio molitor and Tenebrio obscurus

Life History - Because of their tendency to seek out dark places, the family Tenebrionidae to which the mealworms belong has been known as darkling beetles. Both the larvae and adult mealworm are found beneath sacks of grain, under grain boxes, in grain, and other related foods. Two species of the genus

Tenebrio interest bait fishermen. The yellow mealworm, Tenebrio molitor, according to Black and Cotton (1922), is a polished dark brown or black beetle little more than a half an inch long with longitudinally striated wing covers. The dark mealworm, Tenebrio obscurus is similar in form, size, and color but differs in being dull pitchy black instead of polished dark brown or black. Males can usually be distinguished from females by the comb-like row of hairs along the inner edge of the tibia. To make a positive identification, however, the genitalia should be examined; for in addition to the females, some males lack this row of hairs. If the underside of the abdomen is pressed gently with the tip of a pencil, the valve covering the sex organs is revealed. In the male this valve is cut in the mid-line by a V-shaped incision. The valve of the female is smooth and curved possessing no such cut (Cotton and St. George, 1929).

Cotton and St. George (1929) state that mating takes place a few days after emergence and is repeated at intervals throughout the life of the beetles. The average length of life of T. molitor is two months; T. obscurus lives about three months. During this time, eggs are laid at irregular intervals

Figure 18. Mealworm. X 2
*Tenebrio molitor*

over irregular periods. The number of eggs laid per day varies from 1 to 62. T. obscurus in a lifetime has laid as high as 970 eggs and as few as 73, the average number being 463. Numbers laid by T. molitor average 276, 576 being the greatest number per female and 77 the smallest. Eggs may be laid singly or in small clusters either in the food or along the sides of the storage bin. Black and Cotton (1922) describe them as bean-shaped white eggs covered with a sticky secretion which causes the flour or other food in which they live to adhere to them. Within about two weeks eggs hatch into slender white larvae two to two and a half mm. long. Cotton and St. George (1929) state that they begin to feed at once, and acquire a yellowish brown color. When fully grown, the larvae of both species are one to one and a half inches long. T. obscurus is dark brown, shading to much darker brown toward each end and at the articulation of each segment. T. molitor is bright yellow, shading to yellowish-brown toward each end and at the articulation of each segment (Figure 18). After each molt, the larvae are white but soon attain their normal coloring. Both larvae and adults feed on meals and flours of all kinds: bran, refuse grain, coarse cereals, bread, crackers, mill sweepings, meat scraps, dead insects, and feathers. About

three months are required for larvae to mature, after which, they continue feeding and molting until cold weather causes them to hibernate. In the spring they change to pupa and remain as such for two weeks (Black and Cotton, 1922). Cotton and St. George (1929) state that a short prepupal period of sluggishness is passed at the surface of the food. Newly formed pupa are white except for the tip of the caudal spine and tips of the lateral appendages. With age, pupa turn yellowish brown, but throughout the pupal stage they are always naked and unprotected by pupal cases. The length of the pupa is about 14 to 20 mm. Adults hatch out in May or June, T. obscurus usually is a month earlier than T. molitor.

T. obscurus is found all over North America but T. molitor does not breed freely in the South and prefers the cooler climates of northern states.

Rearing - Considerable work has been done in past years on culture methods for mealworms. Several technics have been devised which bait dealers or fishermen will find most satisfactory. Both yellow and black mealworms have been raised successfully.

The proper diet, described by Martin and Hare (1942),

contains not less than 50 percent carbohydrates, and not less than 15 percent nor more than 25 percent protein. Fats in excess of 3 percent inhibit growth. Diets that have been used successfully are: white wheat flour with 5 percent dry yeast, crushed dog food pellets, wheat bran, corn meal, and oat meal. The first two seem to produce the best results. A 15 gram portion of food will carry 25 larvae to the adult stage; but to complete the life cycle, 25 to 30 grams should be supplied for this number of individuals.

Moisture is of major importance, although it is not of significance to immature stages, adults cannot do as well without it. Accessibility to water is not necessary, it seems rather to be a high humidity that is demanded. Water should not be allowed to touch the food, since, it will become moldy or ferment killing the insects.

A wide variety of rearing containers have been used. Large cans, old bread boxes, milk bottles, gallon jars and similar containers are all suitable. All containers should be supplied with lids, since, adults do fly occassionally. Moisture may be supplied in large containers by a damp sponge placed on a glass plate. In the case of gallon jars with screw

on tops, a sponge may be wired to the lid. For milk bottles, a plug of dampened cotten batten in the top of the bottle will keep the humidity within safe limits, but it must be moistened every four or five days. Neither the sponge nor the cotton plug should be saturated to the extent that water drips down on the food.

The initial supply of larvae or beetles placed in each container will depend upon the size of the container and the amount of food supplied. Twenty or thirty are plenty for a one gallon jar half full of food. Martin and Hare (1942), used two five-gallon cans with two hundred grams of beetle diet (white flour and five percent brewer's yeast) per can. They placed 1500 beetles in each can and within ten weeks counted 500,000 small larvae. For optimum results in rearing mealworms, a constant temperature between 80° to 88°F. should be maintained. The incubator discussed under the rearing of waxworms may prove useful for this purpose. At the above temperature, eggs require from four to seven days to hatch, and larvae reach maturity in about six months. The pupal period is six to eight days.

Holding - After reaching bait size, larvae may be held at this

stage under refrigeration for an indefinate length of time. On February 20 eight apparently mature larvae were placed in each of two bottles with corn meal. The first bottle was refrigerated at 34°F.; the second bottle was held at room temperature. Three weeks later all of the larvae in the second bottle had hatched; and after a month and a half, examination revealed a large number of tiny larvae in the corn meal. Three months later, the first bottle was examined. All of the larvae were alive, and none of them had pupated.

Quality as a Bait - At one time, mealworms were a very popular winter bait for bluegills, but bait dealers state that within the last few years the demand has dropped considerably. Apparently better baits have replaced them to a large extent. Some fish are taken on mealworms in the summer, but, here too, better baits are to be had. At the present time in the Lansing area, mealworms sell for 15 cents a dozen.

## WHITE GRUBS, Phyllophaga

Life History - White grubs are the larvae of the well known June beetle or May beetle. They belong to the family Scarabaeidae and the genus Phyllophaga which has over a hundred

species in this country. The family is most easily recognized by the lamellate club of its antenna which is composed of from three to seven thin plates (Matheson, 1948). It is a clumsy, stout bodied beetle, 12 to 25 mm. long, pale reddish, brownish to almost black in color, with yellowish wings sticking out beneath polished wing-covers. The bulk of the adult population appears in May, however, some are found throughout June, July, and August. At dusk, the beetles emerge from their diurnal retreats in the soil to swarm about street lamps, dash against lighted screens, or crawl over the foilage of trees. When the first bird signals the dawn, a hasty retreat is made back to the soil. Adults, according to the U.S. Department of Agriculture (Yearbook of Agriculture, 1952), feed upon the foilage of oak, hickory, poplar, elm, willow, locust, blackberry, pine, walnut, and others.

Forbes (1907) states that copulation takes place on the foilage of trees and believes that repeated fertilization is necessary since eggs are laid a few at a time for an extended period. Mating probably does not occur until a month after adults first appear in the spring. The preferred site for oviposition is in sod soil at a depth of one to eight inches.

Each egg is enclosed in an earthen ball half an inch in diameter. The egg is milky colored and oval shaped, 1 1/4 x 2 mm. when fresh, later swelling to 2 x 2 1/2 or 2 3/4 mm. Females deposit from 44 to 67 of these eggs in June or July. They hatch in 10 days to 4 weeks and the larvae start feeding on decaying vegetation soon afterwards, later attacking living roots. By winter the larvae are 1/2 an inch long. They then burrow deep in the soil, sometimes to a depth of five feet, and pass the winter. With the coming of spring, they return to a few inches beneath the surface where they spend the summer actively feeding on the roots of grasses or grains, or potatoes, carrots, and others, often doing much damage to pastures, lawns, and golf courses. By the second winter, they are one inch long; their bodies are white, heads brown, and six prominent legs are present. "The hind part of the body is smooth and shiny, with dark body contents showing through the skin" (Metcalf, Flint, and Metcalf, 1951). The second winter, too, is spent deep in the soil. With the coming of spring the grub returns again near the surface where it continues to feed until June or July, then, pupates in a rough oval cell in the earth. Adults emerge from the pupa in August or September but

remain in the pupal cell until the following spring at which time the three year life-cycle is completed. In the South this life-cycle is completed in two years, but in the northern part of the range four years are usually required.

Collecting - White grubs can be collected by digging in or rolling back sod, by following a plow, or by turning over dried "cowpies" in a pasture. The latter is the easiest method, though perhaps for some not the most acceptable.

Holding - No tests were run as regards the length of time white grubs may be held under varied conditions. Bait dealers say that they are difficult to keep for extended periods and that "soft dirt" (probably free from sand) should be used for the best results. Wood, fiber, or paper containers should not be used to hold or transport grubs because they can cut their way through such materials. In The Wise Fisherman's Encyclopedia (1951) it is recommended that white grubs be given the same sand box treatment as discussed under the rearing of earthworms. When given such treatment, they shrink in size becoming tough and yellow.

Quality as a Bait - White grubs are one of the best summer baits for bluegills. Most fishermen prefer to collect their own but

some bait dealers handle them. They usually sell for about 25 cents a dozen.

## CRICKETS, *Gryllus*

*Life History* - The genus *Gryllus* is represented by many different forms. It includes those crickets commonly known as field and house crickets. They are of medium to large size, robust in form, and dark colored. The hind tibia is armed with strong, fixed spines and the first segment of the hind tarsus has two rows of teeth above. Each fore tibia bears two auditory tympana (Comstock, 1950).

As regards the habits of field crickets Blatchly (1920) quotes Bruner as saying:

> "Usually most of our North American *Grylli* live singly or in pairs in burrows which they dig for themselves. These are used as retreats during the daytime and serve as shelter from ordinary inclemencies of weather. These burrows are generally forsaken about mid-summer for some sort of above-ground shelter. From this time on, until fall, they appear to be more social and live in colonies under various sorts of rubbish. During late summer and fall the females commence preparations for the continuance of their kind by thrusting their long, slender ovipositors into the loose soil and dropping their eggs. These sometimes hatch the same year, but, as a rule, lie over until the following spring. The young generally live above ground, where they hide among fallen leaves, grasses, and other debris, though sometimes they also creep into chinks and crevices in the earth."

Blatchly states that these remarks of Bruner apply in Indiana mostly to the form G. lectuosus and that G. pennsylvanicus and vernalis usually hatch in autumn and pass the winter in the nymphal stage, while G. domesticus, the house cricket, spends the winter either as adult or nymph. Matheson (1948) states that G. assimilis, common black field cricket may hibernate in either the adult or nymphal stage, but as a rule passes the winter in the egg stage.

Rearing - The common black field cricket (Gryllus assimilis) has been raised successfully with a simple and inexpensive type of equipment. Garbage cans, lard cans, metal drums, small metal tanks, or metal lined boxes may be used for rearing cans as long as the depth is not less than 18 to 24 inches. The container should be placed in the basement or garage in such a way that ants, spiders and various parasites can't get in. A window screen over the top of the container will go a long way toward keeping out unwanted visitors. Ants which kill crickets may be kept out by dusting insect powder on the floor about the container, taking care not to get any powder in the can. The top of the can should be sanded smooth and waxed down to a distance of 8 to 10 inches to prevent the crickets from climbing out.

About four to six inches of clean, fine sand is placed in the bottom and moistened until it feels damp to the touch. Crickets will not lay eggs in dry sand. No more than one wetting should be applied per generation, for young crickets are susceptible to diseases when exposed to dampness. It takes about 15 to 25 days for the eggs to hatch, and within three months the young will be mature enough to lay. Another wetting should then be applied. About four to five inches of wood excelsior is placed over the sand to provide cover and additional surface for the young to rest on.

Water may be supplied by the glass-jar drinking fountains used for poultry. Cotton placed in the saucer to a point slightly above water level prevents the young crickets from drowning. The fountain should be cleaned and filled every four to eight weeks.

A saucer or tray of poultry laying mash placed on the sand in the bottom of the can will supply them with a satisfactory food. Excellsor is then drawn about the food to make it readily accessible to the crickets. When young, they will consume a saucerful of mash in two or three weeks. Older crickets will eat that much in four or five days.

Each rearing can up to two feet in diameter should be stocked with from 20 to 30 adults. Mature crickets have well-developed wings; the immature stages are wingless or have wing patches. Equal quantities of males and females should be supplied. Females may be identified by their ovipositors. The containers should be examined every three or four days for the first two weeks and the dead ones removed.

In the summer crickets will do well without additional heat unless they are kept in a cool place where the temperature remains less than 80°F. Growth practically ceases at temperatures below 70°F. If they are to be raised all year around, containers may be heated efficiently with electric light bulbs. They will regulate their own temperature by moving toward or away from the bulb according to their needs. The bulb should be hung five or six inches above the excelsior both to prevent fire and to prevent the crickets from climbing out of the container on the light cord. The can should be covered with paper, cloth, or cardboard to seal in the heat. A 100 watt bulb is large enough to heat a container two feet in diameter and two feet in depth in an unheated room. If the crickets do not move toward the bulb during the coldest periods, the container is

being kept too warm and a smaller bulb should be used. At temperatures of 90°F. growth is reduced and the life of the cricket is shortened. A bulb will last about two weeks under continuous operation.

When the crickets have attained proper bait size, the heat may be removed. They will then become sluggish and grow very little. It is desirable to raise a large stock in the warmer fall months to avoid the cost of heating during the cooler parts of the year. They may be held in a cool room through the fall, winter, and early spring. Extra supplies may be raised in heated cans, if the stock gets too low.

Four broods of crickets may be raised in the same can without cleaning it but larger broods are produced if the container is cleaned after every two or three generations. Four hundred crickets may be produced every three months in a can 24 inches in diameter. About two pounds of laying mash are required for each 100 crickets produced.

This rearing technic for crickets was developed by H. S. Swingle of the Alabama Polytechnic Institution.

Quality as a Bait - Crickets are taken by all game fishes. Their frantic efforts on the water plus their ability to float

either when dead or alive make them most effective. The soft texture of crickets, however, makes it difficult to keep them on the hook; and under the rough treatment, they die easily. In nature they do not reach full size until the fishing season is nearly over, but artificial rearing technics offer to overcome this. Crickets in the Lansing area generally retail for one cent apiece.

## COCKROACH, BLATTIDAE

Life History - Cockroaches belong to the family Blattidae which in this country is represented by over 40 species. They may be recognized by their smooth, dorso-ventrally flattened bodies brown to chestnut black in color. The head is nearly horizontal and bent ventrally so as to place the mouth back between the first pair of legs. Long hair-like antennae composed of many short segments often exceed the body length. The outer pair of wings (tegmina) is thick and leathery and covers the membranous fan-like folds of the inner wings. Though equipped for flight, cockroaches prefer to make use of their extraordinary running ability. Hotels, laundries, restaurants, grocery stores, and homes are the haunts of better known species of Blattidae.

During the day they hide in crevices, beneath boxes, between boards, or any other narrow place that will conceal their flattened bodies. After dark hordes of them may come forth scampering across the floor or running along lunch counters sampling a great variety of foods. Not only do they eat provisions of all kinds; but books, wallpaper and other paste bound articles may show the effects of their omnivorous appetites. While eating, cockroaches have the disgusting habit of disgorging part of the meal from time to time and dropping their feces in most unwanted places. In addition, they secrete both from the mouth and scent glands a substance which imparts to the surroundings a most disagreeable pungent odor not easily eradicated.

According to Blatchly (1920), Blattidae differ from the usual method of oviposition carried on by Orthoptera in which one egg is deposited at a time. The eggs of cockroaches are deposited within a capsule or egg case called an ootheca. Capsules of different species differ in size and egg numbers but agree structurally in that each is divided lengthwise into two cells by a membranous partition. These two cells are further divided into a single row of pouches each of which

contains a single egg. Females carry the ootheca protruding from the abdomen for several days, finally dropping it in a dark corner or crevice. Herms (1948) believes that the female keeps her brood close together for a short time after hatching. Adults live a year or more during which time a great number of ootheca are laid. As high as 90 within the lifetime of one American cockroach has been recorded.

Newly hatched young are almost white and very soft, but they soon harden and darken to the color of adults, which they resemble in all respects except for size and the possession of wings. Development is slow. With the exception of the small German roach which may have two or three generations a year most roaches produce only one. In heated buildings there is no particular time of the year that may be designated as a mating season, and all stages of development may be observed at any time.

Blattella germanica, according to Blatchly (1920), may be found throughout the United States, being most abundant in the central states. A great variety of local names have been applied to this species. The most common are croton bug and German roach. In Russia it is known as the Prussian roach while

Figure 19. American cockroach.
*Periplaneta americana*

Figure 20. Crayfish.
*Orconectes propinquus*

in Germany it is referred to as the Russian roach. Nova Scotians call it the "Yankee settler". Sometimes it is known as the "water bug". Males are dull brownish-yellow; females are often darker. All limbs are paler than the body and the pronotal disc bears two dark brown, longitudinal stripes separated by a yellowish one. The antennae are dark brown, exceeding the length of the tegmina. Tegmina and wings of males extend to the end of the abdomen; those of females are slightly longer. Male bodies are longer and narrower than females. The ootheca of German roaches is light brown, a little over twice as long as broad, 7.5 x 3.5 mm., with flattened sides and parallel edges. Within it are 36 eggs arranged in two rows. Apparently eggs hatch the same night they are laid.

Periplaneta americana, American roach, is found throughout the United States but attains a greater abundance in the southern states than in the North. Its head is chestnut brown, tegmina shiny reddish-brown, pronotum broadly marginated on the sides and base and narrow in front with yellow enclosing a large, sharply defined bilobed spot (Figure 20). Legs and under surface are pale brownish-yellow and the middle of the abdomen is darker. The sub-elliptical pronotum is wide at the

middle and narrowed in front with all angles broadly rounded. Females are stouter, the head and pronotum broader, and the tegmina and wings stouter. The body length of females is 27.8 to 34 mm. as compared to the 29.7 to 34.2 mm. of males. The ootheca is 7.8 mm. long, 5.2 mm. wide and has a narrow sutural ridge with a row of circular discs.

Rearing - Cockroaches are easy to raise, and several suitable technics have been devised. Hutchins lists the American cockroach, Periplaneta americana and the German cockroach, Blattella germanica as the common species best suited for large scale rearing. He states that any container from which they cannot escape is suitable. Jars, large cans, trays, drums, or cages are satisfactory. These containers should have a narrow band of oil or vaseline applied to the inside just a few inches from the top to prevent the cockroaches from escaping. Cheesecloth or wire screening across the top keeps out mice which may reduce production by eating egg capsules. Containers two feet in diameter should be stocked with 50 to 100 adults. Their ability to withstand high population concentrations makes it unnecessary to divide stock cultures when the young appear. Sand or sawdust should be placed in

the bottom of the containers and loose coils of corrugated paper above this for shelter. Of the many foods suitable for rearing cockroaches, dog biscuit is one of the best. A diet consisting of 50 percent ground whole wheat, 45 percent dried skim milk powder, and 5 percent dry bakers yeast has been used by McCay and Melampy (1937). This mixture should be moistened, then allowed to dry to a crumbly consistancy before it is placed in the containers. Cockroaches require considerable quantities of water which may be supplied by a baby chick feeder (with cotten in the tray to avoid drownings) or vials plugged with loose cellulose wadding. When the vial is placed on its side, the plug provides a soft wet surface, yet retains the water. In large containers several vials should be used. Water supplied either by vial or chick feeder lasts a long time; since the food is not subject to mold, cultures need cleaning and replenishing infrequently. If a temperature of 80°F. is maintained, the young reach maturity within five to six weeks. The incubator discussed under the rearing of wax-worms may prove valuable for maintaining this temperature.

To remove cockroaches from the rearing cans, the corrugated coils are shaken over a small container rimmed with vaseline. Placing this container in the refrigerator for ten minutes or

adding a few ice cubes to it slows them down so they may easily be handled.

Quality as a Bait - Cockroaches are popular as bait only in certain localities. They are used on bluegills, sunfish, and other panfish with much the same success as is obtained with crickets. The price at which bait dealers sell cockroaches, fluctuates with the demand. It usually is concurrent with the price of crickets, one cent apiece; but in some Southern States, 50 cents a dozen is charged.

## CRAYFISH, ASTACIDAE

Life History - The old genus Canbarus has recently been split into the following genera: Troglocambarus, Procambarus, Cambarellus, Cambarus, and Orconectes (Pennak, 1953). All of these genera may be found east of the Rocky Mountains where, according to Storer (1953) the various species inhabit six different ecological situations: 1. ponds, lakes, and slow rivers; 2. swift streams; 3. large rivers; 4. upland streams; 5. marshes and meadows where they burrow one to three feet down to water and build "chimneys" of mud at the surface; and 6. the water of underground caves.

Most crayfish are solitary bottom dwellers that spend the daylight hours beneath stones or in crevices or burrows. Locomotion may be forward, sideways, obliquely, or backward, but the greatest speed is attained in a posterior direction.

The food of crayfish consists of insect larvae, snails, worms, crustaceans, small fish, tadpoles, and dead animal matter. Burrowing species eat stems and roots of plants. Since the exoskeleton of crayfish does not grow, it must be shed several times a year to allow for an increase in size. Young crayfish molt three or four times during the rapid growth of their first year (Langlois, 1937). Storer (1943) states that prior to each molt some inorganic salts are withdrawn from the exoskeleton and used in the new soft shell that forms beneath the old one. Soft crayfish are heavily pryed upon by other crayfish and as a result remain concealed throughout this stage. Young crayfish and older ones to a lesser degree have the ability to replace lost appendages.

Tack (1941) found in his study of Orconectes immunis (Cambarus immunis) at Cornell that mating begins about mid-June, reaches a peak late in August, and slacks off until mid-October when the females retire to their burrows and prepare

for oviposition. He found this species to be promiscuous, mating repeatedly with different individuals. Storer (1943) states that in mating, the male inverts the female and stands over her. Seizing her walking legs with his chelae, he bends his telson over the outer end of her abdomen holding her motionless. With his fifth walking leg he presses the tips of his two modified pleopods against the sperm receptacles on the females thorax. The sperm, embedded in mucous, passes along his pleopods to her receptacles, after which, they separate. Orconectes immunis, according to Tack (1941), begins to prepare for egg laying four or five days before its occurrence. This preparation consists of removing all corroded algae and foreign matter. The fifth pair of walking legs are used as brushes and the claws of the second or third pair of walking legs are used for more persistent particles. Females are extremely nervous during the cleaning period and remain in their burrows throughout that time. Eggs are laid during the last ten days of October or the first few days of November. They are immediatly attached to the swimmerets where they remain until hatched. Females spawning for the first time lay an average of 84 eggs; those spawning the second time produce an average of 195.

During the greater part of the spawning period, eggs are dark, nearly black. A week before hatching they change to reddish orange; as the time draws nearer, they become even more pale until a day or two before hatching when the embryo becomes visable. After the surrounding membrane ruptures the young crayfish remains attached to the female by the egg stalk on its telson. A short time later the hatchling grasps the egg stalk with its chelae and is then attached at both ends. About 24 hours later, the embryonic skin loses its attachment to the egg stalk leaving the young crayfish fastened to the adult by its chelae only. Two and one-fourth days later, at a temperature of 65.7$^{o}$F., the first molt occurs; seven days later the second molt takes place. The hatchling remains attached to the female until the second stage, then after spending a few more days at her side, it becomes independent (Storer, 1943).

Carbine (1939) states that eight species of crayfish are native to Michigan and that four of these species are common enough to be used as bait. Orconectes virilis is abundant throughout the state and is found in rivers, streams, and lakes. Pearse (1909) describes it as a large species, 118 mm. long with a brown carapace and abdomen more or less mottled. The chelae

are greenish blue with light orange tips and the walking legs greenish. The rostrum is deeply excavated and bears lateral spines. Orconectes immunis is small, 64 mm. long, dark olive green in color, mottled with small dark markings and has reddish tipped chelae. The chelae are usually slender and the inner border of the hand serrate. Dense tufts of hair cover the inner side of the second pair of walking legs near their extremities and hooks adorn the third pair of walking legs. This is a mud-loving species, usually found in the small pools of the southern part of the state, though, it sometimes occurs in brooks and rivers. Orconectes propinquus (Figure 20) is the most common of our Michigan species, according to Carbine (1939). It is found in nearly all our rivers, brooks, and lakes where it preferes a stony bottom. This species is medium sized, being about 80 mm. long. Pearse (1909) states that the carapace and abdomen are brown and mottled; chelae are cream or light green with fine mottlings of darker green and light orange tips. The rostrum has small lateral teeth between which is a low longitudinal ridge.

Rearing - Crayfish are relatively easy to raise, since no special type of pond is required. Carbine (1939) recommends

that plenty of shade be provided because crayfish do better when direct sun rays do not fall on the water. He also suggests that dikes be constructed in ponds if a burrowing type crayfish is to be reared. This supplies a greater surface area in which the burrows can be constructed. The species stocked will depend on the type of pond used; for example, if the crayfish are to be reared in a stream, the stock supply should come from a stream; or if a pond is used, pond species should be provided. Langlois (1937) working in Ohio found Orconectes rusticus a suitable species for production in ponds. This species is not abundant in Michigan and is present only in the southern part. Any one of the three species mentioned by Carbine is probably suitable for rearing: Orconectes virilis, O. immunis, and O. propinquus. It is doubtful that any bait dealers have ponds specifically set aside for the rearing of crayfish, but great numbers may be harvested as a byproduct of minnow rearing ponds. Carbine (1939) estimates that one ton of crayfish can be produced per acre of pond surface. He goes on to say that over a ton and a half (approximately 600,000) have been removed annually from a four acre bass rearing pond at the Comstock Park State Hatchery near Grand Rapids.

Langlois (1937) states that the best bait size is two to three inches; this size is attained faster in warm water ponds. Table 1 shows the average growth rate he recorded in ponds in Central Ohio with Orconectes rusticus. No mention was made of the temperature of this pond, however.

Table 1 - Growth Rate of O. rusticus in Central Ohio (Langlois, 1937)

| Date | Av. length in inches | Av. length in mm. |
|---|---|---|
| May 15 | 1/4 | 6 |
| June 8 | 3/4 | 17.5 |
| June 21 | 1 1/8 | 29 |
| July 14 | 1 7/16 | 36 |
| Aug. 18 | 1 11/16 | 43 |
| Oct. 30 | 2 3/8 | 60 |

Since ponds are usually maintained all year around, a variety of sizes will be available at any time. The desirable size may be sorted out after seining and those that are too small or too large returned to the pond. Fishermen prefer "soft shells" or "peelers" that have molted and not turned hard yet. The most practical way to supply these is to maintain a large stock of crayfish at all times. Feeding them induces growth causing the shell to be cast more often. Carbine (1939) recommends the following foods: fish, meat scraps,

plants of all kinds, potatoes, and table scraps. At least part of the pond if not all of it should be kept free from rubble to facilitate seining operations. Seining at night in an area where food has been placed makes harvesting easier. Crayfish are more active at night and tend to gather in areas with an abundant food supply.

Holding - Probably the single factor limiting the use of crayfish as a bait is the difficulty with which soft shelled crayfish are collected and kept in that state. Both Langlois (1937) and Carbine (1939) state that crayfish may be kept soft for a week or two by placing them in rainwater or under refrigeration.

Several tests were run on crayfish to see how effective these methods really are. Most of those tested were O. propinquus which were seined from a swift, stoney brook; a few of the larger specimens were O. immunis taken from ponds. The stock supply was kept in a large concrete tank and fed on fish scraps and dog food. It was thought at first that a space factor might inhibit growth if the stock supply was kept in a small aquarium, thus limiting the shedding of shells. Later it was found that such is not the case; since six

O. propinquus kept in a dish pan with two quarts of water, all cast their shells within three weeks. Thirty-seven crayfish were originally placed in the stock tank, and an attempt was made to determine how many soft shells might be expected from this number over a period of time. It was necessary to abandon this part of the test, however, when it was found that more "soft shells" were being eaten by the hard crayfish than were recovered. Each day the crayfish were examined and the soft ones placed under one of the following experimental conditions: 1. distilled water, 2. hard water, or 3. refrigeration. Two slate bottomed aquaria 29 1/2 inches long and 15 3/4 inches wide were used for the tests with distilled water and hard water. Four inches of distilled water were placed in Tank 1 and four inches of hard water at 315 ppm. $CaCO_3$ were placed in Tank 2. Both tanks were supplied with air by bubbling it into the water through pumice stones. These crayfish held under experimental conditions were not fed at first; but later it was found that they ate each other if food was not supplied. Therefore, a small quantity of dog food was placed in the aquaria. As each crayfish became soft it was marked by removing a certain number of walking legs. The length, date, and species

was then recorded and the crayfish placed in one of the two tanks. Those to be refrigerated were put in individual pint bottles with two inches of 315 ppm. ($CaCO_3$) tap water at room temperature. The bottles were then refrigerated, at $34^{o}F$. This gradual method of reducing the temperature eliminated the shock that would have been incurred had they been dropped into cold water. Each day the experimental crayfish in the aquaria were examined and a record was made when the first sign of hardening occurred and at the time when they became nearly as hard as those in the holding tank. It should be pointed out that this data is subjective to a large extent since squeezing the crayfish and noting the relative hardness is the only means of measuring the progress the animal has made toward the forming of a new shell. The point at which the crayfish became nearly as hard as those in the holding tank was used because, after reaching this point, the process slowed down so that as high as three weeks were needed to complete it from this point. For these reasons all of the data in Tables 2 and 3 should be considered as approximate rather than exact. Those crayfish placed under refrigeration showed no sign of hardening throughout the test but all of them died

within about three weeks as Table 4 indicates; therefore it was the date of death recorded in this case rather than the relative degree of hardness.

Table 2 - Data from tank 1 showing length of time required for soft-shelled crayfish to harden in distilled water.

| Crayfish number | Species | Length in mm. | Length in inches | Days before 1st sign of hardening | Days before shell is nearly as hard as will get |
|---|---|---|---|---|---|
| 1. | propinquus | 44 | 1 3/4 | 14 | 19* |
| 2. | immunis | 70 | 2 3/4 | 10 | 35 |
| 3. | propinquus | 38 | 1 1/2 | 12 | 18 |
| 4. | propinquus | 50 | 2 | 15 | 20 |
| 5. | immunis | 76 | 3 | 12 | 23 |
| 6. | propinquus | 50 | 2 | 14 | 22 |

*This crayfish was eaten by others.

Table 3 - Data from Tank 2 showing length of time required for soft-shelled crayfish to harden in hard water (315 ppm. $CaCO_3$).

| Crayfish number | Species | Length in mm. | Length in inches | Days before 1st sign of hardening | Days before shell is nearly as hard as will get |
|---|---|---|---|---|---|
| 1. | propinquus | 44 | 1 3/4 | 3 | 5 |
| 2. | propinquus | 38 | 1 1/2 | 3 | 8 |
| 3. | immunis | 75 | 3 | 3 | 7 |
| 4. | propinquus | 38 | 1 1/2 | 4 | 8 |
| 5. | propinquus | 44 | 1 3/4 | 3 | 7 |
| 6. | immunis | 62 | 2 1/2 | 4 | 8 |

Table 4 - Data from soft-shelled crayfish held under refrigeration at 34°F. showing the length of time they lived at this temperature.

| Crayfish number | Species | Length in mm. | Length in inches | Days before death occurred |
|---|---|---|---|---|
| 1. | propinquus | 50 | 2 | 19 |
| 2. | propinquus | 56 | 2 1/4 | 3* |
| 3. | propinquus | 56 | 2 1/4 | 22 |
| 4. | propinquus | 45 | 1 3/4 | 21 |
| 5. | propinquus | 53 | 1 1/8 | 16 |
| 6. | propinquus | 56 | 2 1/4 | 12* |

*These crayfish laid with their ventral sides up from the time they were found soft until they died in the refrigerator.

# SUMMARY

Twenty natural baits have been discussed in this paper; of these, eleven play an important role in the bait industry of Michigan. Those found most frequently at dealers specializing in seasonal baits are: earthworms, minnows (not included in this paper), wigglers, caddis, white grubs, corn borers, mousies, sand grubs, waxworms, crickets, and gall insects. Horse bots, cattle grubs, oak twig pruners, nut weevils, and leeches are popular only in certain areas of the state. Hellgrammites, cockroaches, and soft-shelled crayfish are occasionally found in bait shops, but supply and demand has minimized the use of these organisms. Woodborers and mealworms were at one time popular, but dealers now claim that better baits are gradually replacing them.

Rearing technics have been developed for certain species that eliminate the task of collecting bait from its natural habitat. These methods of artificial propagation promise a supply of the desired species all year around. Baits for which a simple rearing technic has been developed are: crickets, waxworms, leeches, earthworms, mealworms, and cockroaches. Others can also be raised, but a certain amount of expense,

labor, or inconvenience is involved. Included in this group are crayfish, corn borers, and mousies. A means of artificial propagation has not been discussed for horse bots, cattle grubs, wigglers, caddis, white grubs, woodborers, oak twig pruners, nut weevils, or hellgrammites because such a technic is either impossible or impractical.

Most baits, whether they can be reared or not may be held for at least three weeks. Holding technics involve either keeping the organism alive and fresh or keeping it in that stage of its life cycle used as bait. Tests have shown that terrestrial species such as waxworms, mousies, corn borers, etc. may be held in a cool, moist situation. Such aquatic species as wigglers, hellgrammites, and caddis can be kept in tanks of water supplied with air or under refrigeration where the reduced rate of metabolism has lowered the oxygen demand.

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