Captive Rearing of Eastern Lubber Grasshoppers *Romalea microptera*

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Introduction

This paper describes the natural history of the eastern lubber grasshopper, *Romalea microptera* Beauvouis (= *guttata*: see Otte 1995), and details the methods used to breed these animals at Brookfield Zoo in Chicago and at Illinois State University (ISU).

The eastern lubber grasshopper is an interesting animal with characteristics that make it ideal for zoological exhibition, education, outreach programs, and scientific research. At Brookfield Zoo, we have displayed *R. microptera* in The Swamp exhibit since 1996. During this time, we have learned a lot about rearing and care of this insect.

Most of the methods discussed in this paper were developed at Illinois State University. The Brookfield Zoo obtained individual grasshoppers for exhibit and breeding from the University's colony.

Materials and Methods

Brookfield Zoo obtained its first grasshoppers on February 7, 1996. Because a steady supply was available from the University, a breeding program was not initiated until the beginning of 1999. During the next two years, data on the length of time egg pods took to hatch as well as a sampling of egg numbers in a random sampling of pods, were recorded.

Biology & Natural History

Taxonomy
Lubber grasshoppers are in the family Romaliedae, within the order Orthoptera. The family can be distinguished from the other families by the inner and outer spines of the hind tibia which are immovable at the tip, and by the prosternum, which is usually with a median spine or tubercle. (Borror, DeLong, and Triplehorn, 1976) The Romaliedae are a largely neotropical group, with a few species living in the United States.

Range & Habitat
Eastern lubber grasshoppers range from North Carolina to Florida, and west to east Texas. They inhabit both temperate and subtropical climates. These grasshoppers do well in disturbed habitats, including gardens, old fields, and weedy vegetation along roadsides, and open pine woods. They survive well in suburban habitats. *R. microptera* is the only lubber found in the eastern USA; however, about 15 other members of this group occur in the arid West.

External Morphology
R. microptera is the largest grasshopper in the United States. Adult females can weigh up to 18 grams and reach 8 cm in length, making them larger and heavier than some birds and mammals.

Both larvae and adults have striking coloration. Hatchlings are about 1 cm long. They are black and have yellow lines along the ventral and dorsal sides going anterior to posterior- on the femur of the hind legs, edging of the prothorax, and on the front of the head on the gena and around the eyes. They will maintain this coloration through each molt until the final molt, when they change to adult coloration.

The adults are 4 to 8 cm long. They are usually a dull, yellow-orange color with numerous black markings. A reddish stripe on the tegmen varies to mostly black with only the median ridge and edges of the pronotum and hind margins of the abdominal segments the dull yellow-orange (Scherer, 1996). Only the adults have wings. The hind wings are pink to red with black edging and are short - half the length of the thorax. The wings are not functional for flight. Female lubber grasshoppers are 10% to 25% larger than the males. Adult females are easily identified by the presence of the sharp ovipositor valves at the tip of the abdomen. However, even nymphs can be separated by sex, based on the morphology of external genitatlia.

Feeding Behavior
Lubber grasshoppers are polyphagous herbivores and will eat approximately 60% of plant species. They appear to require less food/gram than other grasshoppers (Scherer, 1996). They will occasionally feed on carrion, mushrooms, and feces.

Defense
Eastern lubber grasshoppers possess a rich armory of defenses. They are aposematically colored, signaling to predators that they are toxic. When handled, *R. microptera* may

give off a volatile, pungent, bubbly froth, which they squirt out with a hissing sound. They store this secretion in glands located in the thorax. The mixture of bitter-tasting phenols and toxins is derived, in part, from their food plants. (Yosef and Whitman, 1993). In addition, powerful toxins in the blood can cause vomiting and even death in predators that consume lubbers.

Like most grasshoppers, the eastern lubber grasshopper can also regurgitate recently consumed plant material. This dark-brown colored liquid, commonly referred to as "tobacco," is composed of partially digested food material along with some semi-toxic compounds from the insect's crop region.

In addition to its color and chemical defenses lubber grasshoppers bite, kick and possess spines on their hind legs that can deter small predators (Milne and Milne. 1994).

Predation

With such a potent chemical defense, the eastern lubber grasshopper has very few predators. Though toxic to most vertebrates, the lubber grasshopper defense has little to no effect on invertebrates (Yosef and Whitman, 1993). The chemical defense does not deter the parasitic fly *Anisia serotina* (Diptera: Trachinidae), which in some years infests > 90% of lubbers in South Florida (Lamb, Otto, and Whitman. 1999).

One vertebrate has found a way around the lubber grasshopper's chemical defense. Observations and studies by Yosef and Whitman (1993) have shown that some loggerhead shrikes, *Lanius ludovicanus* Linnaeus, have evolved a technique to overcome lubber defenses. They impale lubber grasshoppers on thorns or spines, and let it dry a day or two. During this time, the toxins apparently degrade, and the insect becomes palatable. However, the shrikes still reject the grasshopper's legs and wings.

As Pests

With few predators, lubber populations sometimes build up to high densities, damaging gardens. Lubbers like to sun themselves on warm asphalt, and occasionally hundreds of lubbers will become squashed on the road. If they do occur in large numbers, the adults can easily be collected by hand or a small net and destroyed. Unless eaten in large numbers, lubbers are essentially harmless to humans.

Locomotion

The eastern lubber grasshopper is so named because of its slow, clumsy movements and travel (Feiblman, 1986). This is truer for the adults. The younger instars can be harder to catch and are agile jumpers. Except when escaping, lubbers are slow-moving, almost sluggish, which is a consequence of their chemical defense. There is little reason to move quickly when nothing eats you. Both adults and instars are capable of walking on smooth surfaces, such as the sides of glass aquariums, and their tarsal claws allow them to climb rough surfaces.

Life Cycle
After mating, the female uses the ovipositor at the sharp ovipositor valves at the tip of her abdomen to dig a 3 – 7 cm hole in the soil and deposit an egg pod containing approximately 40 eggs topped by a foam plug. The eggs are about 1 cm long. The foam plug blocks the oviposition hole from egg predators and from soil collapsing into the oviposition hole. When the eggs hatch, the tiny nymphs wiggle up through the foam plug to the surface (Ewer, 1977). Eighteen individual pods laid by individuals at The Swamp contained an average of 41.1 eggs per pod. The maximum number of eggs in a single pod was 71, while the minimum was 20.

In nature, the eggs overwinter and require about 8 months to hatch. In south Florida, the young emerge from the ground in late February to early March. The young aggregate forming tight clumps of up to 200 individuals. Nymphs pass through five larval stages before molting into the adult stage. The length of these stages averages 9 to 15 days each.

Individuals start mating at 15 days into the adult stage. Females lay their first egg pod on about day 32, and thereafter a new pod ~ every 18 days. Individual adults can live up to five months.

Husbandry

Enclosures and Materials
ISU has maintained a colony of lubber grasshoppers for 12 years. They factory-rear large numbers of lubbers in a room dedicated to this task. This room is kept about 25° to 30°C (77° to 86°F), with variable humidity. Ceiling mounted racks house electrical outlets and timers. Long, cafeteria-style tables allow for easy sweeping and mopping.

ISU uses various sized aluminum wire-screen cages. The cage front has a large door for replacing branches and food, while a smaller door is used to add or remove individuals. The bottoms of the cages are open and contain no screen. This enables debris to fall directly onto absorbent newspaper. The paper is easily changed twice a week by simply lifting the cage, sliding out the old paper, then sliding in new paper. The absorbent paper reduces disease by reducing moisture. Cages are washed and autoclaved as needed.

In contrast, The Swamp can only afford several small areas for the breeding of lubbers. These areas are seasonally occupied and have to be shared with other animals. Temperatures can range from 10° to 35°+ C (55° to 95°+F) in these areas. They are subject to the relative humidity of the day.

The Swamp uses ordinary glass aquarium tanks with screen lids. The lids are secured in place. The exhibit aquarium is a specially designed, thick-glassed aquarium with a screen top. A ground bed-o-cob substrate is placed on the bottom of the aquariums. This inch-thick layer helps absorb moisture. Plastic coated construction cloths and thin branches are offered as perches. The construction cloth can be disinfected and reused many times over.

Once a week, the aquariums are cleaned and the substrate replaced. At this time, individuals are removed and counted.

Both institutions use brooder lamps with an outdoor 150 watt flood bulb or 225 watt inferred heat lamps above their cages. This enables the lubber grasshoppers to seek their own preferred temperatures (~36°C or 97°F) by moving into and out of the heat radiated by the lamps. Having the lamps outside the cages and aquariums allows for a quick change of burned-out bulbs without disturbing the lubbers. **DANGER**!! The lamps are hot and care must be taken to prevent fires (mainly from placing combustibles too close to the hot lights, or **by placing cold lights on a surface, such as when cleaning, and then allowing the timers to turn on the lights, when workers are out of the room, causing the surface to heat and ignite**). The lights must never be left on a surface, unless unplugged.

ISU feeds its colonies a mixture of Romaine lettuce, rolled oats, and wheat bran. About every third day, green onion, carrot root with leaves, parsley, cabbage, or green bean pods are provided. The Swamp offers their colonies dried rolled oats and fresh Romaine lettuce each day. All vegetables are carefully washed in tap water. The onions, green beans, and carrots are sliced diagonally so there is always a sharp edge for the grasshoppers to feed on. Each day, moist, uneaten food items are replaced. A small amount of clean dried lettuce or carrot leaves are left in the cage because grasshoppers regulate moisture levels by switching from wet to dry foods.

Eggs

Female lubbers are allowed to deposit pods into slightly moist (not wet), inorganic silica sand. Eggs can survive in a wide range of moisture levels between 1% and 80% saturation, but ~ 6% moisture (= 6% of total saturation (= standing water)) is best. We use 6-in tall "deli-cups" obtained from the Deli Department of a national chain grocery store. Cups can also be obtained from restaurant supply companies. Our cups are made of a clear plastic and have a tight-fitting lid. The fine, white, 100% inorganic silica sand is sold at hardware stores for sandboxes or used in aquatic sand filters. In a pinch, any cleaned and washed sand can be used. We fill the cups to about 4 ½ inches high with the moist sand. Once a day, we place each mature & mated female inside a sand cup and attach a lid. Females remain in cups for about 15 min. Those ready to lay, start digging their vertical hole immediately. We often allow 3 females to oviposit into a single cup, over a period of days. Afterwards, cups are sealed with a tight-fitting lid and placed on a shelf in a cool room that does not exceed 29 Degrees F. Cups are tilted about every 2 months, and if the top sand flows (indicating drying), the lids are opened and a few ml tap water is added.

Captive Rearing

Once the eggs are laid, the cups are sealed with tight-fitting lids. They then are placed on a shelf where the staff at ISU checks the soil moisture every other month. This is simply done by looking to see if there is dry sand on the surface. If there is, several milliliters of tap water are added. We also monitor water content by periodically weighting cups.

Ovipostion dates and cup weights can be written on the outsides of the cups with a magic marker.

Chladny and Whitman (1998) examined the effects that soil temperature, soil moisture, and ventilation have on the eggs of *R. microptera.* The results of the ventilation experiment showed that a lack of ventilation does not harm the developing embryos. It was also shown that the eggs can survive between about 3 and 80% moisture. However, the temperature of the soil does have an effect.

The length of time that a pod takes to develop is affected by the temperature of the soil. By maintaining eggs in a controlled environment, eggs that were kept at lower temperatures showed a greater success rate and shorter hatching time (Chladny and Whitman, 1998). At 22° C (72°F), 100% of the pods tested hatched with a median time of 144.5 days. Only 30% of the pods cultured at 30° C (86°F) hatched in 213 days. Pods that were kept over 31.5° C (88.7°F) did not hatch.

The Swamp staff examined the length of time 47 egg pods took to develop. Fluctuation of building temperatures led to a wide range of hatching times. The average time was 140 days. The shortest hatch time was 91 days, while the longest was 248 days. When staff examined the months that the pods were laid, they noticed the same pattern that Chladny and Whitman (1998) found. The pods that developed through the cooler months normally had a shorter hatching time than the pods that developed during the warmer months of the year.

Instars and Adults

Hatchlings are placed in a cage or aquarium with sticks and branches of various sizes. The size and type of the perches that are given to grasshoppers in the instar stage is important. Perches must be stable, strong, and rough enough to provide a good grip. This is important for molting. Normally the young will hang upside-down by their large hind legs. They will emerge from the old exoskeleton and hang from it while the new one hardens. If they fall during this crucial time, they may become deformed and possibly die. Hence, molting sticks should be rough and the approximate diameter of the insect, and placed at about a 45 Degree angle.

Due to the large volume of individuals produced at ISU, juveniles of the same age are grouped in cages. Normally this includes all the lubbers that hatch during a two-week period. Once they reach adulthood, they are transferred to a large adult cage, where they are observed for breeding. The Swamp places newly hatched young into a single aquarium. As they reach the larger instar stages, they are moved to an aquarium with the adults.

The Swamp staff keeps a sand-filled cup in the adult aquariums at all times. These cups are checked daily for the presence of any egg pods. Cups with pods are removed and replaced with fresh, moist cups.

ISU monitors its adult female lubber grasshoppers. Males mate by ridding on the females back for about 8 hrs. Mating and mated females are transferred to a “mated female cage” until they lay their eggs. Female grasshoppers are encouraged to lay by placing each female from the “mated cage” into a plastic cup filled with moist sand for about 15 minutes each day. Females that are ready to lay usually start immediately. After the 15 minute period, any female that is not laying is returned to the “mated cage” and tried again the next day. Those that do lay eggs are returned to an adult cage where they can be mated again.

Education

Because of their large size, striking coloration, and docile nature, lubber grasshoppers are the perfect animal for “show and tell” or hands-on education. Children find lubbers fascinating. We often place lubbers in children’s hands and let them feed the insects with a small piece of lettuce. The natural history of this insect opens up many possible topics of discussion. An example of this is a common question asked during a keeper demonstration, “What do they eat.” This can initiate a discussion of herbivory vs. carnivory, or monophagy vs. polyphagy, and the morphology of feeding. “Why don’t they jump away?” This enables you to discuss the lubber’s toxicity and the warning coloration they use to advertise this defense. Then you can discuss some other local invertebrates with warning colors, such as monarch butterflies (*Danaus plexippus*), and wasps. Animals that have found ways around chemical defenses; invertebrates that mimic warning colors to avoiding predation; and evolutionary changes that separate the lubber grasshopper from the common grasshopper are good discussion topics.

In short, the eastern lubber grasshopper is a great tool for introducing people of all ages to the world of invertebrates. They are interesting, gentile and sedentary, and will remain when held in an open hand. They are inexpensive and easy to rear and maintain. Large numbers can be reared in a relatively small space. They are easy to transport and do not require the number of permits or level of veterinary care that mammals do. No institution should be without them.

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