TIEE
Teaching Issues and Experiments in Ecology - Volume 1, January 2004

ISSUES – FIGURE SET

What Are the Impacts of Introduced Species?

Charlene D'Avanzo [1] and Susan Musante [2]

1 - School of Natural Sciences, Hampshire College, Amherst, MA, 01002 cdavanzo@hampshire.edu

2 - Education and Outreach Program Manager, The American Institute of Biological Sciences, Washington, D.C. 20005, smusante@aibs.org

Brown tree snake, *Boiga irregularis*
photo © G. H. Rodda, USGS
{biology.usgs.gov/s+t/
imagefiles/x181w02.htm}

Figure Set 4: Fire Ant Invasion and Control by a Parasitoid

Purpose: To inform students about fire ants and promote discussion of their control.
Teaching Approach: "paired think-aloud"
Cognitive Skills: (see Bloom's Taxonomy) — interpretation, application
Student Assessment: essay about website

BACKGROUND

The red imported fire ant (*Solenopsis invicta*) arrived in the U.S. from Brazil around 1940. Since then it has devastated arthropods and invaded over 250 million acres in the south (Orr et al. 1995). The red fire ant also kills poultry chicks, ground-nesting birds, lizards, and snakes. The estimated damage to public, livestock, and wildlife health by fire ants is $300 million in Texas alone; an additional $200 million is spent on control. Extrapolating to other states (Florida, Georgia, Louisiana) brings fire ant damage to more than $1 billion per year (Pimentel et al. 2000).

The stinging behavior of fire ants is notorious. They sting repeatedly and cause an intense burning sensation — hence the name "fire ant". White pustules form at sting site, which can become infected, resulting in permanent scaring.

Control of the red fire ant has been a real problem. When pesticides are used, this ant reinvades treated areas more quickly than native ants. The article by Orr et al. (below) provides evidence that a parasitoid fly from Brazil could limit the ability of red fire ants to attack and out compete other ants.

Humans have caused the dramatic spread of imported fire ants. Natural dispersion is by mating flights, colony movement, or rafting during flood events. The movement of ants coincided with the housing boom after World War II, largely due to the transfer of grass sod and woody ornamental plants for landscaping. In 1958, federal regulations limited the movement of nursery stock and grass sod, but by then imported fire ants had moved into eight southern states.

The following is from the University of Minnesota website (see references): "One of the identifying characteristics of a fire ant colony is the earthen nest or mound. The mound is a conically-shaped dome of excavated soil that has a hard, rain-resistant crust. The mound averages 0.40 m in diameter and 0.25 m in height. In heavier soils, a mound can exceed 1.0 m in height and 1.5 m in diameter. There are usually no external openings in the mound; tunnels approximately 25-50 mm below the surface radiate from the mound allowing foraging workers ready egress and ingress. The purpose of the mound is three-fold: 1) to be a flight platform for nuptial flights; 2) to raise the colony above the water table in saturated ground and; 3) to act as a passive solar collector to supply warmth to the colony during the cold winter months. Although mound size and shape differs to some extent based on soil type, during the dry hot days of late summer and early fall, new mounds are not formed and older mounds are not maintained. While mounds are important to a colony, they are not essential for colony survival. Given a dark, protected site with sufficient moisture and an adequate supply of food, fire ants will nest in a wide variety of sites (e.g. rotten logs, walls of buildings, under sidewalks and roads, in automobiles, in dried cow manure).

Fire ants are omnivorous, feeding on almost any plant or animal material; although insects seem to be their preferred food. In rural habitats, fire ants have a major impact on ground nesting animals from insects to reptiles to birds to mammals. The

arrival of imported fire ants into an ecosystem wrecks havoc on the local ecological community. Studies (Allen et al. 1995) have shown that a minimum two-fold reduction occurs among populations of field mice, oviparous snakes, turtles and other vertebrates when imported fire ants are allowed to establish colonies within a given area. In some instances, the depredation by fire ants has completely eliminated some species from an ecosystem (Porter & Savignano 1990). The reduction or elimination of a species or group of species from a system has repercussions throughout the local food web. Not only do imported fire ants reduce animal populations, they also feed on plants. Fire ants attack young saplings and seedlings. They destroy buds and developing fruits and have been shown to feed on the seeds of 139 species of native wildflowers and grasses (Lockley unpubl.). Secondarily, fire ants "nurse" numerous homopteran pests of plants such as aphids and scale insects. Although not conclusively shown, observations indicate that their activity on the plant itself may reduce the ability of pollinators to successfully pollinate flowers.

In agriculture, fire ants have been identified as damaging fifty-seven species of cultivated plants (Adams 1986). Fire ants feed on the germinating seeds of some crops (e.g. corn, sorghum, soybeans) and the buds and developing fruits of others (e.g. citrus, okra).

As an urban pest, imported fire ants cause many of the same problems experienced in rural areas as well as some problems unique to the urban environment. As in agriculture, imported fire ants cause significant damage to numerous plants and, as in rural habitats, fire ants can reduce the number of birds and mammals in an urban landscape. Fire ants nest within urban structures such as the walls of homes and offices. They establish colonies under sidewalks and roadways. When the site is abandoned, subsidence will cause cracks to appear and will occasionally result in the complete collapse of sections of these structures. The presence of fire ants can deter outdoor activities in yards, parks and school grounds. Home invasions can threaten small children and the elderly. House invasions are especially prevalent during periods of heavy precipitation and flooding. Fire ant colonies have been found inside automobiles, trucks and recreation vehicles (Collins et al. 1993). Traffic accidents have been caused by fire ants stinging the drivers of automobiles. Victims of highway accidents can be attacked by fire ants if they are thrown from their vehicles."

References

Adams, C. T. 1986. Agricultural and medical impact of the imported fire ant. Pages 48-57 *in* C. S. Lofgren & R. K. vander Meer (eds.). Fire Ants and Leaf-cutting Ants. Biology and Management. Westview Press.

Allen, C. R., R. S. Lutz, and S. Demarais. 1995. Red imported fire ant impact on Northern Bobwhite populations. Ecological Applications 5(3): 632–638.

Collins, H. C. 1992. Control of Imported Fire Ants: a review of current knowledge. USDA-APHIS Technical Bulletin 1807: 27 pp.

Orr, M. R., S. H. Selke, W. W. Benson, and L. E. Gilbert. 1995. Flies suppress fire ants. Nature 373: 292-293

Pimentel, D, L. Lach, R. Zuniga, and D. Morrison. 2000. Environmental and economic costs of nonindigenous species in the United States. BioScience 50: 53-65.

Porter, S. D. and D. A. Savignano. 1990. Invasion of polygyne fire ants decimates native ants and disrupts arthropod community. Ecology 71(6): 2095–2106.

Web Resources

- http://fireant.tamu.edu/ Texas A&M management plan
- http://ipmworld.umn.edu/chapters/lockley.htm University of Minnesota
- http://www.cdfa.ca.gov/phpps/pdep/rifa/ CA Dept Food & Agriculture
- http://ceris.purdue.edu/napis/pests/ifa/ Federal site
- http://www.ars.usda.gov/is/pr/1998/980216.htm USDA Phlorid fly site
- http://uts.cc.utexas.edu/~gilbert/research/fireants/faq.html Univ. Texas, Austin
- http://www.amesplantation.org/FireAntResearch/fireantres.htm Fire ant research

STUDENT INSTRUCTIONS

First work individually on this problem. Then work in pairs; one person will be the "solver", the other the "recorder". The "solver" explains how s/he figured out the figure, including description and interpretation of the data. The "solver" also poses questions they may have. The role of the recorder is to simply record what the solver says and to encourage them. The recorder does not attempt to help the solver interpret the figure. Your instructor will tell you how much time you have for the individual and paired work and how you will then report back to the whole class.

Read through the information below, and then look at Figure 4. First, make sure that you understand the axes and the experimental design before you attempt to interpret the data. Observe the patterns in the data. Then discuss your interpretations together.

The red fire ant was introduced to the U.S. from Brazil in the early 1940's and since then it has spread throughout the south. It is a ferocious insect. The red fire ant kills baby chickens, ground-nesting birds, lizards, and snakes and it also attacks people. Control estimates in the southern states is about $1 billion per year.

In this study Orr et al. tested the idea that a parasitoid fly from Brazil might reduce the red ant's ability to attack other insects and animals. A parasitoid is like a parasite; it is a fly or wasp that kills its host by laying eggs in the larval stage of another insect and consuming the larva from inside. The design of their experiment is described in the figure legend.

FIGURES

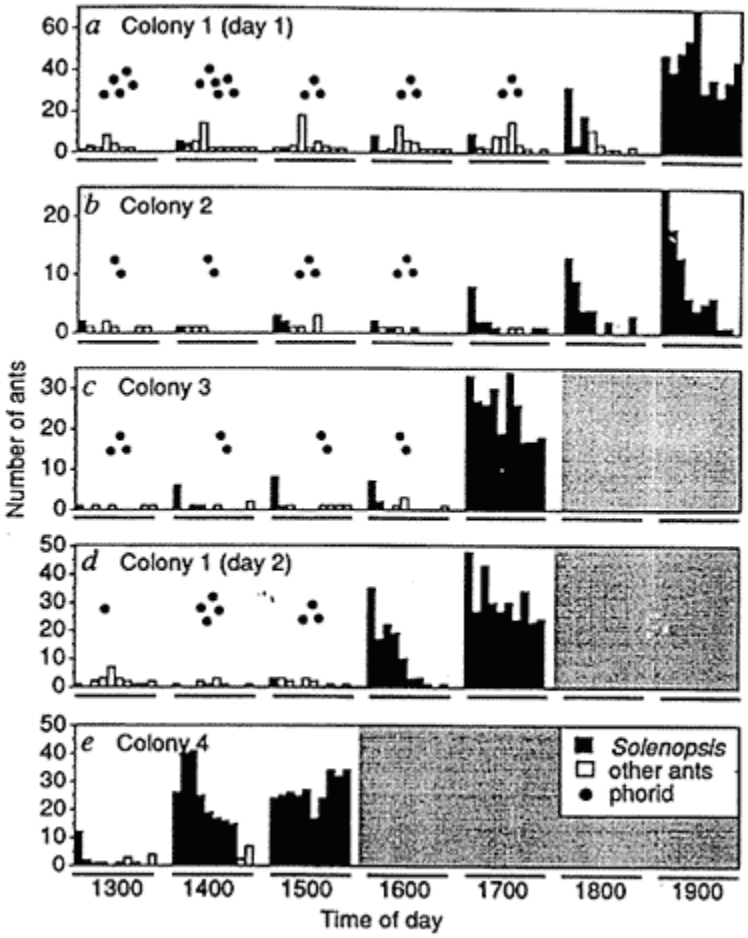

Figure 4. Number of fire ants (*Solenopsis invicta*) surging from an ant colony. There were 10 baits each consisting of a 0.5 cubic centimeter piece of cow heart muscle staked to the ground with a pin. The bait was placed 10 centimeters away from each colony. All ants standing on or feeding on the bait were counted every hour until fire ants dominated all baits. The black circles indicate presence of the added parasitoid fly, called a phorid. Time of day is military time (1300 is 1 PM, 1400 is 2 PM, etc.). Phorids departed naturally at dusk and on day 2 for colony 1 phorids were experimentally removed before dusk. Filled bars are *S. invicta*. Open bars are several other ant genera. Bars further to the left at each hour are baits closer to the mound. Solid circles are maximum number of phorids attacking *S. invicta* during the 30 minute period before the ant count. Fire ants were never displaced from baits by other ants in the absence of the phorid during a 6 week observation period before the experiments. No other ant species visiting the baits were attacked by the phorid (from Orr, M. R., S. H. Selke, W. W. Benson, and L. E. Gilbert. 1995. Flies suppress fire ants. Nature 373: 292-293).

FACULTY NOTES

The point of "paired think-aloud" is to give students who are used to either talking/solving problems or listening/being more passive a chance to practice both sets of skills. In their instructions students are asked to first work alone to understand the figure as best they can. Then they pair up and one person is the "solver" and the other the "recorder". The solver explains their understanding of the data and experimental design and also asks any questions they have. The recorder writes down what their partner says and encourages them; the recorder does not express an opinion but simply guides their partner along. The students then switch roles. You will have to allow enough time for the 3 parts of the exercise and tell the students how much time they have both ahead of time and during the exercise.

Assuming the more dominant or more passive role will be very hard for some students. You should spend some class time explaining why you are using this particular approach and why it is important for all of us to step out of our usual roles sometimes. Make sure that everyone understands the directions for each role.

In this experiment, Orr et al. (2000) found that fire-ant workers feeding on the bait were attacked by the parasitoid, *Pseudacteon solenopsidis*, which “hovered less than a cm in front of an ant and maintained its position by flying backwards as the ant fled. To oviposit, the fly turned 180 degrees, darted quickly down and inserted its ovipositor in the foramen behind the ant’s head…. The behavioural distractions caused by the phorids reduce the competitive dominance of *S. invicta* in Brazil and might also diminish its ability to dominate in its introduced range. Due to their extreme host specificity, phorids are a good candidate for biological control although their affinity for North American ants must first be understood.” Their conclusion about introduction of an insect to control an introduced insect would stimulate good discussion about biological control of the red fire ant.

Discussion questions:

- Orr et al. suggest that introduction of the non-native parasitoid might be a good biological control of red fire ants. How would you determine whether or not this was a good idea from an ecological point of view? What experiments might you conduct?
- Humans have greatly accelerated the rate of red ant movement as a result of the housing boom after World War II. What human activities associated with building houses likely contributed to the rapid invasion of this ant?
- Fire ants live in conical shaped mounds of dirt often about 0.25 m high and 0.5 m across. In what ways might such a mound be helpful to the success of this organism?

Data are from:

Orr, M. R., S. H. Selke, W. W. Benson, and L. E. Gilbert. 1995. Flies suppress fire ants. Nature 373: 292-293.

Student Assessment: Essay

The website http://www.ceris.purdue.edu/napis/pests/ifa/ shows the spread of fire ants through the U.S. from 1918-2000. What observations can you make about the ant's distribution from these visual representations. 250-300 word essay.

Evaluating an Issue: How do you know whether it is working?

On-going (also called formative) evaluation of the approaches your are using is critical to the success of student-active teaching. Why try out new ideas if you don't know whether or not they are working? This is a brief overview of formative evaluation. For more information, go to the Formative Evaluation essay in the Teaching Section.

Course Goals:

Formative evaluation only works if you have clearly described your course goals - because the purpose of the evaluation is to assess whether a particular technique is helping students reach these goals. For instance, most of us have "learn important ecological concepts and information" as a course goal. If I reviewed the nitrogen cycle in a class, for evaluation I might ask students to sketch out a nitrogen cycle for a particular habitat or system. Each student could work alone in class. Alternatively, I might ask students to work in groups of 3 and give each group a different situation (e.g. a pond receiving nitrate from septic systems, an organic agricultural field, an agricultural field receiving synthetic fertilizer). The students could draw their flows on a large sheet of paper (or an overhead transparency) and present this to the rest of the class.

The Minute Paper:

Minute papers are very useful evaluative tools. If done well they give you good feedback quickly. Minute papers are done at the end of a class. The students are asked to respond anonymously to a short question that you ask. They take a minute or so to write their response in a 3x5 card or a piece of paper. You collect these and learn from common themes. In the next class it is important that you refer to one or two of these points so that students recognize that their input matters to you. The UW - FLAG site (www.wcer.wisc.edu/nise/cl1/flag/) gives a good deal of information about using minute papers including their limitations, how to phrase your question, step-by-step instructions, modifications, and the theory and research behind their use.