HOW-TO-DO-IT

INVASION BIOLOGY on Your Campus: Investigating the Red Imported Fire Ant in the Southeastern United States

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Historically, most labs in introductory biology courses emphasized the mastery of technique and focused on dissection, drawing, and identification. While the pedagogical value of these exercises has withstood the test of time, cookbook labs, with their emphasis on confirmation of accepted "fact," often fail to expose students to the tenuous, questioning nature of the scientific method or to the relevance of contemporary issues that drive much of current scientific research. Currently, many instructors are trying to design and offer labs that help students develop cognitive as well as manual skills (e.g., investigating plankton diversity, Kirby & Reinking, 1994; plant/ant interactions, King & Woodell, 1975). One area of introductory biology that is well suited to this approach is "invasion biology" – the science of determining why some introduced species succeed and under which circumstances these species are permitted to succeed. In the lab exercise we describe below, we ask students to formulate and test hypotheses about where a common invasive species will succeed.

Determining and predicting the conditions that will render an ecosystem open to invasion by non-native species is a key endeavor in current ecological studies. Aesthetic, ethical, ecological, and, probably most persuasively, economic evaluations of the consequences of invasive species have driven organizations like The World Conservation Union and the Scientific Committee on Problems of the Environment to explore "new global strategies and resources to help nations better manage introduced species" (Baskin, 1996). Current research indicates habitats that are early successional have a low diversity of native species, and those that are disturbed are most likely to be invaded by non-natives (see Lodge, 1993).

The red imported fire ant (*Solenopsis invicta* Buren) is an excellent model of an invasive, non-native species. This species was inadvertently introduced to the port of Mobile, Alabama in the 1930s (Vinson & Sorensen, 1986). Over the last 60 years, the red imported fire ant has spread through most of the southeastern U.S. (Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas) and is making its way westward (Callcott & Collins, 1996).

Red imported fire ants spread when they are accidentally transported in shipments of sod and fill used in landscaping or when queens take their mating flight after maturity. Newly mated queens can travel greater than 12 miles to form a new colony, and six months after mating, a new mound can house thousands of workers (Vinson & Sorensen, 1986). Red imported fire ants prey on or compete with a wide range of invertebrates (Porter et al., 1988) and vertebrates (Allen et al., 1994). They are attracted to mucous-making newborn mammals, recently pipped birds, and herpetofauna, and species that leave mucous trails particularly vulnerable to predation. The egg and larval stages of

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invertebrates are at risk because of their inability to escape from fire ant attacks.

Solenopsis invicta is an ideal study organism for a high school or introductory college laboratory because it is abundant throughout the southeastern United States, active for much of the year when daytime temperatures are 72 to 97° F (22 to 36° C) and easily identified. In addition, it is found in a variety of habitats common to college and high school campuses. The purpose of the described experiment is to encourage students to test their own hypotheses about where red imported fire ants will be most abundant. This experiment also offers students the opportunity to take part in a field study that will give them experience in basic statistics and scientific writing.

Materials & Methods

Ant Identification

Students can learn to identify fire ants by studying the external features common to *Solenopsis* species. To train students, you can take them to a nearby mound, and run a stick across the surface of the mound, and then point out the worker ants' key physical features as the ants attempt to repair the damage. For additional clarification, the teacher may want to catch some fire ants before class, freeze them, and have students look at these frozen ants using a dissecting microscope in class. Fire ant workers are reddish-brown and range in size from 1/8 to 1/4 inches long. Under a dissecting scope it is possible to see other identifying features of *Solenopsis* such as their 10-segmented antennae with its two-segmented club, two-segmented pedicel, and an unarmed propodeum.

While these methods will only tell you if the ant is a member of the *Solenopsis* genus, it is most likely that the fire ants around your school are red imported fire ants. Several web pages are available for additional help with identification (Apperson, et al., 1993; Lockley, 1996; Gilbert, 1997).

In areas that do not have red imported fire ants, there are other species of non-native ants that will dominate disturbed areas including the crazy ant (*Paratrechina longicornis* Latreille) (Ohio State University Extension, 2001) and the Argentine ant (*Iridomyrmex humilis* Mayr). You may find it helpful to contact your local county extension office to find out what non-native ant is abundant in your area.

Field Research

Solenopsis invicta can be attracted to manufactured bait that simulates the size, shape, and raw fleshiness of newborn mammals. Students should form hamburger meat into one inch diameter balls prior to the day of the experiment. The prepared bait can be frozen in advance, then thawed at room temperature when needed. When in the field, each student team will need pencils, notebooks, two bait balls, two small flags, and a watch.

Two-member student teams should be directed to disturbed areas (grass near parking lots or roadsides) and more natural areas (an abandoned field or a small wooded area) on the campus and asked to propose hypotheses about where red imported fire ants would be most abundant. To test their hypotheses, each team should chose at random a site located in the disturbed areas and one in the more natural ones. At each location, a small, numbered flag should be inserted into the ground to identify the site, and a bait should be placed on the ground immediately next to the flag. Each team should stand a few feet away from the bait and record the time they had begun the study, the station number, and the time elapsed before the first fire ant touches the bait.

Students should be encouraged to wear closed-toe shoes and long pants during the experiment. While most people develop a small pustule with no side effects within an hour of being stung, some may have a severe reaction to proteins in the venom.

Data Analysis

Data can be analyzed by either the teacher or the students. Using all of the data collected by the students, a *t*-test can be used to determine if the mean time it took ants to encounter the baits placed in the disturbed areas was significantly faster or slower than those placed in the natural areas. In areas with a higher density of fire ants, we assume there will be more fire ants foraging for food, and the time to the first encounter will be shorter. For more advanced courses, the students may also be required to write a scientific paper including an introduction, methods, results, discussion, and literature cited sections.

Results

Two sections of an introductory college biology class, one each semester, conducted this experiment on the campus of Eckerd College in St. Petersburg, Florida. Approximately 10% of the campus is undisturbed forest while the remaining portion comprises roads, buildings, parking lots, and maintained grass fields.

Red imported fire ants reached the baits significantly faster in the disturbed areas than in natural areas in both the fall ($t = -2.91$, d.f. = 18, $p = 0.0093$) and spring ($t = -2.62$, d.f. = 18, $p = 0.0175$). The time for the fire ants to discover the baits in the disturbed areas ranged from 3 to 30 minutes; in the natural areas, the range was 9 to 45 minutes. None of the students conducting the experiment was stung by fire ants.

Discussion

The invasion and dominance of the red imported fire ant provides a dramatic illustration of the impact that habitat disturbance has on the ability of ecosystems to resist invasion by non-native species and the impact these species have on our native biodiversity. Red imported fire ants quickly covered the bait in the disturbed areas, whereas the students observed a diverse group of ants at the baits in the more pristine areas. In more pristine areas that have an intact native ant fauna, the native ants can out-compete the non-native fire ants; however, in areas where native ants have declined due to habitat degradation and pesticide applications, non-native fire ants are able to invade (Porter et al., 1988). Once they have invaded, red imported fire ants increase in number and can begin to have an impact on other invertebrate and vertebrate species.

While students in infested areas are generally very familiar with fire ants as a nuisance, they rarely think about why the fire ant is so abundant around their campus. This experiment could be enhanced by having students measure habitat variables such as the diversity and abundance of plant species in various areas and then relate the data to *S. invicta* abundance.

In addition to investigating how ecosystems differ in their resilience to invasion, students should think about why the red imported fire ant has succeeded and why social insects in particular are often good invaders (Moller, 1996). Because attempts have been made to control fire ants using pesticides (Lofgren, 1986) and biological control (Grisham, 1994), discussion about the impacts of these methods can also be explored.

The simplicity of this experiment makes it a perfect opportunity for introducing students to the style and principles of scientific writing. Judith and Calvin Kalman of Concordia University summarize research indicating how writing helps science students learn to think in accordance with paradigms that are quite foreign to them:

> "... students enter introductory [science] courses with viewpoints differing significantly from the interpretations of how nature behaves that will be taught to them and as they progress through the courses, these same students go to great lengths to maintain their original viewpoints. Writing in physics courses allows students to mediate their own "knowledge" with the new knowledge which the course presents to them. Writing to learn and learning to write explores the student's own doubts, gaps in knowledge and groping for the answer." (Kalman & Kalman, 1996)

Students at Eckerd College said they liked this experiment because they were able to conduct the experiment on a real species in "the wild." For the professor, the logistical advantages to this experiment are that it requires little equipment, can be conducted in a 1- to 2 hour class or laboratory period, and has a high probability of success.

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