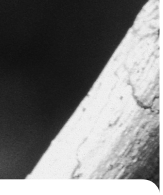
2007

# Using dragonflies as common, flexible, and charismatic subjects for teaching the scientific process

Paul Switzer, *Eastern Illinois University*

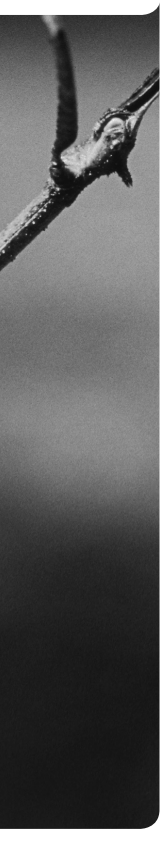


# Using Dragonflies as Common, Flexible & Charismatic Subjects for Teaching the Scientific Process

PAUL V. SWITZER

See this article with its beautiful images in **full color** online at: http://www.nabt.org/sites/S1/File/pdf/069-03-0158.pdf.

Biology laboratories are usually designed around convenient and available subjects. For example, for animal laboratories *Daphnia magna, Drosophila melanogaster*, frogs, rats, and mice are common animals that are relatively easy to obtain, relatively cheap, and consequently lend themselves well to laboratory experimentation. On many campuses, however, a body of water exists–either in the form of a creek or small pond–and this water attracts numerous animals that have tremendous potential as subjects for teaching. Chief among these animals are the dragonflies and damselflies. Dragonflies and damselflies occupy different suborders of the insect order Odonata, and, although both make great subjects for teaching, I focus primarily on dragonflies in this article. Below I explain why dragonflies make great subjects, give some practical advice for using them in your teaching, and then provide a few specific examples for how I have used them in my classes. My hope is that by giving a little background information and a bit of an admittedly biased push in their direction, dragonflies will become more appreciated and more utilized in science teaching.



## Dragonflies as Teaching Subjects

Dragonflies are ideal teaching and research subjects for a number of reasons. First, they are common and relatively easy to work with. Students can approach them closely, watch them, and capture, mark, and release them. Dragonfly larvae are aquatic, easy to capture using aquatic nets, and seem content to go about their business quite readily either in the field or in the lab. For instance, when held in jars after capture, the larvae behave normally and will try to eat other invertebrates in the jar. Adults are a bit more wary, yet if students avoid sudden movements or approaches, they can get within inches of many common species. Capture requires no more exotic equipment than either aerial (for adults) or aquatic (for larvae) nets, and adults can be quickly and cheaply marked with permanent marking pens or with white correction fluid. Moreover, adults can be used in many projects without capture. In addition, males and females of most common species can be distinguished from a distance.

**Figure 1.** Rainbow bluet damselfly (*Enallagma antennatum*) perched on a pond. (Photo by Paul V. Switzer).

Second, dragonflies are very charismatic and are effective ambassadors of the insect/invertebrate world. Probably only butterflies rival dragonflies as the most popular invertebrate in jewelry and clothing, and dragonflies provide interesting links between the natural world and art and poetry. For example, dragonflies have long played an important role in Haiku, as a brief Internet search for "Haiku" and "dragonfly" will demonstrate. Also, in my experience, once students acquire just a little information about dragonflies, only praying mantises (another fascinating insect predator) rival dragonflies for intrinsic "insect interest." Because of their rising popularity with the general public, dragonfly field guides have become more common and more "user-friendly," in the sense that many are now designed with the layperson in mind. Consequently, identifying the common dragonflies and, to a lesser extent, the damselflies, is easier than ever.

Third, dragonflies have a variety of interesting ecological roles and behavior in both the larval and adult stages. Dragonfly larvae are dominant invertebrate predators in many aquatic habitats and can help shape communities. Larvae capture prey by shooting out a modified lower mandible and grabbing prey, and larvae of larger species may eat small vertebrates (e.g., amphibian larvae and fish) as well as invertebrates. Dragonfly larvae move either by crawling or

*PAUL V. SWITZER is Associate Professor, Department of Biological Sciences, Eastern Illinois University, Charleston, IL 61920; e-mail: pvswitzer@eiu.edu.*

by jet propulsion, using water forcibly expelled out their anus. Adults are also predaceous, and males of many of the most common species are territorial, exhibiting a variety of conspicuous aggressive and mating behaviors. Their chases and fights can make quite an impression, especially once the students figure out what they are observing.

# Practical Considerations

## Identification & Seasonality

One of the first things you need to know for studying dragonflies is how to differentiate dragonflies and damselflies; one can easily accomplish this by noting obvious aspects of their appearance. Adult dragonflies have robust bodies, hold their wings out to their sides at rest, and often have eyes that meet in the center of their heads; their larvae tend to be somewhat "cricket-like" and do not have any projections off the posterior portion of their abdomens. Adult damselflies have a long, thin abdomen and are overall more "dainty" looking. They hold their wings together over their backs at rest and have eyes on the sides of their heads that do not meet in the middle. Damselfly larvae are likewise thin and have three flat, paddle-like gills projecting off the posterior of their abdomens.

**Figure 2.** Eastern amberwing dragonfly (*Perithemis tenera*) male in an "obelisk" posture. This posture helps them regulate their body temperature during hot summer days. (Photo by Paul V. Switzer).

**Figure 3.** Widow skimmer dragonfly (*Libellula luctuosa*). The white color on the wings and bluish color on the abdomen only appears as the male matures. (Photo by Paul V. Switzer).

Dragonflies, like most insects, will be affected by weather conditions, time of day, and season. This fact provides some limitations as well as possible questions for student projects. In general, adults are active on sunny days as long as it is warm enough (above 75˚ F or so) and are more active in the middle of the day than morning and evening. On overcast days, dragonflies require higher ambient temperatures to exhibit typical levels of activity. Furthermore, as with many insects, dragonflies (adults and nymphs) are more common in summer and fall than in spring.

## Handling, Marking & Observing Adults & Larvae

Many satisfactory studies can be done without ever handling a dragonfly. However, if your study requires that you capture adult dragonflies, you should keep a few considerations in mind. Students will need good aerial nets and their capture success will be higher if they minimize their bodies' projection against the plain sky background from the perspective of the dragonfly. When possible, students should approach and swing from behind the dragonfly to decrease the chances of the dragonfly detecting them (again, this presents a possible student project!). Once captured, the adults of larger species can and will bite, but if students hold them by the thorax (under the wings) or by the wings, the dragonflies will not be able to reach their fingers. Students should also be careful with the wings; dragonfly wings do not have scales that will rub off as do butterflies and moths, but their wings are still fragile. To prevent damage, students should hold more than one wing at a time, holding them folded over their back.

Adult dragonflies can be marked with white paper correction fluid, permanent markers, or small amounts of acrylic paint on their wings or abdomen. Before marking any dragonflies, consider the following. First, dragonflies are flying insects; this means that students will want to minimize the amount of correction fluid or paint that they apply. Second, after adults are handled and marked, the dragonflies will often fly away. Many of these individuals will come back within minutes, a few hours, or by the next day, but there is no guarantee. Therefore, if you are doing a project that requires individual identification, capture and mark as many as you can well ahead of when you intend to collect data. For many of the territorial species, however, the males tend to remain in the same location, even returning to the same perch after flying away. Students can take advantage of this behavior to avoid pseudoreplication during relatively brief studies.

The territorial behavior of adult male dragonflies provides many possibilities for student research. Perching adults will often use perches you provide; consequently, students can study experimentally the perch characteristics that dragonflies prefer (e.g., Switzer & Walters, 1999). If you do provide perches, however, allow the dragonflies a day or so to become accustomed to the change in their habitat. Many dragonflies also pursue species other than their own, which can make for some interesting and easy observational studies (e.g., Schultz & Switzer, 2001).

Some species have relatively clear territorial boundaries; you can figure out where these boundaries are by observing where the male turns when "patrolling" his territory. Whether a species has distinct boundaries to its territory is, by itself, an interesting question, and by watching several males for a short period of time students will be able answer this question. For those species that often have boundaries (e.g., eastern pondhawks, *Erythemis simplicicollis*), students can observe whether the males will respond to a passing dragonfly only within the territory boundaries, and whether this holds for pursuing both females and males. Indeed, simply trying to determine the function of the territory (why are they chasing things?) can be a fun project, and one that can usually be answered by recording who the males pursue (i.e., what species and what sex).

If your study is on dragonfly larvae, you may want to bring them into the laboratory for a period of time. To feed the larvae, keep in mind that they will eat pretty much any animal smaller than themselves, including some snails. This means that they will also eat each other; students can minimize this by holding them in groups of similar-sized individuals and by providing some aquatic plants/debris. It is important to use pond water or treated tap water as one would for fish. If you plan on holding larvae for more than a day, provide them with a stick so they can climb out of the water if they need to emerge and metamorphose into an adult. If your students pressure you into keeping the adults, keep in mind that adults are difficult to keep in captivity and should simply be released back to the "wild."

**Figure 4.** Two shed skins (exuviae) from dragonflies. These skins were left behind when the larva emerged from the water and became an adult, terrestrial dragonfly. (Photo by Paul V. Switzer).

## Sources of Background Information

In most cases, both you and the students will want to know about the biology of dragonflies and which species you are studying. For a general dragonfly "encyclopedia," one cannot do better than *The Biology of Dragonflies* (Corbet, 1999). As the name implies, Corbet's book has an abundance of information on the all aspects of larval and adult dragonfly biology. To help you identify your dragonflies, I've included possible field guides in Table 1; several other quality guides exist and a little time spent searching might yield a field guide specifically for your area. Also, many beautiful Web sites provide excellent pictures to help generate interest in dragonflies among your students and to help identify the species on your campus. A quick Internet search will yield numerous suitable sites, and these sites often cover the dragonflies and damselflies of particular regions. One of the best Internet sites is the digital dragonfly museum (http://stephenville.tamu.edu/~fmitchel/dragonfly/index.html), a site that has beautiful pictures and allows nonprofit use of its images. Although the site is based in Texas, many of the species are found much more widely; thus, you could even create your own class field guides by including the few key species that are present at your location. To help you get started, in Table 2, I list five of the common pond dragonfly species that occur east of the Rocky Mountains (with their common names and some references on their adult behavior).

## Suggestions for Use in Classes

I use dragonflies for open-ended, investigative laboratories in my introductory zoology course, my upper-division animal behavior course, and my non-majors environmental life science course. In all three courses students seem to have little trouble making behavioral observations or posing original research questions with the dragonflies. Although I give estimates on the time I allow for parts of the exercises, these exercises are completely flexible in terms of the number of students in the class, the time available for the laboratory, and the size of the body of water. Typically, I pair students for initial observations, question formation, and data collection. Any data analysis or follow-up questions are usually assigned on an individual basis. As with any laboratory, spending a small amount of time with a "pilot run" of the exercise will likely save a great deal of time and frustration when you actually conduct the laboratory.

**Table 1.** Possible field guides for dragonflies in North America. Note that many regional or state guides exist (check with your state department of natural resources). The California and Florida guides are listed below to represent regional guides on opposite ends of the United States.

| TITLE | AUTHOR |
|---|---|
| *Common Dragonflies of California* | Biggs, 2000 |
| *Dragonflies and Damselflies of California* | Manolis, 2003 |
| *Dragonflies Through Binoculars* | Dunkle, 2000 |
| *Dragonflies of the Florida Peninsula, Bermuda, and Bahamas* | Dunkle, 1989 |
| *Stokes Beginners' Guide to Dragonflies* | Nikula et al., 2002 |

In my introductory zoology class, students choose and design their own class laboratory project. I've assigned dragonfly larvae as subjects for the past two years in the fall. Student projects have studied the effect of larval density on spacing and movement, effect of different copper sulfate concentrations (a common algaecide for ponds and lakes) on larval survival and activity, and the relationship among larval size, larval abundance, and depth in the pond. Many more suitable projects are proposed each semester. While it is relatively easy to differentiate damselfly from dragonfly larvae, identifying them to the species level can be more challenging. I typically refer to them as "dragonfly" larvae or "damselfly" larvae and make sure the students realize that they may be studying different species without knowing it, so that they must take that potential problem into account when interpreting their data. I allow up to two weeks for data collection in this course; however, depending on the question, data may be collected in a single, three-hour lab period. The necessary equipment will include aquatic nets for collection and white bottom pans for finding larvae in water samples (plastic containers with white paper underneath will work). Other equipment will depend on the question; Petri dishes and a ruler or calipers are likely possibilities.

**Table 2.** Five dragonflies that are commonly found on ponds east of the Rocky Mountains, have easily distinguished sexes, and are reasonably easy to identify from a distance.

| COMMON NAME (SPECIES) | REFERENCES |
|---|---|
| Blue Dasher, *Pachydiplax longipennis* | Dunham, 1998; May and Baird, 2002 |
| Eastern Amberwing, *Perithemis tenera* | Jacobs, 1955; Switzer 1997, 2002; Switzer and Eason, 2000 |
| Eastern Pondhawk, *Erythemis simplicicollis* | McVey, 1988; May and Baird, 2002 |
| Common Whitetail, *Plathemis lydia* | Jacobs, 1955; Campanella and Wolf, 1974; Koenig and Albano, 1985 |
| Widow Skimmer, *Libellula pulchella* | Campanella, 1975; Moore 1987, 1989 |

In my animal behavior course, I use adult dragonflies as the subjects for a laboratory on designing a behavioral project, including the development of an ethogram (a description of the different behaviors an animal performs). For this laboratory, I choose one or two abundant species of dragonfly (usually the eastern amberwing, *Perithemis tenera;* the eastern pondhawk, *Erythemis simplicicollis;* or the blue pirate, *Pachydiplax longipennis*) and have students observe a few different individuals for five minutes each, recording everything they notice the dragonflies doing. For approximately 30 minutes, they then develop an ethogram of the behaviors they observed, we discuss the ethogram, and I have them brainstorm possible research questions. We talk about the research questions, choose one as a group to pursue, and quickly design and conduct a study as a class; data gathering usually lasts for 15-30 minutes. We compile our data and as a laboratory report, the students are responsible for summarizing the data, describing and interpreting any patterns they found, and proposing new questions. So far, students have conducted studies on perch height comparisons among species; the direction dragonflies face when perching in relationship to wind, shore, and the direction they flew; transitions among specific aggressive behaviors; and territory size and perch location

**Figure 5.** Eastern pondhawk dragonfly (*Erythemis simplicicollis*). (Photo by Paul V. Switzer).

relative to the territory boundaries. These studies have required no more than pencil and paper to conduct.

In my environmental life science course, I use adult dragonflies to illustrate the scientific method to fairly large groups of students. I have typically taught this class in our intersession (in May), which is still pretty early for dragonflies in Illinois. Still, we have been able to use species such as the black saddlebag (*Tramea lacerata*) with some success. Much like the animal behavior course, I give pairs of students a short period of time to make and record observations and pose possible research questions. We then spend 15-20 minutes discussing their observations and their research questions, quickly design a study, and collect data. After collecting data, students may use their group's data to summarize the results, make a conclusion, and pose new questions based on their results. Alternatively, we may combine data from all students, use these combined data to answer their question, and students then pose a new question based on the results from the class. I typically focus on the process of science rather than worry about the creativity of the particular question. In this course, students have conducted studies on whether the dragonfly species typically perches or flies, and how it reacts to approaching dragonflies (i.e., whether it is territorial). These simple questions are quick to answer, serve as a good illustration of the scientific method, and require only a pencil and paper. In addition, for such non-majors classes, one could discuss the effect eutrophication might have on dragonflies, or, after explaining Haiku, give students an opportunity (for class credit) to write a Haiku or poem that includes dragonflies.

Obviously, your particular approaches will depend upon your goals, your time, and the species available to you. However, dragonflies are so easy to work with that brief studies can be done within a one-hour period with a minimum of equipment. Adults have the advantage of getting the students out in the field (always a popular feature with the students!) and requiring little to no preparation (always a popular feature with the teacher!). Larvae are fun to watch and will live in the laboratory for quite a while with minimal care; if you are lucky, they will even emerge as adults. So, if you have water near your school and are looking for a new teaching subject, try dragonflies!

## References


Biggs, K. (2000). *Common Dragonflies of California*. Sebastopol, CA: Azalea Creek Publishing.

Campanella, P.J. & Wolf, L.L. (1974). Temporal leks as a mating system in a temperate zone dragonfly (Odonata: Anisoptera) I: *Plathemis lydia* (Drury). *Behaviour*, *51*, 49-87.

Campanella, P.J. (1975). The evolution of mating systems in temperate zone dragonflies (Odonata: Anisoptera) II. *Libellula luctuosa* (Burmeister). *Behaviour, 54*, 278-309.

Corbet, P.S. (1999). *Dragonflies: Behaviour and Ecology of Odonata*. Martins, England: Harley Books.

Dunham, M.L. (1998). Territory tenure in a libellulid dragonfly. Available online at the *Regenerative Science Institute's Bioliterature Repository*: http://biolit.regensci.org/repository/19981226221522/19981226221522.html.

Dunkle, S.W. (1989). *Dragonflies of the Florida Peninsula, Bermuda, and Bahamas*. Gainesville, FL: Scientific Publishers.

Dunkle, S.W. (2000). *Dragonflies Through Binoculars*. New York, NY: Oxford University Press.

Jacobs, M.E. (1955). Studies on territorialism and sexual selection in dragonflies. *Ecology, 36*, 566-586.

Koenig, W.D. & Albano, S.S. (1985). Patterns of territoriality and mating success in the white-tailed skimmer *Plathemis lydia* (Odonata: Anisoptera). *American Midland Naturalist, 114*, 1-12.

Manolis, T. (2003). *Dragonflies and Damselflies of California*. Berkeley, CA: University of California Press.

May, M.L. & Baird, J.M. (2002). A comparison of foraging behavior in two "percher" dragonflies, *Pachydiplax longipennis* and *Erythemis simplicicollis* (Odonata: Libellulidae). *Journal of Insect Behavior, 15*, 765-778.

McVey, M.E. (1988). The opportunity for sexual selection in a territorial dragonfly, *Erythemis simplicicollis*. In T.H. Clutton-Brock (Ed.), *Reproductive Success: Studies of Individual Variation in Contrasting Breeding Systems* (pp. 44-58). Chicago, IL: University of Chicago Press.

Moore, A.J. (1987). The behavioural ecology of *Libellula luctuosa* (Burmeister) (Anisoptera: Libellulidae): I. Temporal changes in the population density and the effects on male territorial behavior. *Ethology, 75*, 246-254.

Moore, A.J. (1989). The behavioral ecology of *Libellula luctuosa* (Burmeister) (Odonata: Libellulidae): III. Male density, OSR, and male and female mating behavior. *Ethology 80*,120-136.

Nikula, B., Sones, J., Stokes, D. & Stokes, L. (2002). *Stoke's Beginner's Guide to Dragonflies*. New York, NY: Little, Brown and Company.

Schultz, J.K. & Switzer, P.V. (2001). Pursuit of heterospecific targets by territorial amberwing dragonflies (*Perithemis tenera*): a case of mistaken identity. *Journal of Insect Behavior, 14*, 607-620.

Switzer, P.V. (1997). Factors affecting site fidelity in a territorial animal, *Perithemis tenera*. *Animal Behaviour, 53*, 865-877.

Switzer, P.V. (2002). Territory quality, habitat selection, and competition in the amberwing dragonfly, *Perithemis tenera* (Odonata: Libellulidae): population patterns as a consequence of individual behavior. *Journal of the Kansas Entomological Society, 75*, 145-157.

Switzer, P.V. & Eason, P.K. (2000). Proximate constraints on intruder detection in the dragonfly *Perithemis tenera* (Odonata: Libellulidae): effects of angle of approach and background. *Annals of the Entomological Society of America, 93*, 333-339.

Switzer, P.V. & Walters, W. (1999). Choice of lookout posts by territorial amberwing dragonflies (*Perithemis tenera*) (Anisoptera: Libellulidae). *Journal of Insect Behavior, 12*, 385-398.