Articles

The Influence of Habitat Complexity on Crayfish Foraging Behavior

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Abstract

I teach an animal behavior course where students conduct independent research projects; however, using live animals for research is challenging at a small university. Often, students choose to conduct a laboratory project over a field project believing that it will be easier to observe animals and control variables, but it can be difficult and expensive to acquire and maintain animals. If students work with vertebrates, there are added complications such as obtaining Institutional Animal Care and Use Committee (IACUC) approval and training. Additionally, following IACUC regulations often involves resources that we do not have. Because of these complications, I suggest to students that they consider an invertebrate species for their projects. In particular, crayfish are a species that are easy to obtain and care for, have low mortality, and exhibit interesting behavior that can be observed over several weeks. This article describes an inquiry-based research activity examining the influence of habitat complexity on crayfish foraging. This activity is well suited for students in ecology, animal behavior, or invertebrate biology classes and gives students flexibility in the hypothesis they test and the methods they use, while providing a framework that lets them successfully complete a behavior project.

Keywords: Habitat complexity, habitat structure, animal behavior, crayfish, aggression, foraging behavior, invertebrate biology

Introduction to Habitat Complexity and Crayfish Behavior

Crayfish are freshwater crustaceans that live in a variety of shallow habitats (streams, lakes, marshes, and swamps). They are opportunistic omnivores, and their diet includes macrophytes, algae, detritus, invertebrates, and small fish. Crayfish can be quite aggressive toward each other and will chase, push, and grab at one another (Baird et al. 2006). Crayfish generally live in structurally complex habitats such as rocky areas of rivers, and vegetated littoral zones of lakes. Habitat complexity refers to the physical structure of the environment. For example, the littoral zone of a lake is generally more structurally complex than the open water limnetic zone. Often, in the littoral zone, there are rocks, woody debris, and rooted plants of a variety of shapes and sizes.

Previous research has shown that habitat complexity can influence prey density, interactions between predators and prey, and foraging rates of predators (Savino and Stein 1982, 1989, Gotceitas and Colgan 1987, 1989, Diehl 1988, Gotceitas 1990, Nystrom and Perez 1998). Previous studies where stem density has been manipulated have found that an increase in habitat complexity generally results in a decrease in foraging rate due to physical interference making it difficult for predators to find prey (Savino and Stein 1982, 1989, Gotceitas and Colgan 1987, 1989, Diehl 1988, Gotceitas 1990). Some studies have found that foraging gains are maximized at intermediate levels of structural complexity (Crowder and Cooper 1979, 1982) due to the interaction between the effects of dense vegetation on prey density, maneuverability and visibility. However, habitat complexity can also influence interactions between foragers. Studies examining the influence of habitat complexity among foragers that are aggressive toward one another have found that as habitat complexity increases, the aggressive interactions between foragers decrease, resulting in the amount eaten per forager increasing (Basquill and Grant 1998, Corkum and Cronin 2004).

General Methods

Format of Research Projects

I prefer to have students pick their own hypothesis and develop their own methods, rather than telling them what to do as it provides students with experience developing a hypothesis and designing their own experiment- which is something that students rarely get to do. Also, this makes the project truly "theirs" and they become more vested in their projects. I find that the crayfish projects work best when students collaborate in groups of three or four. Working in groups enables students to divide up the work so that they can collect sufficient data to allow them to conduct statistical analysis and draw meaningful conclusions. I have found that groups larger than four students tend to increase the probability of conflicts between group members over equity of workload. Additionally, if students work in groups it means that the instructor has a more reasonable number of projects to oversee.

I first provide students with background information on crayfish behavior and habitat complexity, then I ask students to conduct a literature search and write a 2-3 page summary of a local crayfish species, and the influence of habitat complexity on crayfish behavior. After going over their summaries with them, I ask groups to come up with a hypothesis to test regarding the influence of habitat complexity on crayfish foraging behavior. Once students have developed a hypothesis that they plan to test, and their hypothesis has been approved by me, they design an experiment to test their hypothesis. Next, I require that students submit a scientific research proposal. Students are given a detailed handout that outlines how to write a research proposal (Appendix). In the handout I explain that they need an introduction with supporting background literature, and a detailed methods section including a discussion of proposed statistical analysis. I also ask them to include a list of required items, and a detailed calendar outlining what the group will do each week (including set up, animal acclimation, data collection, data analysis, and preparation for presentation of results). Requiring a formal research proposal helps students structure their ideas and prevents students from jumping ahead and making major mistakes in their experimental design.

After reading their proposals, I meet with each group to discuss their projects and make suggestions to their hypothesis and experimental design. I then ask groups to revise their proposals based upon that discussion. After groups rewrite their proposals, I then meet with groups again. Students do not begin data collection until their proposals have been reviewed and approved. Before students begin their projects, I ensure that they have background knowledge on how to care for their animals, have worked out the details of their experimental design, know what data they will record, have an idea of how they will analyze their data, and understand what results will support their hypothesis.

Suggestions and Helpful Hints for Crayfish Research Projects

While students should develop their own hypothesis and experimental design, they may need some assistance. Below I outline some helpful suggestions to consider when discussing projects with each group.

Students should design an experiment to examine the influence of habitat complexity on crayfish foraging behavior. They can do this by manipulating structural complexity in the crayfish's habitat. Exactly how they do this will depend on what hypothesis they choose to address. For example, they could choose to increase structural complexity by adding different densities of plants to tanks. They could use either field-collected aquatic plants, artificial aquatic plants obtained from pet stores, or simulated plants (by using nylon rope pieces tied to nets and anchored in the substrate). Alternatively, students could increase structural complexity by changing the abundance of hiding places. This can be achieved by using small, inverted clay pots placed throughout the tank, by adding medium-sized rocks (roughly 5 cm in diameter), by adding pieces of bricks, or by piling up rocks to create rock caves. They could also compare the influence of different types of complexity (e.g. field-collected plants versus artificial rope pieces, or plants versus rocks). There are many different hypotheses that can be easily tested.

Small crayfish can either be purchased through a biological supply company, or field-caught from local aquatic habitats using hand-held dip nets. Preferably, crayfish should be approximately similar in size. We use both male and female crayfish and randomly assign crayfish to tanks. Students will need sufficient crayfish to provide replicates. If crayfish are field-caught, then they should be returned to the location where they were obtained at the end of the project.

Crayfish are relatively easy to maintain in the lab as they can survive a wide range of water conditions. Tanks should be set up several days before the crayfish are obtained. Crayfish can be housed in tanks containing aerated dechlorinated water. Students should decide on the number of crayfish to place in each tank (which will depend upon their hypothesis), keeping in mind that the tank size needed will depend upon how many crayfish are placed in each tank. Generally, you need a tank large enough to hold 3-10 gallons per crayfish because crayfish can be aggressive. I suggest using two similarly sized crayfish per 10-20 gallon tank. The bottom of the tanks can be lined with washed aquarium gravel to a depth of 2.5 cm and filled with water to a depth of approximately 15 cm. If aeration is not used, crayfish must be given a structure that they can climb up on (e.g. rock) to get out of the water so that they can obtain sufficient oxygen. Water filters are not necessary, but partial water changes (25%) should be done weekly. Water temperature should be between 18-23 C (room temperature). Crayfish can be kept under a light regime of approximately 14hL:10hD. Crayfish should be given approximately a week to acclimate to the lab prior to the beginning of experiments. During the acclimation period, crayfish can be fed sinking shrimp pellets ad lib (which can be purchased from pet stores). It is often useful to set up a larger holding tank (e.g. 20 gallons) to house extra crayfish that may be needed if any die, and as a place to house crayfish if they are switched between treatments. Crayfish can be individually identified by drying a small region on their back with a paper towel and using nail polish to paint a number on their carapace. Students should ensure that the nail polish is dry before returning crayfish to their tanks.

Students can set up treatment tanks depending upon what their specific hypothesis is. For example, if students want to test the hypothesis that increasing plant density influences crayfish foraging, then they could set up three different treatments that vary in plant density. All tanks would be set up exactly the same (same size tanks, same number of crayfish per tank, etc.) with the only difference between the tanks being plant density. Control tanks would not have any plants added, low-plant-density tanks might have two artificial plants per tank, and high-plant-density tanks might have six artificial plants per tank.

Students will need to decide how many replicates to conduct, how long to run trials, and what data to collect. After students have decided upon a hypothesis to test, set up their habitats, and allowed the crayfish to acclimate to the lab, they can begin their experiments. Prior to each feeding trial, crayfish should be deprived of food for 24 hours to ensure that they are hungry. During each trial, equal amounts of food should be placed in the center of each tank. We've had good results using sinking shrimp pellets or redworms as food choices, but there are many possible foods that can be used such as cut-up fresh spinach, cabbage, cucumbers or carrots. After each feeding trial has been conducted, crayfish can be given an additional 5 minutes to feed, and then leftover food should be removed with a net so as not to foul the tanks.

Students should decide what data they will record, but they may need some assistance to ensure that they collect appropriate data for analysis. It is generally useful to have students record latency (time (s) that it takes for crayfish to capture the first food item), the number of food items captured, and the total length of time spent foraging (from when food is first placed until when the last food item is captured). Later, students can calculate capture rate. (# eaten/time).

Results and Discussion

This exercise gives students an opportunity to statistically analyze data. I conduct this project in my class after students have been introduced to statistical analyses. I meet with each group to discuss appropriate data analysis. Graphing the data will help students visualize their results.

Students can graph the results to determine:

1) if average latency (s) decreases as the level of habitat complexity increases (Figure 1)

2) if average capture rate (#/s) increases as the level of habitat complexity increases (Figure 2)

Students can statistically analyze the data to determine whether:

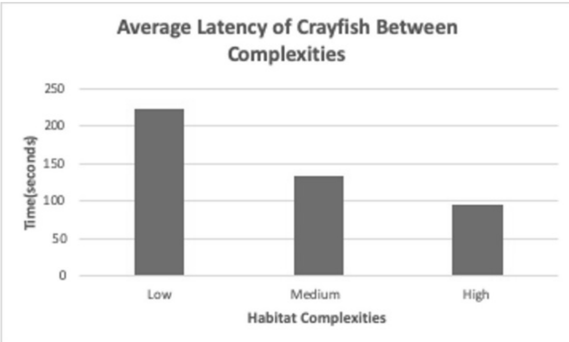
1) average latency significantly changes with increasing habitat complexity

2) average capture rate significantly changes with increasing habitat complexity

Generally, my students have found that as habitat complexity increases, latency significantly decreases, and capture rate significantly increases. However, as in any science experiment, students don't always find what they predict they will find, and this is a great opportunity to discuss with students all of the reasons why they may find results that differ from their predictions. After analyzing their data, I have students present their results in an oral presentation to the class, in a poster presentation at our collegewide poster symposium, and as a full written report.

Figure 1

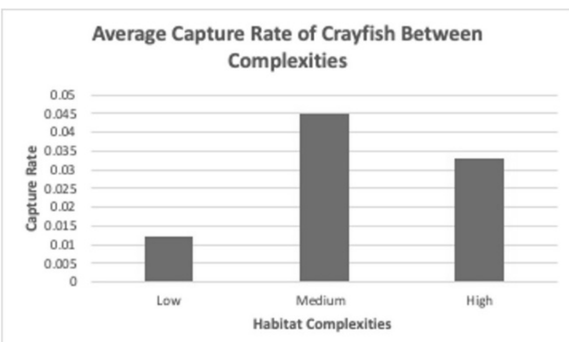
An example of one group's results



The average latency (time it takes to capture the first food item) for crayfish foraging in low, medium, and high complexity treatments. The results showed that there was a significant decrease in latency with increasing habitat complexity (ANOVA $p<.05$).

Figure 2

An example of one group's results



The average capture rate (worms eaten/second) for crayfish foraging in low, medium, and high complexity treatments. The average capture rates in the medium and high-density treatments were significantly higher than the average capture rate in the low-density treatment (ANOVA $p<0.05$).

Conclusion

It can be very challenging to find animal behavior research projects that are doable. This exercise provides an opportunity for students to design and conduct independent research projects and analyze and summarize their results. This exercise provides students with flexibility regarding what hypothesis they test, and what methods they use, while providing a framework that helps them successfully complete a behavior project.

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APPENDIX: Handout on Writing a Research Proposal

ADVICE ON WRITING A SCIENTIFIC RESEARCH PROPOSAL

Each group must hand in a formal type-written (double spaced) research proposal for their project. This research proposal should include:

1) A title for your project (it should be descriptive and concise).

2) An introduction section providing:

   a) **Introductory material** on your topic and the animal species you intend to study (you will need to research the literature and present background theory from the scientific literature). Address the purpose of your project and put your project in context by discussing what is known about the species you plan to research and the behavior you plan to address.

   b) **Your hypotheses and predictions.** What hypotheses do you plan to test? Depending on your question, you may have one hypothesis that you will test, or you may have several hypotheses. What are your predictions?

3) A methods section outlining the **methods you will use**. This should be **very detailed** and written as it would be in a scientific lab report (in paragraph format). You should also include a paragraph or two carefully explaining: **what data you will collect** and **how you will statistically analyze the data**.

   Be sure to include:

   Details of all experimental procedures

   Where the project will be conducted

   Specific details of how animals will be housed and cared for (if a lab project)

   Explanation of what data will be collected

   Explanation of what variables will be calculated how the data will be analyzed (including specific statistical tests).

   If the proposed research involves the use of vertebrates, approval of the Institutional Animal Care and Use Committee must be obtained, and training must be completed.

4) A **<u>complete</u> list of items needed** including sizes of tanks/cages, and the quantity of each item (this will help me know what we need to purchase).

5) A **detailed time schedule**. Look at the syllabus and see how much time you have. Then plan out a week-by-week schedule of exactly what you will do.

   For example (for a fish foraging experiment):

   Week 1 (date): Set up aquaria, introduce fish into tanks, allow fish to acclimate for one week, collect prey to be used, design data collection sheets.

   Week 2 (date): Experiment 1: Provide each fish with prey assemblage. Fish will see the same prey assemblage each day, for seven days in a row. At the end of each day, tanks will be cleaned. Data on the number and type of each prey captured will be collected. etc.

6) A **literature cited** section.