Behavior Experiments with the African Clawed Frog

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A live frog for each student to study during a unit on animal behavior? Too expensive? Too impractical? Not with *Xenopus laevis*, the African clawed frog (fig. 1). In many biology classrooms *Xenopus* is already used to study reproduction and embryology; a male and female frog are injected with reproductive gonadotropins, the pituitary hormones that bring about spawning, amplexus, and the resulting development of hundreds of tadpoles. With proper care the tadpoles grow quickly and undergo metamorphosis within a few months. *Xenopus* tadpoles and the resulting small frogs provide a wealth of specimens for animal behavior studies, and during an era of budget cutbacks making maximum use of specimens already on hand makes sense (fig. 2).

Easy and Inexpensive to Rear

Using young *Xenopus* made available from previous embryological work circumvents problems typically encountered by the teacher who wants each student to conduct his or her own animal behavior study. The frogs are on hand, abundant, healthy, and easy to raise. Unlike *Rana pipiens*, the African clawed frog is completely aquatic and can be reared in large culture bowls or two- to five-gallon plastic covered aquariums, depending on the size and developmental stage of the frog. Students can carry these containers easily and they are convenient for storage in the classroom. Air pumps are not necessary but the water should be changed and replaced with dechlorinated (i.e., leave tap water standing for a minimum of 24 hours prior to use) water at least once a week or as needed.

The tadpoles filter and subsequently ingest food particles from water entering their mouths and require a constant supply of algae, plankton, nettle powder, or, more simply, prepared tadpole food which can be purchased from supply houses carrying the frogs. The adults are carnivorous, have prodigious appetites, and will eat raw, chopped liver, defatted steak, earthworms, or, again more simply, prepared frog brittle or pellets purchased from supply houses. The frogs should be fed at least twice a week; more frequent feeding results in maximum growth.

Xenopus, unlike *Rana pipiens*, is easy to rear in the lab and keep healthy; it eats well and grows rapidly. Larger frogs should not be housed in the same aquarium as smaller frogs or tadpoles since, in the lab as well as in nature, *Xenopus* will eat its own young. The same traits which make *Xenopus* ideal laboratory animals—hardiness and aggressive feeding habits—make them a potential environmental hazard.

Extreme care must be taken not to release any eggs, tadpoles, or

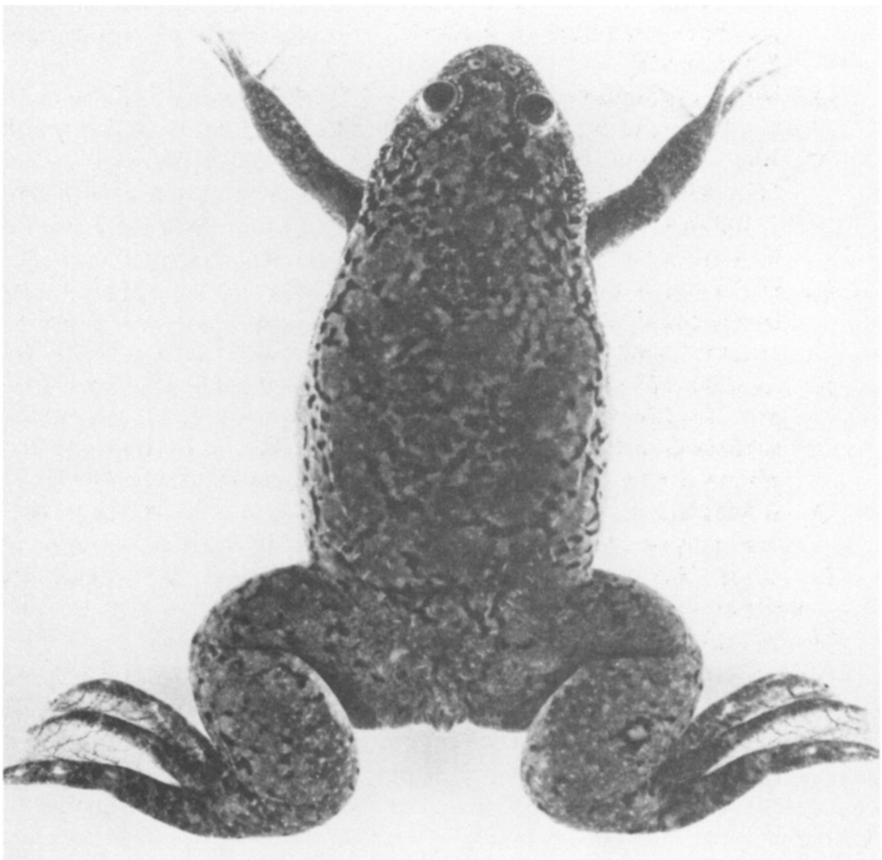

FIGURE 1: Adult female African clawed frog, *Xenopus laevis*. (Photo by Sandra Telander.)

FIGURE 2: *Xenopus* tadpole undergoing metamorphosis. (Photo by Sandra Telander.)

frogs into the environment, particularly in areas where winters are mild. In parts of Southern California, for example, *Xenopus* have become feral in drainage canals and ponds—much to the detriment of other species. The frogs were introduced in the 1940s for human pregnancy tests and later became popular aquarium pets; mishandling of the animals resulted in feral populations.

Conditioning Experiments

Students know little about *Xenopus* and discovering some of the frogs' behaviors can motivate them to learn more. My students attempt to determine their frogs' positive and negative taxes and responses to various stimuli, and then incorporate appropriate stimuli as reinforcements in conditioning experiments. A summary of their activity is outlined below.

1) The young post-metamorphic frogs are introduced to the class. Students observe the frogs with stereomicroscopes, learn how to care for them, and set up aquariums.

2) Students then list ten reasonable and humane stimuli or environmental variables to which they wish to subject their frogs. They also list the materials necessary for each test. The lists are given to the teacher who provides the necessary equipment. Typical requests include accessory lamp to vary ambient light intensity, colored cellophane to vary the wavelength of light received, pebbles for bottom texture variation, food for presentation, small aluminum ball suspended on a string for visual presentation, and a tuning fork for sound production.

3) Students subject their frogs to the stimuli or environmental choices for a specified number of trials and record the responses.

4) Students try to identify positive and negative responses. In keeping with the "NABT Guidelines for the Use of Live Animals at the Pre-university Level" (1980), only positive reinforcement should be used. Also, some variables tested are more appropriate than others for use as positive reinforcements.

5) Students then plan and carry out experiments to condition the frogs to respond to a stimulus in a way they normally would not resond. Positive responses discovered earlier serve as reinforcements to help alter or "shape" the behavior.

Experimental plans of my students included conditioning a frog to associate a light beam with food, conditioning a frog to swim through a partition using light intensity as a positive reinforcement, and conditioning a frog to associate a tuning fork tone with food. Ideally, statistical analysis should be incorporated to state conclusively whether or not conditioning has occurred. With or without the mathematical analysis, however, students gain insight into experimental design, develop responsible attitudes toward animal care, and learn about frog behavior.

A review of the literature shows little research on conditioned learning in *Xenopus.* Miller and Berk's (1977) study on learning retention over metamorphosis is an exception.

Abundant Project Possibilities

Sufficient information is known about these frogs to suggest several worthy projects for high school students. In addition, the experience of merely rearing and maintaining them may provide students as well as teachers with ideas. For example, possible studies include:

1) Does *Xenopus* exhibit social organization? Does a dominance hierarchy exist?

2) Unlike *Rana pipiens, Xenopus* ingests food underwater by rapidly pushing with its forelegs; this response is triggered by sensing food in the vicinity. Does underwater vision play a role in locating food (Brown 1970)?

3) Does lack of movement in prey affect the distance at which the

frog sees it (Brown 1970)?

4) In shallow water, young *Xenopus* respond to a knot in a dark thread as if it were food. Must the suspended object meet size requirements to induce this response (fig. 3)?

5) Does odor play a role in detecting prey (Brown 1970)?

6) What are the food preferences of *Xenopus*?

7) *Xenopus* produces slime on its surface when handled. Is this a noxious chemical mechanism as well as lubrication to enhance escape?

8) The lateral line organs along the surface of the frog detect underwater vibrations. What is the minimum intensity to which a frog responds (Brown 1970)? Will taped sounds from a male *Xenopus* evoke responses?

9) The melanophores of *Xenopus* are sensitive to the background light. Does varying the color of the frog aquarium affect skin color (Brown 1970; and Orlans 1977)? Do all frogs and tadpoles respond similarly?

10) Young tadpoles placed with more mature tadpoles suffer a fatal loss of appetite, and aquarium water from the more mature organisms is sufficient to induce this response. What are the characteristics of this inhibiting agent (Orlans 1977)?

Some of the best ideas will come from the students themselves as they become intrigued with their frogs. With the abundance of novel and hardy subjects on hand, the end of an embryology unit can be the beginning of an exciting animal behavior study.

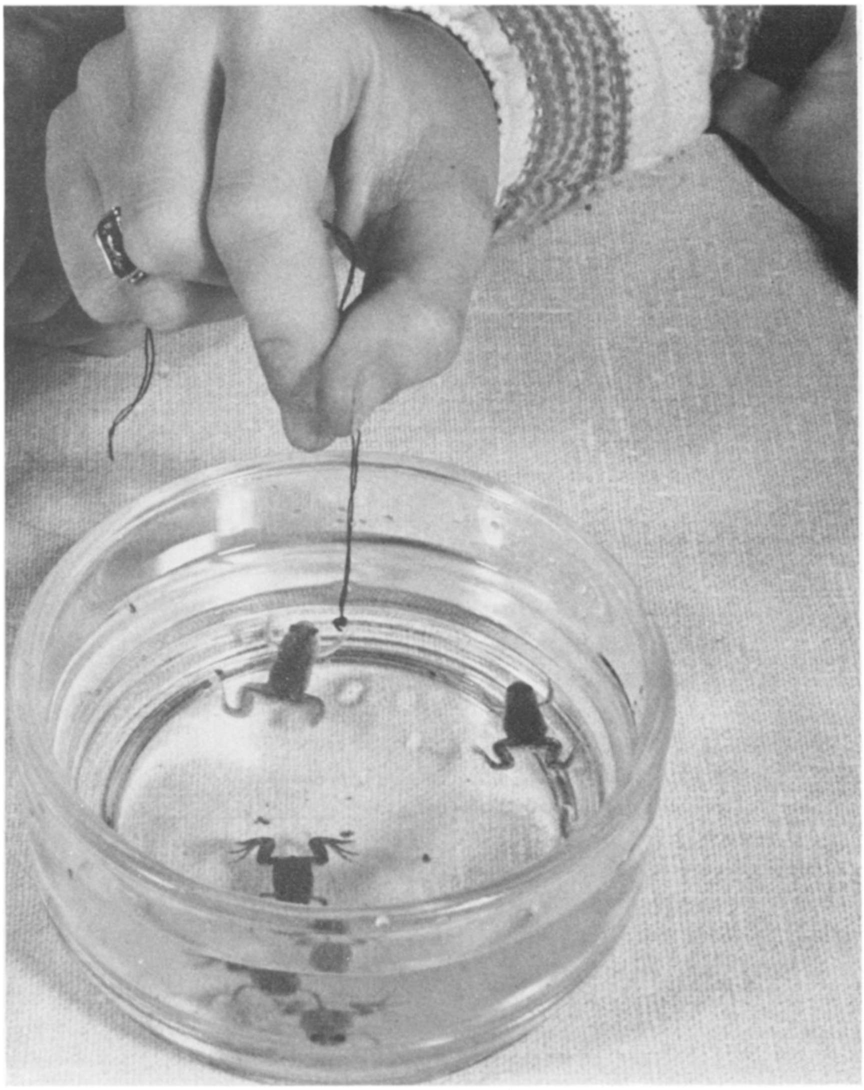

FIGURE 3: Offering knotted thread to young post-metamorphic *Xenopus*. (Photo by James A. Thielecke.)

References

BROWN, A.L. 1970. *The African clawed toad, Xenopus laevis: A guide for laboratory practical work.* London: Butterworths.

DEUCHAR, E.M. 1975. *Xenopus: The South African clawed frog.* London: John Wiley and Sons.

ETHERIDGE, A.L. 1976. *Xenopus laevis, laboratory studies of the African clawed frog.* Fort Atkinson: Nasco.

MILLER, R.R., and BERK, A.M. 1977. Retention over metamorphosis in the African claw-toed frog. *Journal of Experimental Psychology: Animal Behavior Processes* 3(4):343-356.

National Association of Biology Teachers. 1980. *NABT guidelines for the use of live animals at the pre-university level.* NABT Newsletter, Spring.

ORLANS, F.B. 1977. *Animal care from protozoa to small animals.* Menlo Park: Addison Wesley.