Animal Behavior Investigations for High School Students

Warren Marchioni

ANIMAL BEHAVIOR has been offered as a one-semester elective at Montclair (New Jersey) High School for the past four years, and during that time over 300 students have taken the course. The interest in the course is related to the following: (1) the popularity of the works of ethologists, such as Van Lawick-Goodall (1971) on chimpanzees, Schaller (1972) on lions, and Douglas-Hamilton (1975) on elephants; (2) the plight of many large species, such as marine cetaceans, which are almost extinct because of habitat destruction, pollution, or overexploitation; (3) the attraction that many animals, especially predators in their natural environment, have for an increasingly urbanized populace (Remember the incredible success of the film "Jaws"; inaccurate as the portrayal of shark behavior may have been in the film, the subsequent boom in the sale of shark literature was encouraging.); and (4) the innate fascination live animals have for young people.

The course includes lectures, films, experimentation, demonstrations, guest speakers, and field trips. In addition, each student is required to design and conduct an experiment or empirical study in animal behavior, which is written and then presented orally to the class at the end of the course. I first approve the design, based on its complexity and feasibility. For those students who cannot conceive of a working hypothesis, I offer a list of possible investigations. Students work at their own pace and level of ability.

Warren Marchioni teaches biology and animal behavior at Montclair High School, 100 Chestnut Street, Montclair, New Jersey 07042. He received his B.S. degree in biology from Fairleigh Dickinson University in 1961, and his M.A. degree in marine biology from Humboldt (California) State College in 1965. In addition, he attended the Fairleigh Dickinson University Virgin Islands campus for marine studies during its opening year, 1971, where he performed field studies in marine ecology and invertebrate zoology. Prior to joining the faculty at Montclair High School, Marchioni conducted biological research in fish larval distribution and fish behavior, concentrating on biological rhythms, at the U.S. National Marine Fisheries Service laboratory at Sandy Hook, New Jersey. He is active in environmental education within the school district and most interested in still, motion picture, and darkroom photography. Marchioni has produced several audiovisual presentations that he uses in his classes. In his spare time, Marchioni enjoys "cycling for exercise and because I like it."

FIGURE 1: The common black tarantula, *Aphonopelma eutylenum*, from southern California.

In this article, I present some of the experiments and demonstrations that can be employed in the classroom using readily available materials and accessible organisms. Several investigations have developed from the project requirement of the course. In addition, some of the extended classic experiments are included; these are useful for classroom demonstrations that give students opportunities to observe and record data on a weekly basis.

Spiders

Tarantula is a name commonly applied to any member of a family of large, hairy spiders found in our southwestern states and Mexico. The vast majority of these spiders, their history permeated with superstition and legend, do not have a venom potent enough to harm a human. With frequent, careful handling, the animals soon get used to being picked up. Bites are rare and have been described as similar to a bee sting.

Several species of tarantulas have recently become popular among buyers of exotic pets, and they are frequently offered for sale in pet stores. Because they can outlive the average cat or dog, their purchase for the classroom can be considered an investment for demonstrations for years to come.

The common black tarantula (*Aphonopelma eutylenum*) and the Mexican redleg (*Brachypeuna smithi*) are hardy tarantulas that adjust well to captivity and are frequently offered for sale (fig. 1). They can be fed a diet of crickets, mealworms, goldfish, and an occasional mouse. They should be kept in small, covered aquaria because they can walk up the sides.

A pair of redlegs may provide an additional bonus to the classroom if they mate. Female spiders are aggressive and would kill the male if he did not possess spurs on his front pair of legs to hold back the fangs of the female while mating. He bends her over backwards during mating and afterward pushes her away and retreats to the opposite end of the enclosure.

Mating lasts for a minute or two and may be repeated several times. Fertilization is internal and the female will carry the eggs for two or more months. When ready to lay them, she cleans away an area of earth at the bottom of the tank and creates a depression. She lines the depression with silk, lays several hundred eggs in the lining, and then covers them with a second silk layer.

The ball of eggs, wrapped in its silken container, is carried around by her for an additional four weeks until hatching. The young eat at about a week old. Nearly any small, live insects serve as a meal for the tiny tarantulas.

As the young spiders grow, they must periodically shed their constricting exoskeletons. This process is called molting. As they grow older, molting becomes more infrequent. Adult tarantulas usually molt once a year. Molting requires such a drastic reorganization of tissues that occasionally the animal will die during the process. Tarantulas reach sexual maturity at 4-5 years.

Fish

Operant conditioning, also called instrumental learning, is a process of learning where the behavior of an organism is strengthened by its consequences. Hence, the consequences have come to be termed "reinforcers." For example, when a hungry organism exhibits behavior that produces food, that behavior is reinforced by its consequence and will more likely be repeated. The animal has "learned" (Skinner 1974).

Primary reinforcers, termed so because they are naturally rewarding and would normally strengthen a behavior in any healthy animal, are generally used in our conditioning experiments. They include food, water, contact comfort, sexual access, and environmental change or variety.

All vertebrates are possible subjects for experimental studies involving operant conditioning. One such study, using the freshwater angelfish, *Pterophyllum scalare*, produced positive results for a student named Robert Swenson. Bob conditioned several angelfish to choose a triangular object over circular and square ones and to

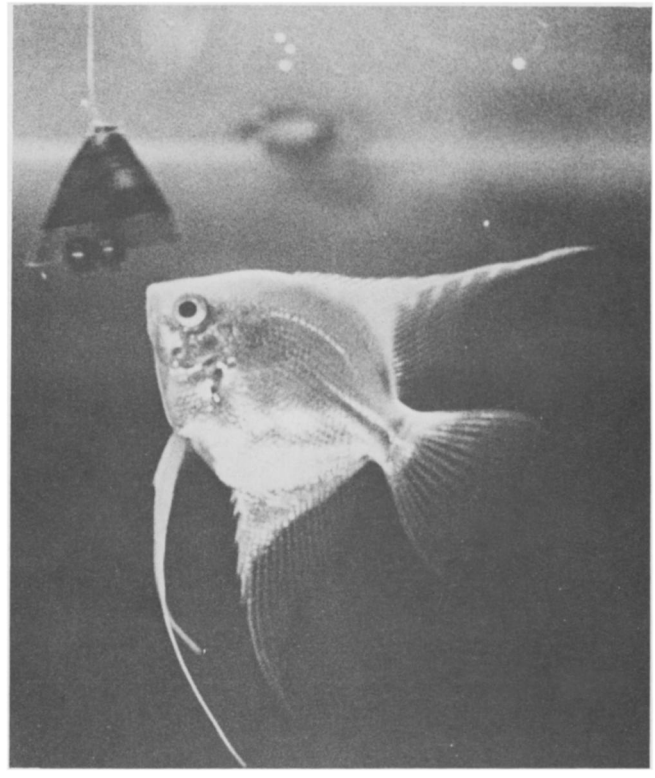

FIGURE 2: A freshwater angelfish prods a triangular object as a result of operant conditioning.

prod the object (fig. 2). Immediately afterward, the fish were reinforced with a dry tropical fish food.

Fish are excellent experimental animals for behavior studies as they are available all year long, are inexpensive to purchase or collect, and do not require much room or maintenance.

Birds

Birds have proven themselves over the years as being the most adaptable, accessible and rewarding of all the animals used for behavioral studies in the course. They have been used for investigations in imprinting, operant conditioning, and reproductive behavior. It has been suggested that the reason for the popularity of birds as behavioral subjects is that they appear more immediately intelligible to humans than most mammals. Birds, like humans, depend upon sight, for interpreting their world. Second, they rely on hearing, principally for social contact. Most mammals, on the other hand, "think through their noses" (Nisbett 1976).

Imprinting occurs, according to Lorenz (1964), when the early experience of many newborn birds determines their subsequent social behavior. In its simplest interpretation, this means that a young duckling, gosling or quail will "imprint" upon or accept as its parent, the nearest available moving object to it during the first day or two after hatching.

This concept is easily illustrated by incubating fertilized

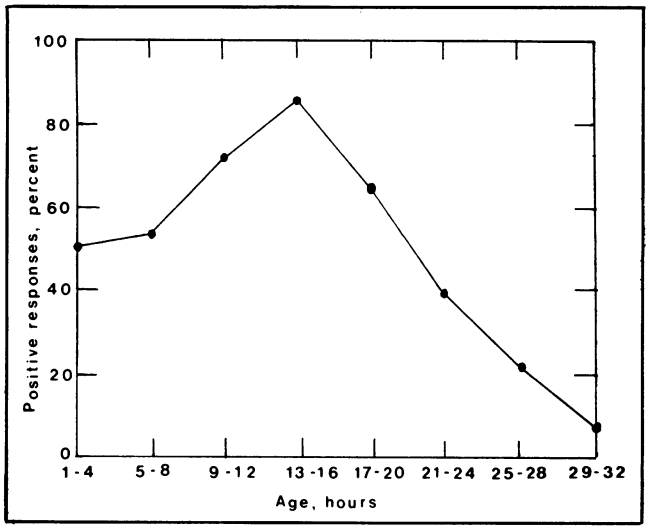

FIGURE 3: The critical period for imprinting in ducklings. The curve shows the test score of ducklings at different ages. After Hess, 1958.

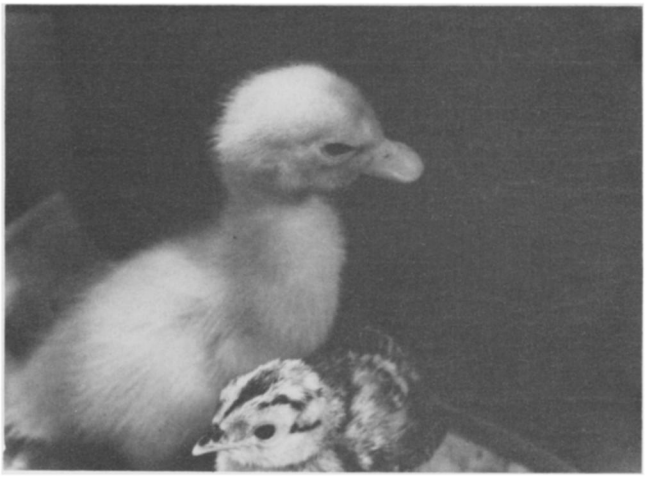

FIGURE 4: A Pekin duckling imprinted to a pheasant chick several days older.

duck eggs at the appropriate temperature and humidity. Humidity can be kept high with the daily use of a plant "mister." After hatching, the duckling is isolated from other newly hatched birds to prevent it from being imprinted to its siblings. Hess (1958) discovered a critical period for maximum imprinting success of between 13 and 16 hours after hatching (fig. 3).

Over the years, students have exposed newly hatched birds to various imprinting stimuli, including an adult or younger bird of another species, a nonpredatory mammal, a human, or a mechanical toy (fig. 4). Some students have felt that such experiments were cruel to the animals because of the use of such unnatural surrogate mothers as toy telephones, but we explained that imprinting does not necessarily influence the animal's adult mating preferances and brooding behavior. Nevertheless, to set young minds at ease, we now only use animal mothers.

Imprinting is an excellent way of entering into a discussion of the role of genetic predisposition to learning, at least in certain species of birds.

Mating and brood-raising behaviors and the stimuli that initiate them can be demonstrated in the ring dove (*Streptopelia risoria*). These birds, smaller relatives of the pigeon and characterized by a black semicircle around the back of their necks, are commonly sold in pet stores. Their reproductive behavior has been studied by Lehrman (1964).

A pair of ring doves were kept in an environmental chamber, although a large aquarium or cage would have sufficed if we had used fluorescent fixtures suspended above and connected to an automatic timer. The light-dark cycle was set for 12 hours on and 12 hours off. We introduced nesting material (straw) into the chamber along with a small glass specimen dish (11.5 cm in diameter). The doves shortly thereafter initiated a series of behaviors in response to the visual stimuli of the bowl and nesting material that resulted in the birth of additional doves to the classroom. Students recorded daily observations of exhibited behaviors related to courting, reproduction, and care of the young.

Courtship consists of a strutting, bowing, and cooing male which, in turn, causes the female to crouch down in the glass bowl and emit a distinctive coo. She selects the nest site. Both birds then use the hay to construct a nest over a period of several days, during which the birds copulate.

Over a week after the commencement of courtship, our female produced her first egg in the late afternoon—unfortunately after classes had adjourned for the day. The laying of the second egg occurred in the presence of an audience two mornings later.

Both sexes shared the duty of sitting on the eggs, which seemed to particularly interest the students at a time of debate over the genetic basis of sexual role behavior. The male was usually seen sitting on the eggs, as his shift coincided with class hours during the middle of the day. Lehrman (1964) states that the female takes on the main burden of the task by covering the eggs for the remaining 18 hours a day.

The eggs, almost always two in number, hatch after about 14 days. The young are fed "crop milk," a nutrient-rich fluid secreted by the lining of the adult dove's crop, a pouch in the bird's gullet (fig. 5).

The entire reproductive cycle provides hours of empirical data for students working on individual or group projects.

Mammals

The white laboratory rat (*Rattus norvegicus*) holds a special place in biological research and, along with the domestic cat and the mouse, has probably yielded more important data about mammalian anatomy and physiology than all other experimental animals combined. Before the relatively recent interest in primate studies, the same could probably have been said for behavior.

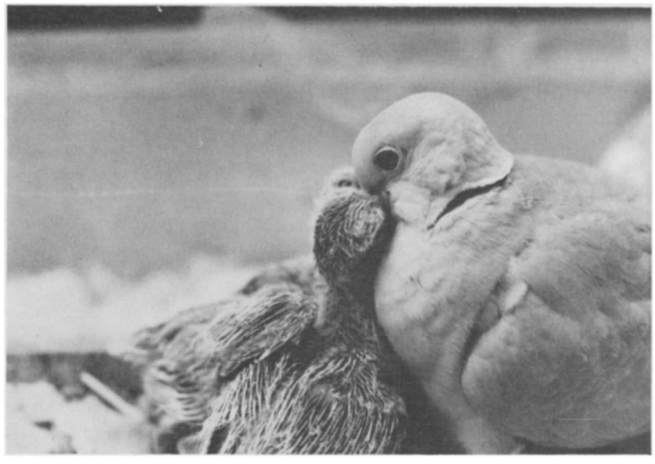

FIGURE 5: Ring dove feeding its young.

Once students overcome their conditioned aversions to rats and are taught the proper way to handle them, several interesting and rewarding investigations can be conducted.

Although operant conditioning can be performed with fish and even lowly invertebrates, the learning abilities of mammals are significantly greater due to their more complex neural structure and their greater ability to manipulate their limbs. Each student in the class, after being assigned to read an article by B.F. Skinner (1951) on teaching animals, is given two laboratory sessions to condition a rat or other vertebrate to perform some simple task (from our vantage point, not necessarily the animal's) through positive reinforcement.

Food is always used for reinforcement; motivation is created by having the animal skip a meal prior to the class period. As the student learns something about patience, the animal slowly builds a new stimulus-response pattern.

One ingenious student conducted a remarkable conditioning experiment during which a rat, after being shown a number on a slip of paper (such as 4), proceeded directly through a passage covered by a hinged door on which were drawn four rectangles. It selected this door from among four other doors, each with a different number of symbols drawn on them. When shown a different number, it went through the corresponding door. Because rats are incapable of abstract thought, the animal was first trained to associate a number with a set series of drawn figures corresponding in quantity to that number (fig. 6).

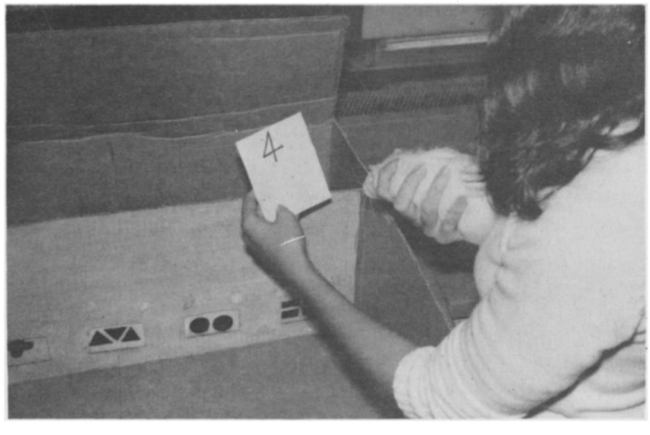

FIGURE 6: A student demonstrates an example of conditioned learning in a rat.

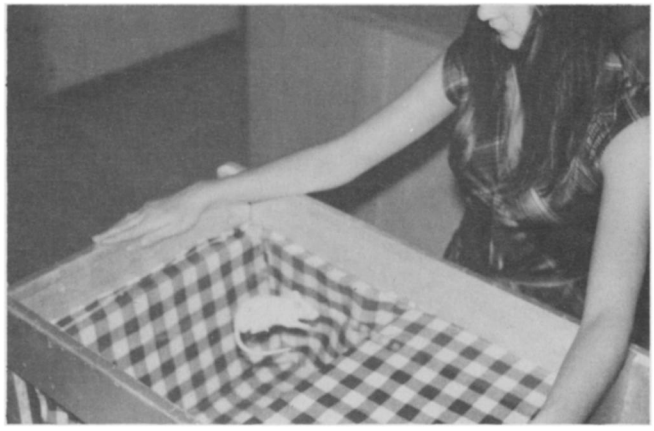

FIGURE 7: Visual cliff.

Visual Cliff

Most animals are born with an instinctive fear of falling from high places. This can be proven in the classroom by the use of a "visual cliff" (Gibson and Alk 1960). Several students and I designed and constructed the "visual cliff" shown in figure 7.

A plate of heavy glass covers two different levels lined by similar checkered cloth. One level is immediately under the glass; the other is 10 inches (25 cm) below. The animal visually perceives a drop in elevation, but tactually a supportive glass flooring.

We tested several species, including ducklings, mice, kittens, and rats, none of which had prior experience with the visual cliff, and found that the animals were inhibited in walking out over the lower level. This line of investigation leads into discussion and further study of inherited and learned fears in both animals and humans.

Conclusions

The course in Animal Behavior has been rewarding both to the students and to me. It would be unusual for more than one or two students enrolled in the course to express an interest in the field as a lifetime career, though several did plan to pursue careers in psychology. Nevertheless, the course answers some of their questions concerning their pet's behavior and, by inference or analogy, human behavior. It introduces them to the different approaches of the ethologists and behaviorists to the study of animal psychology. It also gives them the opportunity to design and conduct individual research. The territory

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I was personally disappointed that the level of participation by other teachers was lower than I expected. Only a few staff members had attempted to correlate their activities with the "Medical Awareness Month" by discussing the social, psychological, and emotional ramifications of disease.

Everything considered, I felt that the potential and realized benefits of the course were undeniable. The interdisciplinary, multi-person approach was extremely successful in teaching the students about disease and disease prevention. Other teachers who use the idea will find that it is quite flexible and useful at all teaching levels—from junior high school through college. Pupils can even "grow-up" with the course as it is adapted for various levels.

Acknowledgment—I am deeply grateful to the Randolph, New Jersey, Rescue Squad, the American Cancer Society, and the American Heart Association for their unselfish cooperation. I am especially indebted to Joseph Mascott, Alex Panas, and Dr. Robert Siroty for their hard work that added immeasurably to the success of our project. Finally, I thank my seventh graders for their attention and their efforts to make this month-long program very special.

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Moore

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facets of education, but has shifted direction in his research efforts. His original work was in development; his current research centers on genetics.

He does not confine his educational interests to the classroom; during the California creationist controversy, he wrote two important papers in support of science.

Moore is a prolific writer. Among his many activities with the Science Education Commission, he was the first to develop the *Bibliography on Science and Society*. He has written textbooks for students at every level—from the very young (ICS Program) to older people at the university level. As Program Officer for the International Congress, he guided the publication of the important proceedings of that Congress. Moore is active in numerous professional societies and was president of the American Society of Zoologists in 1974.

Moore and his wife are inveterate travelers—for business and pleasure. He is an accomplished photographer and a collector of antique photographic equipment and guns. He has an abiding interest in art, especially ancient Russian art, and in books, especially old books and books about the early days of the American West.

Moore has a keen, insatiable fascination with all things biological and an irrepressible sense of humor. But his interest and concern and compassion are unflaggingly directed towards people, especially young people struggling to make their way through the fundamentally dangerous world. He can be counted on if there is work to be done in education—or in any other area of concern to biologists.

It is a great privilege for the National Association of Biology Teachers to award John Alexander Moore our Honorary Membership.

Garland E. Johnson
Chairperson, NABT Honorary Membership Committee

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of this relatively new science to the high school curriculum is broad enough to make each new class an adventure.

Acknowledgments—I am indebted to Ann Wicyniec for volunteering her time in the classroom and displaying her knowledge and collection of tarantulas. I also thank former students, Robert Swenson, for contributing the photograph of the conditioned angelfish and Pamela Wallace.

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