Investigations

TERRITORIALITY AND PECK-ORDER IN CONVICT CICHLIDS

Territoriality and peck-order in animals are generally difficult to demonstrate in the science classroom, owing to the relatively large size and space requirements of most animals exhibiting these behaviors. But by using fish (in this case, a cave-dwelling pink variety of convict cichlids), the traits can be easily observed in a 10-gallon aquarium.

The following materials are needed:

1. A 10-gallon aquarium with filter, heater, thermometer, aerator, and dechlorinated water.
2. Flowerpots approximately 5–6 cm in diameter and 5–6 cm high.
3. Rocks, gravel, and plants. (The plants are optional and the plastic kind are preferred in this case because cichlids are hard on plants.)
4. 3 mature male and 3 mature female pink convicts *(Chiclasoma nigrofasciatum)* that are 6 months old or approximately 6 cm long. Care should be taken to choose specimens that are easily distinguished by sex. The females will have a characteristic orangish cast to their abdomens and should be smaller than the males you choose, because female convicts tend to "henpeck" smaller mates.
5. Fish food (flake and frozen brine shrimp).

Fill the aquarium to within 3 cm of the top and allow the water to filter and aerate for a day or two. Tape the thermometer to the inside of the tank and if the temperature falls below 23° C install the heater. Keep the temperature around 24° C. Then add gravel.

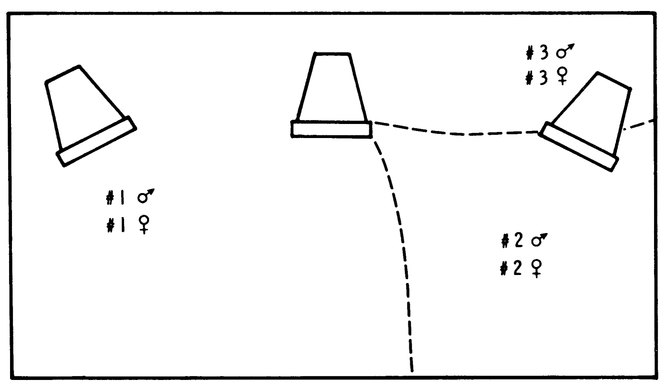
Place three flowerpots in the aquarium in rear positions at the far left, far right, and middle of the tank. Add rocks (and plastic plants if you wish) to be used as visual markers in helping the fish define their territories. Before releasing the fish into the temperature-adjusted water of the aquarium, place the container in which the fish are transported in the aquarium for about 15 minutes. This procedure prevents shock to the fish from sudden temperature change. Feed them twice a day as much as they will consume in 5 minutes. In order to induce the fish to lay eggs, it is best to feed them flake food once a day and frozen brine shrimp once a day.

Students can be asked to make the following observations after fish become accustomed to their new surroundings, usually in a day or so:

1. How do you distinguish males from females?
2. Usually after a short time, you will notice that each male seems to have a preferred mate. Which males and females are paired off?
3. What kind of challenging (or aggressive) behavior do you observe among the fish? Pay special attention to the fins and gill covers of the fish when they are challenging or being challenged. What function does this aggressive behavior have?
4. Determine the peck-order of the six fish in the tank by noticing which fish challenges which fish, which fish has the largest territory, and any other clues. Which fish is most dominant? Which fish is least dominant? Determine whether this peck-order is maintained from one day to the next. Do females challenge males? If so, which fish do the challenging? Does size seem to play a part in the relative position of a fish in the peck-order?
5. Before long, you will be able to tell the fish apart and where they are most likely to be found in the tank. After observing the fish for a couple of days, draw a diagram of the aquarium and map out areas in which each fish is most often found (see fig.).
6. Which seems to be the most desirable territory—top or bottom of the tank, an open area, or an area near rocks and flowerpots? Can you suggest reasons for certain areas of the tank being preferred by the fish?

Students may wish to perform further observations after they have watched the fish for a while:

1. If one of the fish cowers in a top corner of the tank because it cannot obtain territory at the bottom of the tank, try hanging a flowerpot in the corner where it cowers. Will the fish take cover in the flowerpot? After a while, will it defend territory around the hanging flowerpot?
2. What happens to an individual fish's territory if you decrease the water volume by approximately one-fourth?
3. What happens if you position a glass plate in the tank to increase the size of the least dominant fish's territory? After the glass plate is removed, will the least dominant fish now defend a larger territory?
4. You will notice that when fish have mated and are protecting their young, they are much more aggressive and will defend a larger territory than normal. What



Example of a territory diagram. Notice that in this example fish-pair number 1 has a territory containing two flowerpots, while the territory of the third fish pair contains no opening to a flowerpot.

happens to boundaries of territories if you remove the young?

5. What happens to the size of the territories if you gradually move the flowerpots closer together or further apart?

6. How do fish determine the boundaries of their territories? If rocks and plants are used, try moving them and observe what happens.

7. Try varying the size of flowerpots. Is one size more desirable to the fish than another?

8. Place a jar with a cichlid in it in the territory of another cichlid. What response does each fish give?

9. Using resources in the library, find examples of territoriality in other animals.

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DEMONSTRATING NATURAL SELECTION

Laboratory exercises used in basic biology courses to illustrate natural selection are relatively rare and usually time-consuming. Students in one of our beginning ecology courses generated a "hands-on" experiment that they felt gave them an excellent understanding of natural selection. We have modified the investigation and have used it with success in two lower-division biology courses.

The procedure is based on the fact that organisms which blend into their surroundings escape predation (Dice 1947; Kettlewell 1961; Keeton 1972). A chicken is placed in a cage that has a black floor with black gravel scattered on it. Corn kernels are scattered on the floor in known numbers. Some of the kernels are dyed black with food coloring so that they will blend into the black-gravel background. The chicken is left in the cage for a period of time and then removed. The number of kernels of both colors of corn are then counted and the data are analyzed to see if one color of corn was eaten (selected) in preference to the other.

In a typical experiment the students start in the morning with 1,000 kernels of corn of which 200 are dyed black and 800 are left a natural yellow color. The chicken is placed in the cage with the kernels for 12 hours and then the corn kernels are counted. Generally the chicken will eat about 100 kernels of which very few, if any, are black. The students can thus observe that the predator will indeed select against the obvious yellow kernel, thereby selecting for the concealingly colored black kernel.

The students can change the experimental design and increase the complexity to give them more insight into evolutionary processes. One class of students decided to use three colors of corn to simulate a single gene, two-allele system of incomplete dominance. Corn kernels were dyed green and black, and it was decided that the phenotypic expression of the genotypes were to be yellow *(YY)*, green *(Yy)* and black *(yy)*. The experiment was to be carried out over two consecutive days with the selection process occurring during the normal feeding time of the chicken. A total of 1,000 corn kernels was scattered in the cage at 8:00 A.M. (lights on) with beginning ratios (numbers) of kernels of .49 (490) yellow *(YY)*, .42 (420) green *(Yy)*, and .09 (90) black *(yy)*. At 6:00 P.M. on the first day the chicken was removed from the cage as was all the corn and gravel. New gravel and a reconstituted corn kernel sample of a 1,000 kernels (with the same ratios of colors as before) were placed in the cage with the chicken. The lights were turned out until 8:00 the next morning. At the end of both days the corn kernels were separated from the gravel and counted by different groups of students. The raw data obtained were mimeographed (table 1) and given to all the students.

Table 1. Number of corn kernels of different colors remaining after 12 hours of predation by a chicken. Kernels were placed on a black gravel background.

	Yellow *YY*	Green *Yy*	Black *yy*	Total
*Before selection	490	420	90	1000
After selection, day 1	409	410	85	904
After selection, day 2	400	419	87	906

*Number of corn kernels before selection was same on days 1 and 2.

Laboratory reports with data analysis were required. A large number of students used a chi-square test, that had previously been discussed in class, to analyze the data (Sokal and Rohlf 1969). The students hypothesized that the seeds left (observed) should be in the same frequency as at the start (expected). Therefore, the deviation between the observed and expected number of kernels would be due to random chance rather than a causative factor (that is, natural selection).

In analyzing the data in this manner (table 2) the students found that the deviations between expected and observed during the first day were due to random chance ($X^2 = 5.18$; $P > .05$; d.f. = 2) and, therefore, that no selection had occurred. This came as a surprise to the students for they felt the observed data really differed from that expected (tables 2 and 4).

The students thus had a practical lesson in how biologists use probabilities and statistics to solve problems. They

Table 2. Chi-square analysis of different colored kernels of corn remaining after 10 hours of predation by a chicken. Expected ratios, .49 yellow: .42 green: .09 black. Raw data in table 1.

	Yellow *YY*	Green *Yy*	Black *yy*	*Total*
	DAY 1			
Expected	442.96	379.68	81.36	904
Observed	409	410	85	904
X^2	2.6	2.42	0.16	5.18
	DAY 2			
Expected	443.94	380.52	81.54	906
Observed	400	419	87	906
X^2	4.35	3.53	0.37	8.25
	COMBINED			
Expected	886.90	760.20	162.90	1810
Observed	809	829	172	1810
X^2	6.84	6.23	0.51	13.58

$X^2_{.05[2]} = 5.99$