

## **Animal Foraging and the Ideal Free Distribution.**

Guerrero, V., A. Marenco, H. Smith, O. Smith, and G. Tavarez.

University of Miami  
Department of Biology  
Coral Gable, Florida, USA

### **Abstract**

The purpose of this experiment was to test the theory of the Ideal Free Distribution (IFD). The Ideal Free Distribution theory states, animals will distribute themselves according to the amount of food available. The researchers tested the IFD theory at three separate locations; Miami-Dade Metro Zoo, Pinecrest Gardens, and Monkey Jungle. At each location four feeding positions were set up based feeding rates and using spoons of various sizes. The spoon sizes were 1/8 tsp, 1/4 tsp, 1/2 tsp, and 1 tsp. At Miami-Dade Metro Zoo and Pinecrest Gardens, the animals were fish, turtles, and different types of birds. Overall the IFD theory was followed at Miami-Dade Metro Zoo, Pinecrest Gardens, and Monkey Jungle. But during experimentation, the researchers observed some despotic behavior among the birds. Despotic behavior is where one animal dominates the food and limits its availability to the others. At Monkey Jungle despotic behavior was also observed among the Java Macaque Monkeys.

### **Introduction**

In this paper, the researchers tested the theory of the Ideal Free Distribution (IFD). The IFD theory proposed by Fretwell & Lucas in 1970 predicts that animals distribute themselves in proportion to the amount of food available to them. In order for the IFD to be achieved the following assumptions must be fulfilled. First, the group of animals must be free to enter and use the resources on a regular basis. The second assumption of the IFD is that animals with free mobility will ideally distribute themselves at various feeding areas to maximize their energy intake.

As an example, if there were three mango trees, each with a different amount of mangoes, and a family of 20 monkeys, the monkeys should distribute themselves according to the amount of food on each tree. The tree with the most fruit would have the most monkeys.

The hypothesis to be tested states animals will distribute themselves according to the IFD. We predicted that if we distributed food at different sites, the animals would come to the food in proportion to how much food is available.

The prediction was tested by setting up feeding areas available to the animals. This was done for fish, turtles, ducks, and monkeys. Experiments were performed at Pinecrest Gardens, Miami-Dade Metro Zoo, and Monkey Jungle.

### **Methods**

Three locations in Dade County were used for the experiments. Sites included the Miami-Dade Metro Zoo (SW 152<sup>nd</sup> St), Pinecrest Gardens (Red Road), and Monkey Jungle (SW 216<sup>th</sup> St). Sites were selected so the animals were in their natural habitats.

Experimental times were during the morning hours. The selection of morning hours was to limit the variables, such as over-feeding and stressing of the animals by visitors. The animals in the study were allowed to move freely in the feeding range. The animals had no obstacles to prevent them from moving toward or away from the feeding range.

At Metro Zoo and Pinecrest Gardens, feeding positions were randomly selected using a six sided die. Feeding positions were located 2 to 3 meters apart along the edge of the pond or bird enclosure. As multiple trials were completed, the positions of the feeders were kept constant; however, spoon sizes were changed at each position. The spoon for each feeder was randomly selected by a blind selection of the spoon handles. The spoon sizes used in the experimental trials were 1/8 tsp,    tsp,    tsp, and 1 tsp.

All experimental trials were run over a 7 to 10 minute period. At 45-second intervals food was provided by throwing the spoonful of food 1 to 2 meters in front of the

feeding position. Wardley's Pond floating pellets fish food was used. Feeders leveled the food in their spoons to insure the correct amounts were used. Counts of animals, those within the feeding areas, were made 15 seconds after each throw. At locations with a variety of animals, each was categorized during the trial period.

During the Monkey Jungle experiments however, Skittles and M & M's were used. The food was placed in two locations. For the first trial with the Java Macaques, one pile was large with four bags (approximately five ounces of food) and the other pile was small with two bags of candies (approximately 2.5 ounces of food). Candy such as Skittles and M & M's were used because they remain highly desirable by the Macaques even after having been fed fruit and vegetables earlier.

The second trial at Monkey Jungle was performed in an area known as the Rainforest Exhibit. Red Howlers, Black Capuchins, and Squirrel monkeys are free to roam over a four acre area. Visitors are separated from this area by a walkway enclosed in a fence and mesh material. The animal handler provided food in two bins, one with approximately twice the amount of food as the other.

During both Monkey Jungle experiments, animal numbers at each position were recorded at 30 second intervals over a seven and a half minute time span. Additional data records included any notable behavior episodes.

## **Results**

In the first experiment at Metro Zoo the results did not follow the IFD because there was a higher number of fish at the  $\frac{1}{8}$  tsp than at the 1 tsp position. Ducks were mainly located at the  $\frac{1}{8}$  tsp. position. Relatively few fish were observed at the  $\frac{1}{8}$  tsp. position (Figure 1).

In the second experiment at Metro Zoo the initial distribution was not as expected from the IFD theory. However; the distribution shifted over the course of the experiment and during the final five counts the distribution was within the range of that predicted by the IFD (Figure 2).

In experiment three (Pinecrest Gardens) the fish and turtles followed the IFD. The majority of fish and turtles were at the 1 tsp position and the number at each successive position decreased in relation to spoon size. The fewest number of fish and turtles was at the 1/8 tsp position (Figure 3).

In experiment four (Pinecrest Gardens) the birds followed the IFD for the most part except that there was despotic behavior during these experiments. In this trial a dominant goose went to the \_ tsp position and the other birds moved elsewhere.

In experiment five (Monkey Jungle) the Java Macaques followed the IFD (Figure 5). There was a dominant male in the group that took a handful of food and went aside and kept the food to himself and ate it. At the end of the experiment there was a change in monkey troops.

In experiment six (Monkey Jungle), initially the monkeys did not follow the IFD. There was a large number of monkeys at the small pile. However; about halfway through the small pile ran out of food and the monkeys shifted to the large pile (Figure 6).

## Discussion

The Ideal Free Distribution (IFD) is a theory that describes the way animals distribute themselves when given food of different proportions. This was studied at three sites with a variety of animals. An enormous amount of data was collected from which a representative sample was presented in this paper.

In the first experiment, at Metro Zoo, the animals did not follow the IFD theory. The spoons were positioned in the following order: 1 tsp,  $\frac{1}{2}$  tsp,  $\frac{1}{4}$  tsp,  $\frac{1}{8}$  tsp. More animals were located at the  $\frac{1}{2}$  tsp position (mean of 15.0) than at the 1 tsp position (mean of 5.7). This discrepancy was due to a gentle current in the water which caused the food to drift away from one feeding position into the adjacent position. In this particular instance food from the largest spoon (1tsp) drifted into the location where the food from the  $\frac{1}{2}$  tsp site was provided. The means at  $\frac{1}{8}$  tsp and  $\frac{1}{4}$  tsp were lower as expected (Figure 1).

In experiment two, at Metro Zoo, the animals' initial distribution was not in accord with the IFD, but as the time passed, the fish distribution shifted toward the IFD. The results showed the fish were able to assess or sense where more food was available, and adjusted their distribution to better maximize individual resource acquisition (Figure 2).

In experiment three, at Pinecrest Gardens, both fish and turtles followed the Ideal Free Distribution. The mean number of animals at each location was consistent with the IFD. The turtles and fish distributed themselves increasingly from  $\frac{1}{8}$ ,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , to 1 teaspoon, respectively (Figure 3).

In experiment four, at Pinecrest, Gardens the animals followed the IFD for the most part, except despotic behavior was evident. Despotic behavior is where a dominant individual forces all the other animals out of the feeding area. When the dominant goose proceeded to the 1/2 tsp pile and the other birds ran to the 1/8 tsp position. The result was that three birds congregated at the 1/2 teaspoon and four birds at 1/8 teaspoon location. Most birds were at the 1 tsp location with an average of seven birds feeding (Figure 4).

In experiment five, at Monkey Jungle, there was a dominant male Macaque in the group. He grabbed a handful of M & M's from the large pile and sat alone to eat them. Although these data followed the IFD (Figure 5) there was despotic behavior. The dominant affected the amount of food available in each pile. However, more monkeys were found at the large pile (4 bags) than the small pile (2 bags). Another factor influencing our results was that about half way through a new troop of monkeys came to the feeding site.

In experiment six, initially, nine monkeys were at the small bin compared to two monkeys at the large bin. At 3.5 minutes into the experiment, two monkeys were at the small bin and two monkeys were at the large bin. Toward the middle of the experiment the small bin of food was depleted and the large bin of food received an increased number of monkeys. At the seven minutes mark seven monkeys were at the large bin and zero were at the small bin (Figure 6). Thus, the monkey distribution shifted to that which would be expected by the IFD.

These experiments indicate animals in a free feeding environment will distribute themselves so as to obtain the most food. The results were achieved using random order and different size spoons to minimize experimental error. The results indicate despotic

behavior can force animals to alter their distribution. However, despotic behavior aside, IFD patterns were noticed throughout the experiments.

### **Acknowledgements**

The researchers would like to thank the Howard Hughes Medical Research Institute for funding the program. They also are grateful for the assistance provided by our Faculty Mentor Dr. Don DeAngelis, our Graduate Facilitator Mr. Jim Spurney, and Program Coordinators Dr. Michael Gaines and Dr. Dana Krempels. We would also like to express our gratitude to our teachers; Mr. Barr, Mr. Landon and Ms. Morejon. Last, but not least, we would like to thank our Undergraduate Facilitator Ms. Terry-Ann Pearson.

**All figures for this paper can be downloaded here:**

**[www.bio.miami.edu/ecosummer/eco2003/dolphins\\_figures.pdf](http://www.bio.miami.edu/ecosummer/eco2003/dolphins_figures.pdf)**

### **Literature Cited**

Fretwell, S.D. and H.L. Lucas. 1972. On territorial behavior and other factors influencing habitat distribution in birds. *Acta Bioethica* 19:16-36.