Testing Alternative Models To Estimate Population Size

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Abstract

Estimating population occurs in many fields of study and professions. In order to accurately receive the closest estimate, it is important to know what model is the most accurate to use. After using the removal sampling method to test population size of the red flour beetle, we thought that a simple model can be used to estimate the population of beetles in a jar and that the best model would be the Moran-Zippin Model. "The principle of removal sampling is based upon the fact that a known number of animals are removed from a habitat with each sample, thus affecting subsequent catches" (Ballard). After conducting this research, we discovered that the Modified Moran-Zippin Model gave the most accurate estimate and had the lowest error rate compared to the regression and normal Moran-Zippin model. The results are important because the chosen model can be used to estimate population sizes for endangered animals and pest control.

Purpose

The purpose of this research is to find the best model to use to estimate population size.

Questions, Hypotheses, and Predictions

Question: Can you estimate the population of beetles in a jar using a simple model?

Hypothesis: It is possible to estimate the population size of beetles in a jar using the Moran-Zippin Model.

Study System

Tribolium castaneum, also known as the red flour beetle is an insect that infests grain products such as flour, cereals, meal, crackers, dried pet food and pasta (Baldwin). It is reddish-brown in color and is only 1/8 inches long. It comes from the Indo-Australian origin and is found in temperate areas. As long as there are areas with central heat, red flour beetles can survive winters. The U.S doesn't have a huge population, hoowever, they can be found in the southern states. The average life cycle is between 40-90 days, and as an adult, it can live for three years (Baldwin et al 2003).

Removal Sampling Models

The Moran-Zippin Model (Moran 1951; Zippin 1958) $N_{\text{population size}} = \dfrac{n_1^2}{n_1 - n_2}$

The Modified Moran-Zippin Model (new here) $N_{\text{population size}} = \dfrac{(n_1 + n_2)^2}{(n_1 + n_2) - n_3}$

The Regression Method (Hayne Method) $y_{\text{current catch}} = mx_{\text{previous catch}} + b$

solve x for $y_{\text{current catch}} = 0$

Methods and Experimental Design

To set up this experiment, we used 6 petri dishes and labeled them 50A, 50B, 50C, 100A, 100B, and 100C. After labeling them, we put 1 Tbsp of Organic Golden Buffalo Flour with 5% Brewers Yeast, and 2 Tbsp of Organic Soft White Winter Wheat seeds in each petri dish. Then, we used an air tweezer to pick out 10 beetles and place them in 5 different shell vials, 3 times to make sure we adequately counted the correct number of beetles for the three 50-sized populations. For the 100-sized populations, we repeated the same process, but we placed 20 beetles in each of the 5 vials.

For the experiment, we had 1 minute to pick up as many beetles as possible with metal featherlight tweezers. The captured beetles were not placed back in their original petri dishes. Then we counted the beetles collected in that 1 minute period. This process was repeated for all 6 petri dishes on three different days. All trials were run between 9:45 am and 10:45 am.

Results

Trial Number	Trial 1	Trial 2	Trial 3
50A	19	14	12
50B	20	8	13
50C	16	22	9
100A	40	27	20
100B	25	21	23
100C	47	24	10

	Regression model	Moran-Zippin	Modified Moran-Zippin
50A	58.71	72.2	51.86
50B	32.67	33.33	52.27
50C	102.03	-42.67	49.79
Average	64.47	20.95	51.3
Range	32.67-102.03	-42.67 - 72.2	49.79-52.27
Error rate	28.94%	58.10%	2.60%

	Regression model	Moran-Zippin	Modified Moran-Zippin
100A	105.52	123.08	95.51
100B	181.28	156.25	92
100C	77.99	96.04	82.64
Average	121.6	125.12	90.05
range	77.99-181.28	96.04-156.25	82.64-95.51
Error rate	20.64%	25.13%	9.95%

Conclusions

We found that the Modified Moran-Zippin model works best to estimate population size because the error rate is the lowest and it has higher accuracy than the other models. This finding is significant because it can help give the most accurate estimate for endangered animals and pest species in a given area. It is important to continuously keep track of the population sizes of animals.

Future Directions

If I were to continue this research, I would begin with focusing on how the the time of day affects beetle activity, which helps determine how many beetles can be caught in a minute. I would continue this research by repeating the same steps as I did for this experiment, during the afternoon and at night.

Another thing I would test is how the amount of beetles changes the accuracy of the models. I would repeat the experiment using 250, 500, and 750 beetles.

Another potential area of study I would test, is how the living environment affects the accuracy of the models. "Environment plays an important role in influencing behavioral movements among individuals and groups of insects" (Gerken). I would change the environment by using bigger and smaller containers, and change the type of flour and seeds.

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