1.9) FEED CONVERSION IN MEALWORMS

Objective: In this activity you will raise mealworms to calculate feed conversion efficiency. This provides a rough estimate of the energy transfer that occurs between trophic levels.
Video instructions: https://vimeo.com/114429301

Introduction: The 1973 sci-fi thriller "Soylent Green" depicts a dystopia where the general population unknowingly consumes a product manufactured from human remains. Even though energy transfer inefficiency that characterizes trophic pyramids renders this practice is unsustainable, the movie serves as a cautionary tale on how governments and corporations are able to exploit environmental concerns for the purpose of growing their power and wealth.

Livestock farmers observe the phenomenon of energy transfer first-hand: Feed conversion ratio (FCR) is obtained by dividing the total feed applied by the weight gain of the livestock. FCR varies according to the species used, feed quality, and management practices. Based on agricultural practices in the US, this ratio ranges from a high of 10 kg feed per kg beef to a low of less than 2 kg feed per kg fish (*1*).

Some environmentalists recommend that people resort to vegetarianism in order to minimize their environmental impact, but animal products (including milk and eggs) not only provide the highest quality proteins; they are also the only natural sources of vitamin B-12. Consequently, research for improving FCR of livestock may be the preferable strategy for sustainable agriculture.

Literature Cited:

1. Kiernan, B. 2012. *Further Investment in Aquaculture is Critical to Meeting the Food Demands of a Growing World*. Global AgInvesting. June 29, 2012; Retrieved on June 28, 2014, from http://www.globalaginvesting.com/news/blogdetail?contentid=1439

Procedure:

1) Count your worms and weigh them all together and record the mass to the nearest 0.1 g. Place them in a shallow plastic container from which they cannot crawl out (Fig. 1).
2) Weigh out about 2-3 g of the cat food and record the mass to the nearest 0.1 g (Fig. 2). Weigh out an apple slice between 5-10 g and record the mass to the nearest 0.1 g (Fig. 3).
3) Place a moist folded piece of paper towel in the middle of the tray that will hold your worms to provide moisture (Fig. 4).
4) Place worms and food items in the tray (Fig. 5). You will need to cut the apple in smaller slices and break some of the cat food nuggets in two pieces so the worms can feed on them more effectively. Try not to create small "crumbs" that are difficult to retrieve. Record the date.
5) The next day, remove all uneaten apple slices and place them in a labeled sealable bag. Use forceps to remove every single crumb of cat food and place them in a second labeled sealable bag. Use forceps to remove all molted exoskeletons and dead worms and place them in third labeled sealable bag. Discard the moist paper towel and place all three bags in the freezer.

Fig. 1

Fig. 2

Fig. 3

6) Repeat steps 2-5 for 10 days. At the end of this time period, weigh all the surviving worms. If the increase in mass is 30% or more you may terminate the experiment. If not, you need to continue until your reach at least 30% increase in mass.
7) Upon termination of the experiment, count all surviving worms, weigh them all together to the nearest 0.1 g, and record the date.
8) Subtract the number of surviving worms from those that were alive on day 0 to obtain the number that died. Use this to calculate the percent mortality:

   100% × number of dead worms ÷ number of live worms on day 0 = % mortality

9) Remove the three bags from the freezer containing the leftover apple, cat food, and nonliving worm material and place contents in three separate evaporating dishes (Fig. 6).

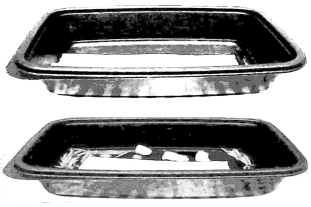

Fig. 4

Fig. 5

Fig. 6

10) Weigh out 5-10 g fresh cat food to the nearest 0.1 g and place it in another evaporating dish. Break the nuggets in two to make them comparable in size to the leftover cat food from the freezer so they dry at the same rate.
11) Weigh out 10-15 g fresh apple to the nearest 0.1 g, cut it to a size comparable to the portions fed to the worms, then place it in a drying dish. This makes for a total of five drying dishes.
12) Place all items in the drying oven for at least two days at a temperature between 70-90° C. Do not let the temperature exceed 100° C because this may result in chemical changes that will affect your mass.
13) In order to convert all masses into dry weight, you will need to create "dry mass" conversion ratios for the cat food and apple slices. Use the formula below to make separate conversion ratios for both cat food and apple slices. The conversion ratio for worms is already provided so you do not need to dry your worms:

    dry mass for food type ÷ fresh mass for food type = dry mass conversion ratio

14) Insert all your values in the tables below:

Worms	Fresh (g)	Dry mass conversion ratio for worms	Dried (g)
1) Final mass living		× 0.338	
2) Mass of dead and molted portions	N/A	N/A	
3) Final total dry mass: Dried column (1) + (2)	N/A	N/A	
4) Initial mass		× 0.338	
5) Fresh mass gained: Fresh column (1) – (4)		N/A	N/A
6) Dry mass gained: Dried column (3) – (4)	N/A	N/A	

Cat food	Fresh (g)	Dry mass conversion ratio for cat food	Dried (g)
7) Mass fed		× _____	
8) Mass leftover	N/A	N/A	
9) Dry mass eaten: Dried column (7) – (8)	N/A	N/A	

Apple	Fresh (g)	Dry mass conversion ratio for apple	Dried (g)
10) Mass fed		× _____	
11) Mass leftover	N/A	N/A	
12) Dry mass eaten: Dried column (10) – (11)	N/A	N/A	

15) Calculate FCR and efficiency based on dry biomass of the worms. Show work:

(9) + (12) = total dry mass consumed

total dry mass consumed ÷ (6) = FCR for dry worm biomass

(1 / FCR) ×100% = feed conversion efficiency for dry worm biomass

16) Calculate FCR based on fresh biomass of the worms. Show work:

total dry mass consumed ÷ (5) = FCR for fresh worm biomass

Questions:

1. What is the percent mortality?

2. How would FCR be affected if you were to do the experiment with adults instead of larvae?

3. Pelleted food is used because it is easier to retrieve the uneaten portions. How might the FCR be affected if the mealworms were fed on grains instead of cat food?

4. The rule of thumb for dry biomass conversion between trophic levels is about 10%. Does your value differ significantly from the rule of thumb? If so, why does it differ?

5. List three processes other than growth that require food intake.

6. Farmers who raise livestock calculate FCR based on fresh biomass gained by the animals. Compare the FCR you calculated for fresh worms to other values provided in this link for other livestock and answer the questions below: https://www.navfarm.com/blog/fcr-guide/

    a. Which livestock FCR in the link is closest to that of the worms?

    b. List one thing that can adversely affect (increase) FCR:

Assignment Checklist:

1. Did you enter the values in the tables?
2. Did you complete the calculations?
3. Did you answer all the questions?