

## The Number of Animals Killed to Produce One Million Calories in Eight Food Categories

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<http://www.animalvisuals.org/data/1mc>

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### Introduction

In a 2003 article in the *Journal of Agricultural and Environmental Ethics*, Steven Davis advanced the argument that fewer animals would be harmed if we consumed a diet containing large herbivores (namely cattle) fed on pasture than if we consumed a vegan diet, based on his calculation that more wild animals would be killed in crop harvesting than in producing food from a ruminant-pasture-forage system<sup>[1]</sup>. Gaverick Matheny identified a crucial error in Davis's calculation: it assumed that equal amounts of land will produce equal amounts of food from crops or from animals on pasture<sup>[2]</sup>. In fact, an amount of land will produce much more food when used to grow crops for direct human consumption than when used to raise cattle, provided it is suitable for growing crops. Once Matheny corrected the calculation, Davis's argument made the case for, rather than against, a vegan diet, given an objective to cause the least amount of animal death. Davis's argument was also criticized by Andy Lamey, who pointed out that the case that Davis makes for the numbers of animals being killed by harvesting activity is weak, as his numbers included animals who were killed by predators, and that the argument overlooks ways that humans can be harmed or killed by beef production but not vegetable production<sup>[3]</sup>.

The idea that a vegan diet kills as many or more animals than a meat-based diet is sometimes used as a rationalization for consuming meat, and this idea serves to add uncertainty to the ethical case for a plant-based diet. In an attempt to help clear up this uncertainty, I have made estimates of the number of animals killed directly by slaughter as well as through crop harvesting in order to produce one million food calories from eight different categories of food, shown in Figure 1. One million calories is an annual calorie intake for someone consuming 2740 calories / day, so the numbers would reflect an annual number of animals killed if all one million calories came from the same category. Of course, no one eats this way, but what is important is the number of animals killed per calorie. If you could determine what percentage of calories in a complete diet came from each category, you could determine a number of animals killed for that diet. To do this, you would probably need a more complete list of food categories than the eight presented here.

Figure 1 shows that more animals may be killed for beef than for pork when animals killed in harvest are taken into account. However, compared to beef, more of the animals killed for pork are raised on factory farms, and most of the animals killed for beef are free wild animals who we can assume had natural lives and were killed relatively quickly by farm machinery. Pigs raised on factory farms suffer castration, tail removal, and having their teeth cut with no painkillers. They also suffer intensive confinement in barren crates, physical abuse, and transport without food and water through all weather conditions. Undercover investigations have exposed that pigs suffer astonishing cruelties<sup>[4]</sup>.

Figure 1 also shows that the number of animals killed for dairy products may be relatively small compared to other animal-derived foods, but animals forced to give milk for dairy products suffer a great deal, and this suffering is not something that can be quantified in a chart. Dairy cows are repeatedly artificially inseminated to keep them producing milk, and their calves are taken away from

them within 48 hours of birth. This is traumatic for both the mother and the calf. Many dairy cows also suffer tail docking mutilations, and mastitis infections of their udders. Undercover investigations have shown sick dairy cows living in miserable conditions<sup>[5]</sup>.

Based on this estimation, someone with a desire to modify their diet to reduce the number of animals killed for their food, or someone who is interested in gradually moving towards a plant-based diet for ethical reasons should start by removing chicken and eggs from their diet, but the most animal suffering and death can be prevented by following a vegan diet.

## Methods

Two categories of animal deaths were examined: animals slaughtered directly for food, and animals killed in the harvesting of crops. There are other possible sources of animal death associated with our diets, such as predators killed in defense of livestock, animals prevented from existing by the destruction of their habitat, and human deaths from food poisoning, disease, or accidents on farms or in slaughterhouses. It is likely that these other sources of animal death would increase the numbers of animals killed for animal-derived foods more than they would increase the numbers of animals killed for plant-derived foods, and would not significantly affect the conclusions presented here.

To determine the number of animals directly killed to obtain one million human-edible calories from animal carcasses, the following formula was used:

$$n_a = \frac{c_t}{c_a \times y \times w}$$

where  $n_a$  is the number of animals killed,  $c_t$  is the target number of food calories,  $c_a$  is the number of calories per kilogram of each food,  $y$  is the yield of live weight to edible weight, and  $w$  is the average live weight of the animal. Calories per kilogram for each food were obtained from the USDA National Nutrient Database for Standard Reference, accessed through WolframAlpha. Carcass yields were obtained from Wulf<sup>[6]</sup> and Kokoszyński<sup>[7]</sup> Average live weights were obtained from USDA statistics<sup>[8,9]</sup>.

To determine the number of animals directly killed to obtain one million human-edible calories for eggs, the following formula was used:

$$n_a = 2 \times \frac{c_t}{c_a \times n_y \times n_e}$$

where  $n_a$  is the number of animals,  $c_t$  is the target number of food calories,  $c_a$  is the calories per egg,  $n_y$  is the number of years each bird lays eggs for, and  $n_e$  is the number of eggs laid per year per animal<sup>[10]</sup>. So,  $n_a$  is the number of chickens it takes to lay  $c_t$  food calories of eggs. Once these chickens have reached the end of their economic usefulness (after  $n_y$  years), they are killed. This number is then multiplied by two, as hatcheries that breed chickens for egg-laying ability kill the males at birth because they have no economic value. If it is assumed that half of the chicks are born male, then this doubles the number of animal deaths associated with egg production, because for every egg-laying hen, there will be two deaths. In the United States in 2008, 467,242,000 egg-type chicks were hatched<sup>[11]</sup>. If half of these were male, then 233,621,000 male chicks were killed in hatcheries at birth. Egg-laying

hens are not bred for meat, so those who are slaughtered have low carcass yields, and yield low-quality meat that may go into soups or other processed foods for human consumption. They may also be buried on site, or ground up and added to livestock feed. If the meat from the spent layers were counted as “egg calories,” and if the contribution to human-edible foods from the flesh of spent layer hens could be estimated, then this could account for a proportion of the one million calorie total and reduce the number of animals killed to get one million calories. For the purposes of this project, I have only included the number of animals killed to get one million calories directly from eggs, and estimated chicken meat separately.

A similar formula was used to determine the number of animals killed to produce one million calories of milk, taking into account the number of years a dairy cow is typically used for milk, average kilograms of milk given per year per cow, and the number of calories per kilogram of milk. Dairy cows are impregnated three times in their 4-year life so that they keep giving milk, and their calves must be taken away so that we can collect the milk for ourselves. The female calves become more dairy cows, and the males, having no economic value as a dairy breed, are raised for veal. The deaths of veal calves (if we assume half of the calves are male, this would add 1.5 deaths per dairy cow) are not included in this total. If their deaths were counted, then their human-edible calories would also have to be counted as “milk calories.” For the purposes of this project, I have only counted calories directly from milk. It would be possible to estimate veal as a separate category, but I have not done so for the purposes of this project.

To produce fruits, vegetables, and grains, it is not necessary to kill any animals directly. However, there probably are some wild animals killed in the process of planting and harvesting plant-based foods on a large scale. Some possible causes of these deaths are farm machinery such as harvesters, ploughs, or tractors, chemical pesticides, or direct poisoning or trapping of animals who pose a threat to the crops. As Davis puts it,

*“Although accurate estimates of the total number of animals killed by different agronomic practices from plowing to harvesting are not available, some studies show that the numbers are quite large.”*

Davis draws his estimates from a study done on field mice in England<sup>[12]</sup>, and from a study done on sugarcane fields in Hawaii. In the English study, 33 field mice were fitted with radio collars and tracked before and after harvest. The researchers found that only 3 percent of them were actually killed by the combine harvester (amounting to one mouse). An additional 52 percent of them (17 mice) were killed following harvest by predators such as owls and weasels, possibly due to their loss of the crop cover. It is unknown how many of these mice would have been eaten by owls or weasels anyway.

I was able to find two additional studies on the effect of harvest on wild animal populations. One study done in Argentina measured small mammal densities in a corn and a wheat field, and in surrounding border areas before and after harvest. The researchers found that there were lower densities of small mammals in the crops after harvest, and comparable higher densities in the surrounding areas, which may indicate a level of escape from the harvested fields<sup>[13]</sup>. Another study that measured small mammal densities in South Dakota corn fields and neighboring areas did not find a significant difference in the density of small mammals before and after harvest<sup>[14]</sup>. This study also did not have a large sample size (88 animals). I am not aware of any data that exists that would support a national average of number of animals killed per area land due to crop harvesting activity.

Even if no data exists on the number of animals killed due to harvesting crops, we can still draw meaningful comparisons between different food categories by using a constant estimate of number of animals killed per acre for different types of land, and then determining how many acres of each type of land it takes to produce the same amount of food in each category. Davis estimates that 15 wild animals per hectare per year are killed as a result of harvesting annual crops, and guesses that maybe half that, or 7.5 animals per hectare per year, are killed on grazed land with managed perennial forage. He does this by averaging a mortality rate from the English mouse study (including animals killed by predators in the week following harvest), and a mortality rate from a study of a number of rats killed in sugarcane harvesting. Even though these numbers may be inaccurate, I think that until better data is available, it is reasonable to use Davis's estimates for the sake of comparing different categories of food.

A 2006 Cornell University study on the land requirements of complete diets in New York State determined the average amount of land required to produce one human edible calorie of various categories of food<sup>[15]</sup>. It is important to point out that this study is for food produced within New York State only, and while it might be useful to apply the results to regions with similar climates, soil quality, and other characteristics as New York State, the results would differ for other climates and for a national average. Another 2006 study conducted in the Netherlands estimated land required to produce one kilogram of beef, chicken, and pork based on world average crop yields and on the world's highest crop yields<sup>[16]</sup>. The amount of land required to produce a given quantity of food can vary greatly depending on many factors, including region, climate, seeds, growing methods, and soil quality. The data in the Cornell study and the Netherlands study concurred that it takes about 30 percent as much land to produce the same number of calories from chicken as it does from beef. On pork, the studies differed. The Cornell study calculated that it takes about 23 percent of the land to get the same number of calories from pork as it does from beef, and the Netherlands study came up with 44 percent for the world average, and 40 percent if the highest worldwide crop yields are used. For the sake of determining the number of animals killed in harvesting activities, Figure 1 uses the land requirements determined in the Cornell study, because even though they are only for New York State, they give an indication of the relative land requirements of different food categories.

## Discussion

One conclusion of the Cornell study was that meat generally increases land requirements of a diet, but diets including a small amount of meat could result in less land required per capita than some high-fat vegetarian diets (that include milk and eggs) because of cattle converting forage on land unsuitable for crops into human-edible calories. It is probably true that raising ruminant animals on pasture unsuitable for crops would increase the total amount of human-edible calories in the food supply, but it is critical to point out that chicken, pork, and at least 85 percent of beef is fed corn grown on land that could be divided between growing food for direct human consumption and wildlife habitats<sup>[17]</sup>. The gain of human edible calories achieved by grazing cattle is not much of a benefit considering that there is enough suitable cropland to feed everyone without the additional calories gained from raising cattle on pasture, and that cattle grazing has an environmental cost. Cattle are a non-native species to the United States, and cattle grazing is destructive to the environment in numerous ways, including soil loss to erosion, reduced survival of seedling trees, and loss of species diversity<sup>[18]</sup>.

The results of this estimation show that a diet that includes animal products will result in more animal

deaths than a plant-based diet with the same number of calories. The production of chicken meat results in vastly more animal deaths than any other category of food. Based on this estimation, someone wanting to modify their eating habits in order to reduce animal suffering and death should start by removing chicken from their diet, then eggs. Although beef may cause more animal deaths than pork, pork probably causes more suffering, because most of the beef-related deaths are wild animals, and in comparison, a greater number of the pork-related deaths are factory farmed animals. The most animal suffering and death can be prevented by following a vegan diet.

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