Vampire Apocalypse Calculator

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Welcome to the Vampire Apocalypse Calculator[1], you lovely, tasty human. This sophisticated tool is based on the **predator –prey model**, a model that successfully describes the dynamics of ecosystems, chemical reactions, and even economics. Now it's time to use it to answer the question: "what if vampires were among us?" You might think we're joking, but the facts are clear. If we compare the actual world's population[2] (Fig. 1: red points) to the exponential growth model[3], it reveals there are some hidden causes preventing the expansion of humanity.

We could theorise all day why this is, but there's one idea we'd like to check and discuss: **vampires**. Are you ready to unveil the ancient mysteries of vampirism?
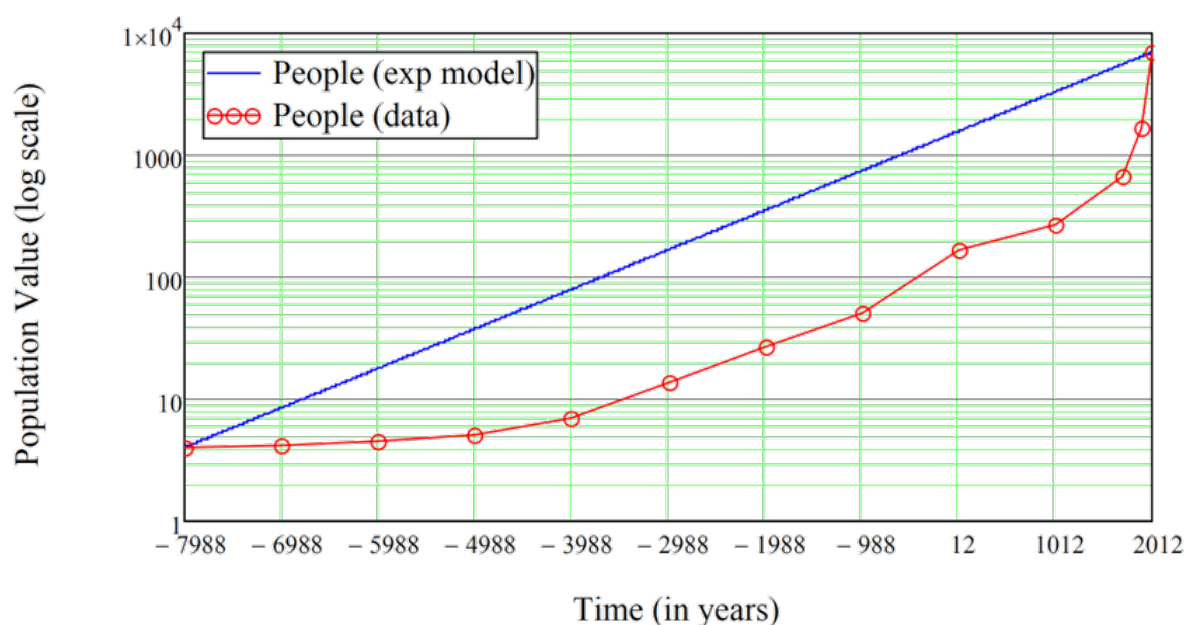
Figure 1. Earth's population growth: expected logarithmic scale vs actual data. Extracted from Strielkowski et al. (2013).

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[1] You can find it at: https://www.omnicalculator.com/other/humans-vs-vampires

[2] World Population Clock, available from: https://www.worldometers.info/world-population/

[3] Exponential Growth Prediction Calculator, by M. Mucha, available from: https://www.omnicalculator.com/statistics/exponential-growth-prediction

WHAT IS VAMPIRISM?

Nearly every culture around the world has its blood-drinking creature. The ancient world had the female demons Lilith (Fig. 2; Babylonia) and Lamia (Greece). In Africa, the Ewe folklore believes in Adze, a vampiric being that can take the form of a firefly. Chilean Peuchen was a gigantic flying snake that could paralyse, and in Asia Penanggal was a woman who broke a pact with the devil and has been forever cursed to be a bloodsucking demon. So, why is it that vampires are known around the globe? Isn't it suspicious?

What about the vampires themselves? Today, they are usually believed to be undead creatures with supernatural powers: they don't age, can fly, and can fully regenerate from almost any wound. They have a taste for human blood (Fig. 3), but are afraid of sunlight, silver, religious symbols, and garlic. Vampires can be killed by decapitation or a wooden stake through the heart. The last but most important thing is that vampires can't reproduce; they can only turn a human into a vampire.

Figure 2. Lilith, by John M. Collier (1892), oil on canvas. Source: Wikimedia Commons.

Figure 3. The Vampire, by Philip Burne-Jones (1897). Source: Wikimedia Commons.

THE CALCULATOR

What if vampires were among us? The Vampire Apocalypse Calculator allows you to check how humanity would fair in some selected scenarios from popular books and movies, as well as creating your own story from scratch. It's your decision!

We present the result in the form of a graph that plots how three populations change: humans (blue points), vampires

(red points), and vampire slayers (yellow points). You can adjust the graph if needed by setting an appropriate time scale (days, weeks, months, years, decades, centuries) and type of chart (linear or logarithmic[4]).

The vampire apocalypse calculator performs real-time numerical calculations that might sometimes be a little demanding, depending on your machine specifications. But, please, be understanding! The algorithm can receive up 13 parameters from the three populations:

• **Humans**: if not interrupted by vampires, their population size will grow exponentially. The available settings are the initial population, the probability of turning into a vampire when attacked, and annual population growth. Humans' unique ability is to **grow faster** when their population becomes smaller than its starting value.

• **Vampires**: bloodthirsty humanoids that hunt people and turn them into new vampires. The available parameters are their initial population and their aggression level towards humans and slayers. You can make vampires smarter with their special ability. When activated, vampires will **refrain from killing** too many humans, so they do not lose their only source of blood.

• **Vampire slayers**: an organization of brave people with one objective: save the world from vampiric domination. The available parameters are their initial population, annual recruitment speed, aggression level towards vampires, and vampire transformation probability. They cannot afford their members' salaries if the entire world population is made up of vampire slayers, so you can turn on the vampire slayers special ability to **limit the maximum size** of the organization.

So, go ahead and test the Vampire Apocalypse Calculator. It's freely available online: https://www.omnicalculator.com/other/humans-vs-vampires. If you find a set of parameters that creates an incredible story, don't hesitate and share it with your friends and us (there is a 'Send this result' on the website). See also the Box 1 below for more information on how the calculator came to be.

PREDATOR–PREY MODEL: LOTKA–VOLTERRA EQUATIONS

Italian astronomer and physicist Galileo Galilei (known for his experiments with falling bodies and inclined planes) once said that "mathematics is the language in which God has written the universe". Indeed, scientists all around the world try to find suitable mathematical equations that describe the natural world properly.

If you consider a simple ecosystem with two species, e.g., foxes and rabbits, the Lotka–Volterra equations[5] generally work just fine. They are also called the predator–prey model. Why? Let's stick with our example. The population of rabbits can peacefully live and reproduce if we assume that they have access to an unlimited source of food in the forest. On the other hand, foxes are carnivorous, so their population size depends on the accessibility of food, i.e., rabbits. Can you see where the problem is? More rabbits mean more foxes, but more foxes mean fewer rabbits.

A similar situation exists with humans (prey) and vampires (predators). Our calculator makes use of the Lotka–Volterra equations, with a few modifications. First of all, we created some vampire slayers that control the population of vampires. Secondly, we gave each group a special ability that is implemented indirectly in the algorithm. Eventually, we came up with the following differential equations:

$$dx/dt = x(k_1 - a_1y)$$

$$dy/dt = y(b_1a_1x + b_2a_2y - cz)$$

$$dz/dt = z(k_2 - a_2y)$$

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[4] See also Log Calculator, by Haponiuk & Pal, available from: https://www.omnicalculator.com/math/log

[5] See also Yorke & Anderson (1973).

where:

- x, y, and z are the sizes of the human, vampire, and vampire slayers populations, respectively;

- k_1 and k_2 are the growth rates of the human and vampire slayer populations;

- b_1 and b_2 are the probabilities that a human and a vampire slayer will turn into a vampire;

- coefficients a_1, a_2, and c describe the aggression levels: vampires towards humans, vampires towards vampire slayers, and vampire slayers towards vampires, respectively.

For more explanations, please refer to Strielkowski et al. (2013). We based this calculator on the fourth-order Runge–Kutta method to solve the problem of differential equations.

BLOODSUCKERS - ARE VAMPIRES AMONG US?

There are species in the animal kingdom that suck and feed on their preys' blood. This practice is called **hematophagy**, and many small animals adopt it because blood is basically a fluid tissue rich in nutrients.

So, what's the main difference between animal bloodsuckers and fictitious vampires? The former can't turn their prey into something else by biting it or killing it. Lucky for us!

Some known bloodsucking animals are (Fig. 4):

- **Vampire bats**: they mainly hunt birds and reptiles, but they occasionally turn their fangs on humans. Interestingly, vampire bats often share the blood that they

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Box 1. How the Calculator came to be

The Vampire Apocalypse Calculator combines two things that I find fascinating: fiction and science. I love it when we can apply mathematical models to even the most surprising things and describing a vampire apocalypse using differential equations definitely makes the top of my list. I got inspired when I found an interesting paper regarding vampires, where the authors subtly suggested the existence of vampires based on real-life data.

That drew my attention and I decided to test it out in a scientific way with the well-known theory of the predator–prey model, based on game theory. Secondly, I needed to prepare an algorithm itself with adequate populations (humans, vampires, vampire slayers) and to create proper relationships between them. Lastly, the implemented calculations are numerical, so I needed to make them stable, no matter the set-up. That required, for example, setting a time step that on one hand, wasn't too small (to avoid the calculations taking literally forever) and that on the other hand, wasn't large enough to make the algorithm unstable. All of this was challenging and because I focused on the Calculator in my free time, it took me about a month to finish everything.

The last part was the hardest. I wanted my calculator to work with various input parameters so everyone could create their own scenarios. The problem with numerical calculations is their stability and the time required to compute them. A stable algorithm requires more time, but it has to be executed within a finite time, even on mobiles. So, depending on the user's input, I needed to predict the appropriate time-step of consecutive calculations to make sure that everything will be estimated in a reasonable period. Choosing sensible parameters was a challenging task too! I had to give meaning to raw numbers to build the atmosphere of a vampire apocalypse. I'm happy that I built a tool that people find interesting and fun.

Figure 4. Top left: vampire bat *Desmodus rotundus*, from Peru; source: Wikimedia Commons (Acatenazzi, 2005). Top right: medicinal leech *Hirudo medicinalis*; source: Wikimedia Commons (GlebK, 2011). Bottom left: *Aedes* (*Ochlerotatus*) sp.; source: Wikimedia Commons. Bottom right: vampire finch *Geospiza difficilis septentrionalis*; source: Wikimedia Commons (P. Wilton, 2009; cropped).

have sucked with their hungry compatriots. That's a real friendship!

• **Leeches**: bloodsucking annelid worms that live in water. They can be used medicinally, as they can restore blood flow to damaged veins.

• **Mosquitoes**: flying insects that you're probably familiar with. They can be dangerous to humans, since mosquitoes can carry many diseases. An interesting fact is that only female mosquitoes suck blood from their victims (they need it to fuel egg production).

• **Vampire finches**: don't let these lovely looking birds deceive you! When other food sources are scarce, they sometimes feed by drinking the blood of other birds.

Humans also practice hematophagy! There are meals that contain animal blood. For example, many people around the world eat blood sausages – sausages filled with blood that has been cooked or dried. With that, we can conclude that vampires are actually among us! Of course, that's only a half-truth; real bloodsuckers can't turn people into vampires.)

REFERENCES

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ABOUT THE AUTHOR

Dominik Czernia is a PhD candidate in the Institute of Nuclear Physics of the Polish Academy of Sciences. When he was a child, he really liked mysterious and bloody stories. As an adult, he realized that blood doesn't give you immortality in the literal sense, but it can save someone's life! Since he turned 18, he has been donating blood regularly: 16 liters so far and feeling the need to donate more. One could say he's the perfect prey for vampires! ;)

As part of his involvement with The Omni Calculator Project, Dominik has built a few interesting tools such as The Hot Car Calculator (https://www.omnicalculator.com/health/car-heat), which helps people understand the lethal consequences of leaving kids unattended in cars, and The Coffee Kick Calculator (https://www.omnicalculator.com/food/coffee-kick), in collaboration, which allows you to maximize your caffeinated efficiency. He's also created many more super scientific ones that may not be as fun but are still worth a mention, such as the Space Travel Calculator, the Acceleration Calculator, and a few Velocity tools.