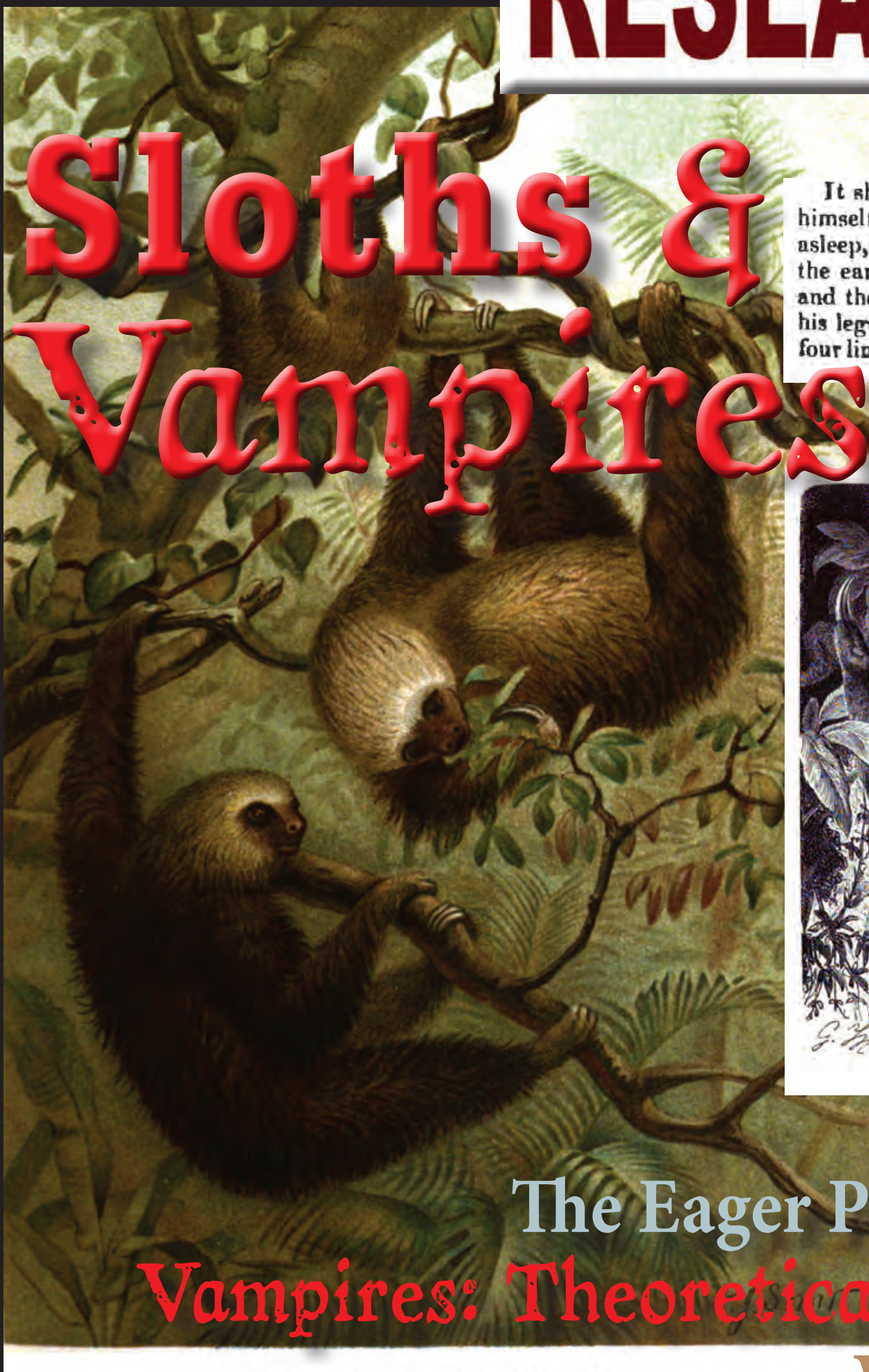
ANNALS OF IMPROBABLE RESEARCH

Special Issue

Sloths & Vampires



THE TWO TOED SLOTH.

It should be observed that the sloth does not suspend himself head downward like the vampire,—but, when asleep, he supports himself from a branch parallel to the earth. He first seizes the branch with one arm, and then with the other; after which he brings up both his legs, one by one, to the same branch; so that all the four limbs are in a line. He rests in perfect security in

THE COMMON THREE-TOED SLOTH (¼ nat. size).

The Eager Pursuit of Sloths,

Vampires: Theoretical Coexistence,

Worm Turns?…

JANUARY | FEBRUARY 2013 (VOLUME 19, NUMBER 1)

Contents

The features marked with a star (*) are based entirely on material taken straight from standard research (and other Official and Therefore Always Correct) literature. Many of the other articles are genuine, too, but we don't know which ones.

Special Section: Sloths and Vampires

Improbable Research Reviews*

News & Notes

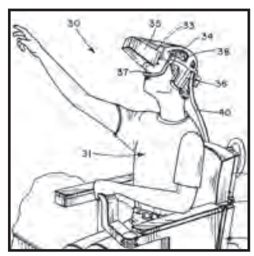
Every Day

Read something new and improbable every day on the Improbable Research blog, on our web site:

WWW.IMPROBABLE.COM

On the Front Cover

"It should be observed that the sloth does not suspend himself head downward like the vampire…"



On the Back Cover

A technical drawing from US patent #5610674, issued to David A. Martin on March 11, 1997: "A fragrance dispenser for use with synchronized visual images may have a breath sensor located adjacent a person's nose and actuated by inhaling and exhaling through the nose to produce a fragrance dispensing signal and a plurality of fragrance dispensers each having a fragrance release portion positioned adjacent a person's nose for dispensing a fragrance adjacent the nose responsive to a fragrance dispensing signal from the breath sensor." *(Thanks to Christina Agapakis for bringing this to our attention.)*

Some Coming Events

See WWW.IMPROBABLE.COM for details of these and other events:

January 19, 2013	ARISIA, Boston
February 16, 2013	AAAS Annual Meeting, Boston
March 2013	Ig Nobel Tour of Scandinavia
March 2013	Ig Nobel Tour of the UK
April 7, 2013	British Festival of Neuroscience
April, 2013	MIPS, Cannes, France
April, 2013	Cambridge (Mass) Science Festival
September 12, 2013	Ig Nobel Prize Ceremony
September 14, 2013	Ig Informal Lectures
ALSO:	Our monthly appearance on the NPR "Science Friday" radio program

Coexistence of Vampires and Humans Is Possible: Proofs Based on Models Derived from Fiction, Television, and Film

Wadim Strielkowski (Charles University, Prague), Evgeny Lisin (MPEI, Moscow), and Emily Welkins (University of Strasbourg)

Our paper describes intertemporal interactions between vampires and humans based on several types of vampire behavior described in popular fiction, films, and television series. Our main research question is: If vampires were real and lived among us, would their existence be possible? We draw several scenarios of vampire–human equilibria and use models with differential equations to test under what provisions vampires could have existed amongst humans. Mathematical modeling reveals that several popular culture sources outline the models describing plausible and peaceful coexistence.

Recent Research About Vampires

Since the 1980s, such topics as behavior of vampires, economic significance of vampirism, and optimal bloodsucking strategies (e.g. preventing the depletion of renewable human resources) have found their way into the research literature, becoming an inspiration for several academic papers (Hart and Mehlmann, 1982, 1983; Hartl, Mehlmann and Novak, 1992; Neocleus, 2003; Efthimiou and Gandhi, 2007).

Vampires are often described in legends and folklore. The word "vampire" comes from the Hungarian language. The first myths and legends about vampires can be found in Mesopotamian texts dating back to 4000 B.C.E. (Campbell Thompson, 1904).

Consider introducing vampires into the model of population growth denoted by $dx/dt = kx$. The vampire population is denoted by the function $y(t)$, $y0 = 1$. Vampires act as natural predators for humans. The human population dynamics can therefore be presented as the following function: $dx/dt = kx - v(x)y$, where $v(x)$ is the rate at which humans are killed by vampires.

Assume that the number of any vampire's victims is growing proportionally. Thence, the function $v(x)$ can be presented as the following: $v(x) = ax$, where $a > 0$ is the coefficient of the human's lethal interaction with a vampire (a human is either killed by a vampire or is turned into a vampire). As a result, the differential equation describing the growth rate of human population can be formulated as the following: $dx/dt = x(k-ay)$.

Assume the dynamics of vampire's population change to be $y(t)$. The growth of vampire population will be determined by the quality and quantity of interactions with humans. After selecting its victim, any vampire can kill it by draining its blood, turn it into a new vampire, or feed on it but leave it to live.

Let us also introduce vampire slayers into the model. The slayers regulate the population of vampires by periodically killing vampires. The equation will then be modified to be $dy/dt = baxy - cy$, where $0 < b \leq 1$ is the coefficient reflecting the rate with which humans are turned into vampires and $c \geq 0$ is the coefficient of lethal outcome of the interaction between a vampire and vampire slayer.

In order to solve this, we need to consider a Lotka-Volterra system, or a "predator–prey" type model (Volterra, 1931). The system allows for the stationary solution, meaning that there is a pair of solutions for the system that creates a state when human and vampire populations can coexist in time without any change in numbers. The size of human population is determined by the effectiveness of slaying vampires by vampire hunters c and the number of cases when the humans are turned into vampires ba. The size of vampire population depends on the growth rate of human population k and vampires' thirst for human blood a. The stationary solution shows that when vampires are capable of restraining their blood thirst, the size of both populations can be rather high in mutual co-existence. The system is held in balance by the existence of vampire slayers.

The Stoker-King model

Bram Stoker's *Dracula* and Stephen King's *'Salem's Lot* describe interactions between vampires and humans in the following way: A vampire selects a human victim and gets into the victim's proximity. This typically happens after dark. Sometimes the vampire needs the victim to invite the vampire in, but often the vampire does not require permission to enter the victim's premises and attacks the sleeping victim (Stoker, 1897; McNally and Florescu, 1994). The vampire bites the victim and drinks the victim's blood and returns to feed for 4–5 consecutive days, whereupon the victim dies, is buried, and rises to become another vampire (unless a wooden stake is put through the new vampire's heart). Vampires usually need to feed every day, so more and more human beings are constantly turned into vampires (Stoker, 1897; King, 1975).

Assume the events described in *Dracula* were real. How would things evolve given the Stoker-King model dynamics

continued >

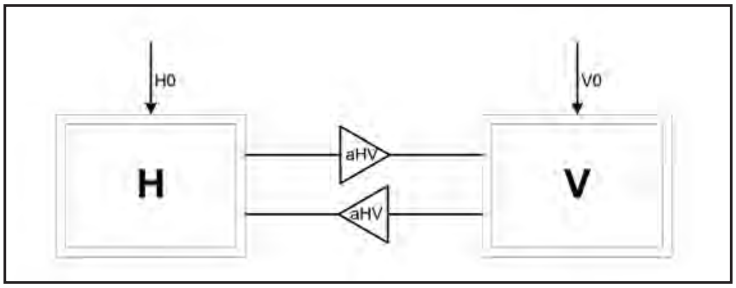


Diagram 1: The Stoker-King model

Note: H denotes humans and V denotes vampires, H0 is the initial state of human population, V0 is the initial state of vampire population, and aHV describes an interaction between a human and a vampire (with a as the coefficient of a lethal outcome for humans in a typical vampire–human interaction).

described in both sources? Let us take 1897 as the starting point (the year Stoker's novel was published). In 1897, the world population was about 1.65 billion people (UN, 1999). The model is presented on Diagram 1.

Let us calibrate the parameters of this specific case of predator–prey model. The calculation period is set at 1 year with a step of 5 days ($t = 0 \ldots 73$). The coefficient of human population growth k for the given period is very small and can be neglected, therefore $k = 0$. The coefficient of lethal outcome for humans interacting with vampires can be calculated according to the scenario presented in the Stoker-King model $y_0(t) = y_0 q^t$, where $y_0 = 1$, $q = 2$. The probability of a human (who interacts with a vampire) being turned into a vampire is very high, thence $b = 1$. Jonathan Harker and Abraham van Helsing could not be considered very efficient vampire slayers; therefore we can put $c = 0$.

The resulting simplified model is presented in a form of a Cauchy problem. Due to the fact that the total sum of humans and vampires does not change in time (human population does not grow and humans gradually become vampires), the predator-prey model is diminished to a simple problem of an epidemic outbreak (Munz et al., 2009).

The solution to this problem is presented in Chart 1. It is clearly visible that the human population is drastically reduced by 80% by the 165th day from the moment when the first vampire arrives. At the end of our one-year study window, the world will be inhabited by 1,384 million vampires and 266 million people.

It is obvious that the growth of vampire population is extreme: at first, the number of vampires jumps up abruptly, but then slows down and declines. The maximal growth of the number of vampires (infected humans) will be observed on the 153rd day, when the number of vampires is the highest and equals 825 million with 286 million newly turned vampires every day. It is apparent that the increase in one population (vampires) inevitably leads to the decrease in another (humans). The presence of vampires in the Stoker–King model brings the mankind to the brink of extinction and the model becomes very similar to an epidemic outbreak caused by a deadly virus (e.g. Ebola or SARS). According to the Stoker–King model, vampires need just half a year to take up man's place on Earth.

The Harris-Meyer-Kostova model

Stephenie Meyer's Twilight series of books, Charlaine Harris's Sookie Stockhouse (Southern Vampire) series of books (turned into the *True Blood* television series), and Elizabeth Kostova's novel *The Historian* show worlds where vampires peacefully coexist with humans.

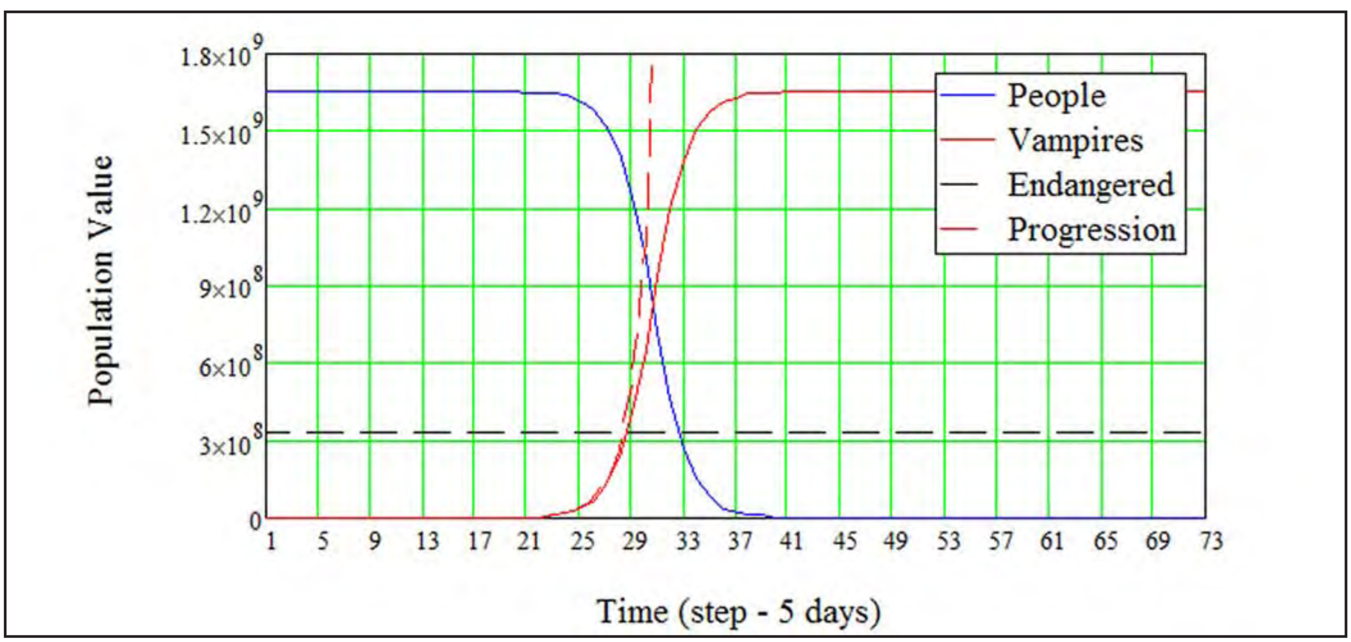


Chart 1: Humans and vampires (1 step = 5 days) in the Stoker-King model

In Meyer's Twilight series, vampires can tolerate the sunlight, interact with humans (even fall in love with them), and drink animal blood to survive (Meyer, 2005), but they have to live in secrecy and pretend to be human beings. In the Sookie Stackhouse books and *True Blood* television series, however, vampires and humans live side by side and are aware of each other. Vampires can buy synthetic human blood of different blood types that is sold in bottles and can be bought in every grocery store, bar, or gas station (Harris, 2001). They cannot walk during daytime, so they usually come out at night. Vampire blood is a powerful hallucinogenic drug that is sought by humans and traded on the black market. (Sometimes humans capture vampires with the help of silver chains or harnesses and then kill them by draining their blood.) Some humans seek sex with vampires, as vampires are stronger and faster than humans and can provide superb erotic experiences. There is a possibility to turn a human being into a vampire, but it takes time and effort.

In *The Historian*, vampires are rare and do not reveal themselves to humans too often. Their food ratios are limited and they spend lots of time brooding in their well-hidden tombs (Kostova, 2005).

In Harris's series, vampires have decided to reveal themselves to humans and coexist with them, peacefully exerting their citizens' rights (Harris, 2001). Assume that at the time of the events described in the first book of the series, *Dead Until Dark* (2001), the world's vampire hypothetical population was around 5 million, the population of the state of Louisiana in 2001 (Maddison, 2006). The initial conditions of the Harris-Meyer-Kostova model are therefore

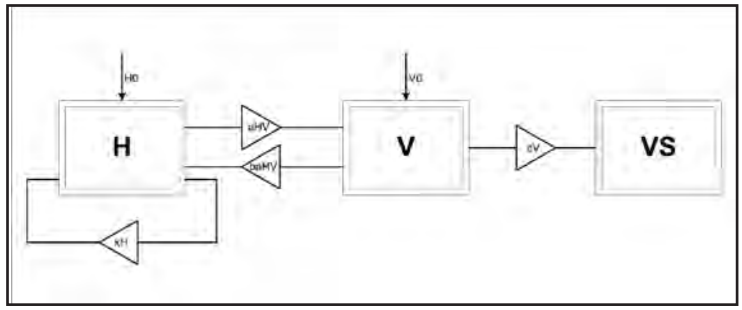


Diagram 2: The Harris-Meyer-Kostova model

Note: *H denotes humans, V denotes vampires, and VS denotes vampire slayers. H0 is the initial state of human population, kH denotes the exponential growth of human population, V0 is the initial state of vampire population, aHV and baHV both describe interactions between a human and a vampire (with a as the coefficient of a lethal outcome for humans in a typical vampire–human interaction and b as the coefficient describing the rate with which humans are turned into vampires), and cV denotes the death rate for vampires.*

the following: 5 million vampires, 6159 million people, organized groups of vampire "drainers". The model is presented in Diagram 2.

Humans almost always come out alive from their encounters with vampires, hence the coefficient of lethal outcome $a = 0.01$. The probability of a human being turned into a vampire is $b = 0.1$. There are numerous groups of vampire drainers (although the number of drained vampires is

continued >

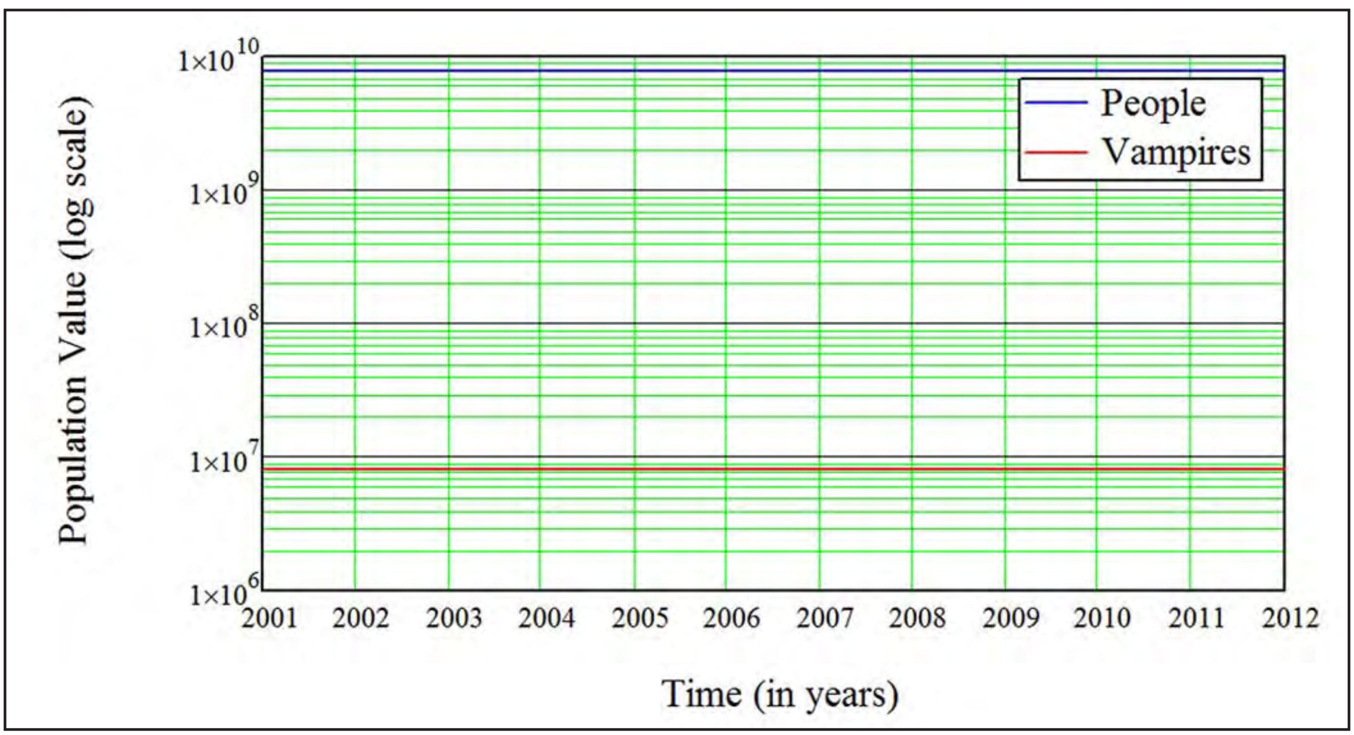


Chart 2: Chart with stationary solution presented on a logarithmic scale for the vampire (ys) and human (xs) populations in the Harris-Meyer-Kostova model.

relatively low and would not lead to their total extinction), so we can put $c > 0$ (c is calculated similarly to the coefficient k). The model allows for a stationary solution: there are system parameters (x_s, y_s) that would stabilize the populations of humans and vampires in time. In order to find the stabilized populations of both species, x_s and y_s, the equality is: (x_s, y_s) = (7704.8) million individuals. Chart 2 shows us the stationary solution presented on a logarithmic scale.

This stationary solution for 2001 cannot be found with the chosen population growth coefficient k and can be reached applying some conditions only after 2012. The deviations in the number of people and vampires from the stationary state at the initial period of time are quite small, which points at the fact that the system might be stable and auto-cyclical.

Our calculations yield that the human population will be growing until 2046 when it reaches its peak of 9.6 billion people, whereupon it will be declining until 2065 until it reaches its bottom at 6.12 billion people. This process will repeat itself continuously. The vampire population will be declining until 2023 when it reaches its minimum of 289 thousand vampires, whereupon it will be growing until 2055 until it reaches its peak at 397 million vampires. This process will repeat itself continuously. Chart 3 shows the phase diagram of the cyclical system of human–vampire co-existence. Under certain conditions, the Harris-Meyer-Kostova model seems plausible and allows for the existence of vampires in our world. Peaceful coexistence of two species is a reality.

The Whedon model

The television series *Buffy the Vampire Slayer*, created by Joss Whedon, presents the most simplistic, yet the most dreadful doomsday scenario of vampire–human interaction (similar to zombie infection outbreak in movies like *28 Days Later* or Resident Evil and described in Munz et al. (2009)). The vampire bites its victim, who (in a very short period of time) rises as another undead vampire and, in turn, bites another human victim, and so on. Luckily enough for humans, the world is populated by an unknown (but considerably large) number of vampire slayers, with a girl named Buffy Summers being their most remarkable representative, and killing a vampire is relatively easy.

The Whedon model is a modified version of the Harris-Meyer-Kostova model. It uses the higher coefficient of vampire-slaying effectiveness, c. The initial conditions of the Whedon model are: 5 million vampires, 6159 million people, organized groups of vampire slayers. The model is presented in Diagram 3.

Let us calibrate the parameters of the model. The calculation period is set at 10 years with a step of 1 year, and the coefficient of human population's growth is calculated as $k = ln(x_1/x_0)/t_1\text{-}t_0$ where x_1 = 7000 million people in 2012, x_0 = 6150 million people at time t_0 = 2001. Humans are always turned into new vampires after their encounters with vampires, so the coefficient of lethal outcome a is high. The probability of a human being turned into a vampire is b = 0.1.

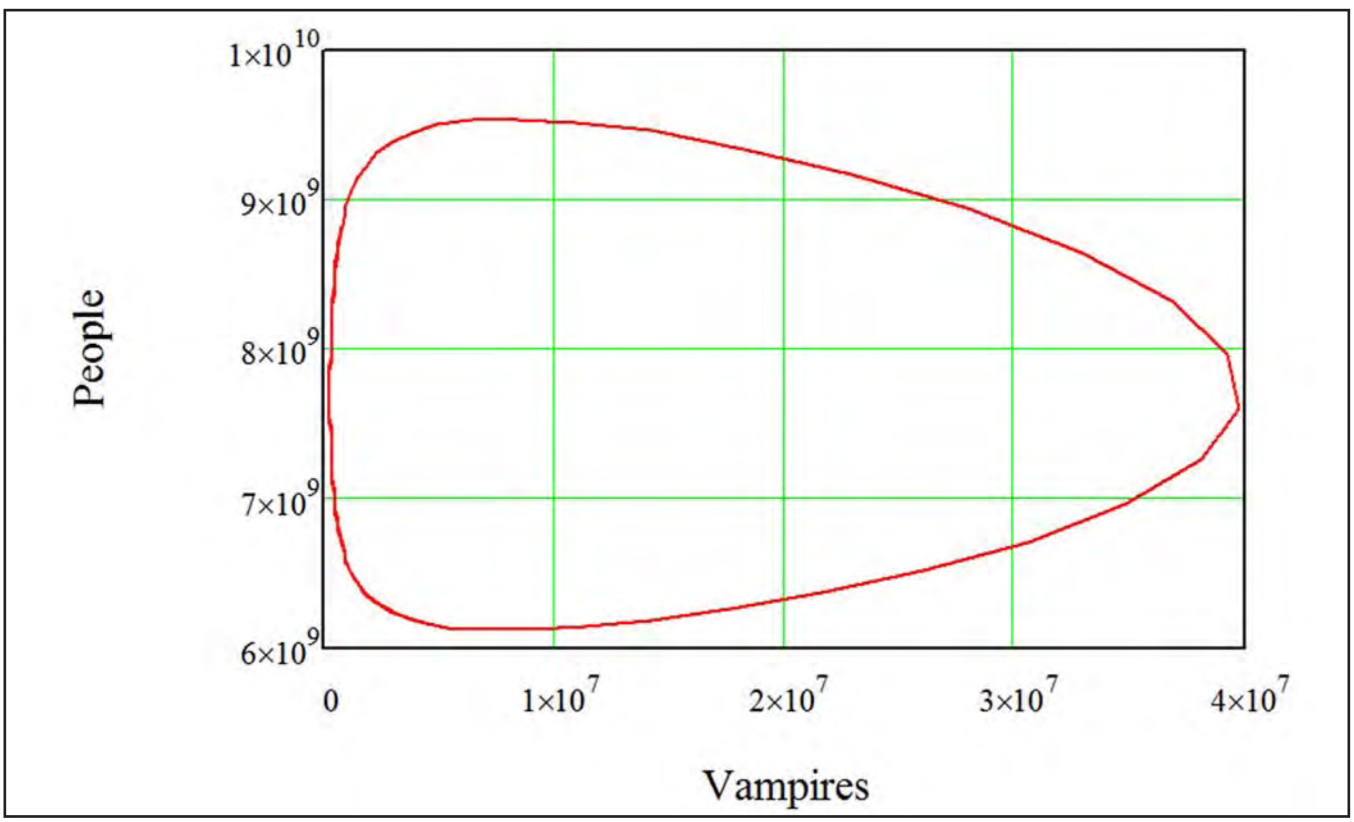


Chart 3: Phase diagram of vampire (z^2) and human (z^1) populations in the Harris-Meyer-Kostova model.

There are groups of vampire slayers, therefore we put $c = 10$. The resulting model is presented in Chart 4.

Although the Whedon model's structure theoretically allows for coexistence of humans and vampires, the laborious vampire slayers contribute to putting the system out of balance by killing all vampires. The human population recovers from the damage caused to it by vampires and continues to grow steadily.

Conclusions

Overall, it appears that although vampire–human interactions would in most cases lead to great imbalances in the ecosystems, there are several cases that might actually convey plausible models of coexistence between humans and vampires.

The Stoker-King model described the explosive rate of growth in vampire population that would lead to exterminating 80% of the human population on the 165th day of the first vampire's arrival. The scenario is similar to severe epidemic outbreaks and would lead first to the complete extinction of humans and then to the death of all vampires. The Harris-Meyer-Kostova model allows for the peaceful existence of vampires in our world. The Whedon model allows for the coexistence of humans and vampires, but in this case vampires become one of the endangered species due to the existence of super-effective vampire slayers. Unless the slayers calm their rigor, the vampire goes extinct.

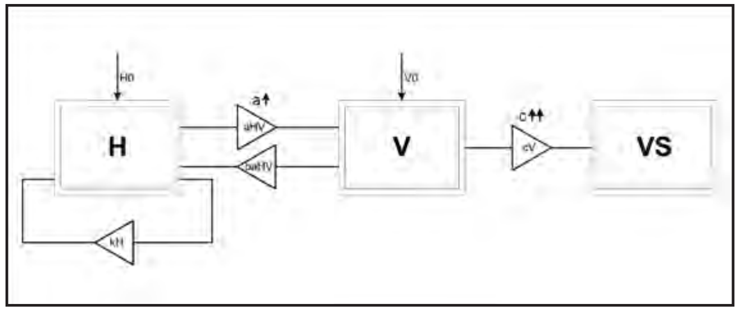


Diagram 3: The Whedon model.

Note: *H denotes humans, V denotes vampires, and VS denotes vampire slayers. H0 is the initial state of human population, kH denotes the exponential growth of human population, V0 is the initial state of vampire population, aHV and baHV both describe interactions between a human and a vampire (with a as the coefficient of a lethal outcome for humans in a typical vampire–human interaction and b as the coefficient describing the rate with which humans are turned into vampires), and cV denotes the death rate for vampires (with a much higher c than in the Harris-Meyer-Kostova model).*

References

Campbell Thompson, R. (1904), "The Devils and Evil Spirits of Babylonia", 1st edition, Vol.2, Luzac, London, 504 p.

Efthimiou, C.J., Gandhi, S. (2007), "Cinema Fiction vs. Physics Reality: Ghosts, Vampires and Zombies", *Sceptical Inquirer*, Vol. 31.4, July/August, p. 27

Frayling, C. (1992), "Vampyres: Lord Byron to Count Dracula," 1st edition, Faber & Faber, London, 429 p.

continued >

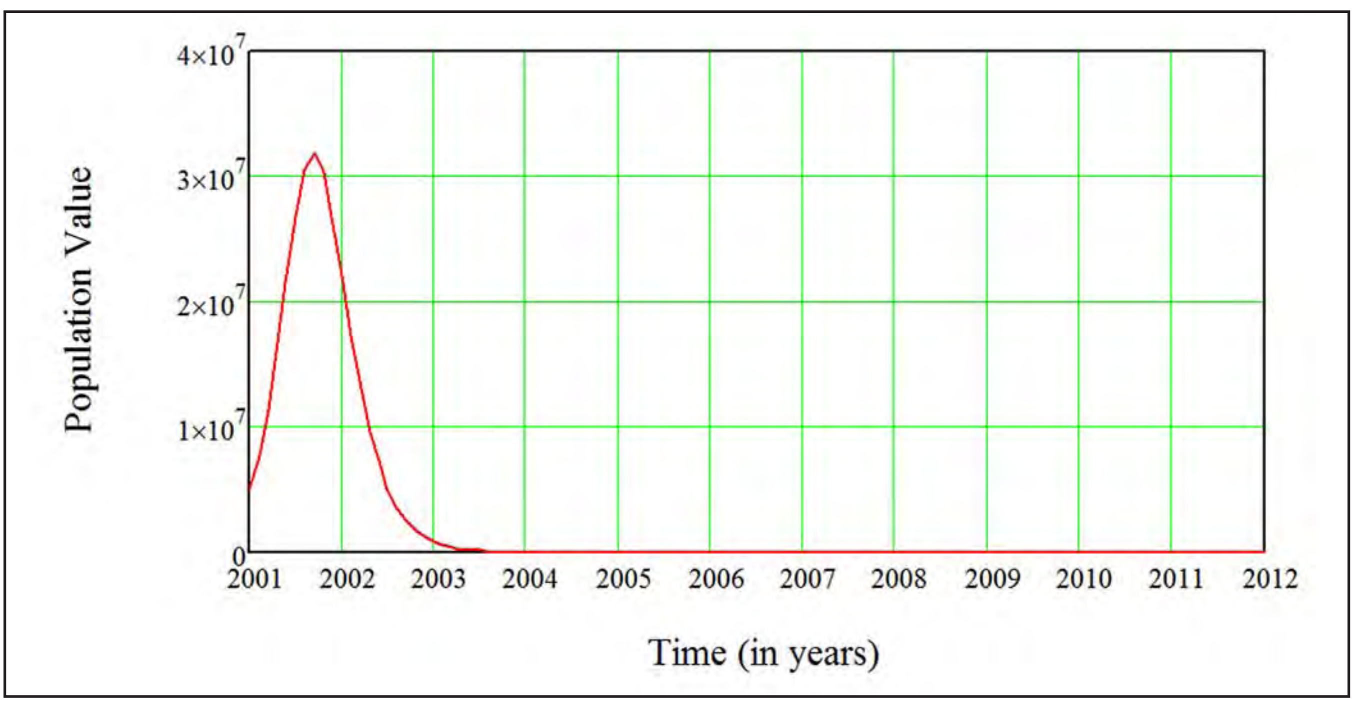


Chart 4: Vampire population in the Whedon model (vampires are exterminated).

Harris, C. (2001), "Dead Until Dark". Ace Books, New York, 260 p.

Hartl, R. F. and A. Mehlmann, A., (1983), "Convex-Concave Utility Function: Optimal Blood Consumption for Vampires". *Applied Mathematical Modelling*, Vol. 7, pp. 83-88

Hartl, R. F., Mehlmann, A. (1982), "The Transylvanian Problem of Renewable Resources," *Revue Francaise d'Automatique, Informatique et de Recherche Operationelle*, Vol. 16, pp. 379-390

Hartl, R.F., Mehlmann, A. and Novak, A. (1992), "Cycles of Fear: Periodic Bloodsucking Rates for Vampires, *Journal of Optimization Theory and Application*, Vol. 75, No. 3 (December), pp. 559-568

King S. (1975), "'Salem's Lot", Doubleday, 439 p.

Kostova E. (2005), "The Historian", New York: Little, Brown and Company, New York, 734 p.

Maddison, A. (2006), "The World Economy. Historical Statistics" (Vol. 2), OECD 2006, 629 p.

McNally, R. T., Florescu, R. (1994), "In Search of Dracula". Houghton Mifflin Company, 320 p.

Meyer, S. (2005), "Twilight saga", 1st edition, New York: Little, Brown and Company, New York, 544 p.

Munz, P. Hudea, I., Imad, J., and Smith?, R.J. (2009), "When zombies attack!: Mathematical modelling of an outbreak of zombie infection", In Tchuenche, J.M. and Chiyaka, C. (eds,) , *Infectious Disease Modelling Research Progress*, University of Ottawa Press, pp.133-150

Neocleous, M. (2003), "The Political Economy of the Dead: Marx's Vampires," *History of Political Thought*, Vol. XXIV, No. 4. pp. 668-684

Rice, A. (1997), "Interview with the Vampire ", Vampire Chronicles, Random House Publishing, 352 p.

Stoker, B. (1897), "Dracula", 1st edition, Archibald Constable and Company, London, 390 p.

UN (1999), "The World at Six Billion", Population Division, Department of Economic and Social Affairs, UN, New York, 63 p.

Volterra V. (1931), "Variations and fluctuations of the number of individuals in animal species living together". In Chapman R. N. (ed.), "Animal Ecology", New York, NY: McGraw Hill, pp. 409–448.

Whedon, J. (1997), "Buffy the Vampire Slayer", television series, Mutant Enemy Production

AIR Teachers' Guide

Three out of five teachers agree: curiosity is a dangerous thing, especially in students. If you are one of the other two teachers, *AIR* and *mini-AIR* can be powerful tools. Choose your favorite h*AIR*-raising article and give copies to your students. The approach is simple. The scientist thinks that he (or she, or whatever), of all people, has discovered something about how the universe behaves. So:

- **Is this scientist right—and what does "right" mean, anyway?**
- **Can you think of even one different explanation that works as well or better?**
- **Did the test really, really, truly, unquestionably, completely test what the author thought he was testing?**
- **Is the scientist ruthlessly honest with himself about how well his idea explains everything, or could he be suffering from wishful thinking?**
- **Some people might say this is foolish. Should you take their word for it?**
- **Other people might say this is absolutely correct and important. Should you take their word for it?**

Kids are naturally good scientists. Help them stay that way.