

Discovering novel pathways of cross-species pathogen transmission



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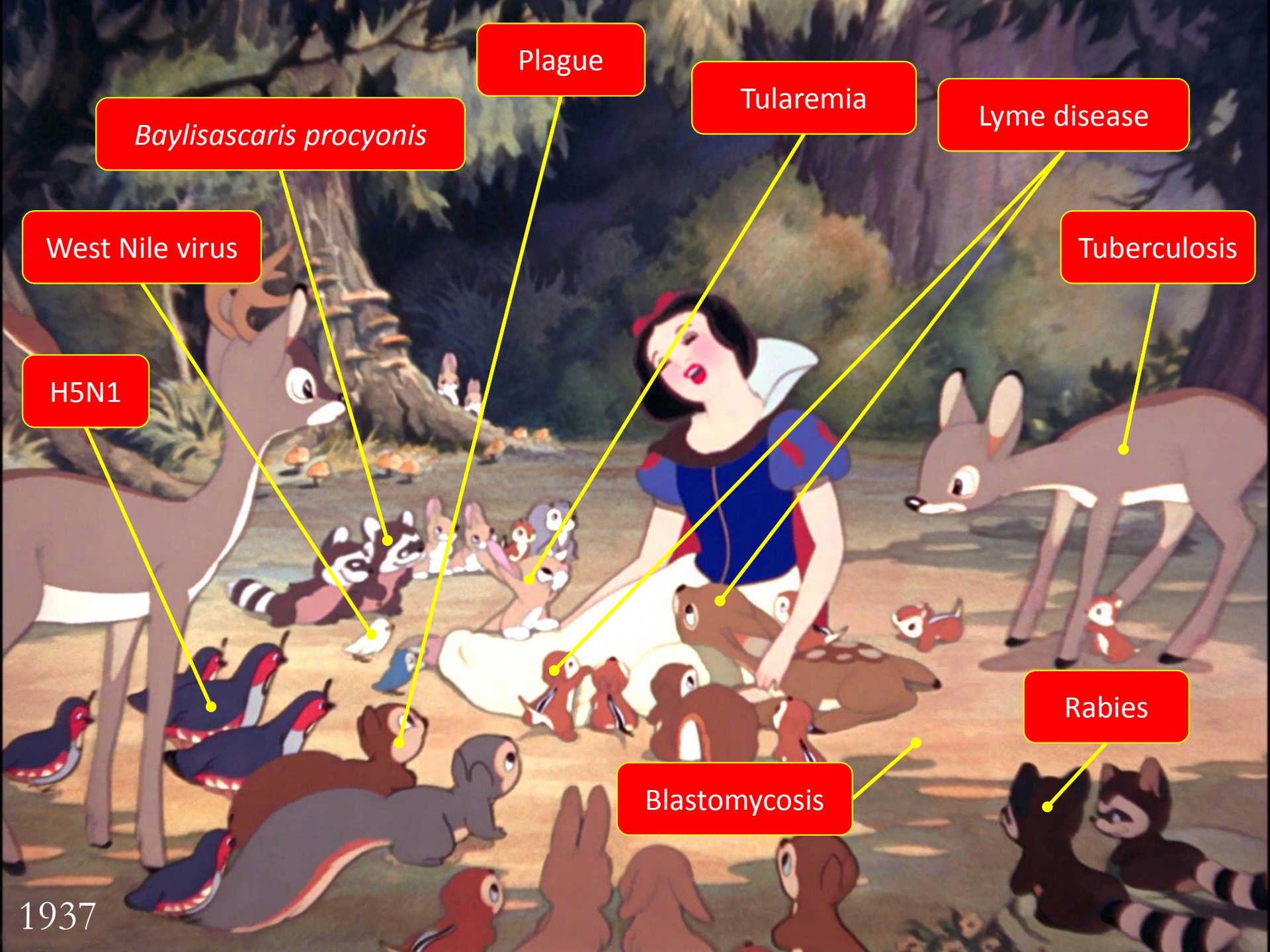
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UW-Madison Nelson Institute for Environmental Studies, Center for Sustainability and the Global Environment

UW-Madison Departments of Population Health Sciences, Zoology, and African Studies Program

Makerere University, Uganda, Department of Zoology



Baylisascaris procyonis

Plague

Tularemia

Lyme disease

West Nile virus

Tuberculosis

H5N1

Blastomycosis

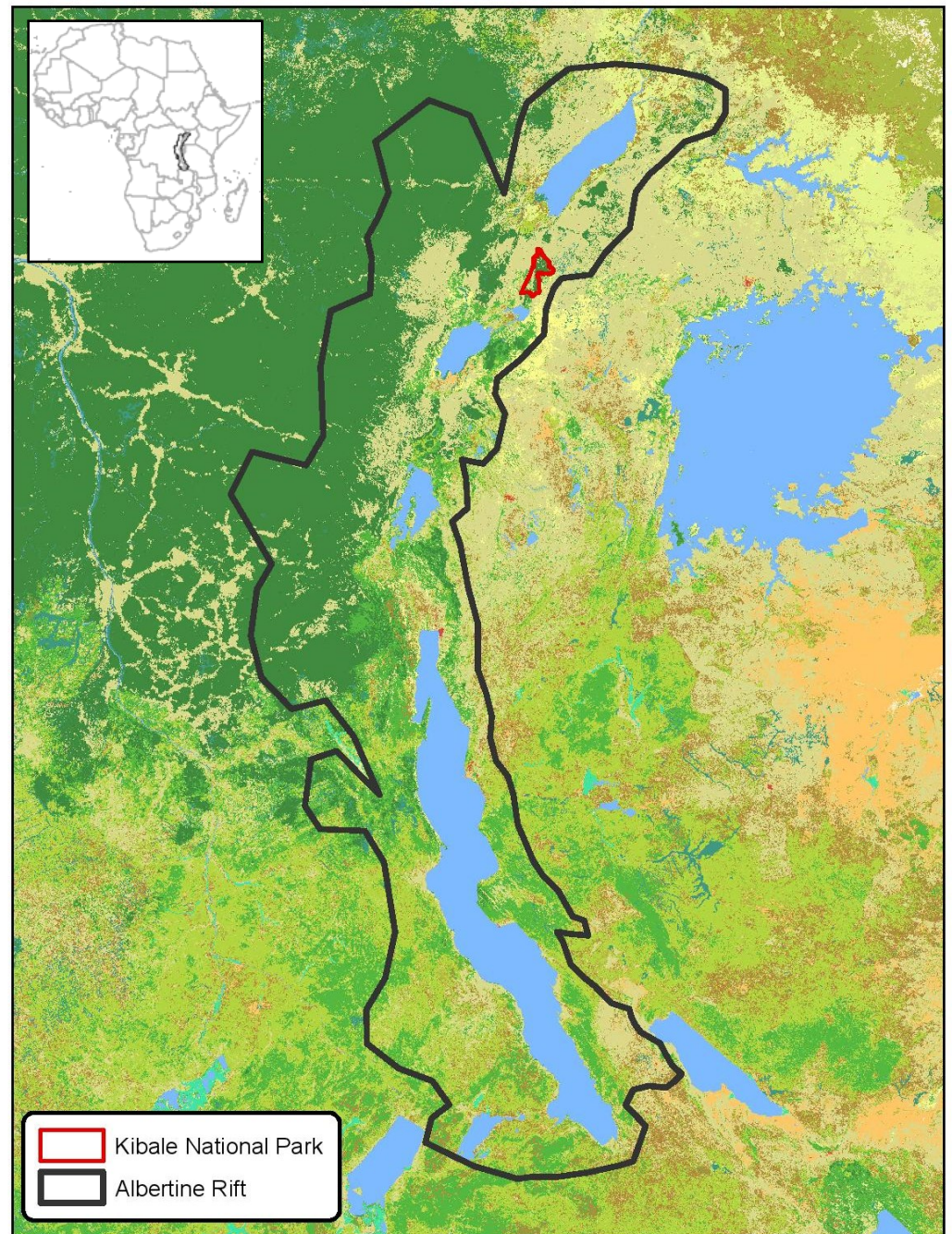
Rabies



J. Robbins, "The Ecology of Disease." *New York Times*, July 14, 2012

Kibale National Park

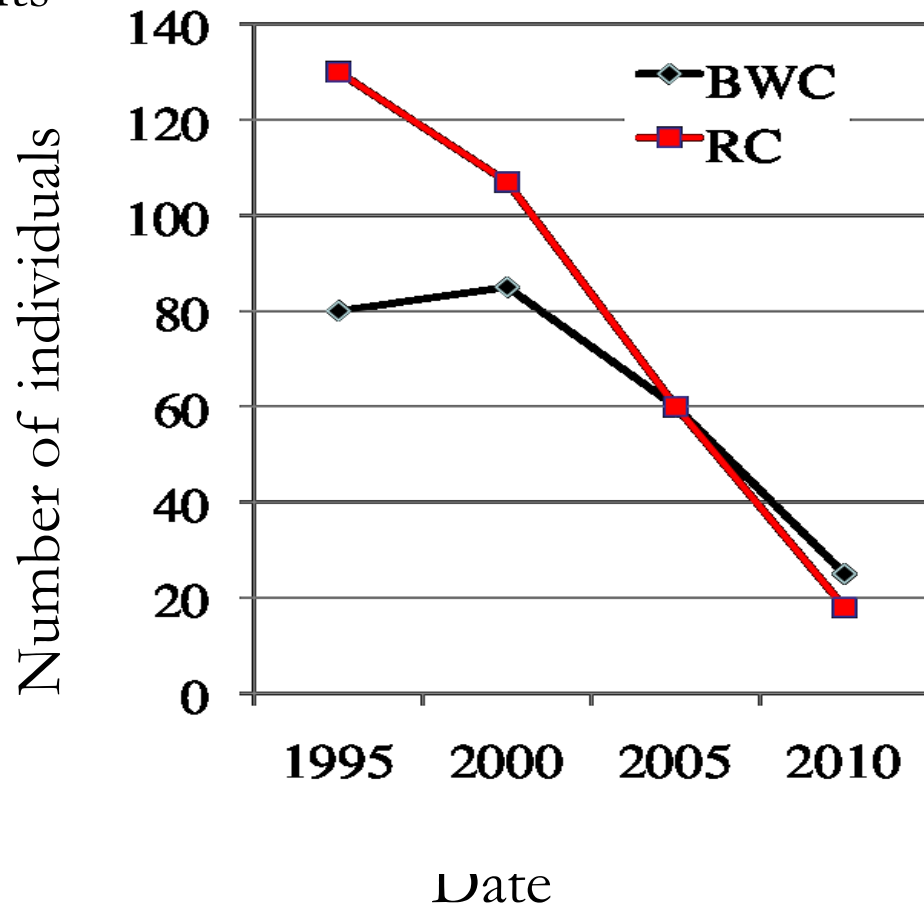
- In the Albertine Rift
 - Biodiversity hotspot
- High primate biodiversity and biomass
- High rate of human population growth



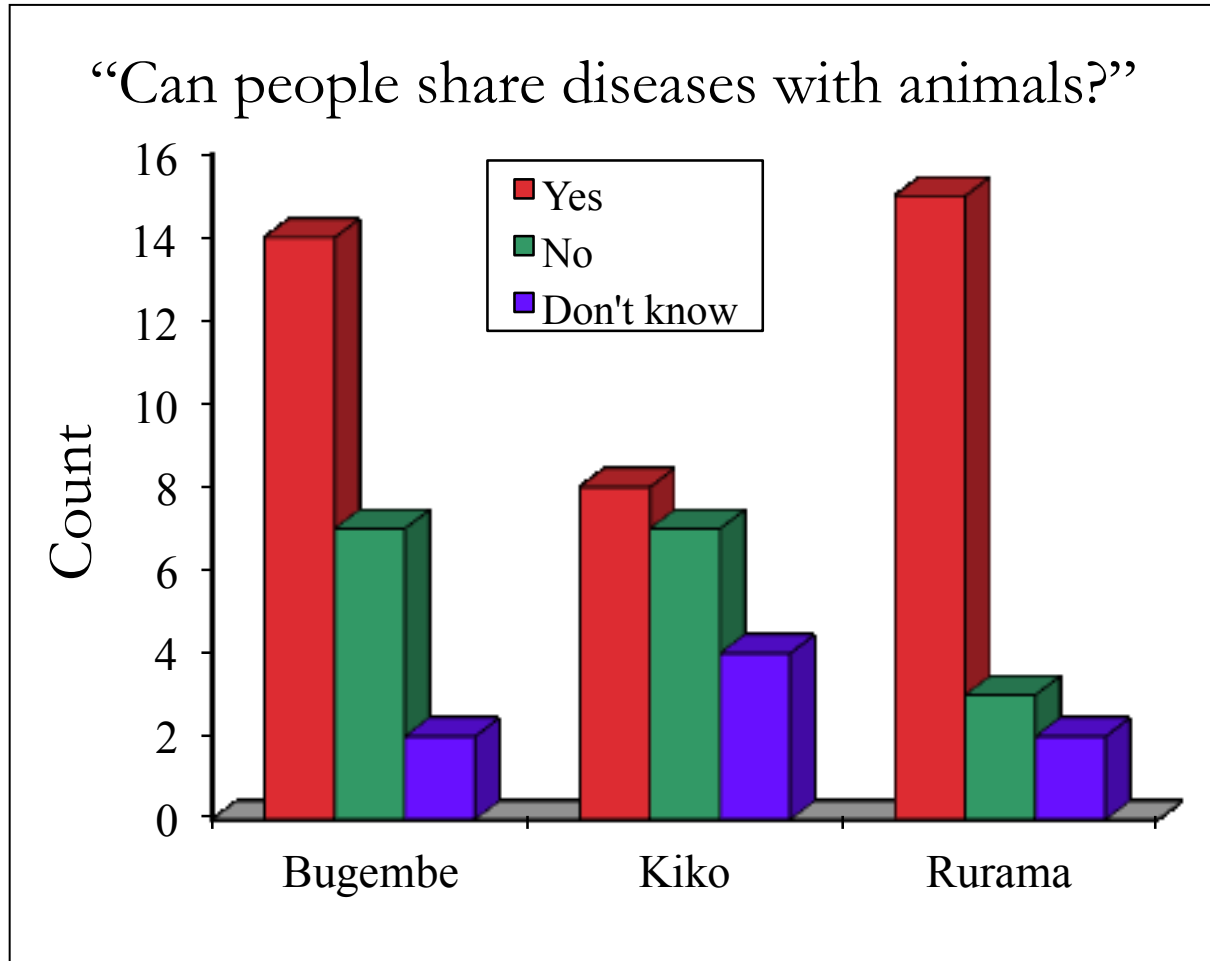
Created by Johanna Bleecker, Chapman Lab 2012. Albertine Rift outline provided by Wildlife Conservation Society. Land use imagery courtesy of the ESA GlobCover 2009 Project.

Primate extinction in forest fragments

24 fragments



General knowledge about zoonoses



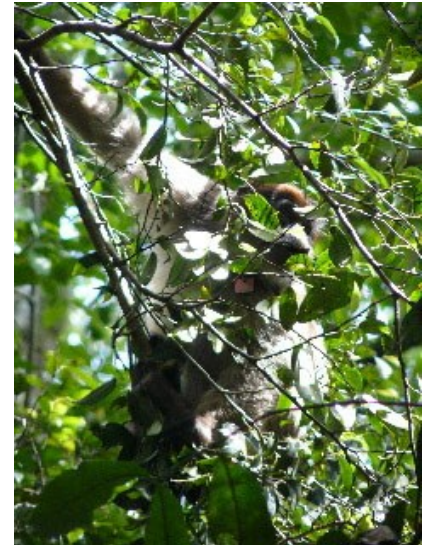
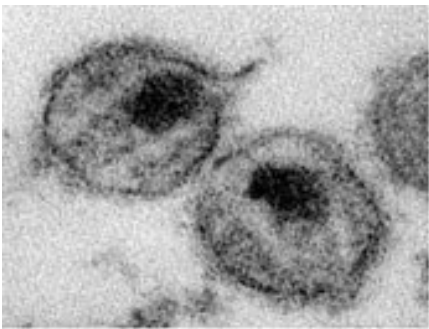
“We are all coughing, and so are the goats!”

Paige, S. B., C. Malave, E. Mbabazi, J. Mayer and T. L. Goldberg (2015). Uncovering zoonoses awareness in an emerging disease 'hotspot'. *Soc Sci Med* 129: 78-86.

An interesting story from an open-ended interview

- “Yes, primates can as well bring diseases to people. Because in this community we hear people telling us [stories]. Like two years back, or three, that ‘a red colobus bit my two children and they died.’ Apart from we don’t know if it’s poison from their teeth or a disease from their blood, but yes, they also have diseases.” (*37 yr old male “enrolled nurse”; owns drug shop*)

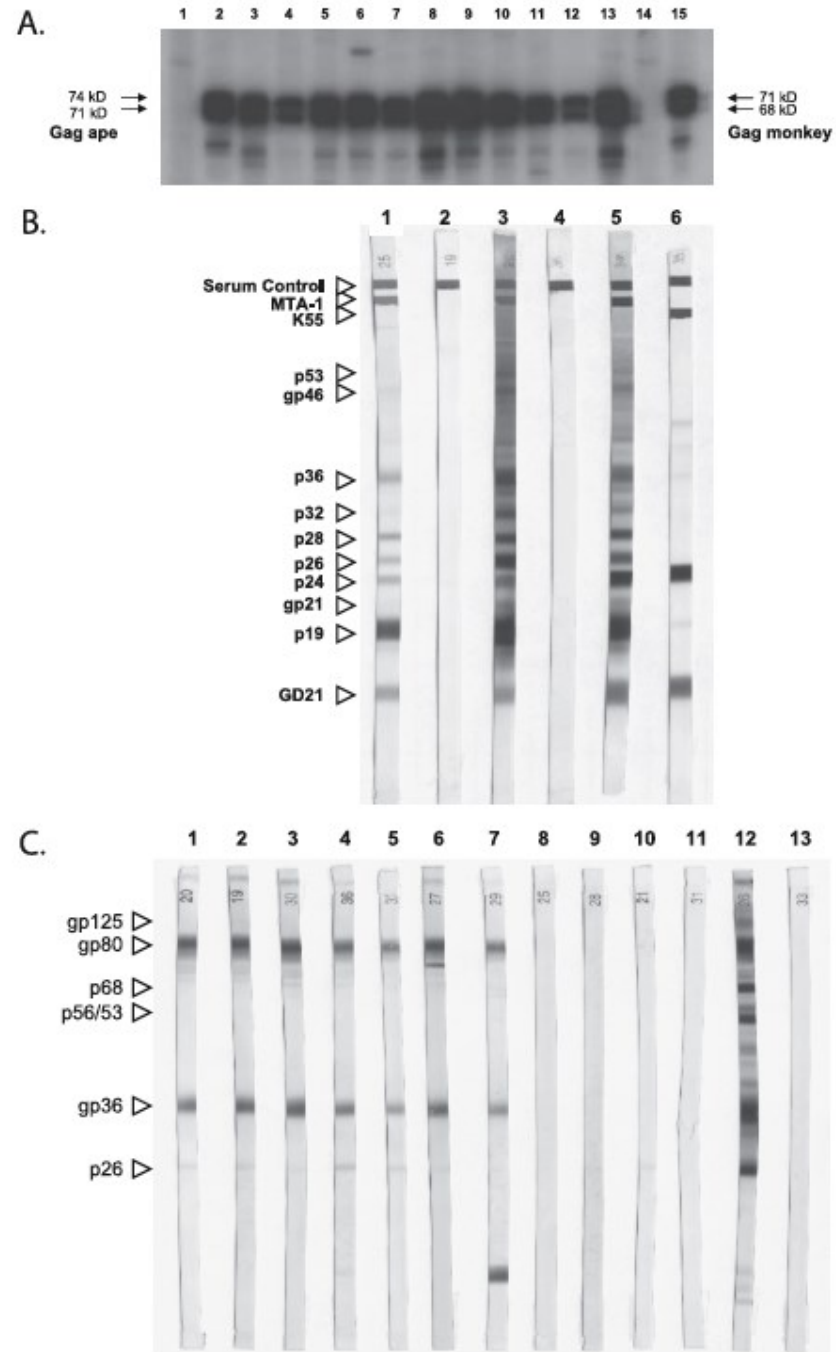
Virus hunting



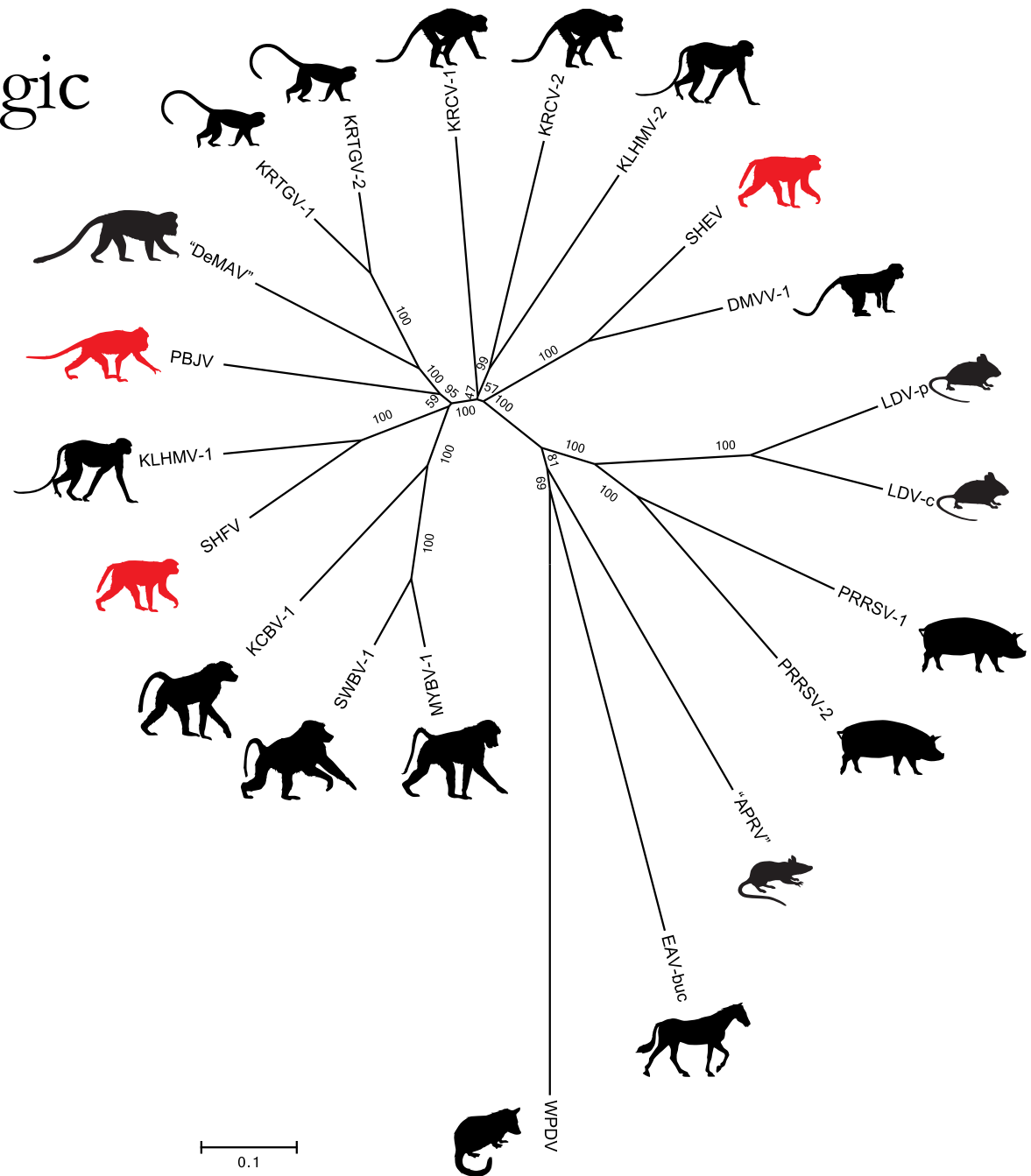
Multiple infection of Kibale red colobus with three novel simian retroviruses

<i>Virus</i>	<i>% infected (n = 31)</i>
SFV	97
SIV	23
STLV	7
SIV + SFV	23
STLV + SFV	7
SIV + STLV + SFV	3

Goldberg *et al.*, 2009. *Journal of Virology*
83:11318-29.

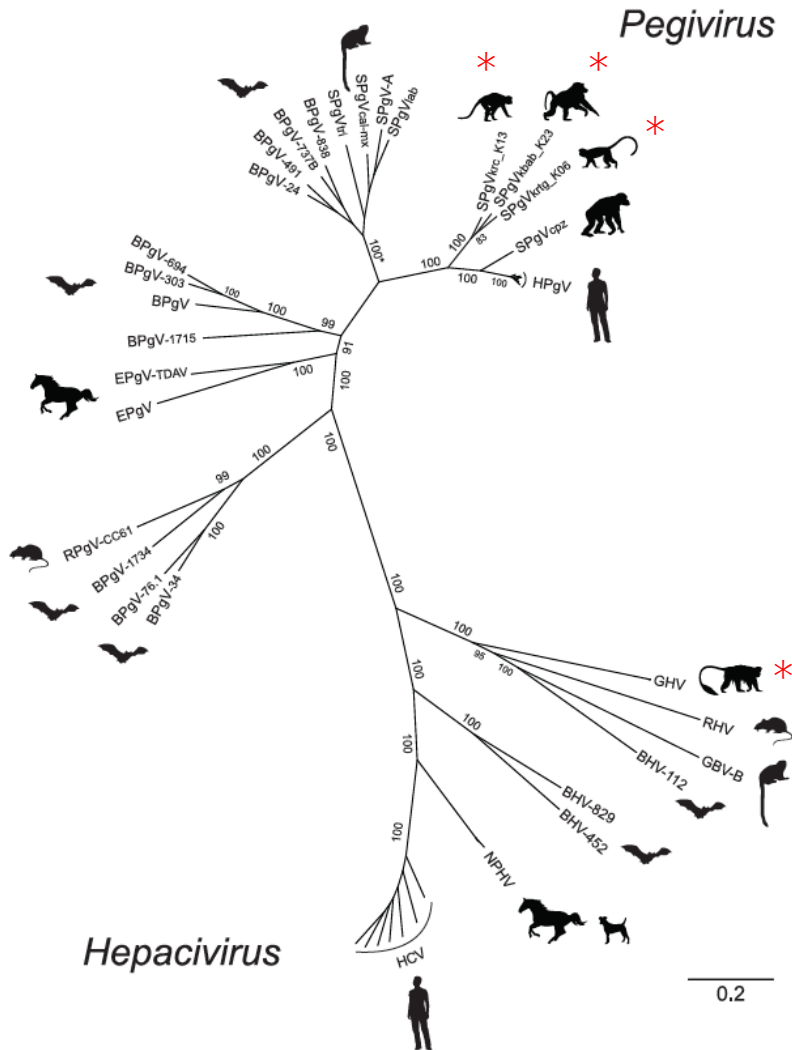


Simian hemorrhagic fever virus and its relatives

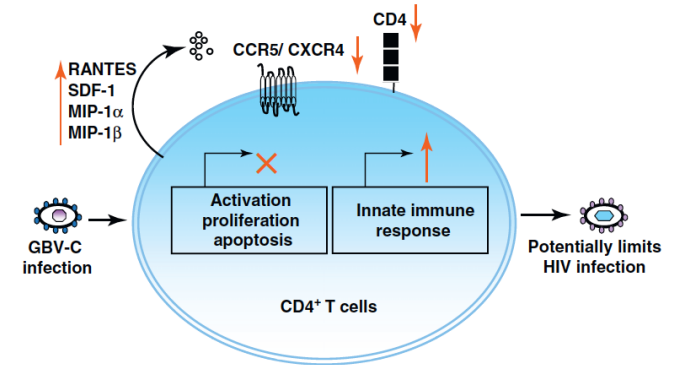


Lauck et al. (2011). PLoS One 6(4): e19056.
Lauck et al., (2013). *J Virol* 87(1): 688-691.
Bailey et al., (2014). *J Virol* 88(22): 13231-13239.
Lauck et al. (2015). *J Virol* 89:8028-8087.
Kuhn et al., in revision (ICVT taxonomy proposal).

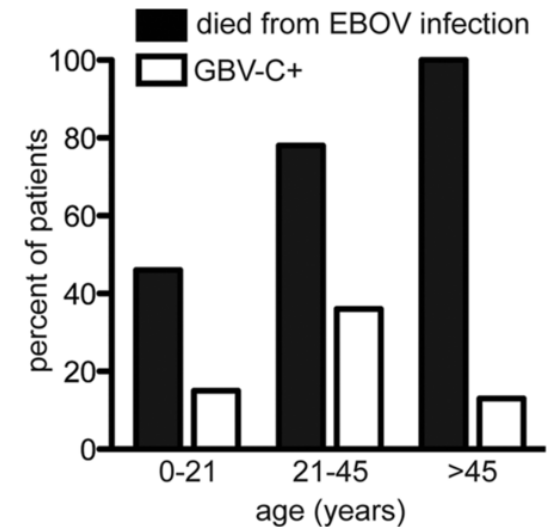
GBV-C: a “good” virus



Sibley et al., (2014). *PLoS One* 9(2): e98569.



Bhattarai, N. and J. T. Stapleton (2012).
GB virus C: the good boy virus?
Trends Microbiol 20(3): 124-130.



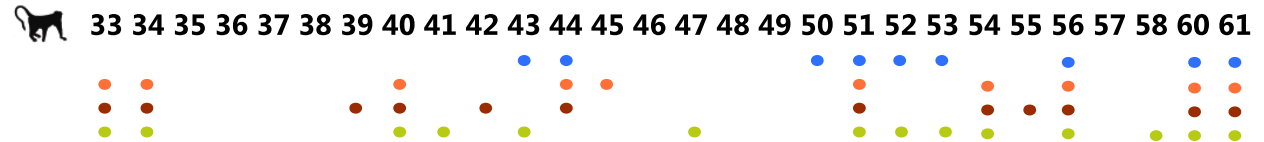
Lauck, M., A. L. Bailey, K. G. Andersen, T. L. Goldberg, P. C. Sabeti and D. H. O'Connor (2015). GB virus C coinfections in west African Ebola patients. *J Virol* 89(4): 2425-2429.

Kibale primate RNA viral diversity

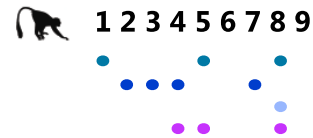
red colobus



red colobus



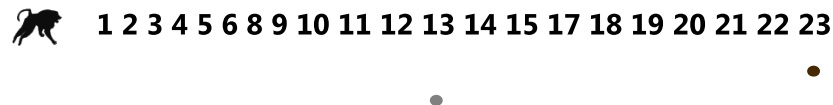
black-and-white colobus



red-tailed guenon

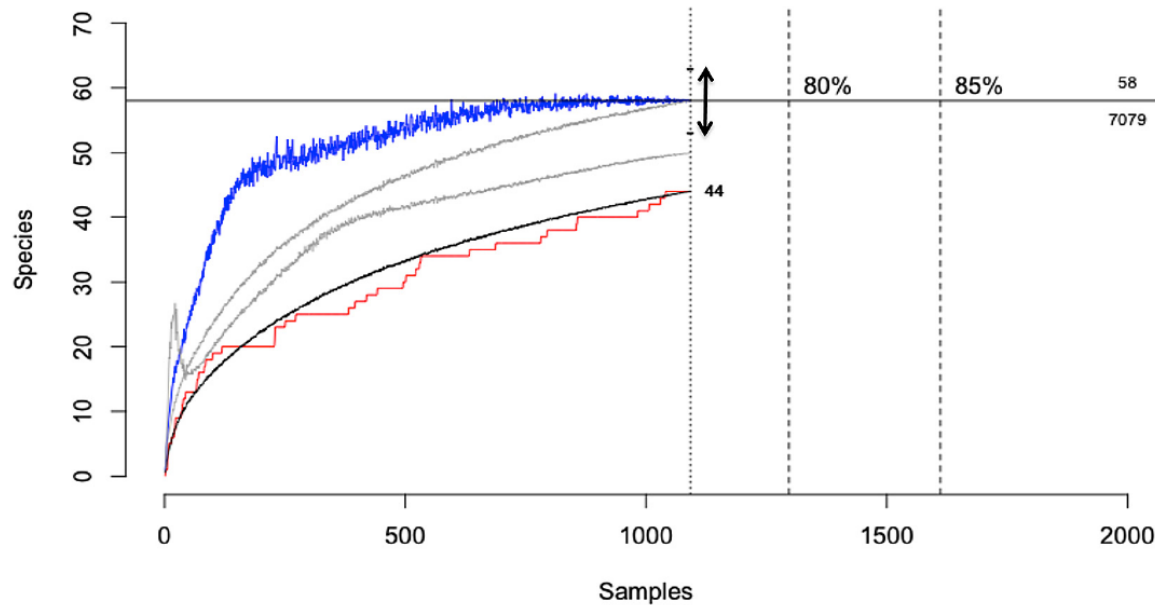


olive baboon



Option 1: pathogen discovery

- Discover pathogens for “pandemic prevention”
 - Discover them all, prevent them all



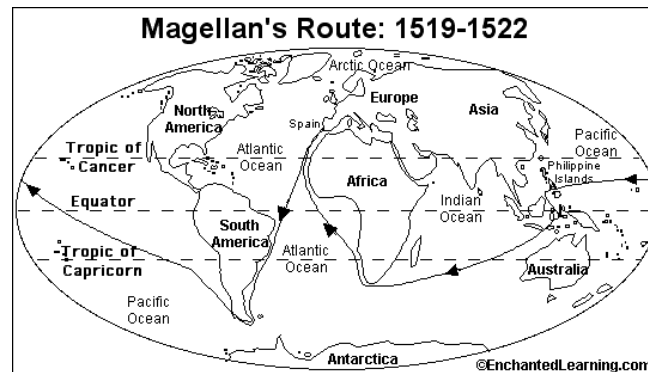
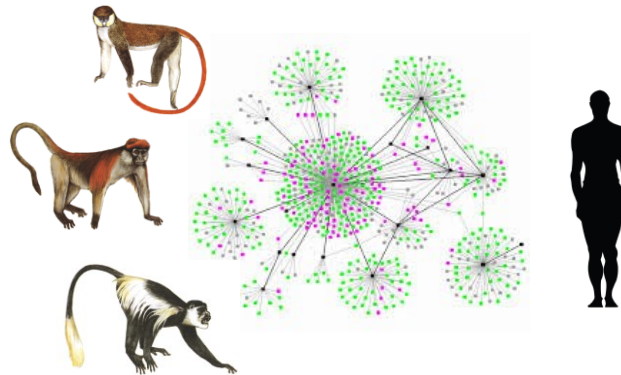
Viral discovery curve. 1,092 Indian flying fox samples PCR-tested for nine viral families. black = rarefaction curve; red = empirical accumulation of novel viruses; blue, gray = other estimators.

Cost to discover all 320,000 unknown mammalian viruses = **\$6.3 billion.**

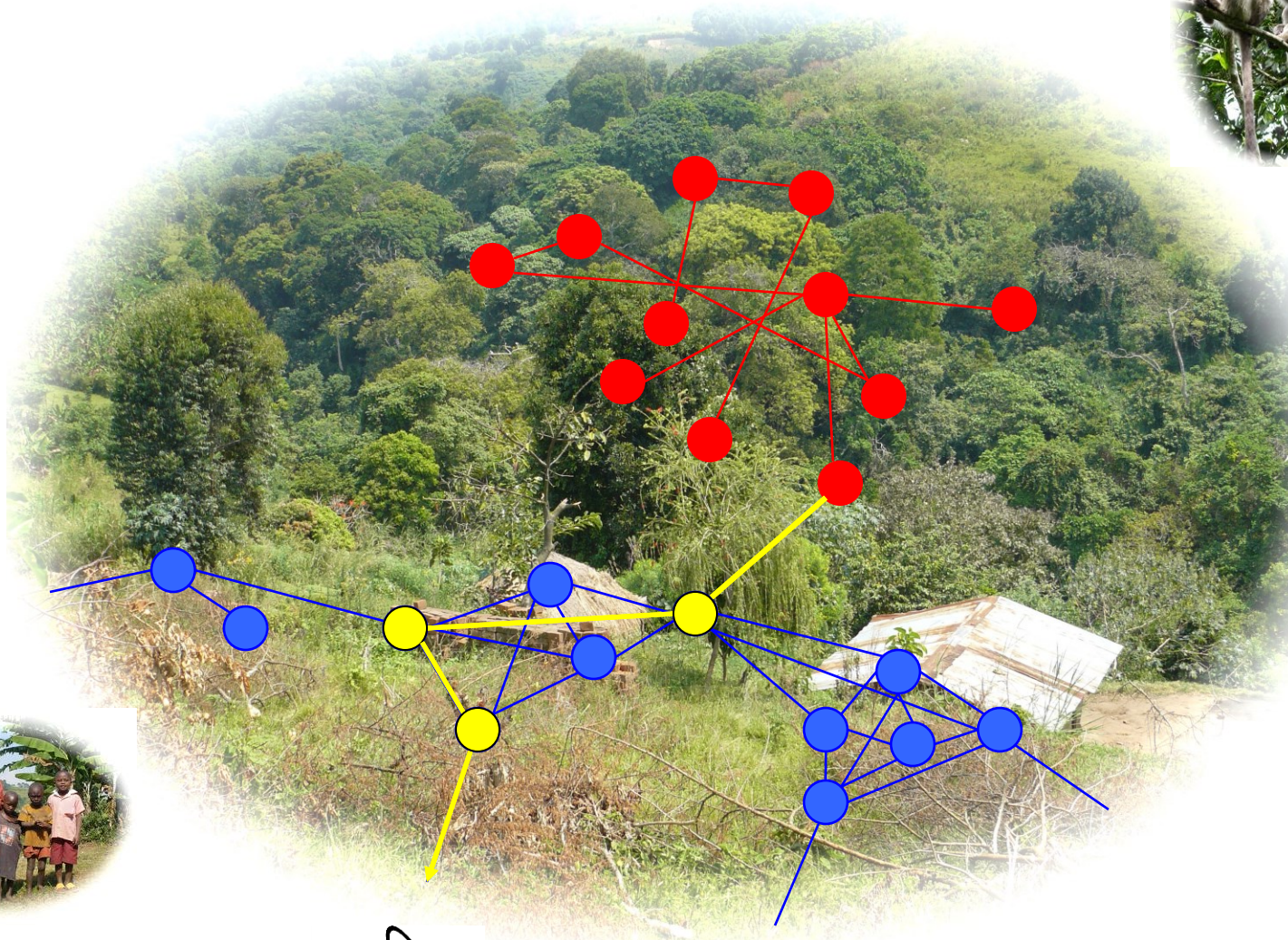
From Anthony et al., 2013. *Mbio* 4(5): e00598-13

Option 2: “pathway discovery”

- Discover novel transmission pathways
 - “Hunt” for unknown routes of pathogen transmission



Transmission pathways

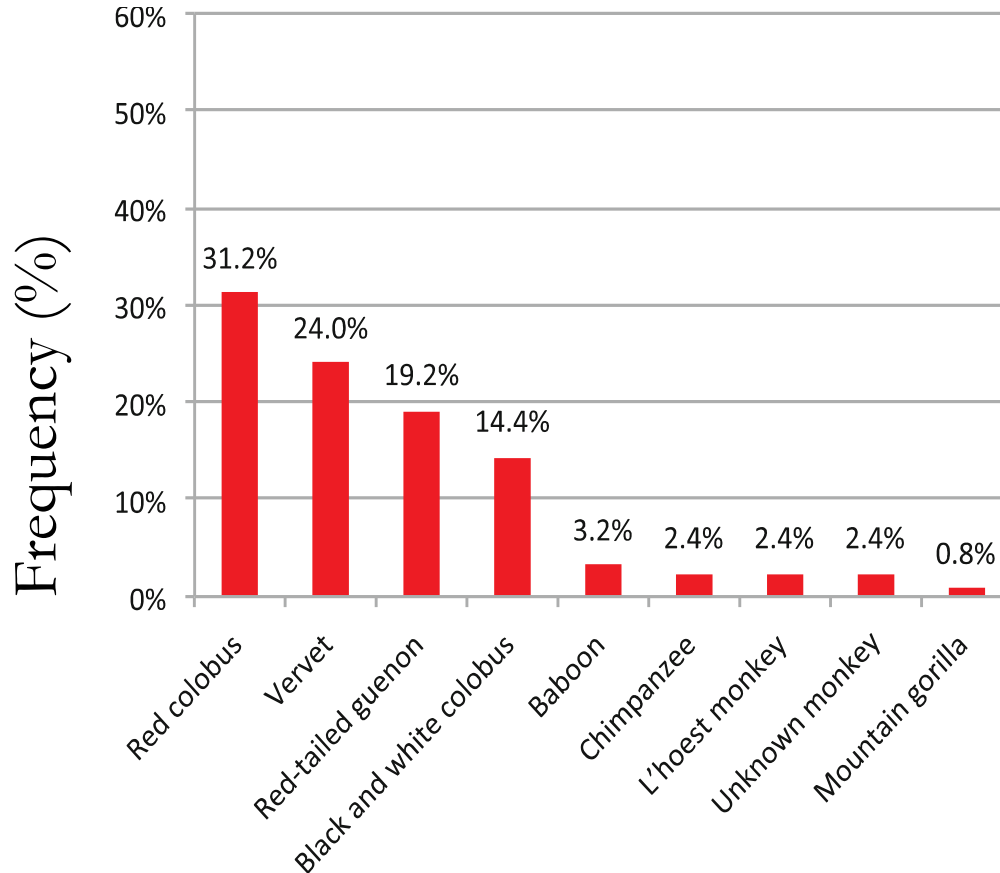


Example 1: Beyond Bushmeat



Primate contact

(1299 interviews, 124 contacts reported)




- Modes of contact
 - Chased and bitten
 - Killed by school children
 - Killed by dogs
 - Found dead, fed to dogs
 - “Crop guarding”
 - Baboon traps
 - “Rogue chimps”

NO “BUSHMEAT!”

Specific knowledge about zoonoses

Animal	Reported diseases/symptoms	% Respondents
Pig	Worms, fever, cholera	30
Monkeys	Ebola, monkeypox, fever, cough, worms	25
Other domestic animals	Fever, cough	15
Cows	Fever, worms	13
Birds	Flu	2
Goats	Cough	2
Mosquitoes	Fever	2



Pig and pork zoonoses in Uganda

Presented at a training course for pig farmers organized by
Pig Production and Marketing Uganda Ltd

Kristina Roesel
ILRI Uganda/ Freie Universität Berlin, Germany
Matuga, Uganda, 15 February 2014

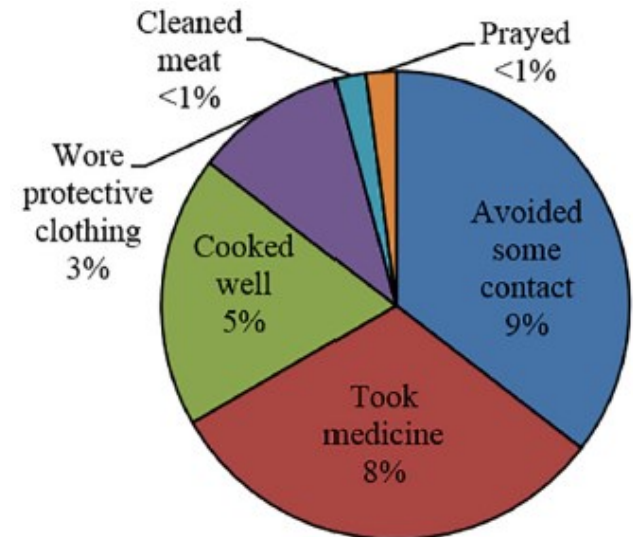
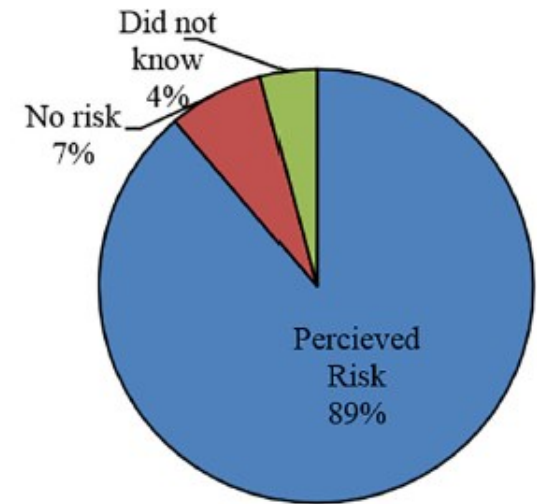
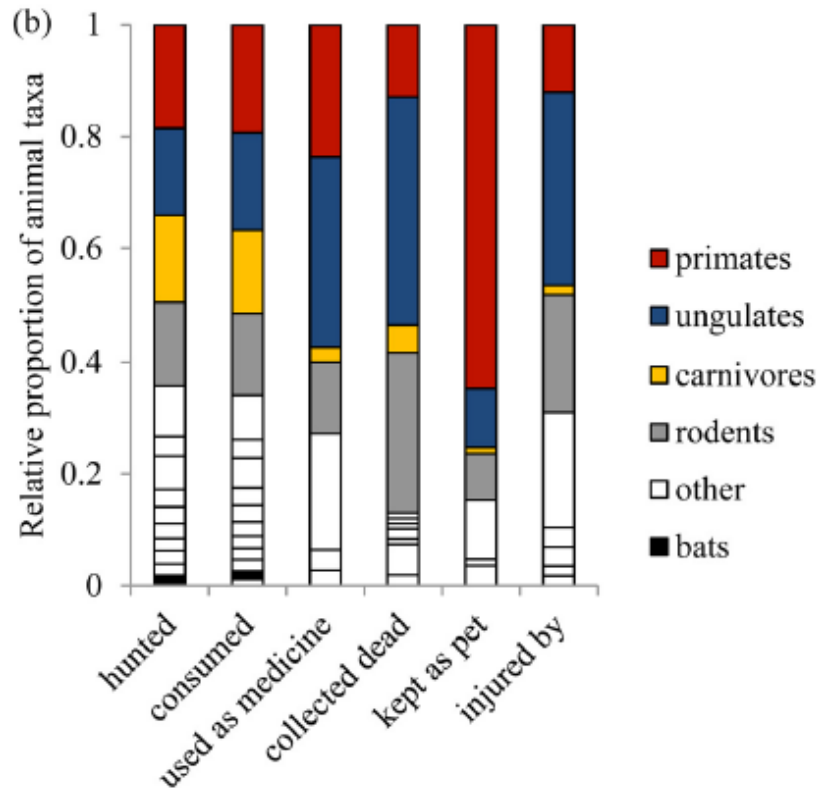
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Paige, S. B., C. Malave, E. Mbabazi, J. Mayer and T. L. Goldberg (2015). Uncovering zoonoses awareness in an emerging disease 'hotspot'. *Soc Sci Med* 129: 78-86.

Nigerian hunting communities



Friant, S., S. B. Paige and T. L. Goldberg (2015).
 Drivers of bushmeat hunting and perceptions of zoonoses in Nigerian hunting communities. *PLoS Negl Trop Dis* 9(5): e0003792.

Education

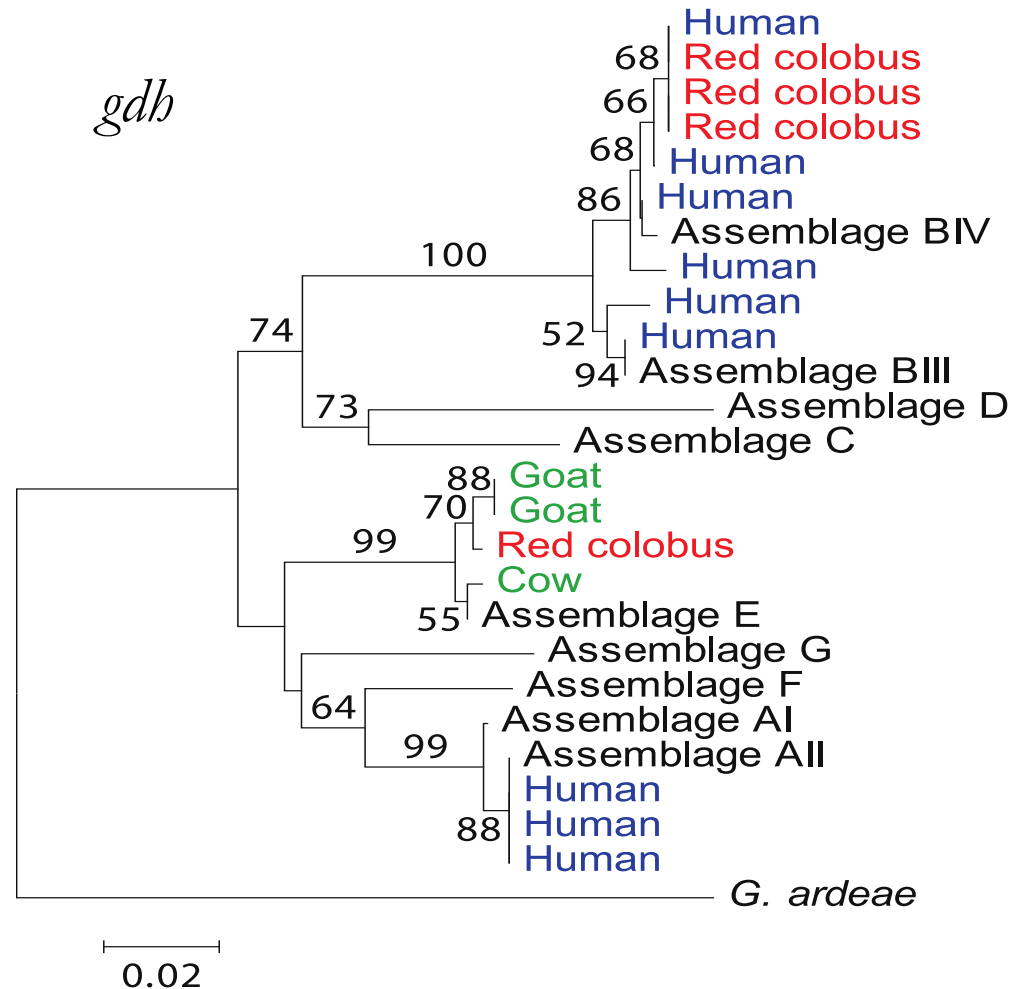
- Lack of education may be the most important of the common pathways.
 - Germ theory
 - Hygiene
 - Public health
 - Zoonoses



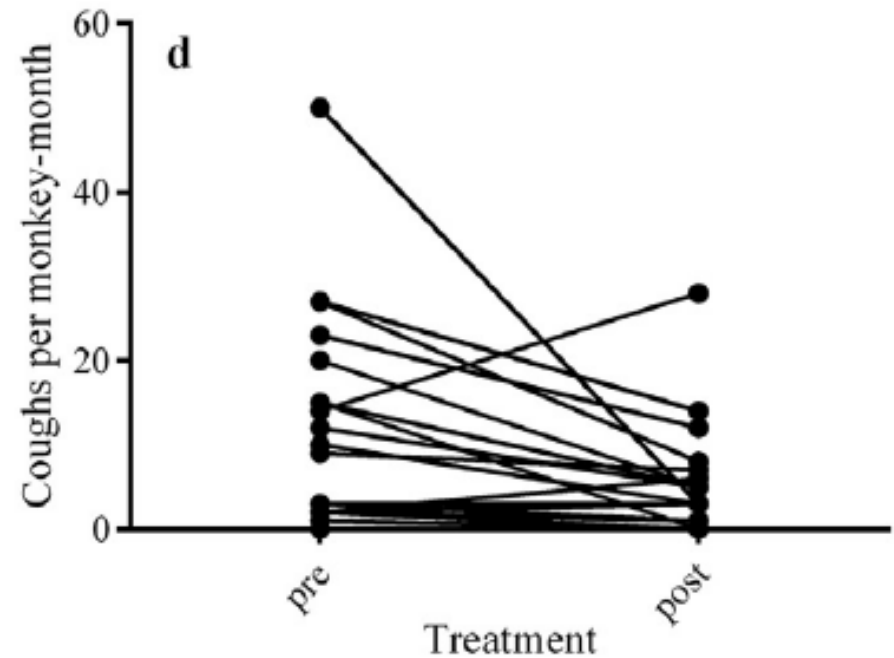
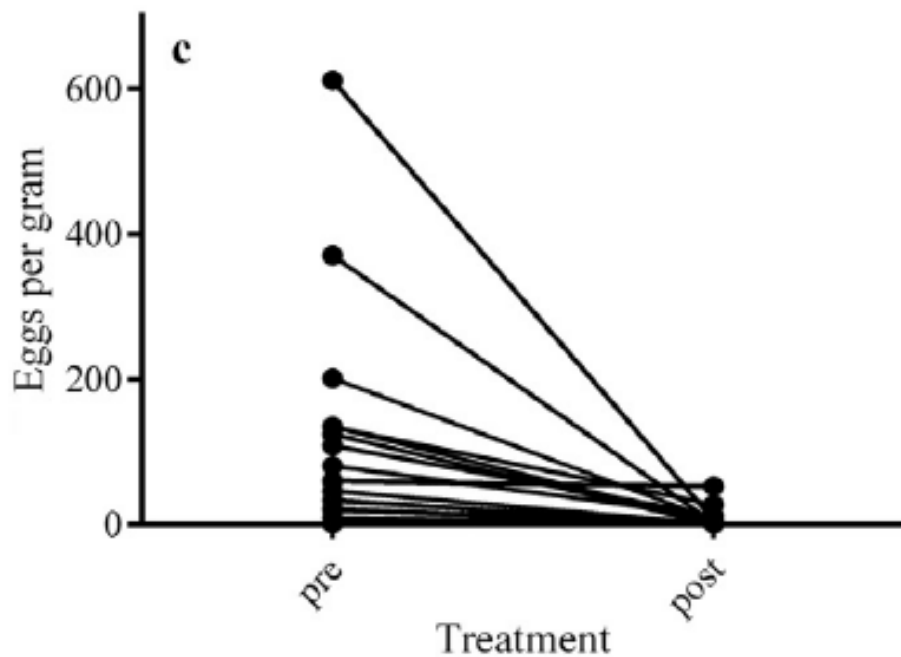
Example 2: “Maize daubing” and food safety



Cross-species transmission of *Giardia duodenalis* in western Uganda



Example 3: Coughing monkeys



Friant, S., K. Brown, M. T. Saari, N. H. Segel, J. Slezak and T. L. Goldberg (2015). Lung fluke (*Paragonimus africanus*) infects Nigerian red-capped mangabeys and causes respiratory disease. *International Journal for Parasitology: Parasites and Wildlife* 4: 329-332.

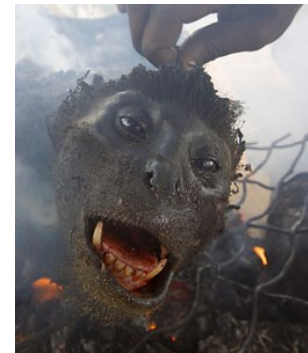
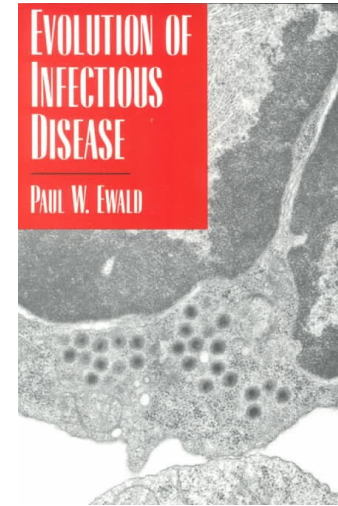
Cultural practices and feedback loops



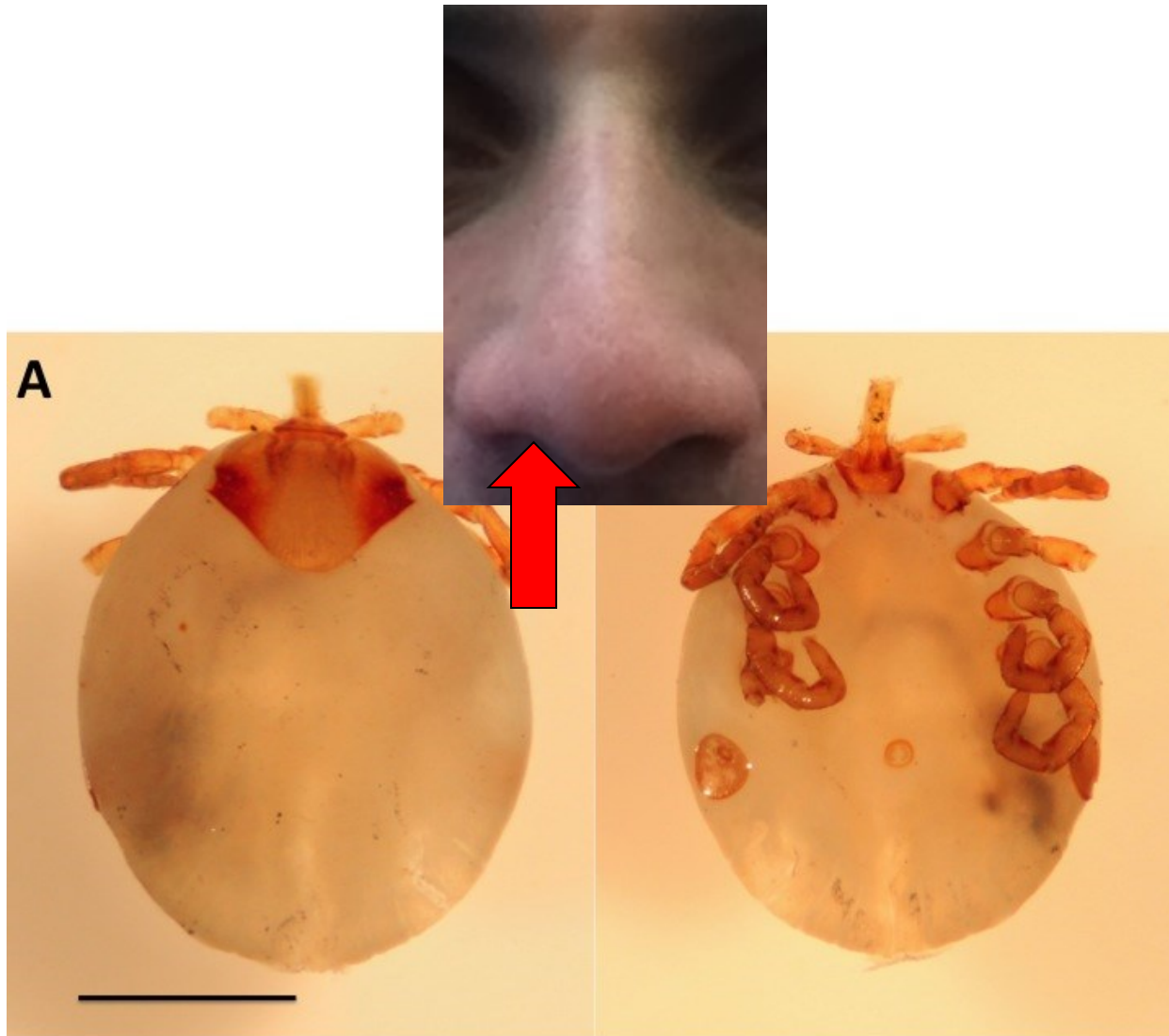
“Interestingly, hunters in this area report using primate skulls and feces to treat cough (Friant *et al.*, 2015). In interviews, hunters made reference to seeing monkeys in the area cough as justification for these traditional remedies (S. Friant, *unpub. data*), indicating an intriguing link between parasitism, clinical disease, local beliefs, and primate conservation.”

Friant, S., K. Brown, M. T. Saari, N. H. Segel, J. Slezak and T. L. Goldberg (2015). Lung fluke (*Paragonimus africanus*) infects Nigerian red-capped mangabeys and causes respiratory disease. *International Journal for Parasitology: Parasites and Wildlife* 4: 329-332.

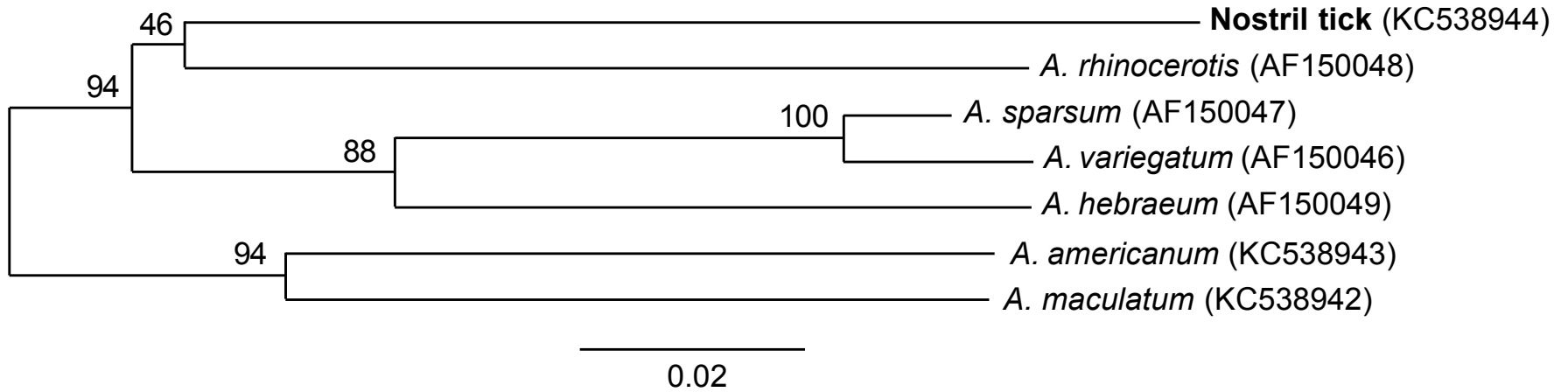
“Cultural vectors”



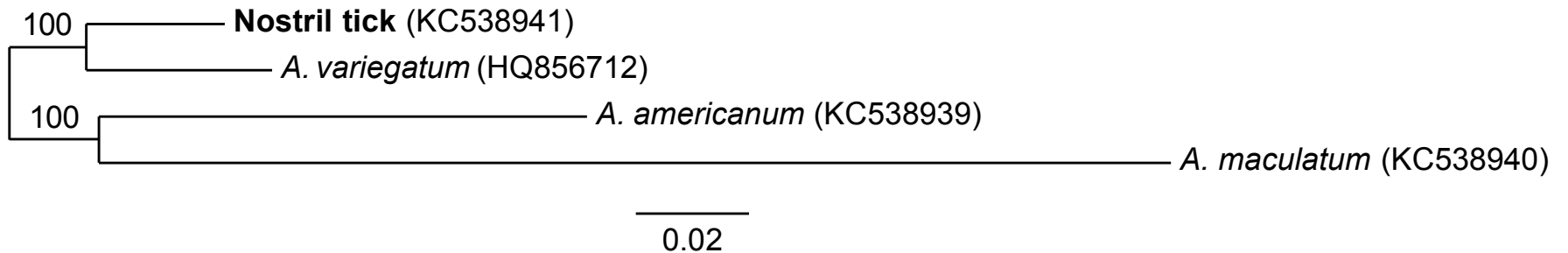
Example 4: Vectors



12s rRNA



ITS2



Hamer, S. A., A. B. Bernard, R. M. Donovan, J. A. Hartel, R. W. Wrangham, E. Oтали and T. L. Goldberg (2013). Coincident tick infestations in the nostrils of wild chimpanzees and a human in Uganda. *AJTMH* 89: 924-927.

wait wait... don't tell me!

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Lightning Fill In The Blank

October 05, 2013 12:00 PM

theguardian

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Life & style Experience

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Experience: I discovered a new species up my nose

'There it was, half a pinkie's length up, right where the cartilage meets the bone: the smooth, rounded backside of a fully engorged tick'

Tony Goldberg
The Guardian, Friday 6 December 2013



'I used a pair of forceps to grasp the tick's mouth parts, which were buried deep in my flesh.' Photograph: David Jackson for the Guardian

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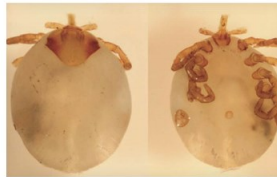
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5 Animals People Found In Insanely Random Places

#2. Mystery Nose Tick

Pathobiologist Tony Goldberg was on his way home from a 2012 research expedition in Uganda when he felt something horrible hiding in his nose: a stowaway tick.



ajmh.org

We're not sure where the mucus ends and the horror begins.

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LIZZIE WADE Lizzie is Science's Latin America correspondent, based in Mexico City.

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Invasion of the Nostril Ticks

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How a Mysterious Tick Ended Up in a Scientist's Nose

Posted by Guest Blogger in Weird & Wild on October 8, 2013

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By Jennifer S. Holland

Please forgive Tony Goldberg for picking his nose.

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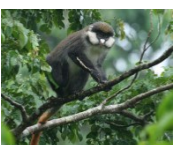
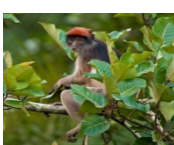
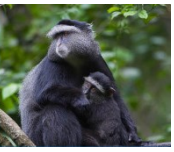
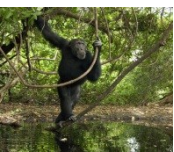
October 15, 2013 3:30 PM EDT



Disrupting pathways

- Targeted education
- Mixing methods (biological and social science)
- “Disruptive” technologies





CH

Example: soil-transmitted helminths in Uganda

BM

BW

GM

HU

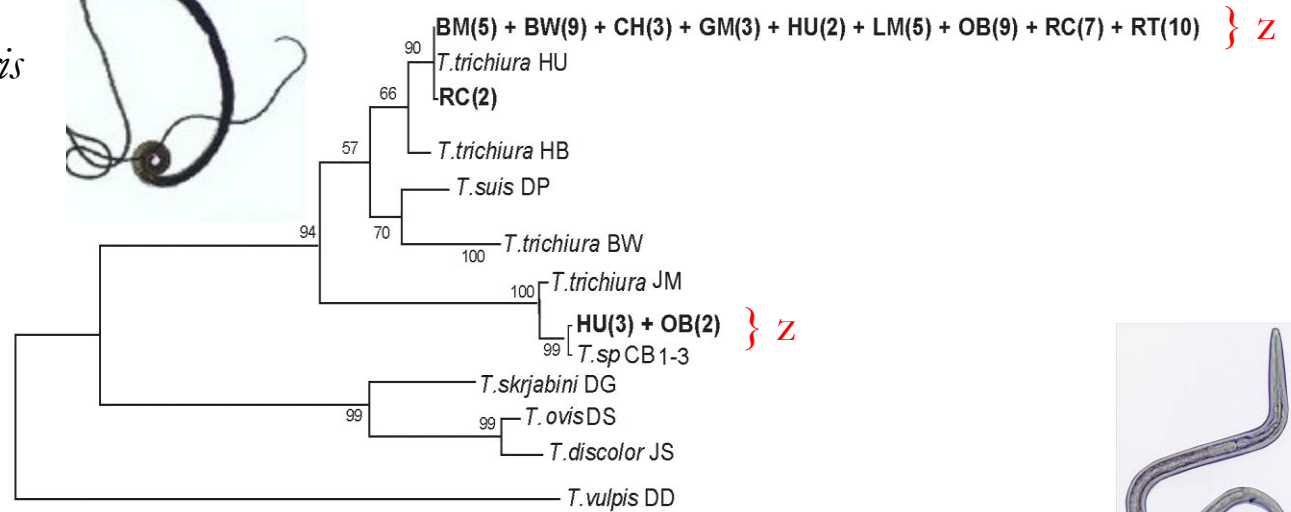
LM

OB

RC

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Trichuris



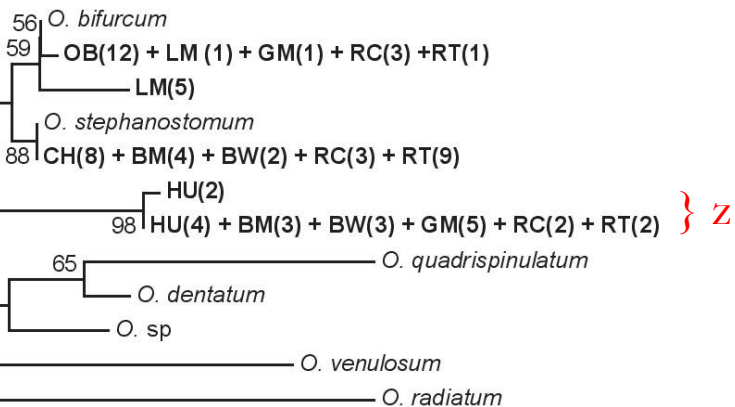
(ITS1 and ITS2)

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Oesophogostomum

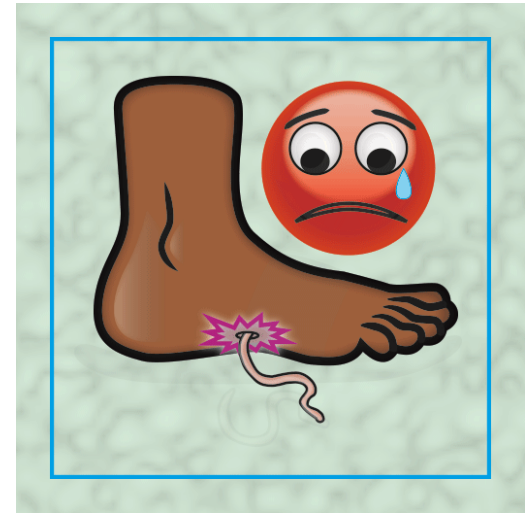
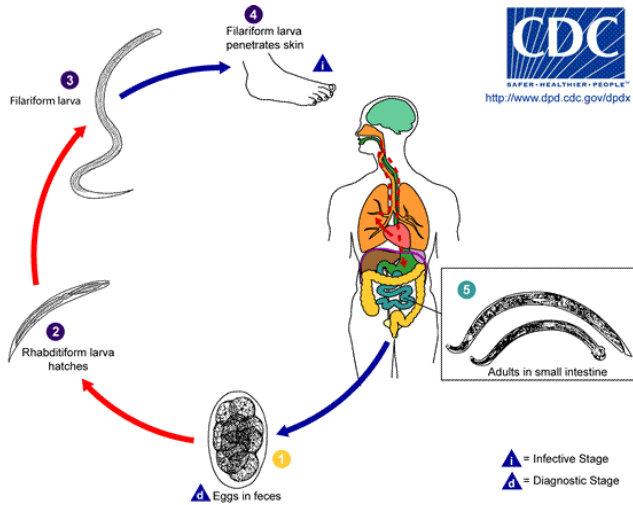


0.05
(ITS1 and ITS2)



Ancylostoma
& *Necator*

The Holo flop: a “pathway disruptor”



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Why focus on pathways?

- Disrupting common pathways can block the transmission of all pathogens that traverse them, whether or not we have discovered them, or even if they have not yet evolved.
- Disrupting pathways can select for less “aggressive” pathogens, thus leading to the evolution of reduced virulence.



Acknowledgments

- **Collaborators**

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- NSF





<http://svmweb.vetmed.wisc.edu/KibaleEcoHealth/>