

Parasite sharing in wild ungulates and their predators: effects of phylogeny, range overlap, and trophic links

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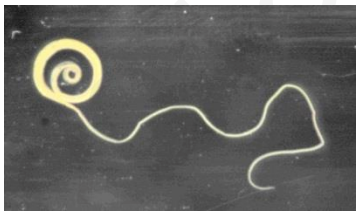
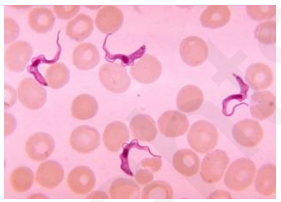
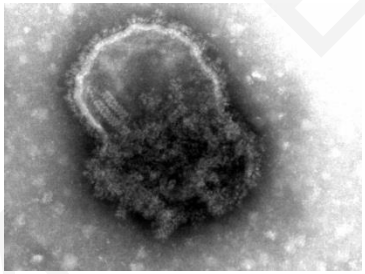




Understanding the factors that allow pathogens to be shared among host species is a key issue for wildlife conservation . . .

Domestic dogs



Canine distemper virus

Black footed ferret

Population extinctions

African wild dog

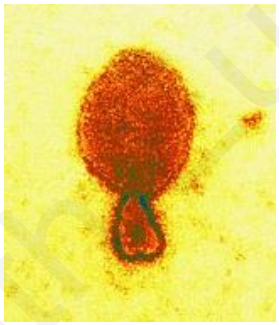
Population extinctions

Ethiopian wolf

Under threat

. . .domestic animal husbandry/ livestock farming . . .

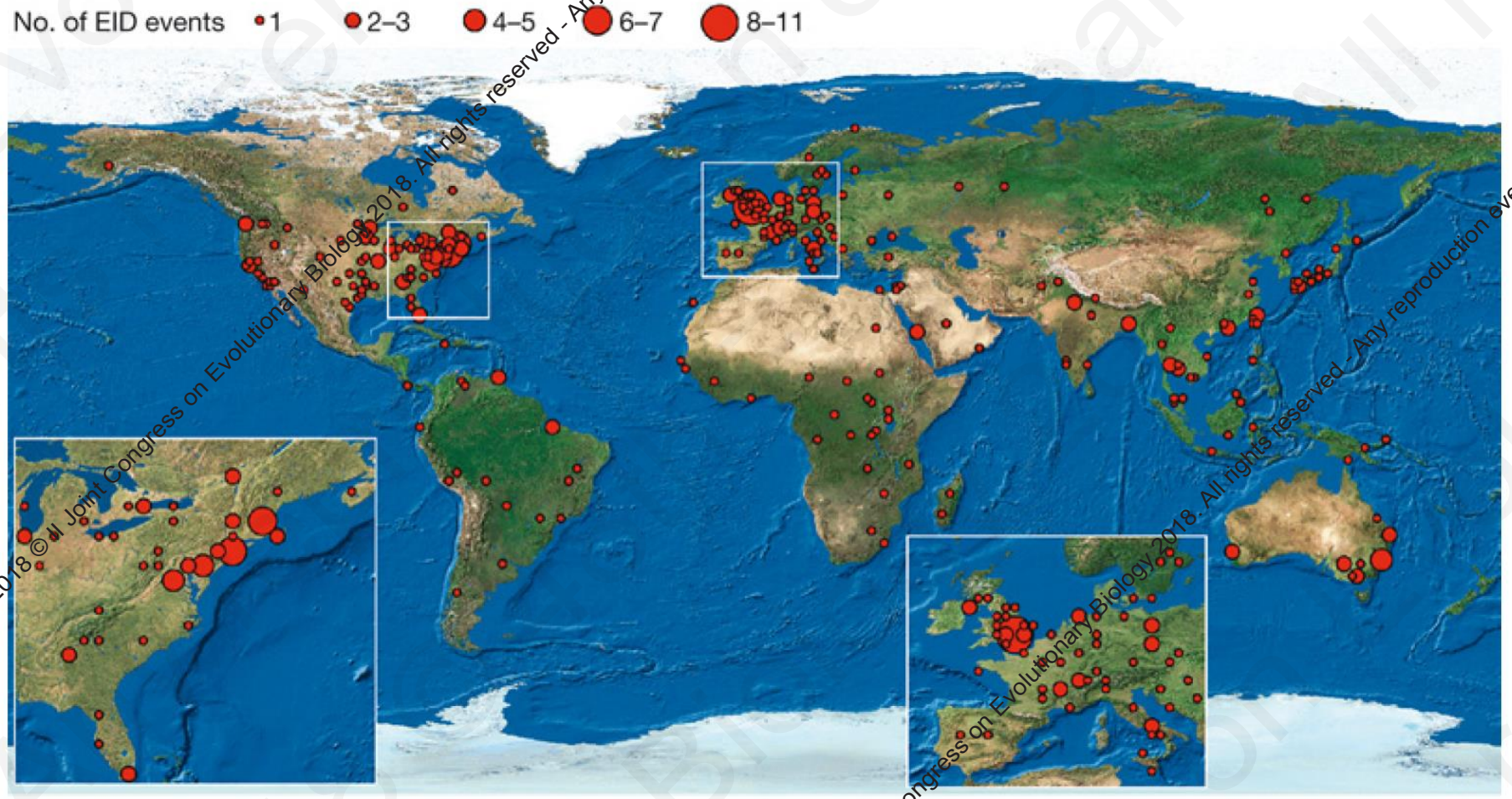
September 1995 thirteen horses and a trainer killed in Brisbane Australia



Hendra virus

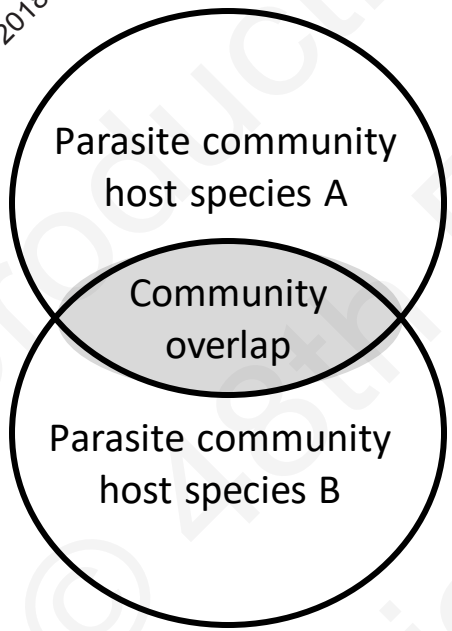
Flying fox

. . . and human health: more than 60% of human EIDs are of zoonotic origin.

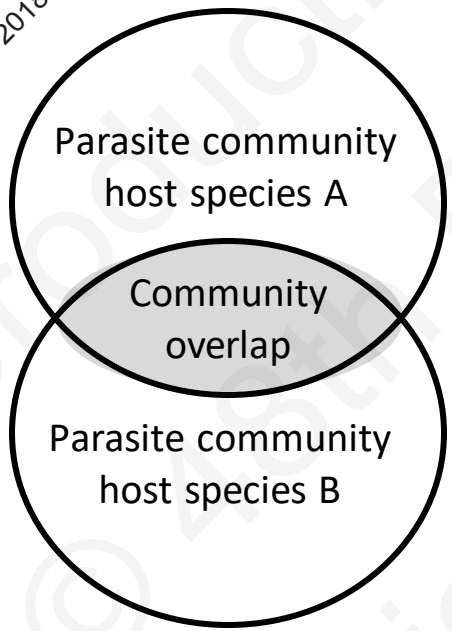


Jones, Kate E., et al. "Global trends in emerging infectious diseases." *Nature* (2008): 990-993.

One approach: parasite sharing / community overlap in wild animals



What traits make it likely that a host species pair will share more parasite species?



Factors correlated with parasite sharing / community similarity in past studies of wild mammals

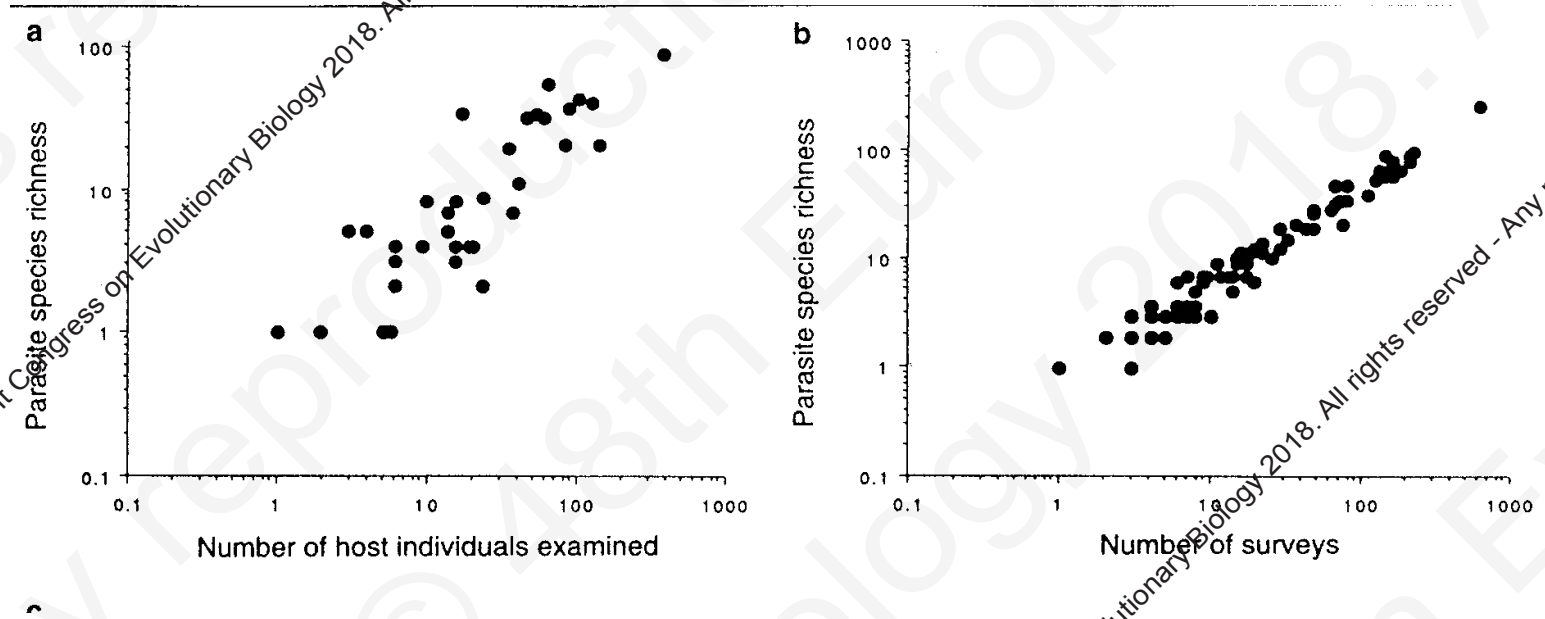
- Geographic range overlap
- Phylogenetic affinity
- Morphological/ ecological similarity

Previous broad comparative studies confined to two groups

Primates (several studies)

Carnivores (one study)

Studies have not considered differences in sampling effort

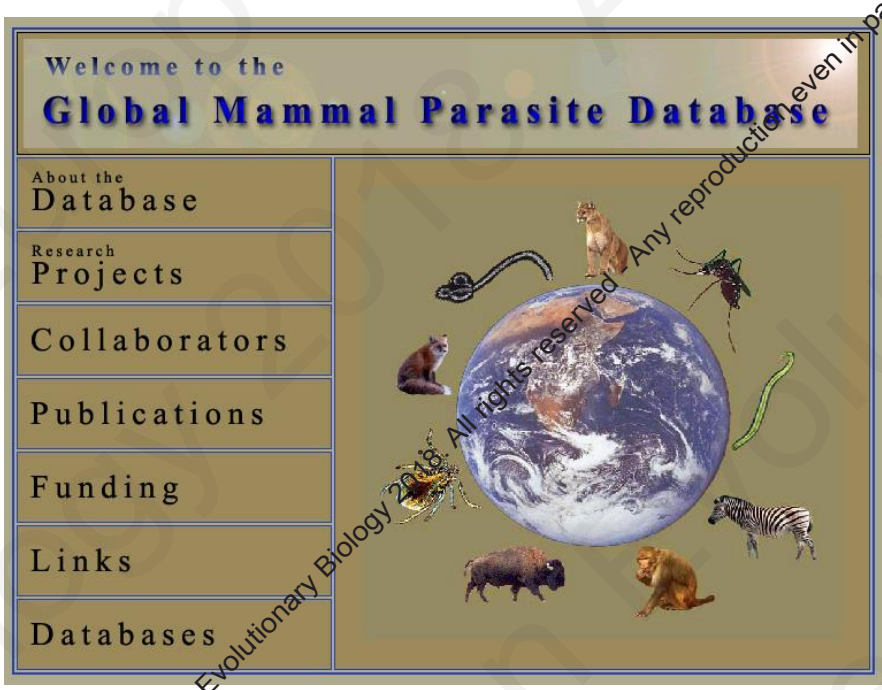


from Walther et al 1995, Parasitology Today

Studies have not considered trophic links or other direct ecological interactions

Parasite sharing in wild ungulates*

- Host-parasite associations from the latest iteration of the Global Mammal Parasite Database**
- Ungulate data includes 11930 lines of data from 1083 literatures sources
- Latest update includes all published studies through early 2010

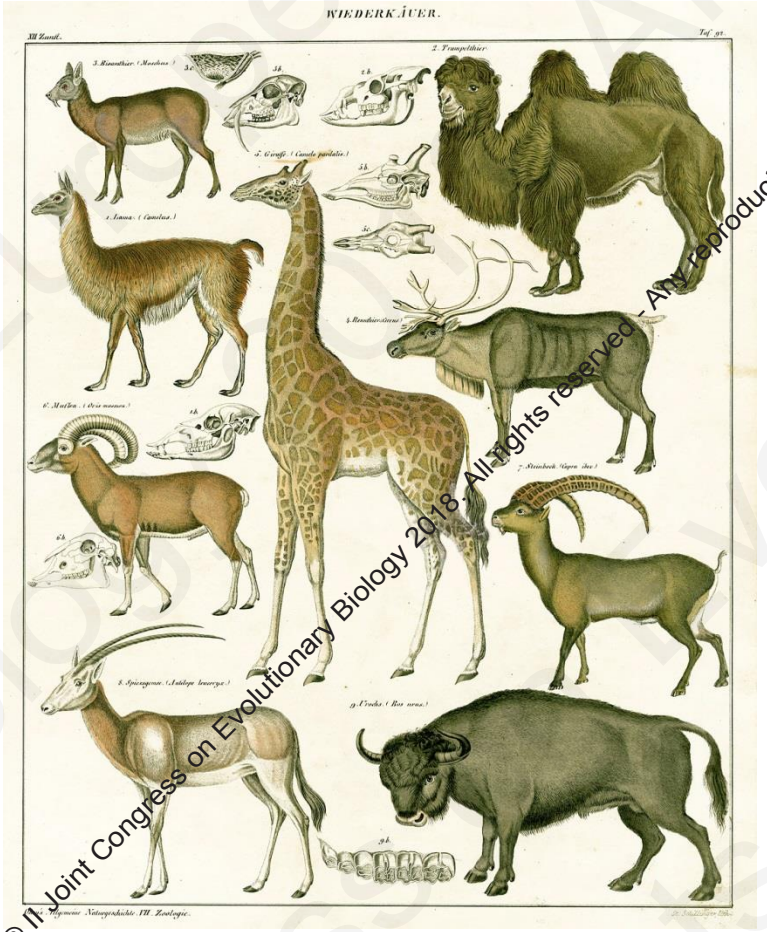


*Stephens, P. R., S. Altizer, V. Ezenwa, J. L. Gittleman, E. Moan, B. Han, S. Huang and P. Pappalardo. 2018. Parasite sharing in wild ungulates and their predators: effect of phylogeny, range overlap, and trophic links. *Journal of Animal Ecology* (in revision, invited resubmission)

**Stephens, P. R., Pappalardo, P., Huang, S., *et al.* 2017. Global mammal parasite database version 2.0. *Ecology*, *98*: 1476-1476.

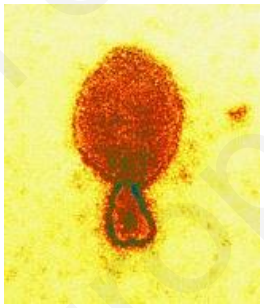
Hosts

- 116 host species including both artiodactyls and perissodactyls
- Wild species from all over the world
- Domestic species and zoo records excluded



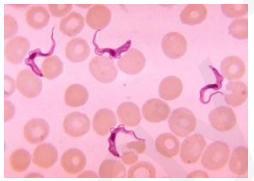
Parasites

- All disease causing organisms from viruses to helminths
- 1298 species total
- Both combined and separate analysis of each parasite group performed



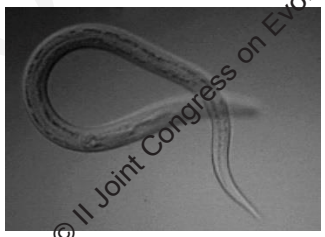
viruses

bacteria



protozoa

fungi



helminths

arthropods

Questions

- Are phylogenetic affinity, range overlap, and ecological similarity correlated with parasite overlap among ungulate hosts?
- Are well studied species more likely to have known shared parasites?
- Are carnivores that feed on ungulates infected by more ungulate parasites than those that don't?

Questions

- Are ***phylogenetic affinity***, ***geographic range overlap***, and ***ecological similarity*** correlated with parasite overlap among ungulate hosts?

- Are well studied species more likely to have known shared parasites?

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Geographic range overlap

- Based on IUCN range data, three measures of host range overlap
  - *Any overlap at all (0 or 1)*
  - *Area of overlap (km 2)*
  - *Percentage range overlap (smaller range/ area of overlap)*
- Nearly identical positive correlations with community similarity

Phylogenetic affinity

- Based on supertree of all mammals*, two measures of host phylogenetic distance
  - *Divergence time in millions of years that separates hosts*
  - *Number of divergence (speciation) events that separate hosts*
- Similar negative correlations with community similarity, number of divergence events slightly stronger

*Bininda-Emonds, Olaf RP, et al. (2007)"The delayed rise of present-day mammals." *Nature* 446: 507-512.
Fritz, S. A., Bininda-Emonds, O. R. P. & Purvis, A. (2009) Geographical variation in predictors of mammalian extinction risk: big is bad, but only in the tropics. *Ecol. Lett.* 12: 538–549

Ecological similarity

- Two measures of host ecological similarity using data from PanTHERIA* supplemented with data from http://www.ultimateungulate.com/
  - *Difference in host median body size (grams)*
  - *Euclidean distance matrix constructed from nine host morphological and ecological traits*
- Similar weak correlations, direction sometimes varied

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Study effort

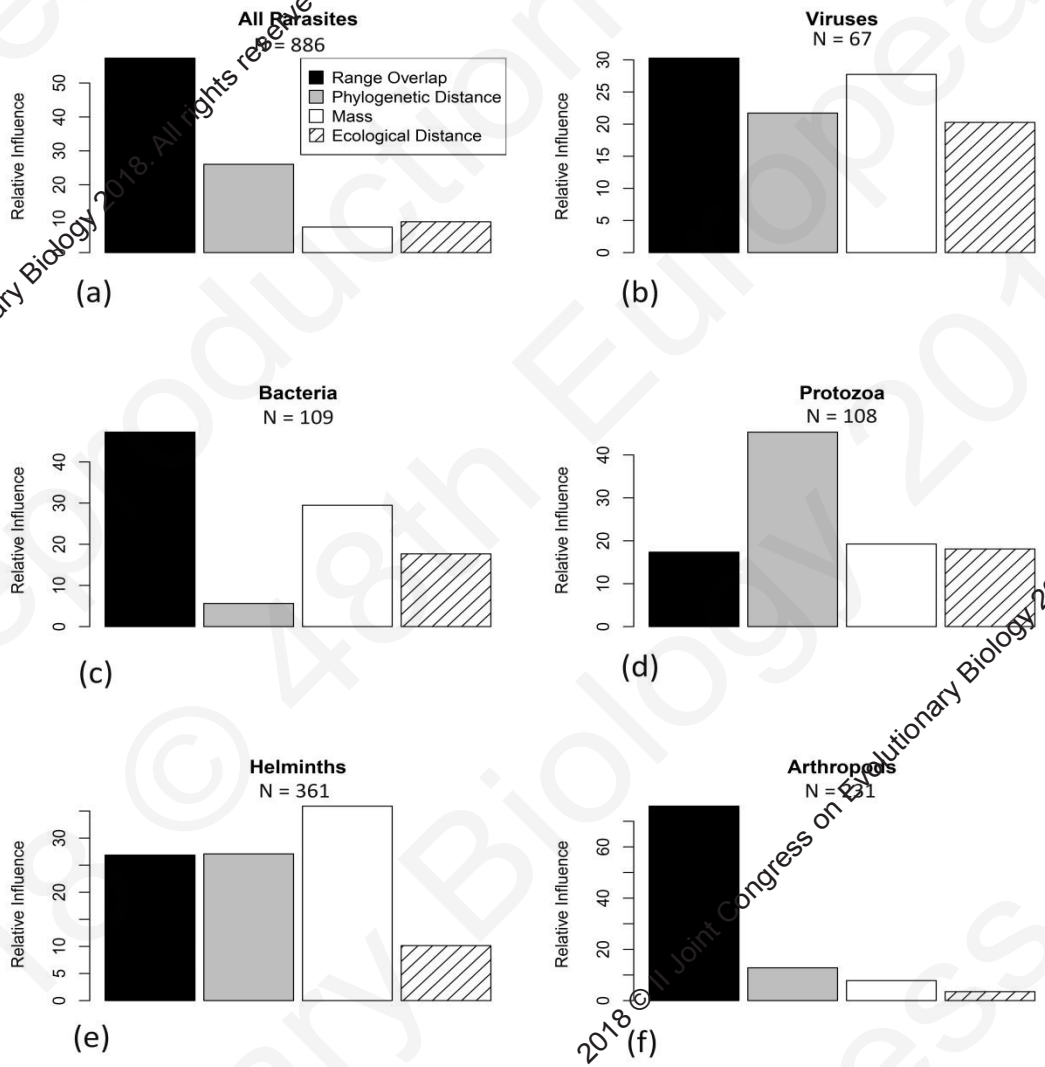
- Study effort measured as the summed Web of Science Citations for each pair of host species binomials (searches included recent synonyms)

- ***Overall:*** better studied pairs of host species more likely to show overlap in known parasite community composition

GAM analyses and boosted regression trees used to assess relative influence of predictors

Predictor (GAM analysis)	F	p-value
Percent Range Overlap	***79.38***	***<0.0001***
log(Divergence Time, mybp)	***43.77***	***<0.0001***
log(Total WOS Citations)	***6.86***	***<0.0001***
log(Mass Difference, g)	*1.73*	*0.092*
log(Ecological Dissimilarity)	*0.51*	*0.283*

Relative influence of predictors varied widely among parasite groups



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Trophic Links

- Carnivore species in GMPD grouped by whether or not they are known to prey on ungulates
- Number of known ungulate parasites (i.e. parasites found in the ungulate GMPD) found in each host species calculated
- Analyses both of raw data and residuals of model of ungulate parasites vs host sampling effort

Ungulate parasites in carnivores

	Ungulate predator?		
	Mean (no)	**Mean (yes)**	*P-value*
Raw Data	3.59	8.85	0.004
Model Residuals	-0.338	0.802	0.269

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Ungulate parasites in carnivores

	Raw Data			Residuals to WOS Citations		
Group	mean 0	mean 1	p-value	mean 0	mean 1	p-value
All Parasites	**3.59**	**8.85**	**0.004**	-0.338	0.802	0.269
Viruses	1.39	1.81	0.152	-0.052	0.082	0.617
Bacteria	2.96	3.19	0.803	0.246	-0.269	0.390
Protozoa	1.34	1.46	0.630	0.070	-0.101	0.382
Helminths	**1.00**	**2.93**	**0.005**	**-0.299**	**0.481**	**0.035**
Arthropods	**1.45**	**3.24**	**0.047**	-0.161	0.361	0.425

Ungulate parasites in carnivores

	Raw Data			Residuals to WOS Citations		
Group	mean 0	mean 1	p-value	mean 0	mean 1	p-value
All Parasites	**3.59**	**8.85**	**0.004**	-0.338	0.802	0.269
Helminths	**1.00**	**2.93**	**0.005**	**-0.299**	**0.481**	**0.035**

Results robust to how carnivores scored

Never prey on ungulates

0

0

Prey upon ungulates on rare occasions

1

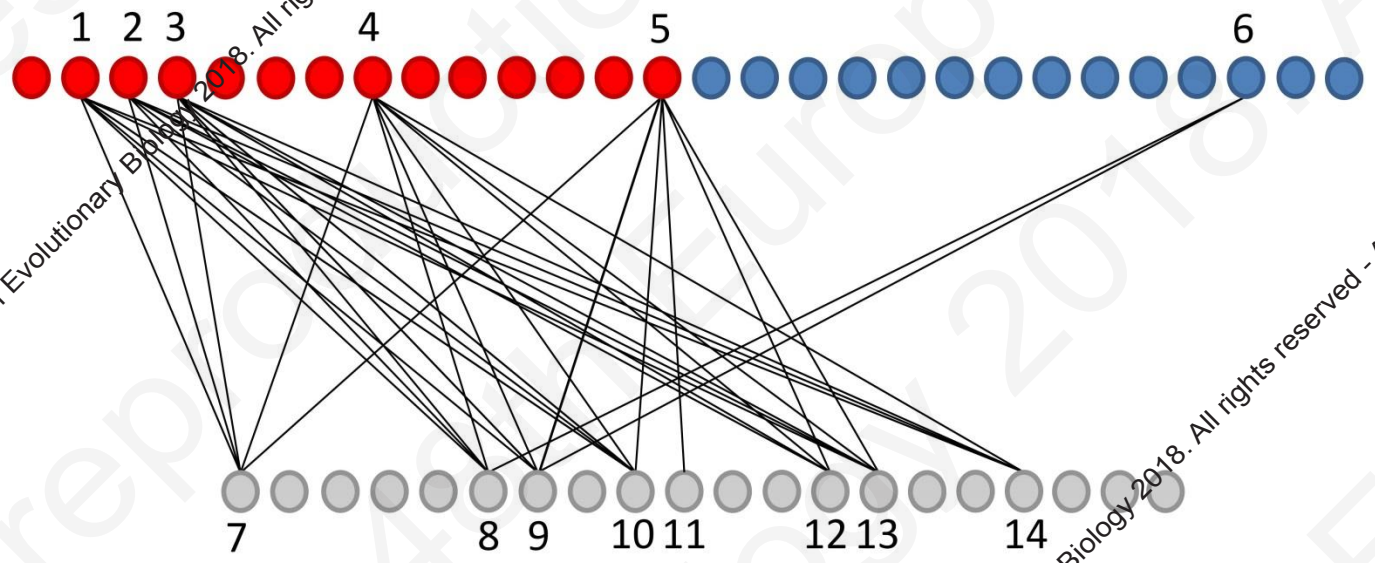
1

Ungulates primary/ consistent prey item

1

2

Helminth sharing in Canids and Cervids



Canidae: *1. Canis aureus*, 2. *Canis latrans*, 3. *Canis lupus*, 4. *Lycalopex culpaeus*, 5. *Vulpes vulpes*, 6. *Vulpes lagopus*

Cervidae: 7. *Alces alces*, 8. *Capreolus capreolus*, 9. *Cervus elpahus*, 10. *Cervus nippon*, 11. *Dama dama*, 12. *Odocoileus virginianus*, 13. *Odocoileus hemionus*, 14. *Rangifer tarandus*.

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Odum School of Ecology

Altizer and Ezenwa lab groups

Research Coordination Network: the Macroecology of Infectious Disease

Search for "Disease Macroecology" for our website, or go to:

http://diseasemacroecology.ecology.uga.edu/