Macroecology of Animal Parasitism

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What macroecology is?

- Macroecology is a branch (or aspect) of modern ecology, whose object is to study the large-scale spatial trends & patterns in structure of com-munities and ecosystem. The scale of research varies from subcontinental to global.

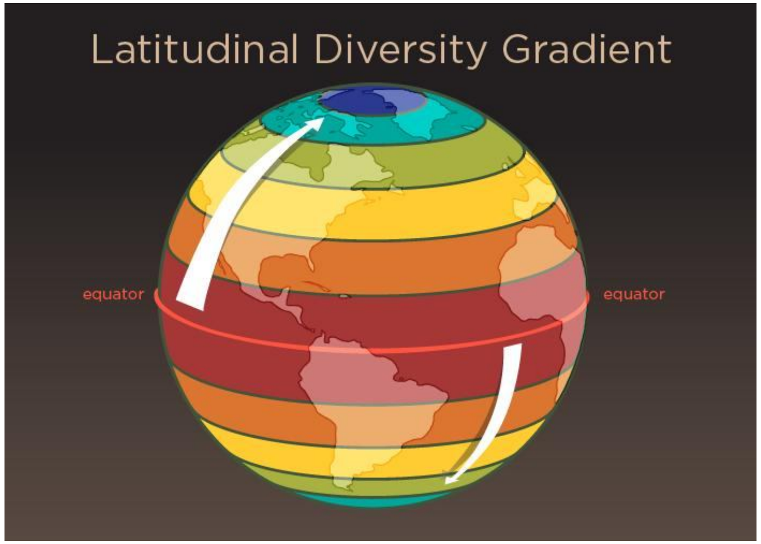
The term ‘Macroecology’ was coined by James Brown in 1989 and became very popular since the mid-1990s.

Articles

Macroecology: The Division of Food and Space Among Species on Continents

James H. Brown and Brian A. Maurer

Classical themes of macroecology



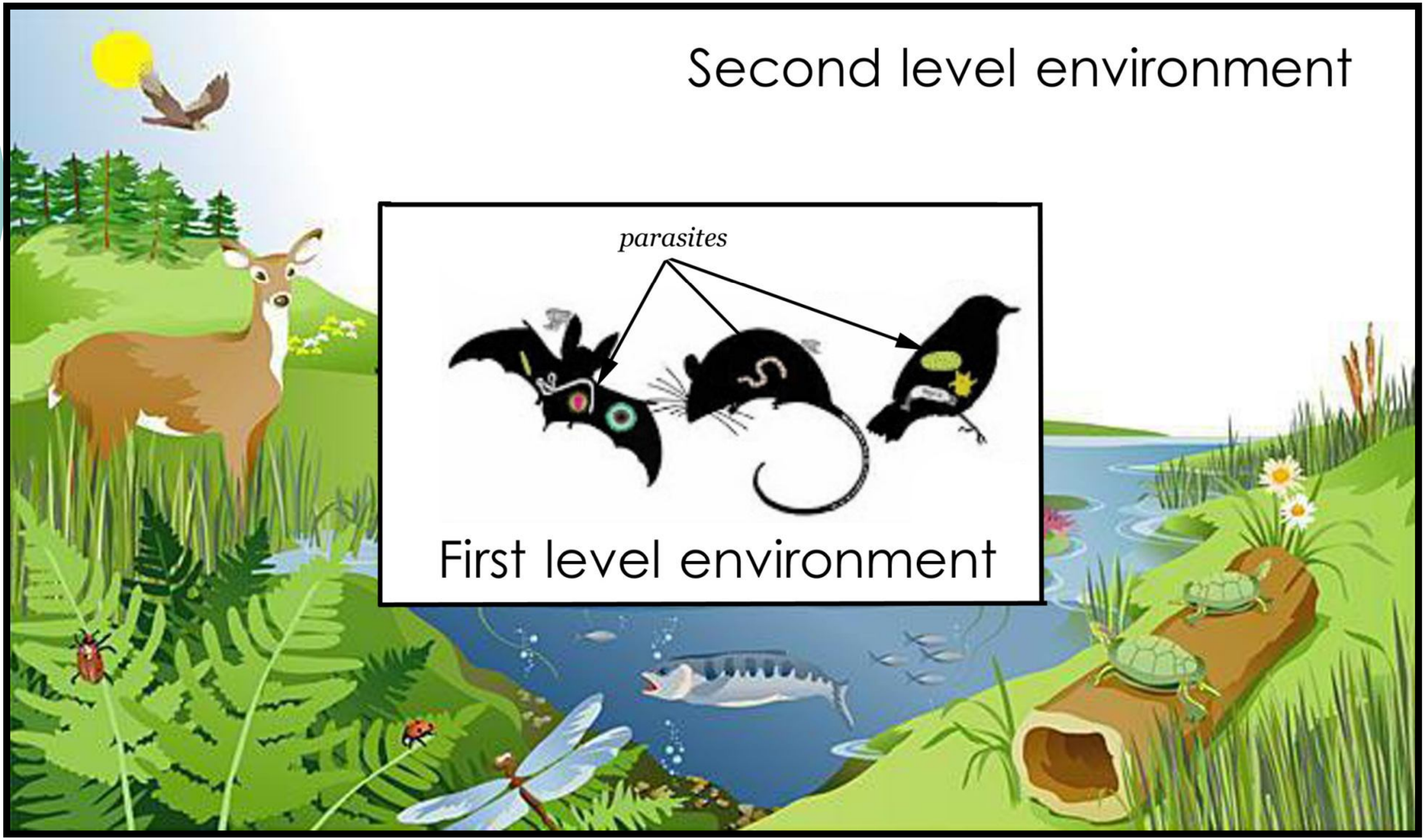
Latitudinal diversity gradient (first discussed by A. von Humboldt more than 200 years ago)

Spatial trends (clines) in body size – first noticed by K. Bergmann in 1847

Biases in recent macroecology

Not surprisingly, most macro-ecological studies have focused on a limited set of organisms. The vast majority of reserch were done on material of free-living vertebrates and vascular plants. Invertebrates, 'lower' plants, and microorganisms are still understudied. Parasitic organisms too..

Why parasites are so interesting?



Parasitic animals interact with external world indirectly, via their hosts (being the first level environment)

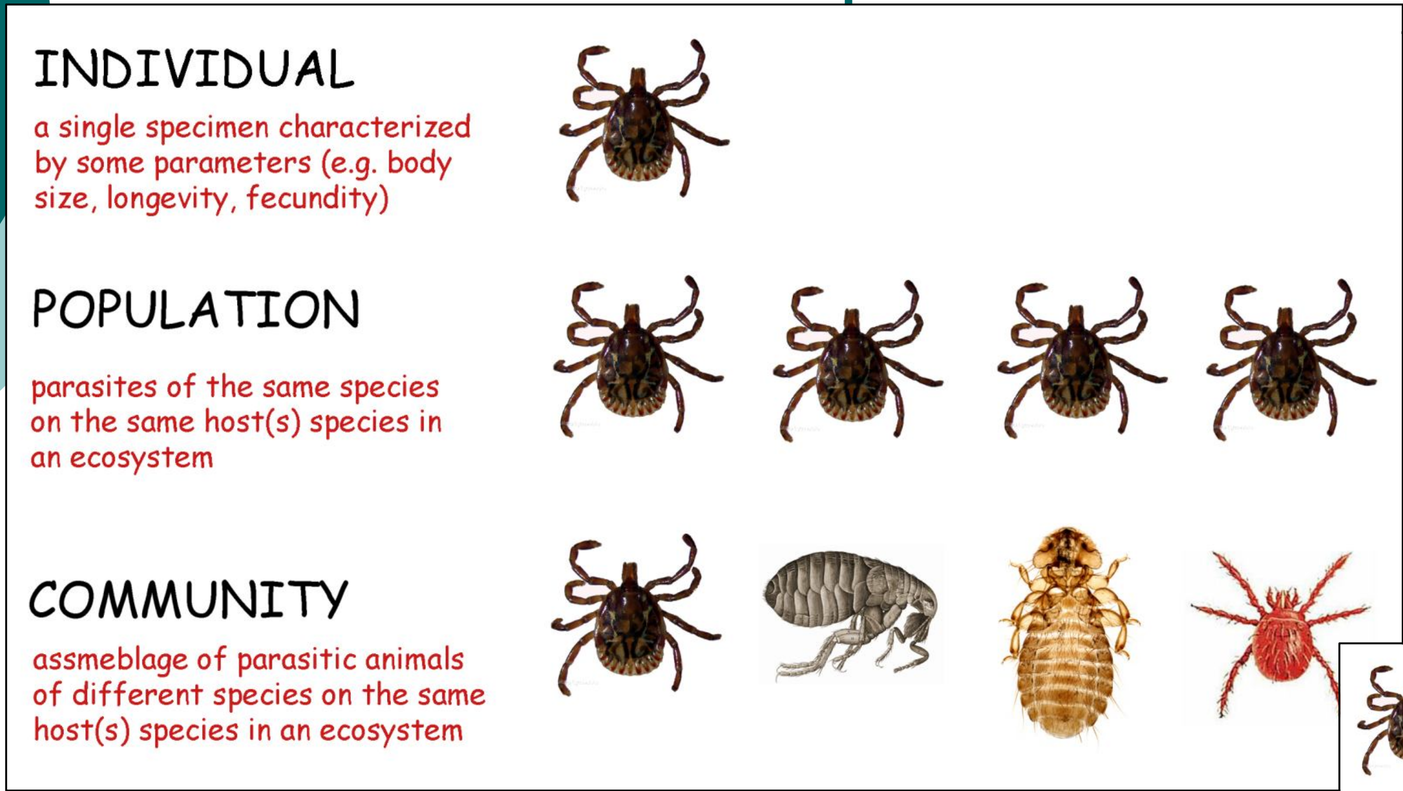
Hot topics of parasite macroecology

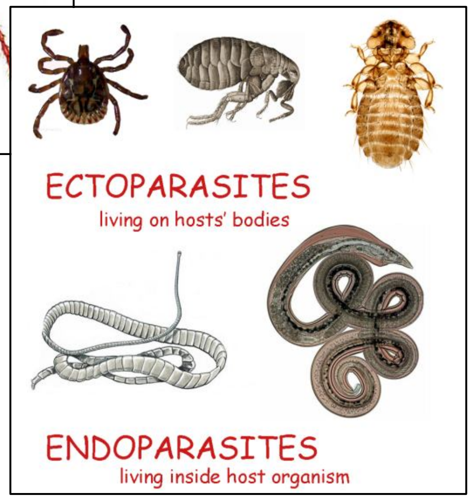
1. Do parasitic animals demonstrate any macroecological patterns (as free-living organisms do)?
2. Is there similarity in macroecological trends across parasitic taxa?
3. What is more important for parasite macroecology: abiotic environment or relationships with host?

Some practical issues

- Ecology and distribution of parasites and agents of infectious diseases may alter under current global changes (e.g. climate warming). We must know *how*.
- Understanding of the host-parasite relationships at the global scale helps us to understand formation of foci of natural infections in different conti-nents and regions.

The structure of parasite macroecology





Three levels of study;
Comparison within and between two main eco-lo-gical groups (endo- vs. ectoparasites)

Individual level: the geographic variation in body size

- In many groups of free-living animals (especially in warm-blooded vertebrates) a continuous increase in body size in the south-north direction (from Equator to the pole) is observed (a.k.a. Bergmann’s rule). Do parasites alter in a similar manner?

A case study: an ectoparasitic mite in Western Siberia

Spatial change in mite body size depends on host identity more than on climate.
Mites on different hosts exhibit different patterns

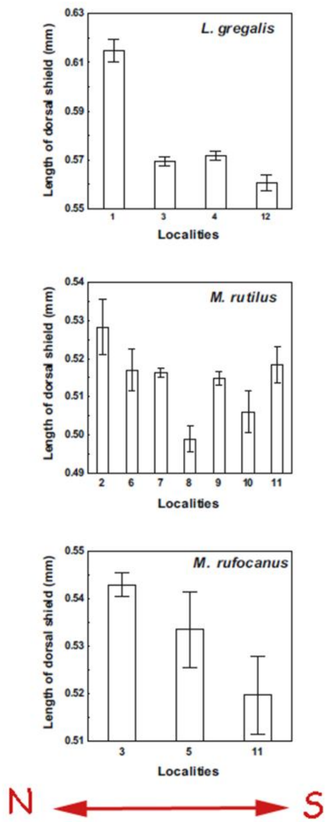
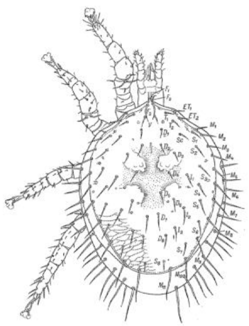


Fig. 1 Mean (±S.E.) length of dorsal and sternal shields in *L. clethrionomydis* collected from *L. gregalis*, *M. rutilus* and *M. rufocanus* in different localities. Localities are ordered from north to south. See Table 1 for geographic positions of the localities



Parasitol Res (2015) 114:3767–3774
DOI 10.1007/s00436-015-4606-9

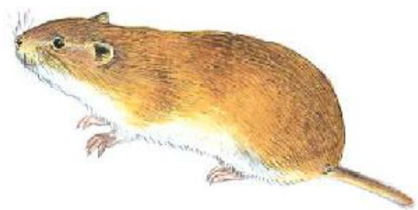
ORIGINAL PAPER

Intraspecific variation of body size in a gamasid mite *Laelaps clethrionomydis*: environment, geography and host dependence

Natalia P. Korallo-Vinarskaya[1] · Maxim V. Vinarski[2,3] · Irina S. Khokhlova[4] · Georgy I. Shenbrot[5] · Boris R. Krasnov[5]

Grey red-backed vole

Narrow-headed vole



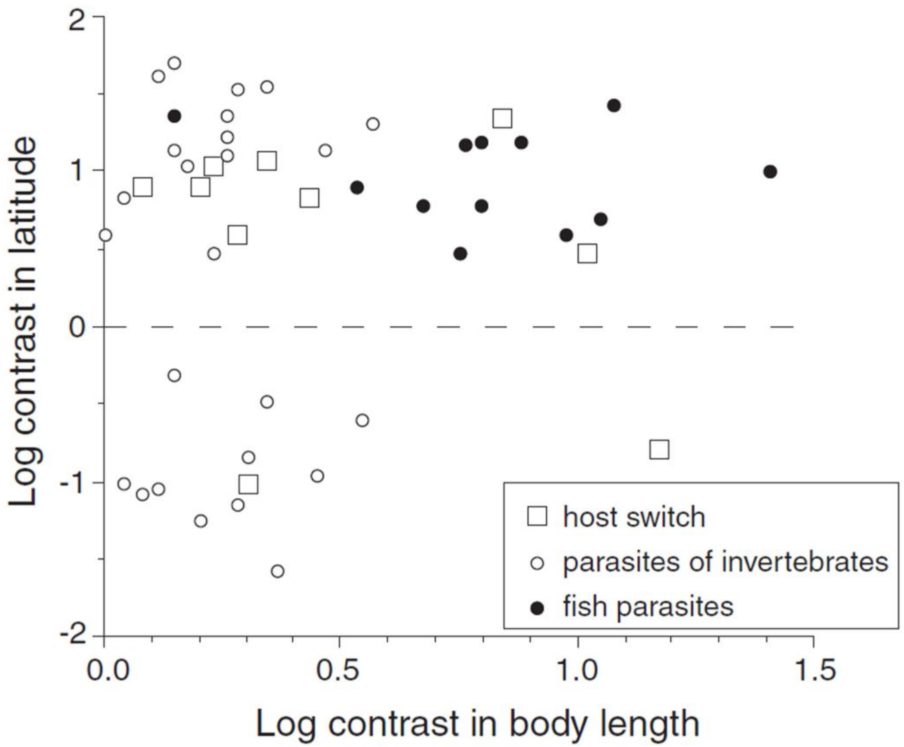
Red-backed vole

Mites *Laelaps clethrionomydis* parasitizing three common rodent species in W. Siberia do not exhibit a uniform pattern of body size variation (Korallo-Vinarskaya *et al.*, 2015).

Why body size is so important for mites?

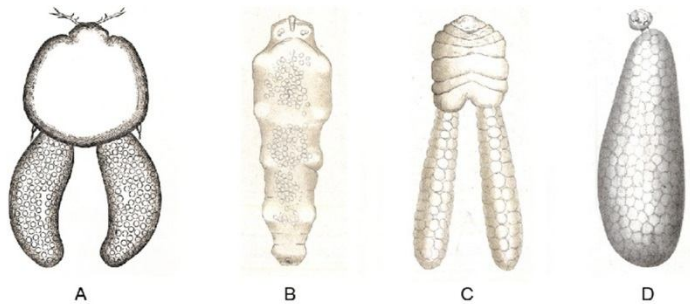
- Body size is positively correlated with fecundi-ty, abundance, and (most probably) with competitive performance. On the other hand, it is negatively correlated with niche breadth (= number of hosts). The observed increase of body size in northern mites may be caused by an interplay of several factors, including adap-tation to harsh conditions of the Arctic and tendency of mite hosts to become larger towards the pole. No simple explanation is enough.

What about other arthropods? An interspecific case study



Each point represents a difference between sizes of two sister species. In most cases the contrast in latitude is positive, indicating that ectoparasitic **copepod taxa with greater body size inhabit higher latitudes** than their sister taxa (Poulin, 2007).

An analysis of body-size latitude relationship in copepodes (crustaceans) parasitizing on fish and invertebrates (after Poulin, 1995, 2007)



A view from inside: helminths say "no!"

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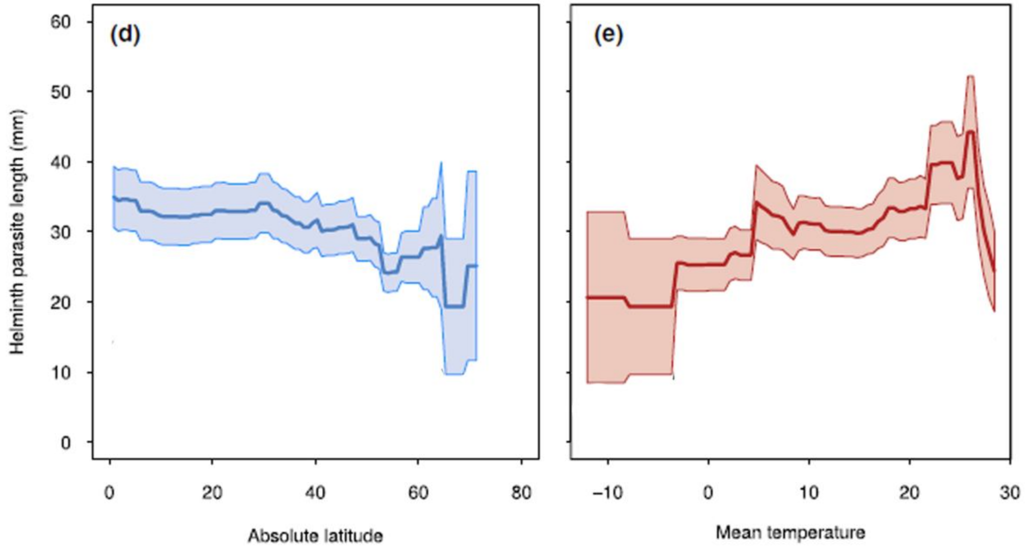
WILEY Global Ecology and Biogeography

RESEARCH PAPER

Contrasting latitudinal gradients of body size in helminth parasites and their hosts

Tad Dallas[1] | Alyssa-Lois M. Gehman[2] | A. Alonso Aguirre[3] | Sarah A. Budischak[4] | John M. Drake[5,6] | Maxwell J. Farrell[7] | Ria Ghai[6,8] | Shan Huang[7] | Ignacio Morales-Castilla[9]

After Dallas et al. (2019), modified



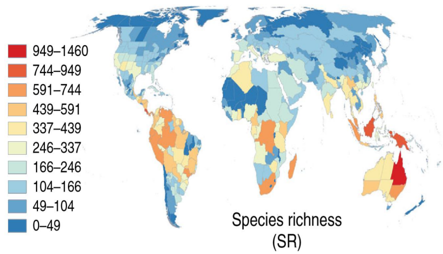
In a recent study of 265 various helminth species (Dallas et al., 2019), it was found that body sizes of these parasites tend to decrease with latitude (conversely to Bergmann's rule). The scale of this study was global.

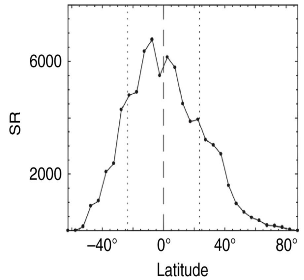
Some conclusions about body size variation in parasites

- In general, ectoparasitic taxa demonstrate a tendency to be larger in higher latitudes, whereas endoparasites exhibit a converse pattern (due to their insulation from ambient temperature)
- Parasite variation depends on its host specificity: host environment influences the pattern strength.

Latitudinal gradient in biodiversity and animal abundance

There is a ‘perceived vi-
ew’ that the tropical
belt maintain the most
diverse communities of
animals, and the num-
bers of living beings in
the tropics is highest.
Whether it is applicab-
le to parasites as well?





Population approach: do parasites are more abundant in tropics?

International Journal for Parasitology 48 (2018) 857–866

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journal homepage: www.elsevier.com/locate/ijpara

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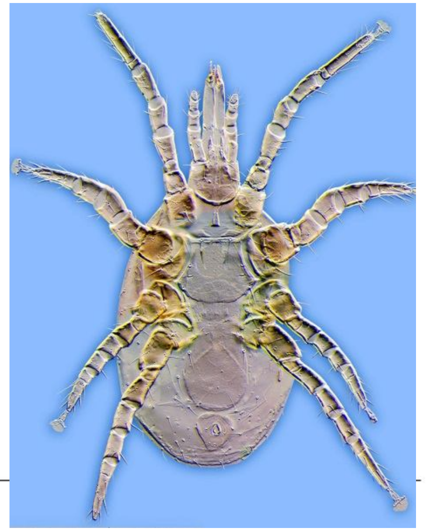
IJP

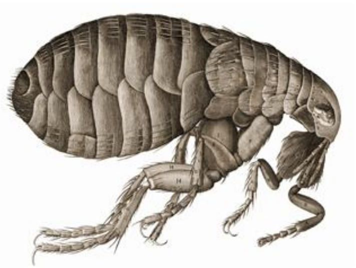
Biogeography of parasite abundance: latitudinal gradient and distance decay of similarity in the abundance of fleas and mites, parasitic on small mammals in the Palearctic, at three spatial scales

Check for updates

Luther van der Mescht[a,b,*], Elizabeth M. Warburton[a], Irina S. Khokhlova[b], Michal Stanko[c], Maxim V. Vinarski[d,e], Natalia P. Korallo-Vinarskaya[f,g], Boris R. Krasnov[a]



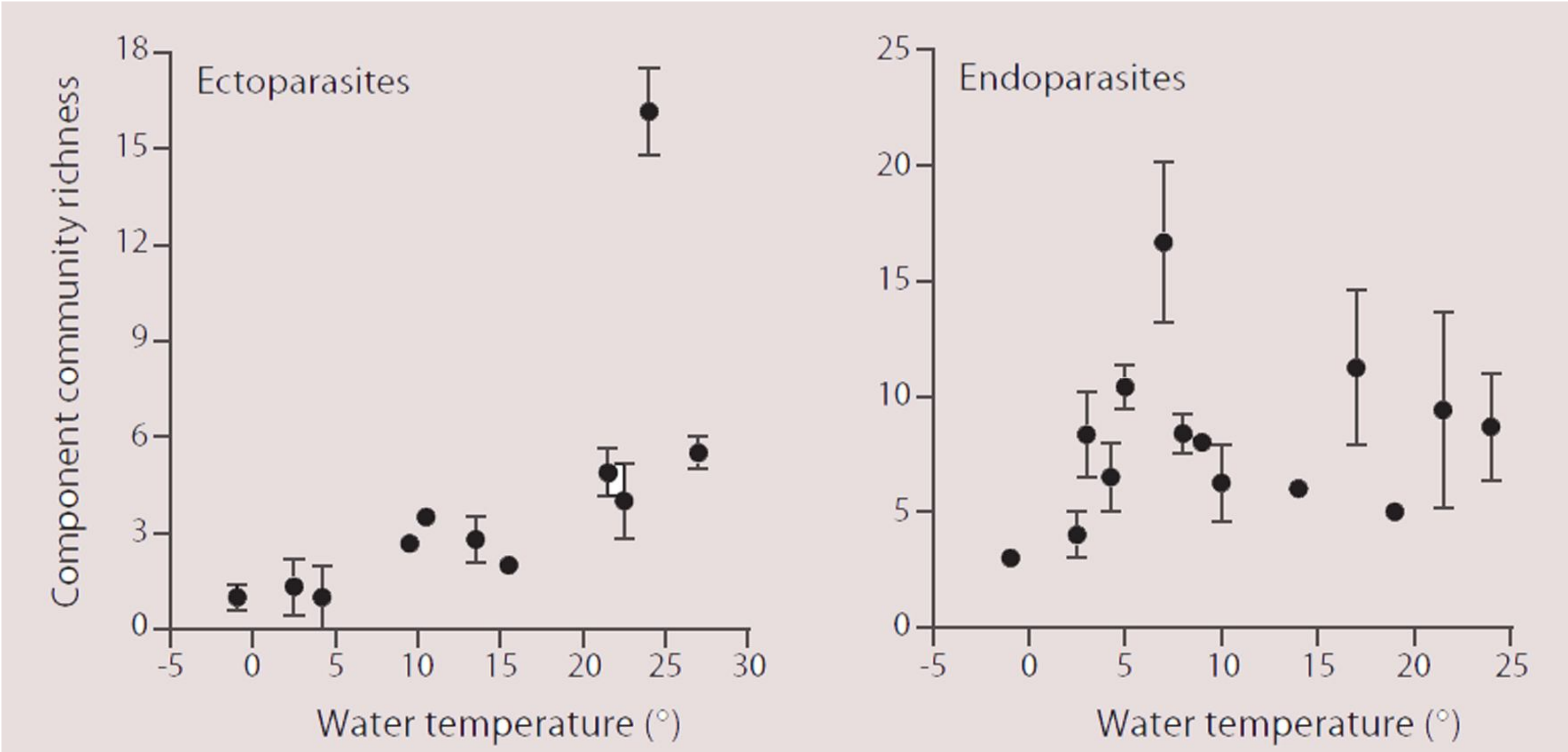
A B S T R A C T



These patterns were generally consistent across the three spatial scales, although environmental variation and dissimilarity in principal host abundance were equally important at the local scale in fleas but not in mites. We conclude that biogeographic patterns related to latitude and geographic distance do not apply to spatial variation of ectoparasite abundance. Instead, the geographic distribution of abundance in arthropod ectoparasites depends on their responses, mainly to the off-host environment and to a lesser extent the abundance of their principal hosts.

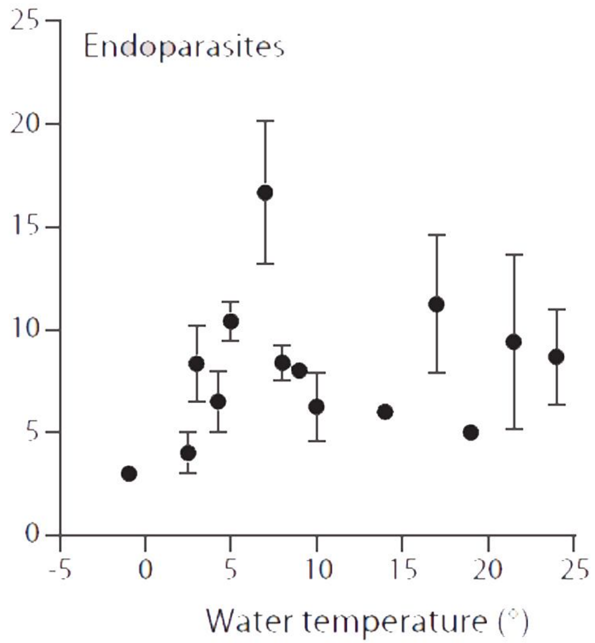
Van der Mescht *et al*. (2018) investigated geographic patterns of variation in abundance of ectoparasites (fleas and mites) collected from bodies of their small mammalian hosts in the Palearctic at continental, regional and local scales. They found no relationship between latitude and intraspecific flea or mite abundance. In both taxa, environmental dissimilarity explained the largest part of the deviance of spatial variation in abundance. No significant spatial trends altogether ☹

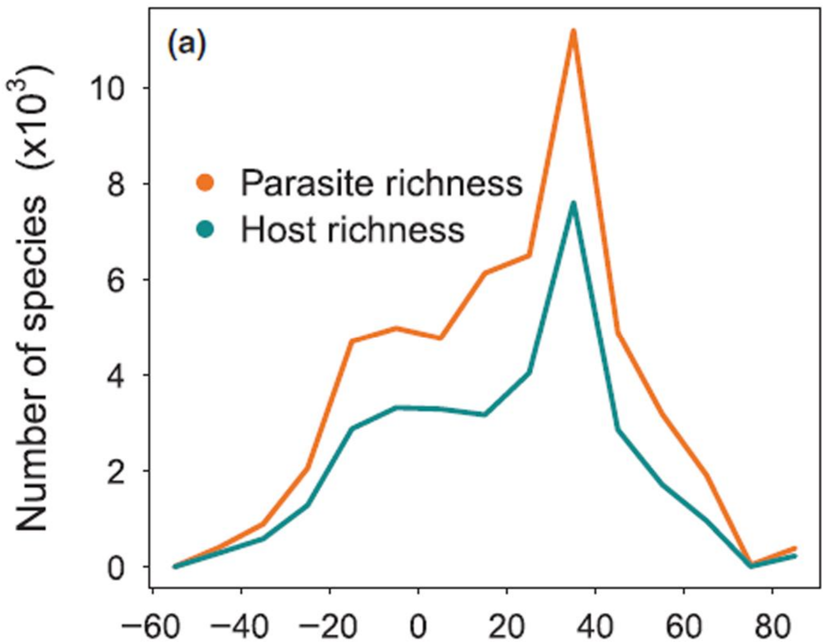
Taxonomic diversity of parasites and climate: no universal rule



And again, ecto- and endoparasites exhibit quite distinct patterns. In parasites of marine fish, species richness of ectoparasites is positively correlated with temperature (and negatively with latitude), while that of endoparasites no (after Poulin, 2007).

Some don’t like it hot: a parasitic worms’ perspective (but see next slide ☺)

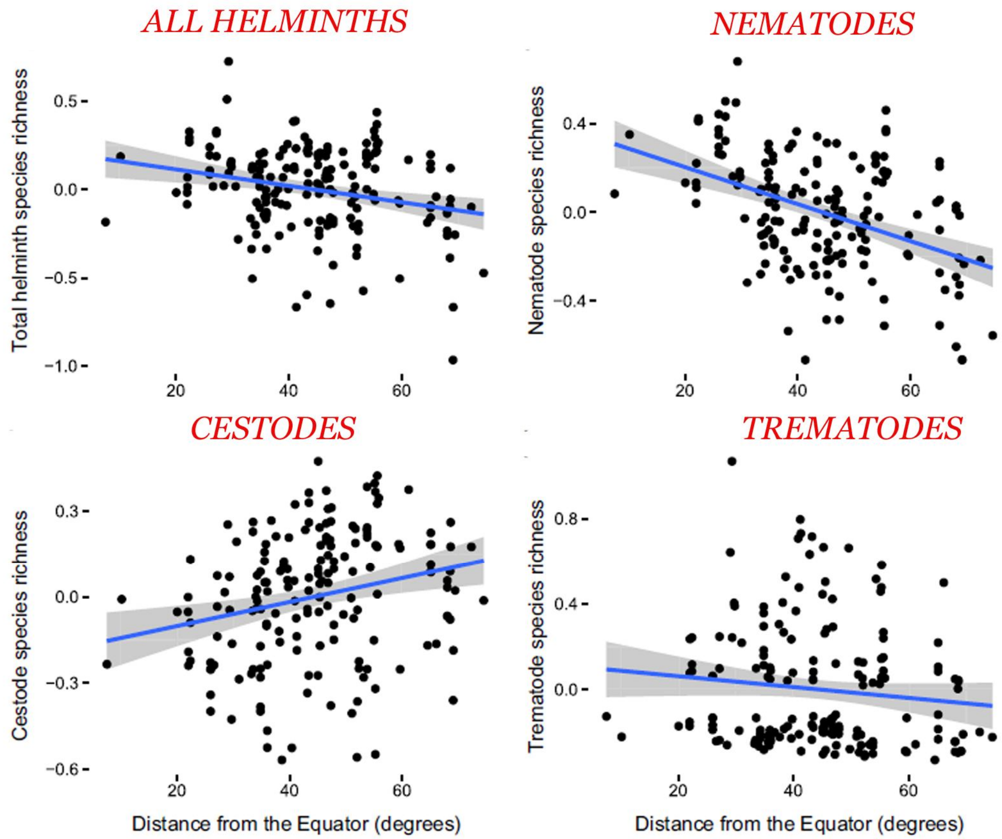




Left – correlation of species richness of endoparasites with water temperature (Poulin, 2007), right – global diversity of helminths and their hosts (Dallas et al., 2018)

It seems that endoparasites (represented almost exclusively by helminths) are most abundant somewhere between Equator and the poles (and note the tight correlation between host and helminth richness in right picture)

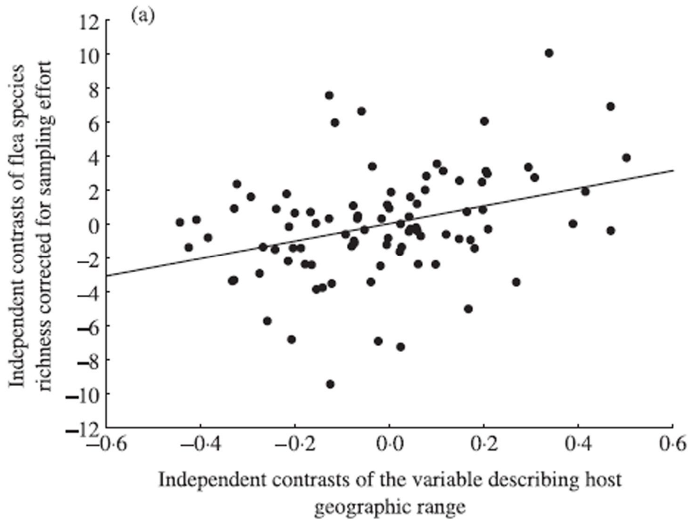
Be careful! “Helminths” are very heterogeneous

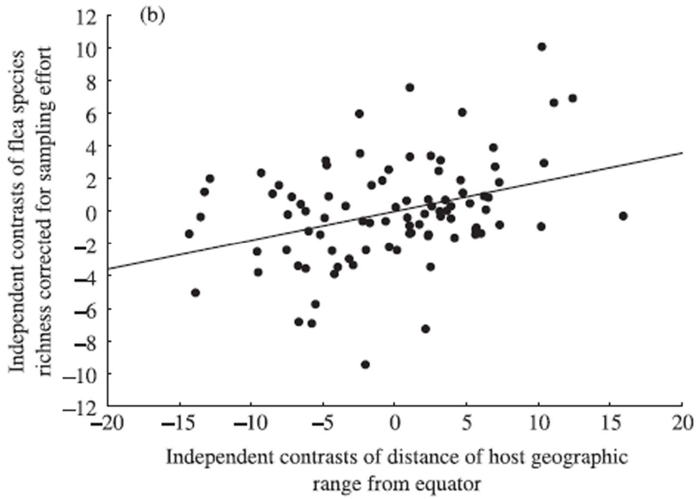


Species richness of several groups of helminths associated with hamsters, voles. lemmings and other members of the family Cricetidae (792 host species in total). After Preisser (2019), modified.

However, within helminths, different higher taxa follow distinct rules! If to analyze the assemblage of endoparasites, the final picture may be not too simple…

Fleas species richness and latitude





Journal of Animal Ecology 2004
73, 1121–1128

Flea species richness and parameters of host body, host geography and host 'milieu'

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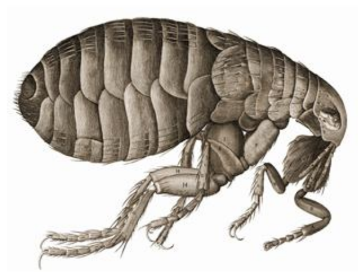
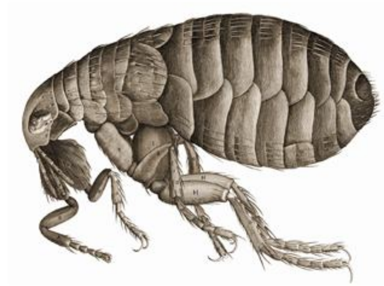




One of rare examples of increasing species richness with latitude represent fleas (Siphonaptera). Their species richness increased with the latitude of the centre of the geographical range. No similar relationship was found in mites.

Discussion and general conclusions

- Parasitic animals demonstrate prominent macroecological patterns at different scales (organismal, coenotic, ecosystemic) similar to those found in free-living animals;
- There is no full parallelism in macroecological patterns of parasitic and free-living animals that may be explained by drastic differences in their life cycles and biotic relations;

No universal rules in parasite macroecology

- It is impossible to indicate any macro-ecological trend, uniform across parasite taxa and applicable to all parasites.
- Even within the same higher taxon (for example, Arthropoda), distinct patterns may be found (compare fleas and mites, for example).

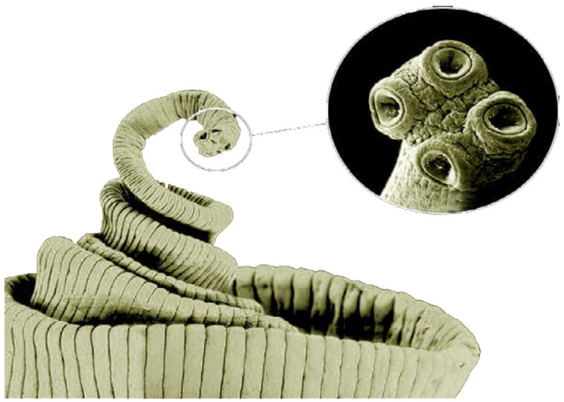
No universal rules in macroecology as a whole!

The percentage of species of terrestrial warm-blooded vertebrates which conform to Bergmann's rule

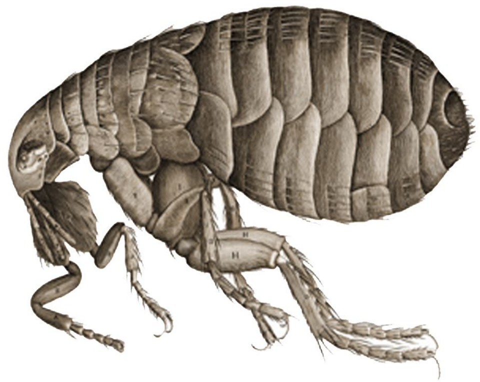
Class	%	Source
Mammals	65.1	Meiri, Dayan (2003)
	70.9	Ashton et al. (2000)
Aves (birds)	72.3	Meiri, Dayan (2003)
	76.0	Ashton (2002)

It is characteristic for macroecology that neither of large-scale patterns or rules has an universal character ("law"). Even most prominent global trends (like latitudinal gradient in species richness) have numerous exceptions.

Ecto- vs. endoparasites



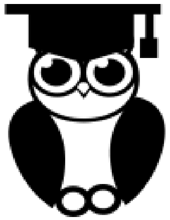
versus



Ectoparasites seem to be more dependent on abiotic factors than on their host identity than endoparasites. It may be explained by the fact that the latter are less exposed to abiotic envi-ronment; host’s body is their “environment” (however, this generalization is also very far from being universal)

On scientific explanation(s)

- Macroecology of parasites gives a good instance of non-applicability of simpicistic explanations in ecology (and science as a whole).
- Each revealed pattern or trend arises as a complex interplay of several factors, and we have to assess sta-tistically the relative contribution of each of them.



THANK YOU FOR YOUR ATTENTION!

ANY QUESTIONS?