

Parasite communities



Community

- ▶ Heterotypic assemblage composed of individuals of different species which may actually interact
- ▶ i.e. communities of gill parasites in fish



Hierarchical classification of parasite communities

▶ **Infracomunity**

assemblage consisting of all parasites of different species in the same host individual

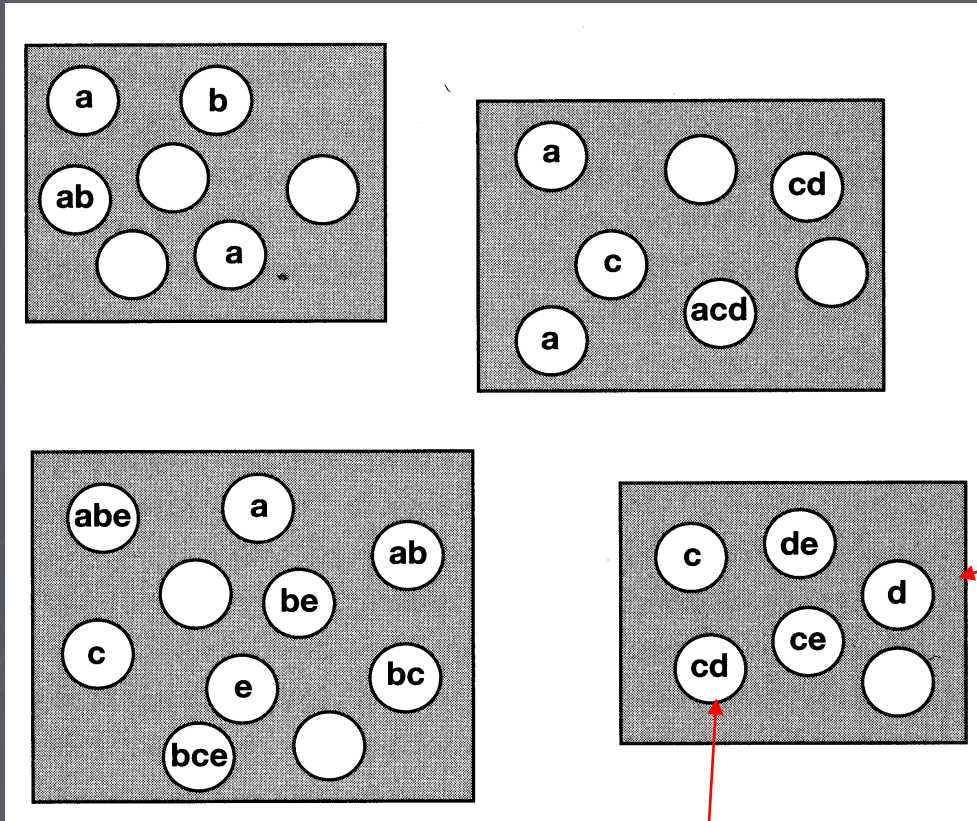
▶ **Metacomunity or component community**

Assemblage consisting of all parasites of different species exploiting host population (in a given time and in a given space)

▶ **Supracomunity or compoud community**

assemblage composed of all metacomunities in a given ecosystem

Hierarchical classification of parasite communities in a given host species

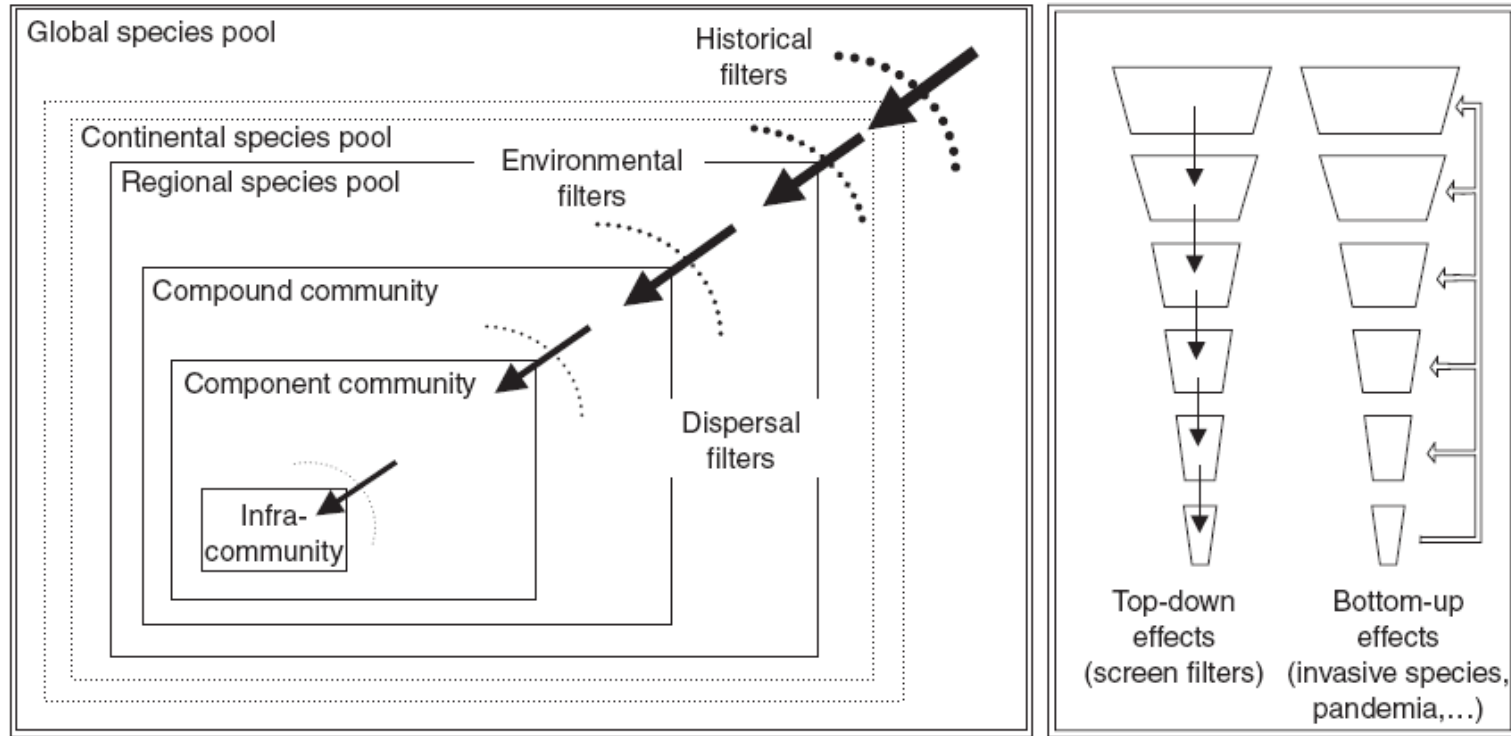


Parasitofauna of a given host species – 5 parasite species

Host population
2 to 4 parasite species

Host individual – 0 to 3 parasite species

Hierarchical level of parasite communities



Infracommunity

- ▶ Number of parasite species
- ▶ Relative abundance (number of specimens of each parasite species)
- ▶ Dynamic system – mobility, natality, mortality
- ▶ Formation during ecological time, influence of infection and demographic processes
- ▶ Typically short-lived

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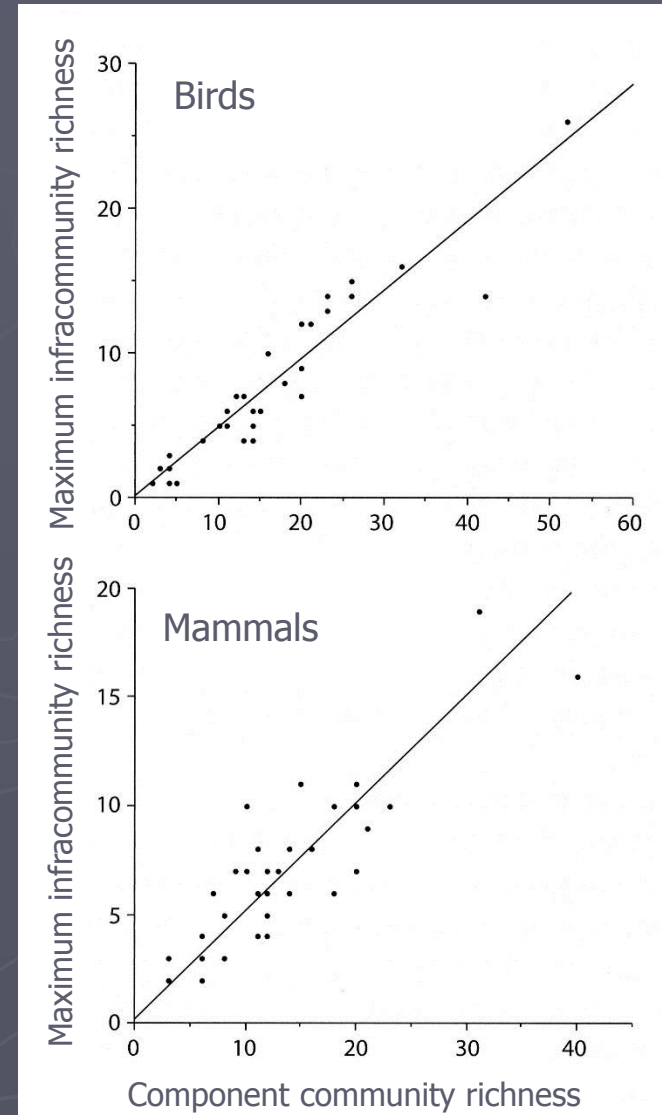


Infracommunity

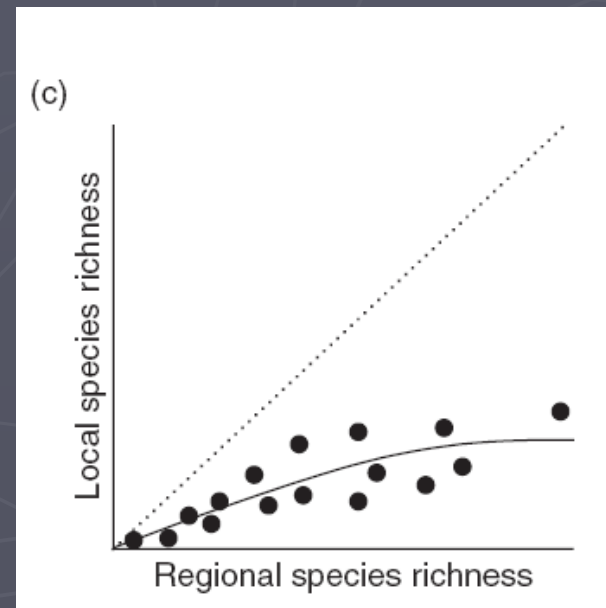
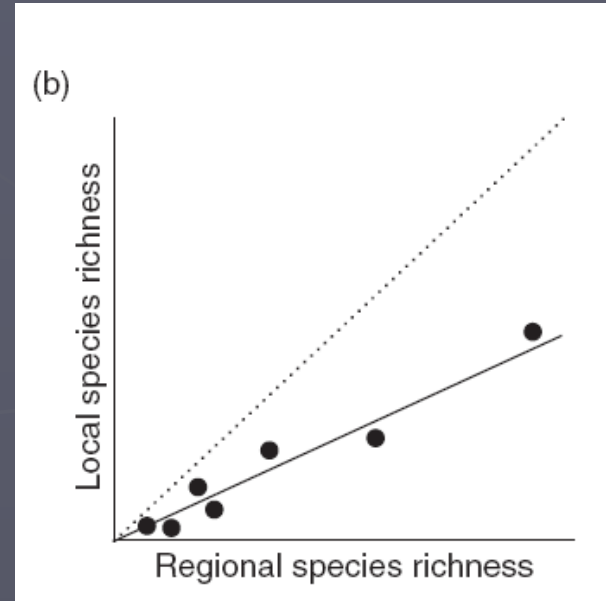
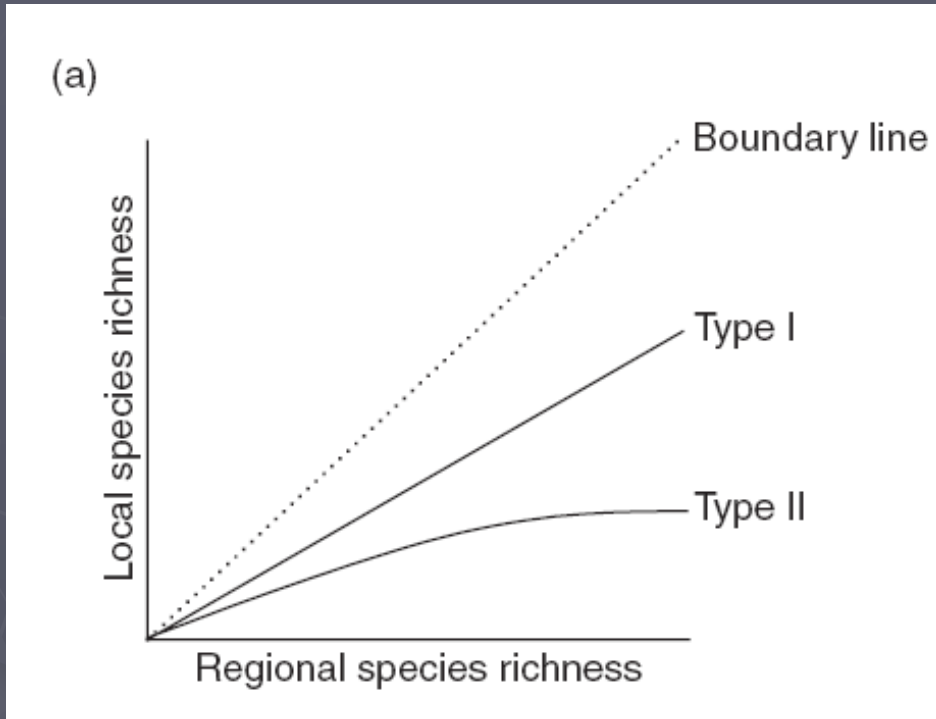
- ▶ Maximum number of species in IC
= number of species in MC
This upper limit is not realized.

i.e. 31 intestinal helminth
communities in birds

37 intestinal helminth
communities in mammals



Saturation of communities



Saturation of parasite infracommunities?

- ▶ Kennedy & Guégan (1996) 64 metacommunities of intestinal helminths

Can the saturation limit the number of species in helminth infracommunities?

maximum number of species in infracommunities = 3

number of species in metacommunities > 3

saturation of infracommunities – number of species in IC
below the number of species in MC

Infracommunities

▶ very rare saturation of infracommunities by parasite species – vacant niches

▶ saturation by parasite biomass

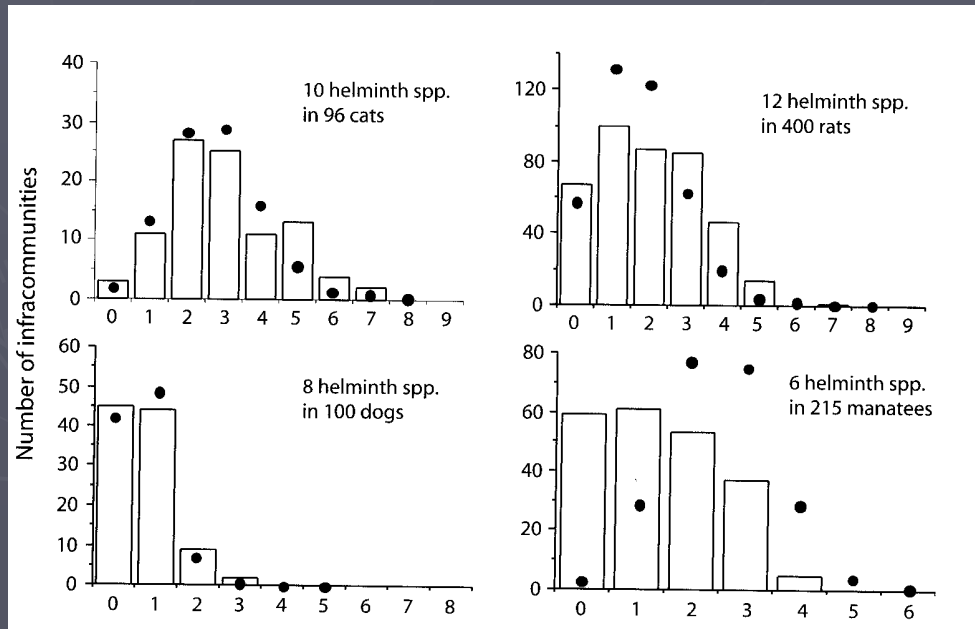
E.g. Helminth communities in 131 vertebrate species
total biomass of intracommunity increased with host body size, large hosts = high biomass of parasites

Infracommunities

- ▶ Variability in the number of species in infracommunities of a given host population
 - infracommunities with low number of species, infracommunities with high number of species
- ▶ Number of species in infracommunities
 1. random distribution of parasite species on/in host
 2. affected by interactions (competitive exclusion) or colonization of one species is dependent on the other species

Infracommunities

- Frequency distribution of parasite species in infracommunities (species prevalence) – observed vs. predicted distribution by null model (Janovy et al., 1995)

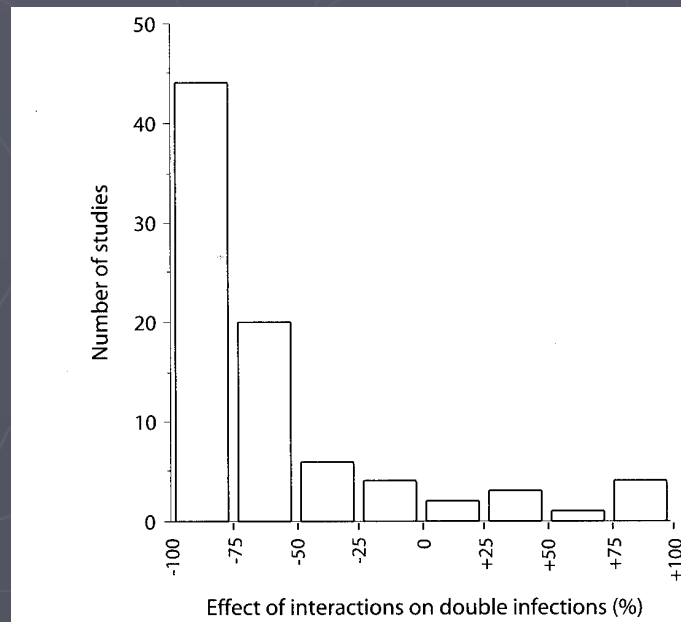


1. interactive community – competitive exclusion
2. positive interactions – using host by other parasite species is facilitated
3. heterogeneity among hosts in susceptibility to infection

4 metacommunities of gastrointestinal helminths in mammals

Infracommunities

- ▶ Larval digeneans in intermediate hosts (snails)
 - very few infracommunities with more than 1 species
 - temporal and spatial heterogeneity in infection rate
 - relative effect of antagonistic interactions on frequency of infections between two larval digenean species

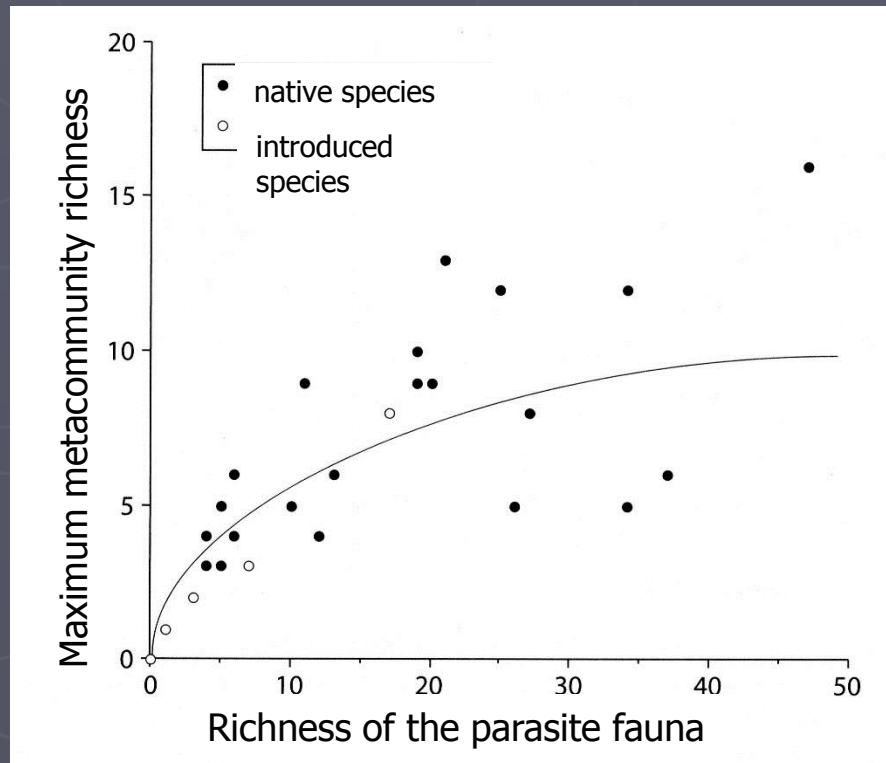


Metacommunity

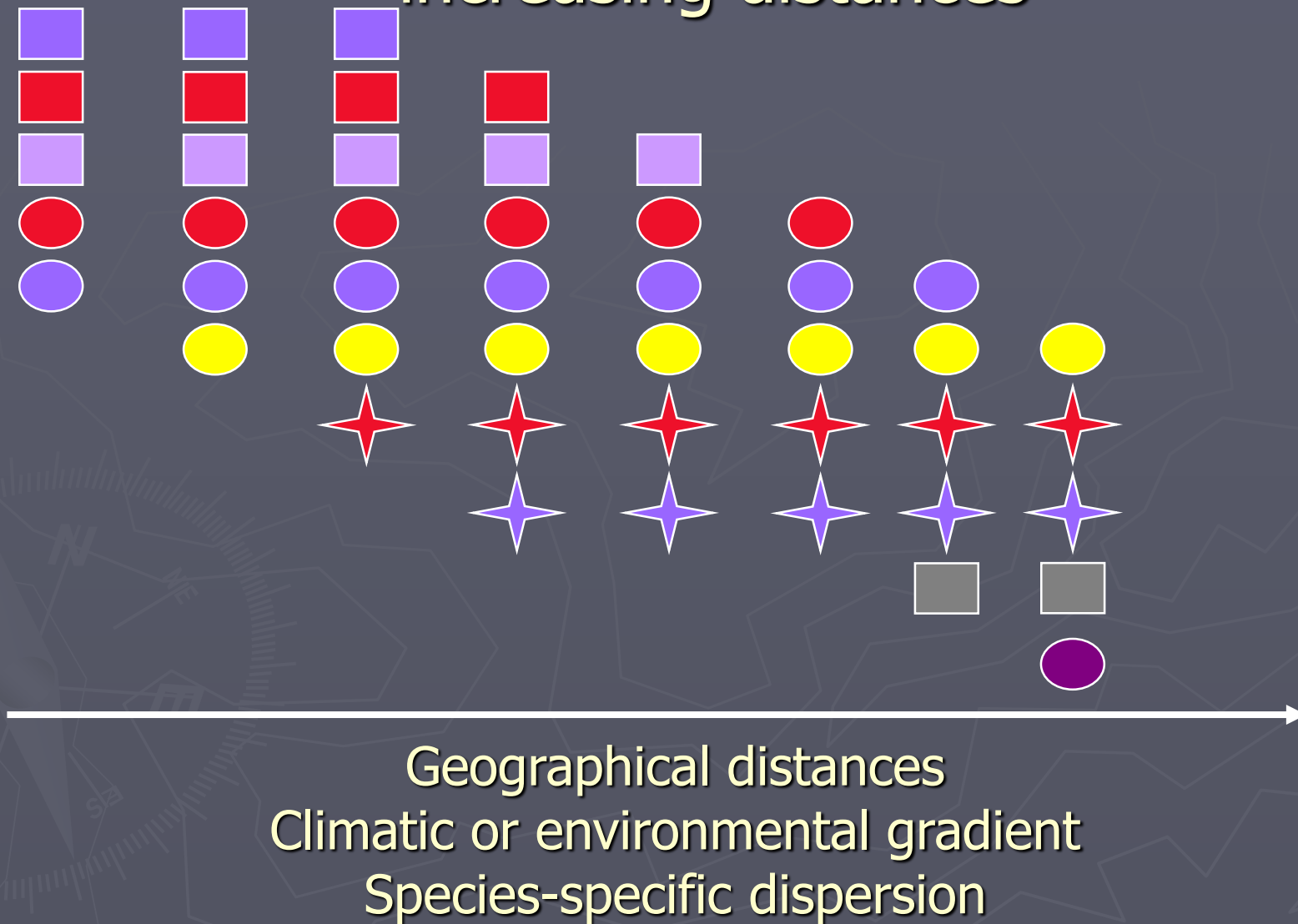
- ▶ Longer-lived assemblages than any of their infracommunities
- ▶ MC is formed over evolutionary time scales by invasion, speciation, extinction, colonization or host switches
- ▶ Maximum number of parasite species in MC = the number of species in the parasite fauna
- ▶ Often a saturation of the level of species below that of the parasite fauna

Saturation of metacommunity

- ▶ Ex. relationship between parasite species richness in MC and richness in the parasite fauna (helminth parasites of 32 freshwater fish species in UK published by Kennedy & Guégan, 1994)

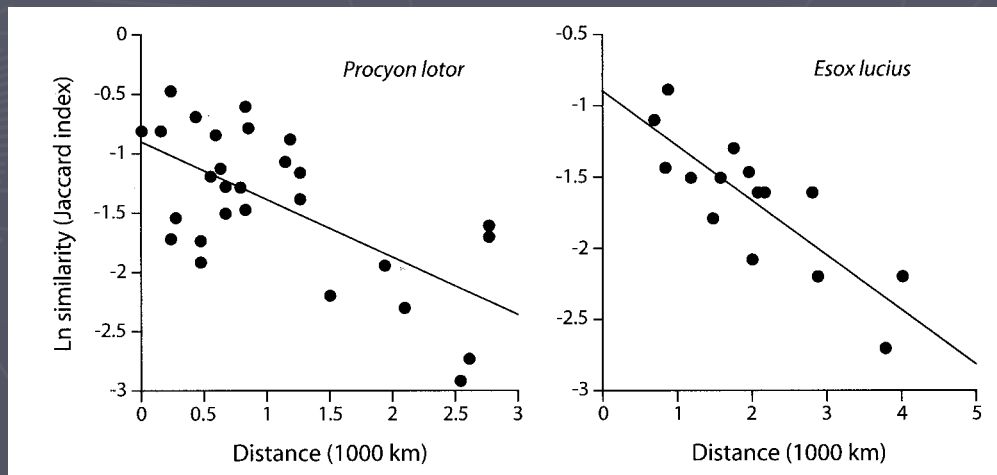


Decay in metacommunities similarity with increasing distances



Similarity in parasite metacommunities

- ▶ **Contacts of host populations** and exchange of parasites
- ▶ Physically isolated host populations – different parasite MC
- ▶ **Geographical distances** – good predictor of similarity in species composition (but this is not universal phenomenon)

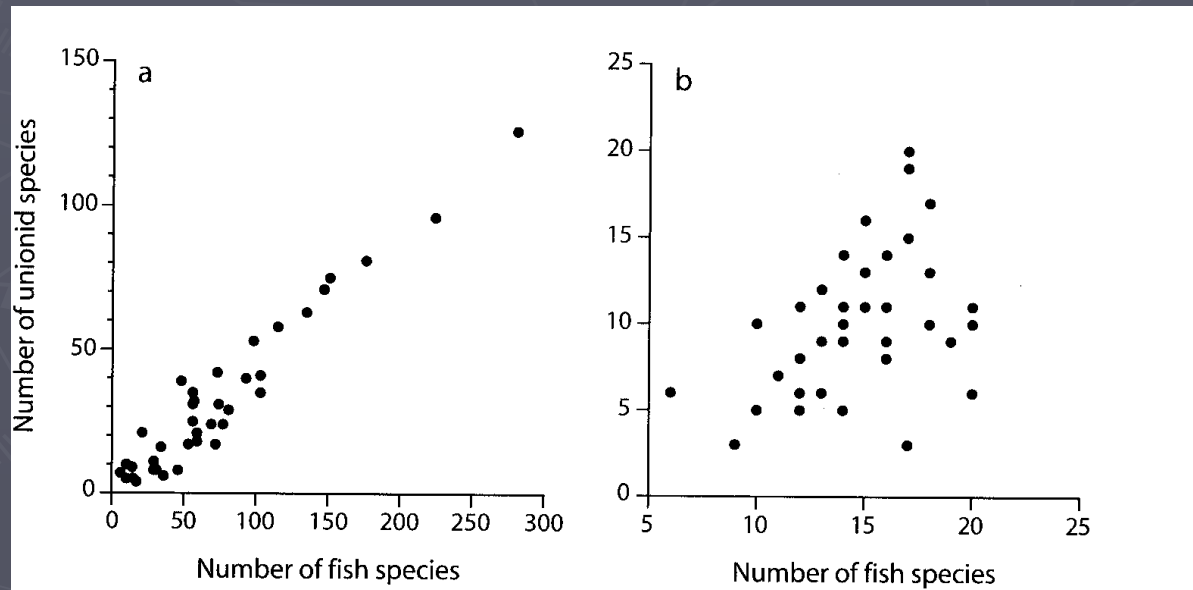


Similarity in parasite metacommunities: role of host

- ▶ **Dispersal capacity and migration** – homogeneity of metacommunities in region
- ▶ e.g. limited dispersal capacity of freshwater fish (fragmented freshwater habitats), no-limited dispersal capacity in open space in marine
- ▶ **Different food availabilities and preferences** in different continents

Diversity of metacommunities: role of host

- ▶ **Higher host diversity** → species-richer parasite metacommunities
- ▶ Positive relationship between number of host species of a given taxon in a habitat and number of parasite species using this taxon

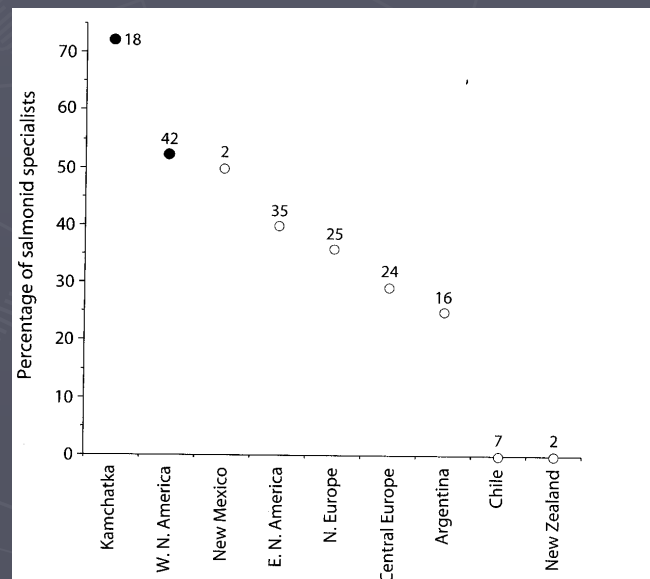


Diversity of metacommunities: role of host

- ▶ Time necessary for evolution of metacommunity
- ▶ Translocation of host populations
- ▶ e.g. introduction of host species
 - initial stage – species-poor metacommunities
 - increasing diversity in time - host switching between sympatric hosts, migration of new parasitized specimens of host

Diversity of metacommunities: role of host

- ▶ Composition of metacommunities in relation to host specificity
- ▶ e.g. *Anguilla rostrata* – metacommunities with mainly specialists on the Atlantic coast, and mainly generalists in the continents
- ▶ in geographical space the number of species in parasitofauna increases, relative number of specialists decreases



Similarity in parasite metacommunities: role of parasite

- ▶ Colonization and dispersion of some parasites associated with life cycle (IH, DH, parathenic hosts)
- ▶ **allogenic** parasites – used birds as a DH – homogenous and predicted metacommunities
- ▶ **autogenic** parasites – used strictly water organisms, different metacommunities

e.g. *Coregonus lavaretus* – helminth metacommunities

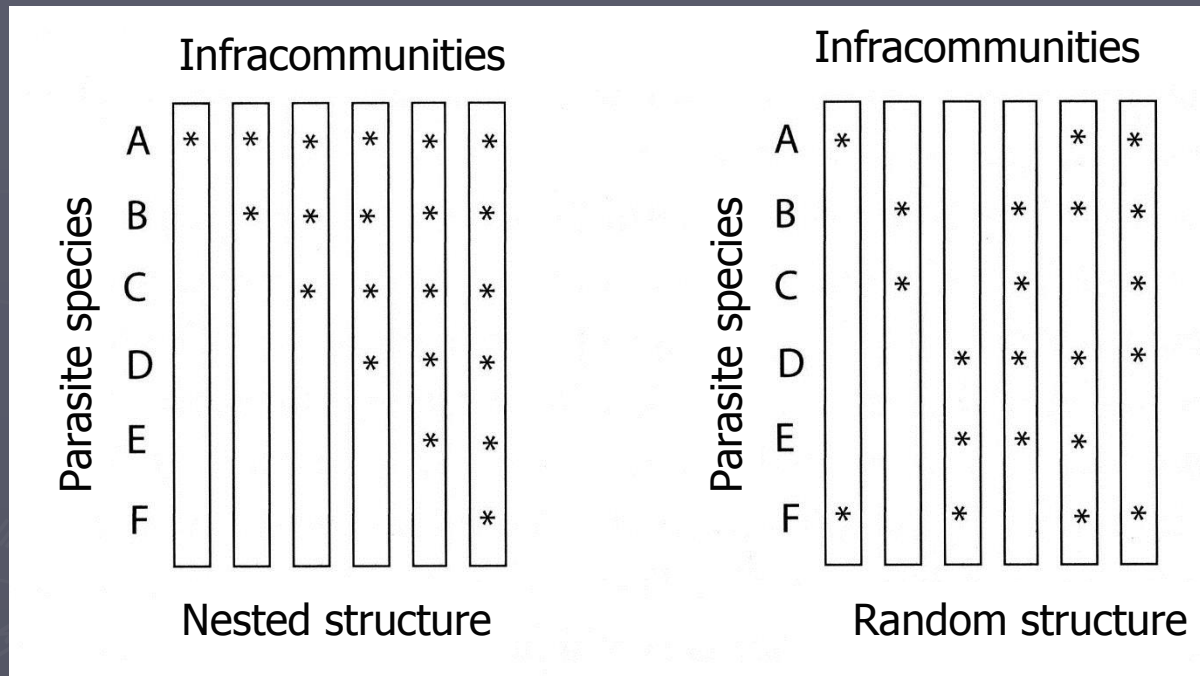
- share allogenic species
- differ in autogenic species depending on the distances between lakes



Nested structure of parasite infracommunities

- ▶ **Nonrandom distribution of species richness** among infracommunities
- ▶ Type of hierarchical structure of communities in fragmented habitats (firstly described for mammal communities in islands)
- ▶ Host = fragmented habitat – nonrandom distribution of parasite species among IC i.e. within MC

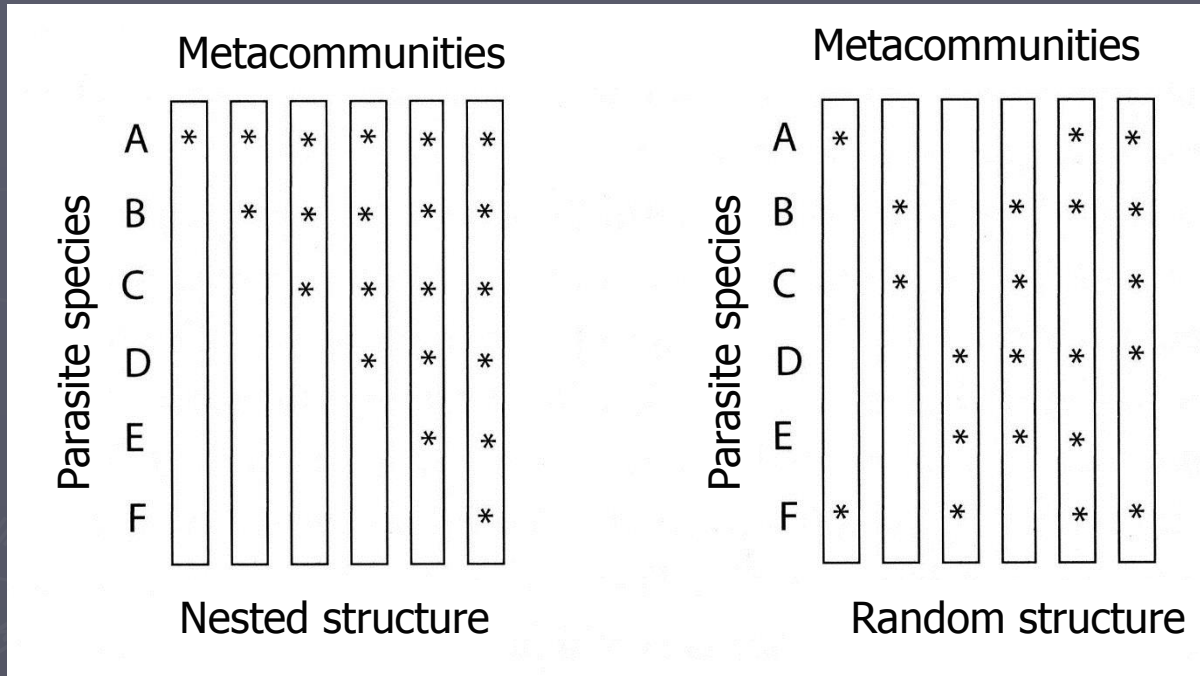
Nested structure of parasite infracommunities



Two hypothetical distributions of parasite species among the infracommunities

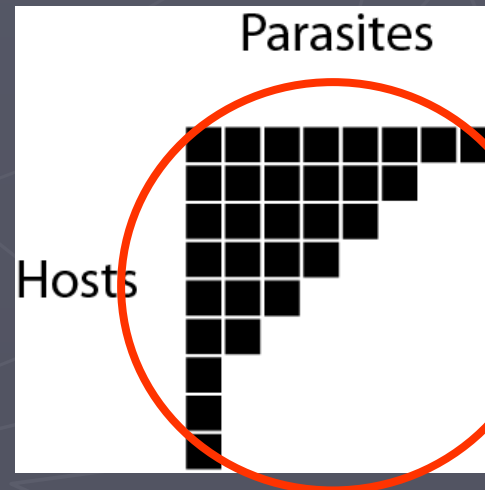
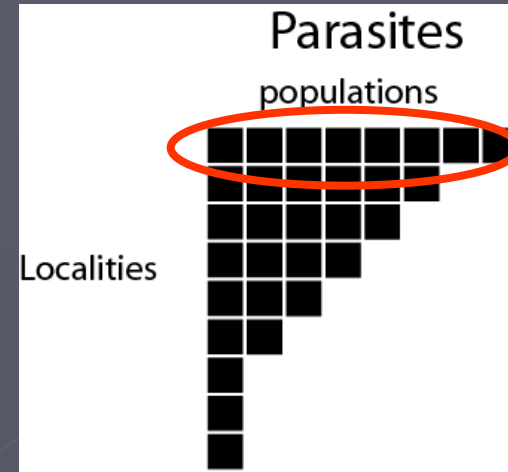
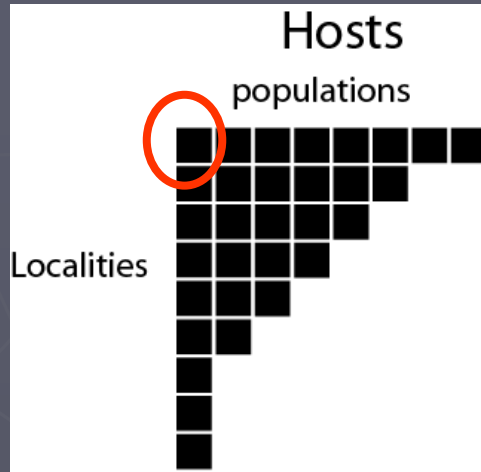
Each parasite species of a species poorer infracommunity is the subset of species-richer infracommunity

Nestedness in parasite metacommunities



Each parasite species of a species-poorer locality (host population) is the subset of species-richer locality (host population)

Nestedness in different hierarchical level of organization of parasite communities



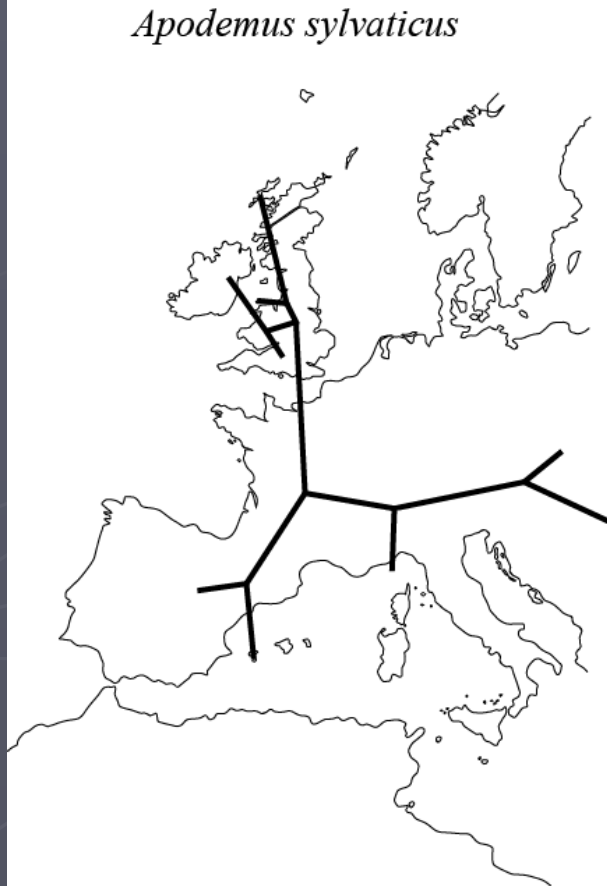
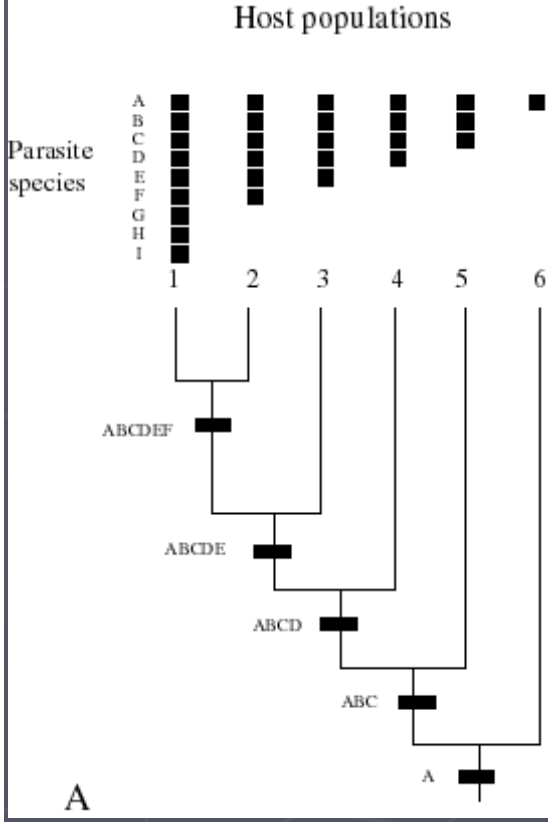
► from local to regional level



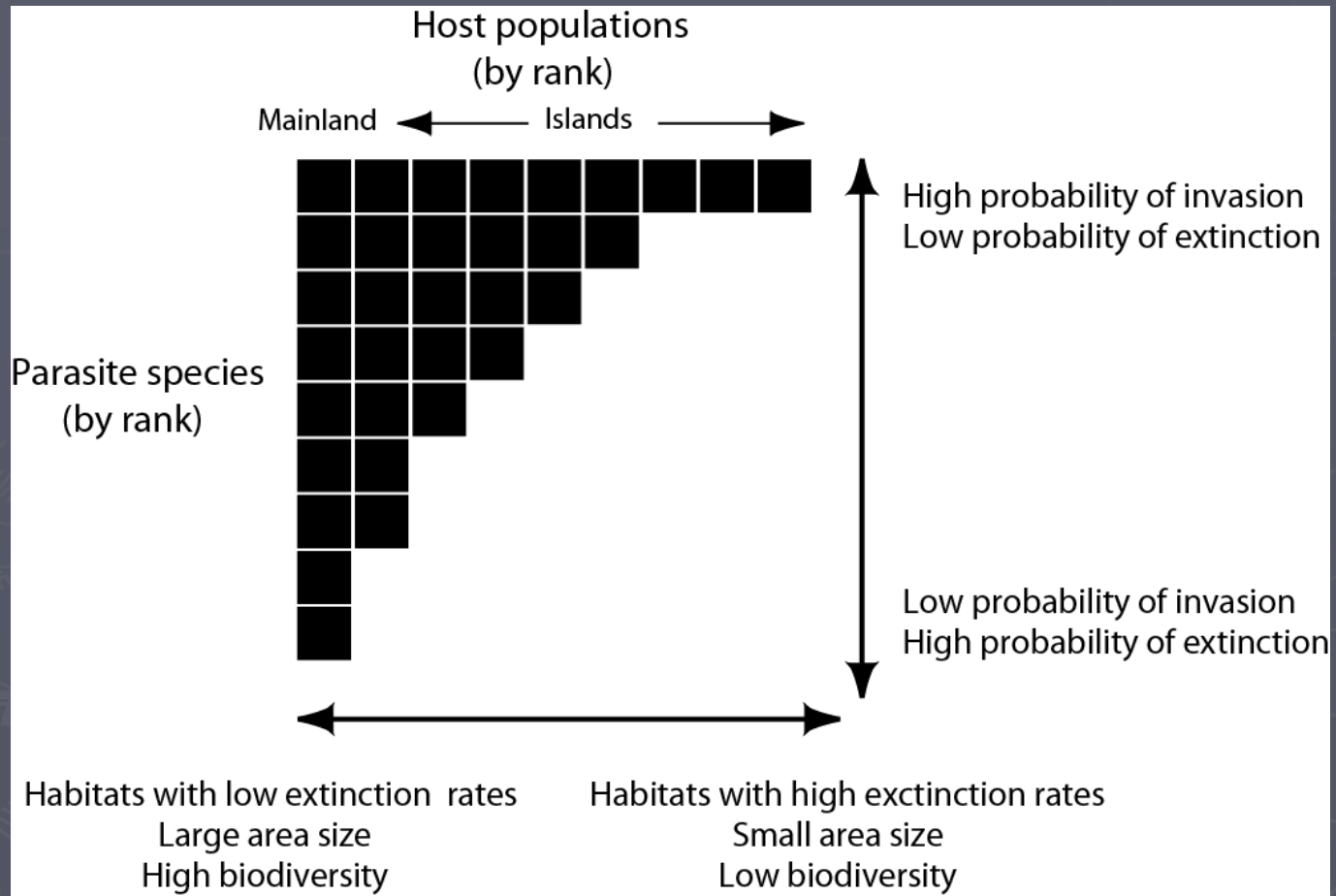
Nestedness of metacommunities and phylogeny

Ex. Helminths in *Apodemus sylvaticus*

Parasite species	Parasite group	Cycle	Spain	C.E.	Mallo.	Cons.	Menor	Itals	Sicily	Ibiza	Forne	Port.	Port.	Port.
<i>Syphacia stromei</i>	N	D												
<i>Syphacia frederici</i>	N	D												
<i>Rodentolepis straminea</i>	C	I												
<i>Trichouris muris</i>	N	D												
<i>Heligmosomoides polygyrus</i>	N	D												
<i>Mesophorus muris</i>	N	I												
<i>Rictisalenia proci</i>	N	I												
<i>Skjoldbotaenia lobata</i>	C	I												
<i>Taenia leucostomaei</i> larvae	C	I												
<i>Brachylema</i> spp.	D	I												
<i>Aonchotheca muris-sylvatici</i>	N	D												
<i>Aspiculuris tetraptera</i>	N	D												
<i>Galegoptes arfaei</i>	C	I												
<i>Hymenolepis diminuta</i>	C	I												
<i>Passodactyloctenella melozi</i>	C	I												
<i>Taenia parva</i> larvae	C	I												
<i>Aonchotheca anisulosa</i>	N	D												
<i>Contiplexus vitellus</i>	D	I												
<i>Eucolpox bacilliferus</i>	N	D												
<i>Ceolodum hepaticum</i>	N	D												
<i>Moniliformis moniliformis</i>	A	I												
<i>Angiostrongylus djedjehi</i>	N	I												
<i>Eucolpox parvulus</i>	N	D												
<i>Gongylonema neoplasticum</i>	N	I												
<i>Heligmosomum castellanum</i>	N	D												
<i>Physaloptera gelsula</i>	N	I												
<i>Brachylema recurva</i>	D	I												
<i>Phlegonchis muris</i>	D	I												
<i>Taenia leucocolis</i> larvae	C	I												
<i>Catenocaulis pustula</i>	C	I												
<i>Cladostoma globifera</i> larvae	C	I												
<i>Rodentolepis thalense</i>	C	I												
<i>Hymenolepis muris-sylvatici</i>	C	I												
<i>Joyeuxiella parvulae</i> larvae	C	I												
<i>Mesocostolex</i> sp. larvae	C	I												
<i>Multiceps</i> sp.	C	I												
<i>Taenia polyacantha</i> (larvae)	C	I												
<i>Heligmosomum akjabseni</i>	N	D												
<i>Nippostrongylus brasiliensis</i>	N	D												
<i>Pharyngodonematis hispanica</i>	N	D												
<i>Syphacia obvelata</i>	N	D												
<i>Aleria alata</i> larvae	D	I												
<i>Collyricobates muzzenae</i>	D	I												
<i>Elsperophyllum melis</i>	D	I												
<i>Mesocylus apodemus</i>	D	I												
<i>Notocotylus reyni</i>	D	I												
<i>Phlegonchis elegans</i>	D	I												
<i>Phlegonchis leucostomaei</i>	D	I												
<i>Psilotheca sibiricum</i>	D	I												
<i>Scolecophorum palaearticum</i>	D	I												
<i>Skjoldbotaenella sibirica</i>	D	I												

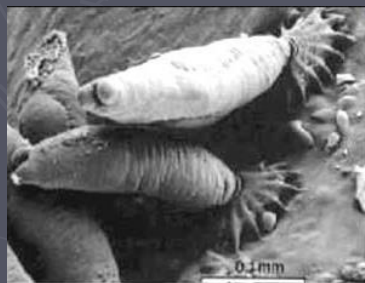


Nestedness in metacommunities



Which processes generate the nested pattern?

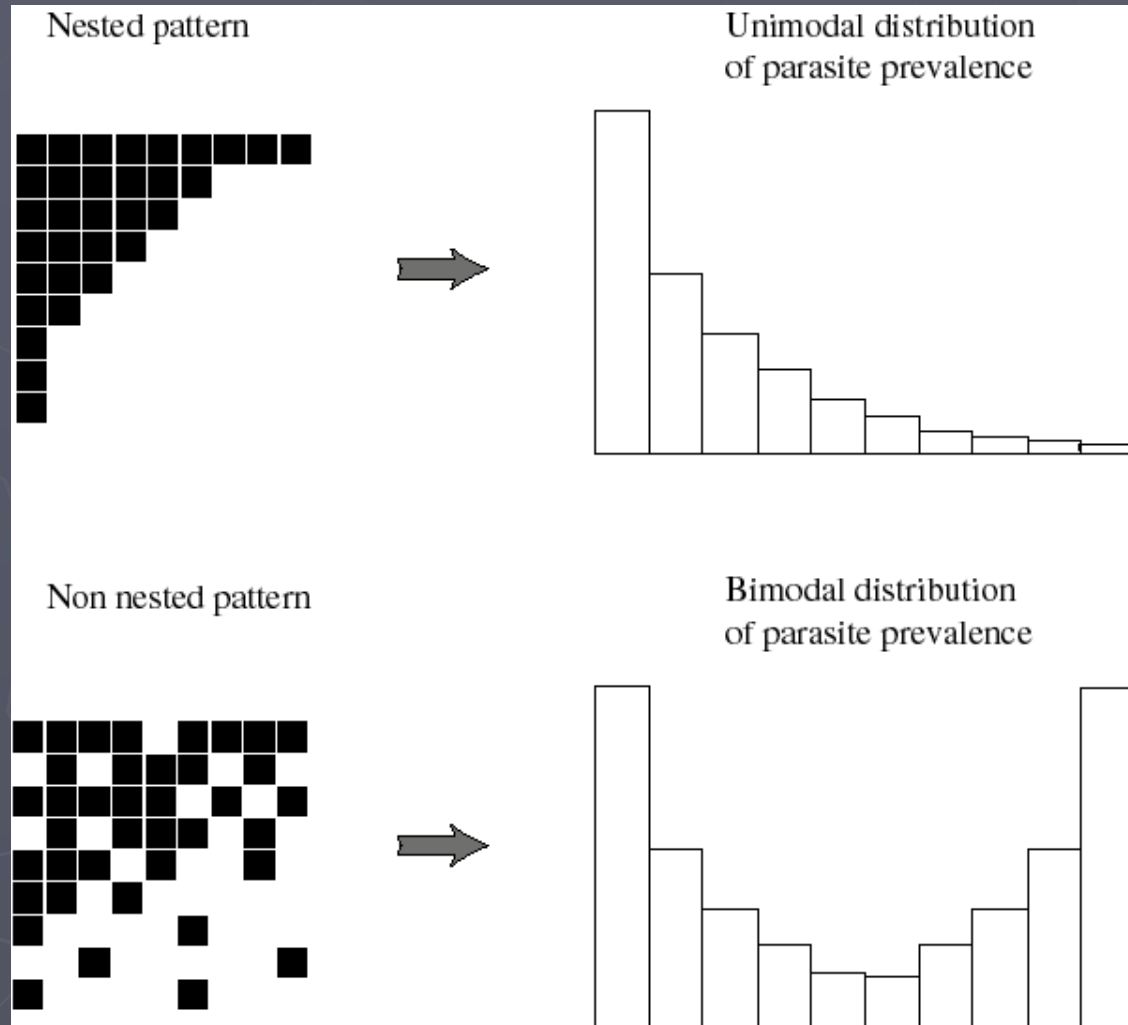
- ▶ Free living species – different extinction, colonization and dispersion
- ▶ Parasites
 - different transmission, **host heterogeneity** generates **different extinction and colonization** of parasites
 - heterogeneity in host size, small host → big host
 - **competition** – different opinions (increase/decrease/no effect)
 - **association to host specificity**
e.g. *Gyrodactylus* in freshwater cyprinids (high nestedness in the communities with dominant position of specialists)



Which processes generate nestedness?

Nestedness – result of **epidemiological processes**
(Morand et al., 2002)

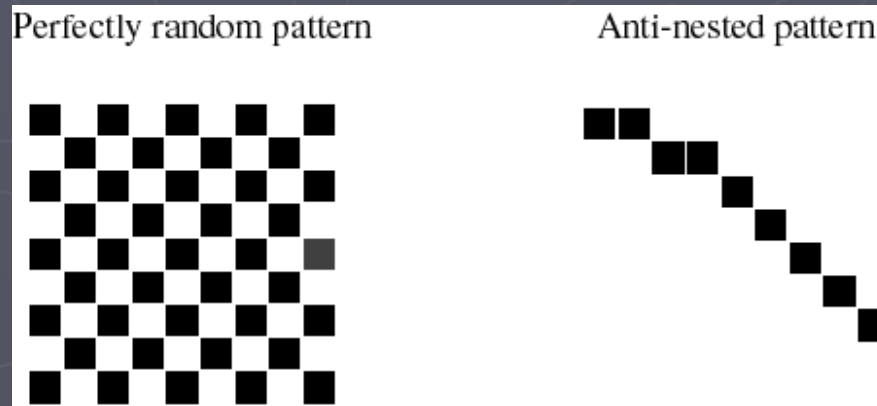
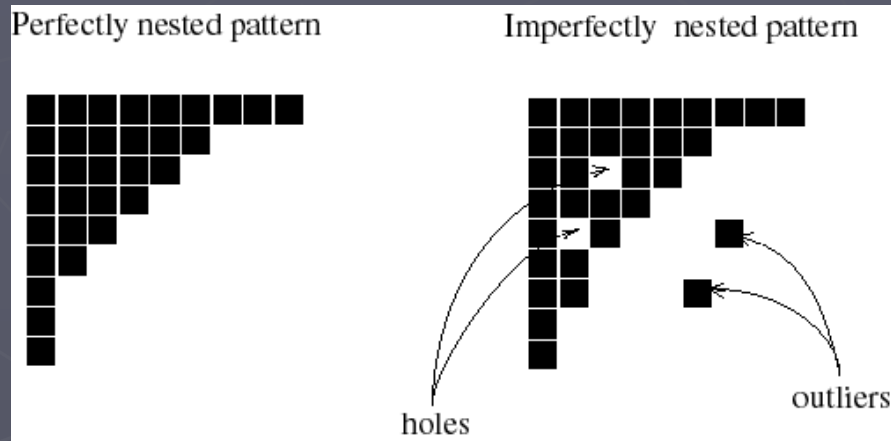
Link between nestedness and parasite prevalence – consequences of different parasite colonization and extinction linked with natality and mortality



Nestedness vs. antinestedness

- ▶ Nested structure = one extreme case of hierarchical structure of parasite communities
- ▶ Alternative **antinested** structure – parasite species present in species-poor communities are never present in species rich communities (some parasite communities of fish)
- ▶ Biological interpretation unclear

Nestedness vs. antinestedness



Basics of data processing of parasitic communities

► Number of parasite species in communities

	Community A	Community B
Species 1	◆◆◆	◆
Species 2	♣♣♣	♣♣
Species 3	♥♥♥	♥♥♥♥♥♥♥

- Analyses of diversity of parasite communities
 - index of diversity – Shannon index diversity
 - Brillouin index diversity

Shannon index diversity

- ▶ it assumes a random selection of individuals from a theoretically unlimited number and the presence of all species of community in the sample
- ▶ to analyze diversity of parasite metacommunities

$$H' = -\sum p_i \ln p_i - \frac{S-1}{N} + \frac{1 - \sum p_i^{-1}}{12N^2} + \frac{\sum (p_i^{-1} - p_i^{-2})}{12N^3}$$

$$p_i = \frac{n_i}{N}$$

where S is the total number of species, p_i is the proportion of individuals of the i-th species, N is the total number individuals, n_i is the number of individuals of the i-th species

- ▶ variability in Shannon diversity

$$\text{Var}H' = \frac{\sum p_i (\ln p_i)^2 - (\sum p_i \ln p_i)^2}{N} + \frac{S-1}{2N^2}$$

Shannon index diversity

- ▶ The difference between the Shannon index values for the two communities can be compared using a t-test

$$t = \frac{H_1' - H_2'}{\sqrt{\frac{1}{2}(\text{Var}H_1' + \text{Var}H_2')}}}$$

$$df = \frac{(\text{Var}H_1 + \text{Var}H_2)^2}{\frac{(\text{Var}H_1)^2}{N_1} + \frac{(\text{Var}H_2)^2}{N_2}}$$

- ▶ The maximum value of the Shannon index for a given community = $\ln S$ = Shannon index at identical species frequency in the community

Indexes of diversity

- ▶ **Equitability = evenness** - the relative value of the diversity depleted by a given community in relation to a community with the same number of species

$$E = \frac{H'}{H_{\max}} = \frac{H'}{\ln S}$$

- ▶ **Brillouin index** of diversity
 - in case it is not possible to ensure random sampling or the sample contains all members
 - describes only the sampled part of the community
 - for the study of parasite infracommunities

$$HB = \frac{\ln N! - \sum \ln n_i!}{N}$$

n_i – number of specimens of i -th species
 N – total number of specimens

Indexes of dominance

- ▶ the most important is the number of the most common species
- ▶ **Simpson index** of dominance
 - strongly dependent on the most numerous species in the community, less sensitive to rare species
 - with increasing value, dominance increases and equitability of community decreases, often uses its inverse or subtraction from one

$$D = \sum \left(\frac{n_i(n_i - 1)}{N(N - 1)} \right)$$

n_i – number of specimens of i -th species
 N – total number of specimens

Indexes of dominance

► Berger-Parker index

- expresses the relative importance of the most numerous species
- its inverse value is often used
- is independent of the number of species but is affected by the sample size

$$d = \frac{N_{\max}}{N}$$

N_{\max} - number of specimens of the most numerous species
 N - total number of specimens

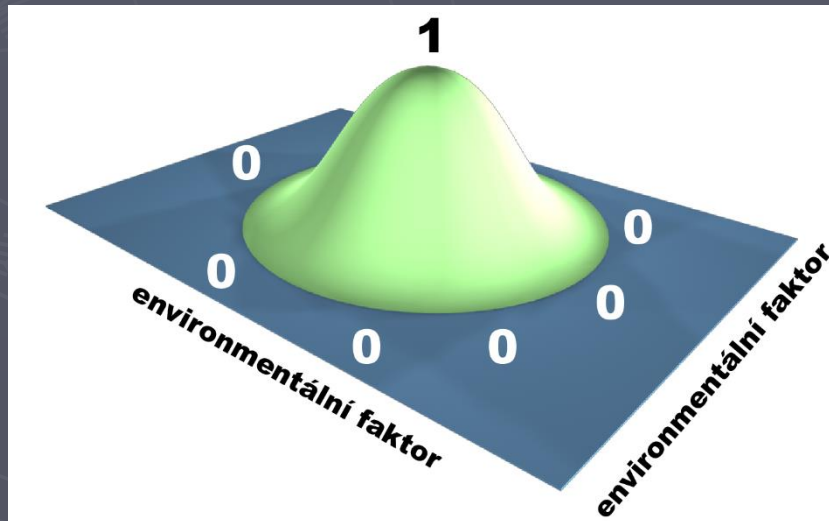
Similarity of communities

- ▶ **Association coefficients**
- ▶ dependence coefficients (0 – no dependence)
- ▶ similarity coefficients (maximum value – identical communities, minimum value – completely different communities)
- ▶ distances coefficients (distances between communities increase with the value of coefficient)
- ▶ Types of data: binary data (presence – absence)
quantitative data (abundance)

Numerical Ecology Legendre & Legendre (1998)

Similarity of communities

- ▶ asymmetric coefficients - zero values are evaluated differently than other values
- ▶ symmetric coefficients - zero values for two objects are evaluated in the same way as other values for pairs of communities
- ▶ **problem of evaluation of double absence of species**



Qualitative similarity of communities

- Association matrix – binary data

		Community B		
		1	0	
Community A	1	a	b	a+b
	0	c	d	c+d
		a+c	b+d	

a - number of parasites present in two communities (in two localities)

d - number of absences of parasites in two communities (in two localities)

b - presence of parasites at the first locality, absence at the second locality

c - absence of parasites at the first locality, presence at the second locality

Qualitative similarity of communities

- ▶ **Jaccard coefficient** - asymmetric binary coefficient

$$S(x_1, x_2) = \frac{a}{a+b+c}$$

a, b, c have the same weight

- ▶ **Sørensen coefficient**

$$S(x_1, x_2) = \frac{2a}{2a+b+c}$$

where the presence of the species is more informative than the absence

Quantitative similarity of communities

Symmetric coefficient

	Abundance of parasites									
Community a	9	3	7	3	4	9	5	4	0	6
Community b	2	3	2	1	2	9	3	2	0	6
congruence	0	1	0	0	0	1	0	0	1	1

$$S(a, b) = \text{congruence}/p = 4/10 = 0.4$$

	Abundance of parasites						aN	bN	jN
Community a	7	3	0	5	0	1	16		
Community b	2	4	7	6	0	3		22	
Minimum	2	3	0	5	0	1			11

$$S(x_1, x_2) = \frac{2jN}{(aN + bN)}$$

where aN and bN are the total numbers of individuals in the community „a“ or „b“
 jN the sum is always the lowest of the abundances of the species found in one of the communities