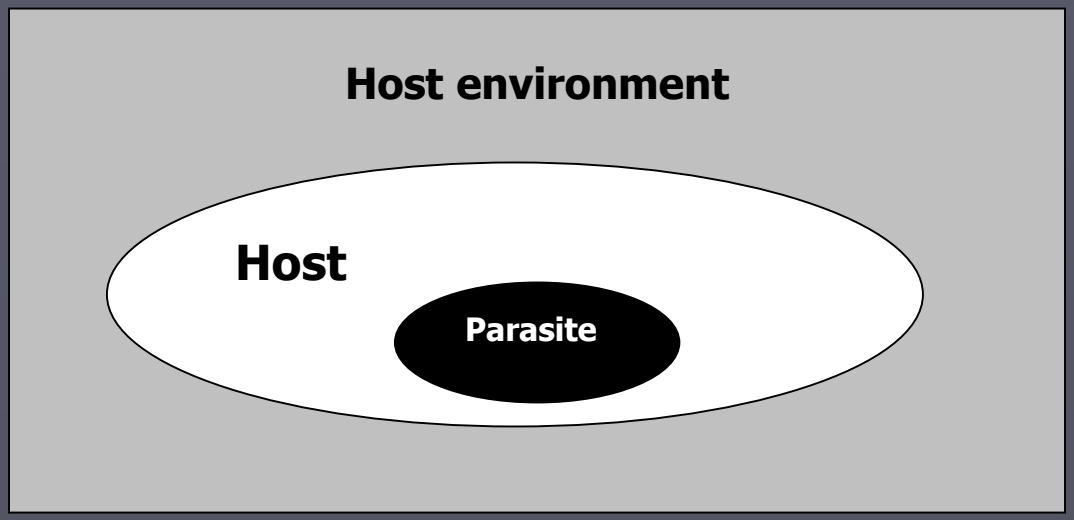
Abiotic and biotic factors affecting parasite abundance

Environment of parasites

- 2 components
- host organism (1st level environment) = biotic factors
- external environment of the host (2nd level environment) = abiotic factors



- Abiotic vs. biotic factors

1st level environment = host

- Host species
- Age
- Host size
- Sex
- Population density
- Food strategies
- Behaviour
- Hormonal activity
- Physiological conditions
- Immune response
- Stress
- Genetically fixed susceptibility to the parasite

2nd level environment = host environment

- Temperature
- Light intensity (length of photoperiod)
- Environmental gas concentrations (O_2 and CO_2)
- Salinity of the environment
- pH of the environment
- Water or air flow
- Size and type of habitat (shape and depth of the water reservoir)
- Environmental pollution - parasites as bioindicators of water quality

Epidemiological characteristics of parasitic infection

- Prevalence - the proportion of infected hosts to all examined hosts
- Intensity of infection - number of individuals of a given species of parasite on infected individual of the host (mean, min-max, median)
- Abundance - number of individuals of a given species of parasite per host individual (mean abundance ± SD, median with CI)

Abiotic factors

- 2nd level environment plus annual seasonality and latitude
- Influence on the abundance and intensity of parasite infection
- In natural ecosystems, the simultaneous influence of multiple abiotic and biotic factors

  e.g. the effect of water temperature and host body size on the abundance of fish monogeneans

Abiotic factors: temperature

- Environmental temperature
- The most important abiotic factor
- direct effect – it stimulates the reproduction of the parasites

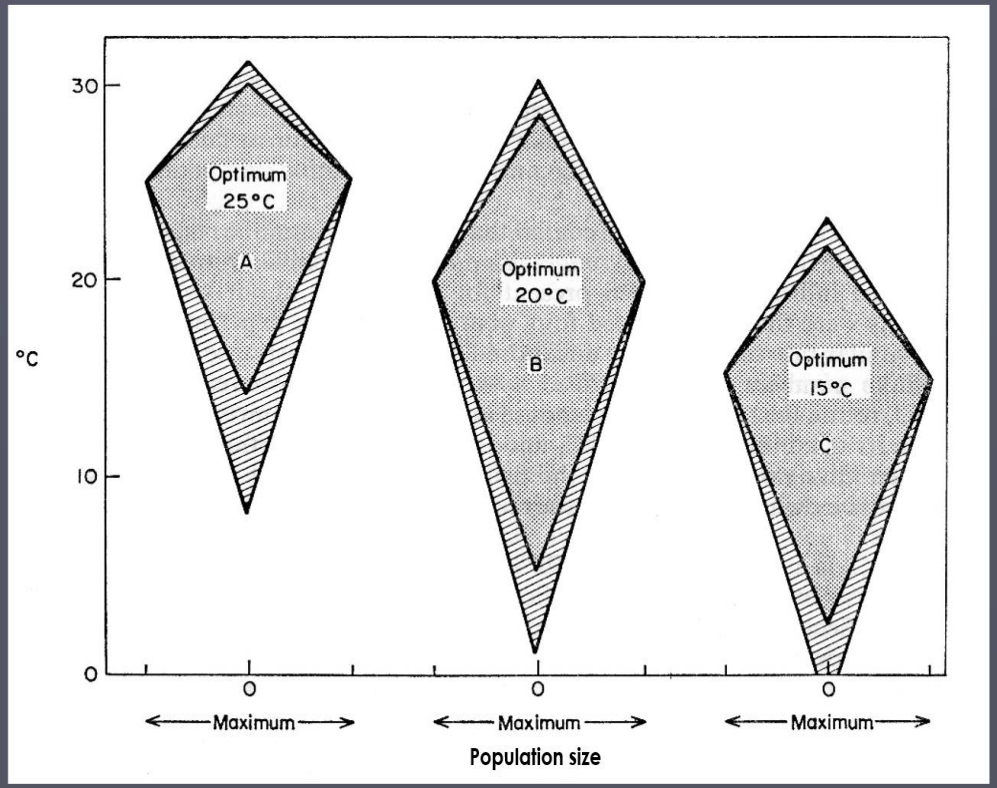
  indirect effect - effect on the physiology and immunity of the host (poikilothermic hosts)
- Temperature affects natality and mortality, presence (Cestoda, Acanthocephala) and abundance, transmission of parasites (cercariae)

Abiotic factors: temperature

- Different tolerance of species to temperature

  Monogenea - genus *Gyrodactylus* - low temperature

  genus *Dactylogyrus* - higher temperature

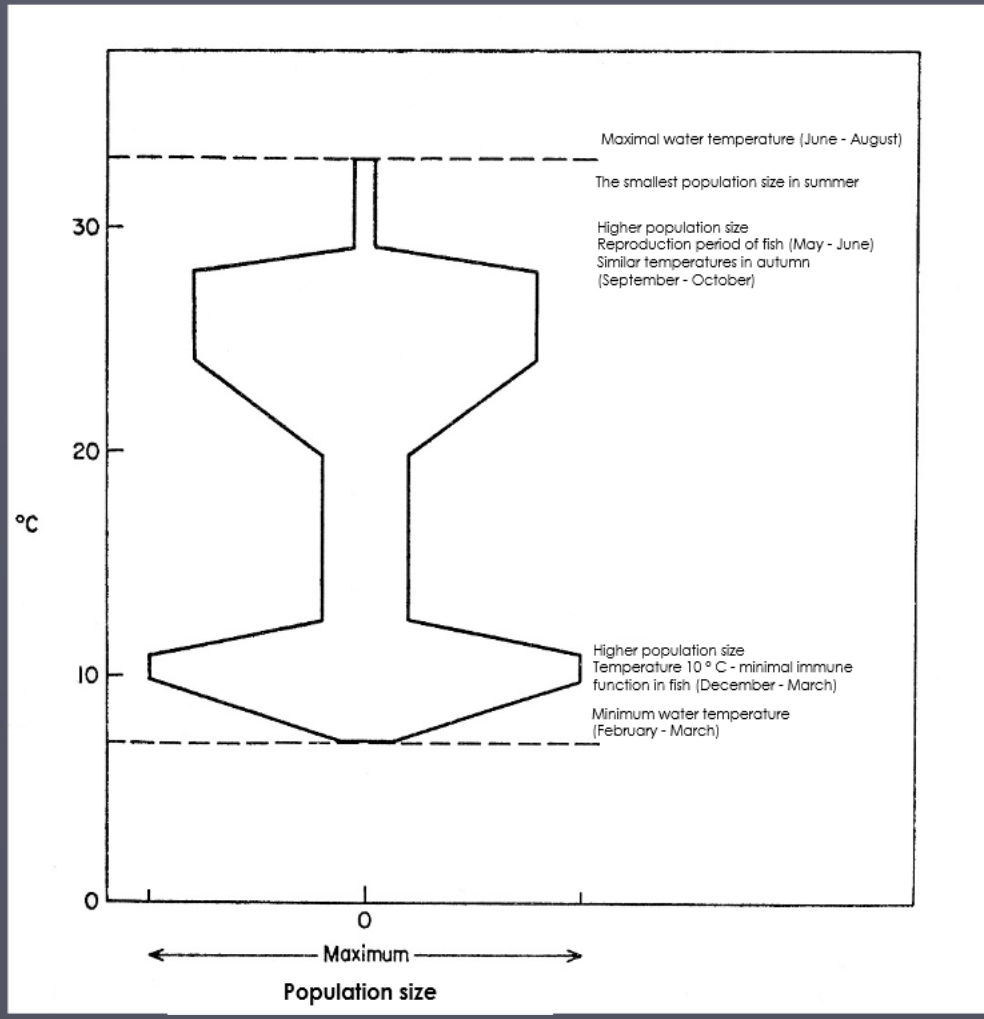


Abiotic factors: temperature

- Indirect effect of water temperature on the composition of parasite communities - temporary absence of competitive species, release of niches
- The effect of temperature can be confounded by other abiotic or biotic factors - interspecies interactions in the case of high population densities induced by temperature change
- Influence of temperature with seasonal changes - in the temperate zone → seasonal dynamics of occurrence and abundance of parasites (temperate zones)

Seasonal dynamics of occurrence and abundance of parasites

- Temperature, photoperiod length, seasonal occurrence of the host, availability of intermediate hosts, feeding behavior of the host
- Seasonal cycles in occurrence of parasites
- Monogenea, Cestoda, Nematoda
- Figure: *Gyrodactylus macrochiri* on fish *Lepomis macrochirus*



Seasonality of parasites

Seasonality of parasite occurrence

e.g. 9 species of the genus *Dactylogyrus* (Monogenea) on the gills of the roach

- abundance of 5 species increase with temperature (summer)
- presence of 4 species related to the period with lower temperature (spring, autumn)

Seasonal variability of morphology

e.g. *Gyrodactylus* – smaller sclerotized haptor structures in summer

Seasonality of reaching sexual maturity and reproduction

direct effect of temperature, indirect effect of temperature - physiology or food ecology of the host, occurrence and abundance of intermediate hosts…

Synchronization of parasite and host reproduction: *Proteocephalus* in *Leuciscus leuciscus* and *Squalius cephalus* during spawning

Seasonal changes in intensity of infection

Monthly changes in the intensity of infection of 5 species of leeches in turtles

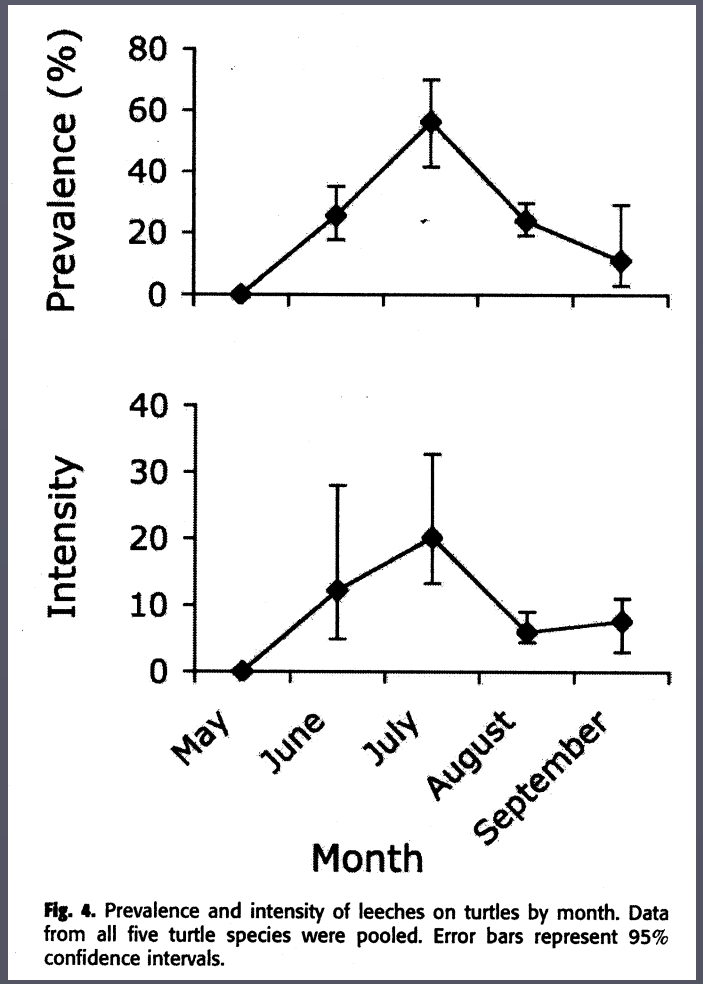
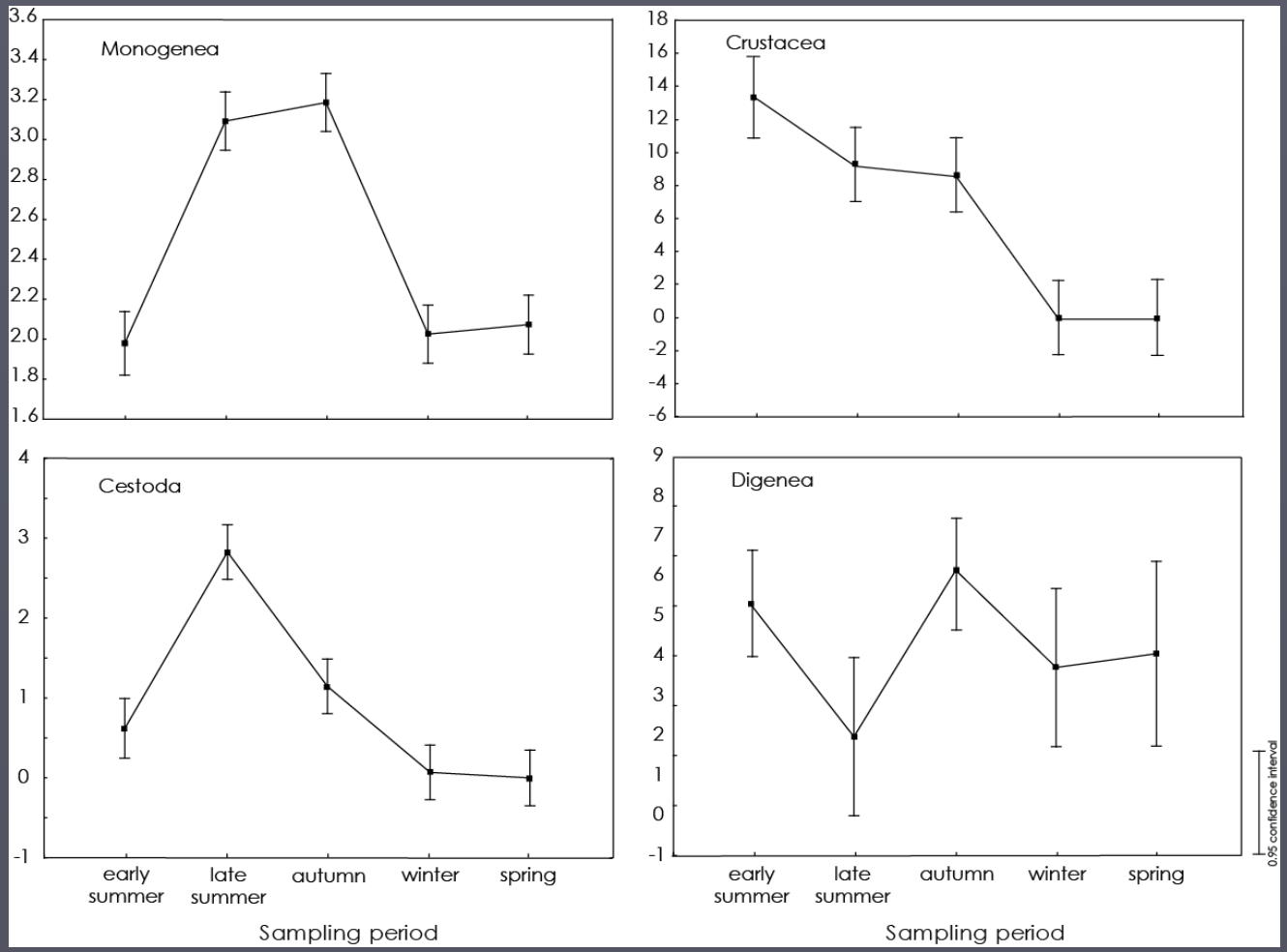


Fig. 4. Prevalence and intensity of leeches on turtles by month. Data from all five turtle species were pooled. Error bars represent 95% confidence intervals.

Seasonal changes in intensity of infection

Ex. Seasonal changes in the abundance of metazoan parasites of common carp (*Cyprinus carpio*)



Influence of water temperature on the occurrence of parasites

- Higher speciation rate
  in warm water than in cold ones
- Ex. Ectoparasites of marine fish

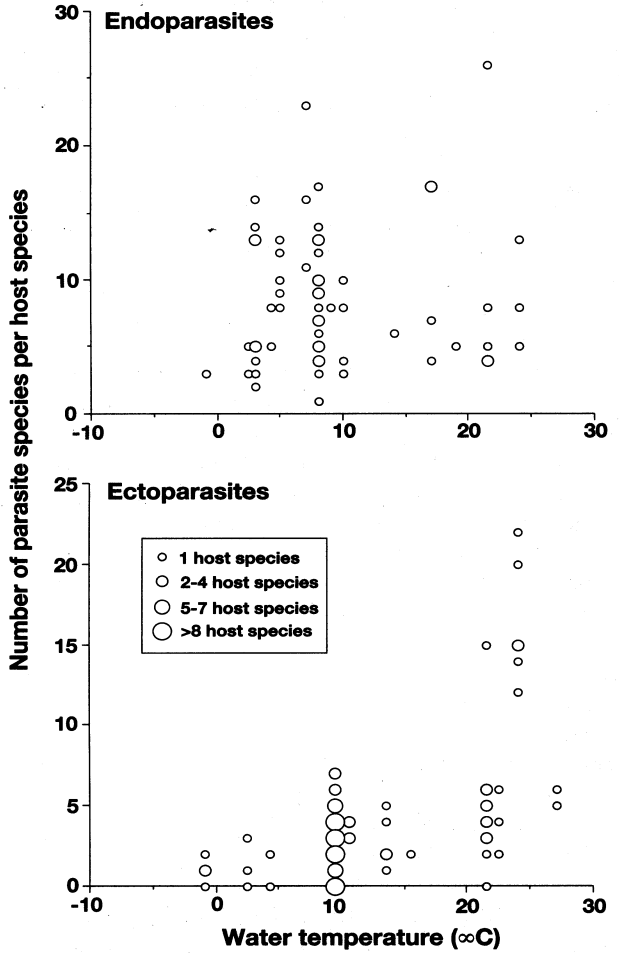


Figure 6.2. Relationship between the number of parasite species per host species and the water temperature at the sampling site. Results for endoparasitic helminths from 55 marine fish species (62 populations) and for ectoparasitic metazoans from 108 marine fish species (109 populations) are shown separately. (Data from Rohde and Heap 1998)

Biotic factors

- 1. Biology of the host - host-parasite interactions
- 2. Parasite-parasite interactions
  intraspecific
  interspecific
- Interconnection of factors
  e.g. age of the host with sexual maturity and food ecology

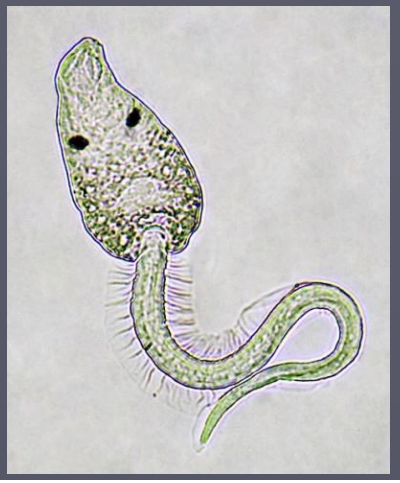
Host size

- The most frequently studied factor
- Larger host = more space for more parasites
- Host length (total length, organ length, host weight)

- Ex. The abundance of monogeneans on fish gills increase with fish size and gill size

Host size

- Ex. Trematode *Euhaplorchis californiensis* in the fish brain (*Fundulus parvipinnis*)



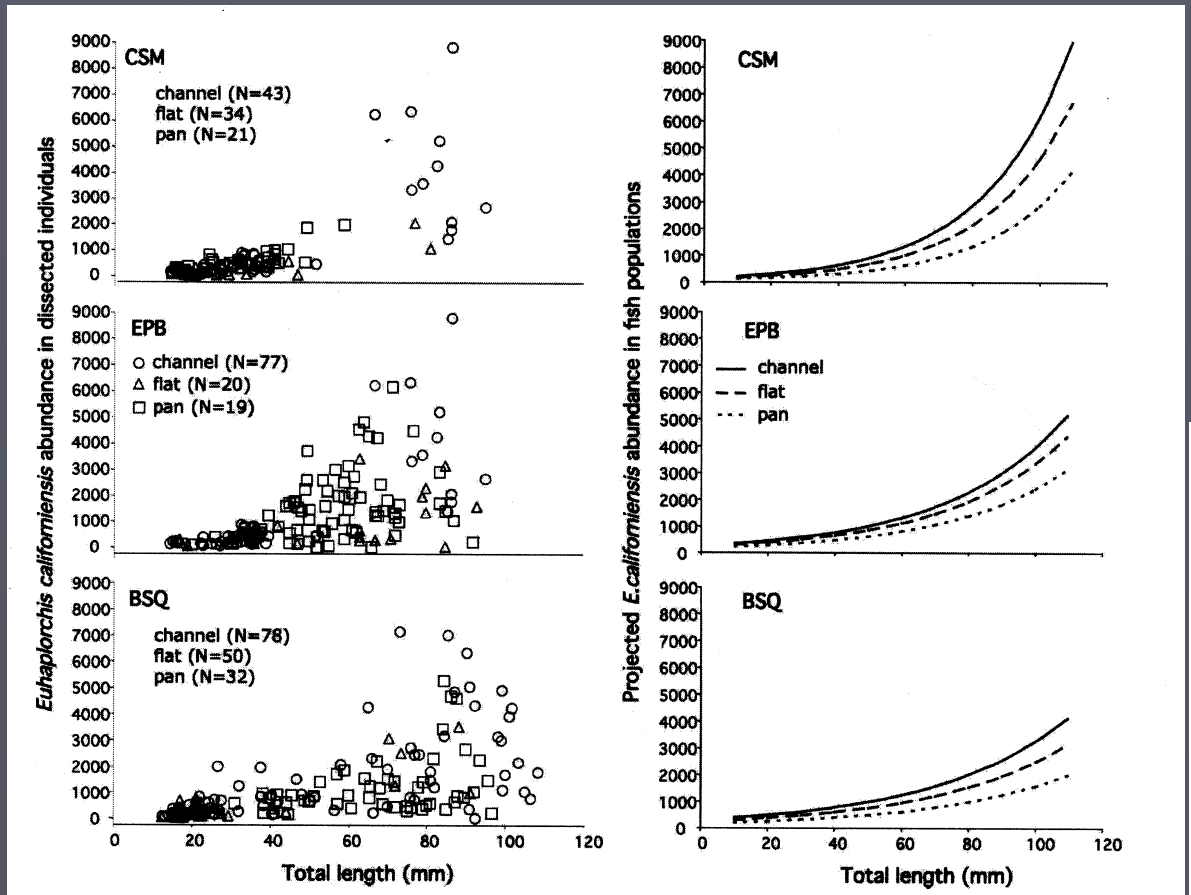
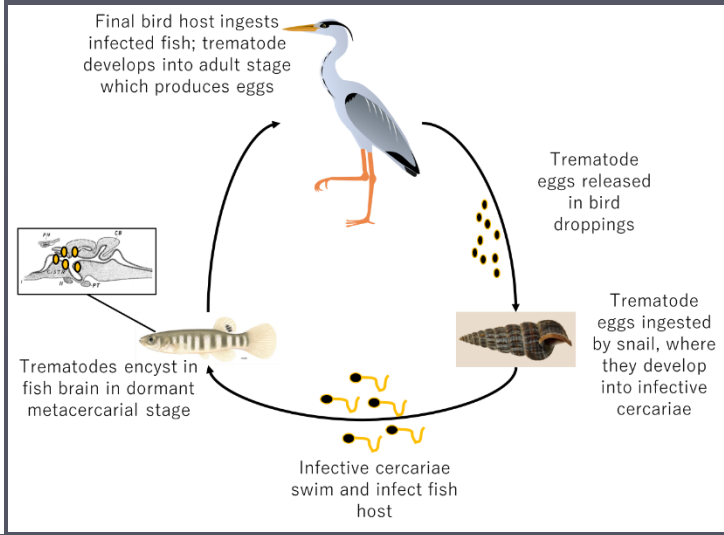


FIGURE 3. Abundance of *Euhaplorchis californiensis* in individual hosts and projected abundance in killifish populations, by habitat and estuary. CSM = Carpinteria Salt Marsh (sampled July 2003), EPB = Estero de Punta Banda (October 2002), BSQ = Bahia San Quintín (July 2004).



Host size

- Ex. Intensity of infection of an ectoparasite (*Argulus foliaceus*) in relation to body weight in different cyprinid species

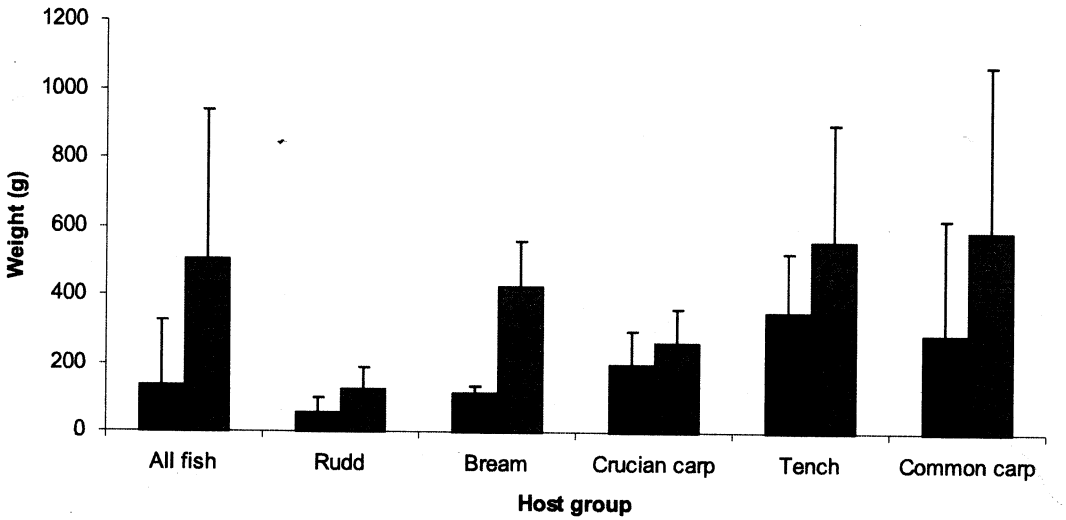


Fig. 2. Mean weight in grams of uninfested fish (black bars) and fish infested by *Argulus foliaceus* (grey bars). Error bars = 1 SD

Host age

- Correlation with the length and weight of the host
- Difference in parasite infection among age groups
  i.e. younger individuals are infected by more helminths
- Link with food strategy
- Difference in the immune system

Host size/age

Ex. Prevalence and intensity of infection of an ectoparasite (*Argulus foliaceus*) for different age categories of fish

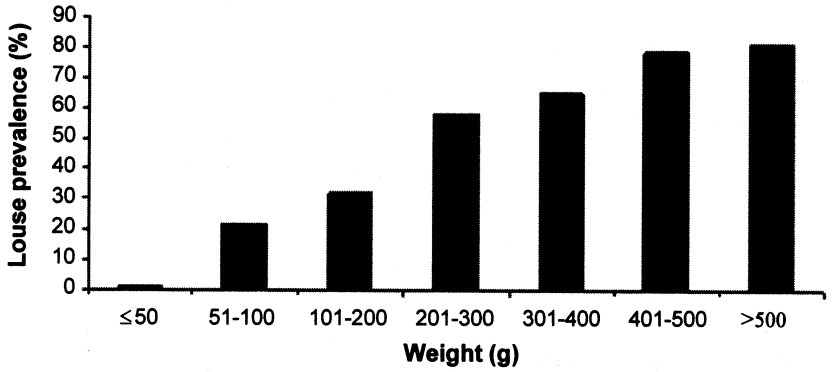


Fig. 4. *Argulus foliaceus* louse prevalence on different size classes of hosts within the whole fish community

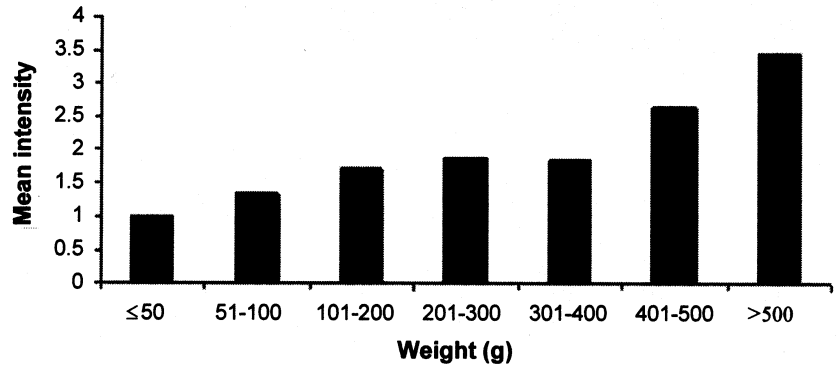


Fig. 5. Mean *Argulus foliaceus* louse intensity on different host size classes within the whole fish community

Host age

- e.g. changes in flea prevalence and aggregation in rodents (species of *Apodemus*, *Clethrionomys glareolus*, two species of *Microtus*)

- Assumption: parasite-induced mortality and acquired age-dependent resistance

  1. highest aggregation of parasites and prevalence in middle age categories (*Apodemus* and *C. glareolus*)

  2. increasing aggregation and prevalence with age (*Microtus*)

  → affected by dispersion, spatial distribution and habitat structure of the hosts

Host sex

- Controversial factor
- Differences in morphology, physiology and behavior
- Influence of steroid hormones
- Possible influence of different food ecology
- Possibly different resistance

e.g. Higher lice abundance in males than females in rodents *Oligoryzomys nigripes* – males with higher mobility and physiological stress - a consequence of the promiscuous mating system

Host sex

- The effect of host sex on parasite abundance depends on the biological attributes of the parasite

- Ex. Ectoparasites (ticks, mites, lice and fleas) in rodents *Rhabdomys pumilio*

  - higher parasitism in males than in females

  - influence of host sex on parasitism variable at the level of parasite species between localities and between species of a given taxonomic group

Host density and social behavior

- Higher density and social behavior - transmission of ectoparasites
- Ex. Relationship between population density of 19 mammalian species and abundance of strongylid nematodes

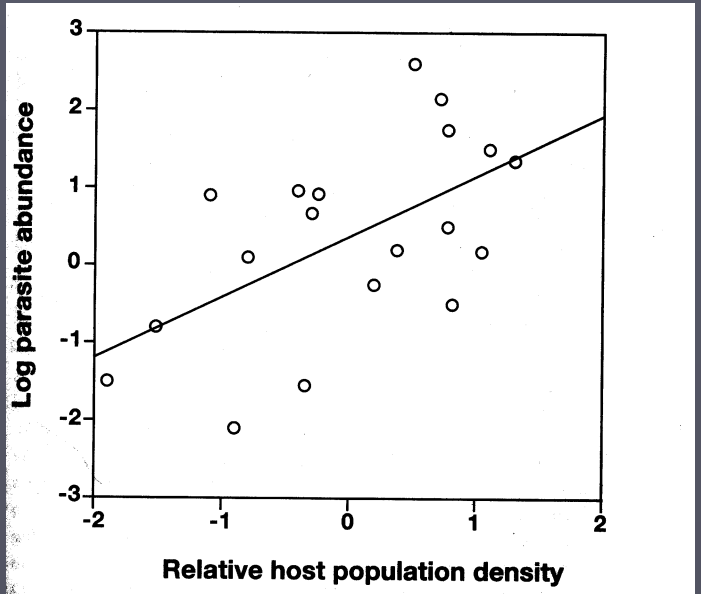
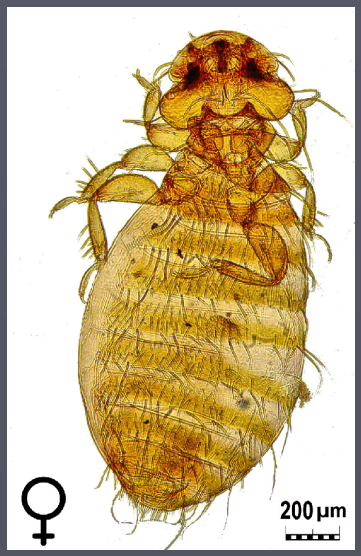


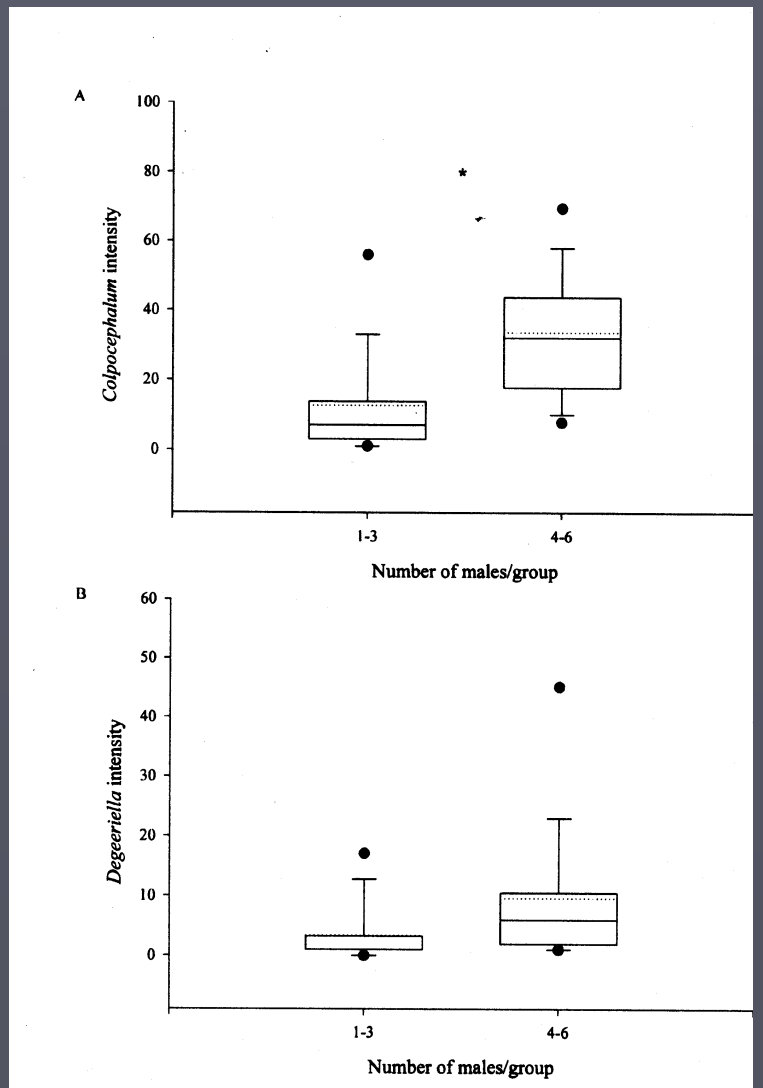
Figure 3.6. Relationship between host population density and abundance (numbers per host individual) of strongylid nematodes across 19 species of mammals. To correct for the effect of body mass, host density is plotted as residuals from a regression of density against host body mass, using log-transformed data; parasite abundance is the within-host average of all strongylid nematodes. (Data from Arneberg et al. 1998)

Host social behavior

- Lice *Colpocephalum turbinatum* in Galapagos Hawk *Buteo galapagoensis*

  - influence of host sociality on abundance of parasite



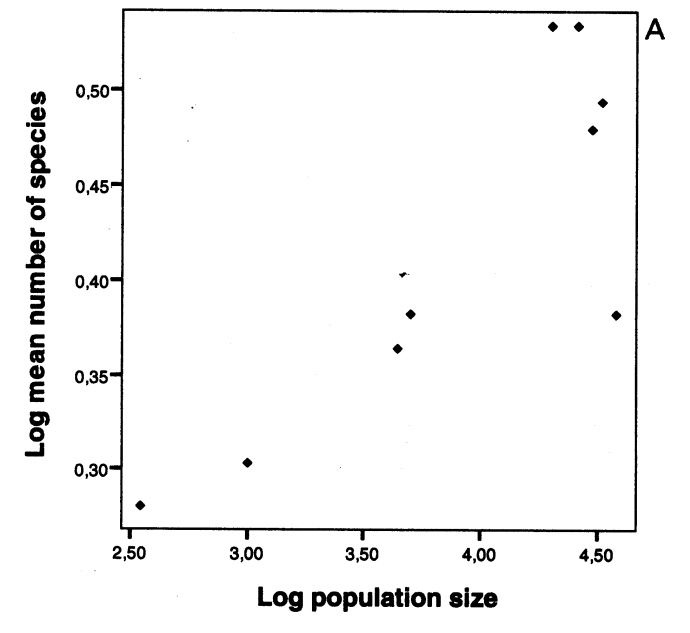


Host population size

- Abundance of Monogenea (*Dactylogyrus formosus*, *D. wegeneri*, *D. intermedius* a *Gyrodactylus carassii*) in fish (*Carassius carassius*)

- Assumption: increasing abundance with increasing host population density (density = distances between individuals)
- density is an insignificant factor
- population size (= total availability of hosts) is a significant factor

Host population size



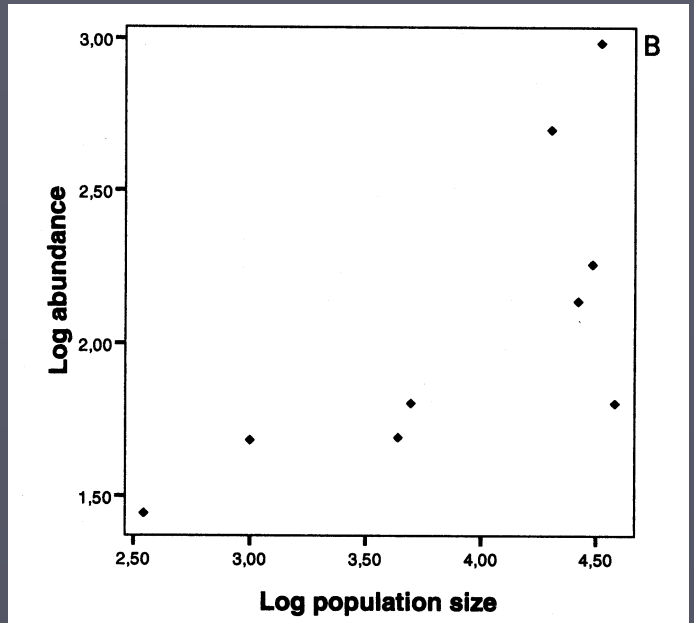
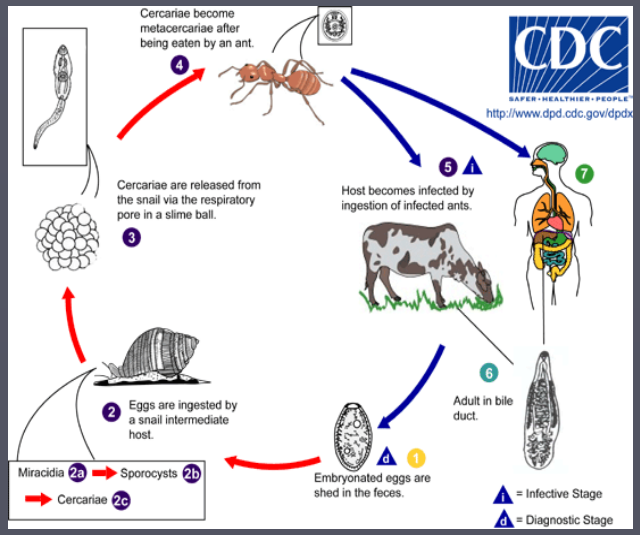


Fig. 3. (A) Relationship between host population size and the mean number of monogenean species per fish in the crucian carp populations from 9 ponds in Finland. (B) Relationship between host population size and the mean abundance of monogeneans per fish in the crucian carp populations from 9 ponds in Finland.

Food strategies

- Transmission of endohelminths (complex life cycle)
- Amount of food, proportion of components with parasite invasive stage
- Influence of seasonal changes in food supply - occurrence of intermediate host
- Position of the host in the food chain



Host physiology

- Dependent on abiotic and biotic factors

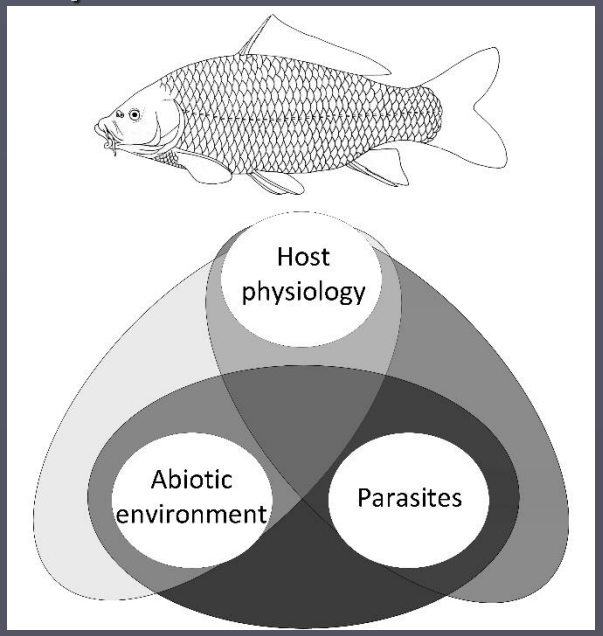
amount of food available
environmental pollution
host age
competition and other interactions

Host immune system

- Genetic factors
- Physiological and hormonal state
- Host age
- Stress
- Previous experience with infection (specific immunity)

Host immune system

- Specific host susceptible, non-specific host resistant
- Break-down of immunity - infection of a non-specific host
- Sensitivity vs. resistance - influence of genetic factors (genetic compatibility)
- Effect of water temperature on immunity in poikilothermic hosts



Host genetics

- Eel (*Anguilla anguilla*), multicellular parasites
- genes implicated in host physiology:
  - host response to environmental stress, i.e., heat shock – protein 70 (HSP70), metallothionein (MT),
  - osmoregulation - thyroid hormone receptor (THR), Na / KATPase
  - THR coloration, rhodopsins (FWO, DSO)
- Lower gene expression = digenean infection (7 species)
- Increased trophic activity of eels = nematode infection (*Anguillicola crassus*)

Host immune system

- Ex. Cellular immunity (CMI) in response to hematophagous mobile ectoparasite - fly (*Carnus haemapterus*) colonizes birds (*Coracias garrulus*) during the nesting season

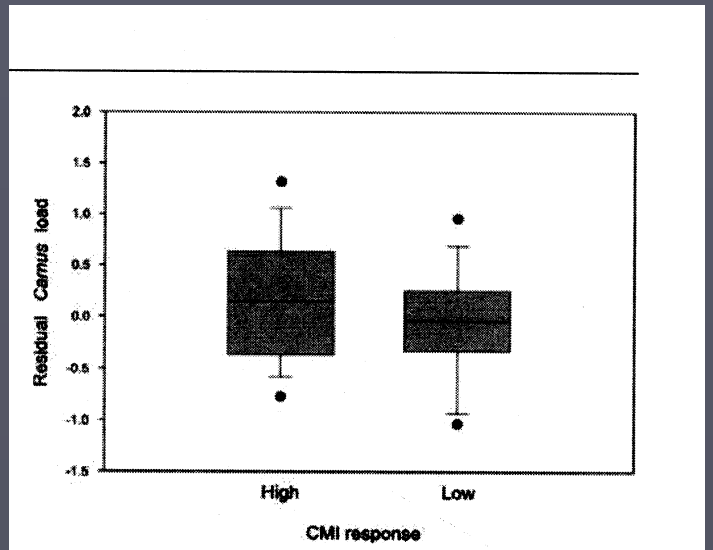


Figure 4. Difference in *Carnus* load between pairs of siblings showing a contrasting cell-mediated immunity (CMI) response but comparable size. *Carnus* load was square-root-transformed, wing length-corrected and then corrected for interannual differences. The plot shows means (solid line), lower and upper quartiles (boxes), 10th and 90th percentiles (whiskers), and outliers (dots).

Influence of environmental and host factors on parasite abundance

- Ex. Epidemiological data from 8 species of coral fish from two South Pacific islands

Table 2
List of environmental and host-related factors (both categorical (cat) and continuous (cont)) used in the multivariate regression tree.

Factors	cat-cont	Factors status (with units)
Host-related		
Host species	cat	- 8 species
Host family	cat	- 2 families
Host length	cont	- standard length, cm
Host health	cont	- hepatosomatic index
Host sex	cat	- 2 categories (male and female, for gonochoric Lutjanidae only)
Feeding behaviour	cat	- 2 categories (piscivorous, macro-invertebrate)
Mobility	cat	- 3 categories (territorial, sedentary and mobile)
Aggregation behaviour	cat	- 3 categories (solitary, group and shoal)
Environmental		
Sampled island	cat	- 2 categories (Moorea, Ua Huka)
Sampling depth	cont	- individual sampling depth, m
Habitat	cat	- 3 categories (lagoon, channel and outer slope)
Channel distance	cont	- distance to nearest channel, m
Coastal distance	cont	- distance to the coast, m
Temporal		
Sampling year	cat	- 3 categories (2005, 2006 and 2007)
Sampling month	cat	- 5 categories (March, April, May, June, July)

Influence of environmental and host factors on parasite abundance

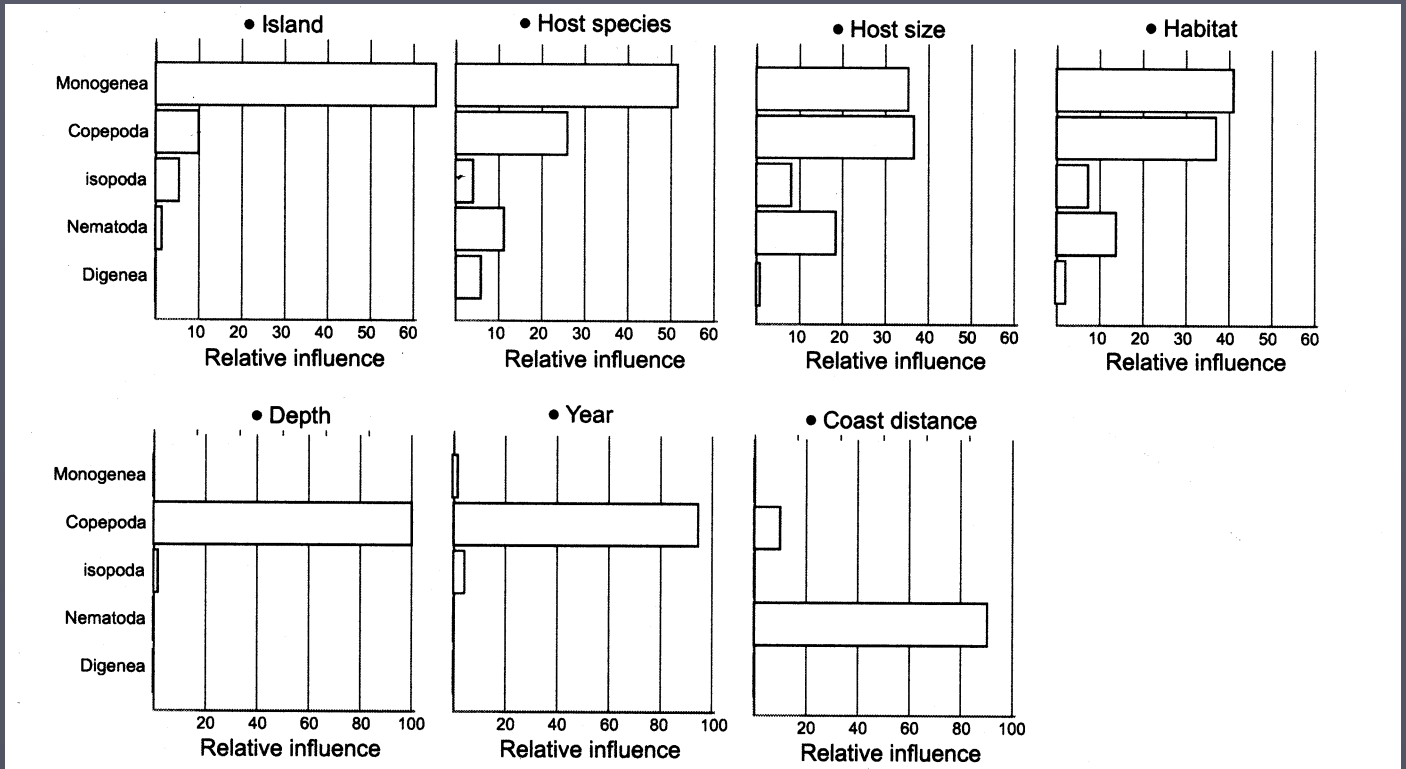


Fig. 3. Relative influence of main environmental and host determinants on the five most abundant parasite taxa. The relative influence of each variable is scaled so that the sum adds to 100, with higher numbers indicating stronger influence on the abundances.