The Ecology of Meiofauna and the Adaption to its Habitat

Marinbiologische Seminar

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What is the meiofauna?

Members of the zoobenthos defined by mesh size of sieves:

>1 mm = macrofauna

1 mm – 63 µm = meiofauna

< 63 µm = nanofauna

Depending on author and on living vs. dead

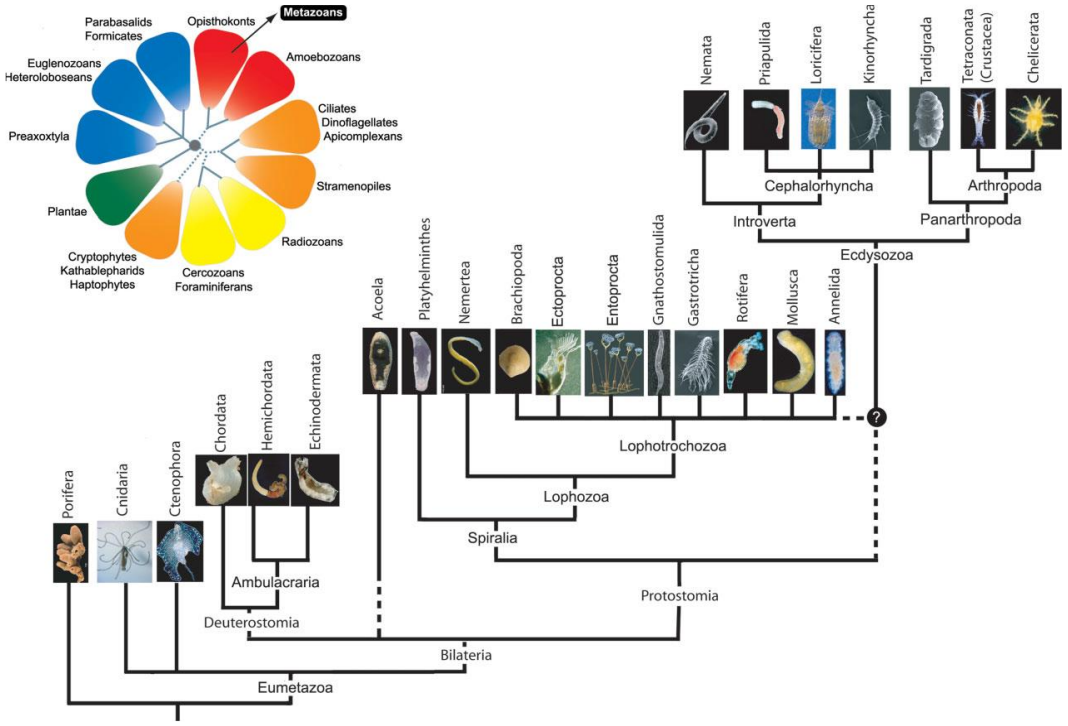
Where do they live?

Interstitial i.e. in-between sand (marine, freshwater, shore to deep sea)

Interstitial = to move between sand grains with minimum of disturbance of constituent particles

Not all interstitial animals are meiofauna! Size matters!

Who's included?



22 of 33 metazoan taxa have meiofaunal species

Only meiofaunal:

- Gastrotricha
- Gnathostomulida
- Kinorhyncha
- Loricifera

Secondary meiofaunal:

- Annelida
- Arthropoda
- Mollusca
- Etc.

Who's included?

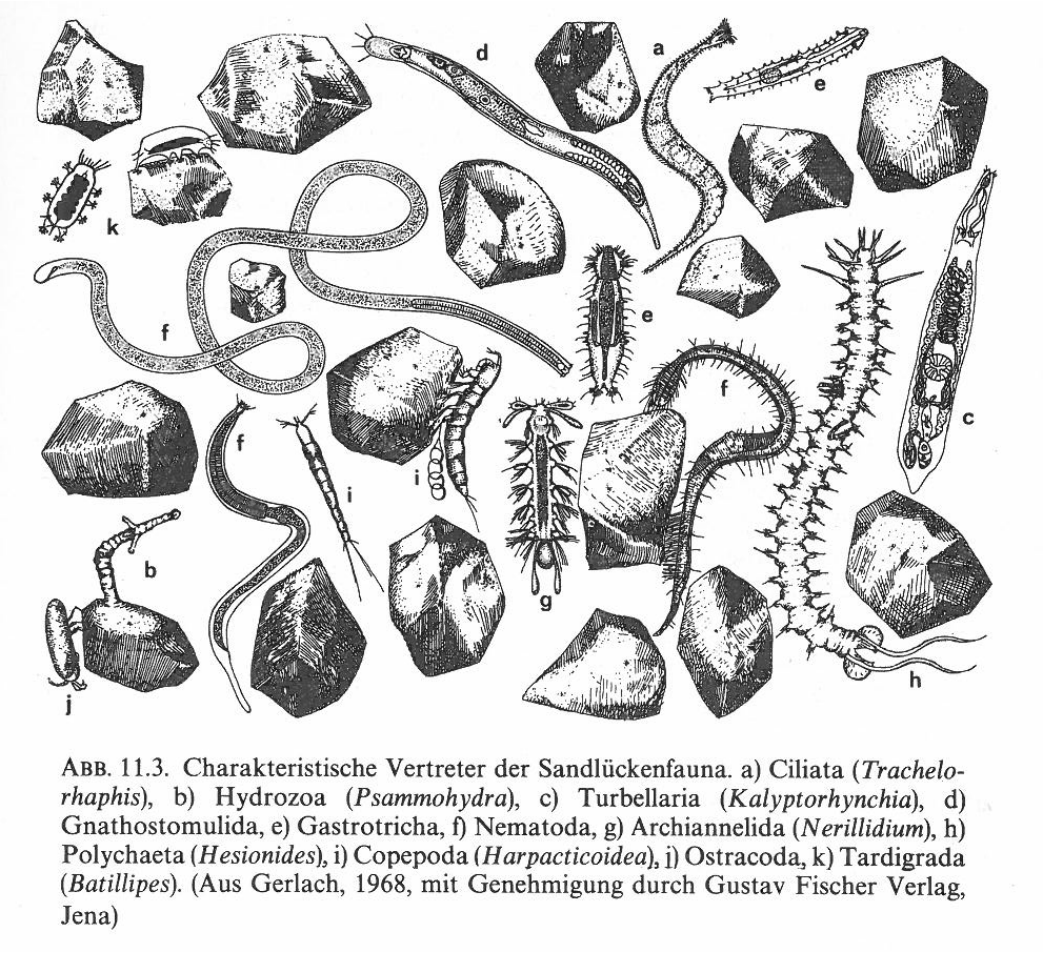


ABB. 11.3. Charakteristische Vertreter der Sandlückenfauna. a) Ciliata (*Trachelorhaphis*), b) Hydrozoa (*Psammohydra*), c) Turbellaria (*Kalyptorhynchia*), d) Gnathostomulida, e) Gastrotricha, f) Nematoda, g) Archiannelida (*Nerillidium*), h) Polychaeta (*Hesionides*), i) Copepoda (*Harpacticoidea*), j) Ostracoda, k) Tardigrada (*Batillipes*). (Aus Gerlach, 1968, mit Genehmigung durch Gustav Fischer Verlag, Jena)

Dominance:
Up to 50 % Nematoda
2nd often Harpacticoid Copepoda

Depending an location also
Gastrotricha, Isopoda, Ostracoda

General aspects

- Certain taxa are restricted to certain sediment types and vertical distribution in the sediment
- Anoxic layers of certain sediment types harbor few meiofauna, most meiofauna in upper 2 cm of sediment
- Meiofaunal biomass in estuaries and deep-sea tend to equal that of macrofauna
- 10^6 meiofaunal organisms per m^2 in most shallow areas of the world
- Changes in tidal exposures are often the primary factors limiting sandy beach interstitial fauna
- Sediment grain size is a primary factor affecting the abundance and species composition – muddy vs. sandy vs. phytal habitats

Grain size

Millimeters (mm)	Micrometers (μm)	Phi (ϕ)	Wentworth size class		Rock type
4096		-12.0	Boulder		
256		-8.0	Cobble	Gravel	Conglomerate/ Breccia
64		-6.0	Pebble		
4		-2.0	Granule		
2.00		-1.0	Very coarse sand		
1.00		0.0	Coarse sand		
1/2 0.50	500	1.0	Medium sand	Sand	Sandstone
1/4 0.25	250	2.0	Fine sand		
1/8 0.125	125	3.0	Very fine sand		
1/16 0.0625	63	4.0	Coarse silt		
1/32 0.031	31	5.0	Medium silt		
1/64 0.0156	15.6	6.0	Fine silt	Silt	Siltstone
1/128 0.0078	7.8	7.0	Very fine silt		
1/256 0.0039	3.9	8.0			
0.00006	0.06	14.0	Clay	Mud	Claystone

www-odp.tamu.edu

Most meiofauna in sand

Pore volume of sand is approx. 30 – 40 % of total volume sandy sediment

Grain sizes below 0,1 mm (silt, mud) exclude most meiofauna

Vertical distribution

- Controlled by redox potential discontinuity (RPD) = boundary between aerobic and anaerobic sediments
  - On sandy high energy beaches to a depth of up to 50 cm
- Desiccation: meiofauna is sensitive to low water content => migrates with tide, seasonally and diurnally

Vertical distribution

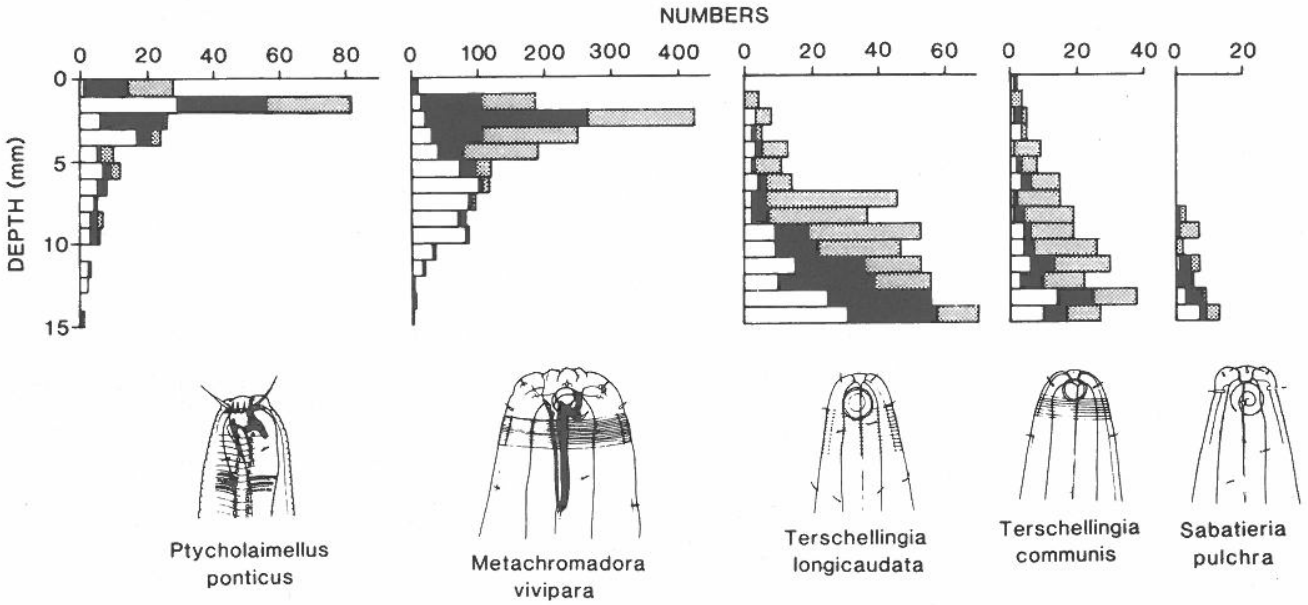


Figure 3.2.--Fine-scale vertical distribution of the dominant nematode species at one site in Tamar Estuary, U.K. Darker shading infers more individuals. Nematode heads are drawn to scale to show buccal structures (from Warwick and Gee, 1984).

Horizontal distribution

- Near estuaries: distinct relation between salinity and meiofaunal assemblages, decrease in number of species as brackish water is approached

- Desication: migration with the tide

Horizontal distribution

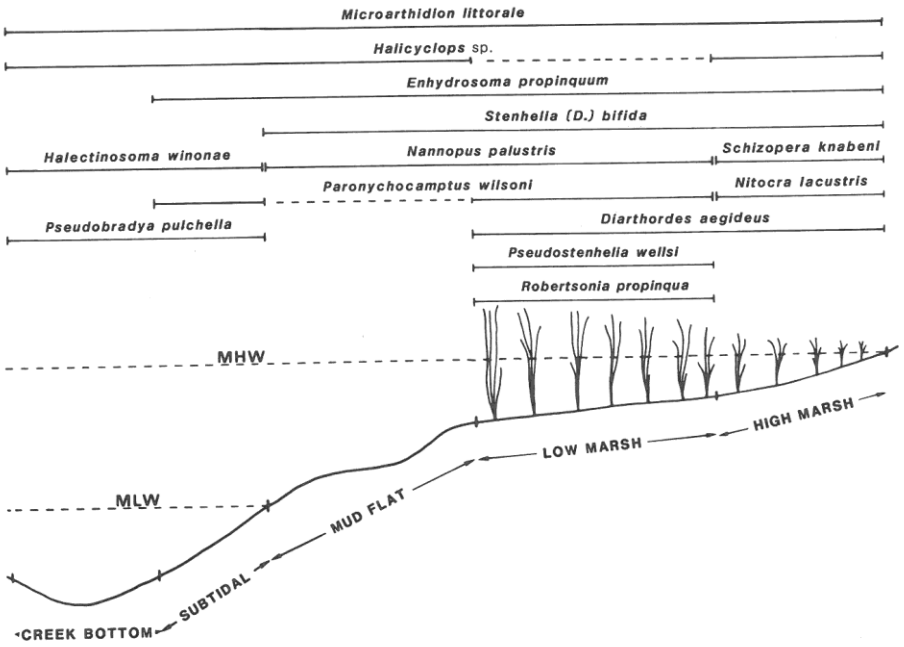


Figure 3.4.--Horizontal distribution of the dominant copepod species in muddy Southeastern United States salt marshes (from Coull et al., 1979).

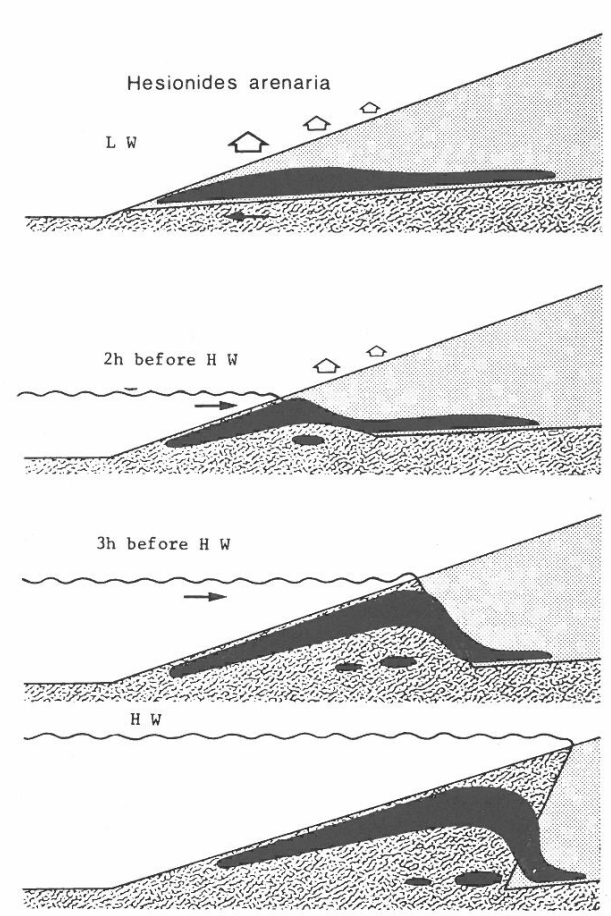


Figure 3.1.--Horizontal migration of the interstitial polychaete *Hesionides arenaria* as the tide floods a sandy beach. The dark striped area represents the *H. arenaria* population (from Meineke and Westheide, 1979).

Dispersion – Patchiness

The meiofauna is patchy in its distribution

- Large scale (km – m): salinity, tidal exposures, sediment granularity, oxygen concentration

- Small scale (cm): animal-habitat processes: food distribution, biogenic structures from macrobenthos, interspezific competition

Dispersal

Meiofauna inhabit some of most dynamic environments but are considered sedentary. Still there is worldwide distribution of some species

Dispersal is given by:

- airborne animals
- rafting and drifting materials
- transport in ballast of sailing vessels
- suspension in water column

Colonization is rapid

Evolution and adaption of meiofauna

- Meiofauna might exist since the presence of its habitat – rock based sediments already before Cambrium; biogenic sand later (corals, mollusks, foraminifers)

- Deep evolutionary origin of meiofauna in marin benthic habitats

Evolution and adaption of the meiofauna

Miniaturization and reduction, convergent evolution

- No coeloms (primary, secondary, acoelomate larval condition)
- Eutely: constant cell number, growth through increase in cell size rather than cell number

Evolution and adaption of the meiofauna

Miniaturization:

Pedomorphosis = retention of the larval stage

No metamorphosis in distinct adult stage

Direct development

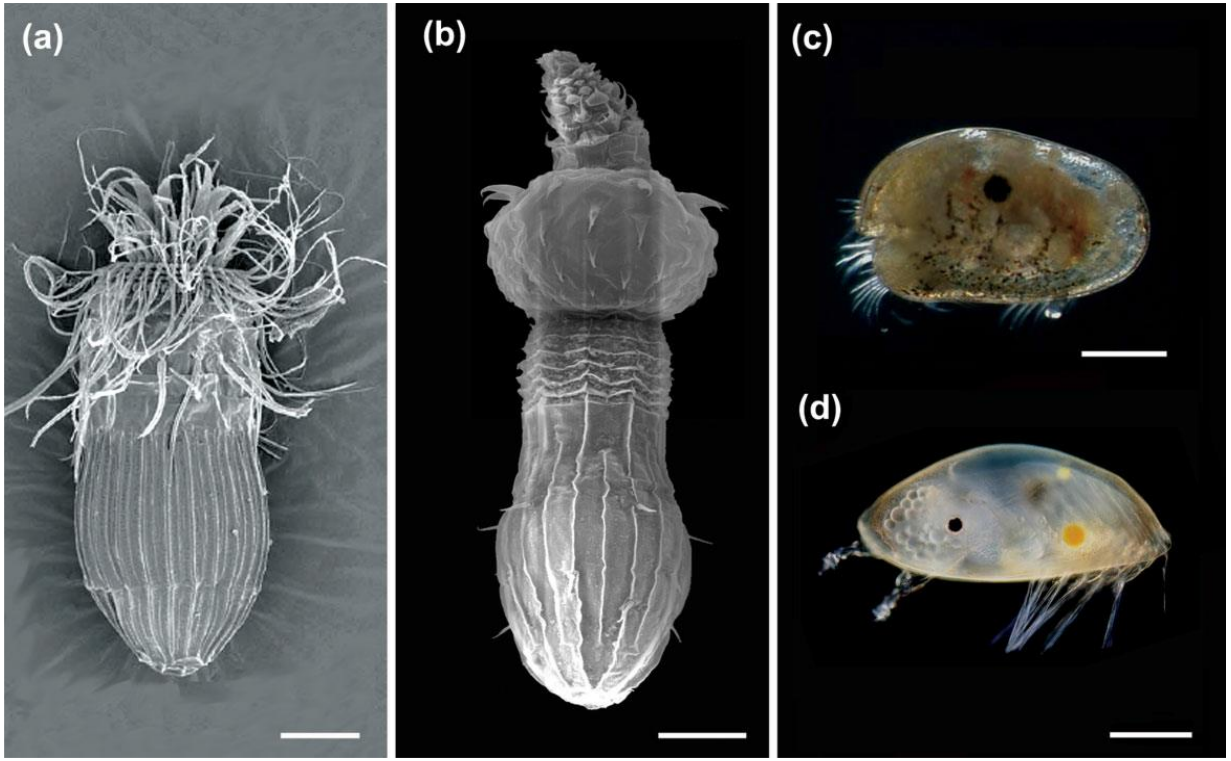
Pedomorphosis

- Progenesis = acceleration in maturation of gonads relative to duration of somatic development

- Neoteny = retardation of somatic development relative to gonadal maturation

Hard to distinguish in practice

Pedomorphosis

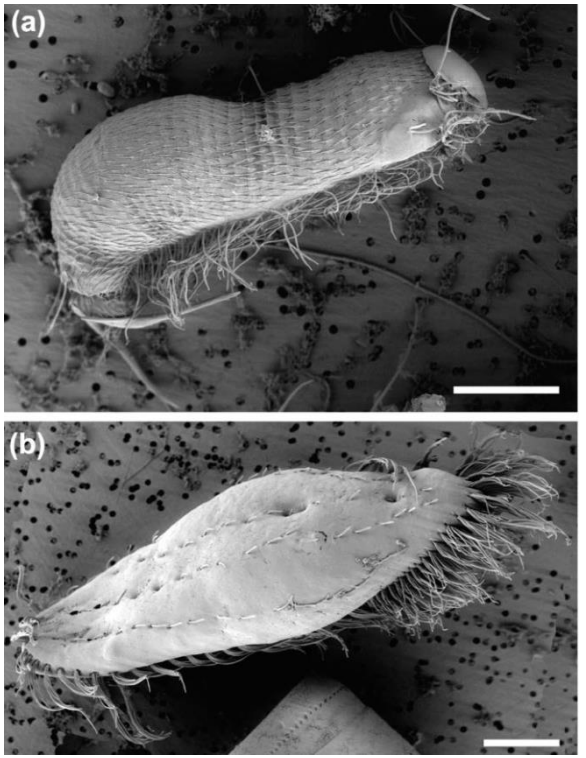


a) Adult loriciferan (Scale-bar 30µm) b) larval priapulid (SB 100 µm)
c) Adult ostracode (SB 100 µm) d) Cypris larva of a barnacle (SB 100µm)

Convergent adaptions

- Vermiform shape
- Highly differentiated cilia
- Adhesive structures
- Direct development

Convergent evolution also between Metazoa and Ciliata



a) Gastrotrich (multicellular)
b) Ciliate (single-celled)
Scale-bars 10 µm

Literature an picture credit

- **S.A. Gerlach**: *Marine Systeme*; Springer, 1994
- **R.P. Higgins, H.Thiel** (editors): *Introduction to the Study of the Meiofauna*; Smithsonian Institution Press, 1988
- **R.J. Rundell, B.S. Leander**: *Masters of miniaturization: Convergent evolution among interstitial eukaryotes*; Bioessays 32: 430-437, 2010