

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

The Edaphon:

- community of all organisms in soil
- makes up for 1-10 % of organic matter in soil (dry weight)
- consists of
 - Phytoedaphon: algae, cyanobacteria, bacteria, actinomycetes, fungi
= soil microflora (3/4 of total edaphon dry weight)
 - Zooedaphon: soil fauna including heterotrophous Protozoa (1/4 of total edaphon dry weight)

Classification of soil biota (the edaphon) according to

- taxonomy
- trophic position
- occurrence - preferred soil layer
- body size / ecological function

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- **taxonomy**
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- occurrence - preferred soil layer
- body size / ecological function

Principal trophic groups:

- saprophages or saprotrophs / detri(ti)vores / decomposers, reducers
 - includes mircobivores (fungivores + bacteriovores)
 - includes necrophages (carrion feeders, scavengers)
- phytophages / herbivores (feeding on roots or algae)
- zoophages / carnivores / predators

Decomposers often synonymous to “**reducers**“ (decomposition processes more often oxidative than reductive), **destruents** (Czech: rozkladači, decompozitoři / reducenti, destruenti)

Reducers sensu stricto: organisms mineralizing organic matter (fungi, bacteria), do not have to be in soil.

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- taxonomy
- trophic position
- **occurrence - preferred soil layer**
- body size / ecological function

Groups according to preferred soil layer:

- Euedaphon: - permanently living in soil, geobionts (Pelikán)
 - in deeper soil layers (Schaefer)
- Hemiedaphon: - occasionally in soil (Pelikán)
 - in the uppermost mineral soil layer and litter layer (Schaefer)
- Protoedaphon: - only some developmental stages in soil, geophiles (Pelikán)
- Pseudoedaphon: - occasionally in soil: refuges, hibernation, foraging (Pelikán)
- Tychoedaphon: - accidental occurrence in soil (Pelikán)
- Epigeon (egigaion, epigeic animals): directly on the soil surface (vs. hypergaion in the vegetation, sometimes synonymus to atmobios)

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Classification according to body size into micro-, meso-, macrofauna (sometimes additionally megafauna) – two alternative approaches based on body length and body width

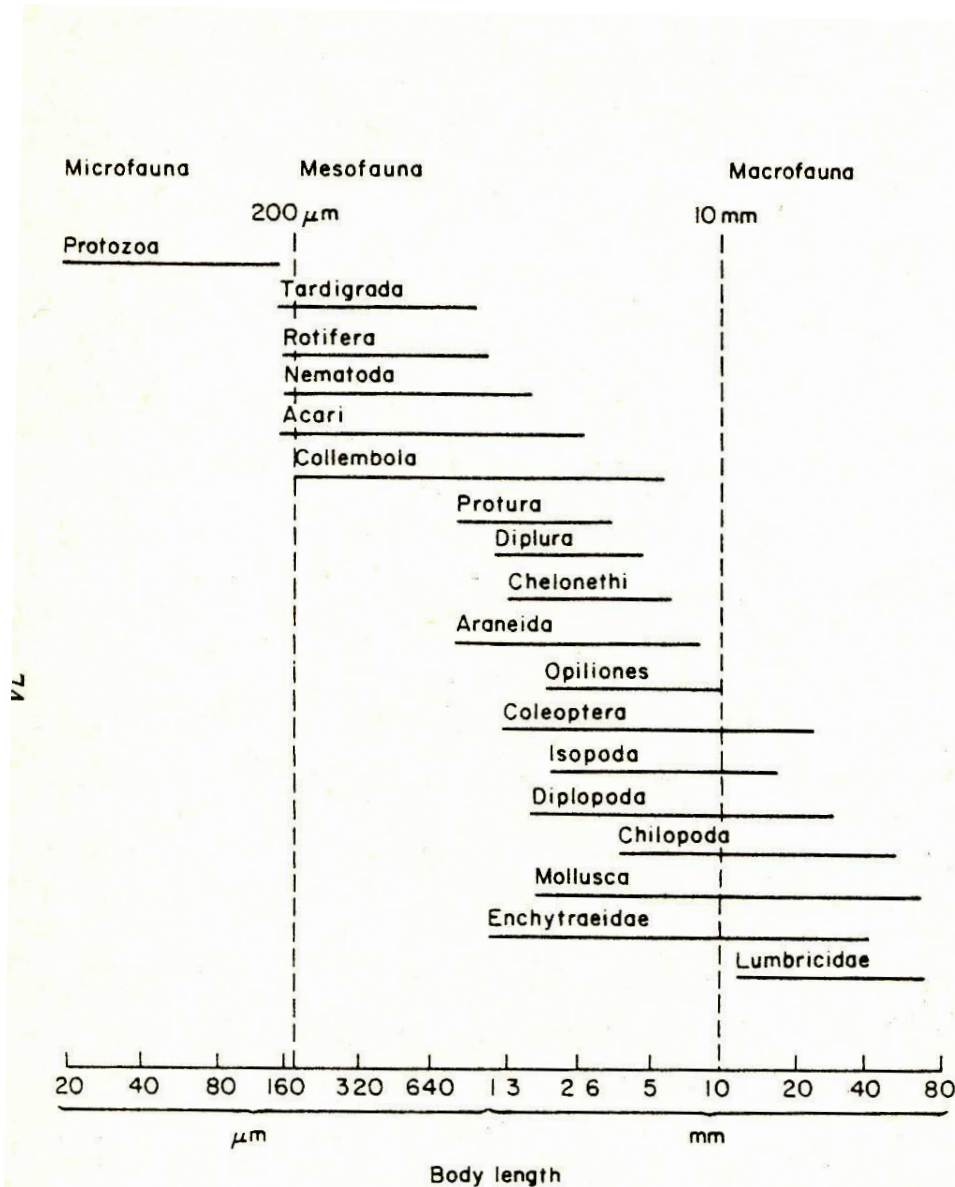


FIG. 3.2. Size classification of the temperate soil fauna by body length (after Wallwork 1970).

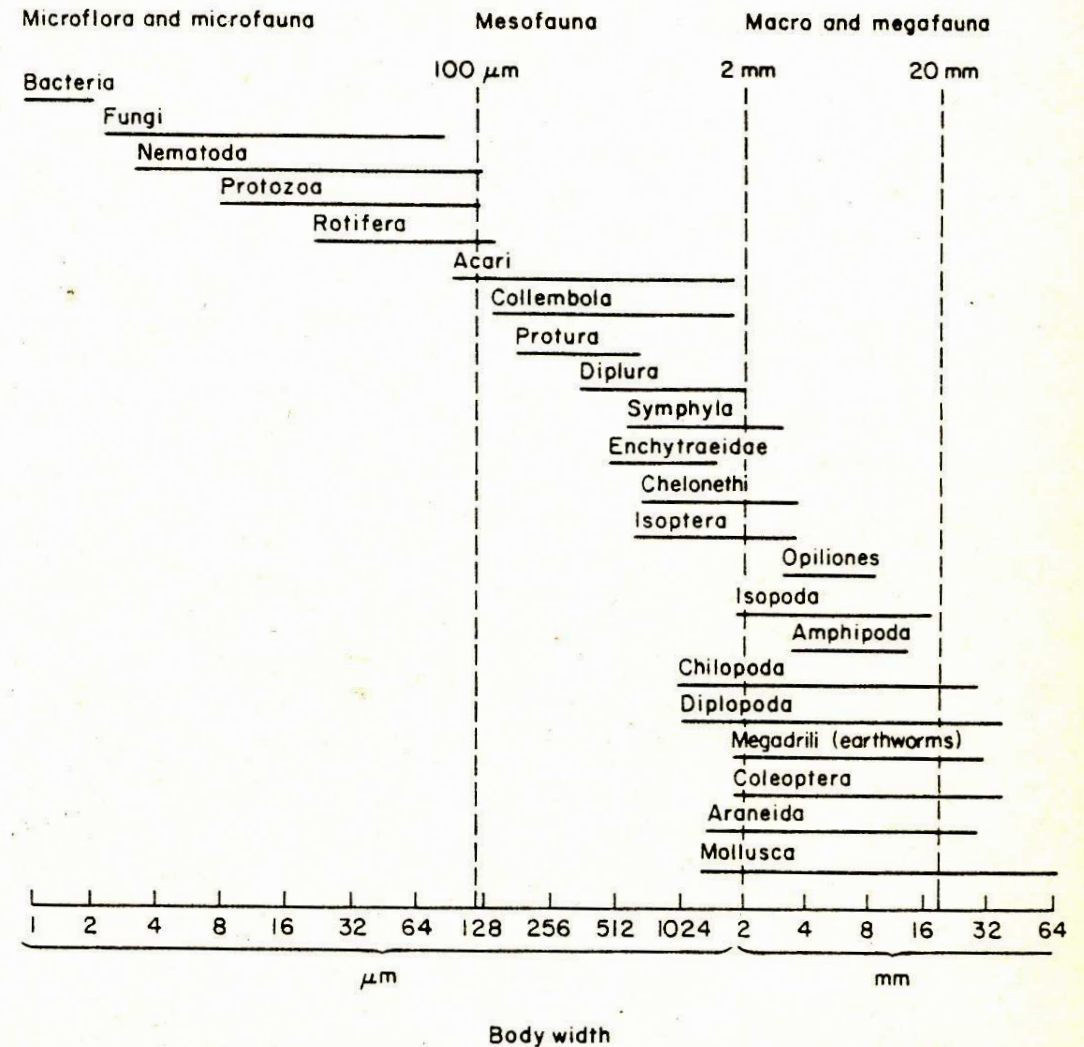


FIG. 3.3. Size classification of organisms in decomposer food webs by body width.

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Vertical distribution of soil animals
(according to soil depth in cm)

- Figure shows soil arthropods only

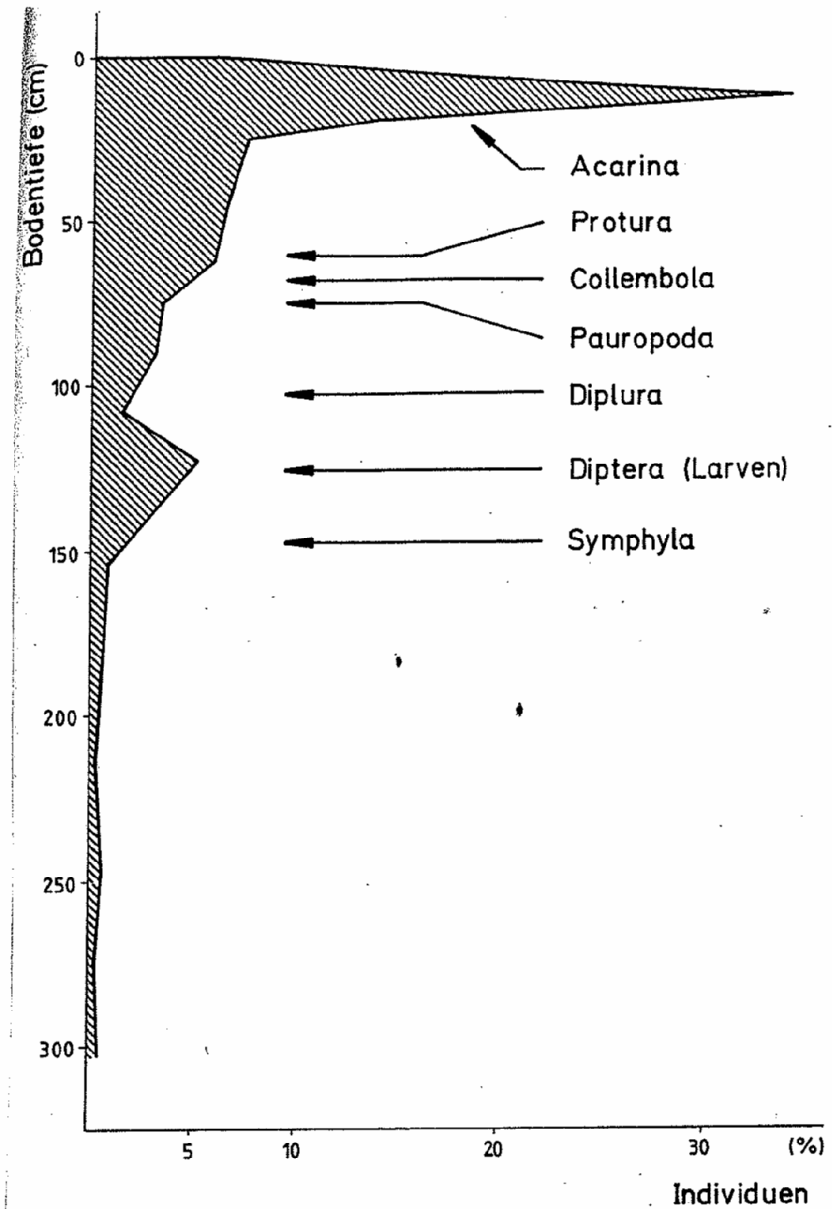


Abb. 66: Vertikalverteilung der Arthropoden in landwirtschaftlich genutzten Böden, und durchschnittliche Besiedlungstiefe der Tiergruppen (Daten nach PRICE und BENHAM 1977).

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Vertical distribution of soil animals s.l. in a beech forest with mull humus

	% carbon	Carbon/nitrogen ratio	Microbial biomass	Testacea	Amoebina	Flagellata	Turbellaria	Rotatoria	Nematoda	Enchytraeidae	Lumbricidae	Tardigrada	Harpacticoida	Cryptostigmata	Other Acarina	Chilopoda	Other macrofauna	Symphyla	Diptera	Protura	Collembola	Dipterous larvae
Litter L+O _f	56	40-25	3								x			32	29	26	x	o	x	9	27	17
Soil depth (cm) 0 - 3	7	14	33	x	60	64	50	58	26	40	x	38	74	36	40	53	x	x	x	25	39	45
3 - 6			15	x	40	36	28	21	25	28	x	24	19	20	11	21	o	o	o	16	20	17
6 - 9	5	13	14				18	15	18	19	x	24	5	9	14		o		o	30	9	
9 - 12	4	13	35				5	7	16	14	x	16	3	3	6		o		o	20	4	12
< 12	<3	<13							15		x						o		o			9

Fig. 6.1. Vertical distribution of the soil and litter biota in a beech forest on limestone with a mull soil (Göttinger Wald). The rectangles indicate the compartments analysed. Numbers are % of the total population. Most values refer to the annual mean of population density for 1980, 1981 or 1982; the microbial biomass refers to the 28th week of 1981. % carbon: % organic C of soil dry wt. x: high value. o: low value. Based on mostly unpublished data from R.G. Jörgensen (soil parameters), K.H. Domsch and M. Vanselow (microflora), R. Meisterfeld (Protozoa), A. Mellin (Enchytraeidae), U. Heitkamp (Nematoda), V. Büttner (other semiaquatic groups), H.-D. Baaske (Cryptostigmata, other Acarina), T. Poser (Chilopoda), Wolters (1983, 1985 and pers. comm., 1986) (Protura, Collembola) and Hövemeyer (1984, 1985 and pers. comm., 1986) (Diptera).

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Horizontal distribution of soil animals

Example: *Isotomurus palustris* (Collembola) – each individual shown as a dot; *Trogophloeus pusillus* (Coleoptera: Staphylinidae) – each individual given as a x) on a 1 square meter plot.

The two distributions are independent from each other.

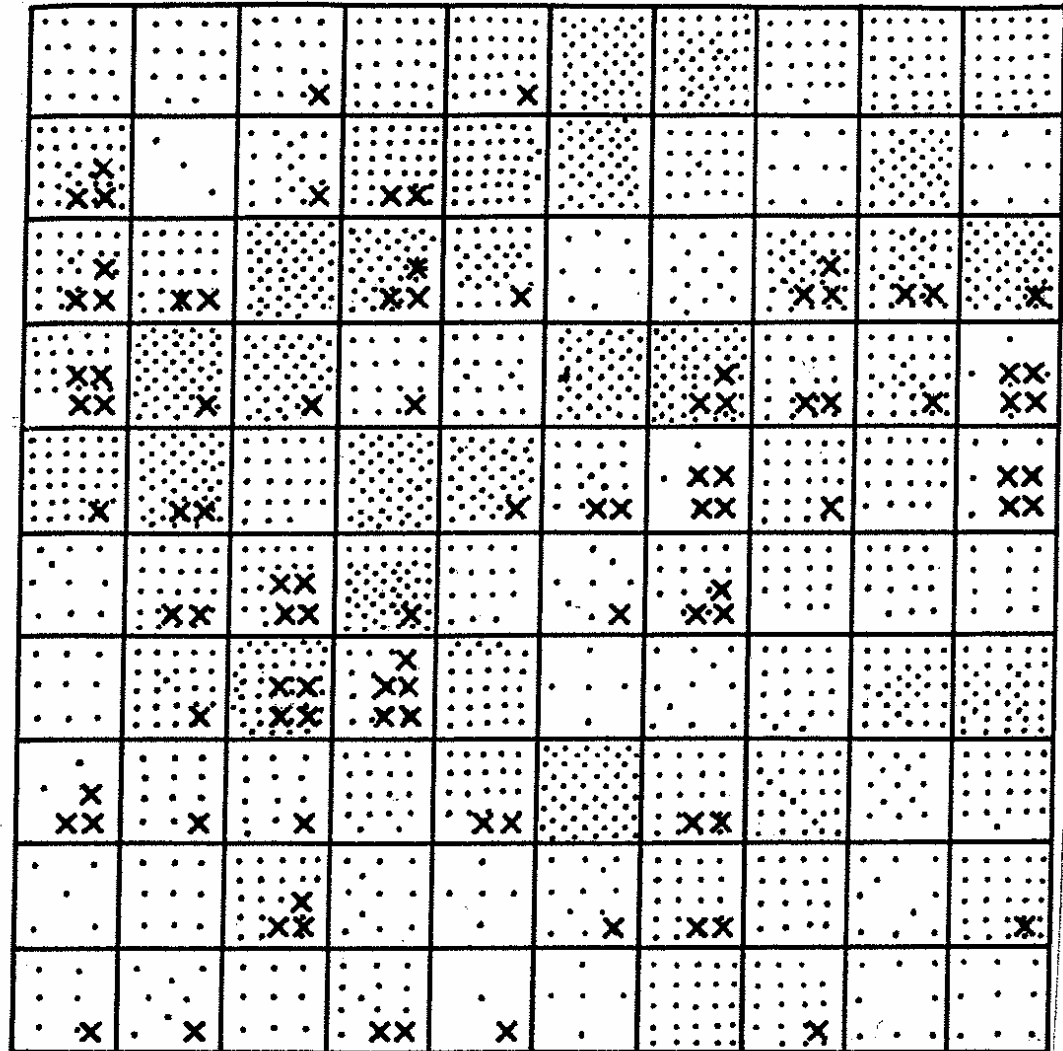


Abb. 65: Verteilungsmuster des Collembolen *Isotomurus palustris* (jedes Tier ist durch einen Punkt wiedergegeben) und des Kurzflüglers *Trogophloeus pusillus* (jedes Tier ist durch ein x wiedergegeben) auf 1 m². Die Verteilungen sind geklumpt und unabhängig voneinander (ver. nach TOPP 1971).

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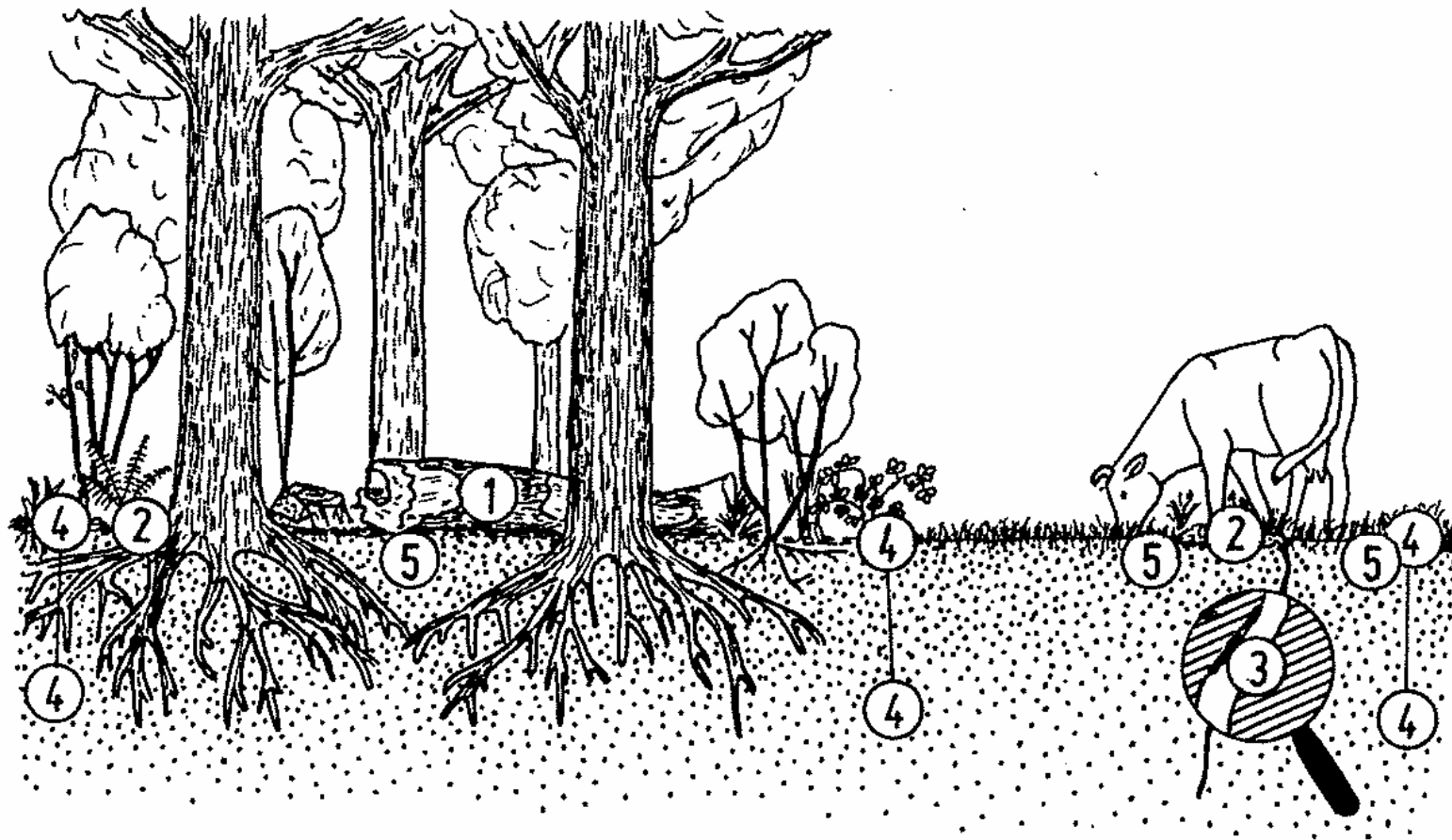


Abb. 72: Räumliche Verteilung der Regenwürmer in einem Wald und einem Weideland: 1) *Dendrobaena tenuis*, 2) *Lumbricus rubellus*, 3) *Dendrobaena mammalis* 4) *Lumbricus terrestris* und *Allolobophora longa* 5) *Octolasion cyaneum* (nach BOUCHÉ 1971).

Spatial distribution of earthworm species in a forest and pasture land: species show different preference for macro- (woodland vs grassland) and microhabitat.

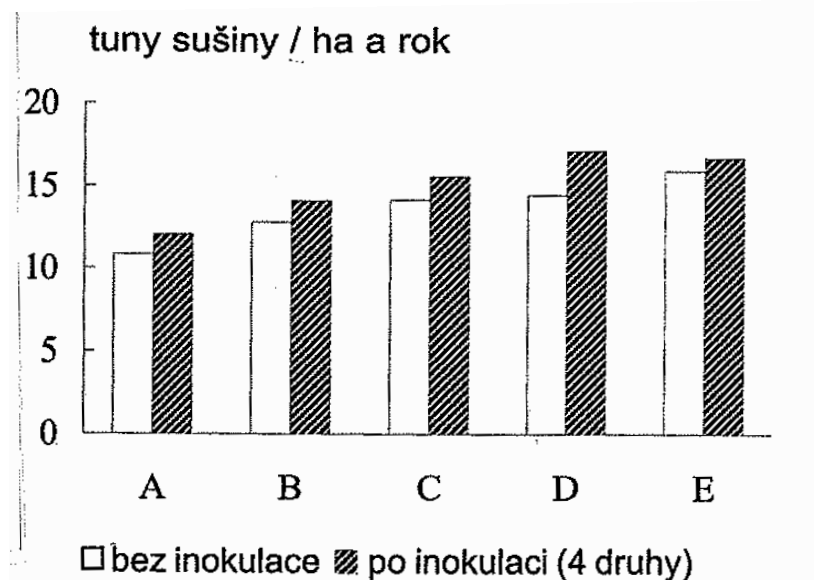
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Effect of earthworm populations and soil erosion: annual surface erosion / annual run off)

Tabulka 6. Vztah mezi populacemi žížal a půdní erozí.

populace žížal jedinců.m ⁻²	roční povrchová eroze t.ha ⁻¹	roční odtok mm
0	75	45
23	13	10
76	0	7
200	0	5

(podle Hopp, 1973)



Obr. VII. Vliv inokulace žížal (10 tisíc jedinců na hektar) na produktivitu pěti luk (jílek ozimý) založených na vysušených poldrech v Holandsku (podle Hoogerkamp a kol., 1987).

Effect of adding earthworms (10 000 ind/ha) on meadow productivity in drained polders, Holland.

Mineral N and exchangeable cations (ppm) In soil and earthworm casts

Tabulka 7. Minerální dusík a výměnné kationty (ppm) v půdě a exkrementech žížal.

	Půda	Exkrementy
NH ₄ ⁺	2,1	89,2
NO ₃ ⁻	63,9	96,4
K _e ⁺	90	460
Ca ²⁺	1800	3400
Mg ²⁺	240	420

(podle Scheu, 1987 a Czerwinski a kol., 1974)

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Tabulka 4. Vybrané charakteristiky ekologických skupin žížal.

	Druhy		
	<i>epigeické</i>	<i>endogeické</i>	<i>anektické</i>
pigmentace	výrazná, často na dorsální i ventrální části těla	žádná či velmi slabá	střední až výrazná, většinou pouze na přední části těla
potrava	málo rozložené organické zbytky na povrchu půdy	organická hmota v promíchaná s minerální půdou	organické zbytky na povrchu půdy, které jsou před pohlcením deponovány v chodbách
velikost	malé až středně velké	středně velké	velké
svalovina přepážek	slabá	střední	silná
forma střeva	jednoduché	široké, silně zvrásněné	relativně jednoduché, ale složitější než u epigeických
počet kokonů	velký	střední	malý
počet mláďat z kokonu	velký	střední	většinou jedno
délka života	krátká	střední	dlouhá
přežívání sucha	ve formě kokonů	v quiescenci	v diapauze
predační tlak	velký	střední	relativně malý
pohyblivost	rychlý pohyb jako reakce na podráždění	pomalé	rychlé zatažení do chodeb, ale pomalejší než epigeické
chodby	žádné, či pouze v několika svrchních centimetrech půdy	podpovrchové, většinou ne vertikální, často bez spojení s povrchem půdy	rozsáhlé systémy vertikálních i horizontálních chodeb, často až k matečné hornině, otevřené na povrch

Live forms of earthworms and their selected ecological traits

- Epigeic

- Endogeic

- Anecic / Anectic (anecique)

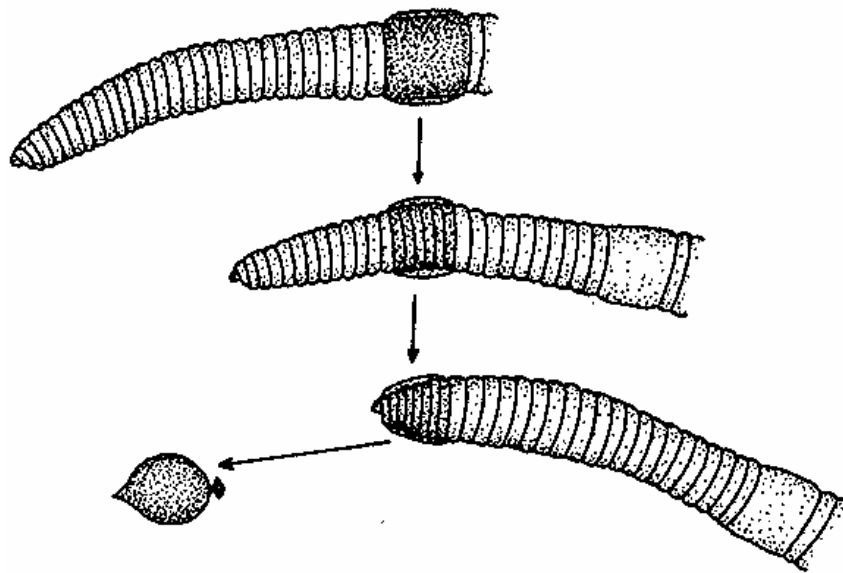
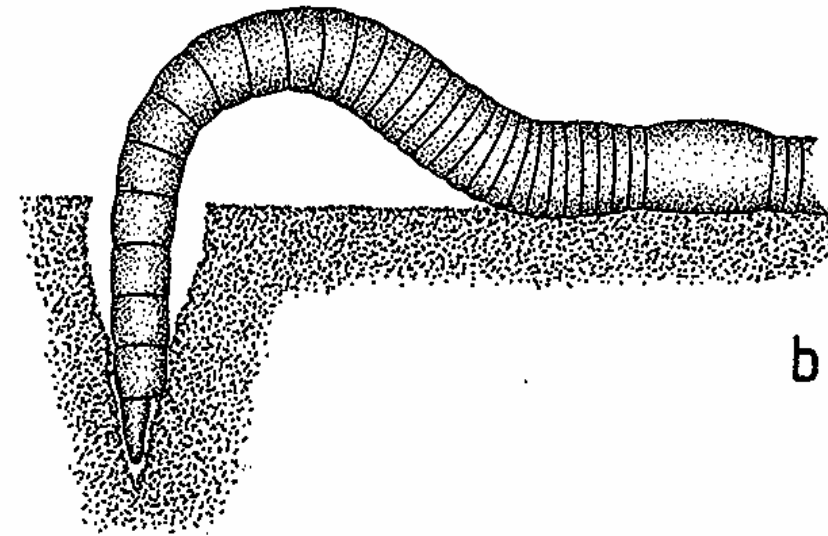
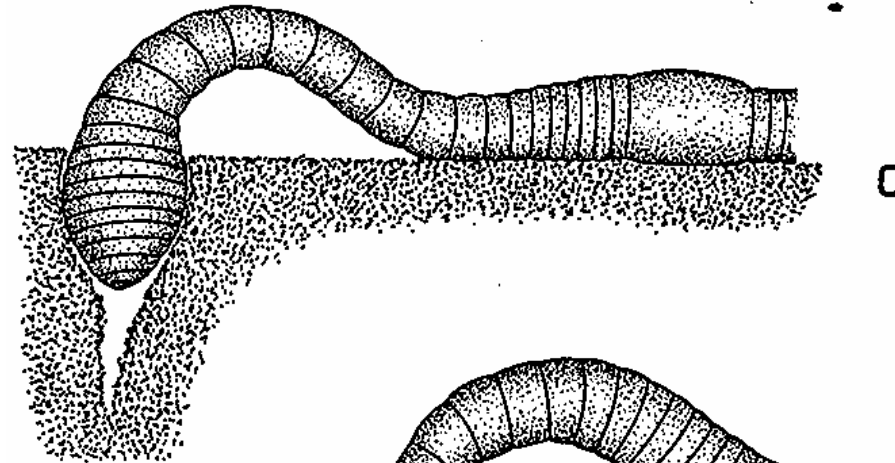
Quiescence: inhibition of development (in any phase of the ontogenesis) directly dependent on environmental factors.

Diapause: inhibition of development (in any phase of the ontogenesis) triggered either by environmental or endogenous factors.

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Digging in of an earthworm:

- a) Anterior segments contracted, widening burrow
- b) Moving body forward (ring muscles contracted, longitudinal muscles relaxed)



Allolobophora chlorotica laying an egg cocoon

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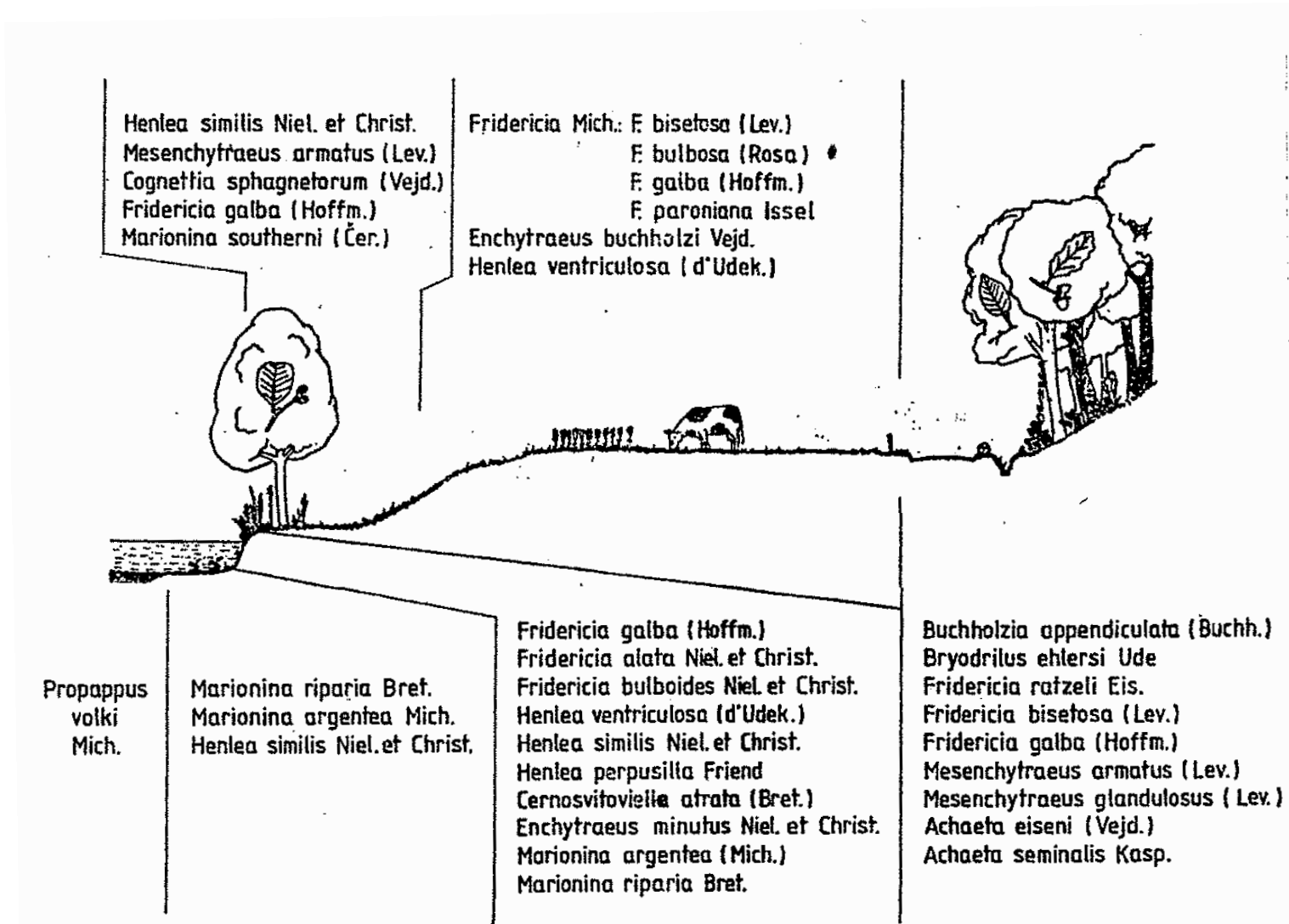


„Oligochaeta“: Enchytraeidae



Cernosvitoviella minor

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Rys. 118. Występowanie gatunków wazonkowców w różnych środowiskach (Oryg.).

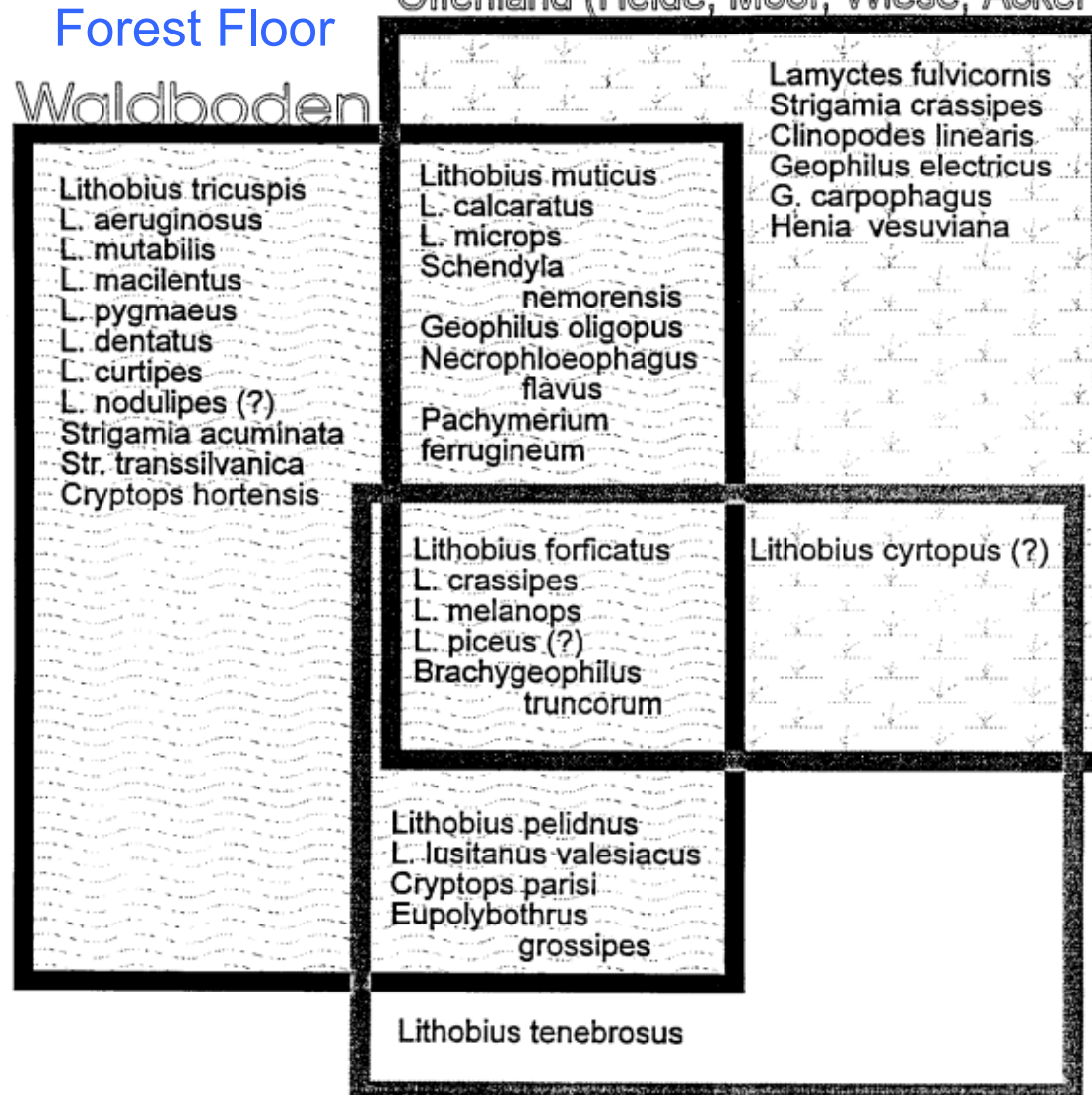
Spatial distribution of enchytraeids in different biotopes

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Centipede (Chilopoda)
assemblages in Central
European macro- and
microhabitats

Open Landscape: heath, mire,
meadow, arable field

Offenland (Heide, Moor, Wiese, Acker)



Totholz (Stämme, Stubben)
Dead Wood (trunks, logs)

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Selected arthropods in the litter layer of three successional stages in a In-land dune landscape

Column 1: species

Column 2: trophic requirements
(s – saprophagous,
P – phytophagous,
z – zoophagous)

Column 3: raw sand (and moss,
grass species)

Column 4: weak podzol; heath

Column 5: weak podzol, mixed broad-
leaved forest dominated by oak

Occurrence: + - scarce / ++ - frequent

Tabelle 2: Auswahl einiger Arthropoden im Bereich der Streuschicht von drei Sukzessionsstufen einer Binnendünenlandschaft (s = saprophag, P = phytophag, z = zoophag; + = vereinzelt, ++ = häufig)

Arten	Ernäh- rung	Roher	Schwacher Podsol	
		Sand (u. Moose, Gräser)	Heide- fläche	Eichen- mischwald
<u>Lumbricidae</u>				
<i>Dendrobaena octaedra</i>	s			++
<i>Lumbricus rubellus</i>	s			++
<u>Isopoda</u>				
<i>Philoscia muscorum</i>	s			+
<i>Porcellium conspersum</i>	s			+
<u>Chilopoda</u>				
<i>Lithobius calcaratus</i>	z		++	
<i>Lithobius erythrocephalus</i>	z			++
<i>Geophilus truncorum</i>	z			++
<u>Collembola</u>				
<i>Entomobrya multifasciata</i>	s	++	+	
<i>Lepidocyrtus lignorum</i>	s	+	++	+
<i>Orchesella multifasciata</i>	s		++	
<i>Hypogastrura denticulata</i>	s			++
<i>Tomocerus longicornis</i>	s			++
<u>Coleoptera</u>				
<i>Cicindela hybrida</i>	z	++		
<i>Calathus erratus</i>	z	++	++	
<i>Carabus hortensis</i>	z			++
<i>Ousipalia caesula</i>	z (s)	++		
<i>Oxypoda togata</i>	z	++	+	
<i>Lathrimaeum atrocephalum</i>	s (z)			++
<i>Byrrhus arietinus</i>	p	++		
<i>Philopodon plagiatus</i>	p	++		
<i>Strophosomus melanogrammus</i>	p			++
<i>Geotrupes stercorosus</i>	s			++
<u>Dermaptera</u>				
<i>Chelidurella acanthopygia</i>	p			++
<u>Mecoptera</u>				
<i>Boreus hyemalis</i>	s	++		
<u>Trichoptera</u>				
<i>Enicocyla pusilla</i>	s			++
<u>Lepidoptera</u>				
<i>Incurvaria spec.</i>	s (p)			++

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Seasonality of soil and litter biota in a beech-wood on limestone (Göttinger Wald, Northern Germany)

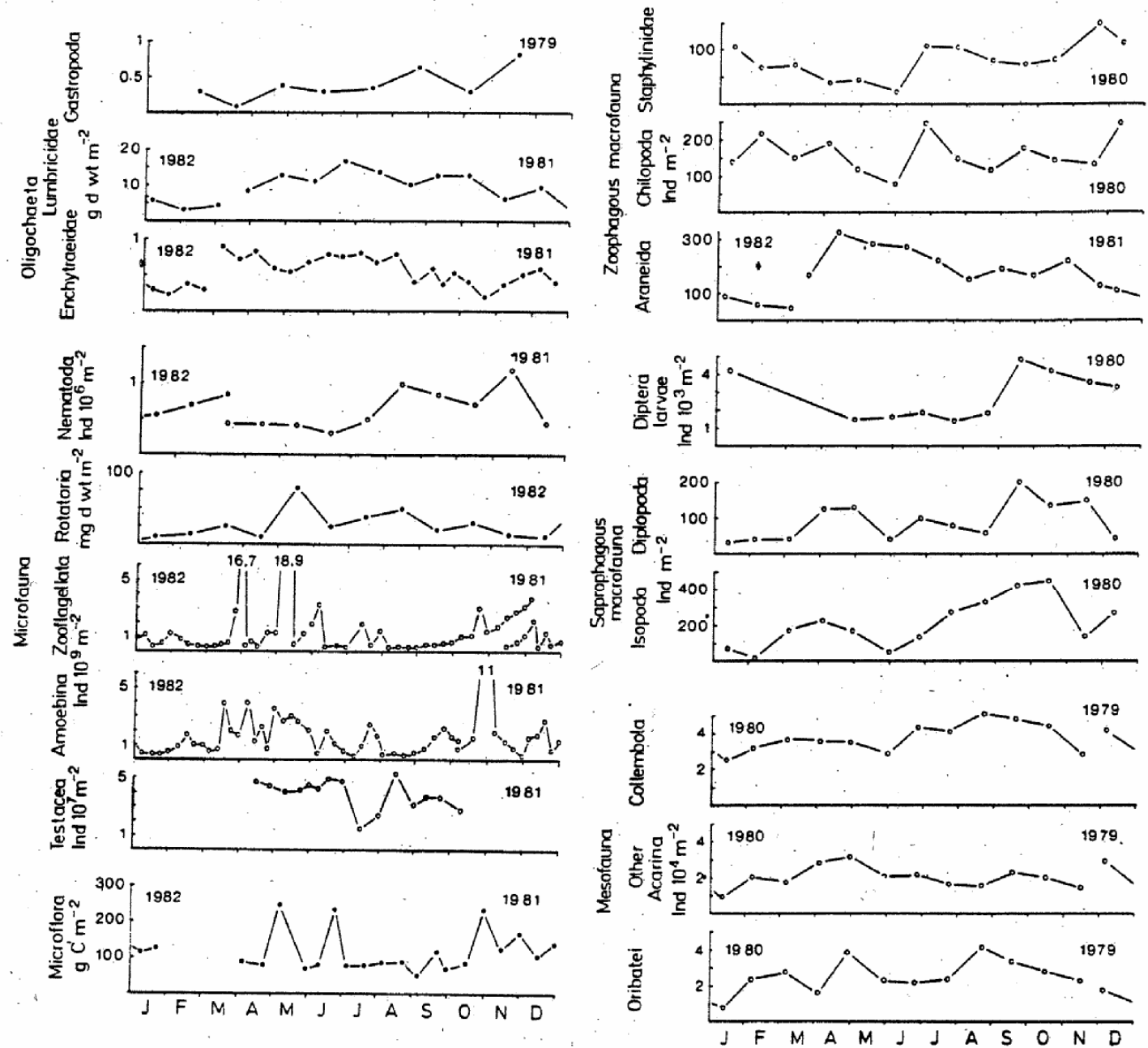


Fig. 6.5. Seasonality of soil and litter biota in a beech-wood on limestone (Göttinger Wald). Based on mostly unpublished data from K. H. Domsch and M. Vanselow (microflora). R. Meisterfeld (Protozoa), U. Heitkamp (Nematoda), A. Mellin (Enchytraeidae), V. Büttner (Rotatoria), M. Schaefer and H.G. Joger (Lumbricidae), Corsmann (1981) (Gastropoda), H.-D. Baaske (Acarina), Wolters (1983) (Collembola), T. Sprengel (Diplopoda), Hövemeyer (1984) (Diptera), T. Poser (Chilopoda), G. Stippich (Araneida), M. Schaefer (1983a) (Staphylinidae).

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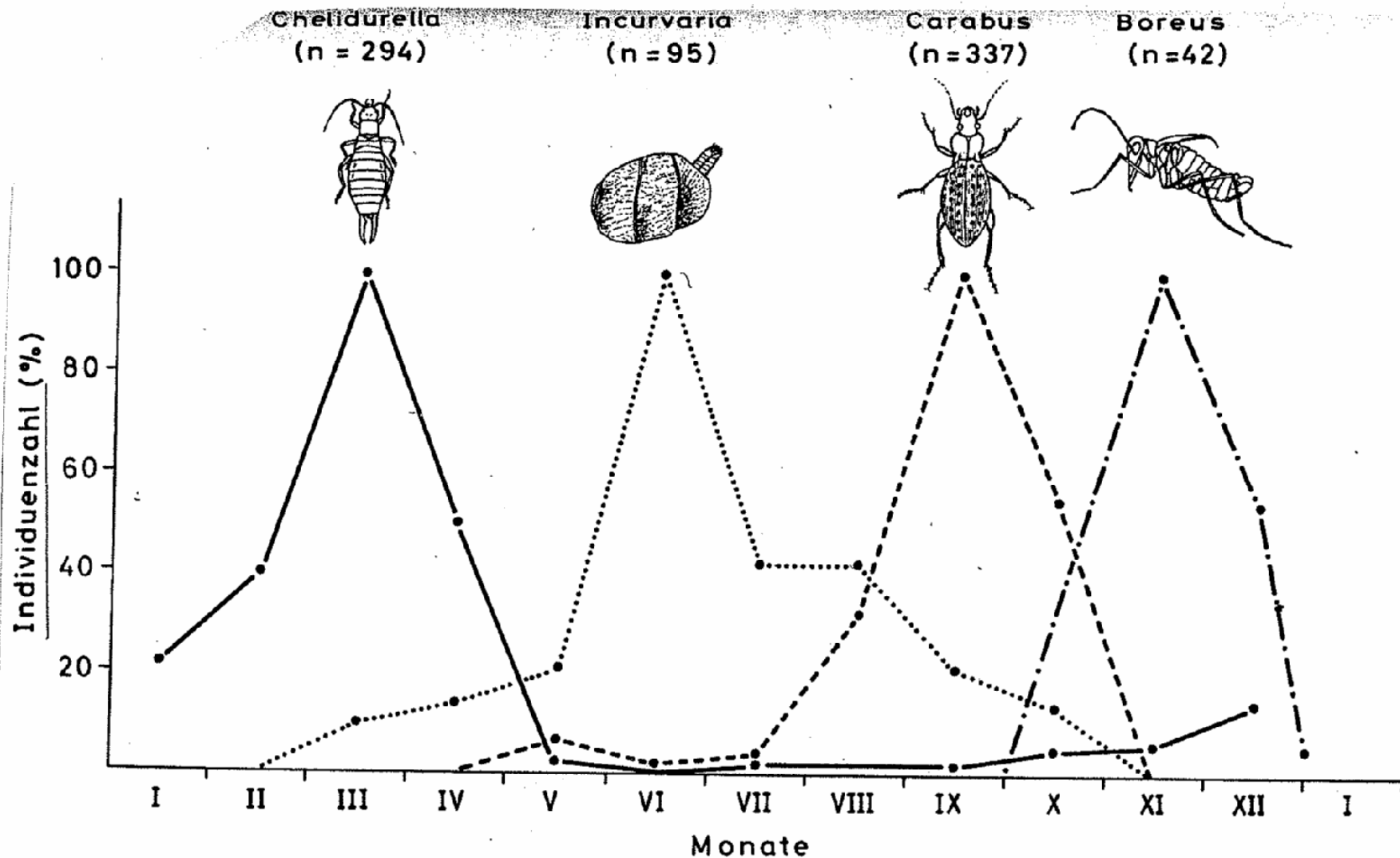


Abb. 39: Jahreszeitlich bedingte Aktivität verschiedener Insekten innerhalb der Streuschicht desselben Lebensraumes (Modalwert = 100%, n = Anzahl der gefundenen Individuen). Der Waldohrwurm *Chelidurella acanthopygia*, Miniersackmotten aus der Gattung *Incurvaria*, der Gartenlaufkäfer *Carabus hortensis* und der Schneefloh *Boreus hyemalis*.

Seasonally dependent activity of various insects in the litter layer of the same habitat (n = number of individuals, highest value given as 100 percent of each taxon)

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Synopsis of invertebrate animal groups characteristic of temperate deciduous forests. Data apply to mull and/or moder (mor) soils. Parasites of invertebrates are not included

Animal group	Size class ^a	Preferred stratum ^b	Number of species ^c	Density biomass ^c	Nutritional type ^d	Some recent references ^e
Protozoa						
Flagellata	mi	s l a	-	-/-	sa (fluids)	
Rhizopoda	mi	s l a	+	+/+	mi	Meisterfeld (1980); Lousier (1982)
Ciliata	mi	s l a	-	-/-	mi	
Turbellaria	mi	s a	-	-/-	zo	
Rotatoria	mi	s a	-	-/-	mi sa zo	
Nematoda	mi	s v a	+	+/+	ph mi sa zo	Phillipson et al. (1977); Popovici (1984)
Mollusca						
Gastropoda	ma	l v(s)	+	+/+	ph sa (zo)	Corsmann (1981); Phillipson (1983); Phillipson and Abel (1983)
Annelida						
Enchytraeidae	me	s(l)	+	-/-	sa mi	Phillipson et al. (1979)
Lumbricidae	ma	s(l)	-	+/+	sa mi	Phillipson et al. (1978); Satchell (1983); Zicsi (1983)
Tardigrada	mi	s a	-	+/+	mi zo	Hallas and Yeates (1972)
Arachnida						
Araneida	ma	l v	+	-/-	zo	Albert (1982); Stuppich (1986)
Pseudoscorpionida	ma	l(v)	-	-/-	zo	Goddard (1976)
Opilionida	ma	l v	-	-/-	zo	Bachmann and Schaefer (1983); Schaefer (1986)
Acari						
Mesostigmata	me	s l	+	-/-	zo sa mi	Luxton (1982); Athias-Binche (1983)
Prostigmata	me	s l v	-	-/-	zo mi sa ph	Luxton (1981g)
Astigmata	me	s l	-	-/-	mi	Luxton (1981f)
Cryptostigmata	me	s l	-	+/+	sa mi	Luxton (1972, 1975, 1981a-e)
Crustacea						
Harpacticoida	mi	s a	-	-/-	mi (sa)	
Isopoda	ma	l	-	-/-	sa mi	
Myriapoda						
Chilopoda	ma	l s	-	-/-	zo	Albert (1980)
Diplopoda	ma	l	-	+/+	sa mi	Sprengel (1986)
Pauropoda	me	s	-	-/-	sa mi	
Symphyla	me	s	-	-/-	mi ph	
Hexapoda (Insecta)						
Diplura	me	s	-	-/-	mi sa zo	
Protura	me	s	-	-/-	mi sa	
Collembola	me	s l v	-	-/-	mi sa	Wolters (1983, 1985)
Blattariae	ma	l v	-	-/-	sa pa	
Dermaptera	ma	l v	-	-/-	pa	
Ensifera	ma	v l	-	-/-	zo ph	
Psocoptera	me	v	-	-/-	mi	
Thysanoptera	me	v	-	-/-	ph zo	
Hemiptera	ma, me	v	+	+/+	ph zo	
Planipennia	ma	v	-	-/-	zo	Nielsen (1977)
Coleoptera	ma	l v	+	+/+	zo ph	Friebe (1983); Schaefer (1983a)
Hymenoptera	ma, me	v l	+	+/+	zo ph	Ulrich (1987)
Lepidoptera	ma	v	+	+/+	ph	Winter (1985)
Trichoptera	ma	l	-	-/-	sa	
Diptera	me, ma	s	+	+/+	sa mi ph zo	Hövmeyer (1984, 1985)

^ami = microfauna, me = mesofauna, ma = macrofauna, meg = megafauna.

^bs = soil, l = litter, v = vegetation, a = semiaquatic.

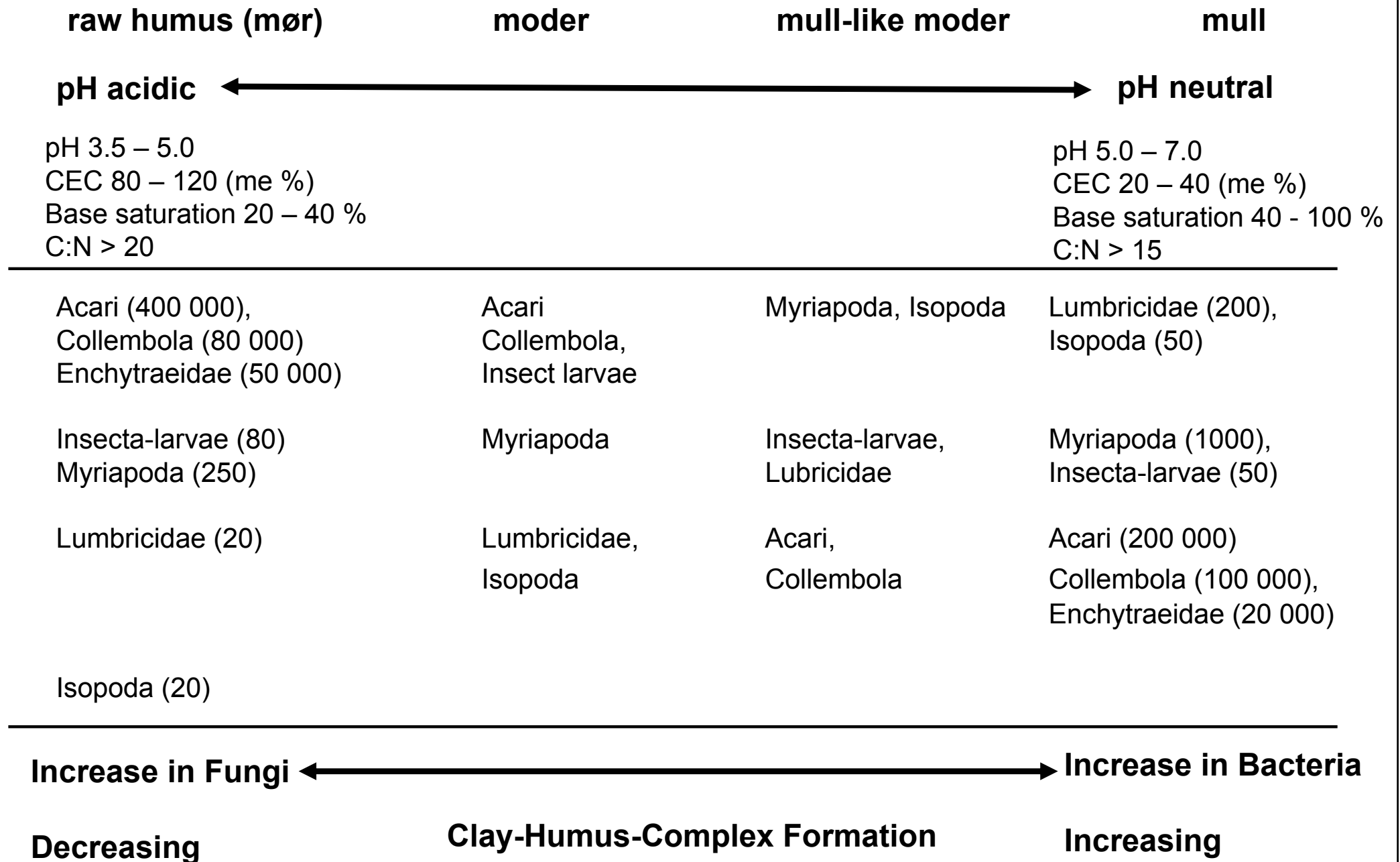
^c+ = high, - = low.

^dsa = saprophagous, mi = microphytophagous, ph = phytophagous, zo = zoophagous, pa = pantophagous.

^eAdditional reference for most of the groups Ellenberg et al. (1986).

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Representation of Soil Fauna in forest soils along a pH Gradient (Central Europe)

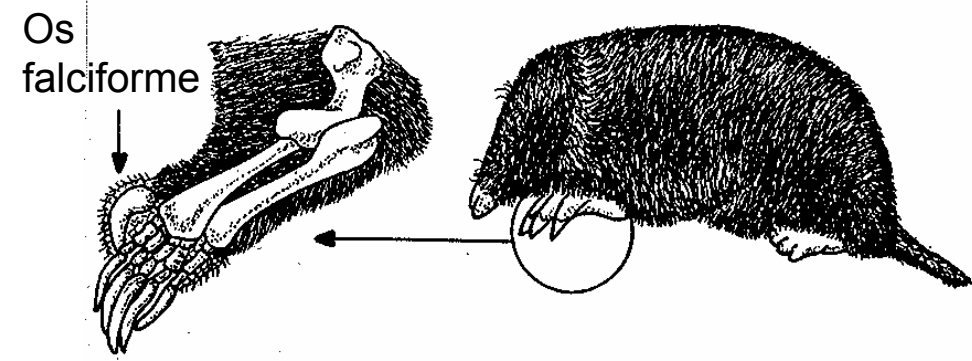


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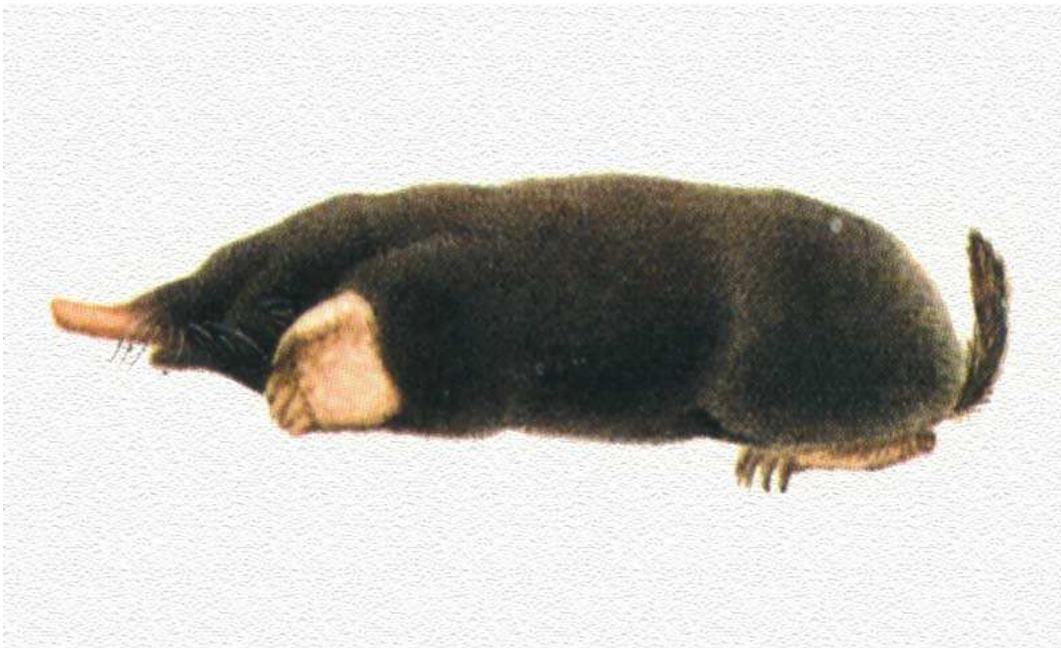


Microstructure of the organic top soil layer – high proportion of invertebrate faeces

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Talpa europaea – European Mole



Talpa caeca (Southern Europe):
eyes covered by fur

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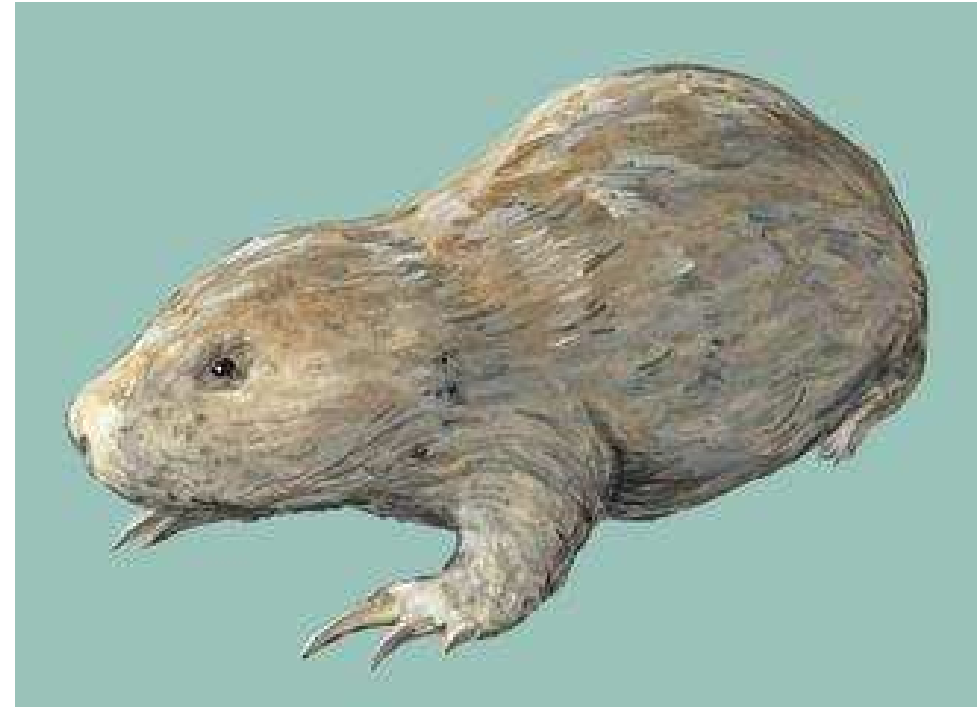
***Condylura cristata* – Star-nose mole** (North America):
sensory cells concentrated in 22 diverticula of the snout



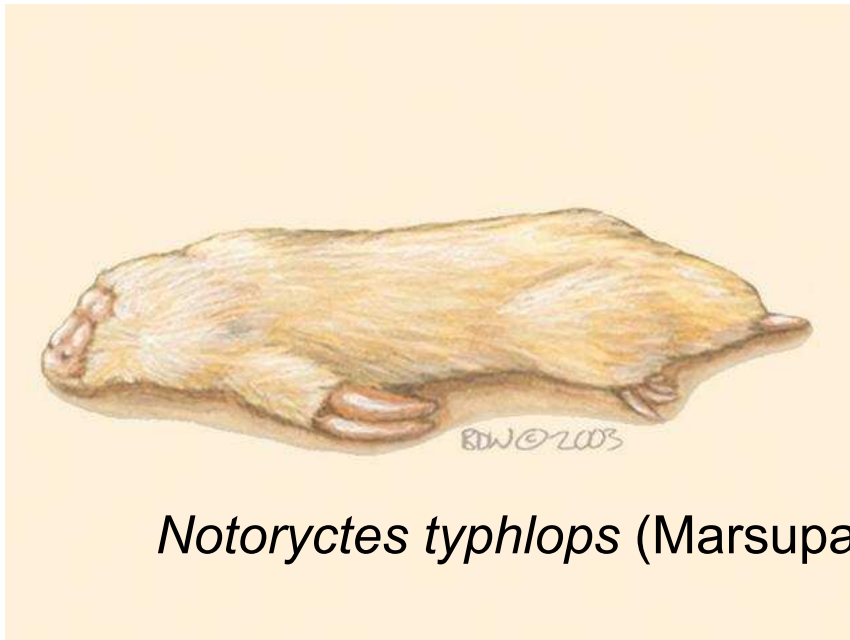
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Cannomys badius – Lesser bamboo rat



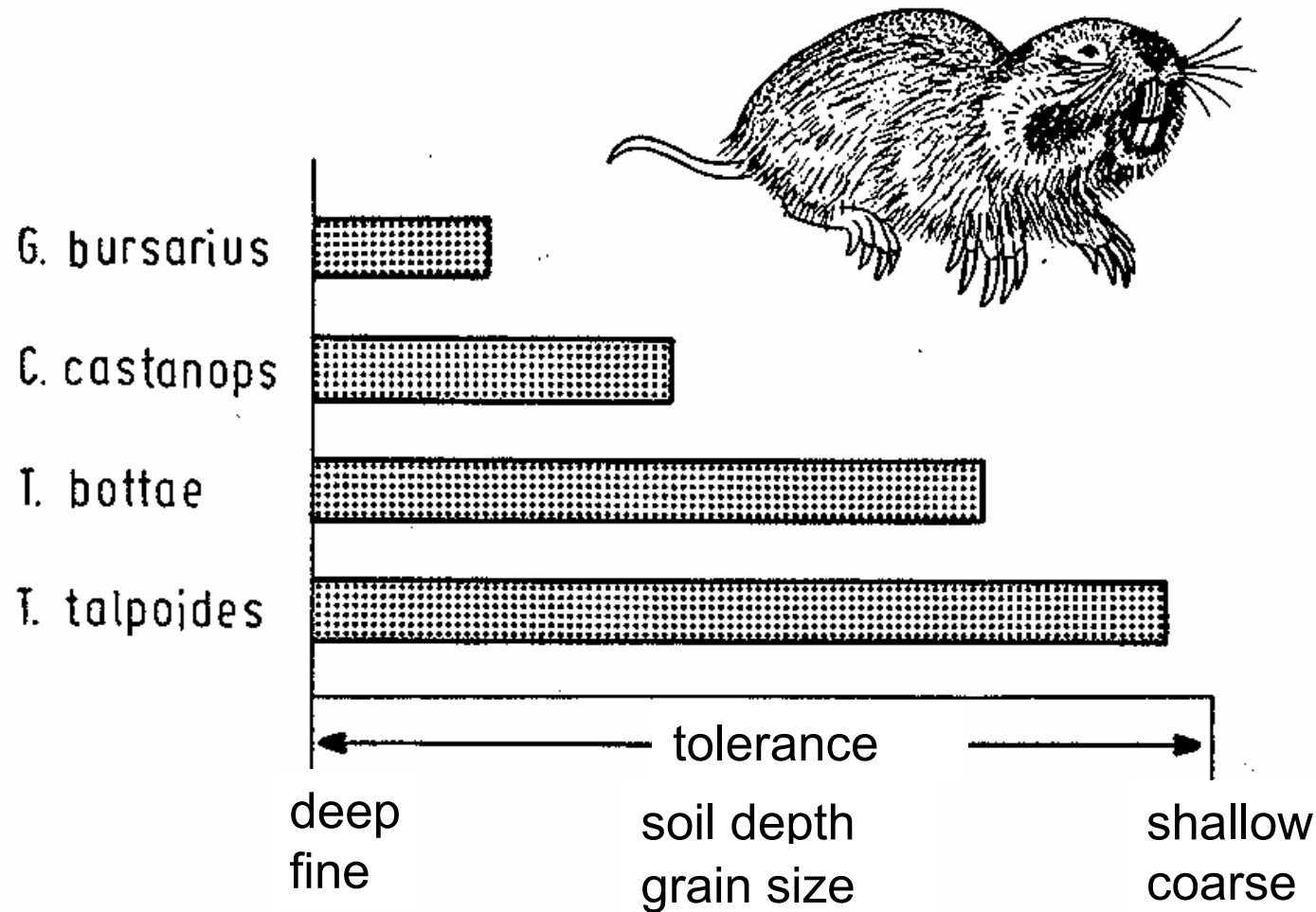
Myospalax myospalax – Siberian Zokor



Notoryctes typhlops (Marsupalia)

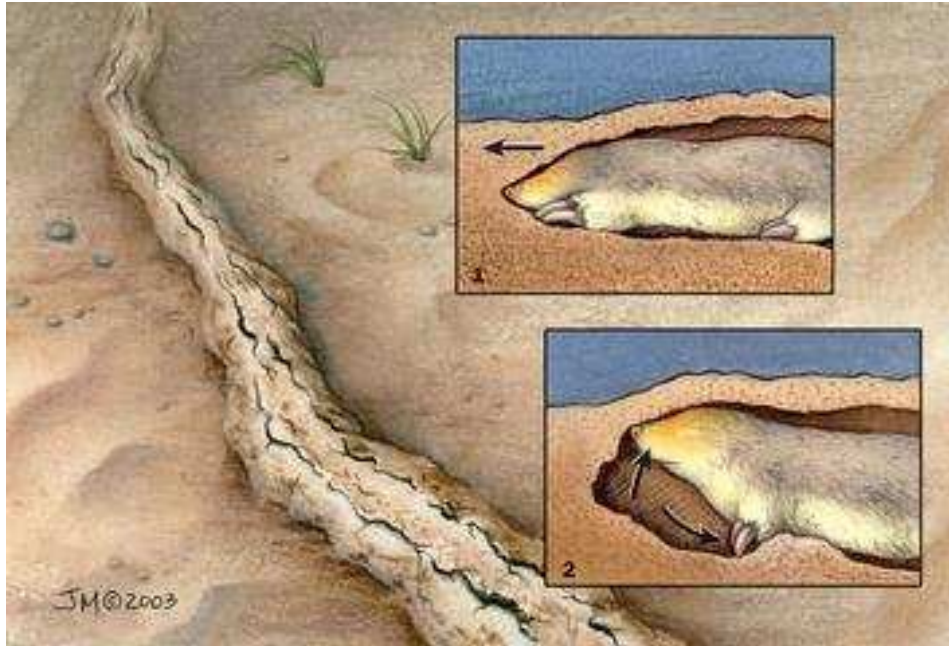


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Relative tolerance of species of the North American pocket gophers (Geomyidae) to depth and grain size of soils

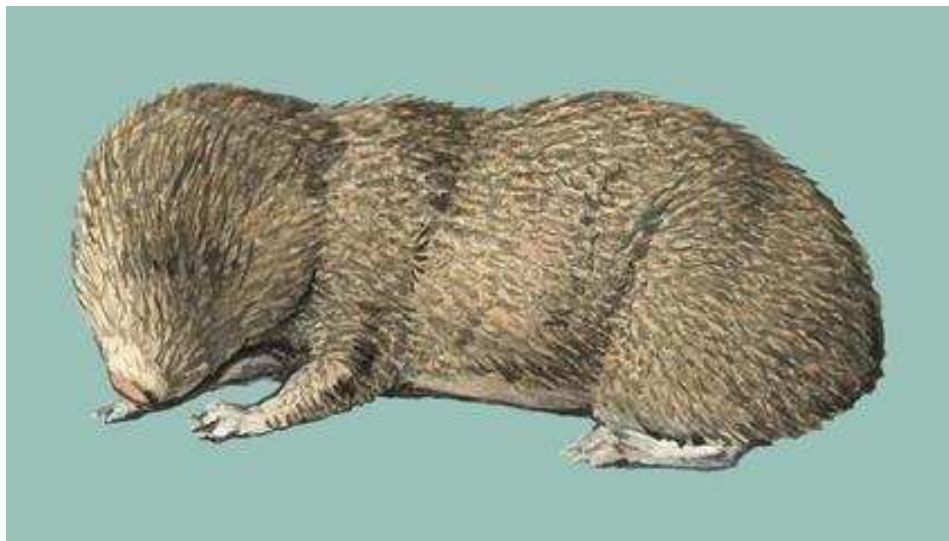
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Golden mole burrow



Eremitalpa granti



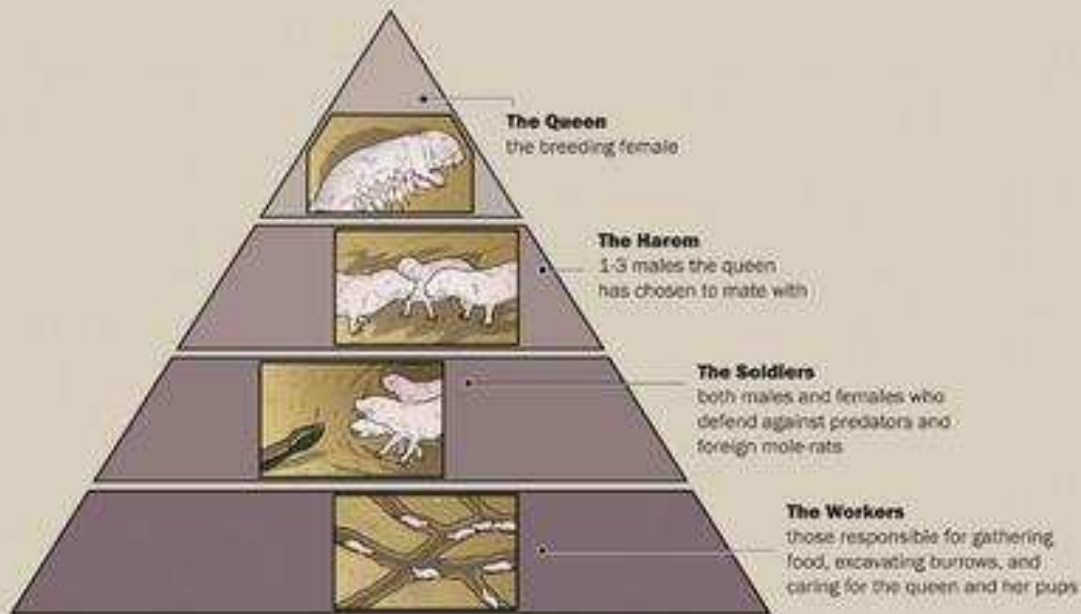
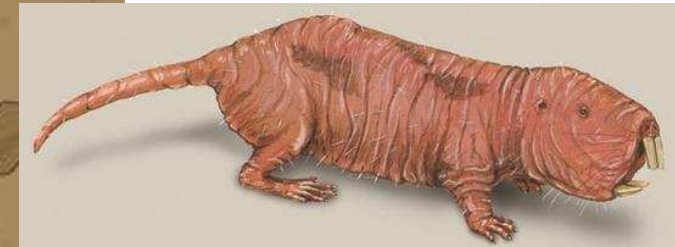
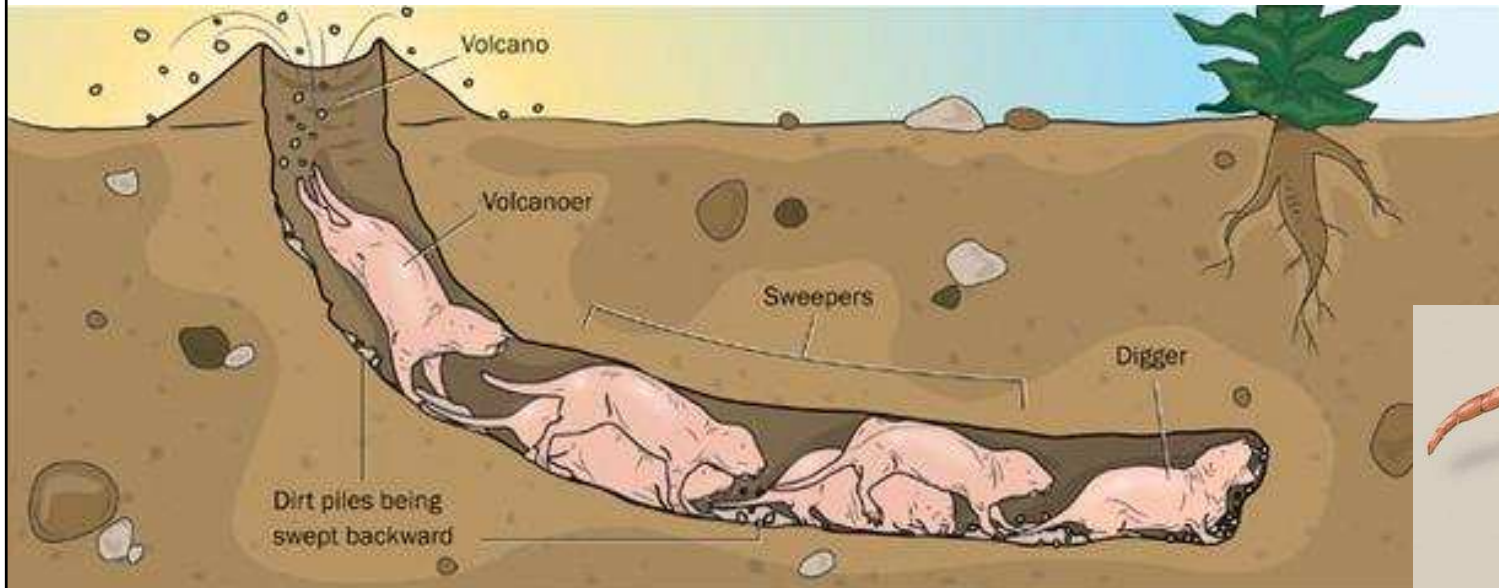
Nannospalax ehrenbergi – Palestine mole rat



Chrysospalax trevelyiani

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Heterocephalus glaber – Naked Mole Rat



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Rhineura floridiana
(Amphisbaenidae)
– Florida worm lizard



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Blanus cinereus – Iberian worm lizard



Blanus strauchi

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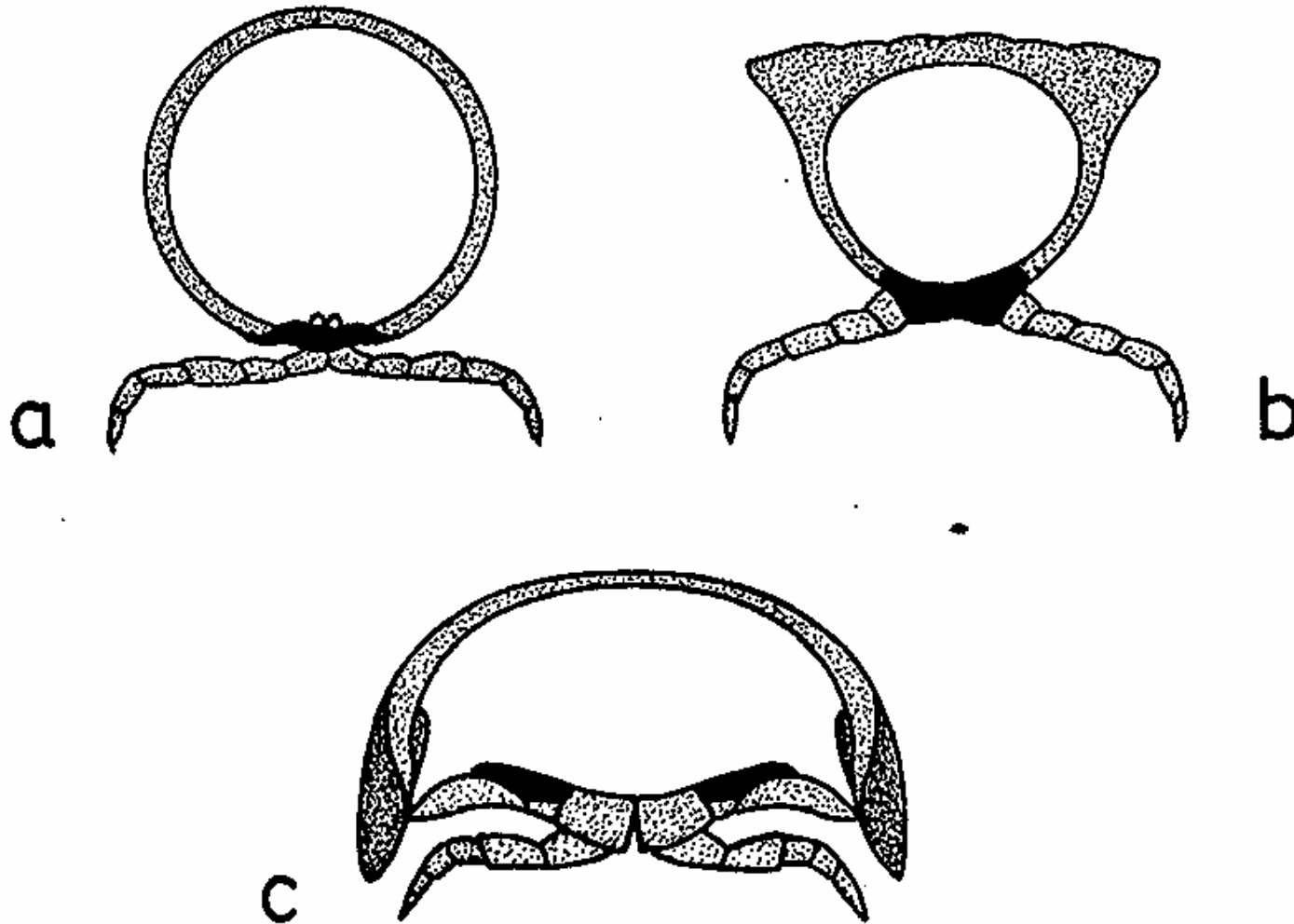


Typhlops vermicularis



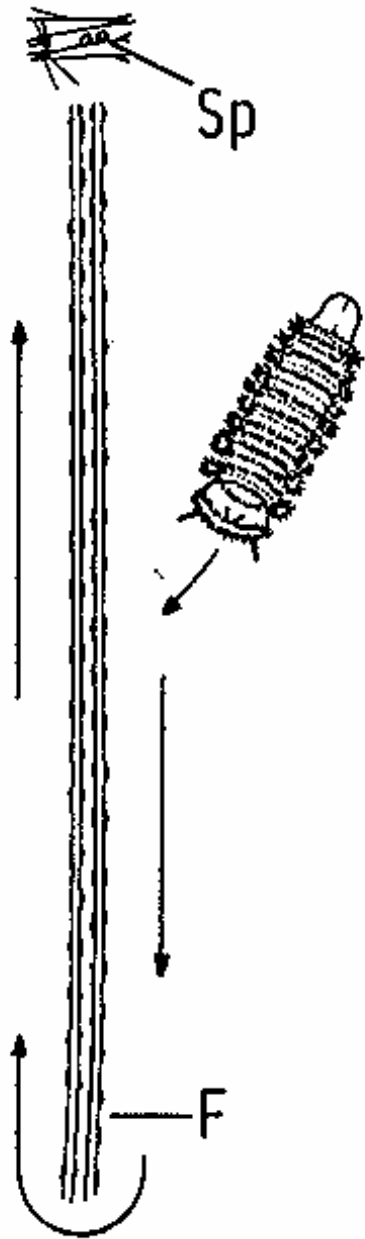
Diplomethodon zarudnyi

The saprotrophic food chain in terrestrial ecosystems : Soil Biota



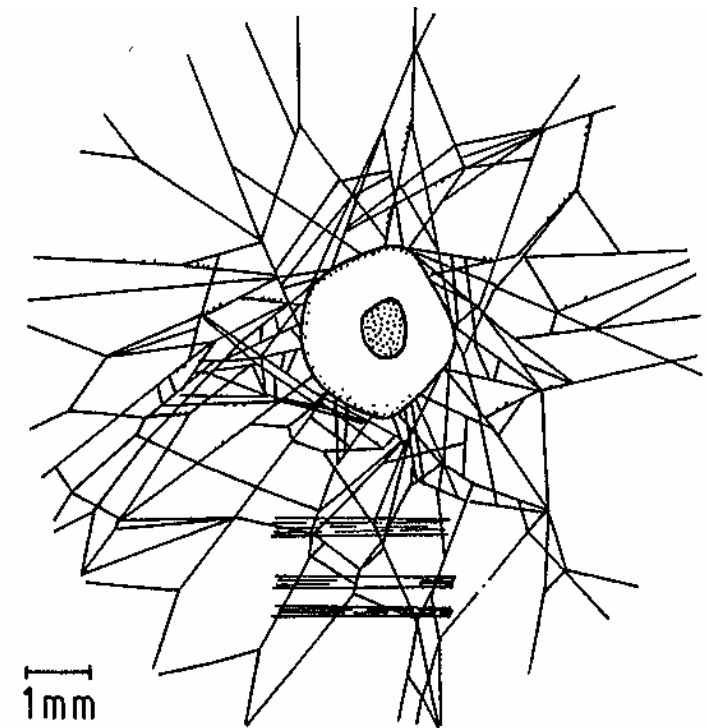
Cross sections through the bodies of millipedes (Diplopoda): a) Juloidea – bulldozer-type with rigid body ring, b) Polydesmoidea – wedge type with rigid body ring, c) Glomeridae – tergites moveable, volvation

The saprotrophic food chain in terrestrial ecosystems : Soil Biota



Polyxenus lagurus:

Threads with sperm droplets (Sp) and thread road (F); arrows indicate direction of female led by the thread road towards the sperm droplets.

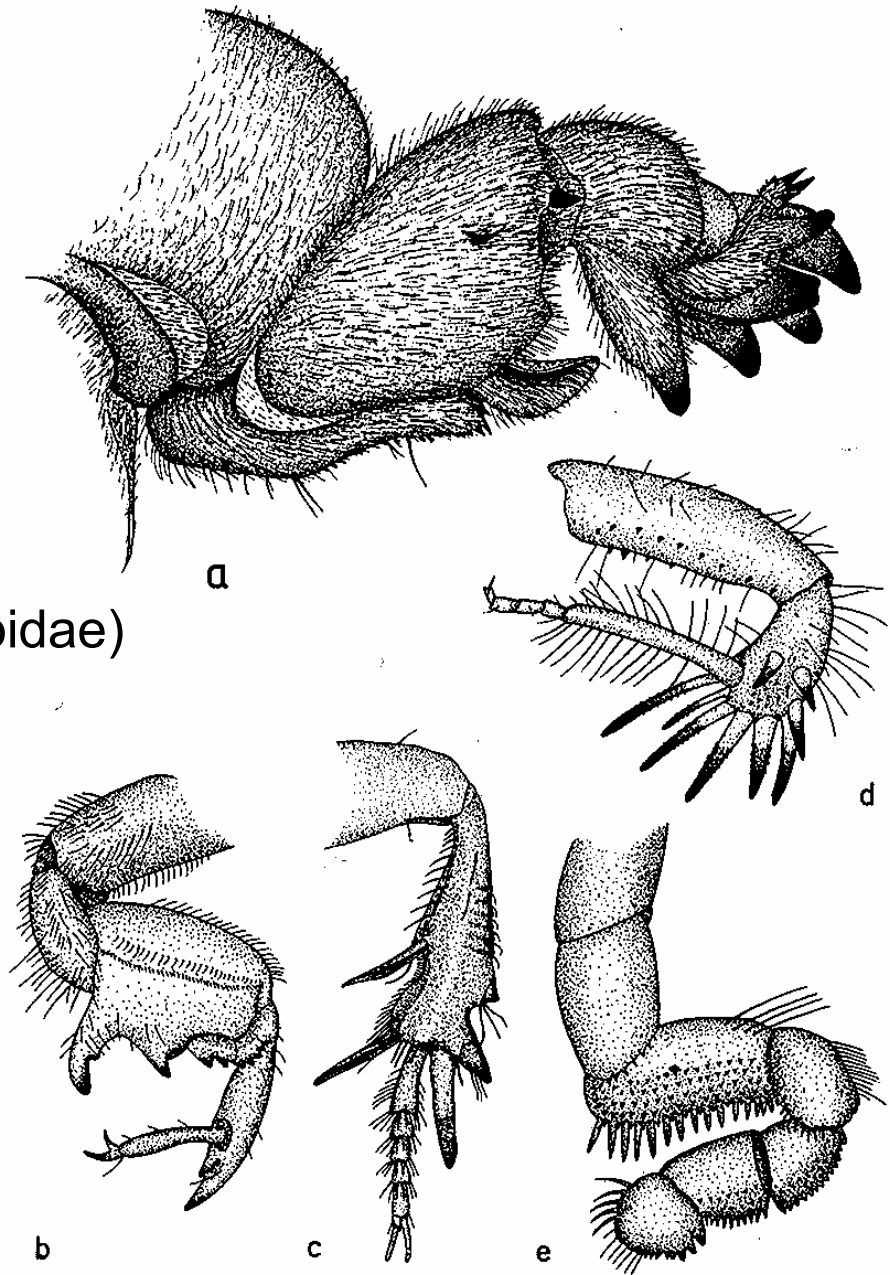


Lithobius forficatus (Chilopoda): Thread web around spermatophore, transverse threads with stopper function for the females.

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Arthropod fore legs adapted to digging:

- a) *Gryllotalpa vulgaris* (Ensifera)
- b) *Lyristes plebejus* (Auchenorrhyncha)
- c) *Scarites buparius* (Coleoptera: Carabidae)
- d) *Arenivaga investigata* (Blattodea)
- e) *Siloannea macrocerras* (Araneae)



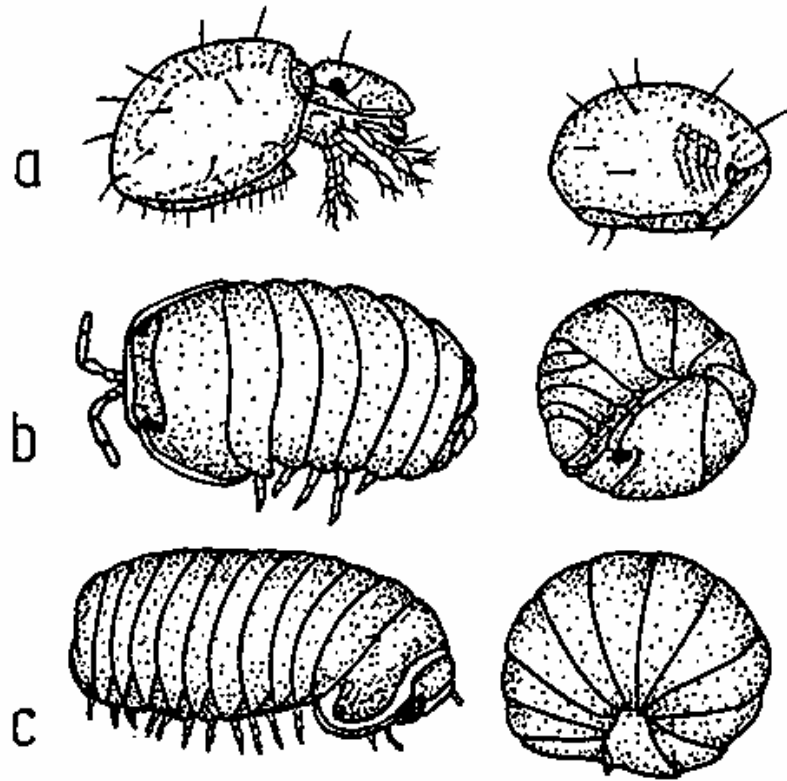
The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Ability of volvation in various groups of soil arthropods:

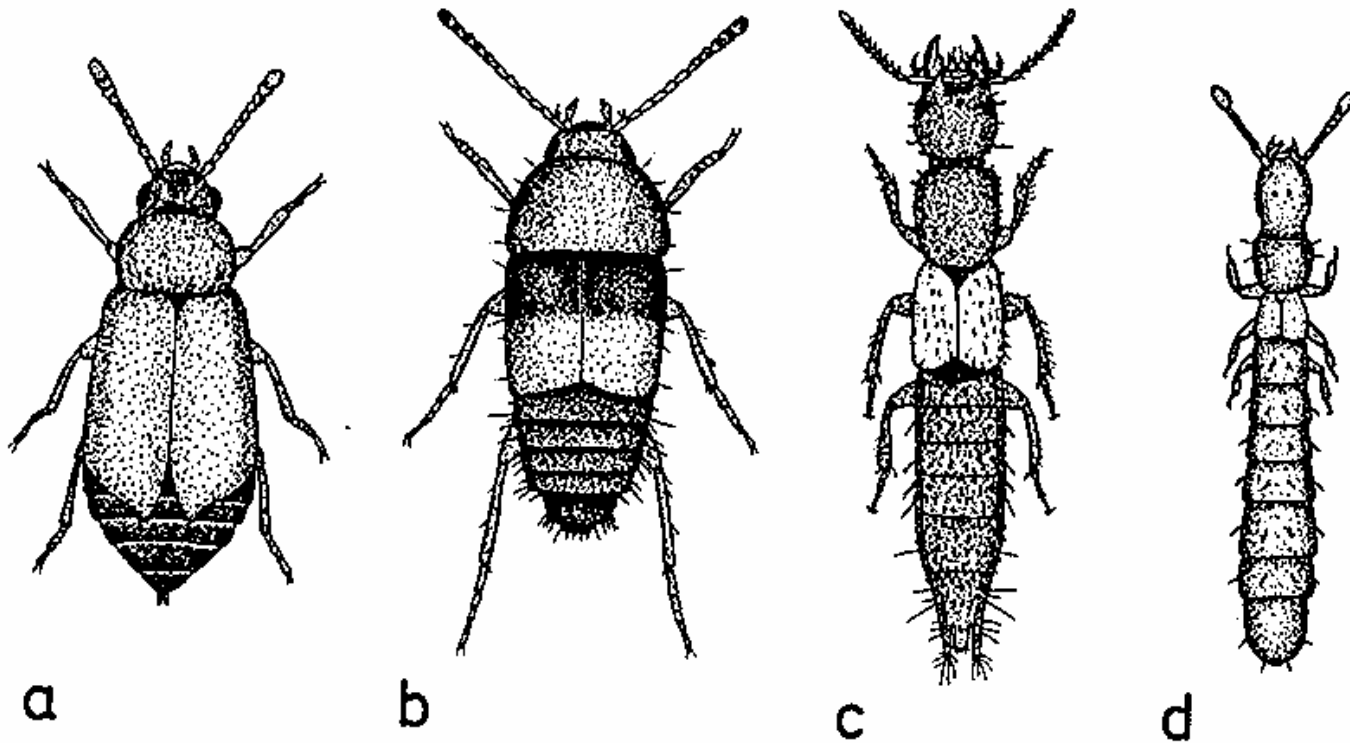
a) *Peudotritia ardua* (walking),
Phthiracarus setosellus (Oribatida)

b) *Cubaris* sp. (Isopoda: Oniscoidea)

c) *Sphaerotherium* sp. (Diplopoda)



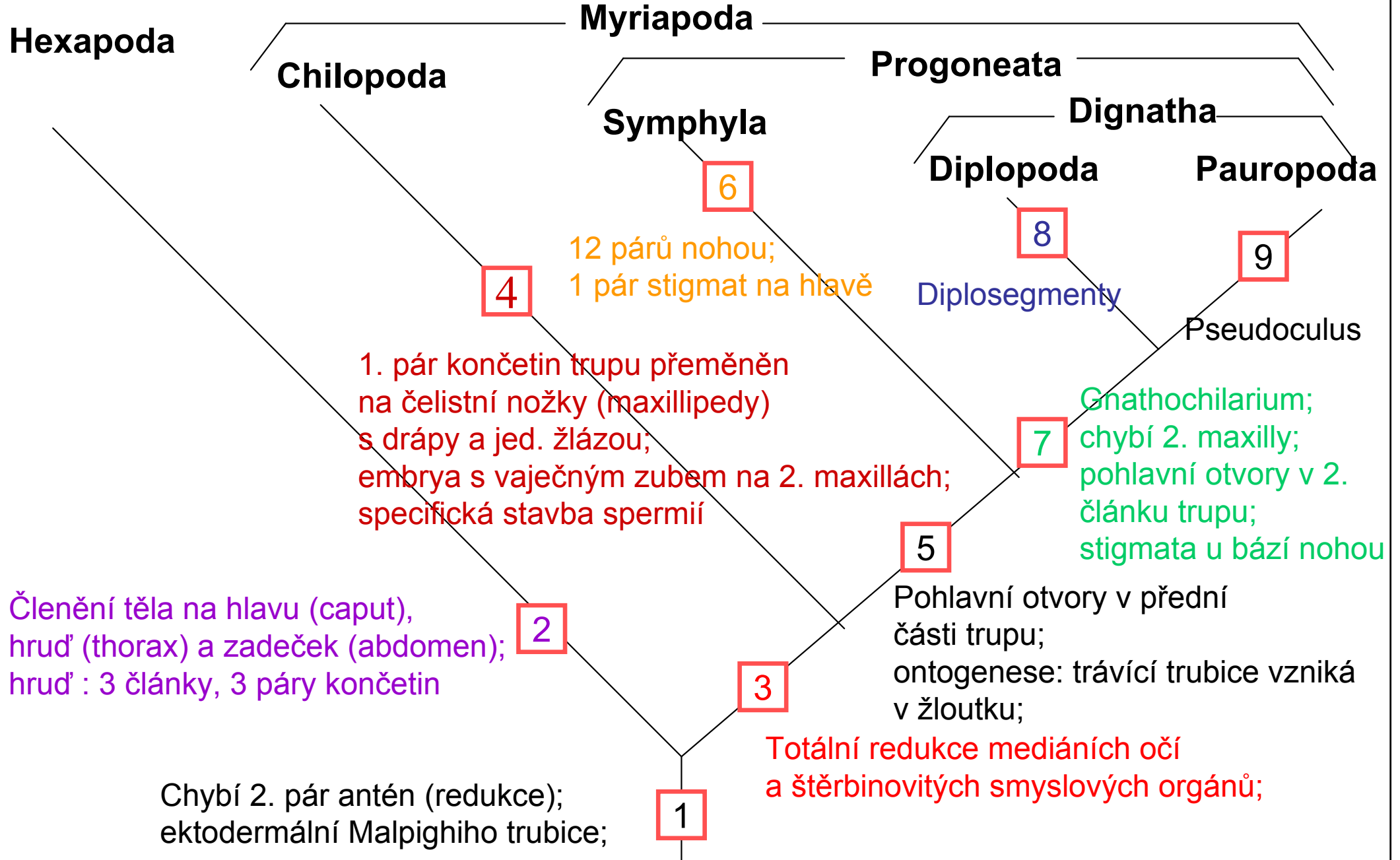
The saprotrophic food chain in terrestrial ecosystems : Soil Biota



Rove beetle (Staphylinidae) life forms:

- a) *Anthobium minutum* (epedaphic)
- b) *Tachyporus obtusus* (epedaphic)
- c) *Othius punctulatus* (hemiedaphic)
- d) *Entomoculia occidentalis* (euedaphic)

Tracheata = Antennata



Tracheata = Antennata

Hexapoda

Chilopoda

~~Myriapoda~~

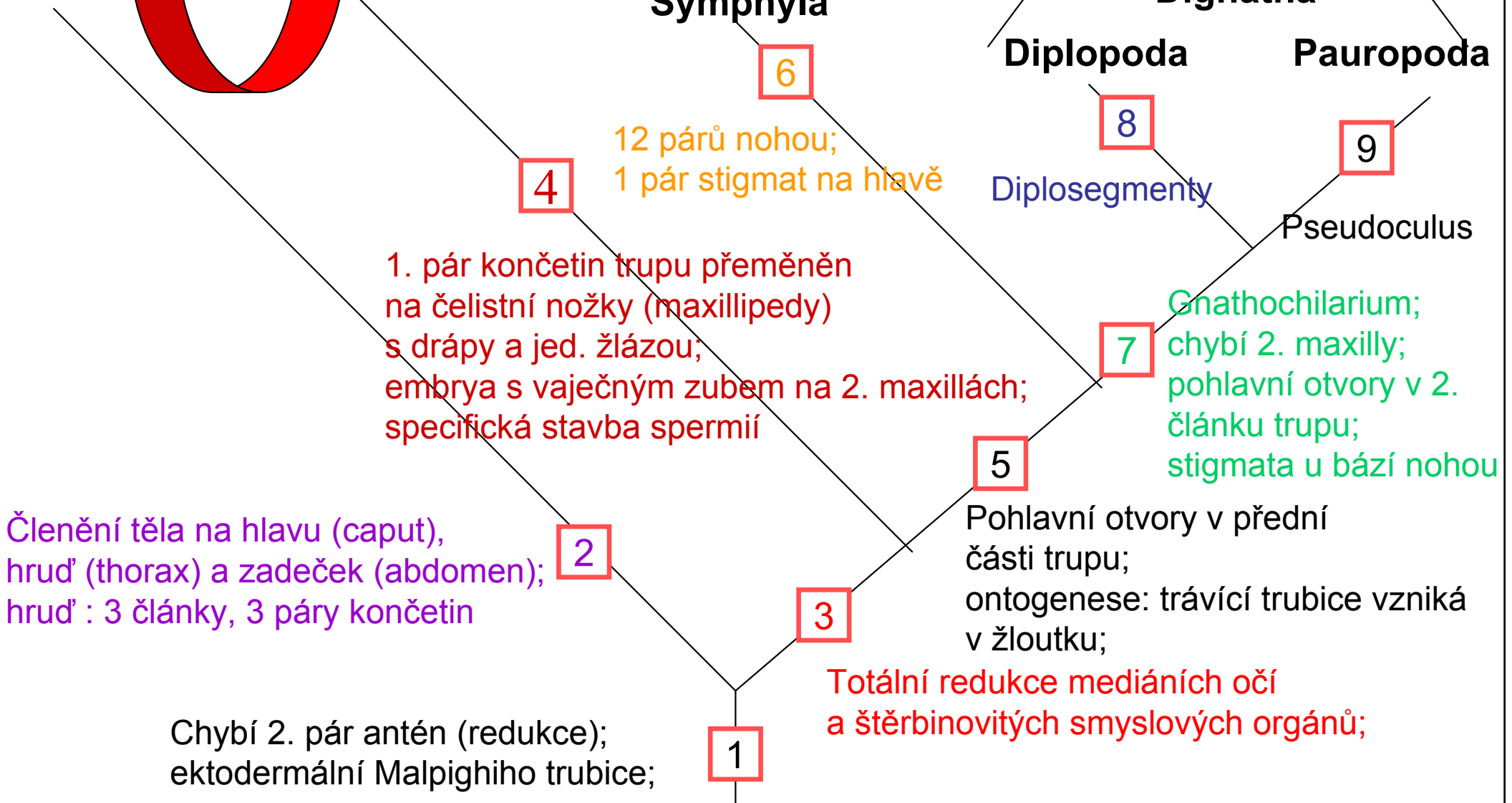
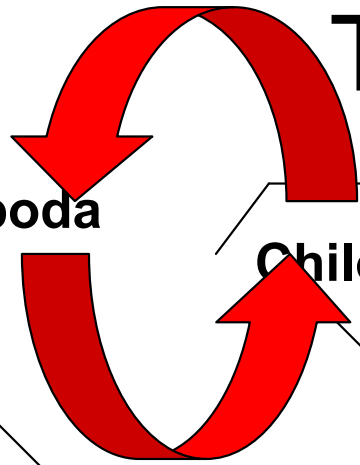
Progoneata

Symphyla

Dignatha

Diplopoda

Pauropoda



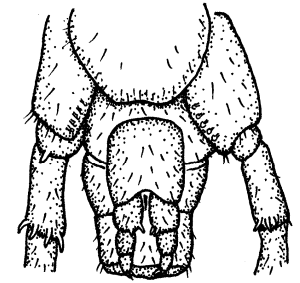
The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Chilopoda – centipedes / stonožky

Predators: litter layer, under stones, bark; Geophilomorpha in mineral soil layers.

Autapomorphies:

- 1. pair of limbs modified to maxillipedes with claws and poison gland;
- embryos with egg tooth on 2nd maxillae;
- specific structure of sperm cells



Last two pairs of legs ^{Bec/02}
© BIODIDAC, Brno

Notostigmophora
Scutigermomorpha



Pleurostigmophora
Scolopendromorpha



Pleurostigmophora
Lithobiomorpha



Pleurostigmophora
Geophilomorpha



The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Diplopoda – millepedes / mnohonožky

Saprophages, in the litter layer, some under bark

Autapomorphy:
Diplosegments



Polydesmus sp.



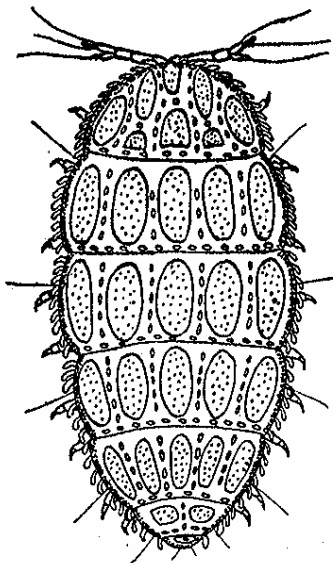
Glomeris hexasticha

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

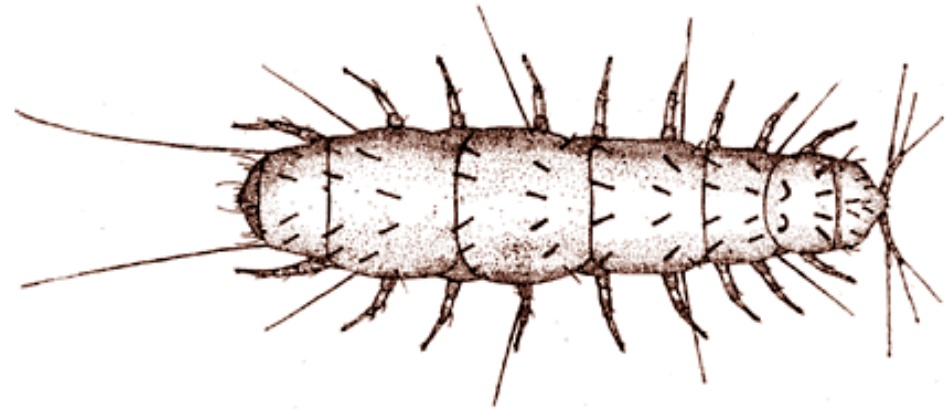
Paupoda – paupods / drobnušky

Mycetophages and/or necrophages / zoophages (Collembola etc.),
Usually in the upper-most soil layer but sometimes down to 50 cm depth
Moist but not water-logged soils
Usually without pigments, white, some brownish.
0.5 – 0.7 (max. 1.9) mm

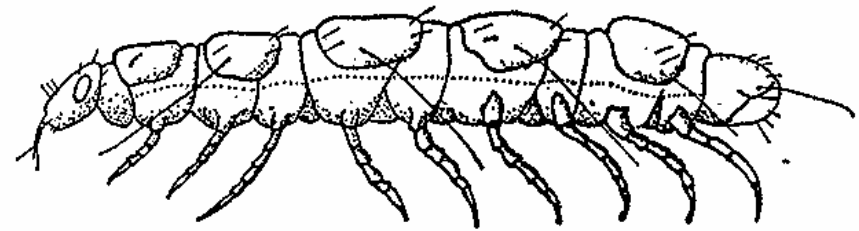
Autapomorphy: pseudoculus



Eurypauropus ornatus (0.8 mm)



Pauropus huxleyi



Pauropus sylvaticus (1 mm)

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Symphyla – symphylans / stonoženky

Feed on algae, bacteria, fungi, dead organic matter including dead animals, as well as on live plant tissues (roots)

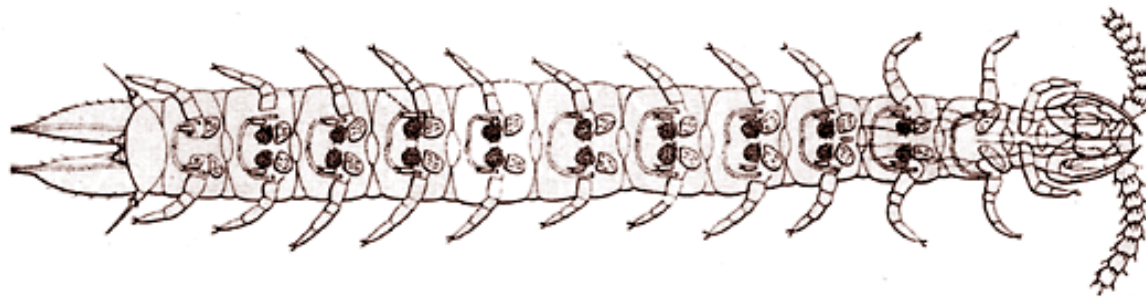
In mineral soil, litter, under stones and bark, in moss cushions

All white, no eyes

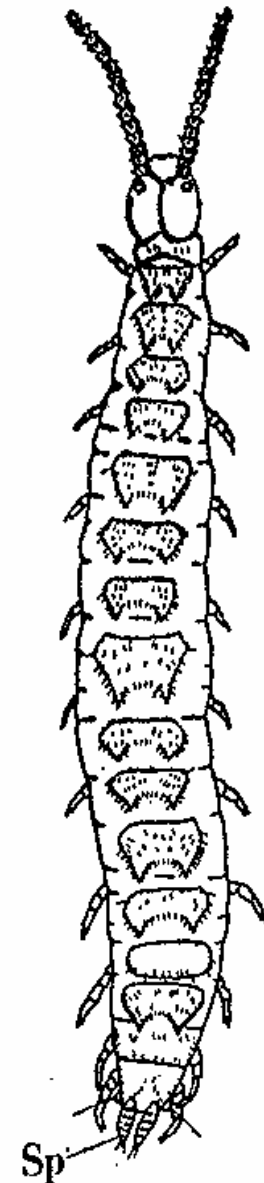
Up to 9 mm long

Autapomorphies:

- 12 pairs of legs;
- 1 pair of stigmata on head



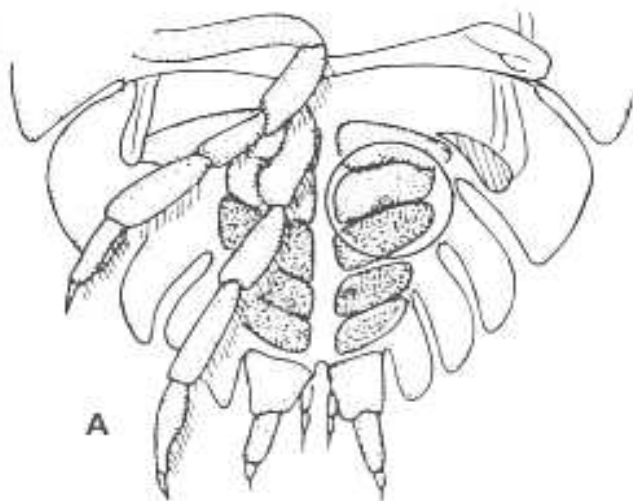
Scutigera immaculata



Symphyllela vulgaris (3 mm,
Sp - spinneret)

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Crustacea: Malacostraca: Peracarida: Isopoda – isopods / stejnonožci
Oniscoidea – wood lice / stinky a svinky



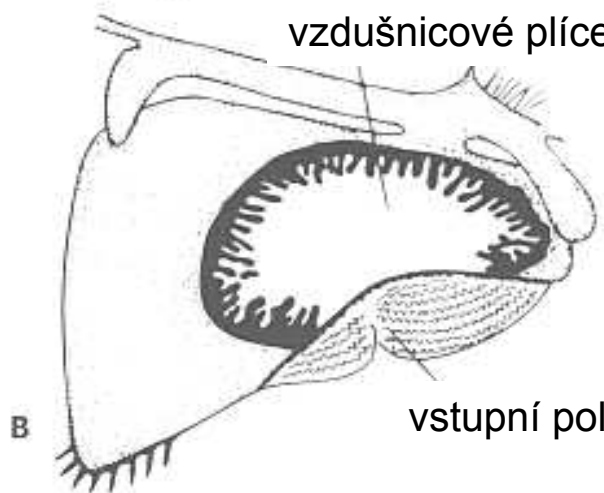
A

Vzdušnicové plíce u suchozemského stejnonožce
- svinky *Porcellio scaber*:

A - pleopody z ventrálního pohledu (v kruhu
exopodity 1. - 3. levého pleopoditu, v důsledku
naplnění vzduchem je 1. - 2. exopodit bílý)

B - exopodit s dýchacím otvorem na vstupním poli

vzdušnicové plíce

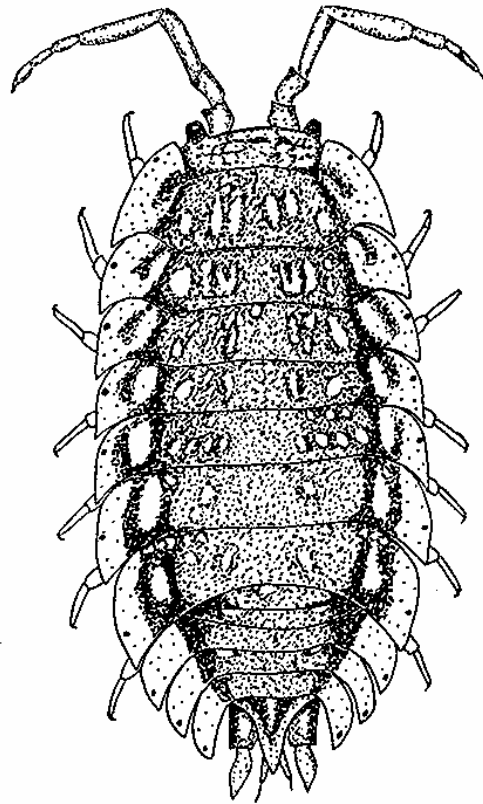


B

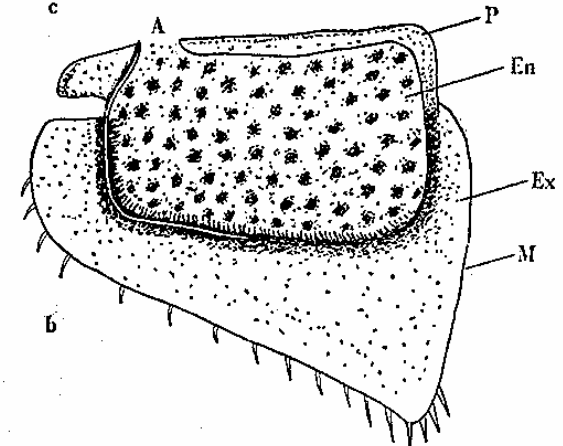
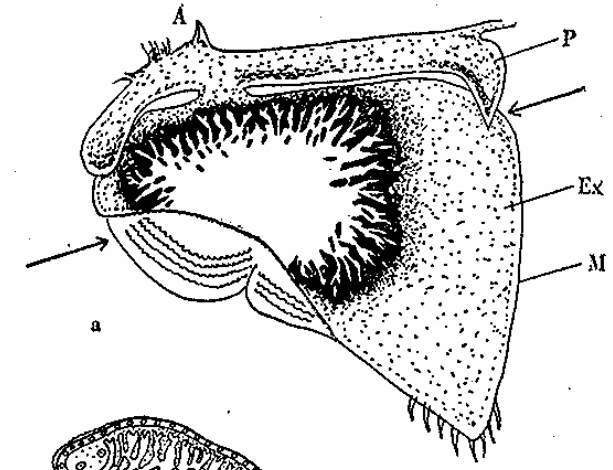
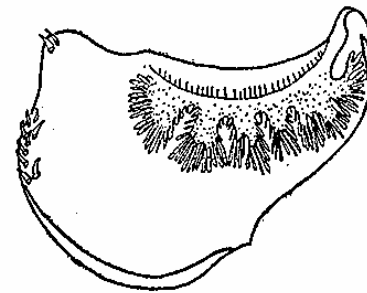
vstupní pole s dýchacím otvorem



The saprotrophic food chain in terrestrial ecosystems : Soil Biota



Oniscus asellus



Left, upper row: pleon of *Philoscia* sp. in ventral view, left exopodites removed to show gills (grey).

Left, lower row: Exopodite of 1st pleopod of *Armadillidium* sp. with lung.

Right: abdominal leg of *Porcellio scaber*, dorsal view; a – exopodite of 2nd pleopod with lung; b – exopodite and endopodite (with gill function) of 3rd pleopod; c – cross-section through 1st pleopod in the direction indicated by arrow in a.

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Crustacea: Malacostraca: Peracarida: Amphipoda – amphipods /
různonožci

Generally aquatic, a few species (also) in moist terrestrial habitats (litter layer), usually close to water bodies.

Only difference of the most adapted species: somewhat shorter pleopods.

Particularly family Talitridae, e.g. *Talitrus sylvaticus* (4 000 ind./m² in Australian rain forest).

In Central Europe *Gammarus pulex* can temporarily leave the water and live in near-by moist litter.



Gammarus pulex



Hyalella azteca

(Podkmen) Chelicerata - klepítkatci

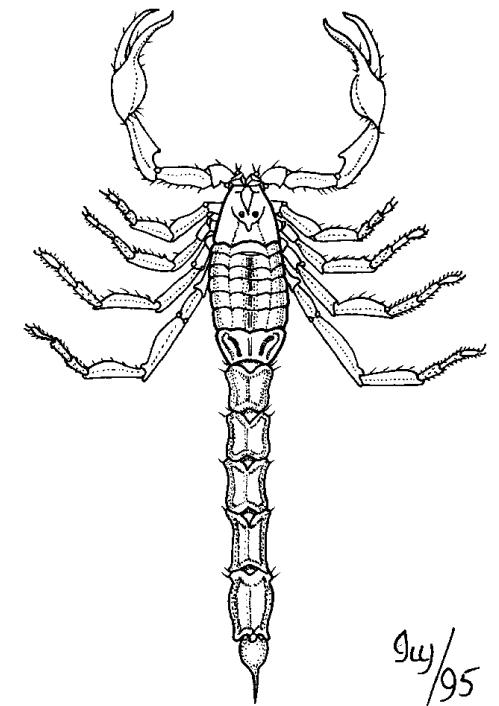
(Třída) Arachnida

Řád **Scorpionida** - štíři

Cca. 1400 druhů (0,9 - 21 cm)

Autapomorfie:

- hřebínkové orgány (pectines)



Livingstone, © BIODIDAC

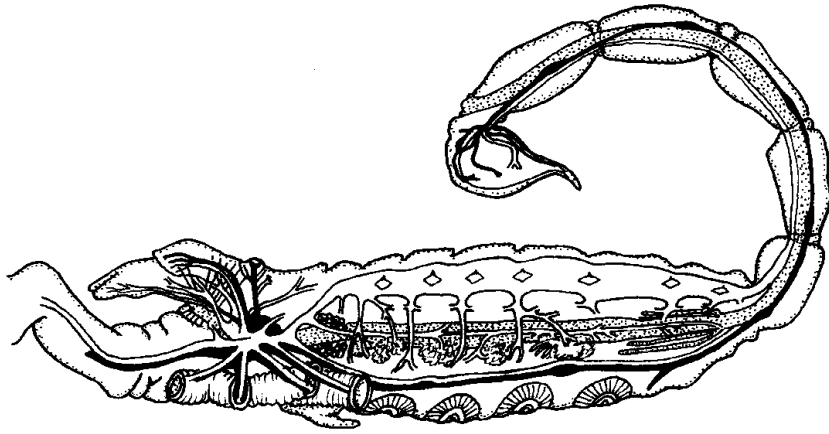


BIODIDAC © Houseman

(Podkmen) Chelicerata - klepítkatci

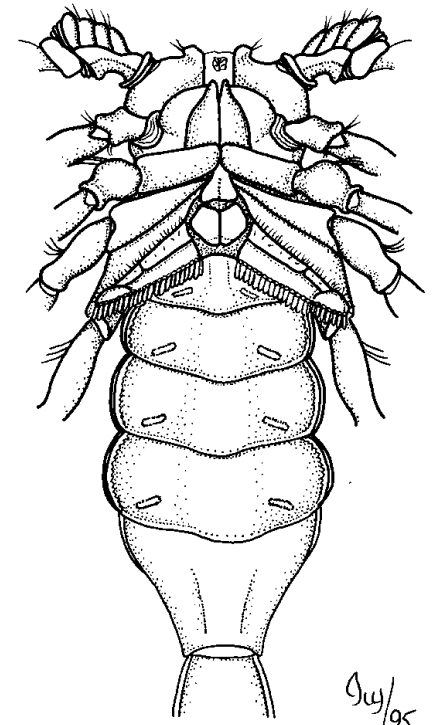
(Třída) Arachnida

Řád **Scorpionida** - štíři



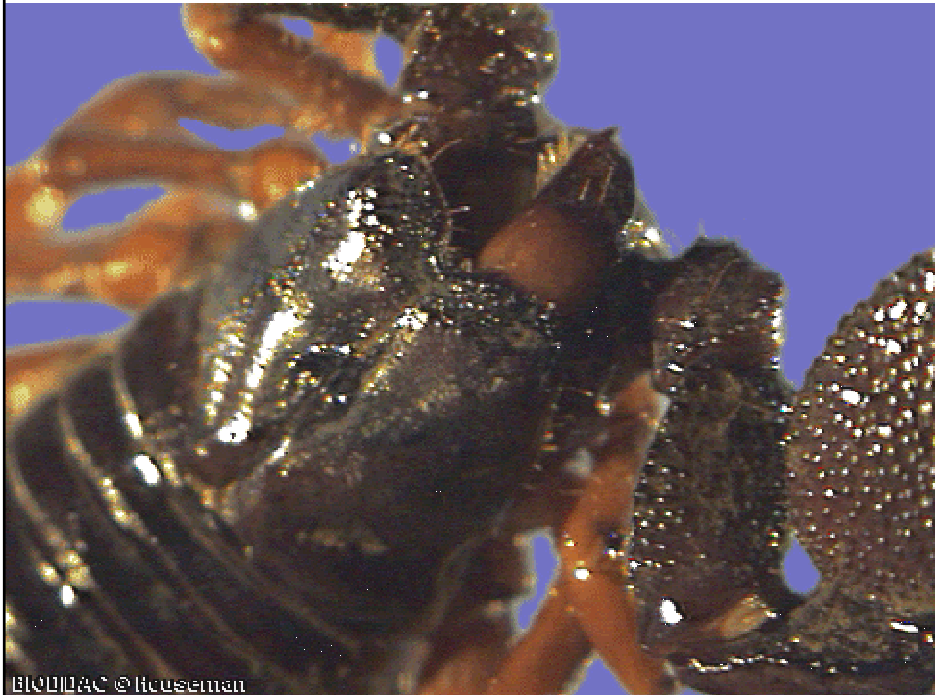
9/11/03

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Livingstone, © BIODIDAC

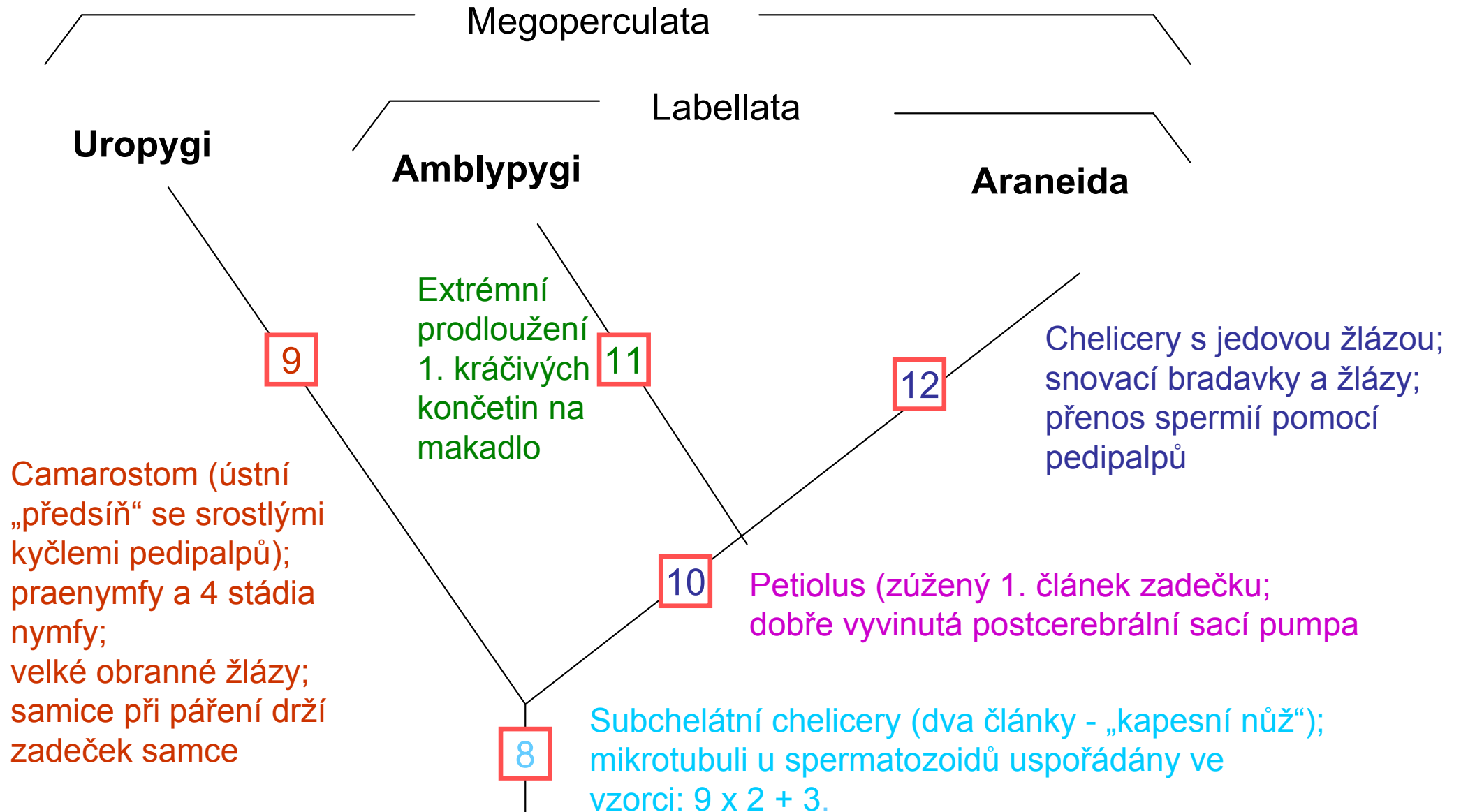
Centruroides vittatus



BIODIDAC © Ricuseman



(Podkmen) Chelicerata - klepítkatci



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád **Uropygi** - bičovci

Cca. 180 druhů (do 7,5 cm); (sub)tropičtí

Autapomorfie:

- camarostom (ústní „předsíň“ se srostlými kyčlemi pedipalpů);
- praenymfy a 4 stádia nymfy;
- velké obranné žlázy;
- samice při páření drží zadeček samce

Thelyphonida



Schizomida



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád **Amblypygi**

Cca. 100 druhů (10 - 45 mm); (sub)tropičtí

Autapomorfie:

- extrémní prodloužení 1. kráčivých končetin na makadlo



(Podkmen) Chelicerata - klepítkatci

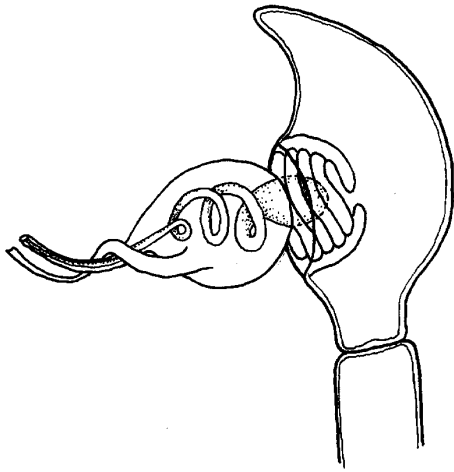
(Třída) Arachnida

Řád Araneida - pavouci

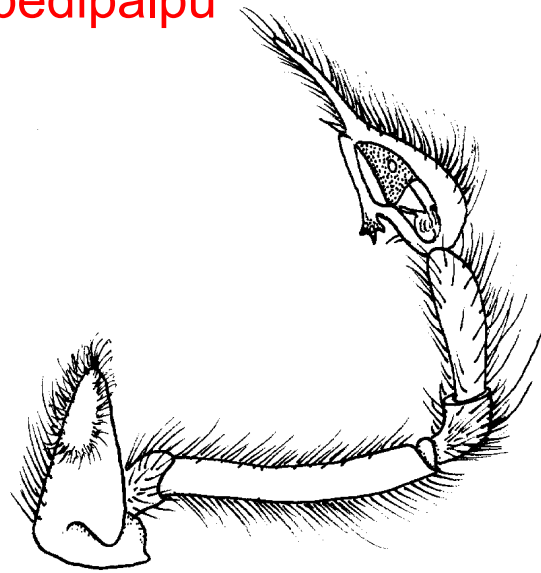
Cca. 34 000 druhů

Autapomorfie:

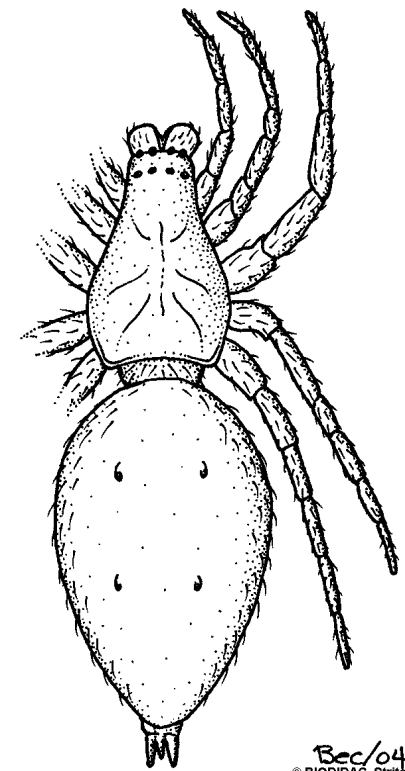
- chelicery s jedovou žlázou;
- snovací bradavky a žlázy;
- přenos spermií pomocí pedipalpů



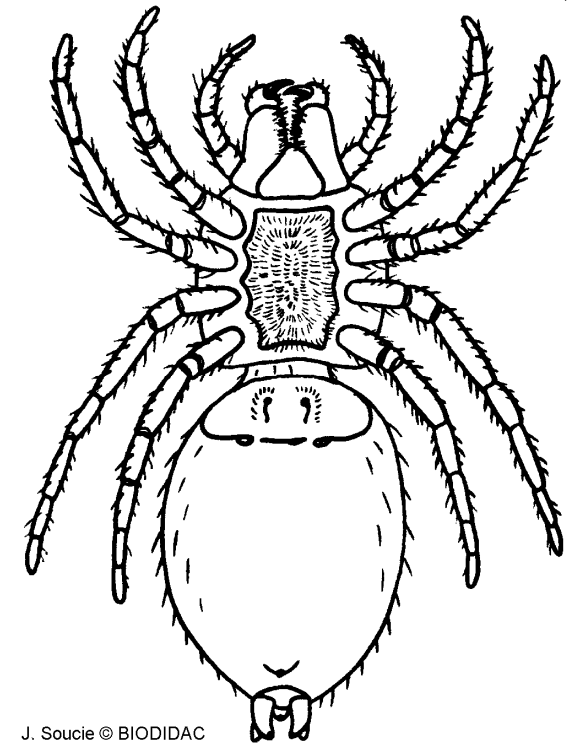
Guy/03
© BIODIDAC, Livingstone



Guy/03
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Bec/04
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J. Soucie © BIODIDAC

Samčí pedipalpus – přenos spermatofóru

(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád Araneida - pavouci

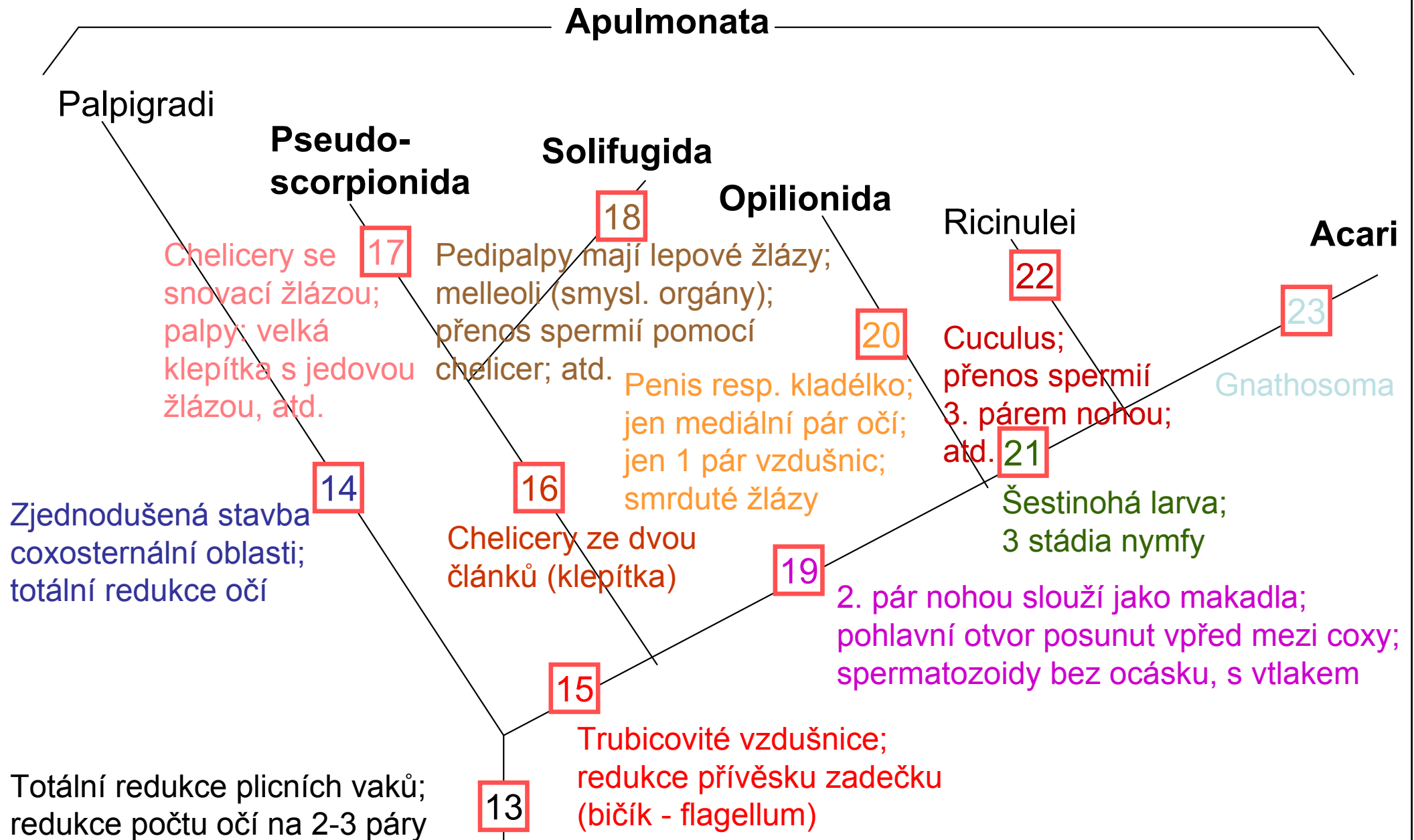
Orthognatha - sklípkaní



Labidognatha - dvouplícní



(Podkmen) Chelicerata - klepítkatci



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád Pseudoscorpionida - štírci

Cca. 3000 druhů (1-7 mm); v listovém opadu, pod kůrou atd.

Autapomorfie:

- chelicery se snovací žlázou;
- palpy: velká klepítka s jedovou žlázou,
- atd.



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád Solifugida - solifugy

Cca. 900 druhů (1-7 cm); pouště, polopouště, step

Autapomorfie:

- pedipalpy mají lepové žlázy;
- malleoli (smyslové orgány);
- přenos spermií pomocí chelicer;
- atd.



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád Opilionida - sekáči

Cca. 4000 druhů

Autapomorfie:

- penis resp. kladélko;
- jen mediální pár očí;
- jen 1 pár vzdušnic;
- smrduté žlázy.



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád Ricinulei

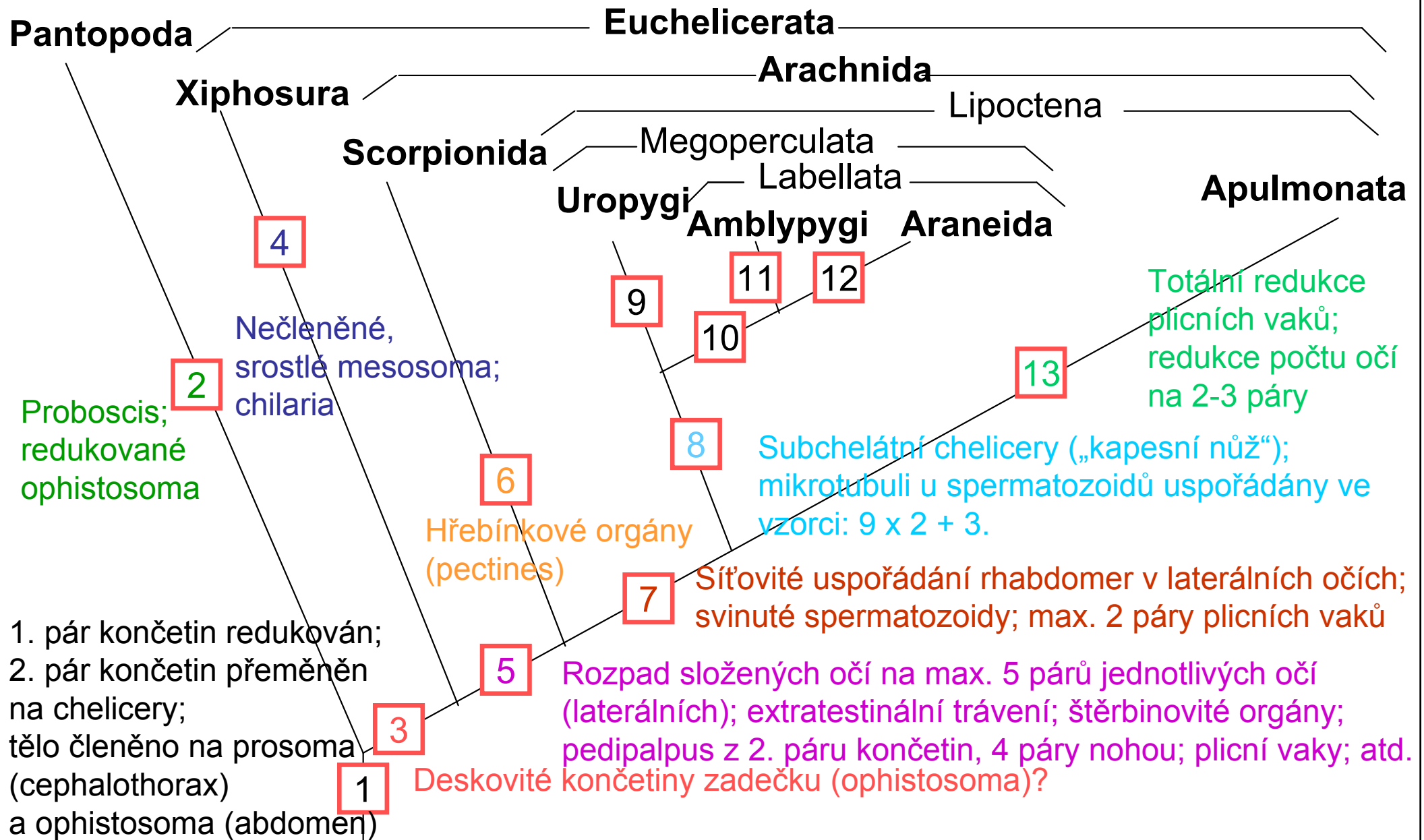
Cca. 40 druhů (do 10 mm) v listovém opadu tropických lesů (Amerika, Afrika)

Autapomorfie:

- cuculus (pohyblivý výrůstek na hřbetu prosoma; v klidu kryje ústní ústrojí)
- přenos spermií 3. párem nohou;
- atd.

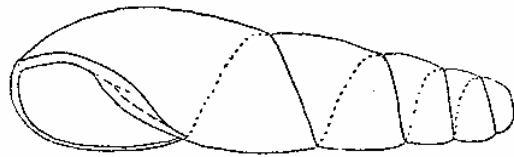


(Podkmen) Chelicerata - klepítkatci



The saprotrophic food chain in terrestrial ecosystems : Soil Biota

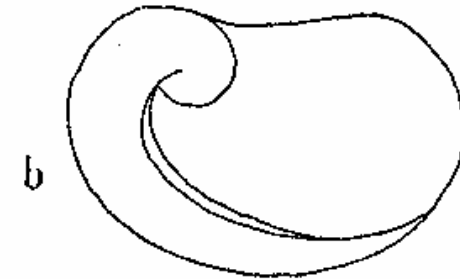
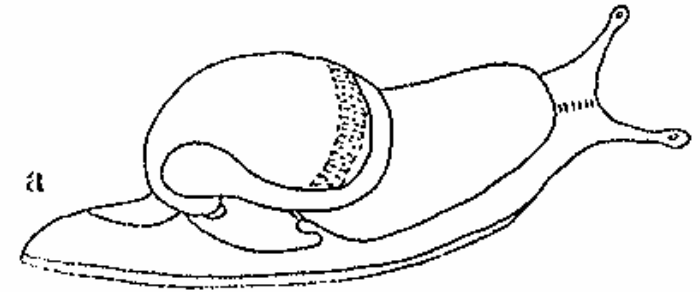
Examples of soil living snails (Gastropoda)



Shell of the soil-dwelling Snail *Cecilioides acicula* (4-5 mm long)

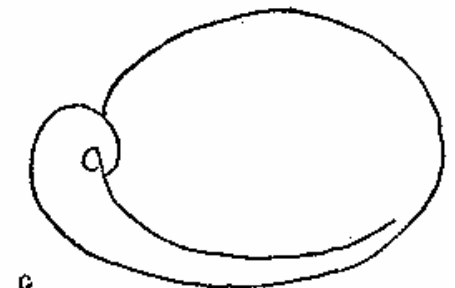
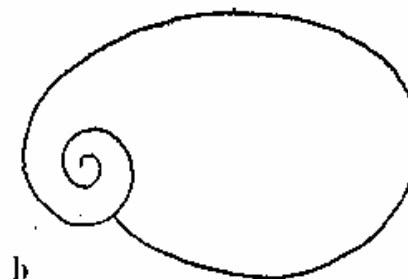
Vitrinobrachium breve dwells in the litter layer or loose mineral topsoil during the day:

- a) creeping individual
- b) ventral view of shell - higher magnification than in a), (max. shell diameter 5.6 mm)

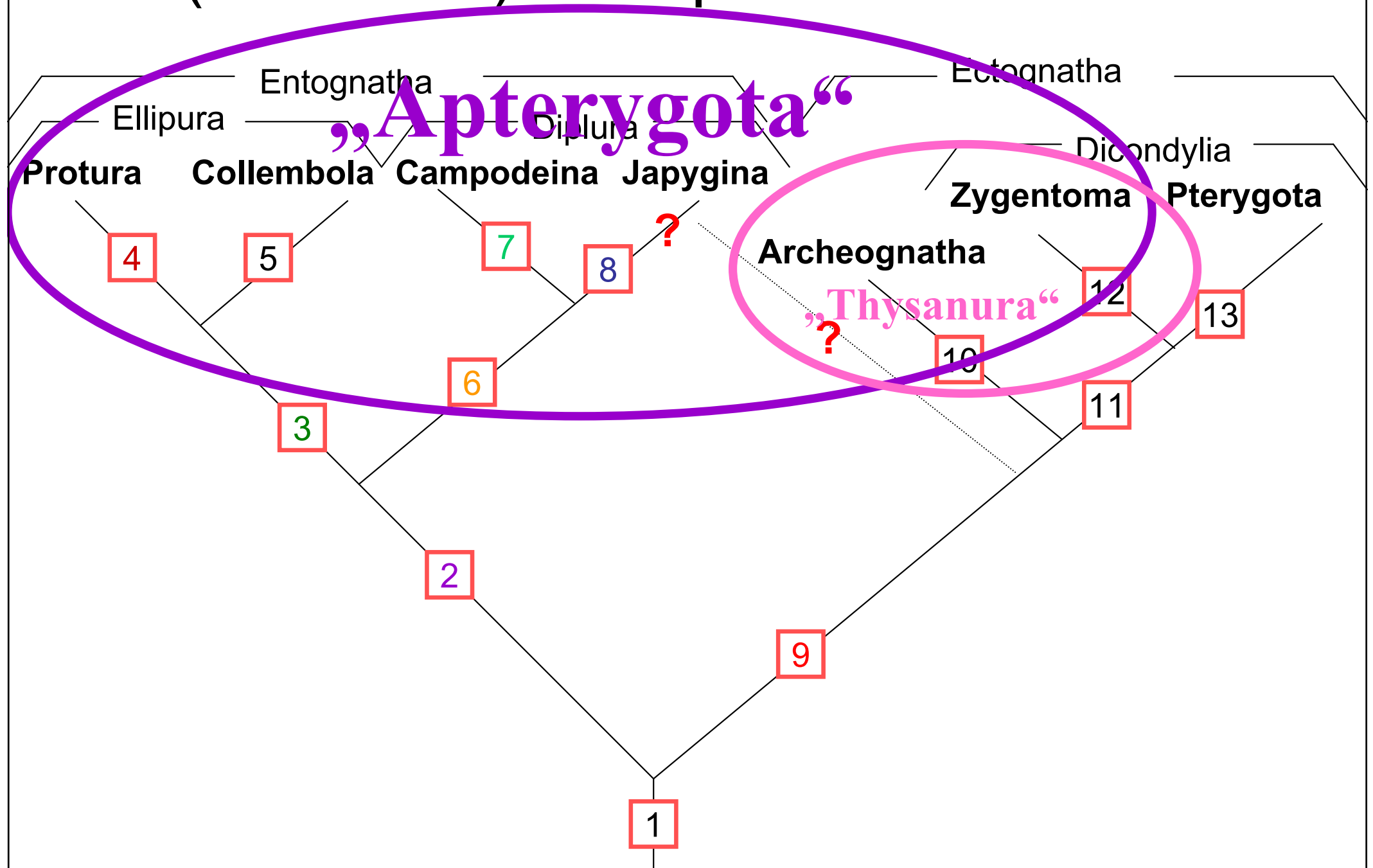


Daudebardia brevipes, a predatory snail with Reduced shell living in the upper soil layer, moist leave litter and moss cushions:

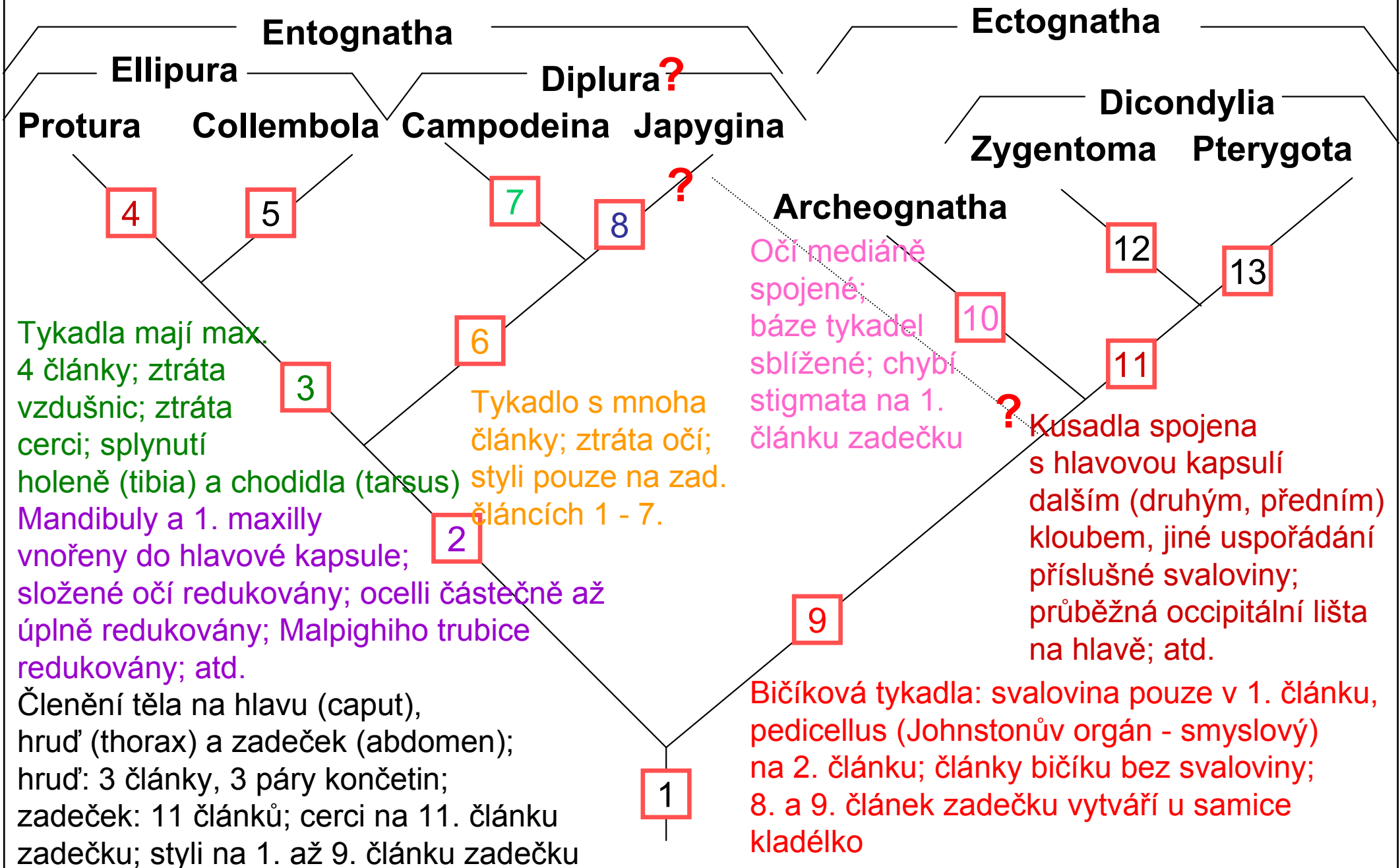
- a) creeping individual
- b) dorsal view of shell
- c) ventral view of shell (max. shell diameter 4.6 mm)



(Podkmen) Hexapoda - šestinozí



(Podkmen) Hexapoda - šestinozí



The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Hexapoda: Entognatha



Protura

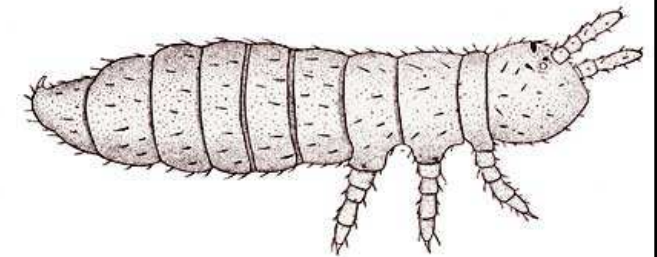
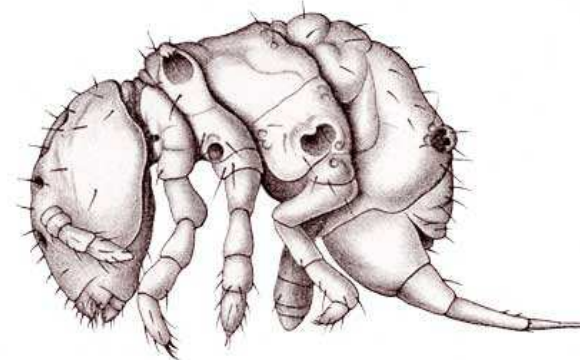


Campodeina

Japygina

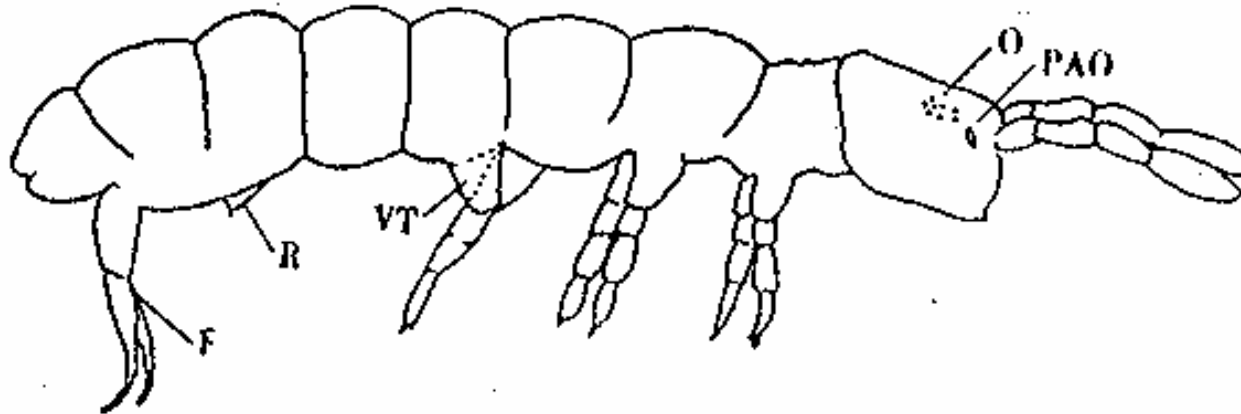


Collembola



The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Collembola – springtails / chvostoskoci



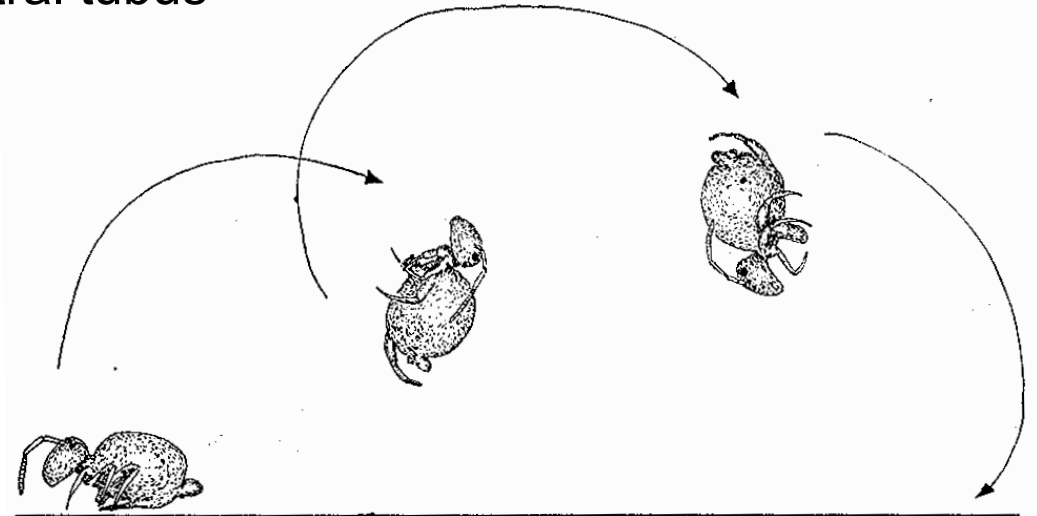
Morphology of a springtail (Collembola: Isotomidae):

PAO – postantennal organ, O – separate eyes,

F – furca, R – retinaculum, VT – ventral tubus



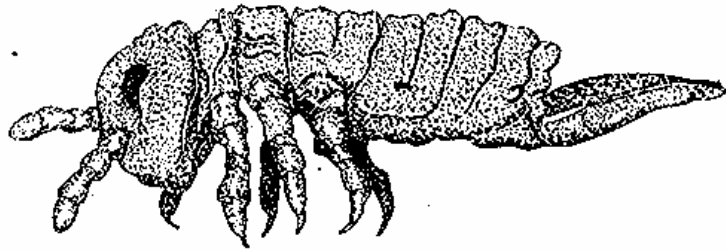
Jumping springtail (*Sminthurus* sp.,
Sminthuridae)



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The saprotrophic food chain in terrestrial ecosystems : Soil Biota



a



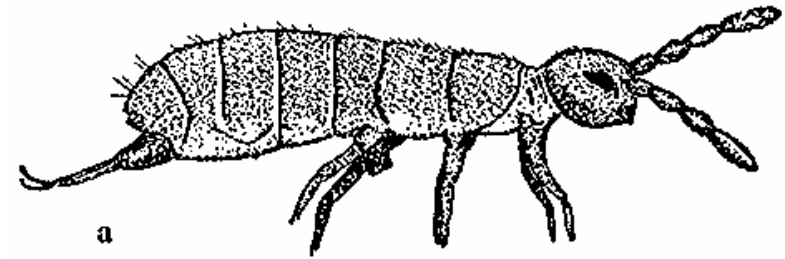
b



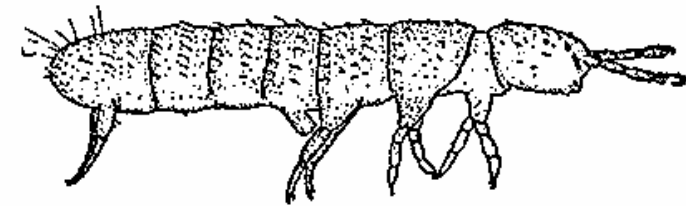
c

Poduromorphous Collembola:

- *Podura aquatice* (1.2 mm) – on the water surface
- *Hypogastrura viatica* (1.6 mm) – hemiedaphic
- *Willemia anophthalma* (0,6 mm, blind) - euedaphic



a



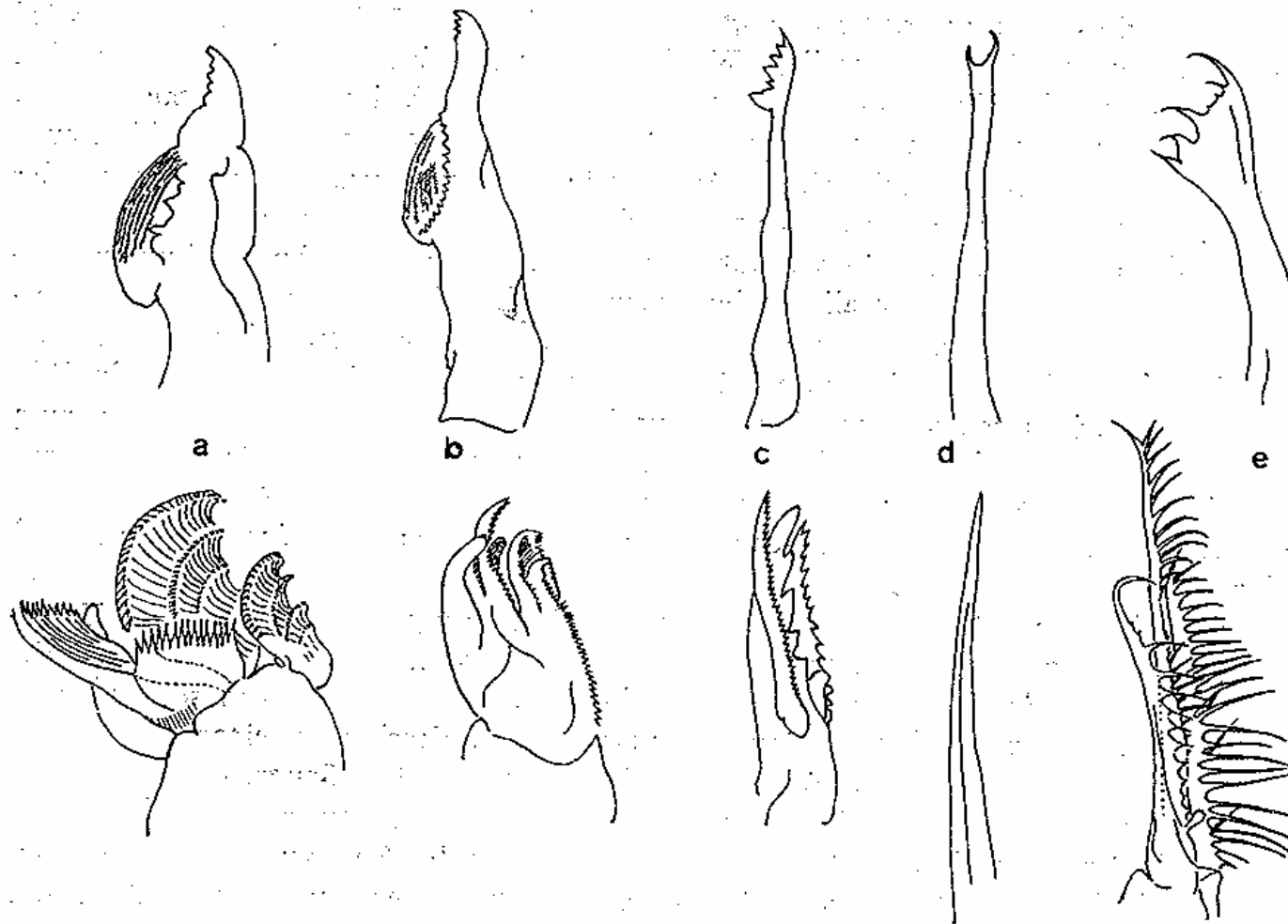
b



Isotomid Collembola:

- *Isotoma viridis* (4.0 mm) – hemiedaphic
 - *Folsomia quadrioculata* (1.9 mm)
 - *Isotomodes productus* (0.7 mm)
- b and c increasingly euedaphic

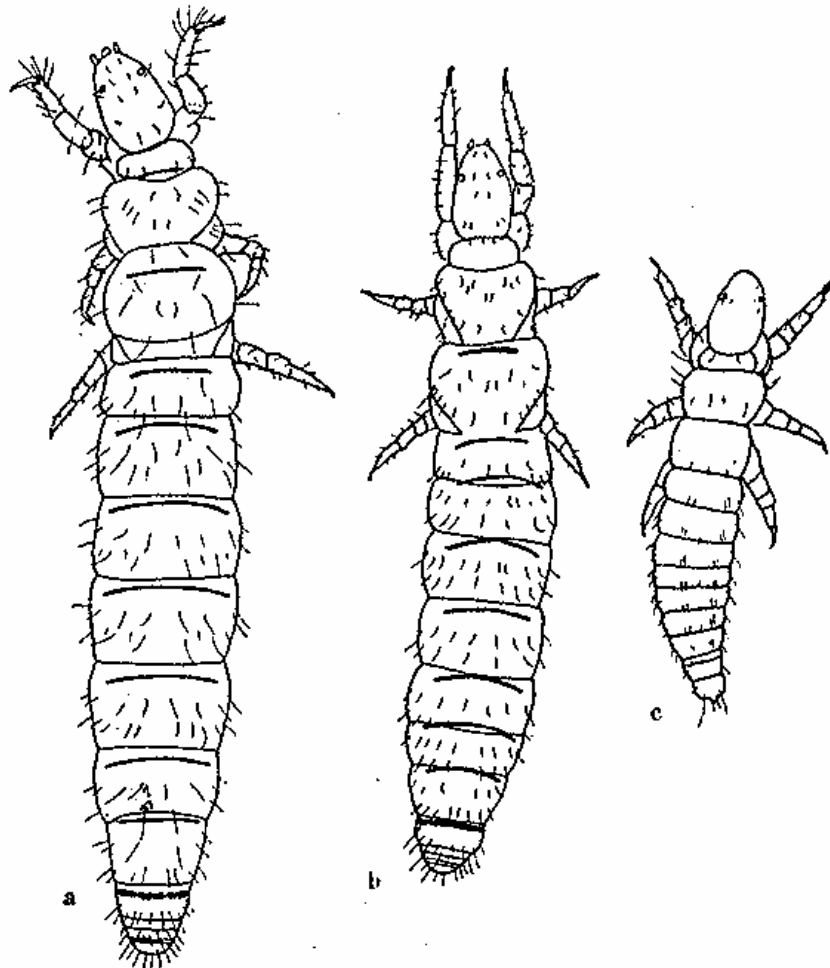
The saprotrophic food chain in terrestrial ecosystems : Soil Biota



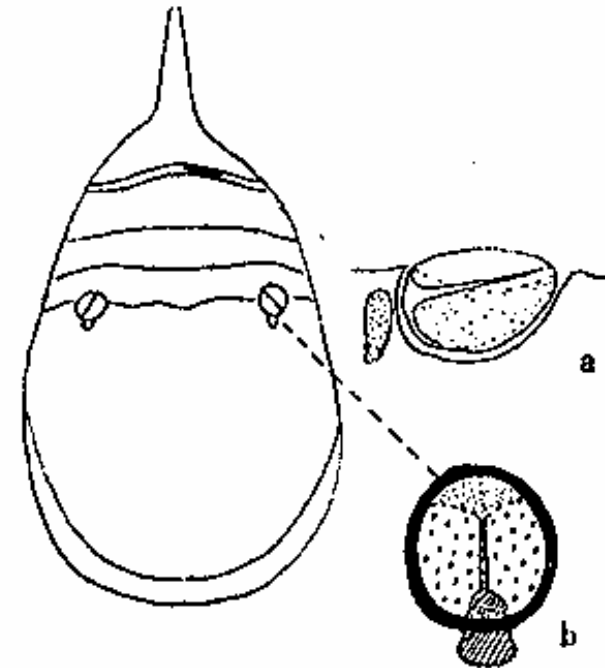
Mouthparts of Collembola: upper row mandibulae, lower row maxillae;
a – chewing, hard food; b) chewing, soft food; c) sucking – cutting;
d) sucking – piercing; e) sucking - brushing

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Protura – proturans / hmyzenky



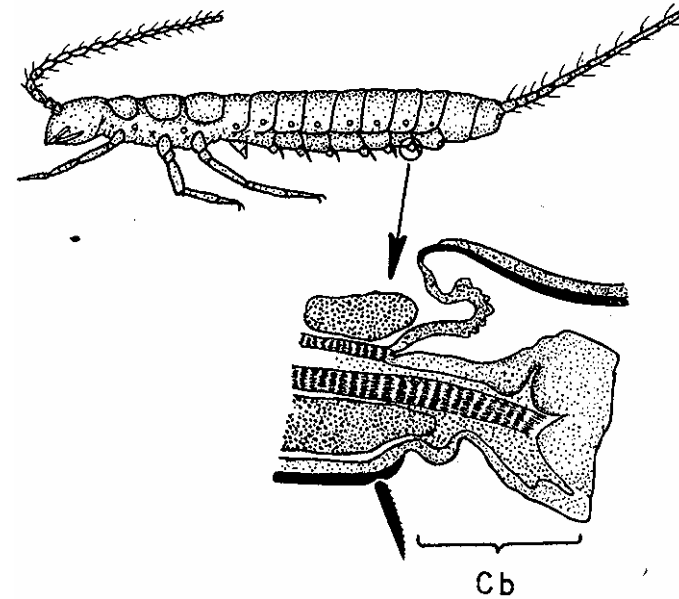
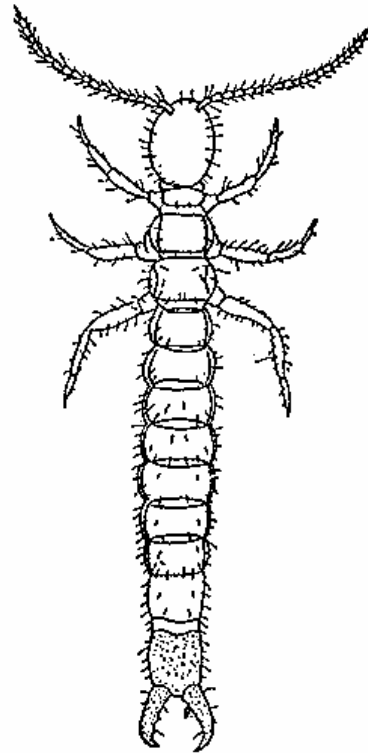
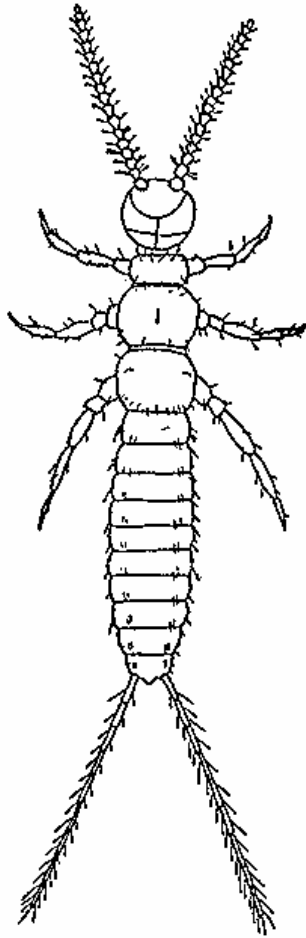
Developmental stages of *Acerella danica*:
a) imago (female), b) praeimago, c) praelarva;
1.0, 0.8 and 0.4 mm, respectively.



Head of *Acerentomon* sp.
With pair of pseudoculi;
a) Section through pseudoculus
b) Dorsal view of pseudoculus

The saprotrophic food chain in terrestrial ecosystems : Soil Biota

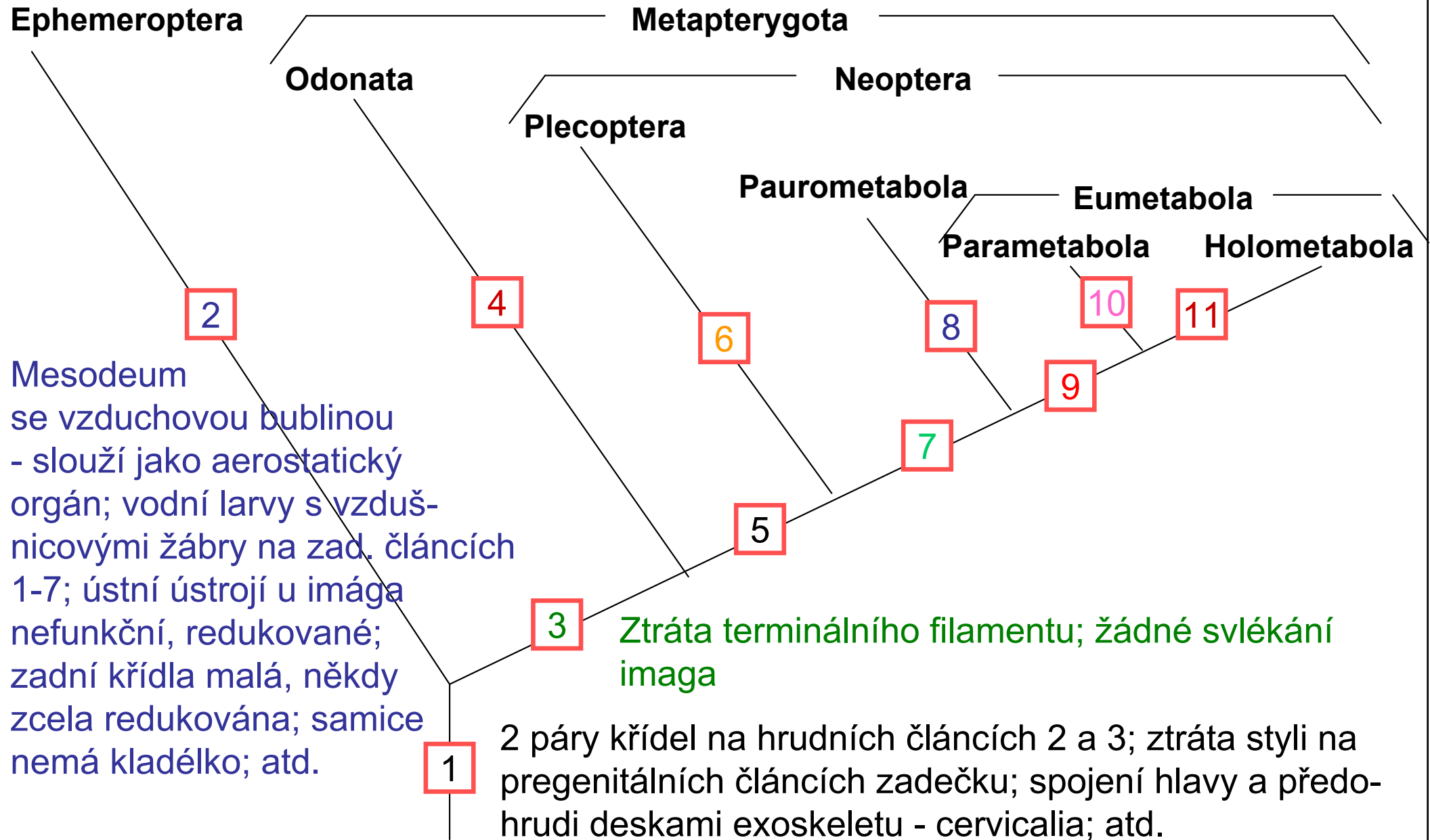
Diplura – diplurans / vidličnatky



Diplura: everted coxal follicles (Cb) serve to take up water from a surface

Campodeina (štětínatky) Japygina (škvorovky)

(Podtřída) Pterygota - křídlatí



(Podkmen) Hexapoda - šestinozí

(Třída) Ectognatha - jevnočelistní

(Podtřída) Archeognatha - chvostnatky

(Podtřída) Zygentoma - rybenky



Archeognatha



Zygentoma



(Podkmen) Chelicerata - klepítkatci

(Třída) Arachnida

Řád Acari - roztoči

Cca 35 000 druhů popsáno
(odhad: 100 000 recentních druhů)

Autapomorfie:

- Gnathosoma

Prostigmata
= Trombidioformes
- sametkovci

Mesostigmata
= Gamasida
- čmelíkovci

Astigmata = Acaridida
= Sarcoptiformes - sametkovci

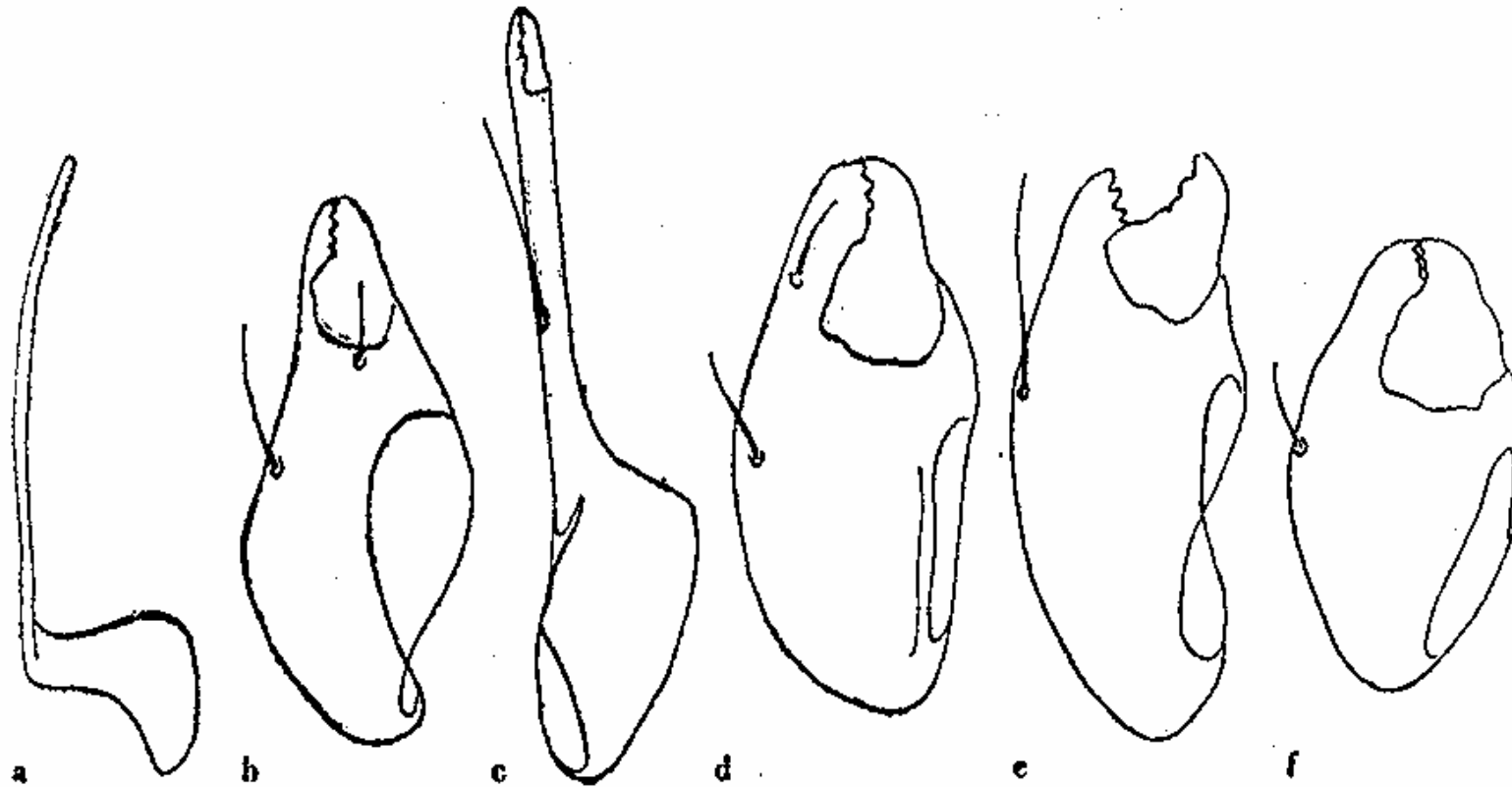


Metastigmata
= Ixodida - klíš'ata

Cryptostigmata
= Oribatida
- pancířníci



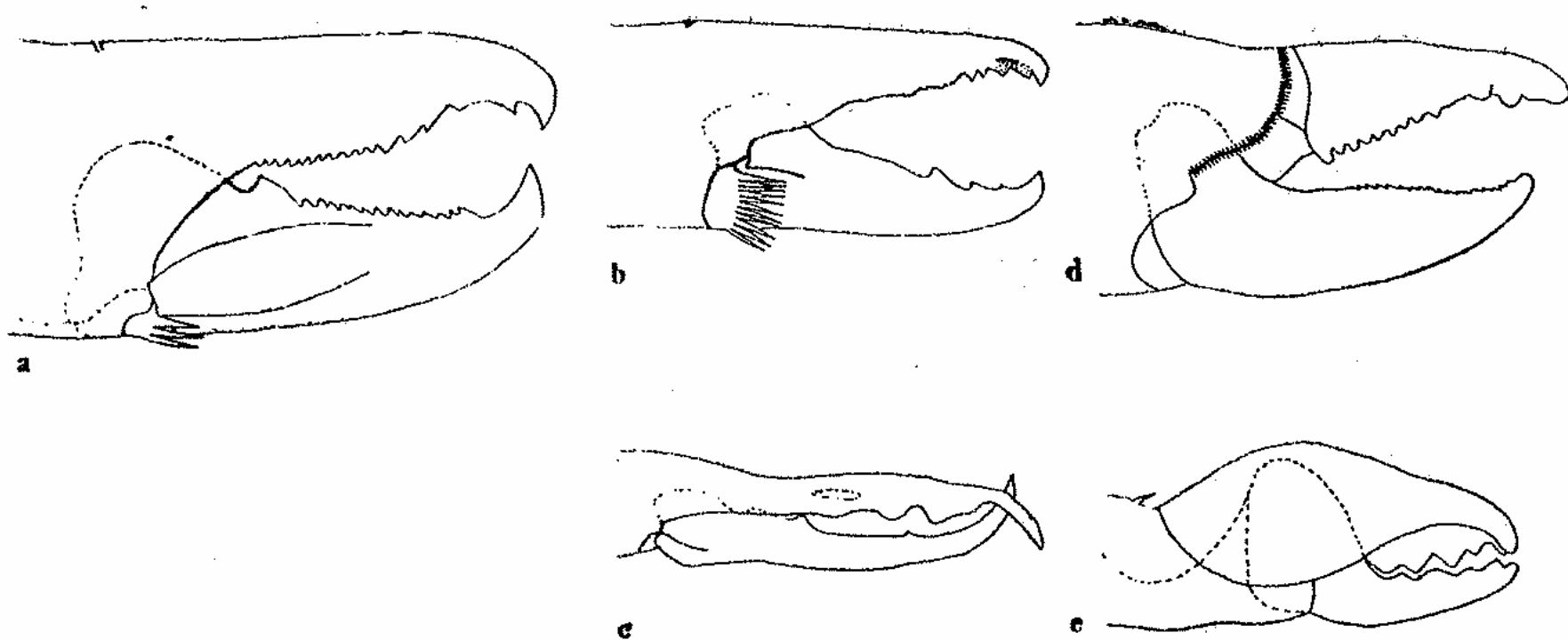
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Shapes of chelicera in different trophic groups of Oribatida:

a) microphytophagous, b) microphytophagous, c) not specialized,
d) not specialized, e) macrophytophagous, f) macrophytophagous

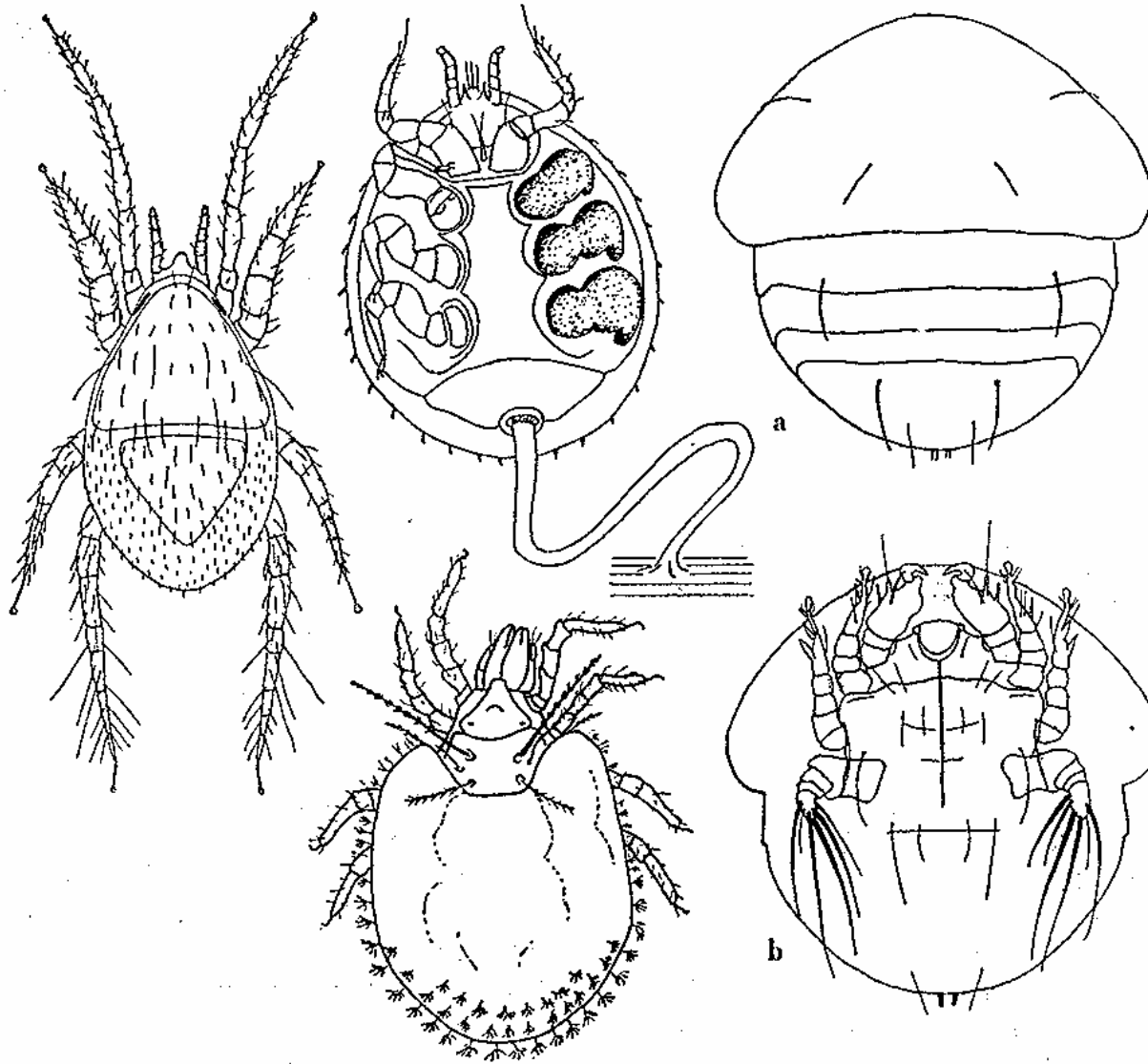
The saprotrophic food chain in terrestrial ecosystems : Soil Biota



Types of chelicera in mesostigmatid mites: a-c zoophages, d-e phyto(sapro)phages;

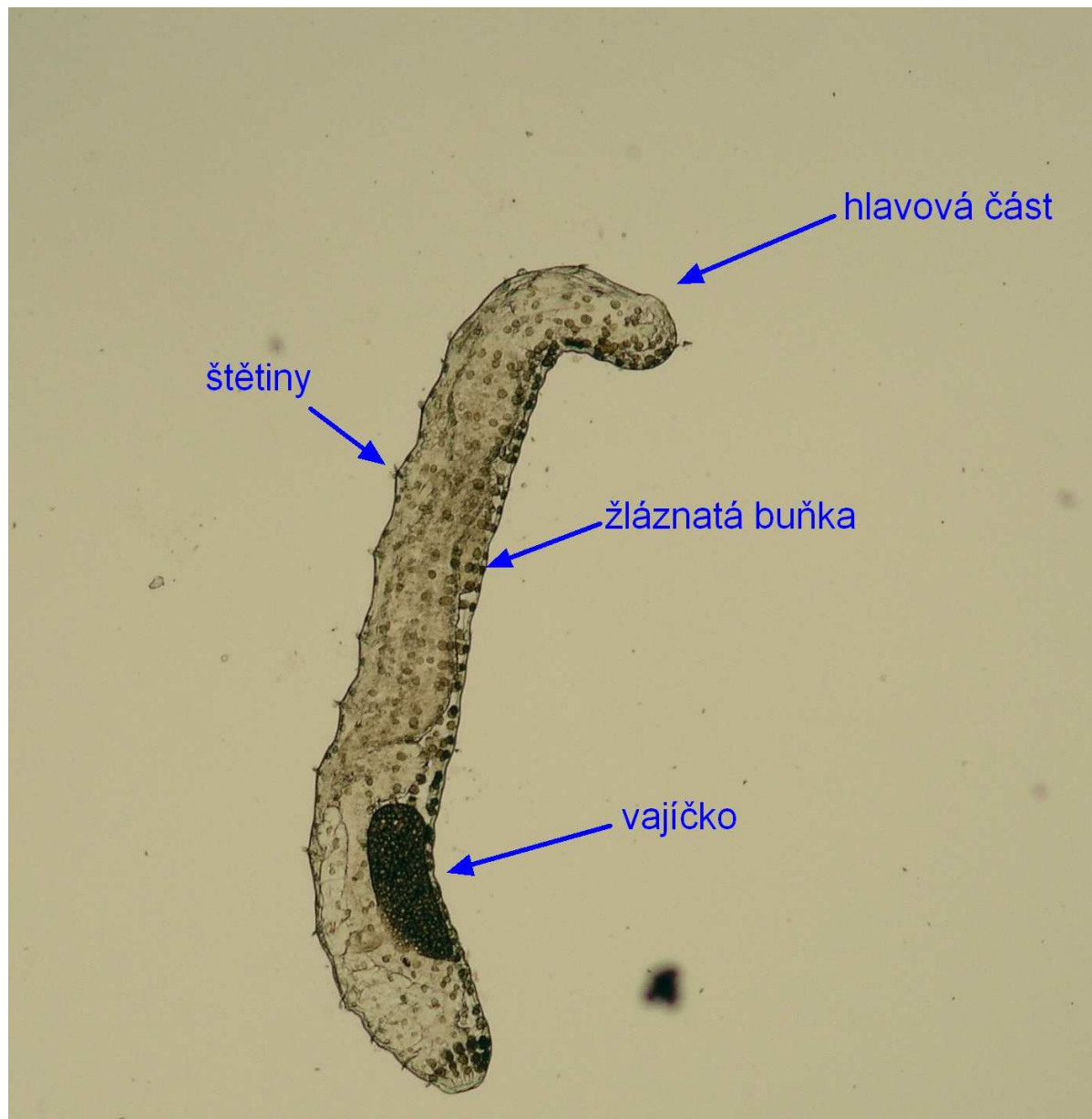
- a – *Dendorlaelaps hexaspinosus* – attacks larger insect larvae, cutting denticles
- b – *Parasitus creapelini* – attacks mites and insect larvae, tearing denticles
- c – *Vergaia verva* – pincer-like cheliceres with sharp apical hooks to hold fast springtails (Collembola)
- d – *Liroaspis togatus* – strong cheliceres with rasper-like denticles to chew dead plant tissues
- e – *Pseudouropoda ovalis* – nutcracker-shaped cheliceres to quash plant spores

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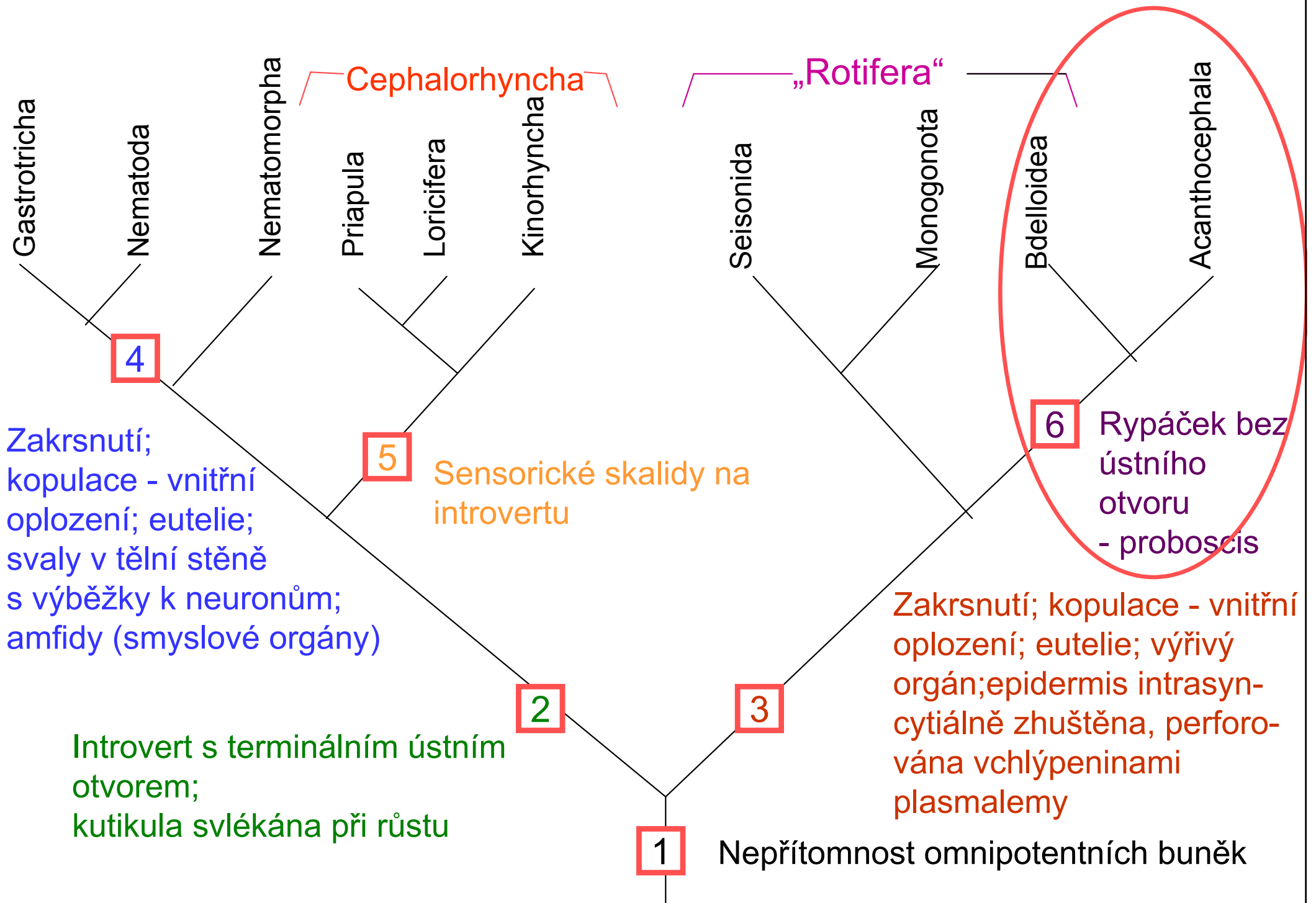
Polychaeta (Annelida) - mnohoštětinatci

Je známo několik mnohoštětinatců z terestrického prostředí tropických lesů. Z Evropy jsou známy také jedině dva druhy skutečně půdní: *Parergodrilus heideri* a *Hrabeiella pariglandulata*. Hlavně systematická pozice druhého druhu je stále nejasná a předmětem výzkumu.



Hrabeiella pariglandulata („Polychaeta“: Parergodrilidae - ?)

Nemathelminthes (= Aschelminthes)

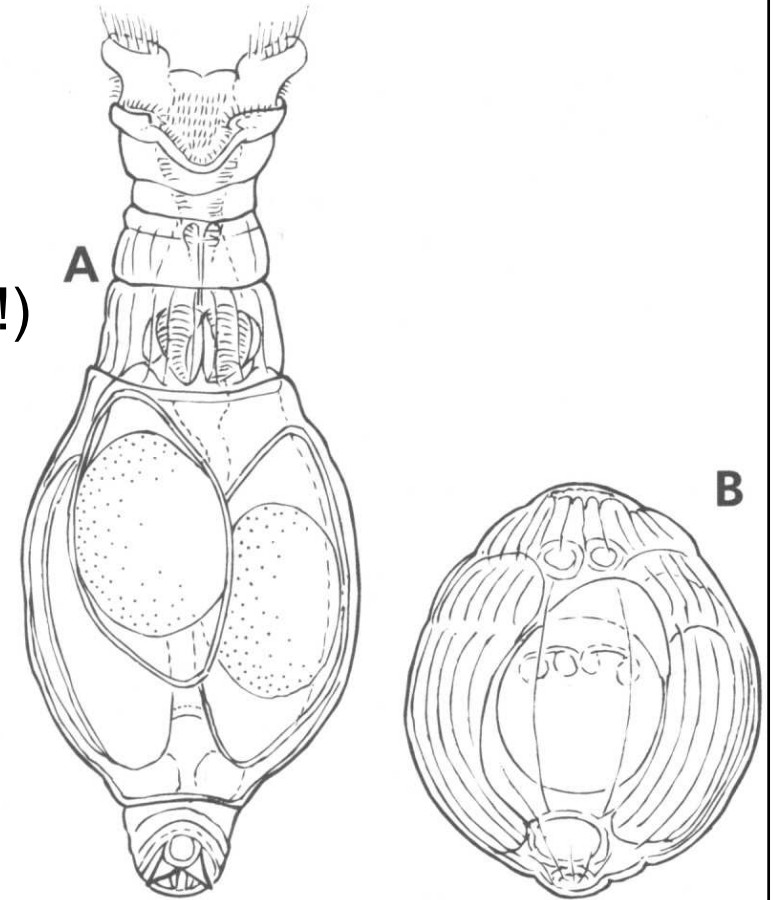


„Rotifera“ (=„Rotatoria“) - vířníci

(Kmen) Rotifera - vířníci

(Třída) **Bdelloidea** - pijavenky

- sladkovodní a půdní (i na meších či lišejnících)
- výrazná **schopnost anabiózy** (životní prostředí!)
- pouze partogenetické samice
- cylindrické, teleskopicky stažitelné tělo („pijavkovitý“ pohyb - jméno!)



Macrotrachela quadricornifera
(Bdelloidea): A - samice s vajíčky
a rozvinutým vířivým orgánem;
B - jedinec v anabióze

(kmen) Nematoda - hlístice

nema = niť (stará řečtina)

- cca. 15 000 popsaných (!) druhů
- z živočichů dosahují největší populační hustoty (až 20 milionů jedinců / m² lesní či luční půdy)
- ekto i endoparasiti rostlin a živočichů; i volně žijící (mořské a sladkovodní sedimenty, půda, mechy)
- velikost většinou 1 - 3 mm, mezi parazity i větší zástupci (největší hlístice - *Placentonema gigantissimum* - žije v placentě vorvaně: délka až 8,4 metrů, tloušťka až 2,5 cm)
- u malých druhů běžně eutelie
- válcovité, protáhlé tělo

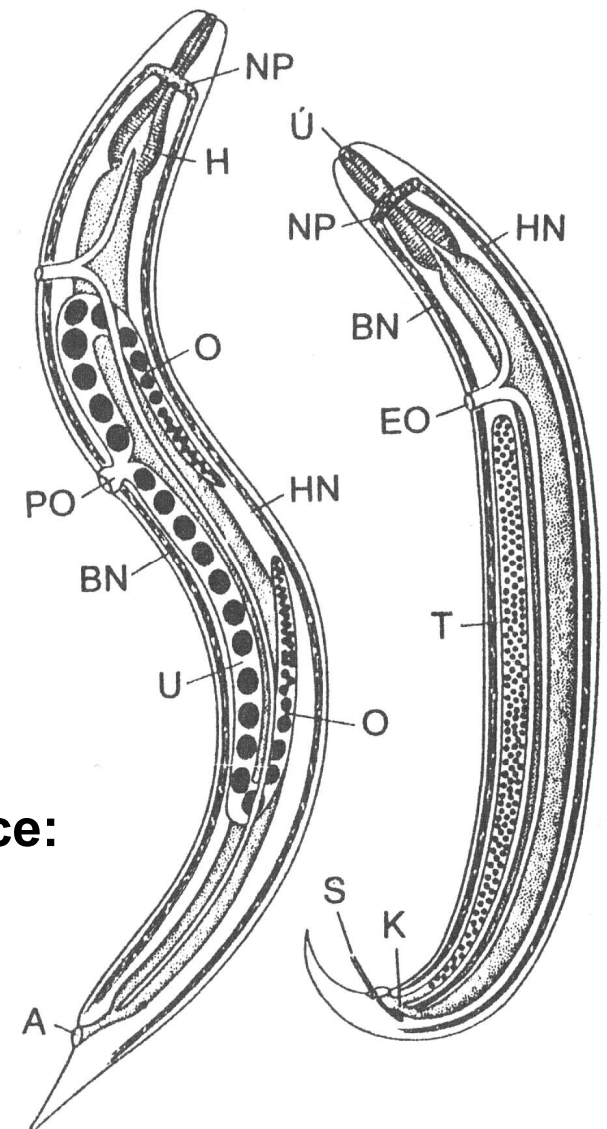
Schema stavby těla samice (vlevo) a samce (vpravo) hlístice:

A - anus; BN - břišní nervový provazec; EO - exkreceční otvor;

H - hltan; HN - hřbetní nervový provazec; K - kloaka;

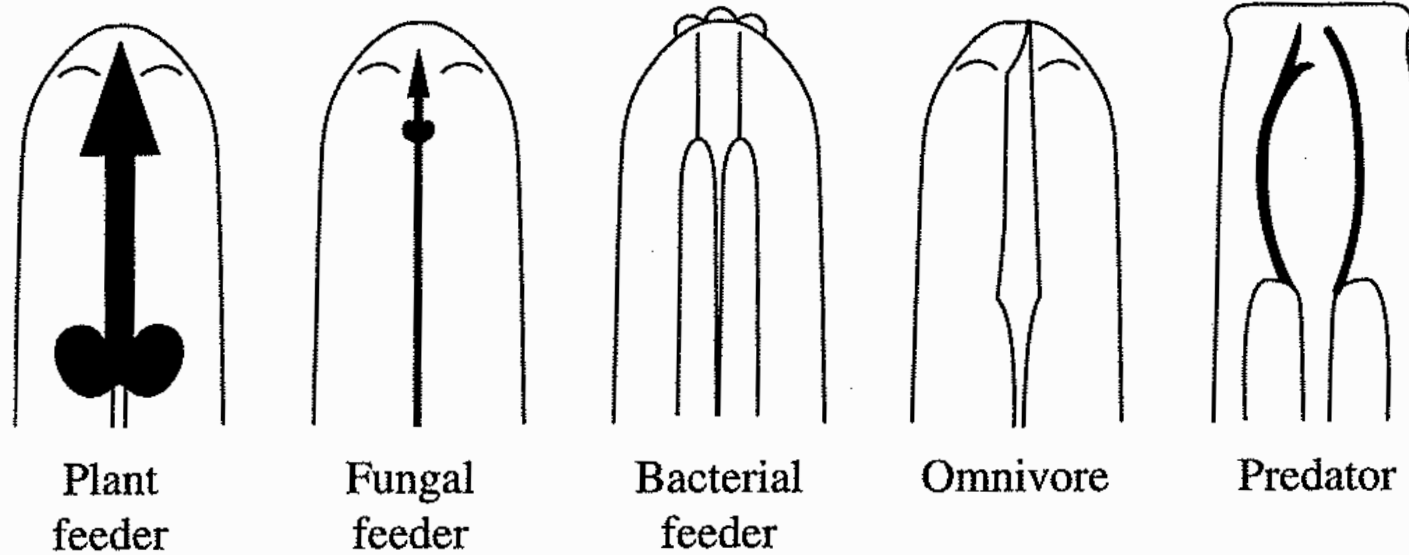
NP - nervový prstenec; O - ovarium; PO - pohlavní otvor;

S - spikuly; T - testes; U - uterus; Ú - ústa

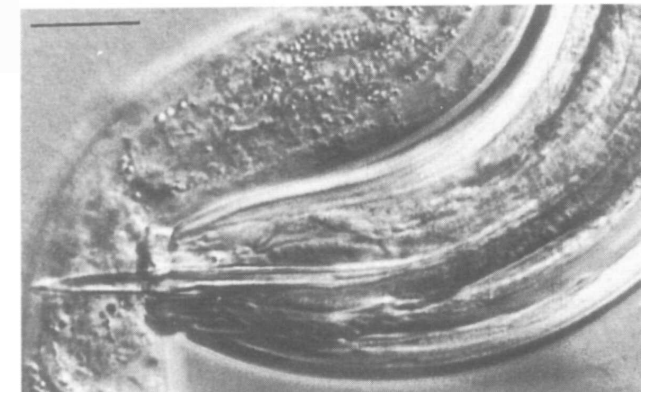
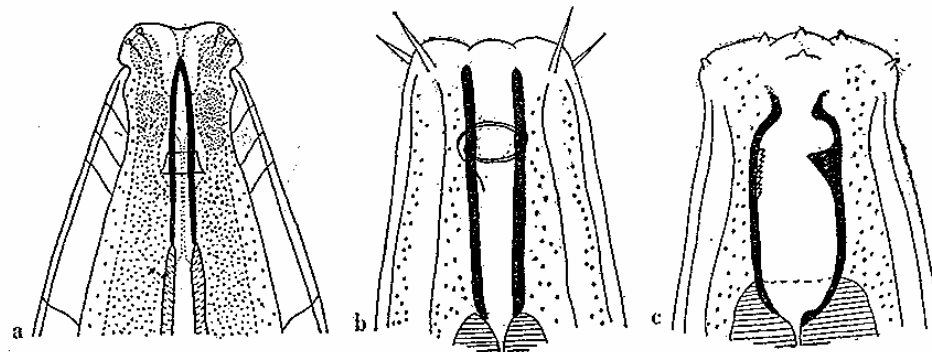


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Nematoda – nematodes / hlístice



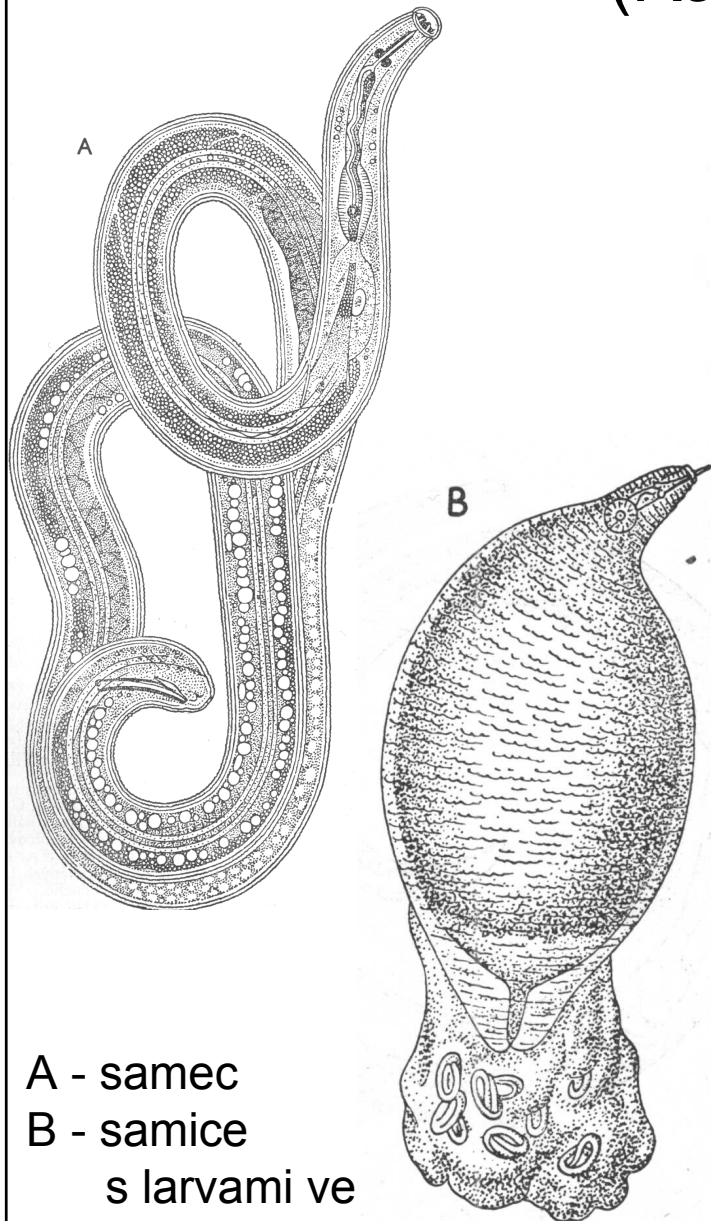
Schematic diagram of mouthparts of nematode feeding groups most commonly found in soil. (Redrawn from Bardgett and Griffith 1997.)



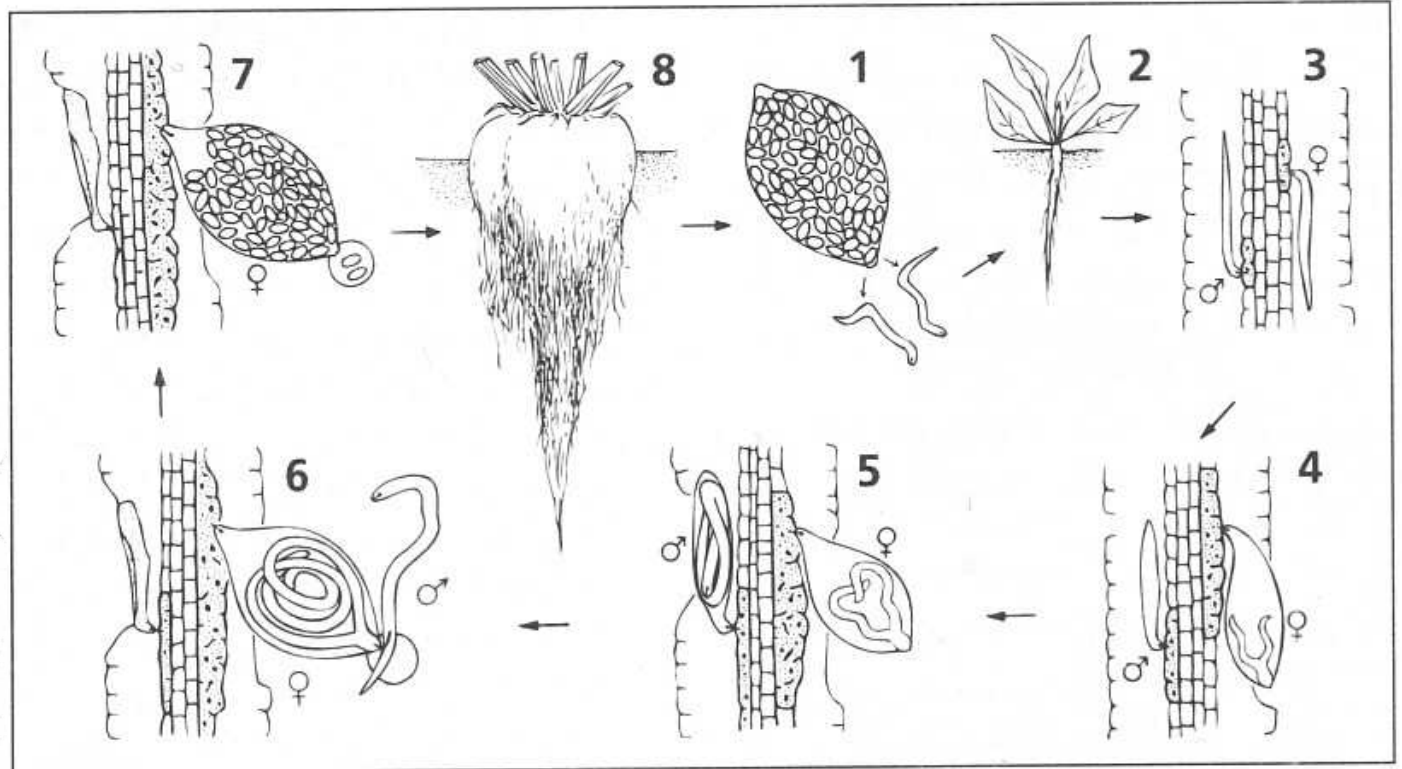
Predacious representative of the order Dorylaimida (*Labronema* sp.)
Attacking other nematode (scale 20 μm)

Nematoda - hlístice

(Řád) Tylenchida - háďátka

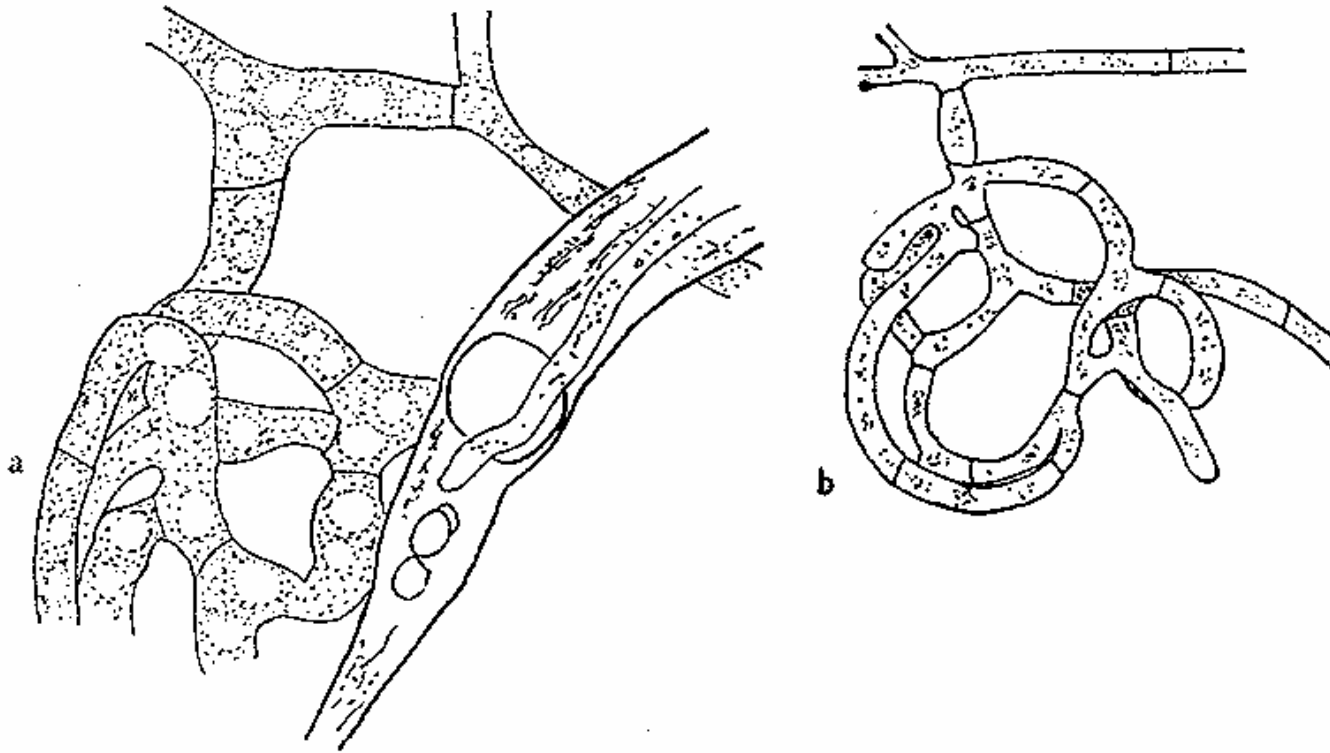


A - samec
B - samice
s larvami ve
vyloučeném hleu

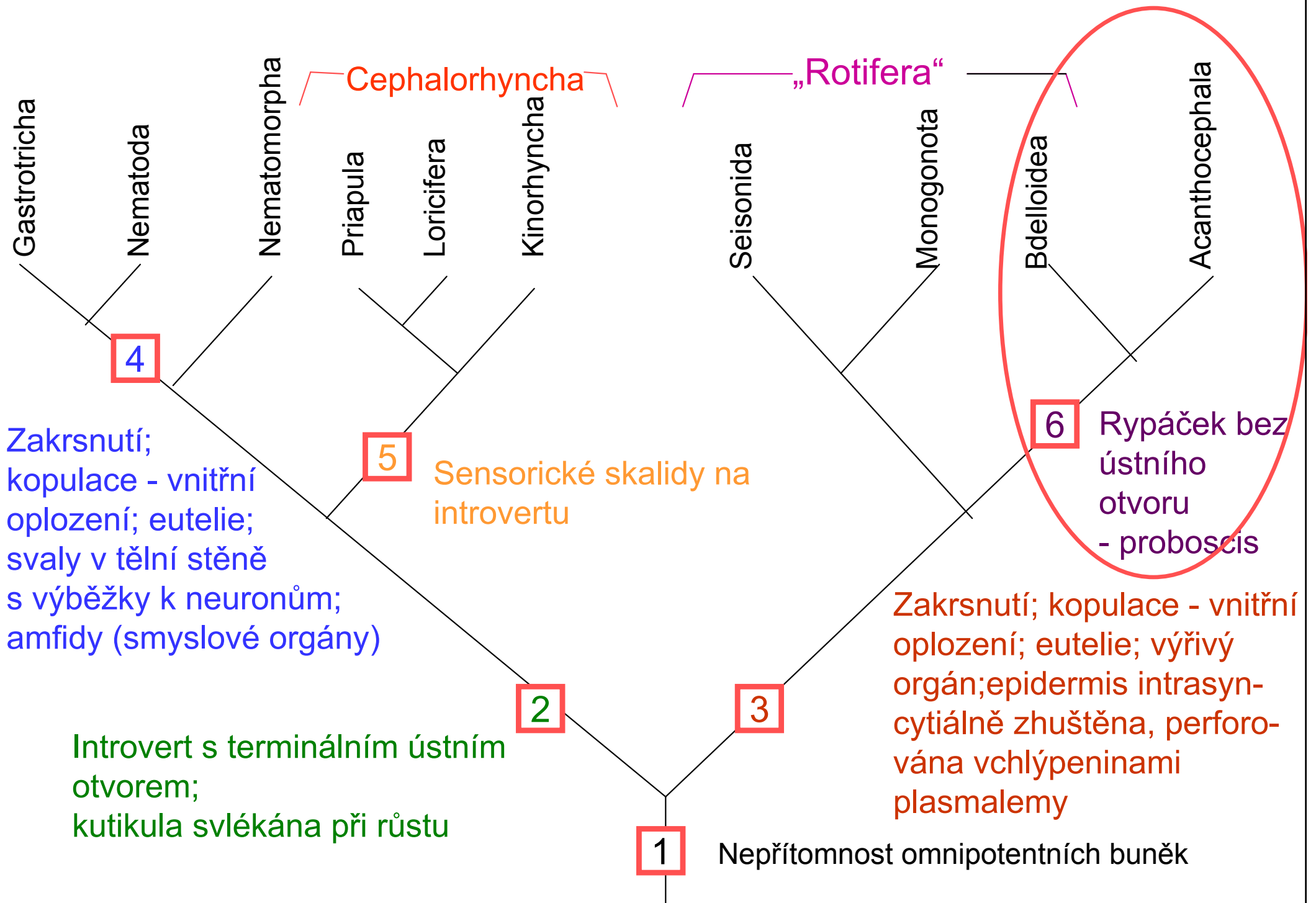


Heterodera schachtii - háďátko řepné: parazituje na merlíkovitých a brukvovitých rostlinách. Životní cyklus: 1 (2. juv. stádia opouští cystu) - 8 (chřadnoucí řepa vytváří nadměrné množství kořínků)

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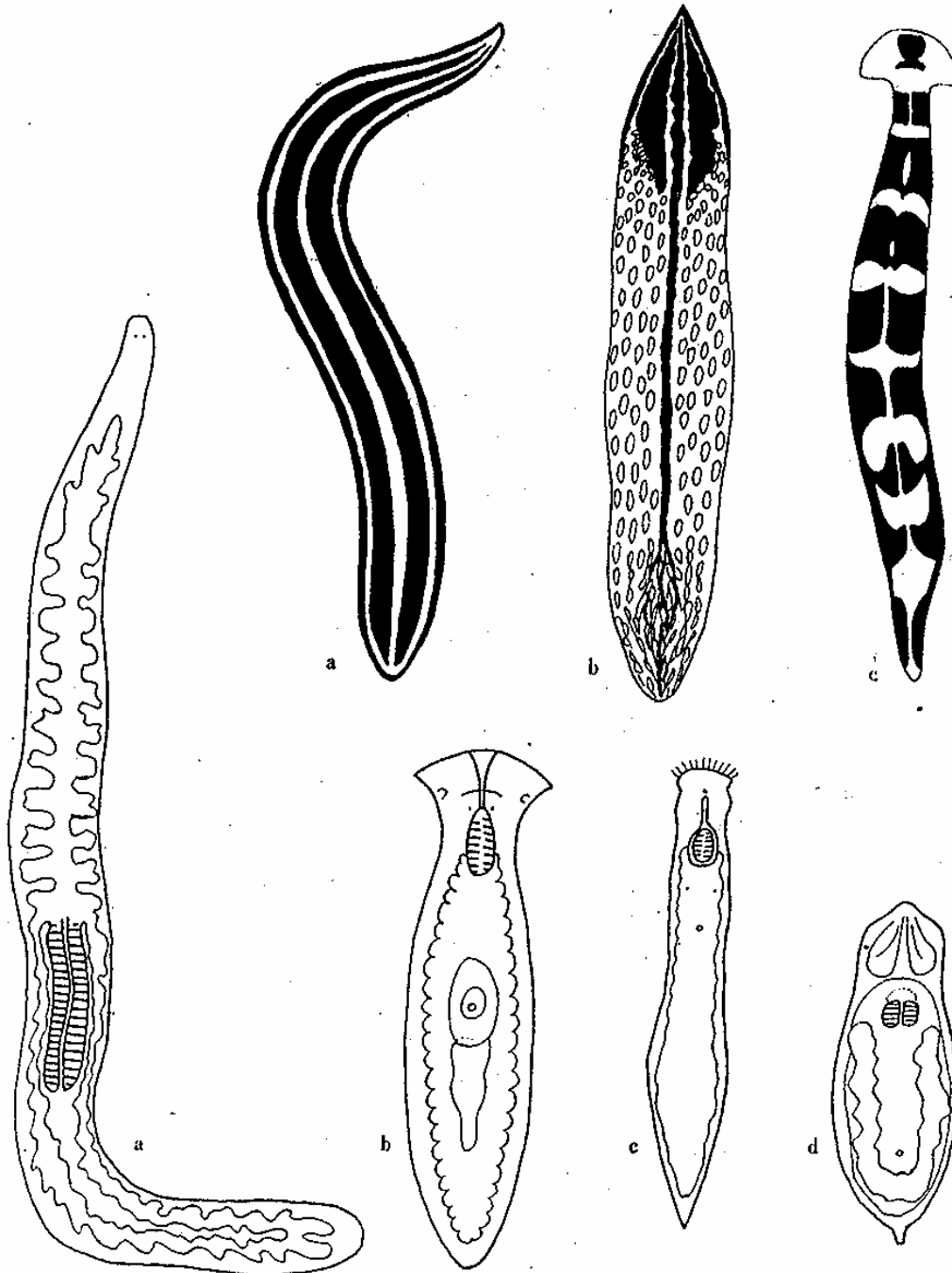
Nemathelminthes (= Aschelminthes)



The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Terrestrial Platyhelminthes:

a-c) Tricladida



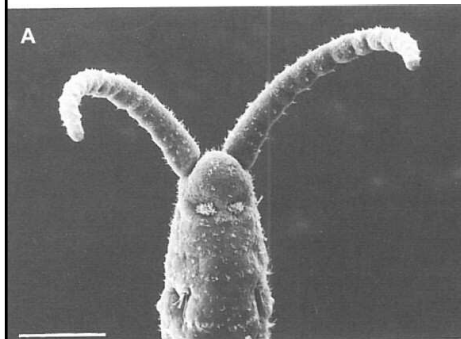
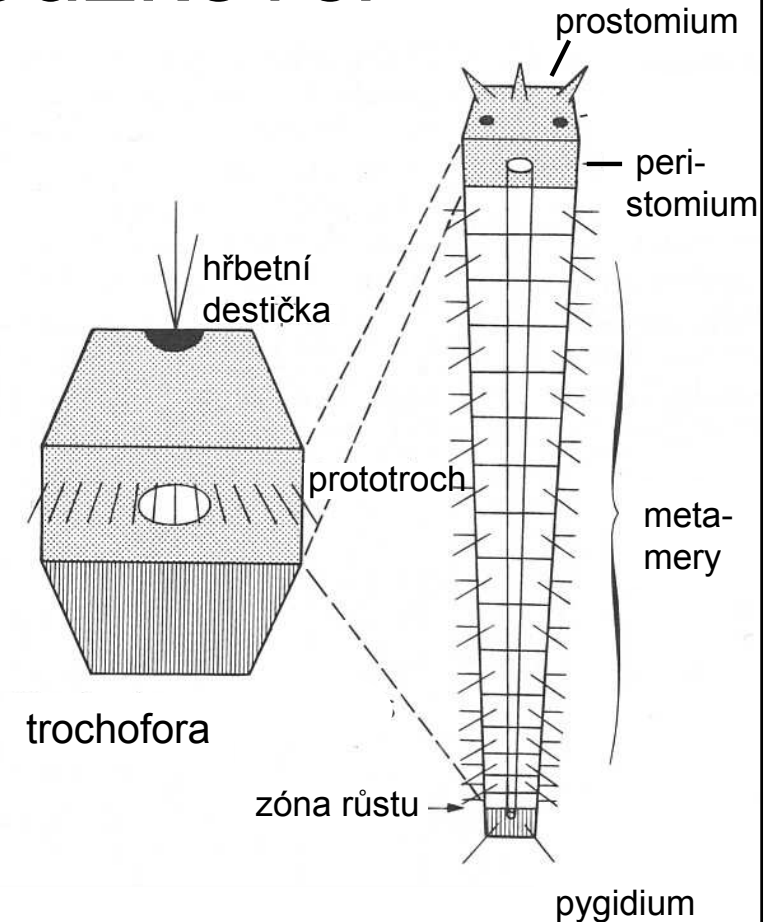
(Kmen) Annelida - kroužkovci

- cca 1 800 druhů
- mořští, sladkovodní, suchozemští (půdní)
- délka 50 μm - 3 m, většinou několik cm

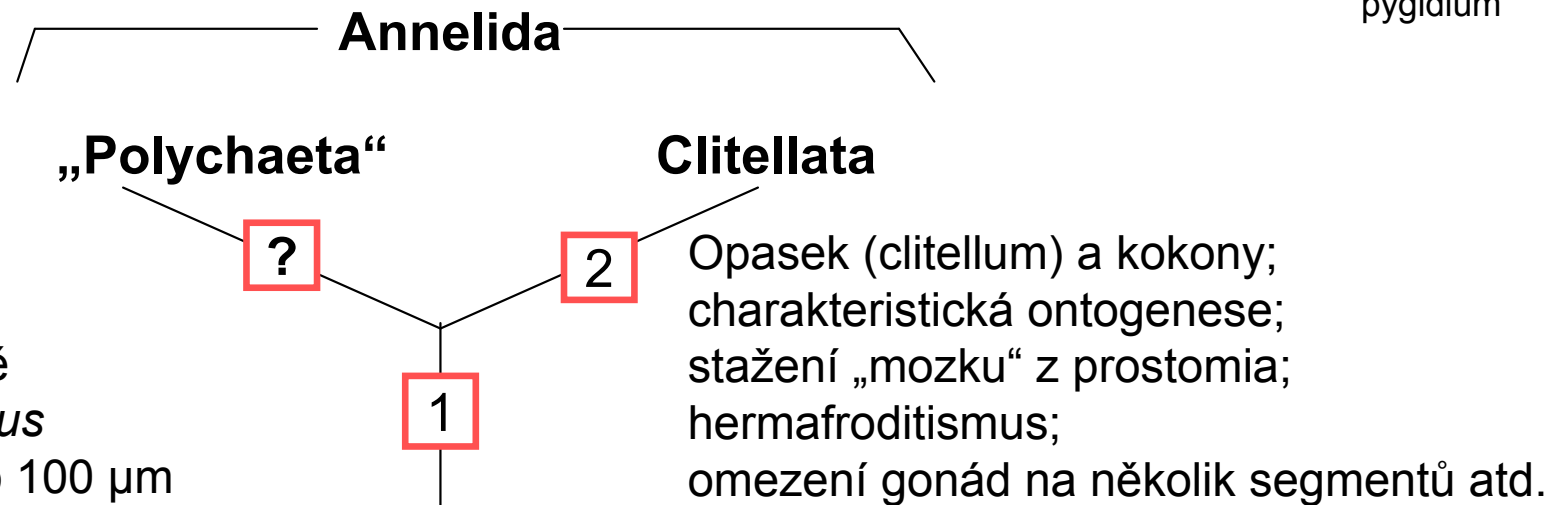
Monofylum?

Možné autapomorfie (1):

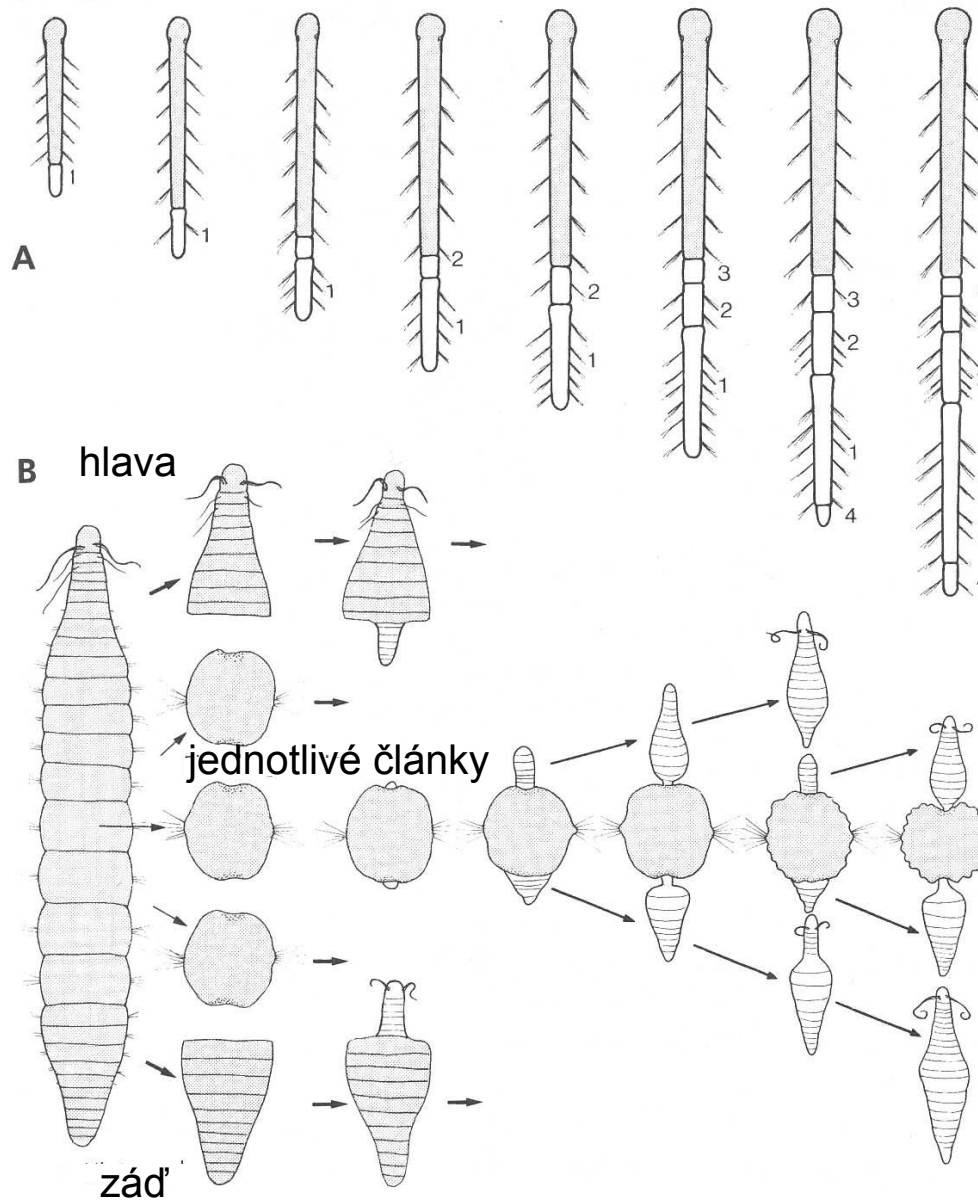
- prostomium s výrůstky
- nuchální orgány (pokud u Clitellata chybí sekundárně)



Nuchální orgány dorsálně na prostomiu u *Saccocirrus* sp. (Protodrilida); měřítko 100 μm



(Kmen) Annelida - kroužkovci

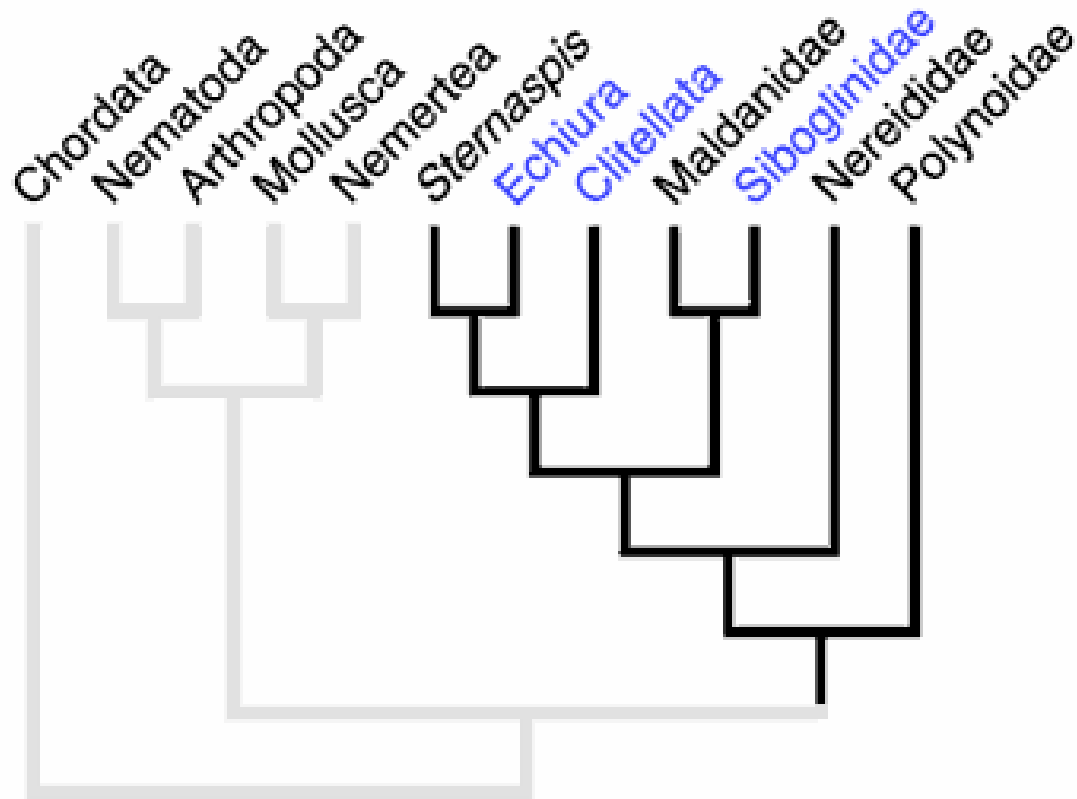


Nepohlavní (vegetativní)
rozmnožování u kroužkovců:

A - *Aeolosoma hemprichi* (Aeolosomatidae - olejnušky): **paratomie**;
čísla uvádí pořadí vzniku jedinců;

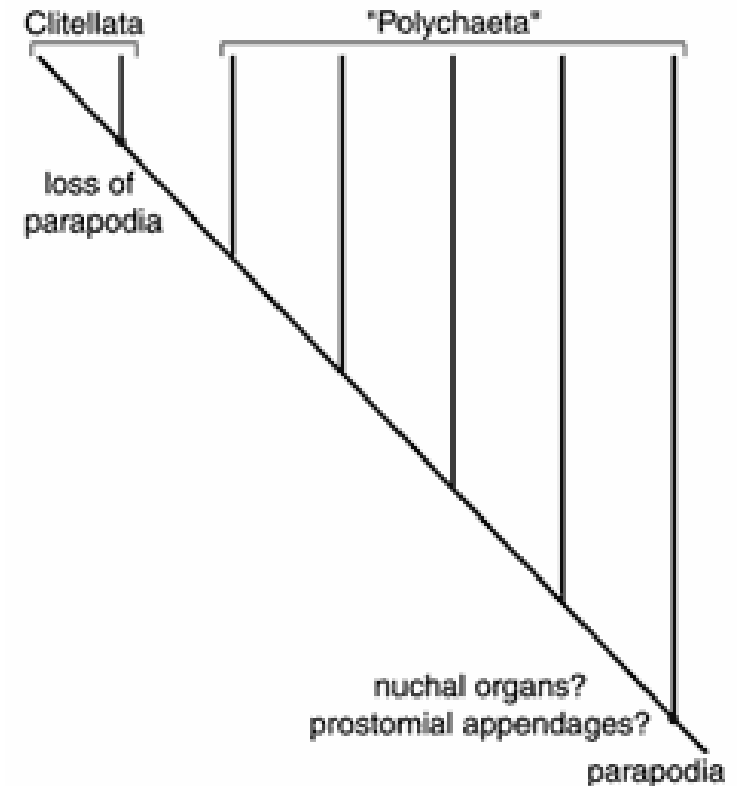
B - *Dogecaceria caulleryi* (Cirratulidae):
schéma fragmentace (**architomie**)
a regenerace; jedinci s více než 40 články
se dělí, ze zadní části těla se postupně
oddělí 14-18 jednotlivých článků; přední
a zadní část regenerují v úplné jedince;
potom co jednotlivým článkům dorostlo
vpředu i vzadu asi po 7 člancích, tyto
regeneráty se odpojí a doroste jím přední
resp. zadní část; původní jednotlivý článek
dá následně vznik dalším 2 jedincům
(stejným způsobem).

(Kmen) Annelida - kroužkovci



McHugh (1997)

Fylogenetická pozice taxonů příslušných k Annelida, Echiura i Pogonophora (= Siboglinidae) na základě molekulárně biologické analýzy



Westheide (1997)

Fylogenetická pozice taxonů příslušných k Annelida na základě kombinace metod

(Třída) Clitellata - opaskovci

(Podtřída) „**Oligochaeta**“ - maloštětinatci

(Řád) „Plesiopora“ - nítěnkovci

(Řád) Opisthopora - žížaly

(Řád) Prosopora (žížalice)

(Poddřída) **Hirudinea** - pijavice

(Řád) Acanthobdellida - štetinovky

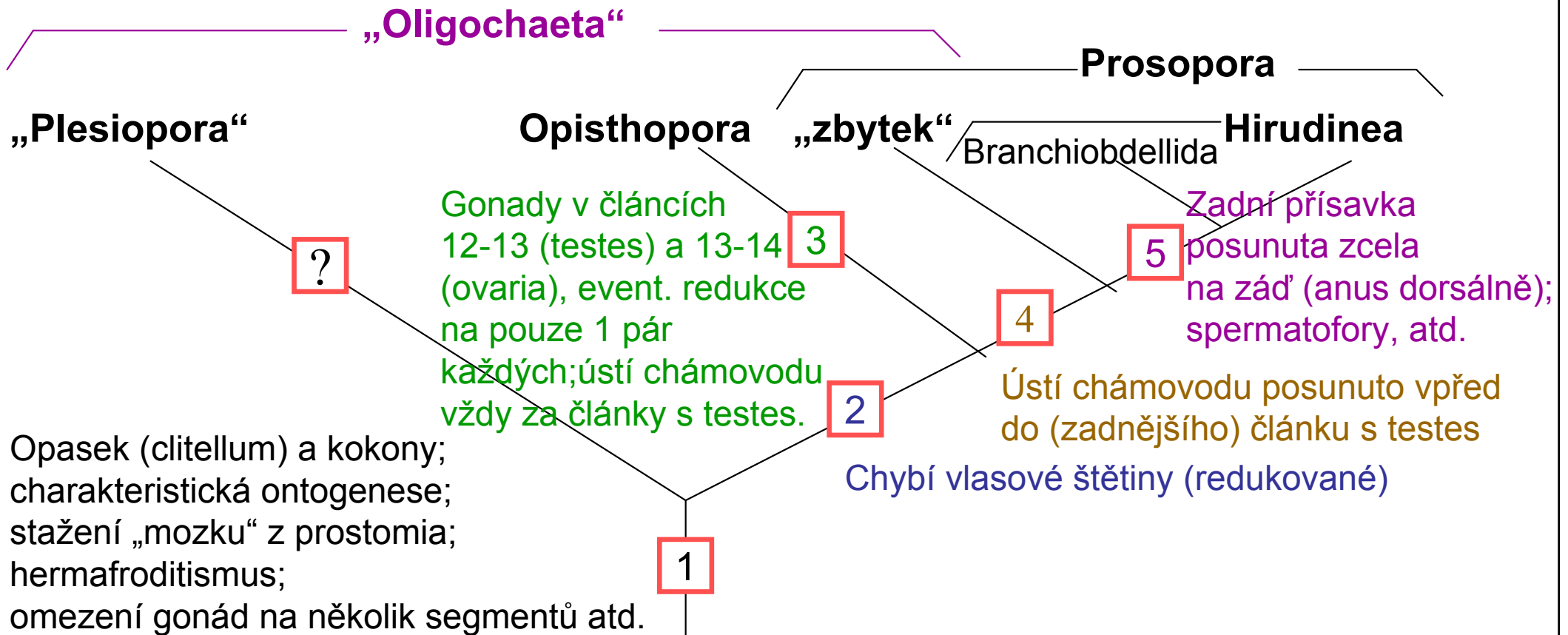
(Řád) Rhynchobdellida - chobotnatky

(Řád) Gnathobdellida - čelistnatky

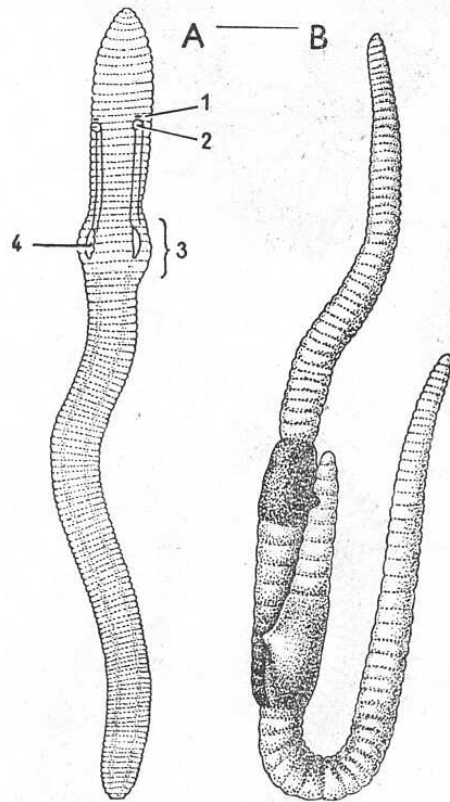
(Řád) Pharyngobdellida - hltanovky

(Podtřída) **Branchiobdellida** - potočnice

Tradičnější pojetí systému kontra důsledná aplikace poznatků fylogenetické systematiky:



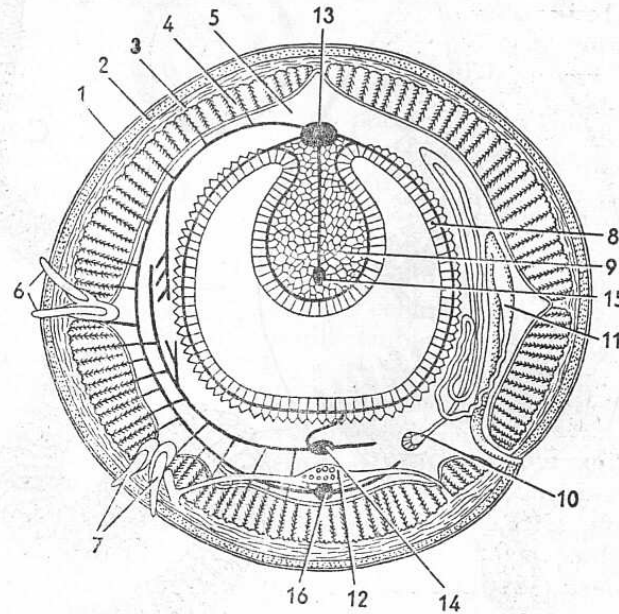
„Oligochaeta“: Lumbricidae



Obr. 193. Máloštetinatci (*Oligochaeta*), (podle Michaelssena).

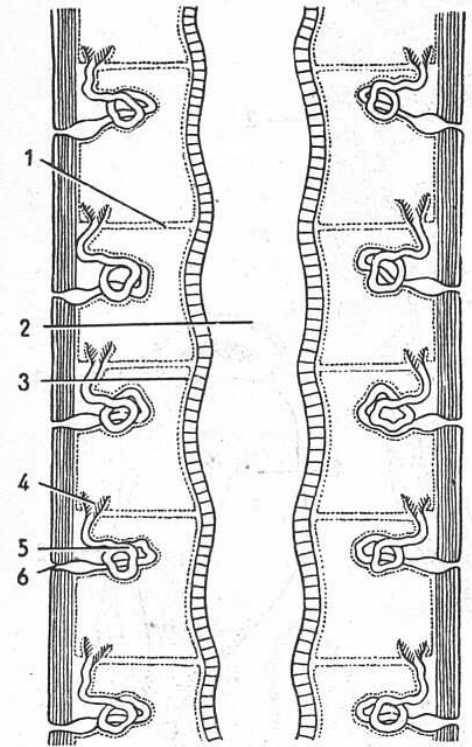
A — žízala obecná (*Lumbricus terrestris*), B — kopulující roupice *Enchytraeus albidus*.

1 — samičí pohlavní otvor na XIV. článku, 2 — samčí pohlavní otvor na XV. článku, 3 — opasek u žízaly obecné na XXXII. — XXXVII. článku, 4 — pubertální lišta.



Obr. 194. Příčný řez žízalou (podle Šimkeviče, pozměněno).

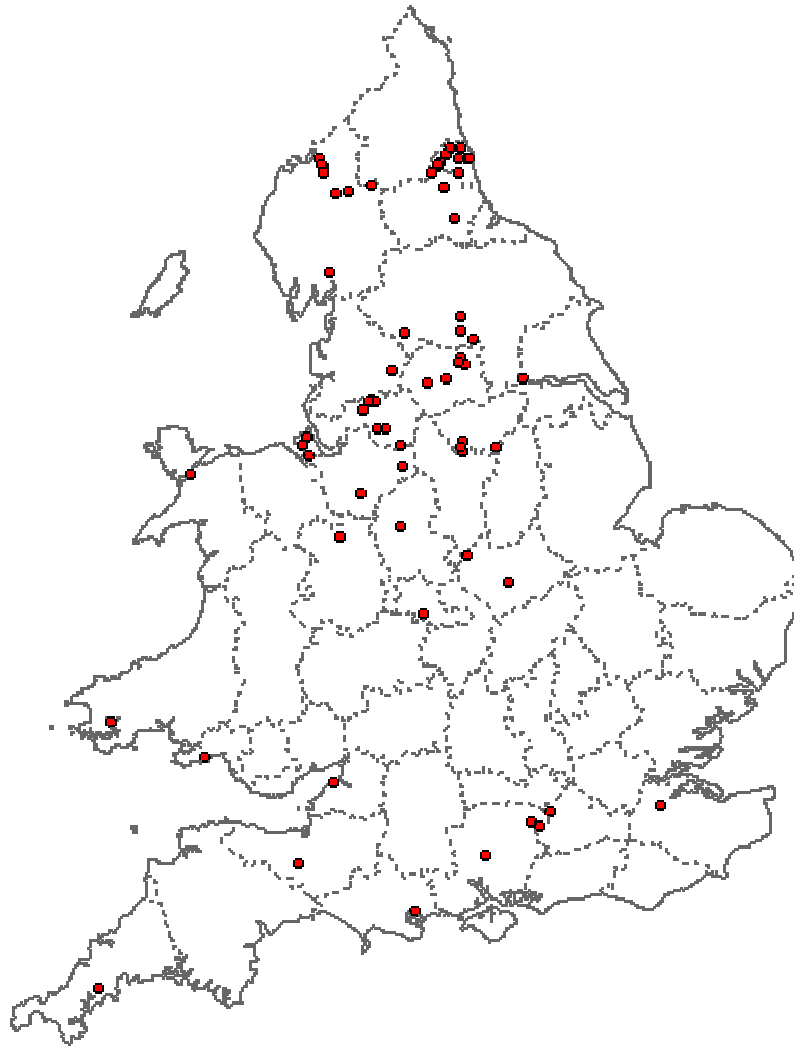
1 — kutikula, 2 — pokožka, 3 — okružní svalovina, 4 — podélná svalovina, 5 — druhotná tělní dutina, 6 — pár hřbetních štětín, 7 — pár břišních štětín (na druhé straně nejsou štětiny zasazeny), 8 — střevo, 9 — tyflosolis, 10 — nálevka metanefridia, 11 — chodba metanefridia, 12 — břišní nervová páska, 13 — hřbetní céva, 14 — břišní céva, 15 — suprintestinální céva, 16 — subneurální céva.



Obr. 198. Metanefridia kroužkovců (*Annelida*), (podle Grobena).

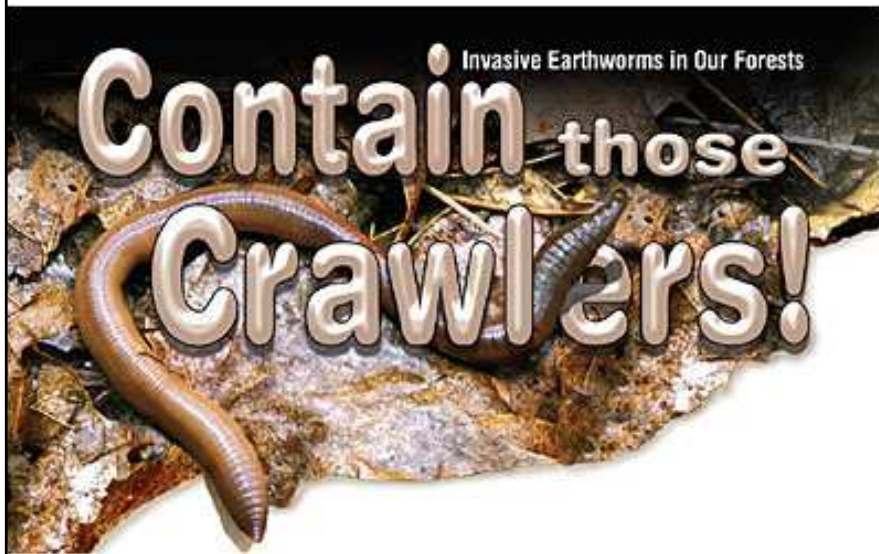
1 — disepiment, 2 — dutina střeva, 3 — peritoneální epitel, 4 — obrvená nálevka metanefridia, 5 — nefridiální chodba, 6 — vylučovací otvor.

The saprotrophic food chain in terrestrial ecosystems : Soil Biota



The occurrence of the soil-dwelling *Artioposthia triangulata* (= *Arthurdendyus triangulatus*) from New Zealand in England and Wales (first records in Europe 1963 from Northern Ireland, 1965 in north-western Scotland). A predator severely reducing earthworm populations.

The saprotrophic food chain in terrestrial ecosystems : Soil Biota



European earthworm species are increasing their range in North America (incl. large areas devoid of native earthworm species) and changing the character of forest ecosystems.



Area (blue) covered by glaciers during the last ice age.

The saprotrophic food chain in terrestrial ecosystems : Soil Biota



The saprotrophic food chain in terrestrial ecosystems : Soil Biota



Forest undergrowth (left) and natural regeneration of *Acer saccharum* (right) in forests without earthworms



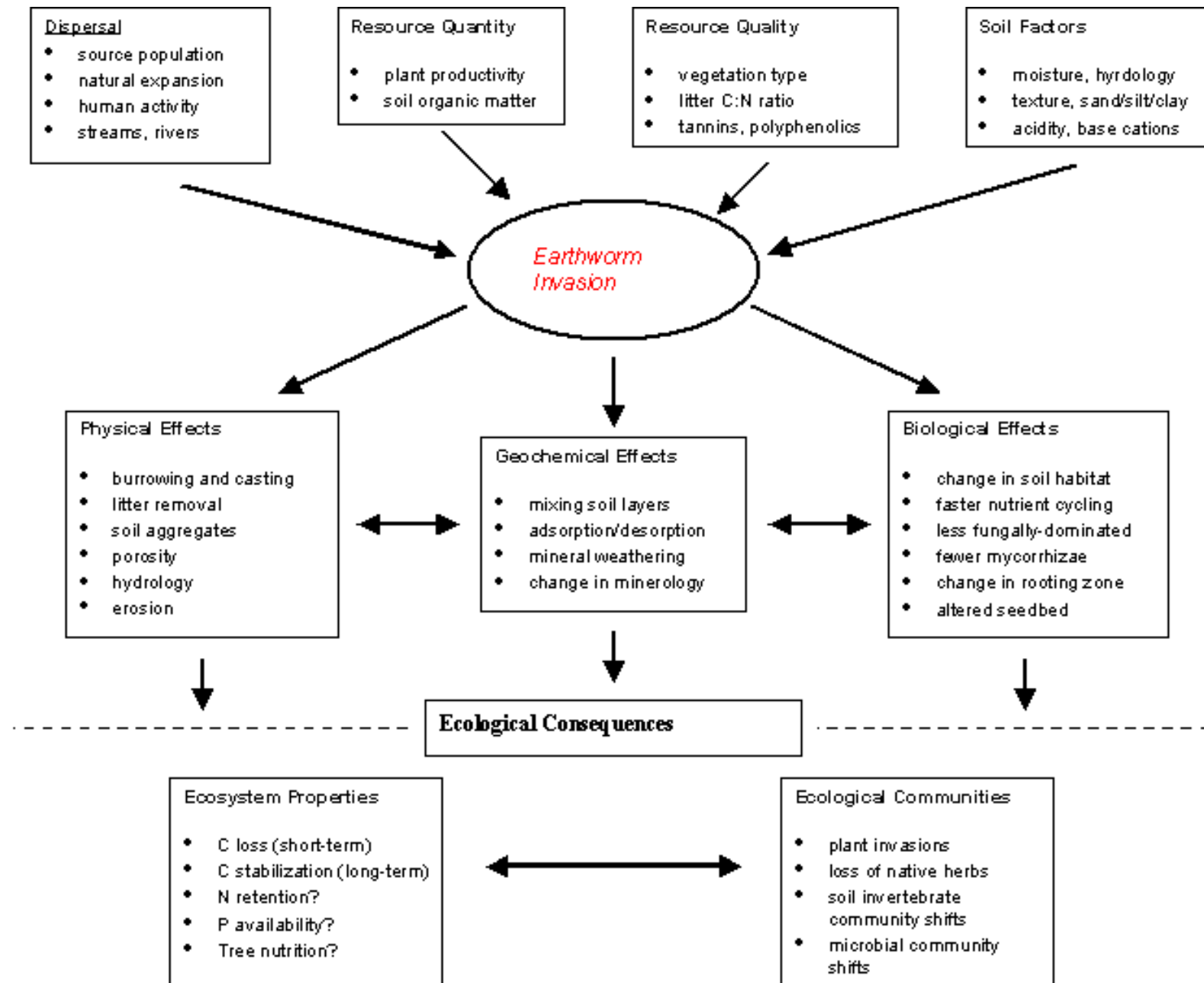
Forest undergrowth (left) and missing natural regeneration of the sugar maple (right) in a forest colonised by earthworms



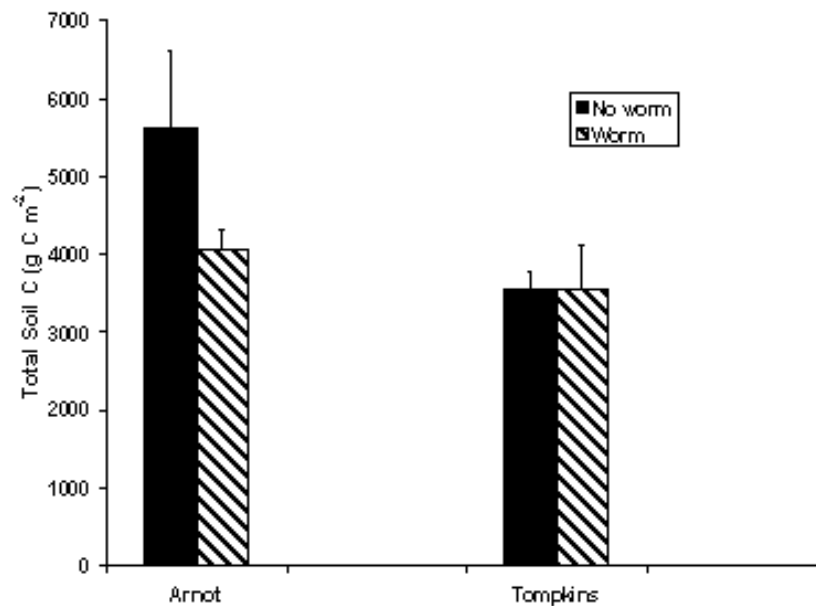
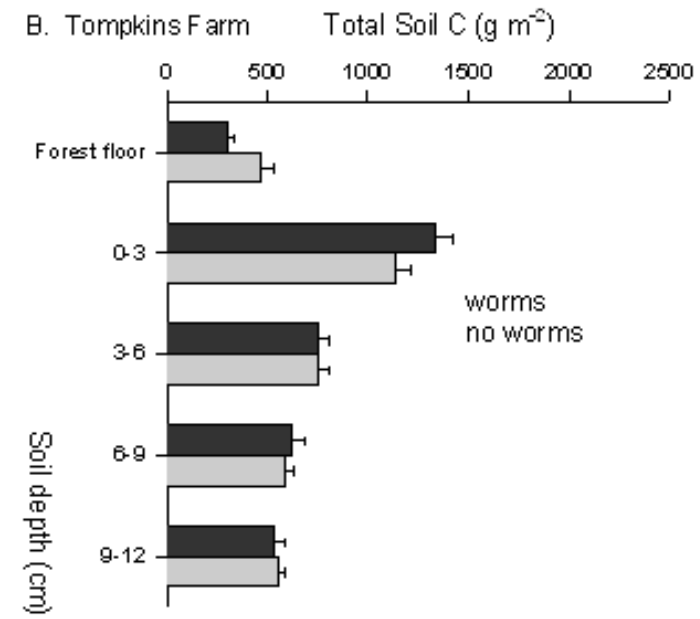
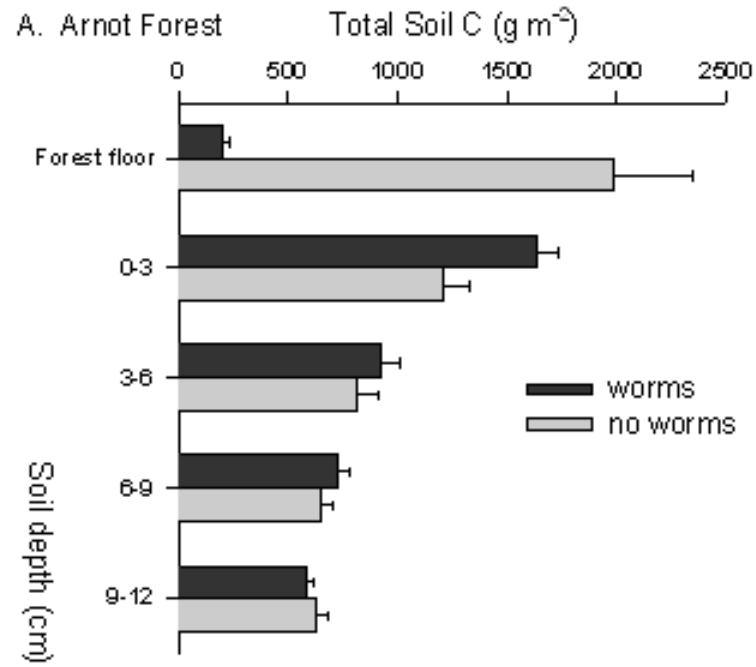
The fern *Botrychium mormo* is disappearing from earthworm invaded forests



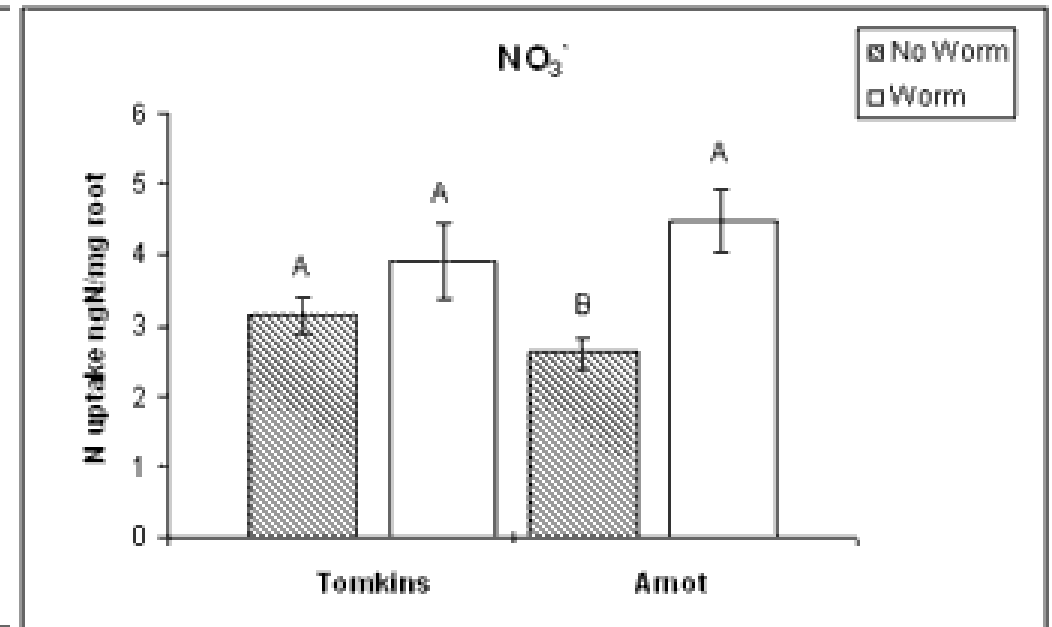
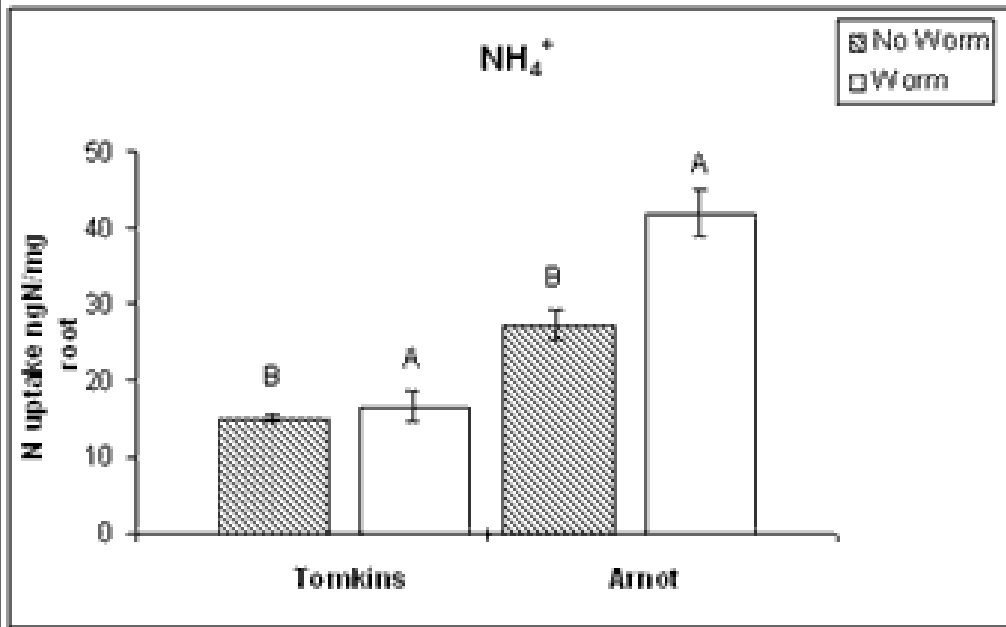
The saprotrophic food chain in terrestrial ecosystems : Soil Biota



The saprotrophic food chain in terrestrial ecosystems : Soil Biota



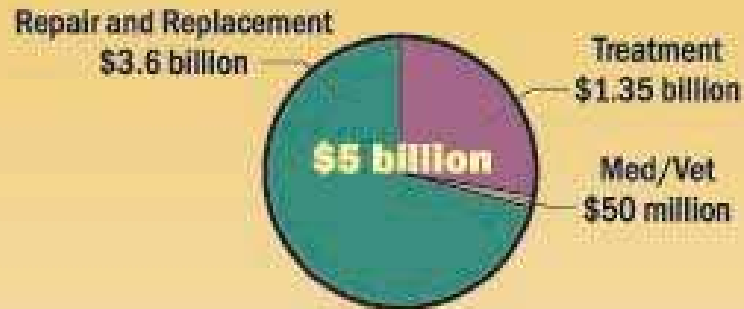
The saprotrophic food chain in terrestrial ecosystems : Soil Biota



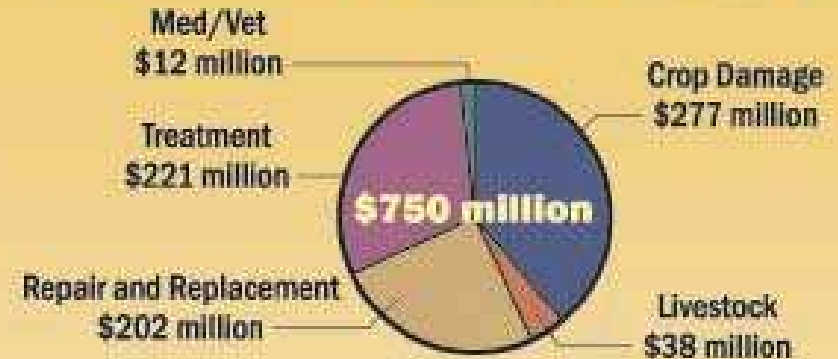
The saprotrophic food chain in terrestrial ecosystems : Soil Biota

Solenopsis invicta

Total Annual Fire Ant Losses to Households, Business, Schools, Government, and Institutions



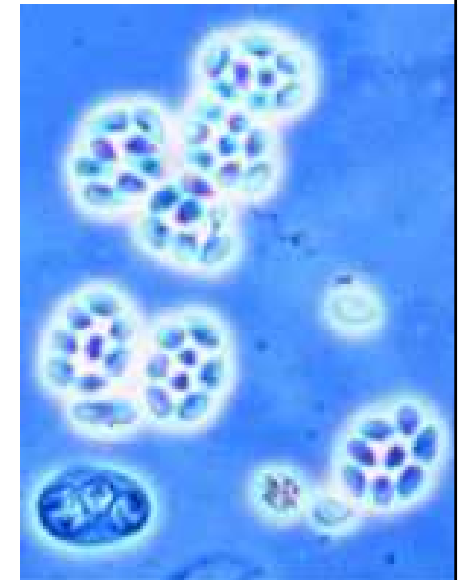
Total Annual Fire Ant Losses to Agriculture



Annual losses caused by the invasive ant *S. invicta* in the USA



Brachycerous two-winged flies of the genus *Pseudacteon* and the protozoan *Thelohania solenopsae* are used as biological agents against *S. invicta*.



The saprotrophic food chain in terrestrial ecosystems : Soil Biota

