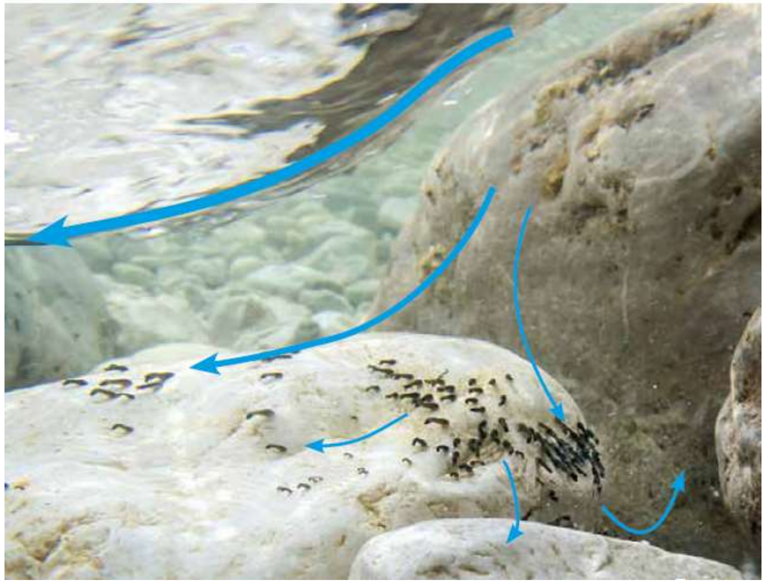

Stream Ecology

Compared with standing water bodies, running waters are <u>highly unstable, dynamic ecosystems</u> with a <u>high capacity of regeneration</u> and <u>diverse habitats…</u>.

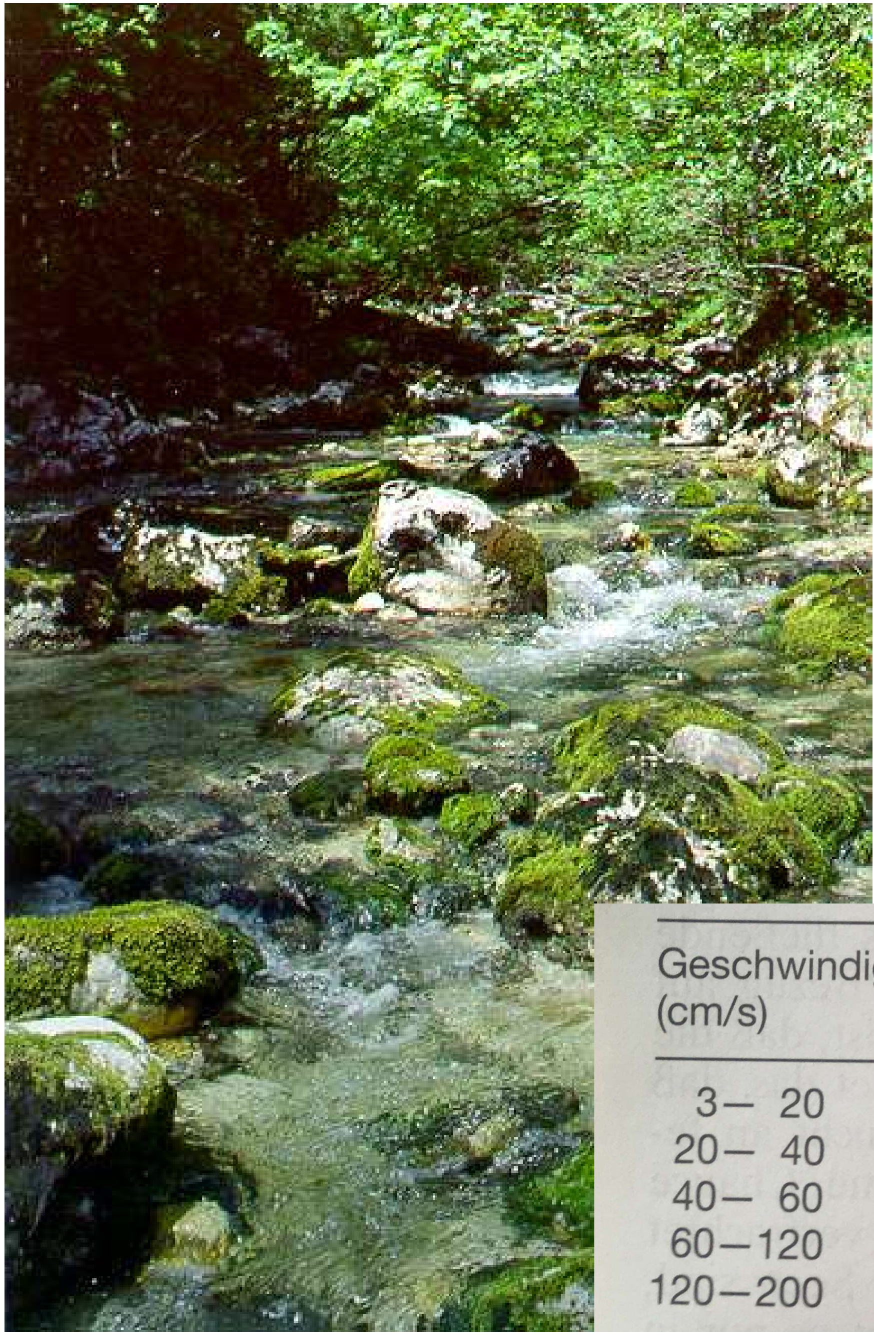
… sharing some unique characters:

- **unidirectional flow driven by gravitation and modified by surface slope**

Due to the current substances (nutrients, CPOM, …) are continuosly transported in as much as they are transported away.



- **unstable bed sediments (bed-load discharge)**



Geschwindigkeit (cm/s)	Bodenbeschaffenheit des Gewässers
3— 20	Schlick
20— 40	Feinsand
40— 60	Grobsand — Feinkies
60—120	kleine — faustgroße Steine
120—200	größere Steine

- **thermostratification lacking due to turbulence, but temperature changes along the longitudinal course of the running water and daily periodic**

- **highly variable discharge and strong fluctuations of correlated parameters such as**

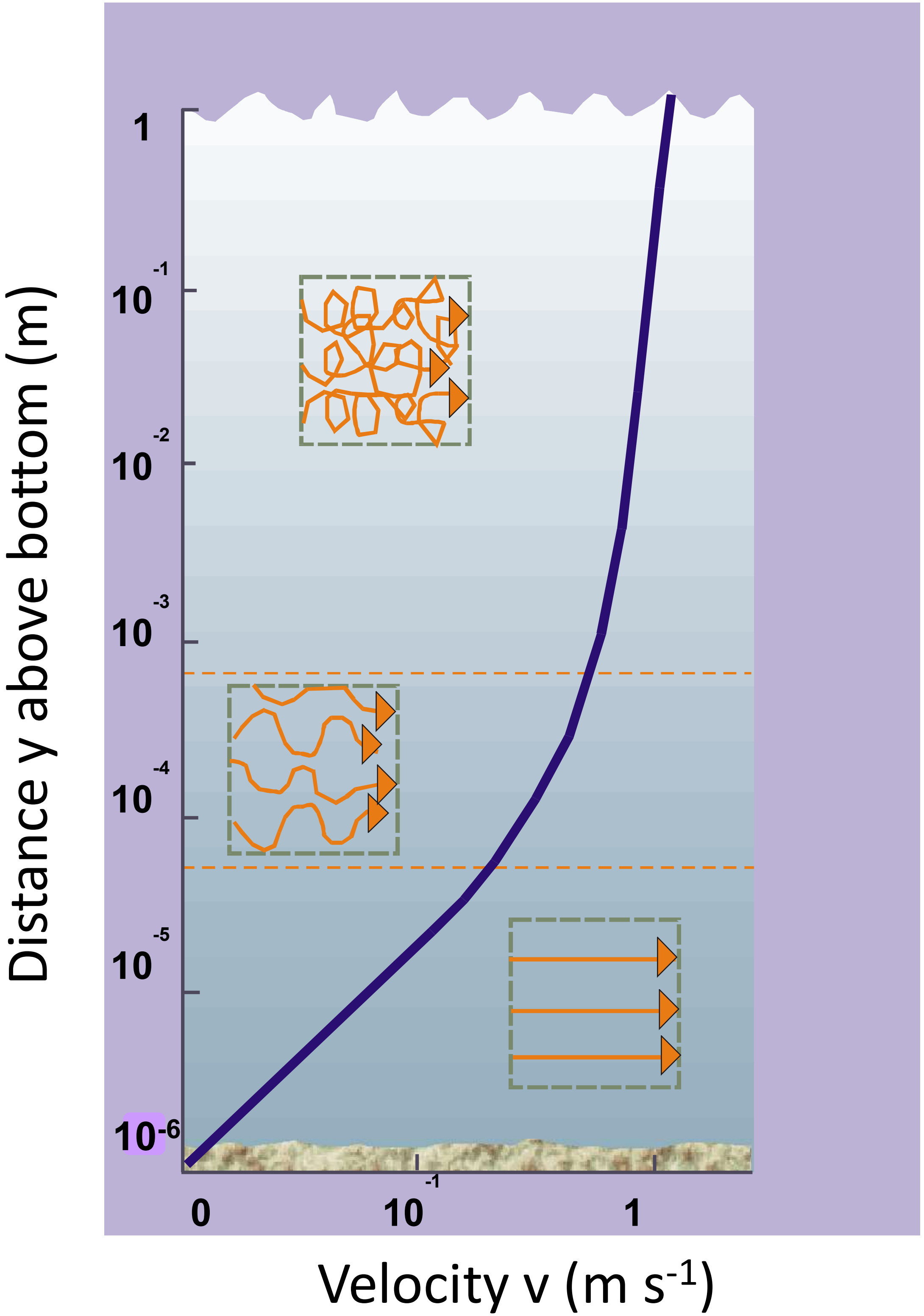
  - water depth

  - width

  - current velocity

  - turbulence

Vertical velocity profile



fully developed turbulence

buffer zone

laminar sublayer

The exponential velocity profile has an important consequence:

mean velocity is measured at six-tenths depth, that is , 0.6 of depth measured from the water surface downward or 0.4 of the distance above the bottom!

Exercise:

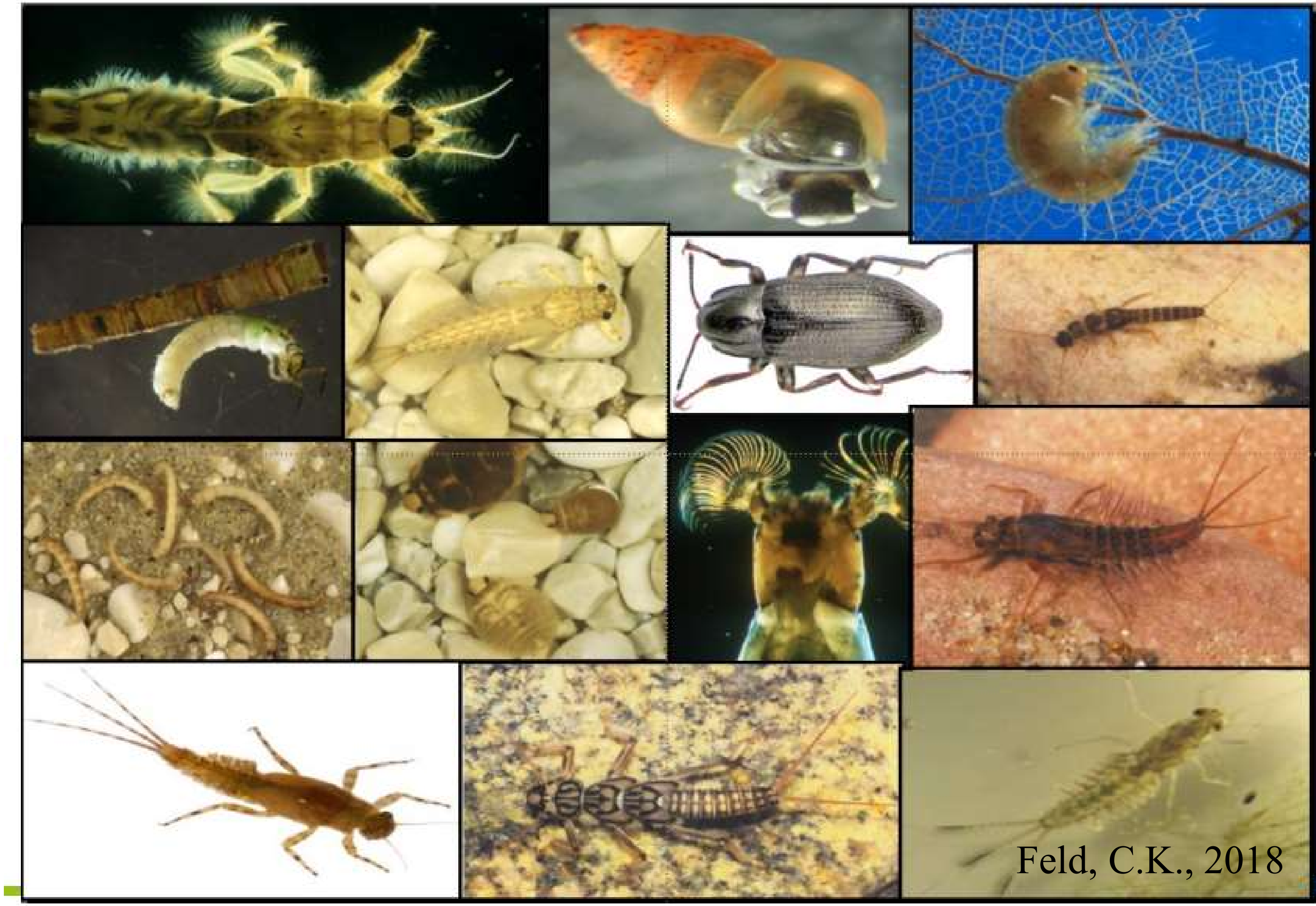
Stream gaging by the velocity – area method using a propeller – meter (Ott-Flügel)

- Step 1: measure stream width using a tape (w);
- Step 2: take the arithmetic mean of equally-distributed water depth measurements (y) along a the chosen profile;
- Step 3: take the arithmetic mean of equally-distributed velocity measurements (v) at a distance above the bottom equal to 0.4 times the depth.

Discharge Q is calculated by: $Q = w * \overline{y} * \overline{v}$ [$m^3\ s^{-1}$]

Benthos (gr.: benthon = depth): substrate-associated organisms

<u>Macro</u>zoobenthos: > 500 µm

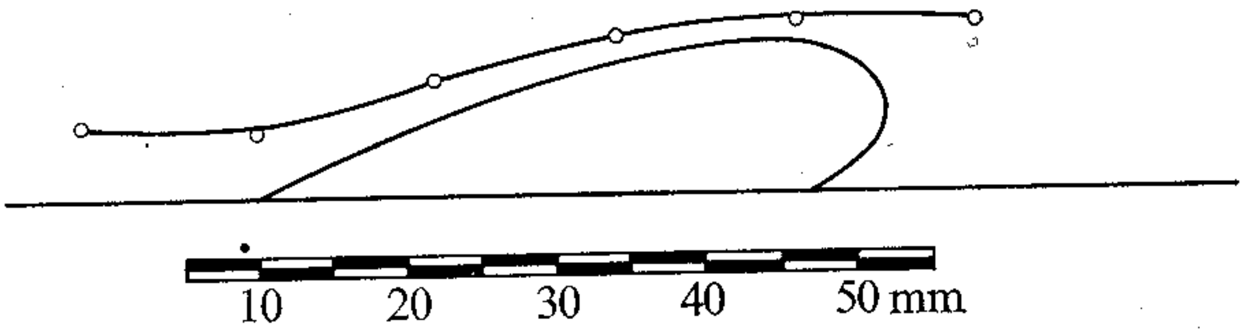


Factors of major importance to MZB in lotic environments:

- current (hydraulic forces)
- substrate properties (grain size distribution, woody debris, pore space)
- temperature
- light
- oxygen availability (related to temperature and light)
- food resources: quality (origin), composition, quantity
- riparian vegetation (e.g. providing allochthonous ressources, affecting light availability,…)

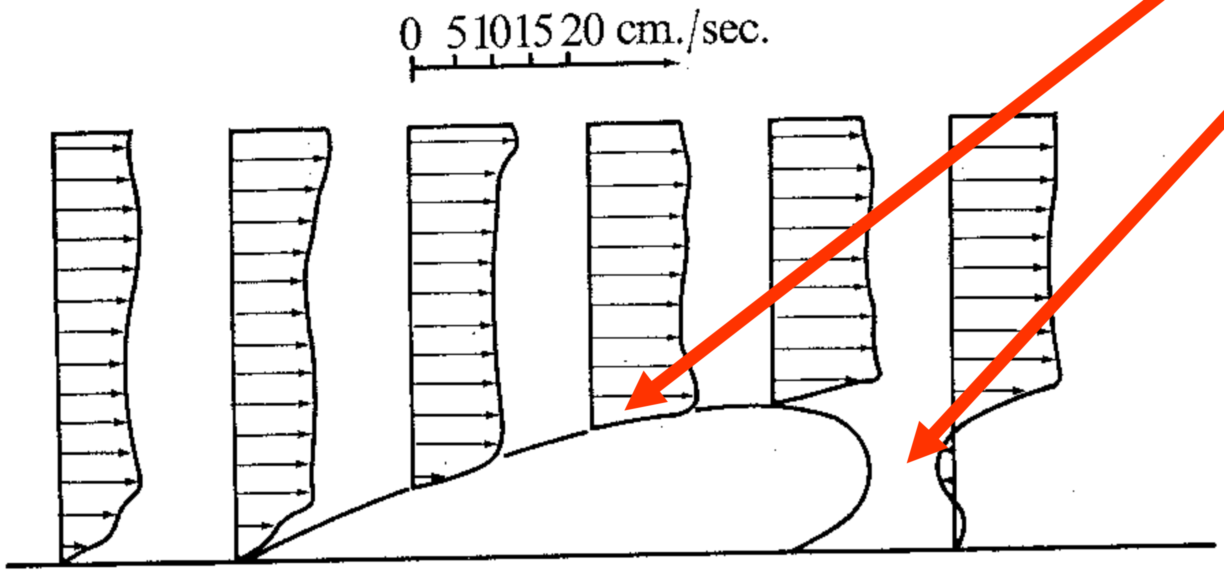
Strategies to cope with current

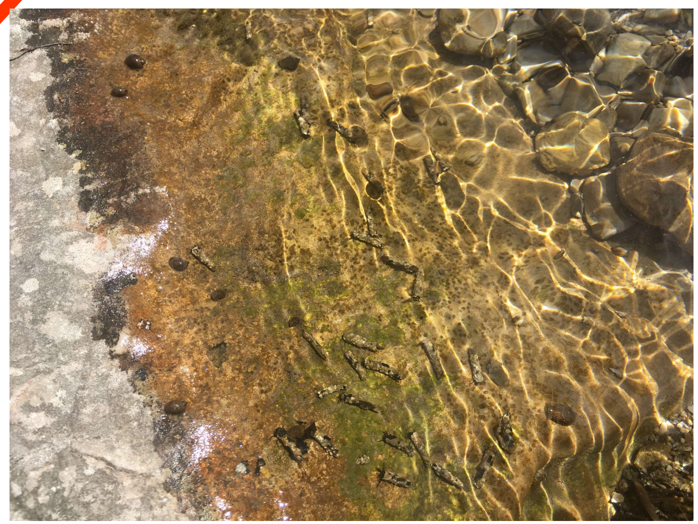
➢ Hydraulic refugia (avoidance of hydraulic stress):



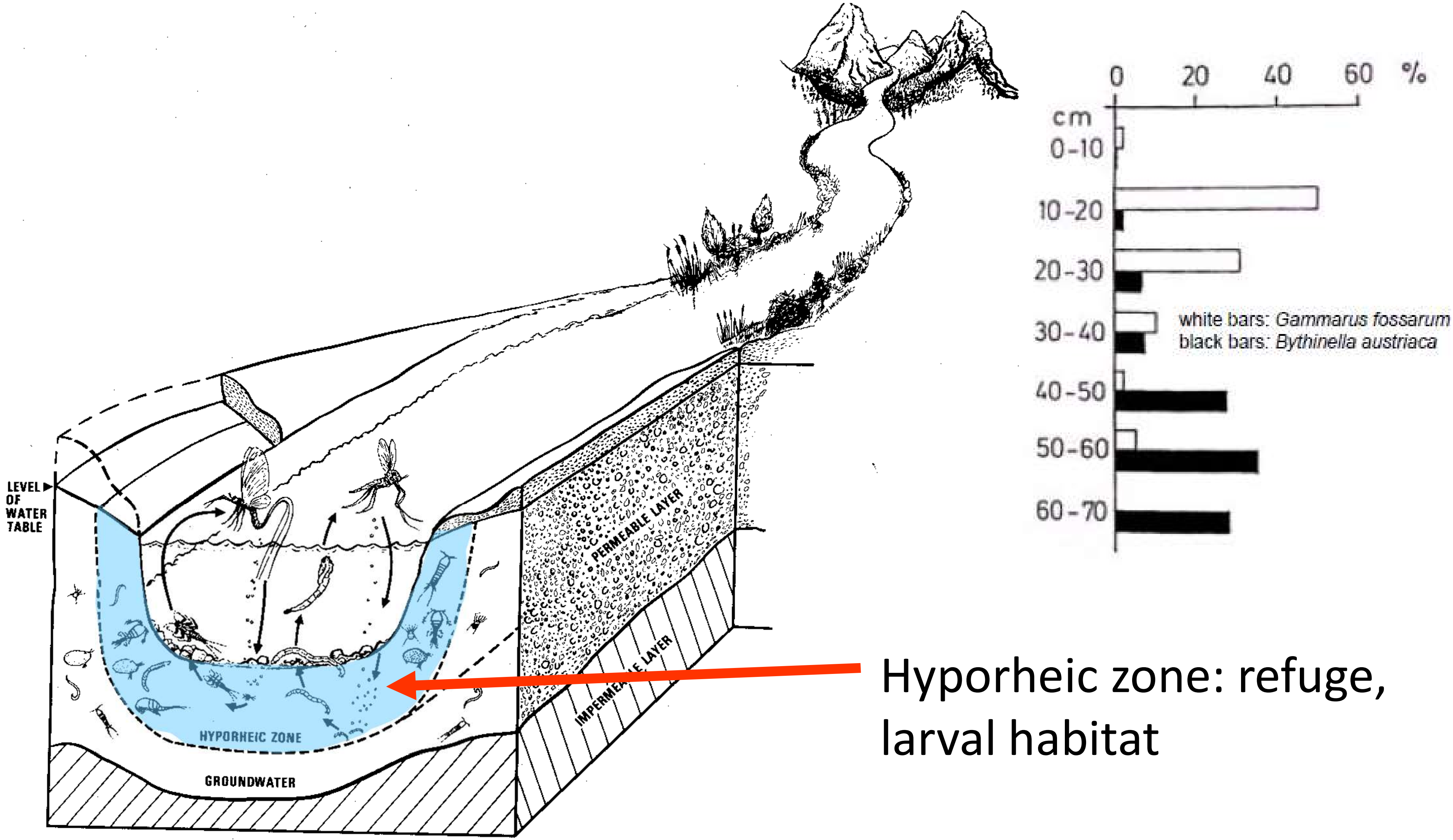
laminar sublayer

dead water areas





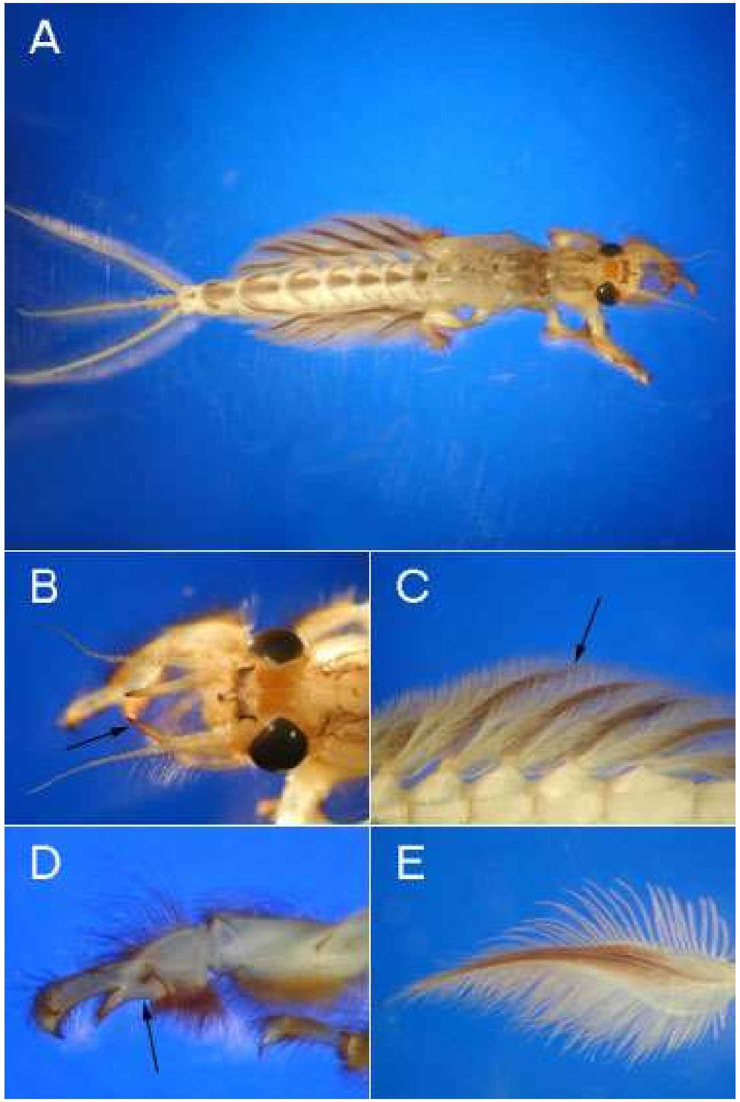
Inhabiting the **hyporheic zone** = stream sediments under and lateral of the main channel, charged with at least 90% surface water mixed with ground water (a classic ´ecotone´)



Hyporheic zone: refuge, larval habitat

Inhabited by a considerable proportion of stream fauna - the **interstitial** community:

Leuctridae: elongated, narrow body

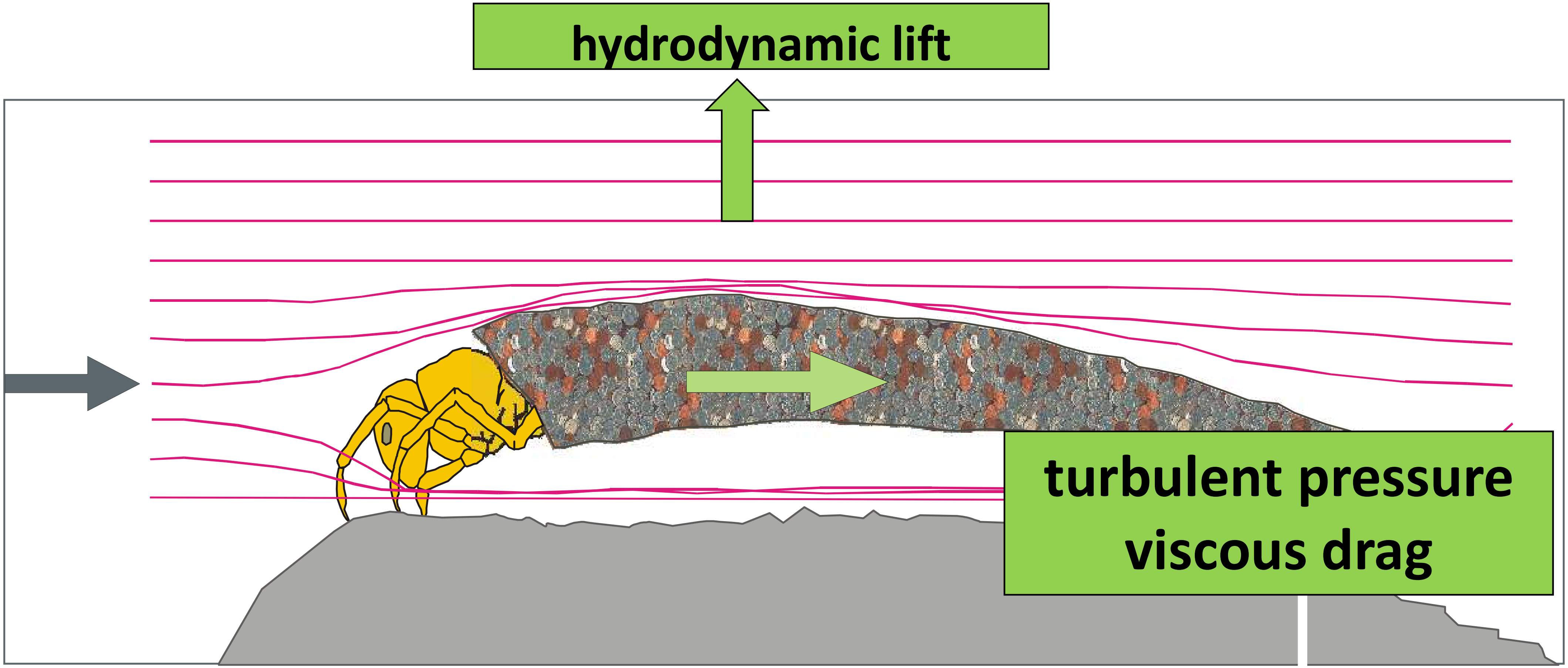


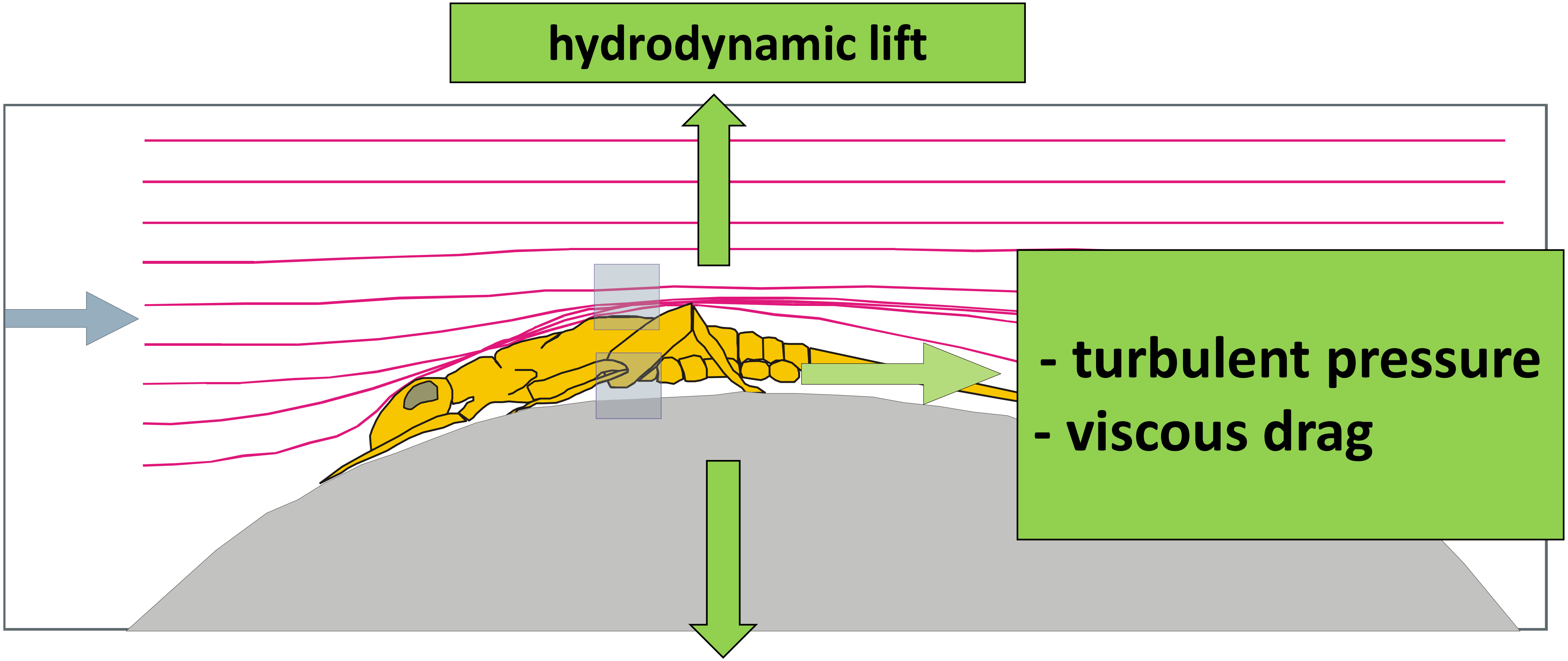
Ephemera danica: digging legs (D), preferred in fine sediment

➢ Resistance to hydraulic stress

(How to remain in a fixed position in flowing water?

For benthic organisms water velocity is very often equivalent to hydraulic stress which consists of two components:





The stabilizing force is

submerged weight

$$M*g - \rho*V*g$$

weight – lifting force > 0

ρ (rho) mass density of displaced solute
V displaced volume (volume of the submerged body)
g gravity acceleration (9,81 m/s2)

Ecological strategies for countering hydraulic stress:

- morphological adaptations:

flattened bodies:

large claws:

Diamesa

Elmidae

Heptageniidae

- morphological adaptations:

suckers:

Blephariceridae

Heptageniidae

Erpobdella sp.

Ancylus fluviatilis

- morphological adaptations:

streamlined body shape:

Baetidae

silk:

Simuliidae

some Rhyacophilidae

- morphological adaptations:

ballast:

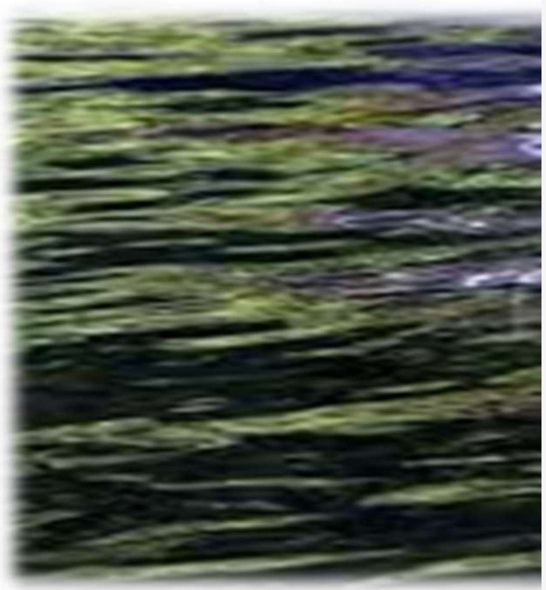
stone cases of *Trichoptera*

tubes in or attached to the sediment:

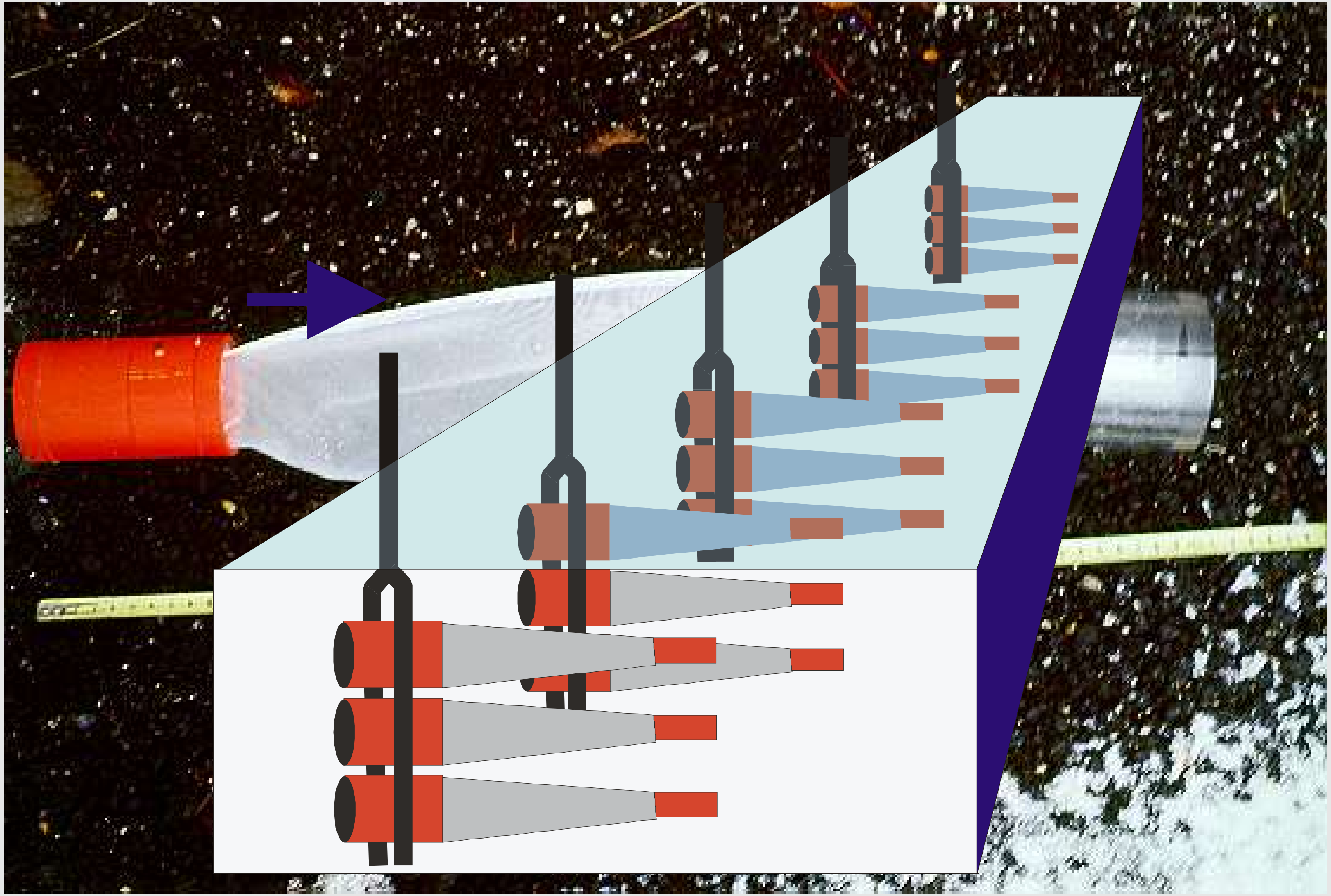
Chironomidae

Despite a high number of ecological strategies for countering hydraulic stress exist, there are always "accidents " at the streambed:

Benthic organisms are removed from the sediment surface by erosion and lifted into the water column where they become part of the organismic drift.



Cone-shaped cases or attached plant fibres increase the rolling resistance of some caddiesflies.



Drift densities in the Lunzer Seebach at water levels 10.0 - 48.9 cm (= below bankfull):

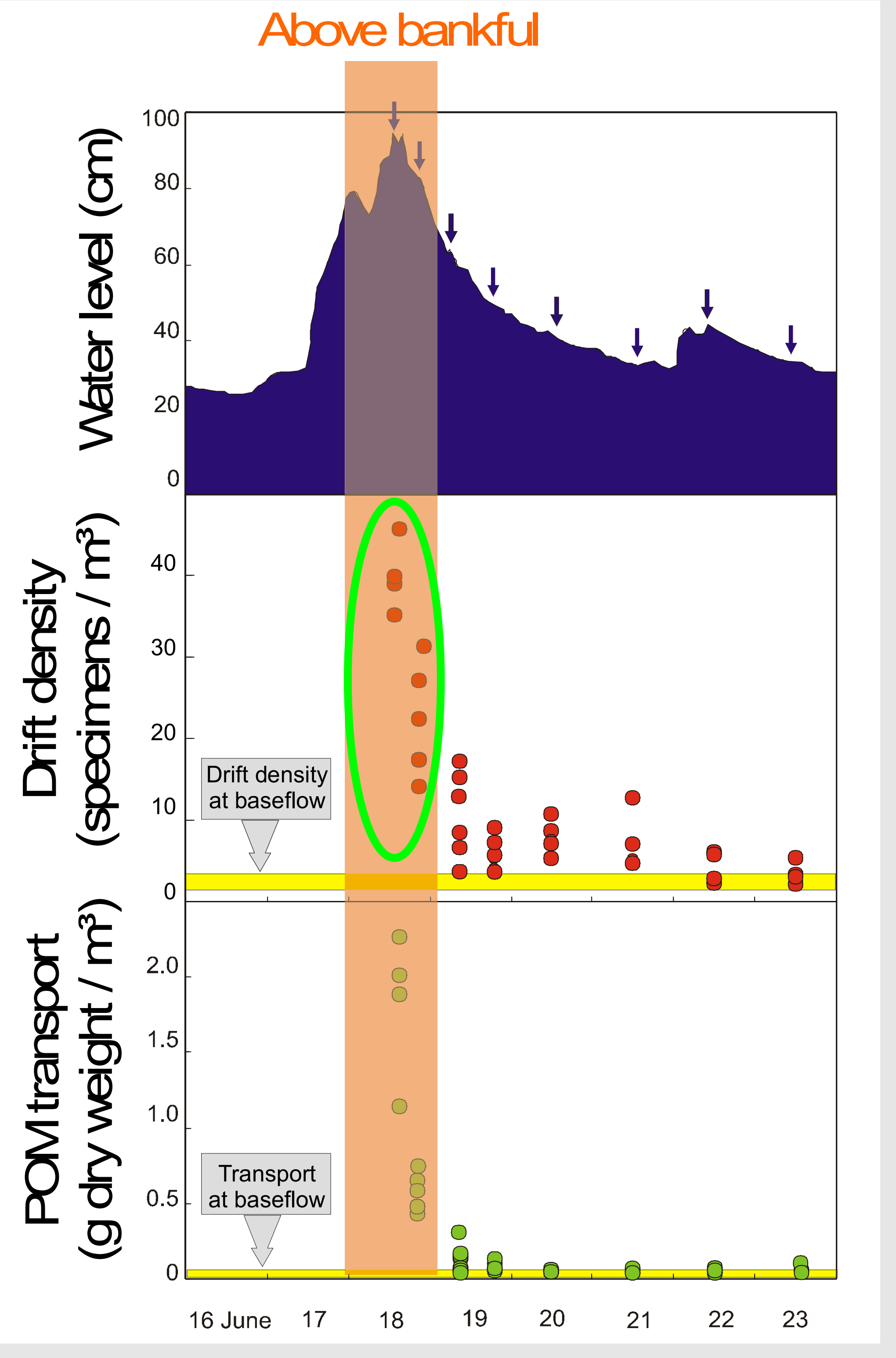
autumn, winter: 2.01 + 0.22 individuals m^{-3}
spring, summer: 2.50 + 0.32 individuals m^{-3}
(P> 0.05)

- Drift density (= number of drifting individuals per cubic meter of water

Drift periodicity

- "catastrophic drift "

Catastrophic drift



Drift rates (= number of drifting organisms over stream cross section per unit of time) in the Lunzer Seebach:

low water level (10 cm):

17 366 ± 1901 individuals day^{-1}

(= **8.99** ± 1.04 **g fresh weight day^{-1}**)

intermediate water level (50 cm):

1 188 000 ± 152 064 individuals day^{-1}

(= **1188.00** ± 228.10 **g fresh weight day^{-1}**)

flood (94 cm):

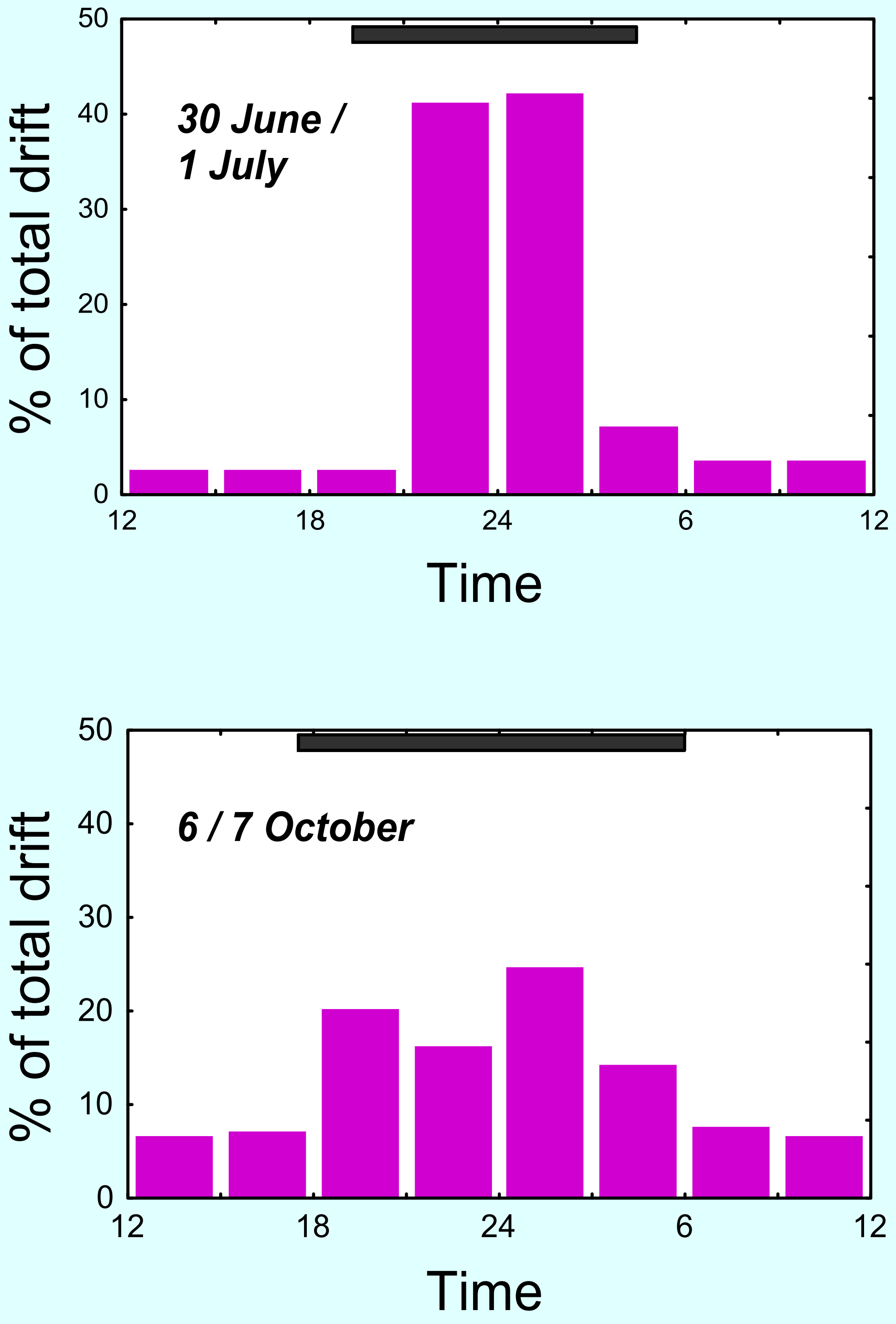
76 816 800 individuals day^{-1}

(= **58.38 kg fresh weight day^{-1}**)

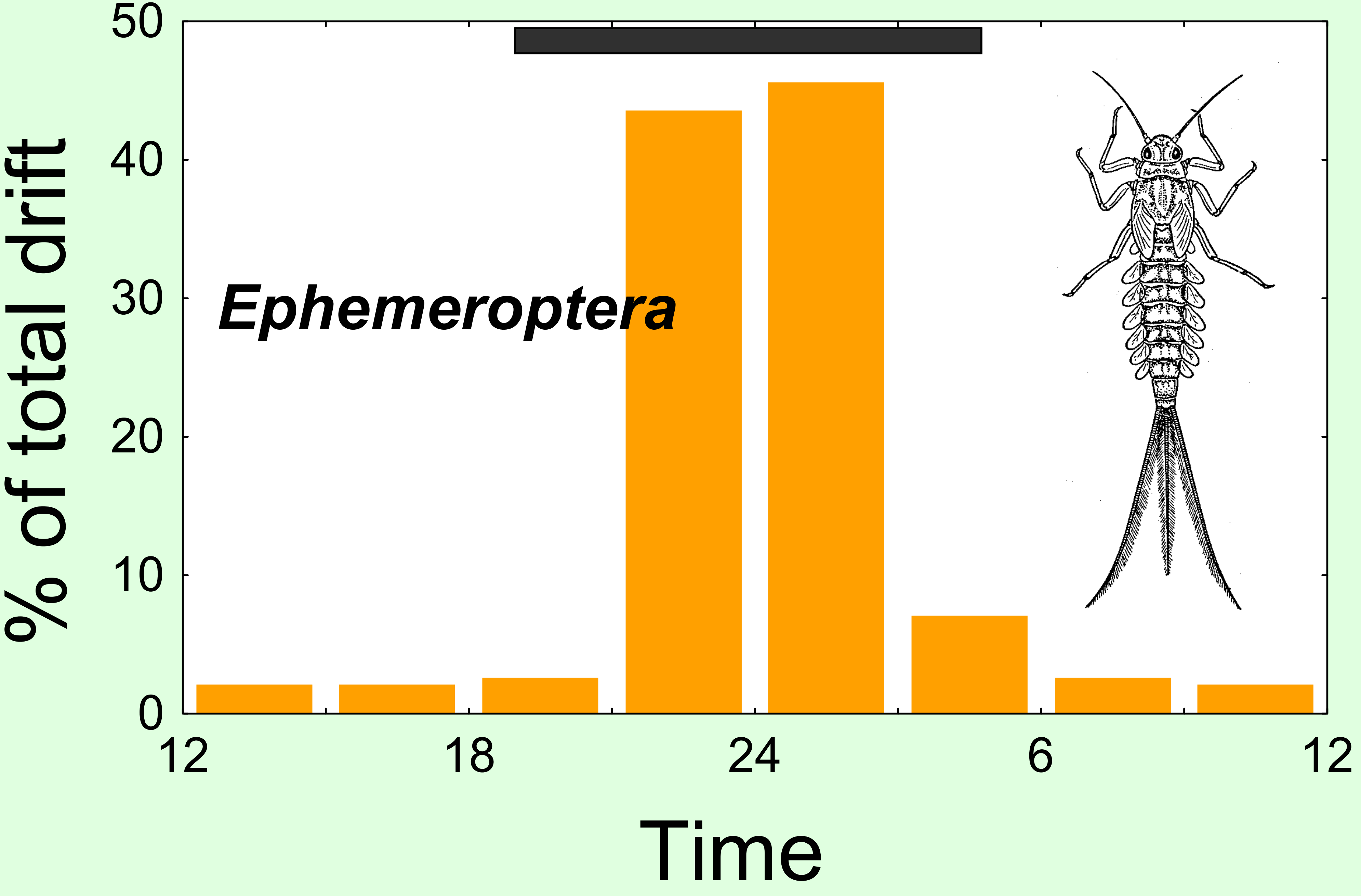
Drift periodicity

- „catastrophic drift“
- day-night drift periodicity

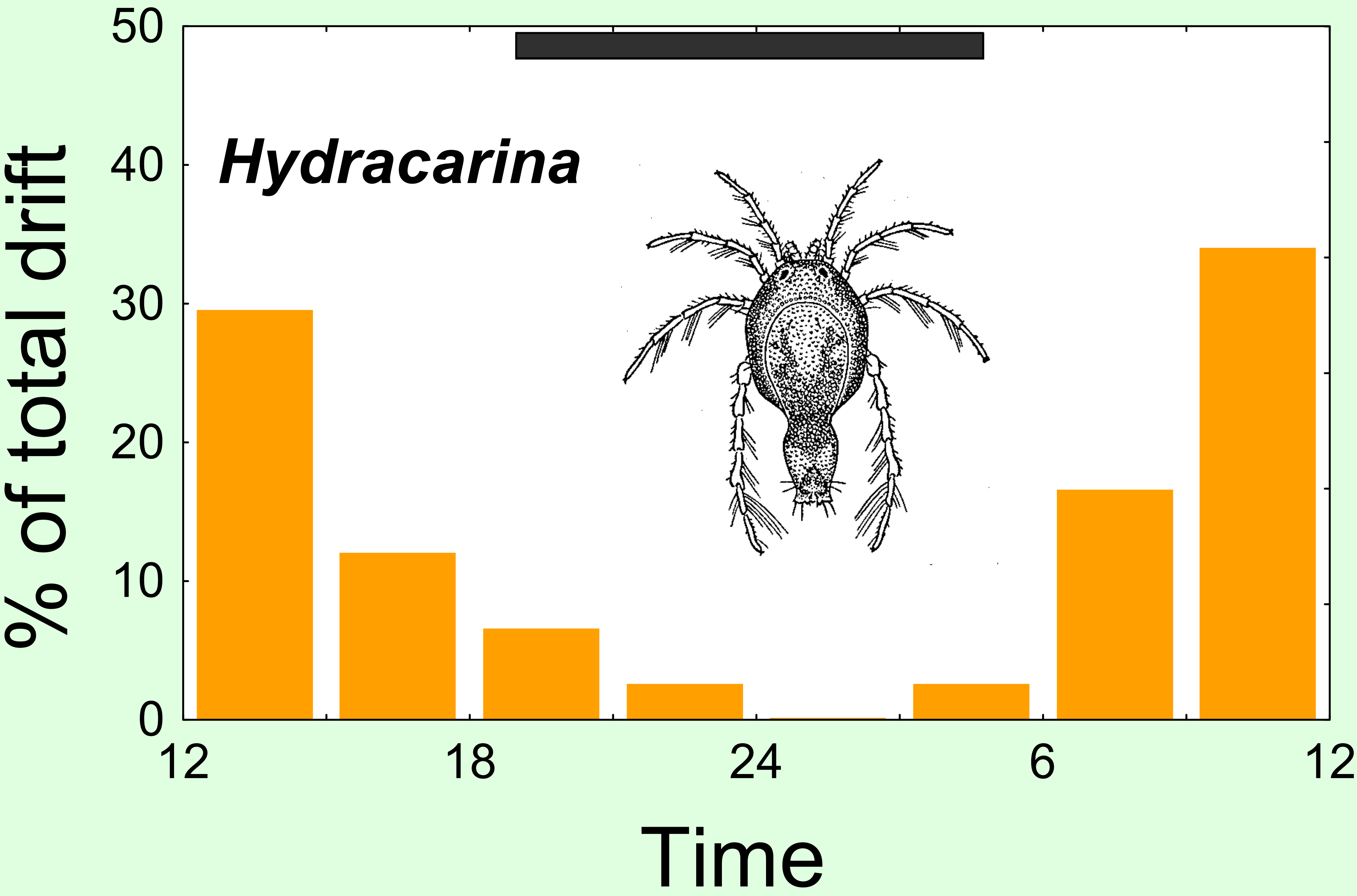
Day-night drift periodicity



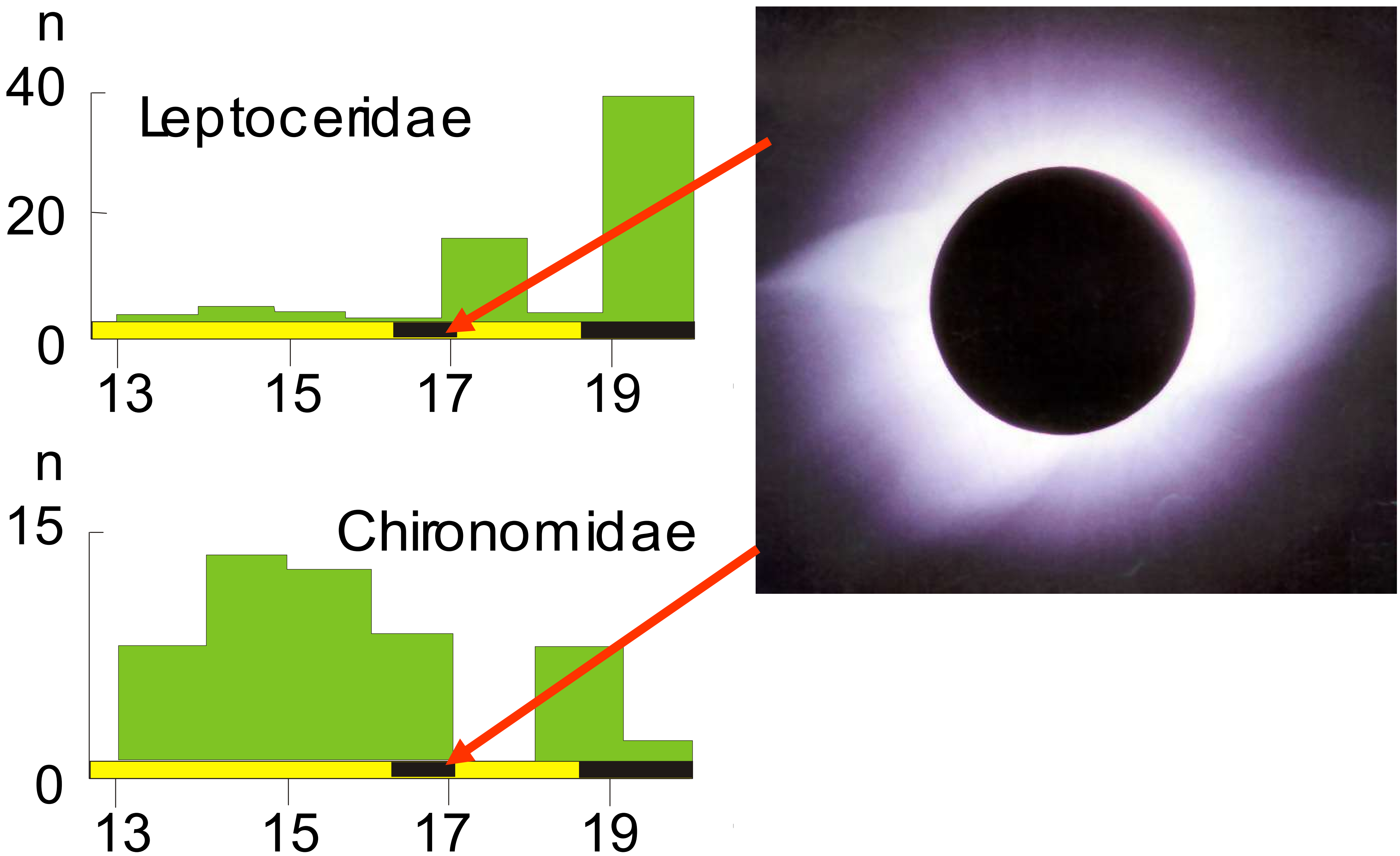
Day-night drift periodicity



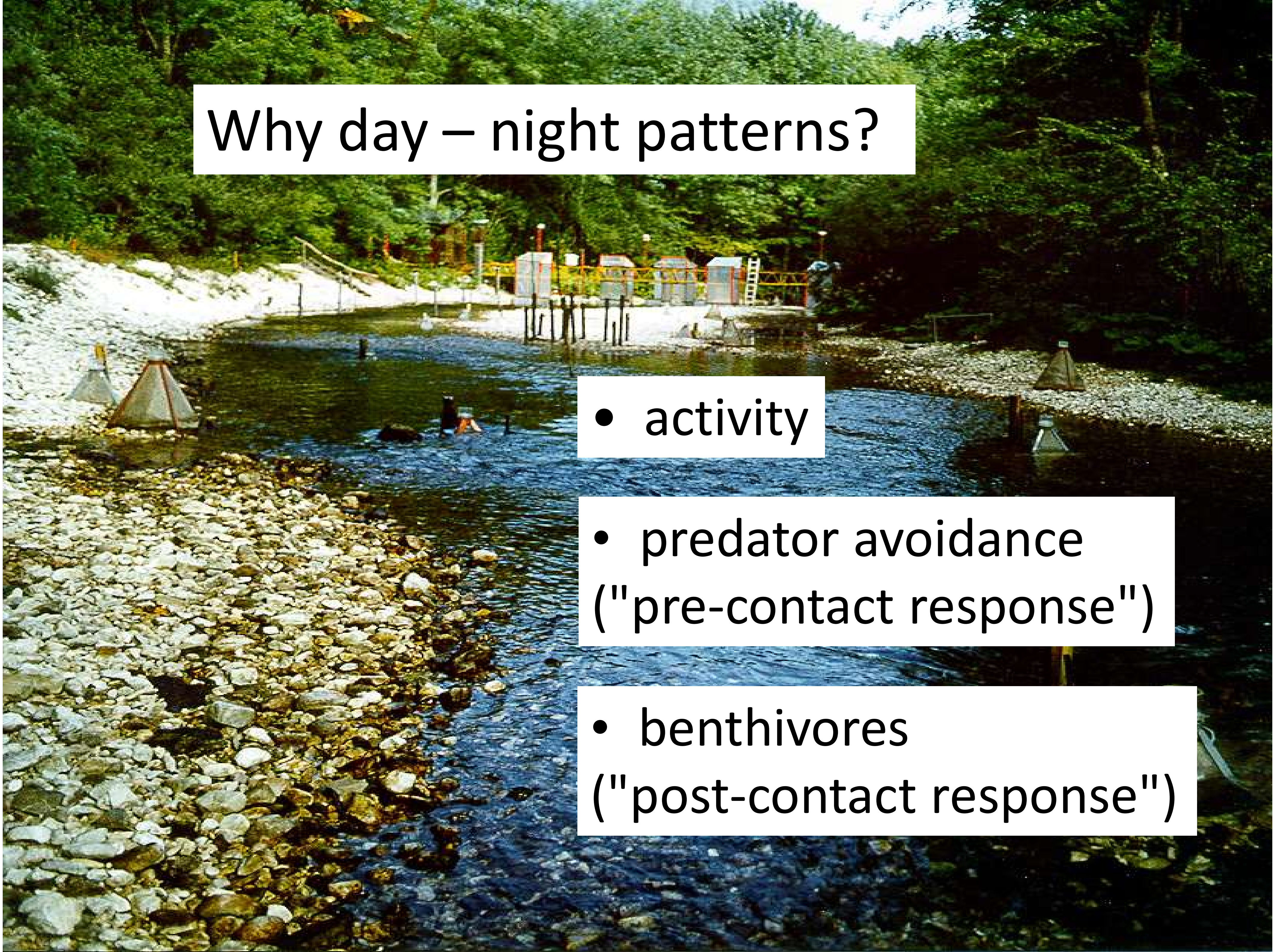
Day-night drift periodicity



Day-night drift periodicity: total solar eclipse



Why day – night patterns?

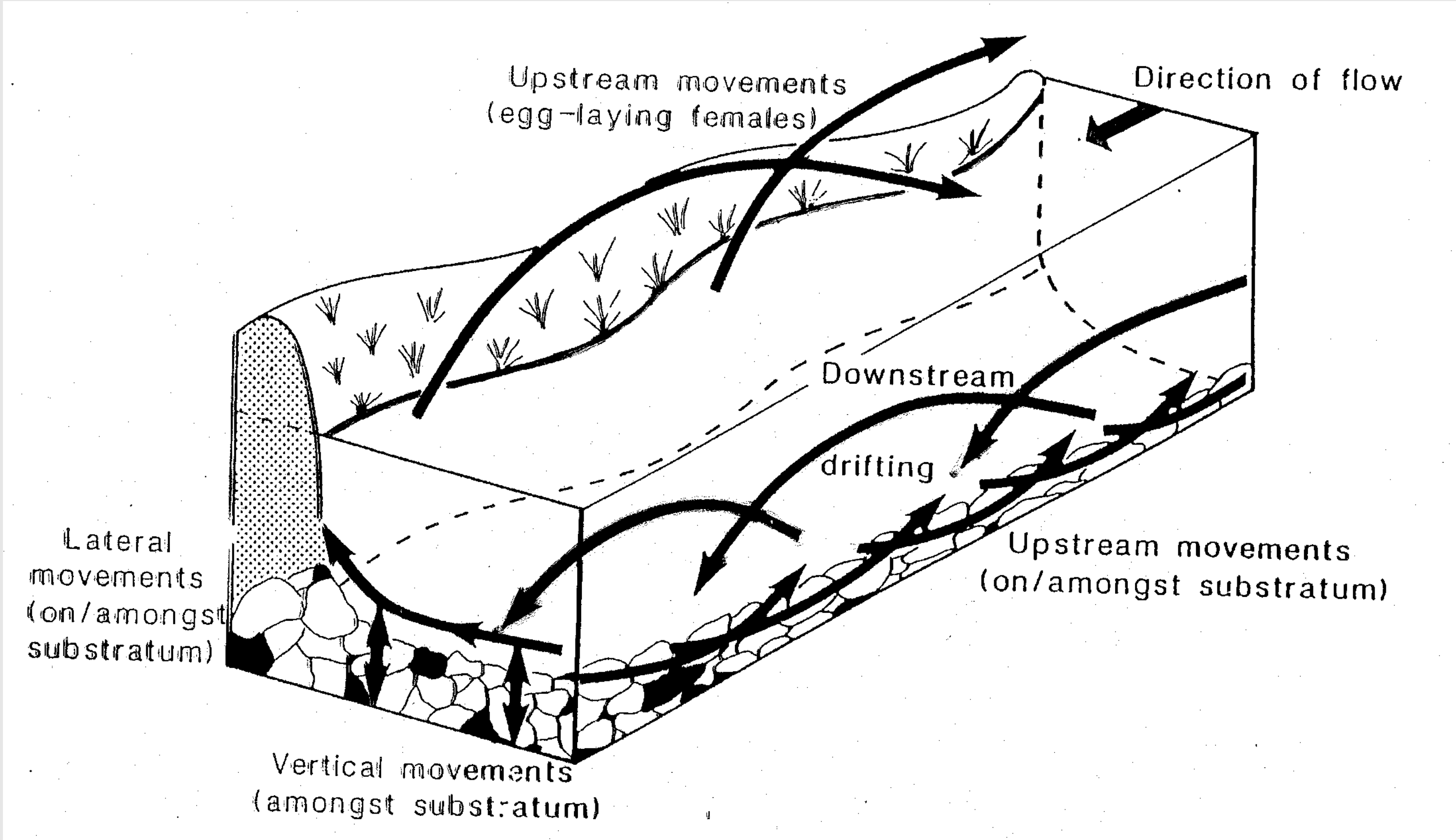


- activity
- predator avoidance
("pre-contact response")
- benthivores
("post-contact response")

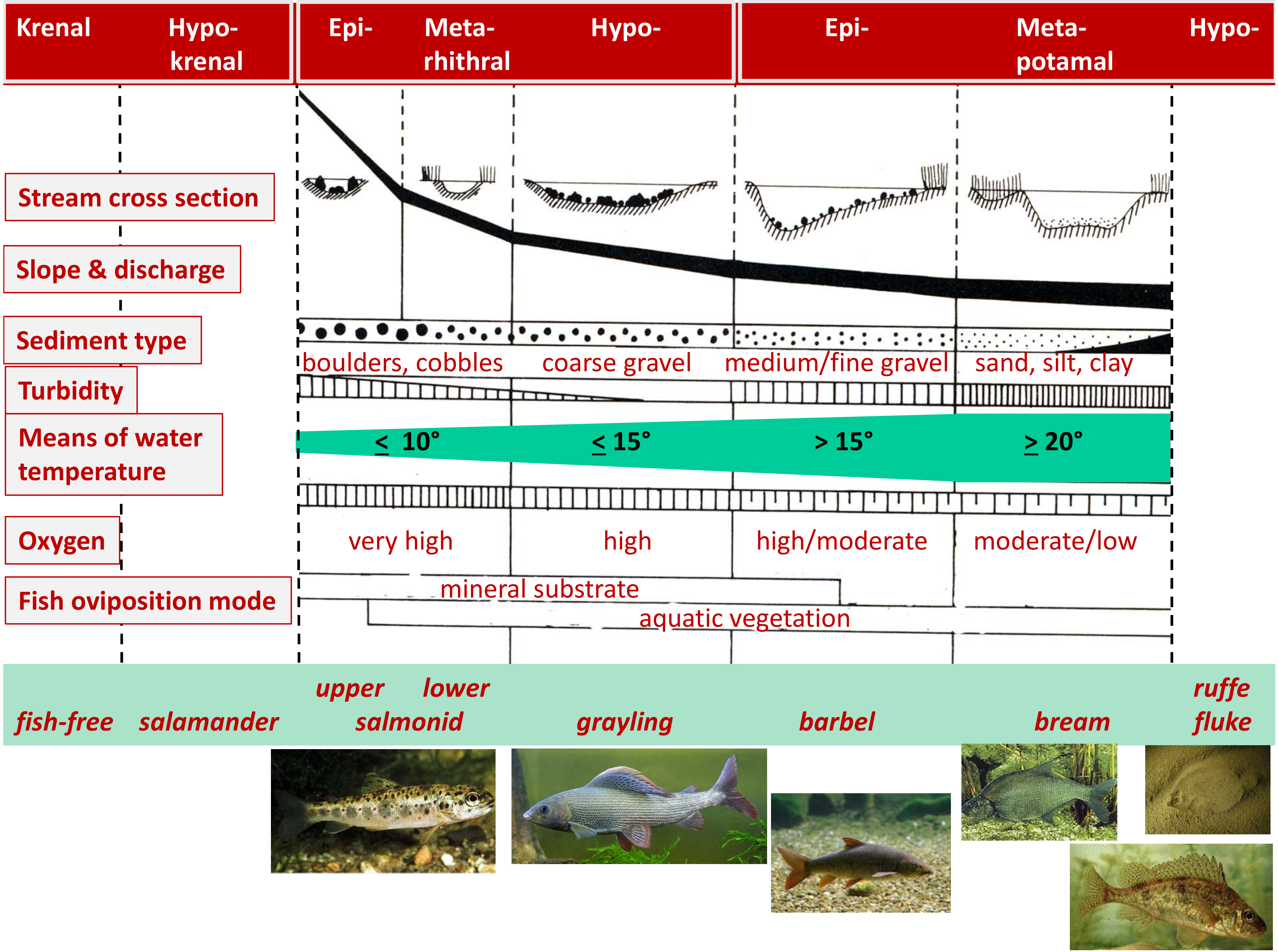
Drift distances

Chironomidae	6,5 m
Baetidae	8,5 m
Heptageniidae	8,0 m
Nemouridae	20,9 m

Drift compensation



BUT drift is also an effective mechanism of populating new or devasteted habitats!



Krenal
Hypo-krenal
Epi-
Meta-rhithral
Hypo-
Epi-
Meta-potamal
Hypo-
Stream cross section
Slope & discharge
Sediment type
boulders, cobbles
coarse gravel
medium/fine gravel
sand, silt, clay
Turbidity
Means of water temperature
≤ 10°
≤ 15°
> 15°
≥ 20°
Oxygen
very high
high
high/moderate
moderate/low
Fish oviposition mode
mineral substrate
aquatic vegetation
fish-free
salamander
upper
lower
salmonid
grayling
barbel
bream
ruffe
fluke

KRENAL RHITHRAL POTAMAL

KRENAL

RHITHRAL

POTAMAL

Mollusca

Trichoptera

Diptera

Salamandra salamandra

Longitudinal zonation concepts

Rhithral - Potamal concept (Illies 1961)

Rhithral

- Annual amplitudes of monthly means of water temperature: ≤ 20°C
- Current velocity: high
- Oxygen concentration: high
- Mean discharge: low
- Bed sediments: bedrock, gravel, sand
- Biota: cold stenotherms, rheobionts, polyoxibionts.

KRENAL RHITHRAL POTAMAL

KRENAL RHITHRAL POTAMAL

Rhithrobenthos:

Ephemeroptera

Plecoptera

Trichoptera

Diptera

Mollusca

Coleoptera

Hydracarina

Rhithronekton:

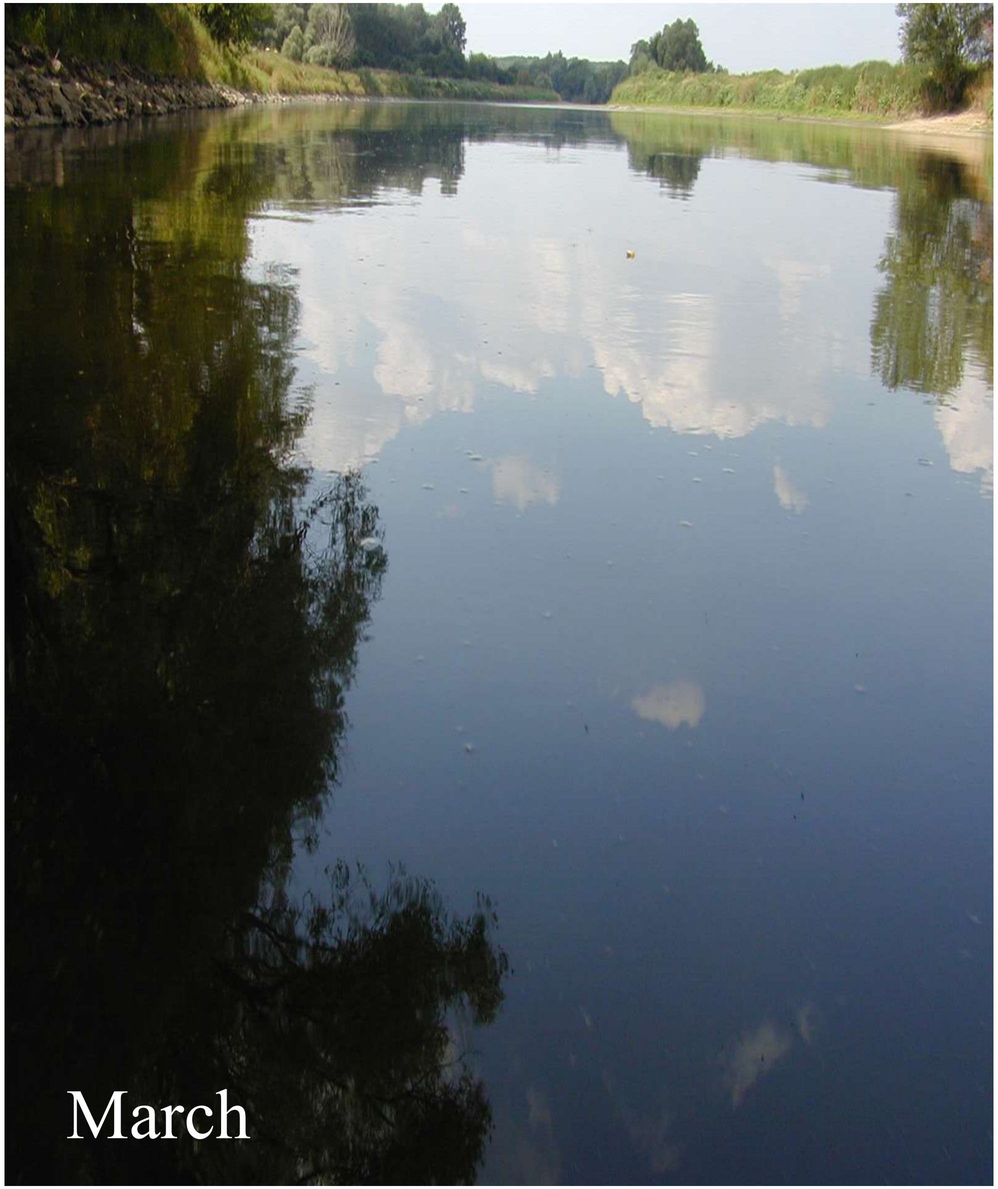
Salmonidae

Longitudinal zonation concepts

Potamal

- Annual amplitudes of monthly means of water temperature: > 20°C
- Current velocity: low
- Oxygen concentration: sometimes low
- Mean discharge: strongly fluctuating
- Bed sediments: sand, mud, bedload
- Biota: eury- and warmstenotherm, rheotolerant, mixed with taxa from standing water bodies.

KRENAL RHITHRAL **POTAMAL**



KRENAL RHITHRAL **POTAMAL**

Potamobenthos:

Odonata

Diptera

Ephemeroptera

Heteroptera

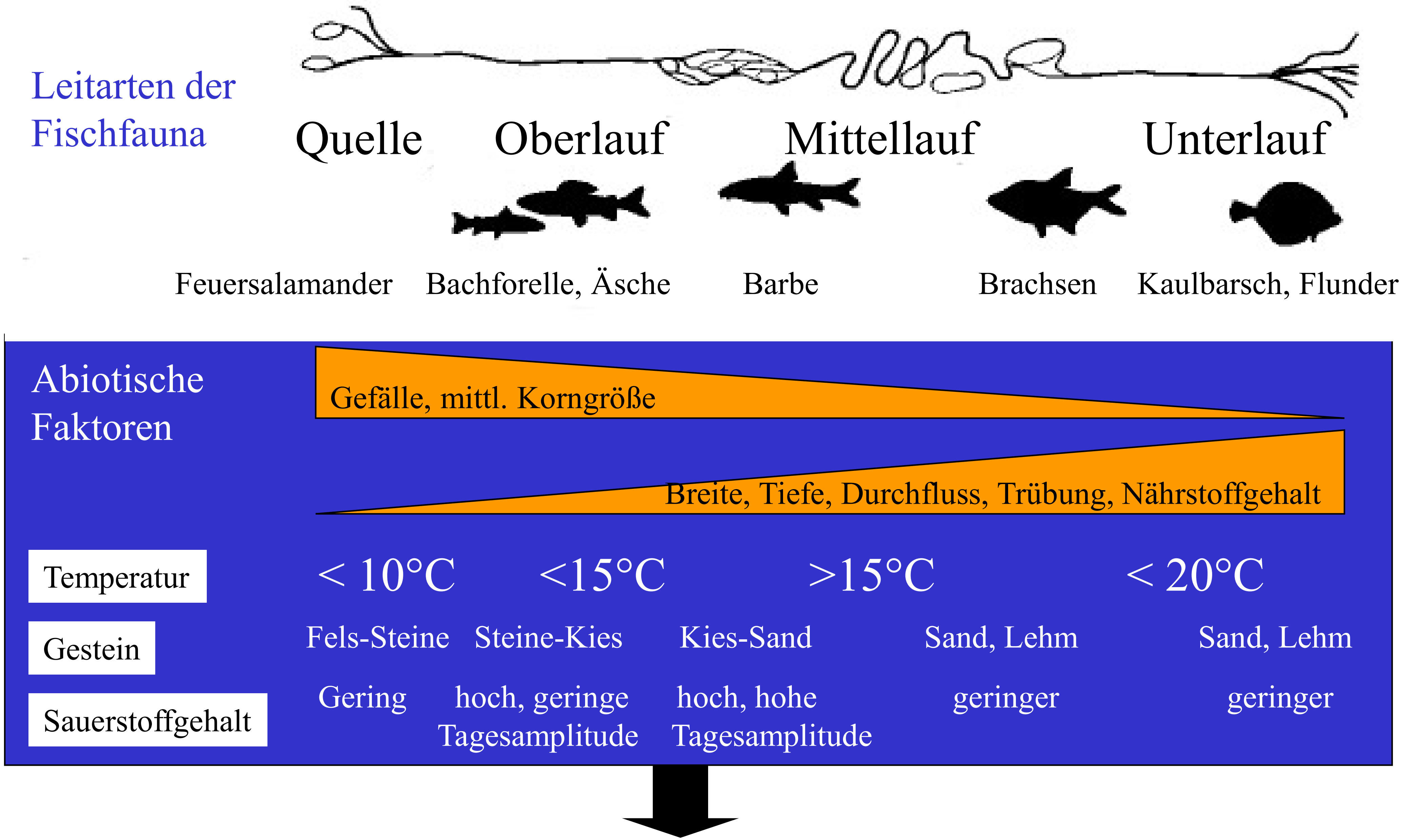
Coleoptera

Trichoptera

Potamo-plankton:

Potamonekton:

Cyprinidae



Leitarten der Fischfauna
Quelle
Oberlauf
Mittellauf
Unterlauf
Feuersalamander
Bachforelle, Äsche
Barbe
Brachsen
Kaulbarsch, Flunder
Abiotische Faktoren
Gefälle, mittl. Korngröße
Breite, Tiefe, Durchfluss, Trübung, Nährstoffgehalt
Temperatur
< 10°C
<15°C
>15°C
< 20°C
Gestein
Fels-Steine
Steine-Kies
Kies-Sand
Sand, Lehm
Sand, Lehm
Sauerstoffgehalt
Gering
hoch, geringe Tagesamplitude
hoch, hohe Tagesamplitude
geringer
geringer

FAUNA AQUATICA AUSTRIACA

A Comprehensive Species Inventory of Austrian Aquatic Organisms with Ecological Notes

FAA

2nd Edition - 2002

www.lebensministerium.at

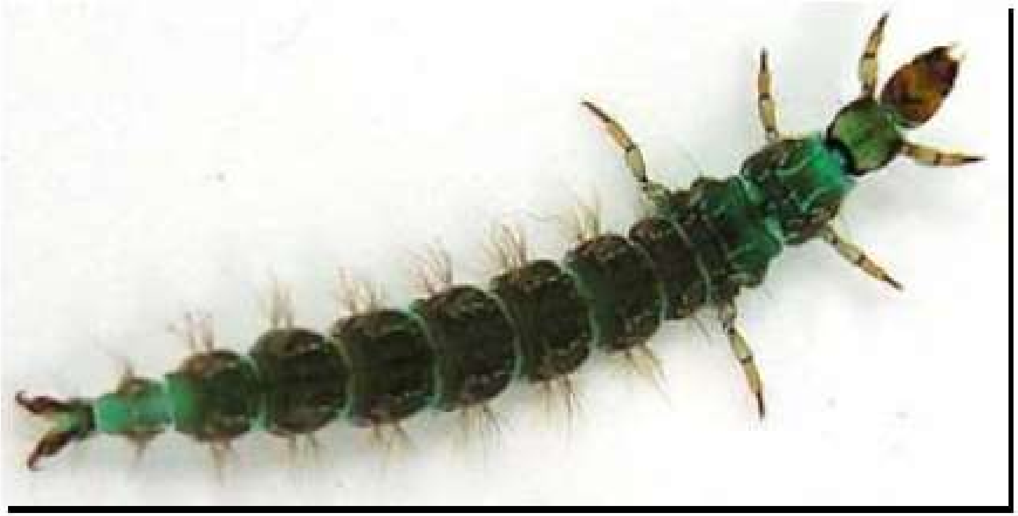
Hydropsychidae: Longitudinal zonation patterns
(Otto Moog, Fauna Aquatica Austriaca 2002)

	Eukrenal	Hypokrenal	Epirhithral	Metarhithral	Hyporhithral	Epipotamal	Metapotamal	Hypopotamal	Litoral	Profundal
Hydropsyche fulvipes	1	7	2							
H. saxonica		2	6	2						
H. tenuis			8	2						
H. dinarica			6	4						
H. instabilis			4	4	2					
H. siltalai			1	5	4					
H. pellucidula			1	2	4	3				
H. incognita				5	4	1				
H. silfvenii				4	6					
H. bulbifera				1	4	5				
H. contubernalis				1	4	4	1			
H. bulgaromanorum				1	3	3	3			
H. guttata					5	4	1			
Cheumatopsyche lepida					3	6	1			

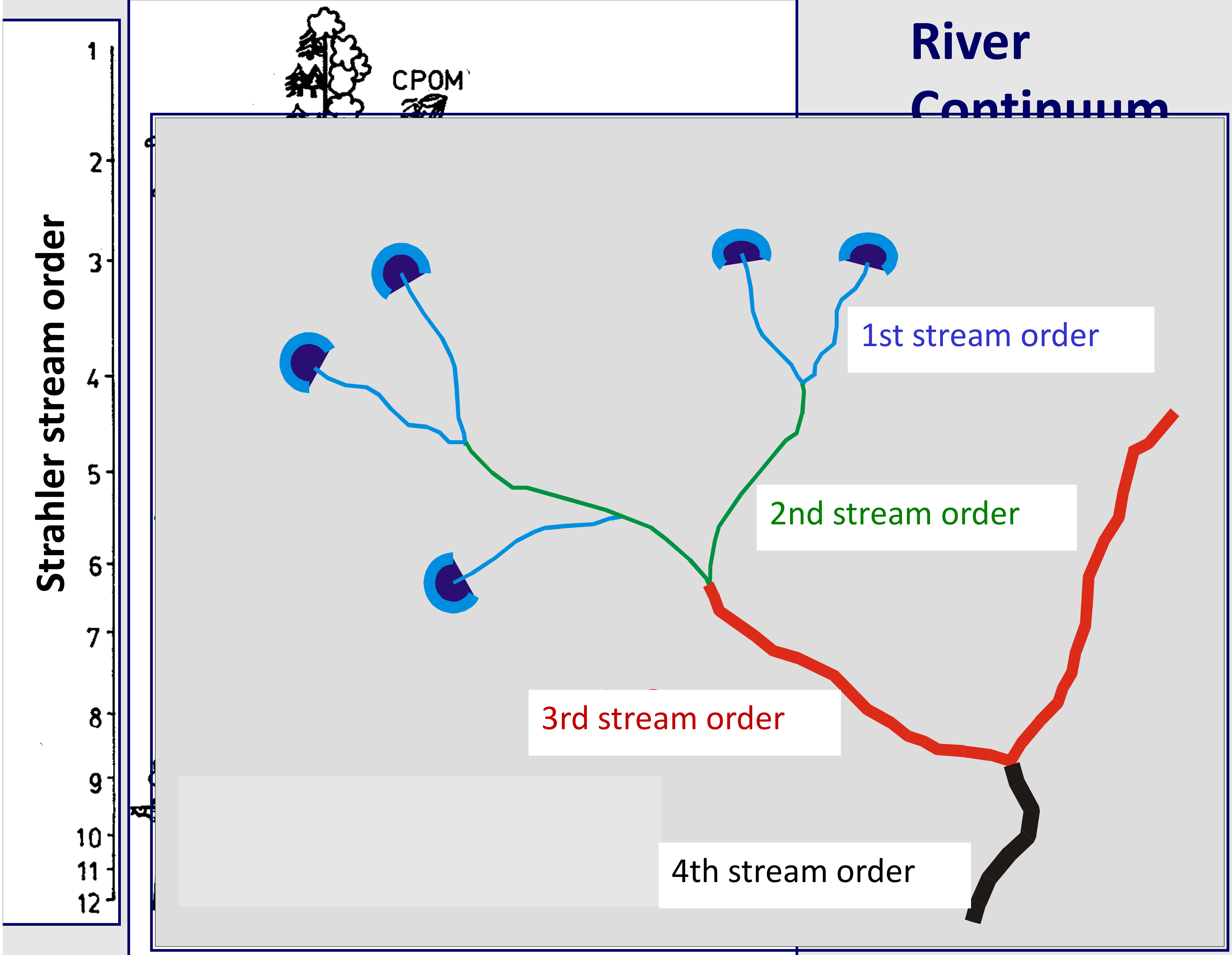
Distribution of *Rhyacophila* species (Trichoptera) along the longitudinal stream/river continuum:

stream source → large river

	EUCRENAL	HYPOCRENAL	EPIRHITHRAL	METARHITRAL	HYPORHITHRAL	EPIRHITRAL	METAPOTAMAL	HYPOPOTAMAL
R. bonaparti	80	20	-	-	-	-	-	-
R. aurata	-	20	20	60	-	-	-	-
R. dorsalis	-	-	10	70	10	10	-	-
R. glareosa	10	30	60	-	-	-	-	-
R. hirticornis	50	50	-	-	-	-	-	-
R. pascoei	-	-	-	20	40	40	-	-
R. tristis	20	20	30	20	10	-	-	-



River Continuum



Weidlingbach

SO= 2

Thaya

SO= 6

Danube

SO= 9

River Continuum Concept

Nahrungsbasis: Größenkategorien

CPOM	Coarse particulate organic matter	$\geq$ 1 mm
FPOM	Fine particulate organic matter	< 1 mm
DOM	Dissolved organic matter	< 0,45 µm

Konsumenten: funktionelle Ernährungskategorien (Gilden, FFG – functional feeding groups)

Zerkleinerer (shredders)	> CPOM
Sammler, aktive und passive Filtrierer (collectors)	> FPOM
Weidegänger (grazers, scrapers)	> Krustenalgen, Aufwuchs
Karnivore (predators)	> alle Gilden
Zellstecher (piercers)	> Algenzellen

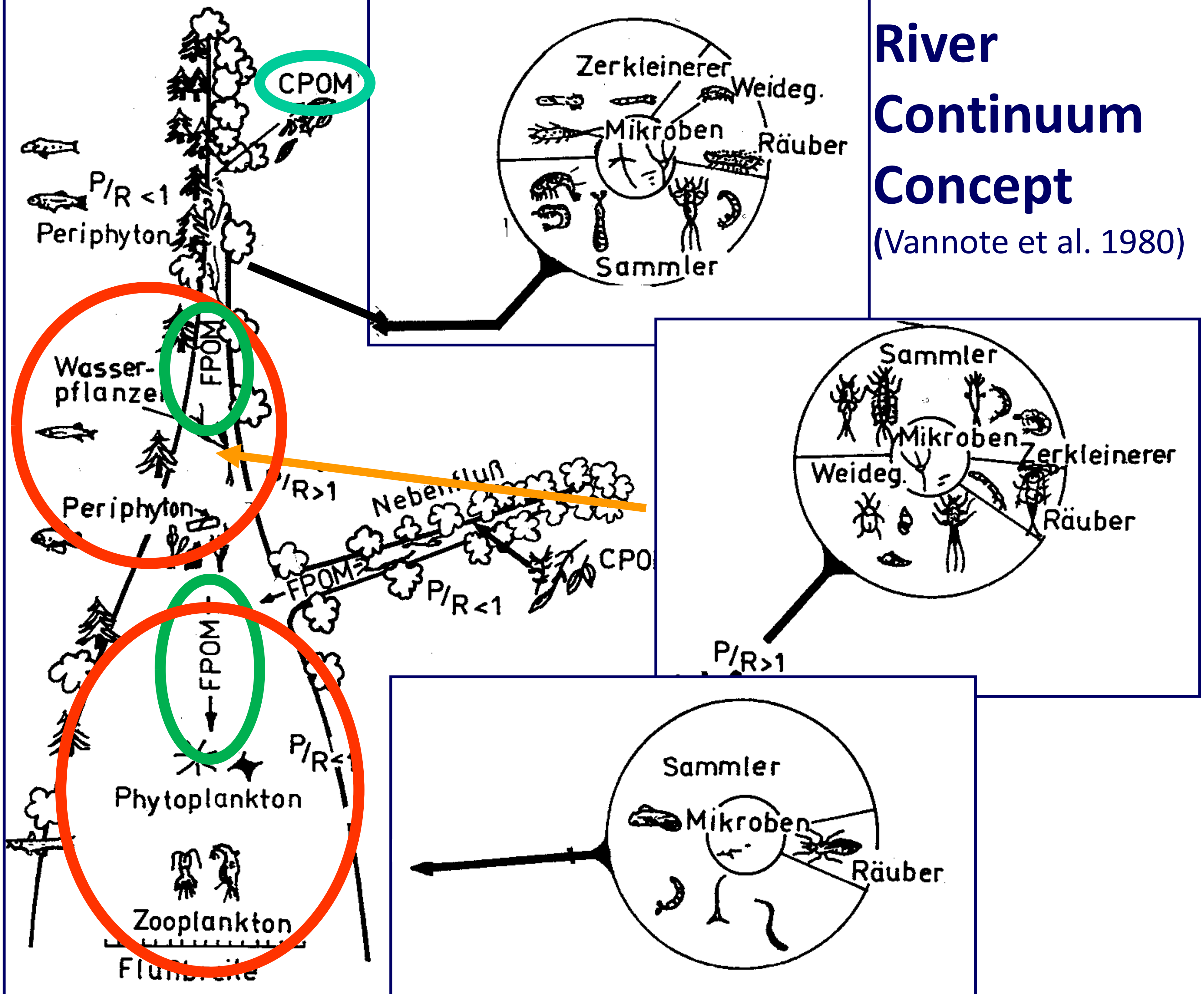
CPOM Coarse particulate organic matter ≥ 1 mm

DOM Dissolved organic matter < 0,45 µm

FPOM
Fine particulate organic matter
< 1 mm

River Continuum Concept

(Vannote et al. 1980)



River Continuum Concept

Nahrungsbasis: Größenkategorien

CPOM	Coarse particulate organic matter	≥ 1 mm
FPOM	Fine particulate organic matter	< 1 mm
DOM	Dissolved organic matter	< 0,45 µm

Konsumenten: funktionelle Ernährungskategorien (Gilden, FFG – functional feeding groups)

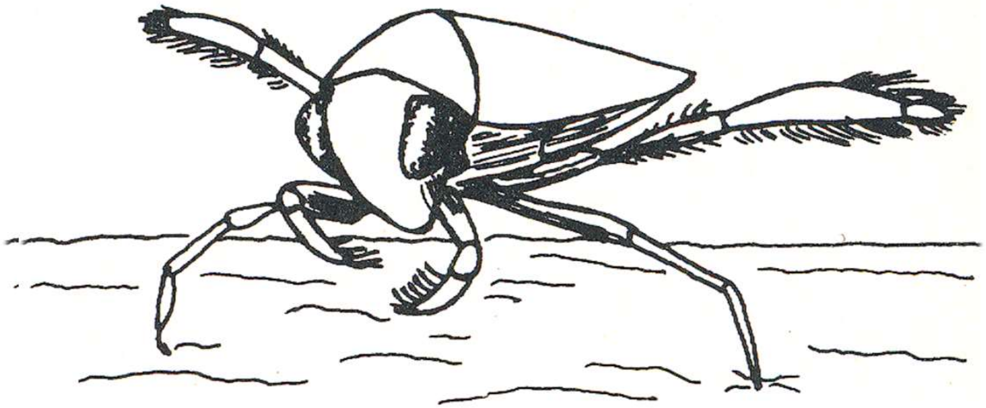
Zerkleinerer (shredders)	> CPOM
Sammler, aktive und passive Filtrierer (collectors)	> FPOM
Weidegänger (grazers, scrapers)	> Krustenalgen, Aufwuchs
Karnivore (predators)	> alle Gilden
Zellstecher (piercers)	> Algenzellen

Shredders use CPOM

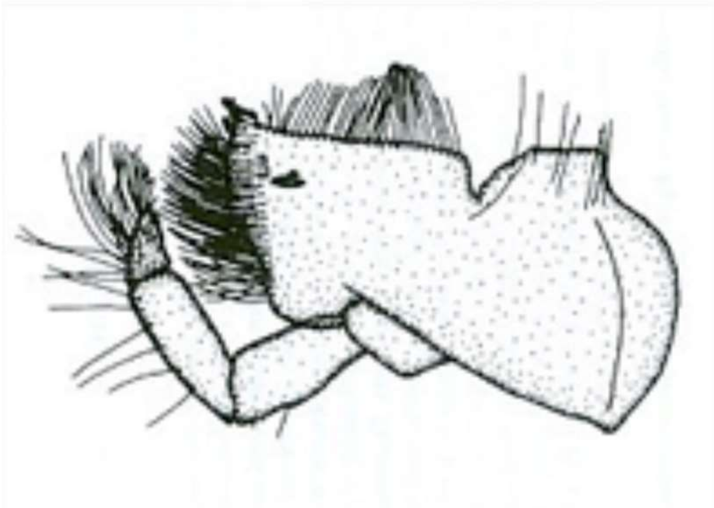
< Trichoptera larvae (Limnephilidae)

Amphipods (Gammaridae)

Gathering collectors use FPOM

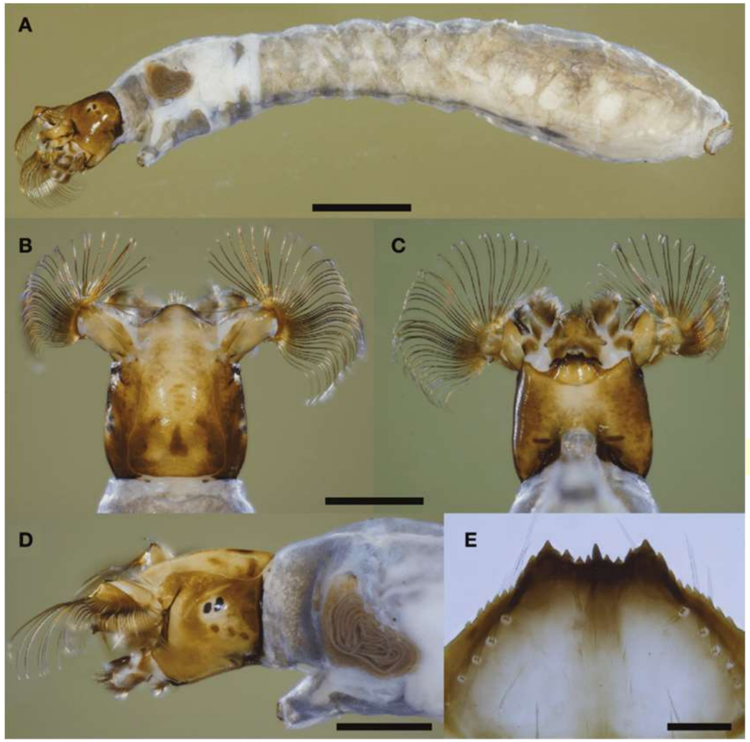


Heteroptera (Corixidae)



Ephemeroptera larvae (Leptophlebiidae)

Filtering collectors use suspended FPOM



Simuliidae (Diptera)

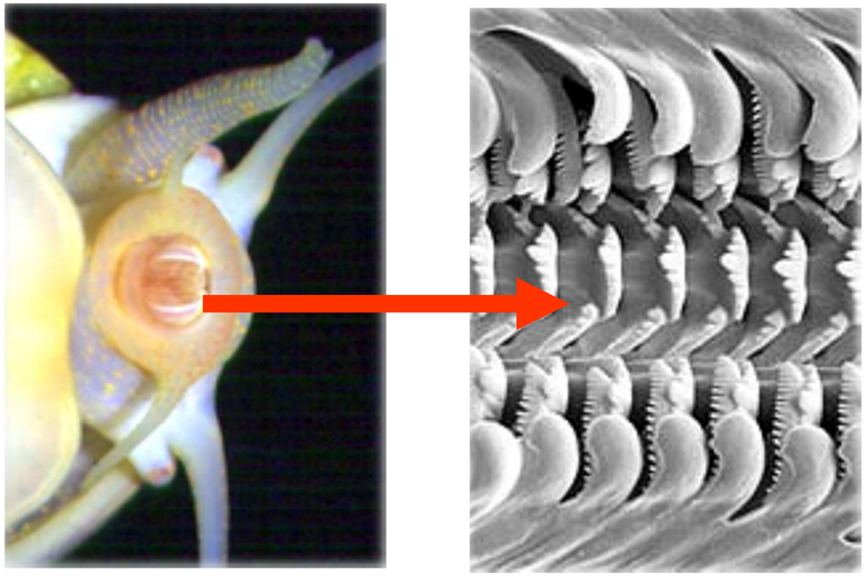
Hydropsychidae
(Trichoptera)

Mussels (Mollusca)

Polycentropodidae (Trichoptera)

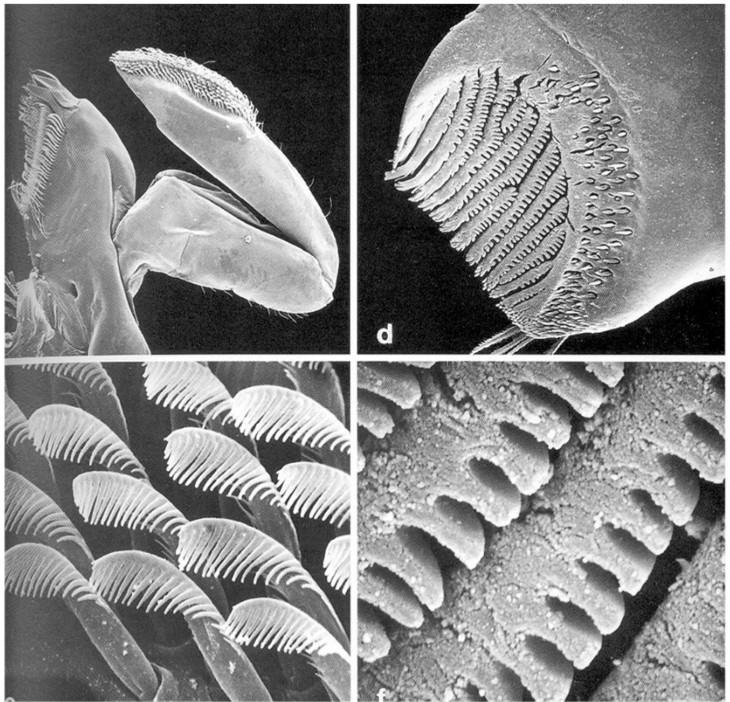
Grazers use epilithic algae and aufwuchs

Trichoptera

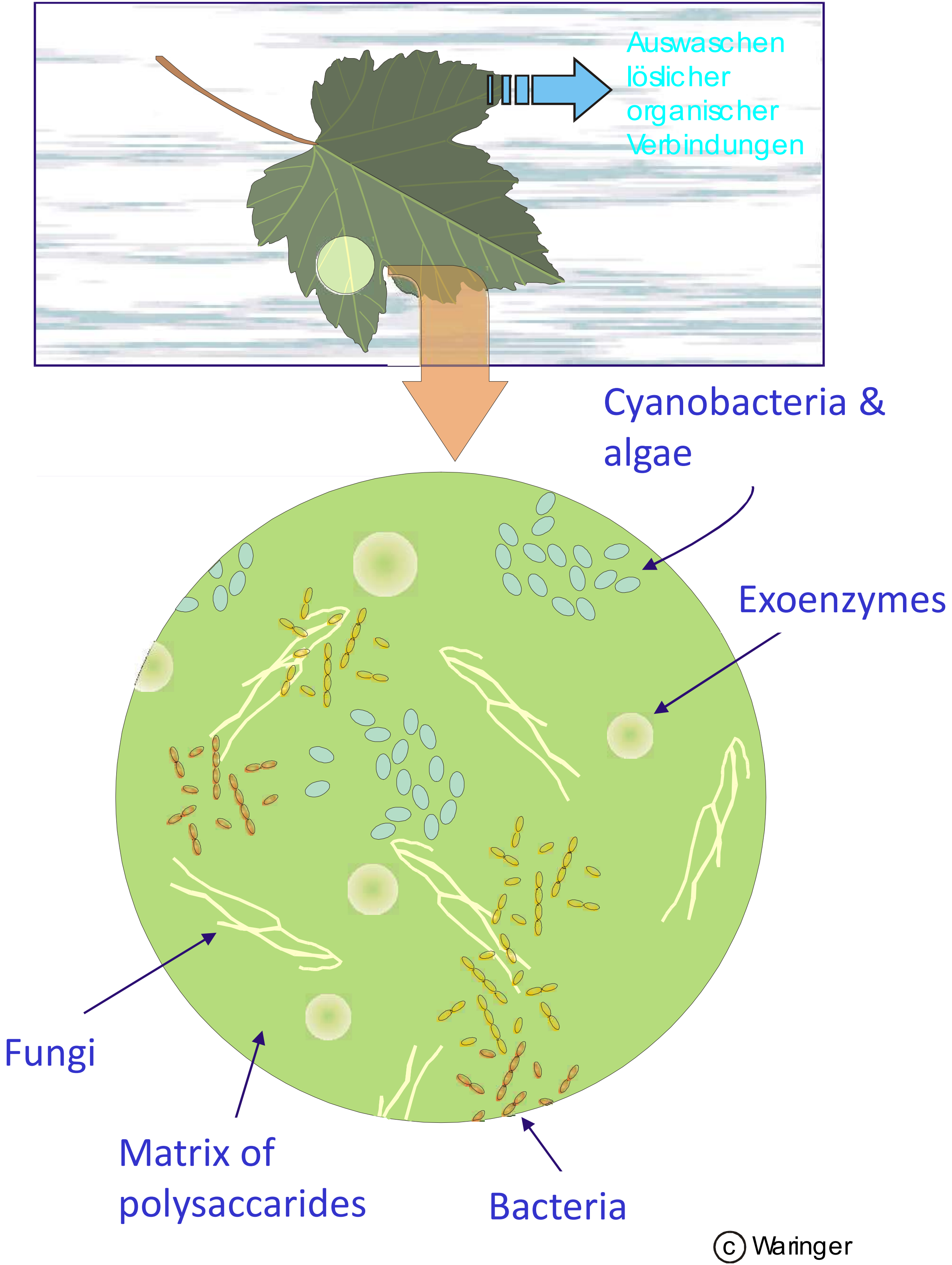


Snails (Gastropoda)

Ephemeroptera >

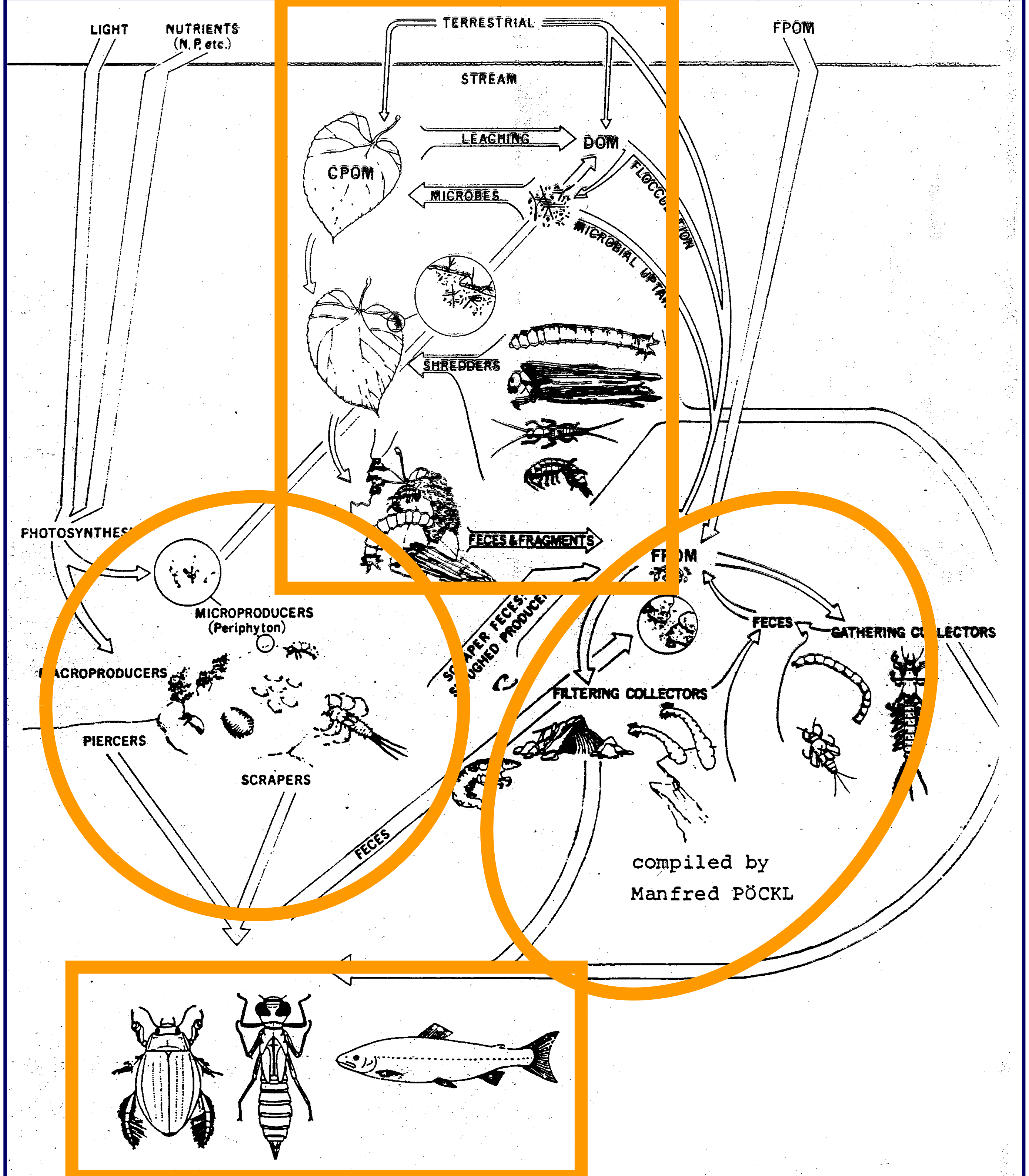


Biofilm components



Predators feed on all groups

e.g. Odonata, Megaloptera, fish



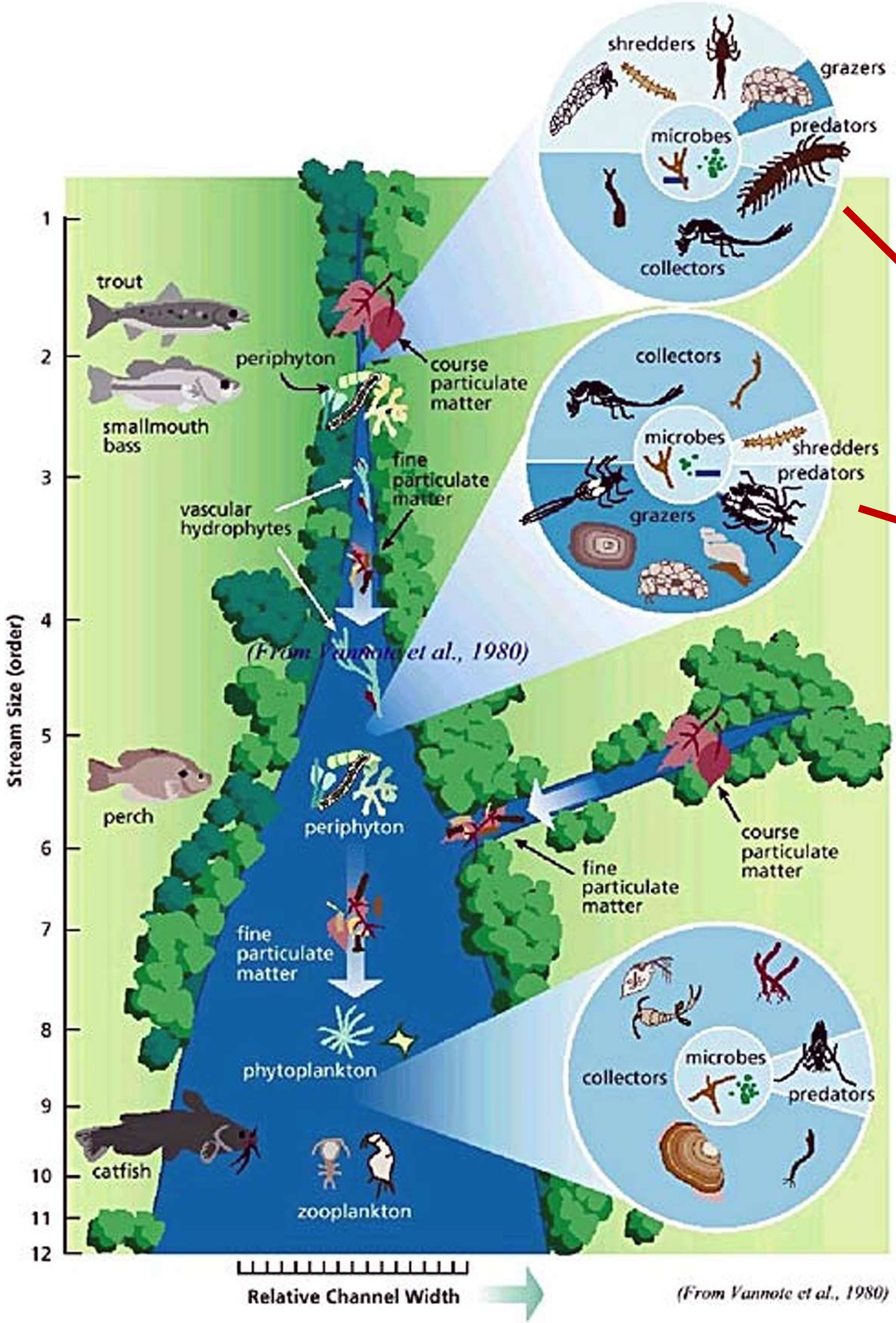
Algen-Weidegänger-System

CPOM-Zerkleinerer-System

FPOM-Filtrierer-Detritussammler-System

Karnivore

River Continuum Concept

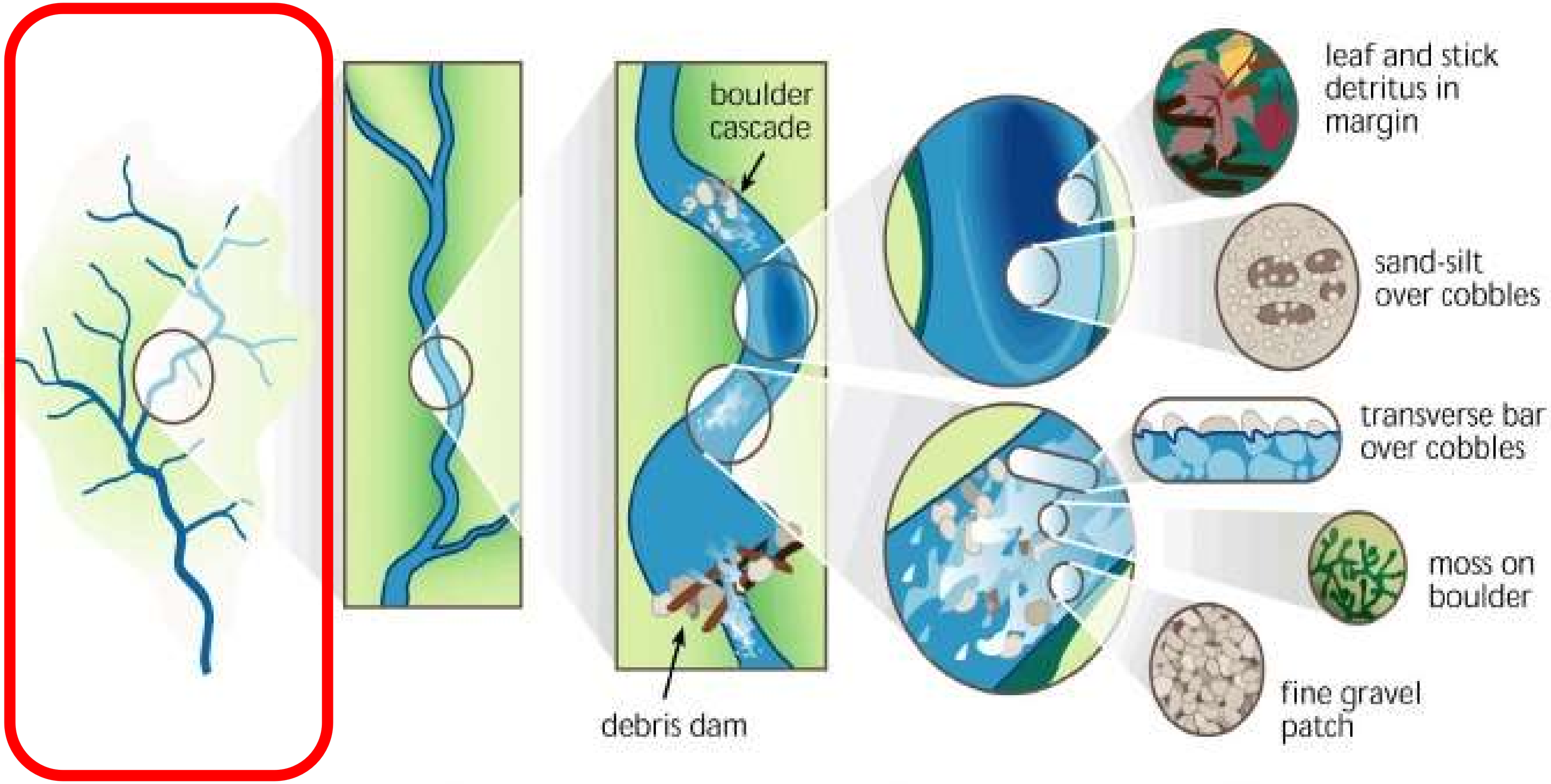


P / R < 1

P / R > 1

P / R < 1

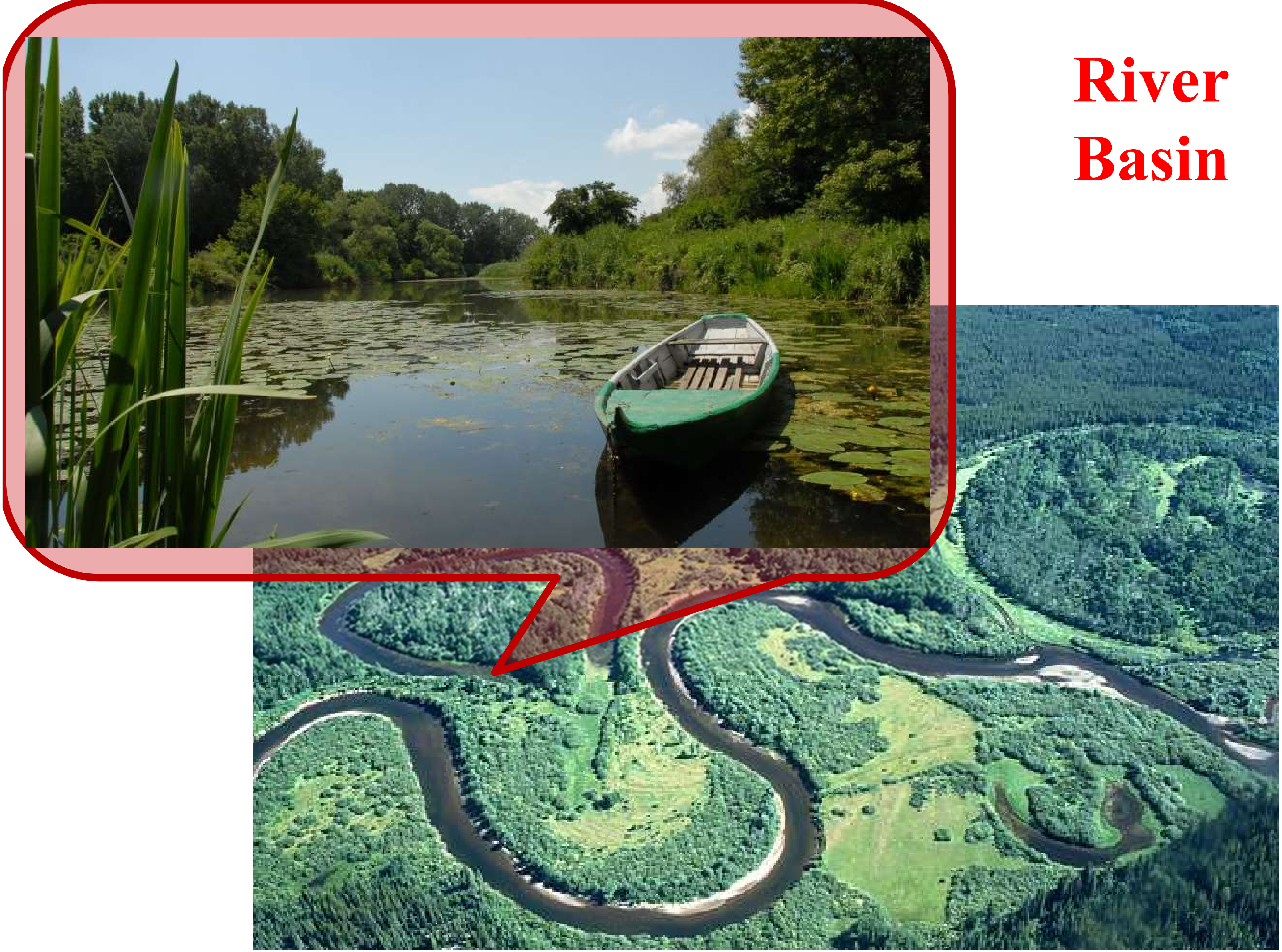
Great diversity of habitat in streams



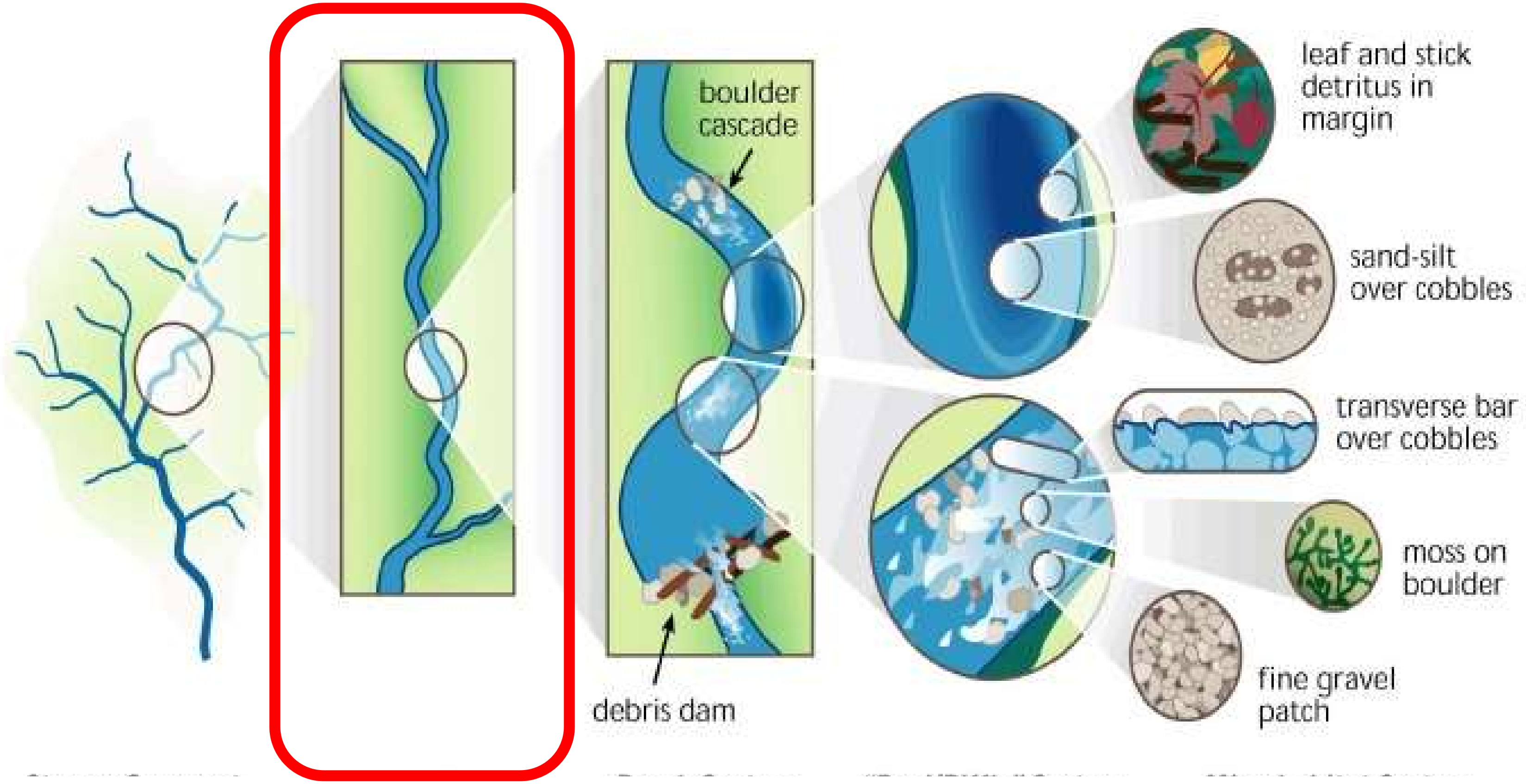
River basin	River segment	River section	River sequence	Small habitats
1 km 1.000-1 Mio. years	100 m 1.000-10.000 years	10 m 10-1.000 years	1 m 1-10 years	10 cm 1 month - 1 year

Spatial/temporal variability

River Basin



Great diversity of habitat in streams



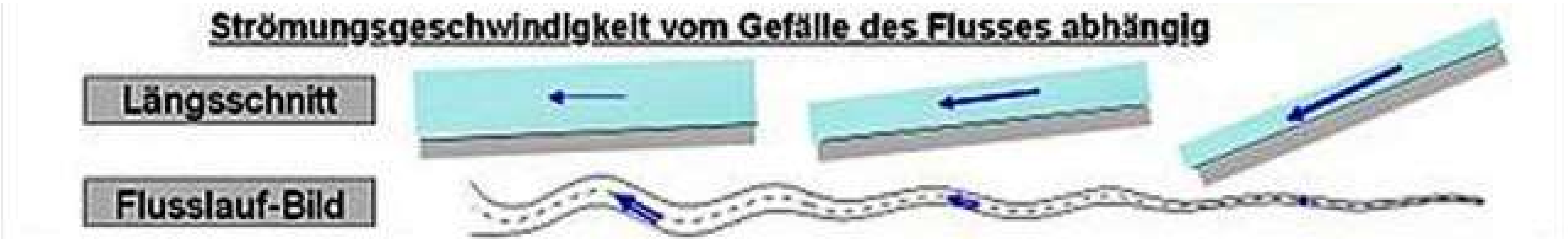
River basin	River segment	River section	River sequence	Small habitats
1 km 1.000-1 Mio. years	100 m 1.000-10.000 years	10 m 10-1.000 years	1 m 1-10 years	10 cm 1 month - 1 year

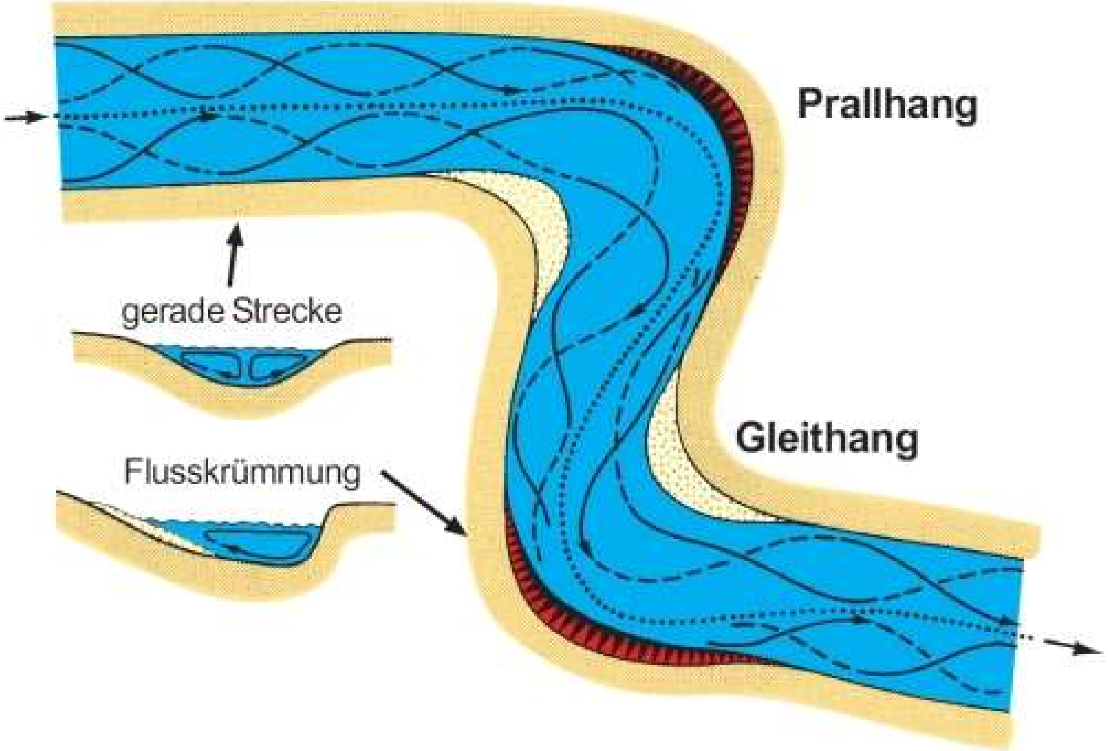
Temporal stability:

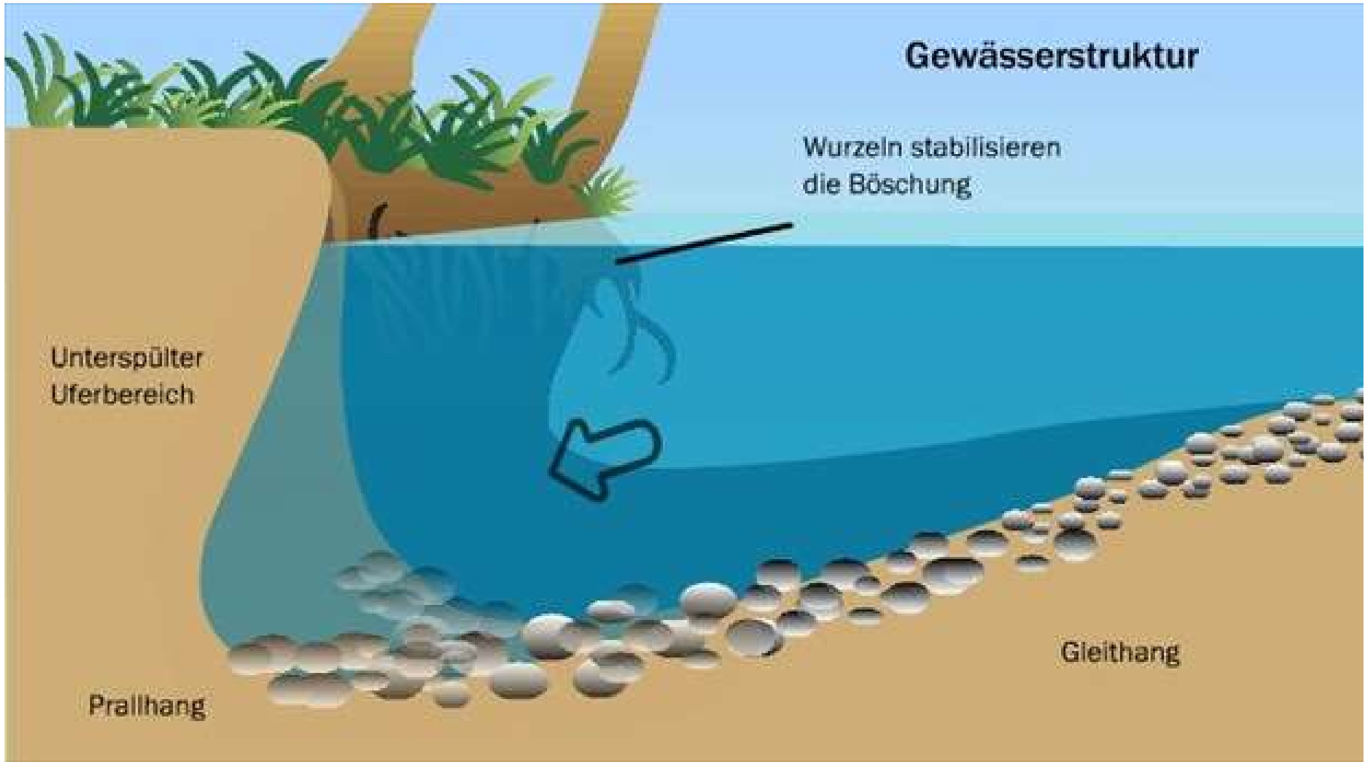
Spatial/temporal variability

River Segment

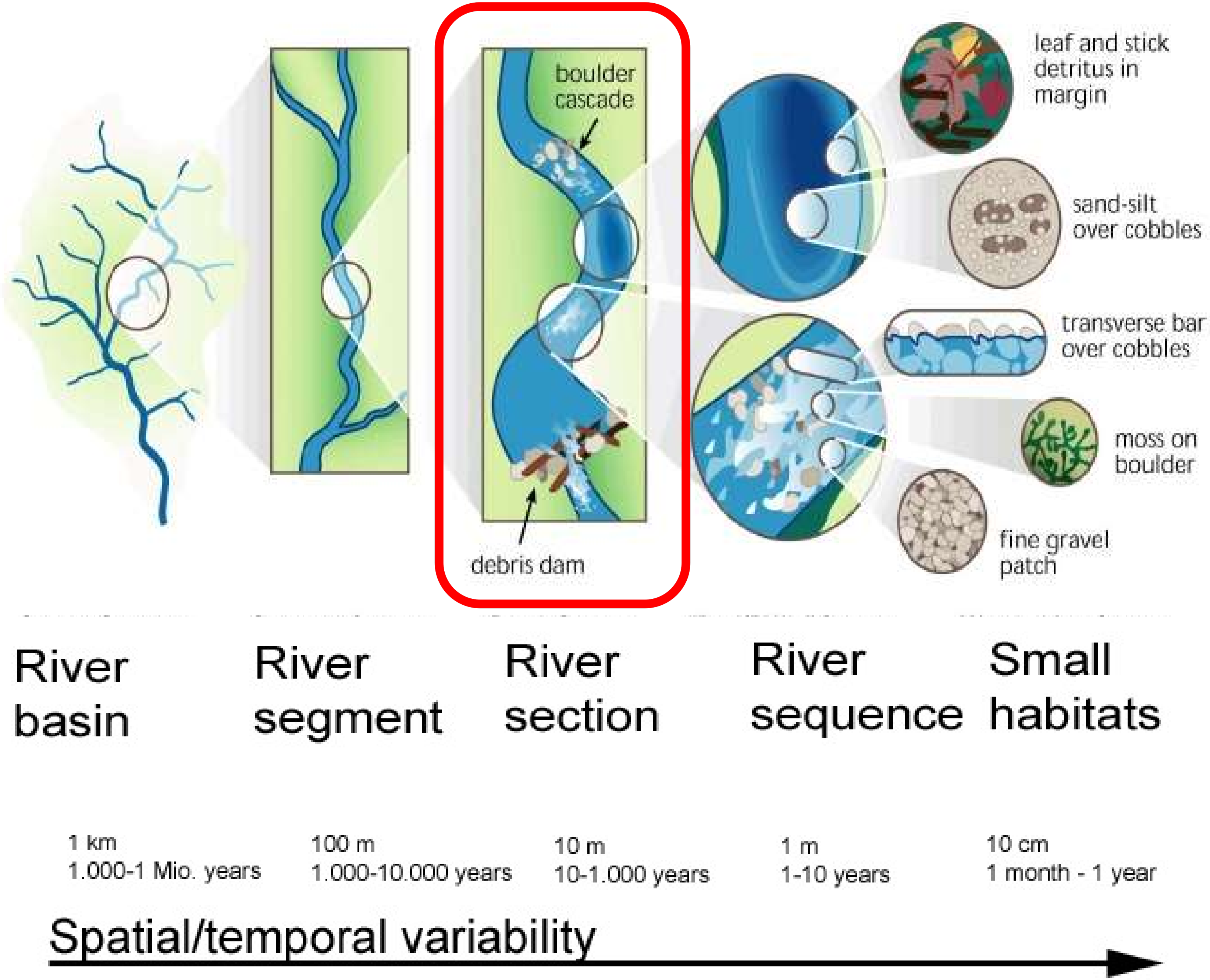

Was ist die Mäandrierung eines Flusses?
allgemein: Schlängelverlauf eines Flusses
Flussdraufsicht
Prallhang mit Erosion
Unterlauf
Oberlauf
Gleithang mit Sedimentation
„Der Stromfaden des Flusses pendelt hin und her"
Verteilung der Strömungs-geschwindigkeit
v max
Flussquerschnitt
Gleit-hang
Sedimentation
Erosion
Prall-hang


Strömungsgeschwindigkeit vom Gefälle des Flusses abhängig
Längsschnitt
Flusslauf-Bild


Prallhang
gerade Strecke
Gleithang
Flusskrümmung

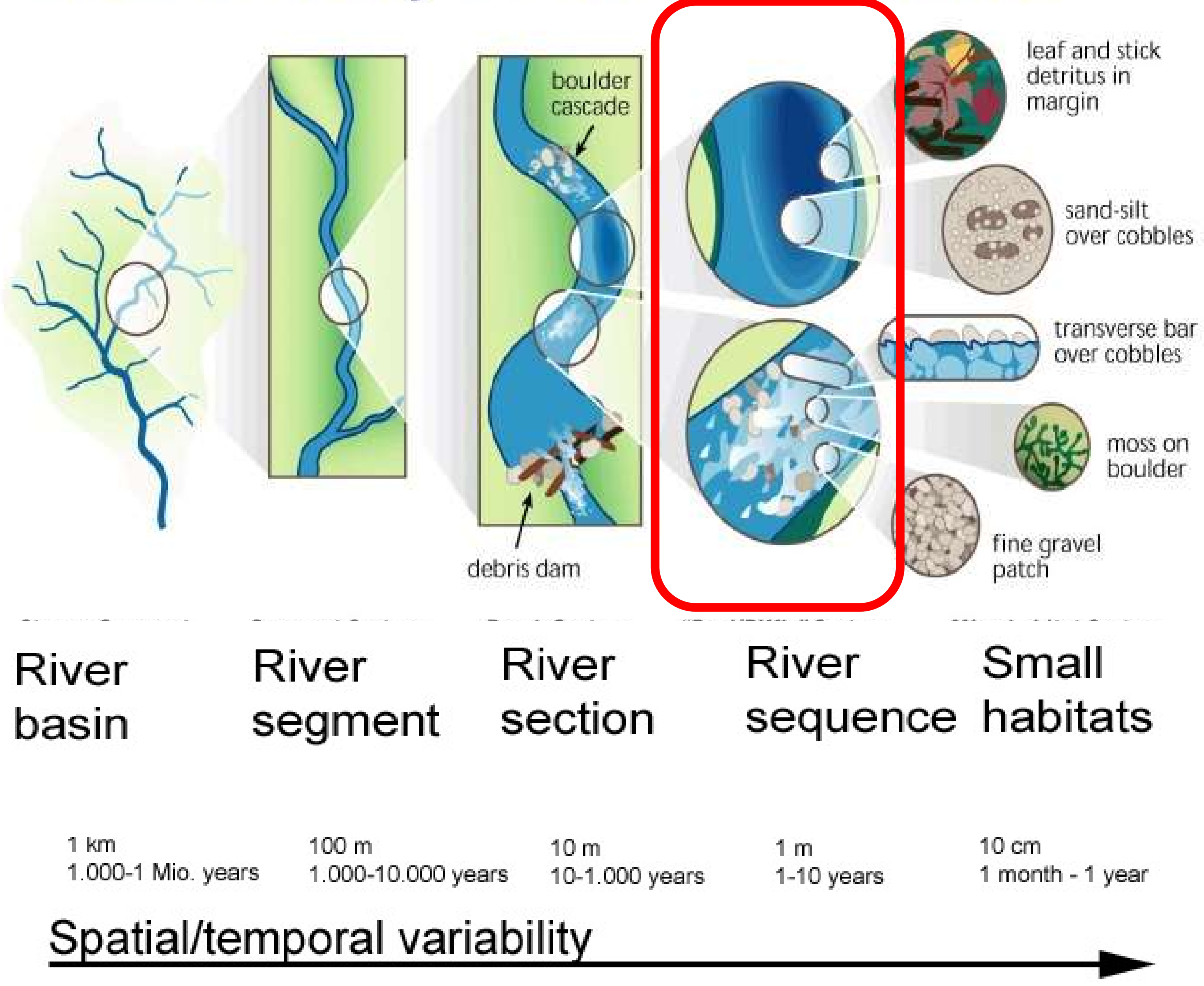

Gewässerstruktur
Wurzeln stabilisieren
die Böschung
Unterspülter
Uferbereich
Gleithang
Prallhang

Great diversity of habitat in streams

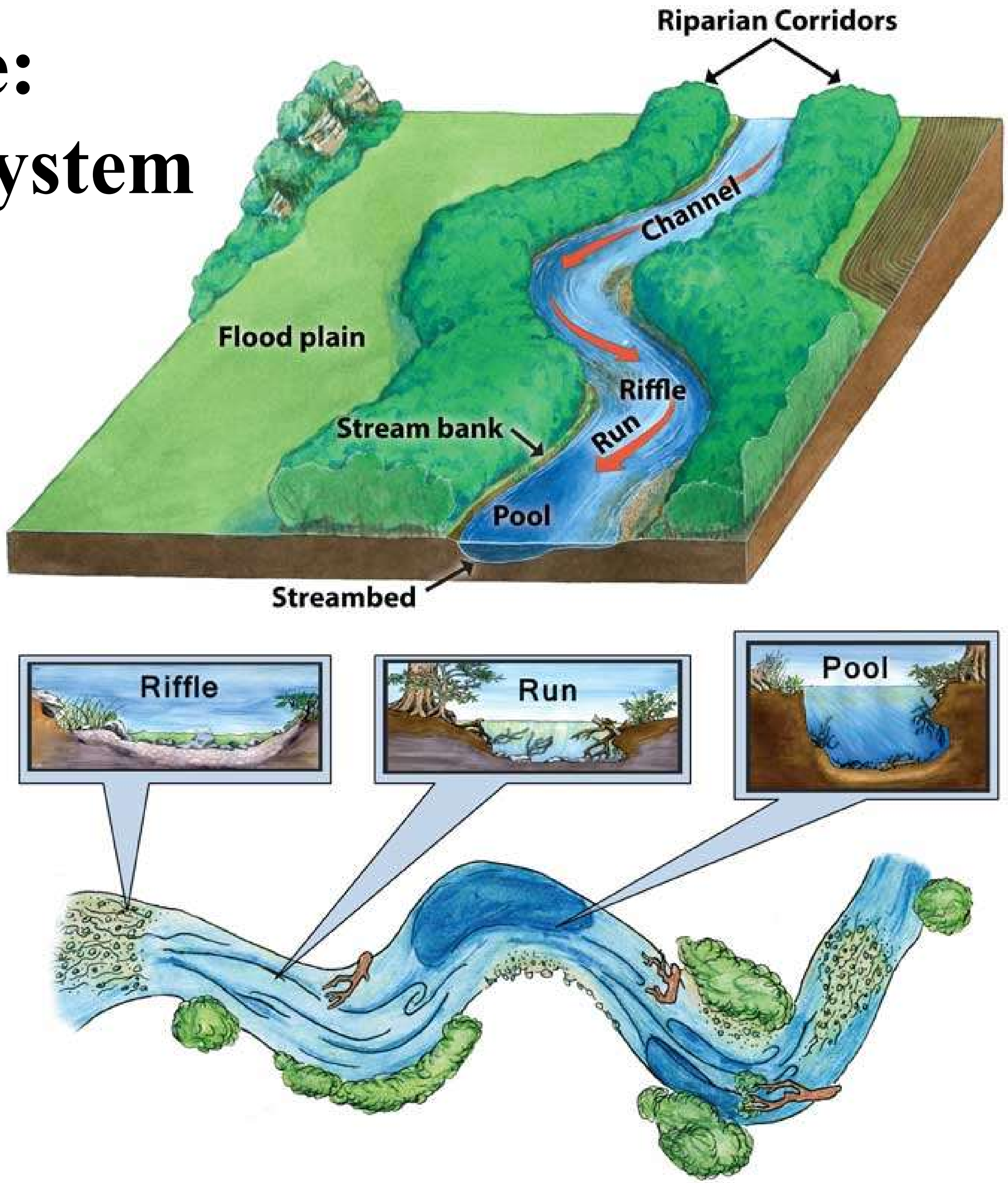


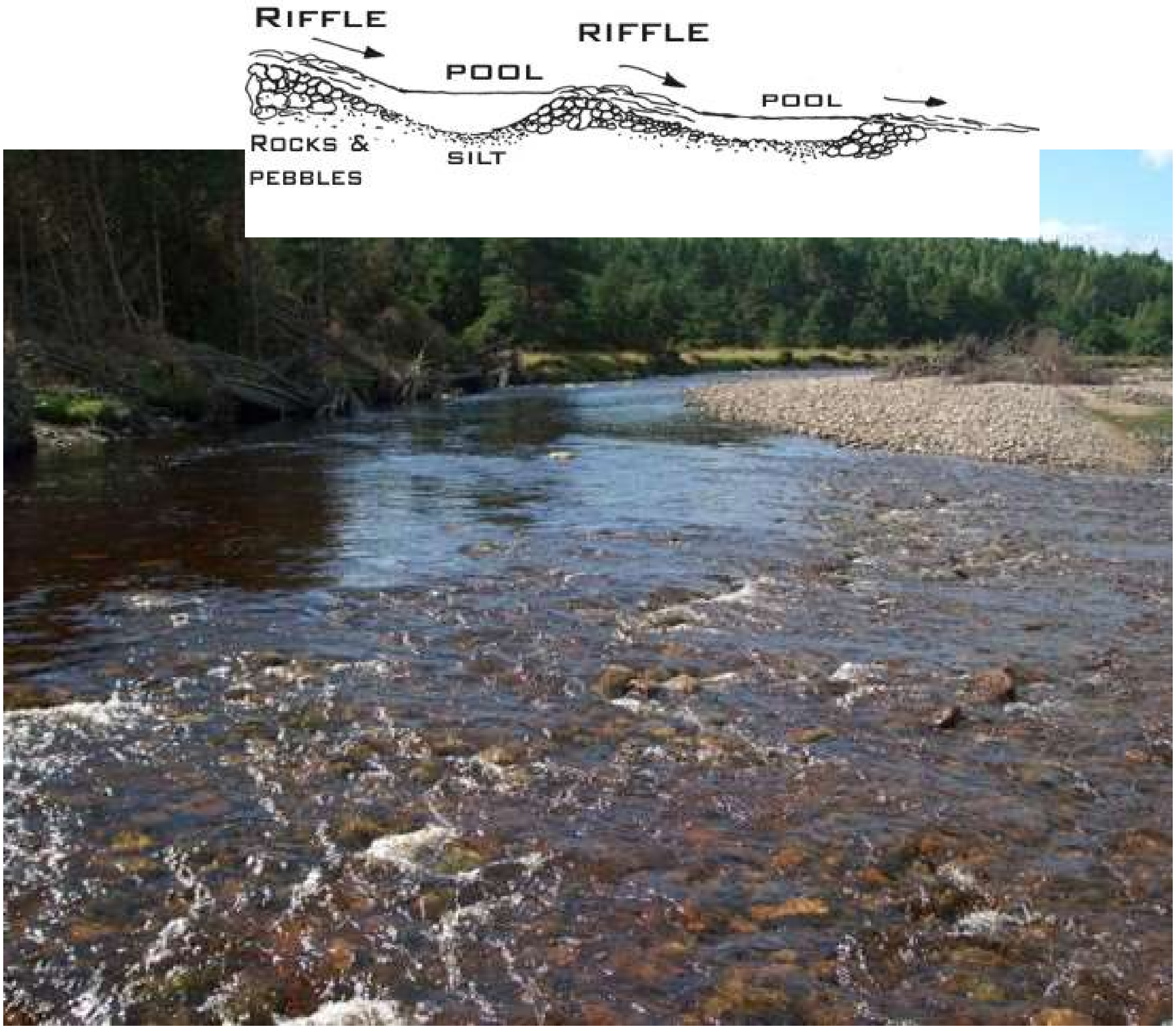
River Section

Great diversity of habitat in streams

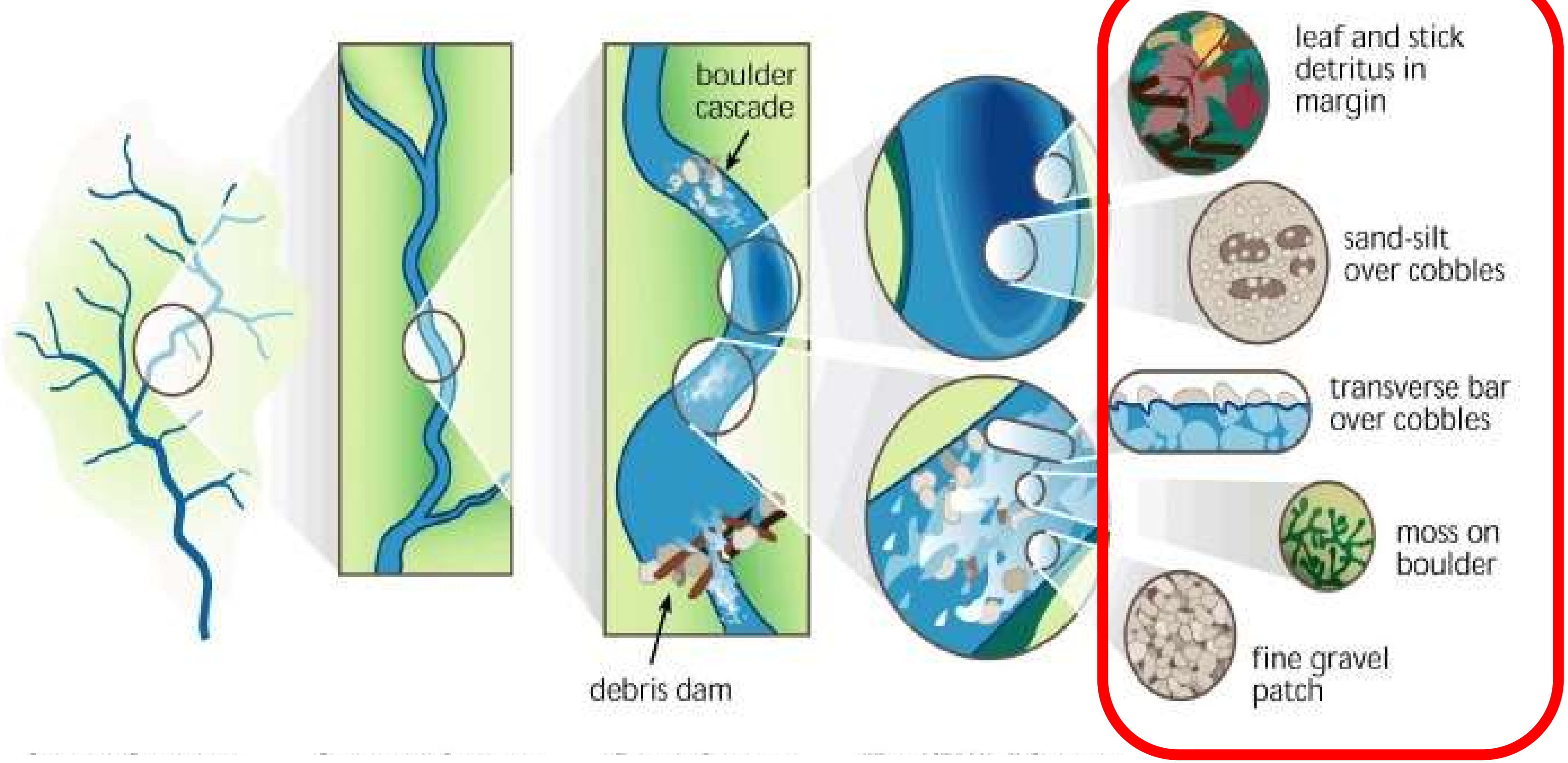


River Sequence: „Pool/Riffle“ System




RIFFLE
POOL
RIFFLE
POOL
ROCKS &
PEBBLES
SILT

Great diversity of habitat in streams



River basin	River segment	River section	River sequence	Small habitats
1 km 1.000-1 Mio. years	100 m 1.000-10.000 years	10 m 10-1.000 years	1 m 1-10 years	10 cm 1 month - 1 year

Spatial/temporal variability

Micro habitats

Oberer Seebach (See-Einrinn):

- a second-order stream underlain by a low-permeability layer of fine lake sediment and calcareous rock
- hydrological regime: nival or nivo-pluvial with low flows in winter, high flows during the spring freshet, and frequent storm events throughout summer and autumn
- catchment area: 20 km², rocky or densely wooded with *Picea abies*, *Fagus sylvatica* und *Larix decidua*
- riparian vegetation: common ash (*Fraxinus excelsior*), sycamore (*Acer pseudoplatanus*), common beech (*Fagus sylvatica*) and goat willow (*Salix caprea*)

Tab.1: Kennwerte des RITRODAT-LUNZ-Versuchsgeländes im Oberen Seebach. Daten sind langjährige Durchschnittswerte aus BRETSCHKO (1998). – Table 1: Identification values of the RITRODAT-LUNZ test area in Oberer Seebach. Data are long-term average values from BRETSCHKO (1998).

Einzugsgebiet	Kennwerte
Lufttemperatur:	
Jahresmittel	6.6 °C ± 0.4 °C
mittleres Minimum	–23.0 °C ± 5.0 °C
mittleres Maximum	32.8 °C ± 1.6 °C
Niederschlag:	
Jahresmittel	1515 mm ± 66 mm
mittlerer Tageshöchstwert	62 mm
Ritrodat-Lunz Versuchsareal	**Kennwerte**
mittleres Gefälle	0.41 cm/m ± 0.003 cm/m
mittlere Breite	14 m ± 1.6 m
Wassertemperaturen:	
absolutes Minimum	1.0 °C (Februar 1986)
absolutes Maximum	11.8 °C (August 1990)
Jahresamplitude	6.5 °C (1989) – 10.5°C (1986)
Oberflächenabfluss:	
Jahresmittel	0.82 m^3/s ± 0.20 m^3/s
mittleres Minimum	0.28 m^3/s ± 0.16 m^3/s
mittleres Maximum	15.13 m^3/s ± 12.12 m^3/s
Sedimentanalyse:	
1. Quartil: Q_{25}	10.6 mm ± 1.2 mm
2. Quartil: Median	23.1 mm ± 2.0 mm
3. Quartil: Q_{75}	47.6 mm ± 1.6 mm
Sortierungskoeffizient	2.31 ± 0.31
Anteil kleiner als 1.0 mm	6.44 % ± 2.47 %
Porenvolumen	24.0 % ± 2.2 %

Sediment grain size distribution

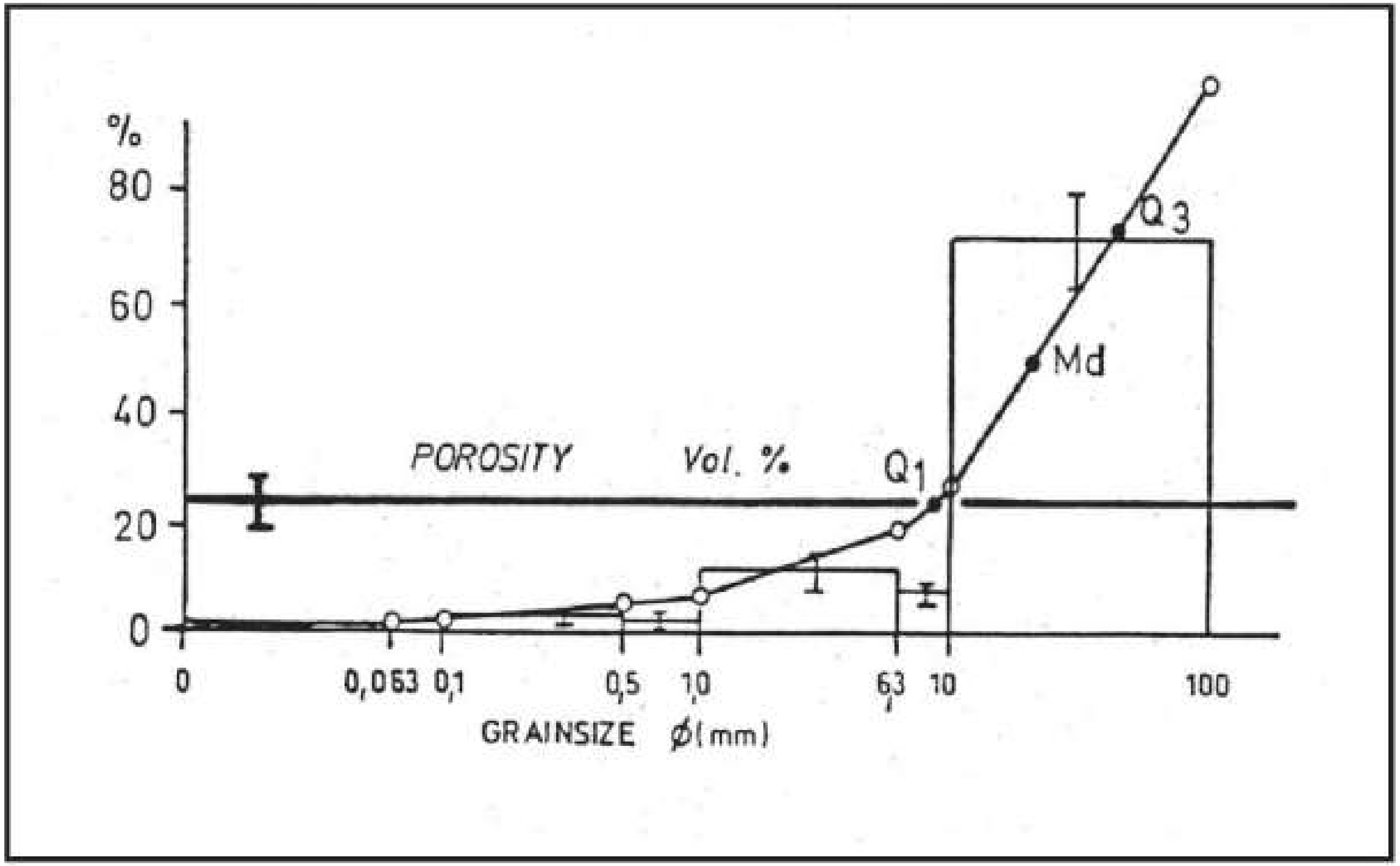


Abb. 7: Korngrößenanalyse im Oberen Seebach, RITRODAT-Areal, Jahresmittelwerte, n = 108 (LEICHTFRIED 1986). – Fig. 7: Grain size analysis at the stream Oberer Seebach, RITRODAT site, yearly means, n = 108 (LEICHTFRIED 1986).

Example from a temperate alpine, oligotrophic stream*, no of species :

Hydracarina	20
Insecta	286
Crustacea	37
Nematoda	46
Rotatoria	101
Annelida	22
Turbellaria	13
others	15
TOTAL	540

Collembola	42
Ephemeroptera	17
Plecoptera	47
Megaloptera	1
Coleoptera	7
Trichoptera	38
Diptera	133

Tipulidae	1
Limoniidae	8
Ceratopogonidae	2
Simuliidae	13
Chironomidae	103
others	6

Orthocladiinae	69
Tanypodinae	8
Diamesinae	8
Chironominae	16

31 genera
69 species

*Oberer Seebach, Austria
(Schmid-Araya & Schmid 1994)

Example from a temperate lowland stream*, no. of species:

Hydracarina	22
Insecta	642
Crustacea	24
Nematoda	125
Rotatoria	106
Annelida	56
Turbellaria	50
TOTAL	1044

Odonata	1
Ephemeroptera	16
Plecoptera	18
Megaloptera	2
Planipennia	2
Coleoptera	70
Trichoptera	57
Diptera	476

Tipulidae	30
Limoniidae	86
Ceratopogonidae	61
Simuliidae	10
Chironomidae	152
Dolichopodidae	50
Psychodidae	35
Empididae	21
others	31

Tanypodinae	15
Diamesinae	8
Orthocladiinae	88
Chironominae	41

*Breitenbach, Germany
(Zwick in Allan, 1995)

Lake outlet communities

(See-Ausrinn)

Abundance peak:
0 - 100 m from outlet

Why such high abundance?
Favourable food conditions

- high quality food
- high density
- high DOC - concentrations

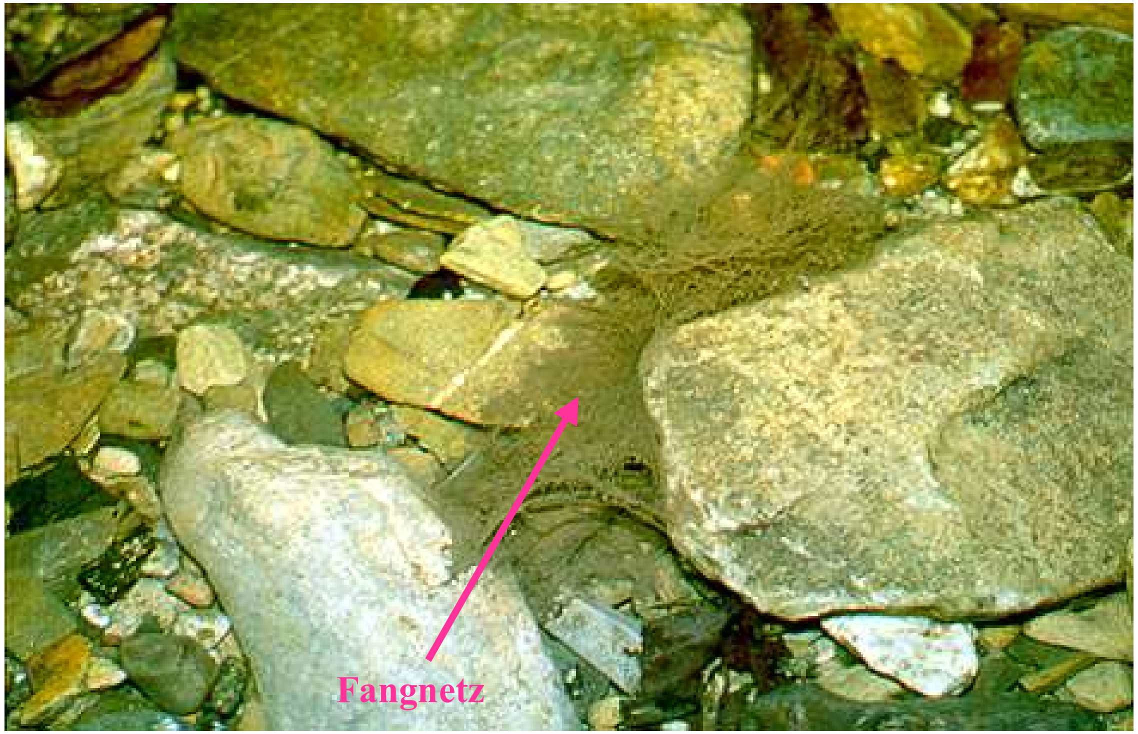
high temperature regime

Lake outlet communities

Main taxa:

Spongillidae

Simuliidae



Net-building
Trichoptera
(Hydropsychidae,
Polycentropodidae)

Bryozoa