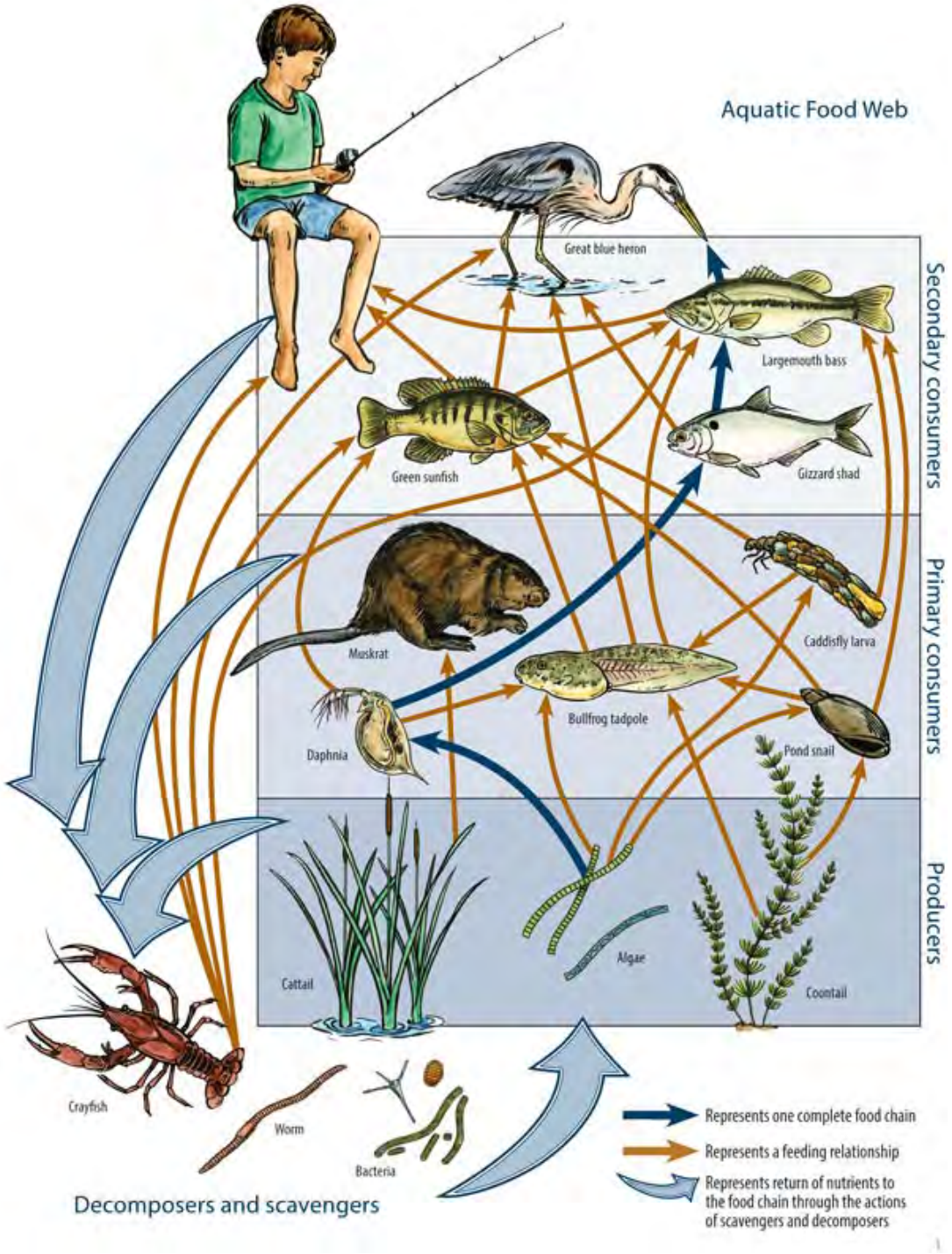
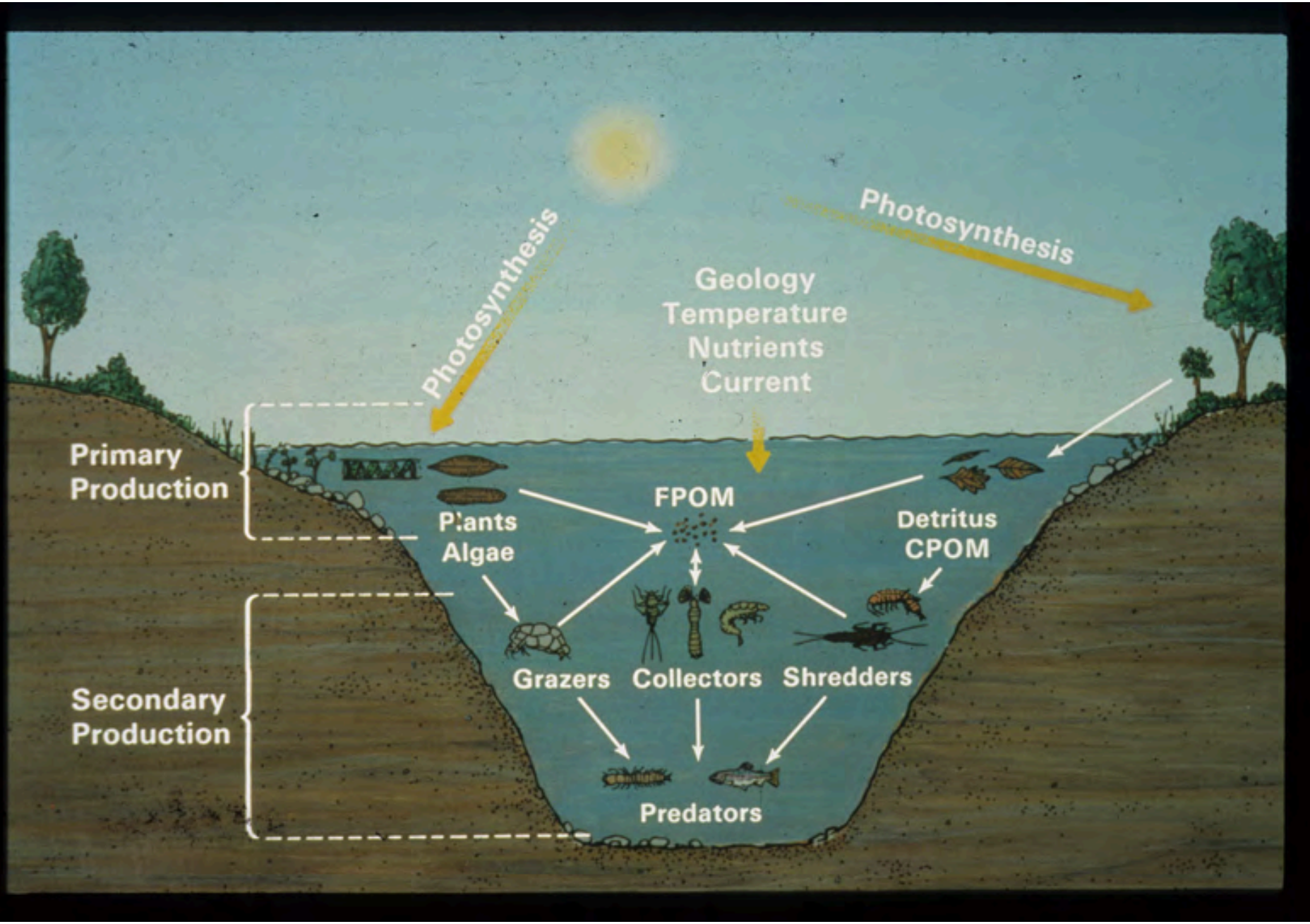
A [benthic] **macroinvertebrate** is the term used for invertebrate fauna that can be captured by a 500--µm net or sieve. This includes arthropods (insects, mites, scuds and crayfish), molluscs (snails, limpets, mussels and clams), annelids (segmented worms), nematodes (roundworms), and platyhelminthes (flatworms).

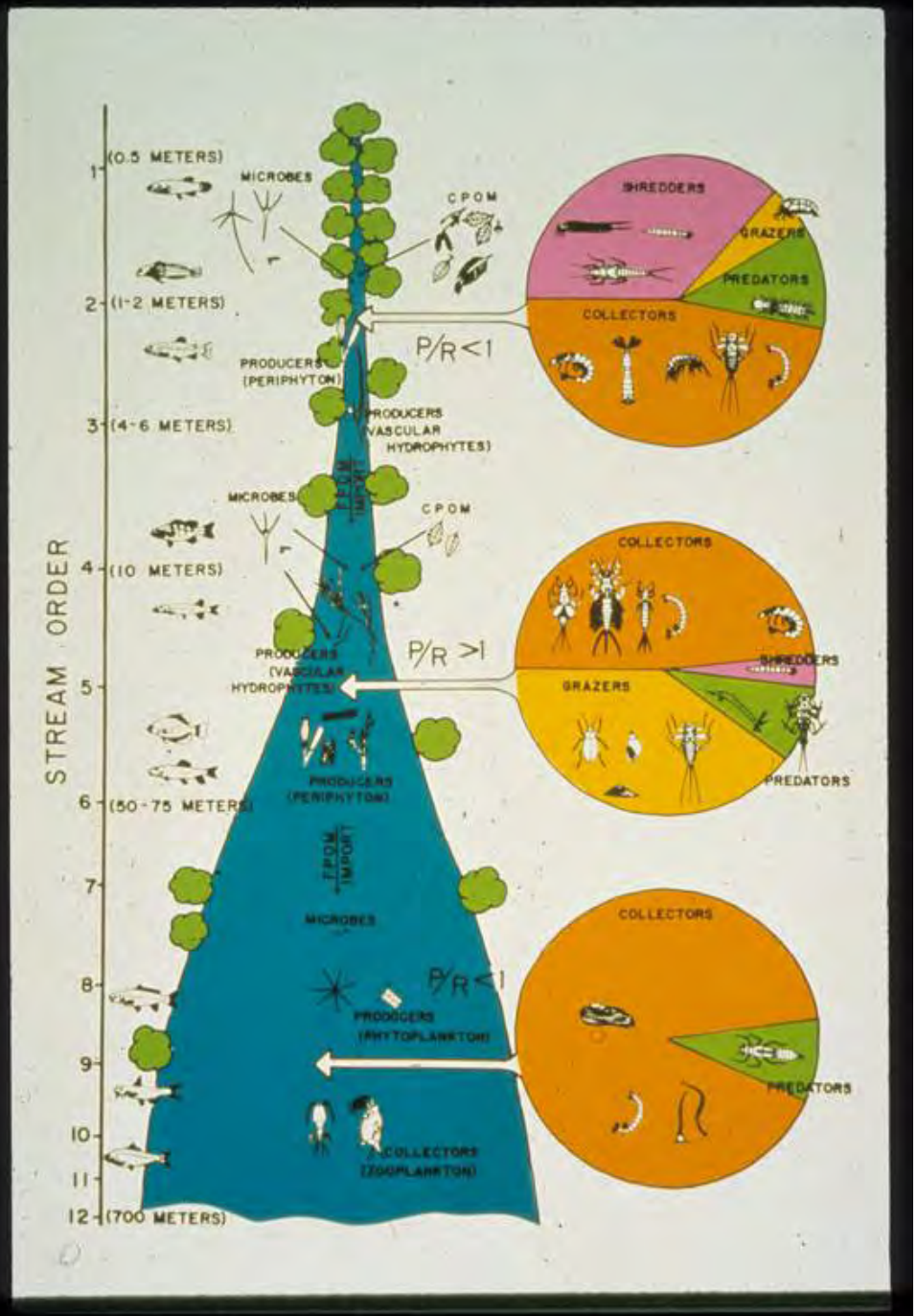
An Introduction to Aquatic Insects


Aquatic Food Web
Great blue heron
Largemouth bass
Green sunfish
Gizzard shad
Muskrat
Caddisfly larva
Bullfrog tadpole
Daphnia
Pond snail
Cattail
Algae
Coontail
Crayfish
Worm
Bacteria
Secondary consumers
Primary consumers
Producers
Decomposers and scavengers
Represents one complete food chain
Represents a feeding relationship
Represents return of nutrients to the food chain through the actions of scavengers and decomposers

Functional Feeding Groups and Feeding Modes of Aquatic Insects.

Functional Group	Feeding Mode
Scrapers	Shear off food material and associated organisms.
Collector-gatherers	Vacuum organic deposits from the stream bottom.
Collector-filterers	Filter suspended organic material from the water column.
Shredders	Skeletonize whole leaves and fragments.
Predators	Capture and ingest animals.
Piercer-herbivore	Pierce plant material.


Photosynthesis
Photosynthesis
Geology
Temperature
Nutrients
Current
Primary
Production
Plants
Algae
FPOM
Detritus
CPOM
Grazers
Collectors
Shredders
Secondary
Production
Predators


STREAM ORDER
1
(0.5 METERS)
2
(1-2 METERS)
3
(4-6 METERS)
4
(10 METERS)
5
6
(50-75 METERS)
7
8
9
10
11
12
(700 METERS)
MICROBES
CPOM
P/R<1
PRODUCERS (PERIPHYTON)
PRODUCERS VASCULAR HYDROPHYTES)
FPOM IMPORT
MICROBES
CPOM
P/R >1
PRODUCERS (VASCULAR HYDROPHYTES)
PRODUCERS (PERIPHYTON)
FPOM IMPORT
MICROBES
P/R<1
PRODUCERS (PHYTOPLANKTON)
COLLECTORS (ZOOPLANKTON)
SHREDDERS
GRAZERS
PREDATORS
COLLECTORS
COLLECTORS
SHREDDERS
GRAZERS
PREDATORS
COLLECTORS
PREDATORS

Aquatic Insect Orders

Ephemeroptera (Mayflies)

Odonata (Dragonflies and Damselflies)

Plecoptera (Stoneflies)

Hemiptera (True Bugs)

Megaloptera (Dobsonflies, Fishflies and Alderflies)

Trichoptera (Caddisflies)

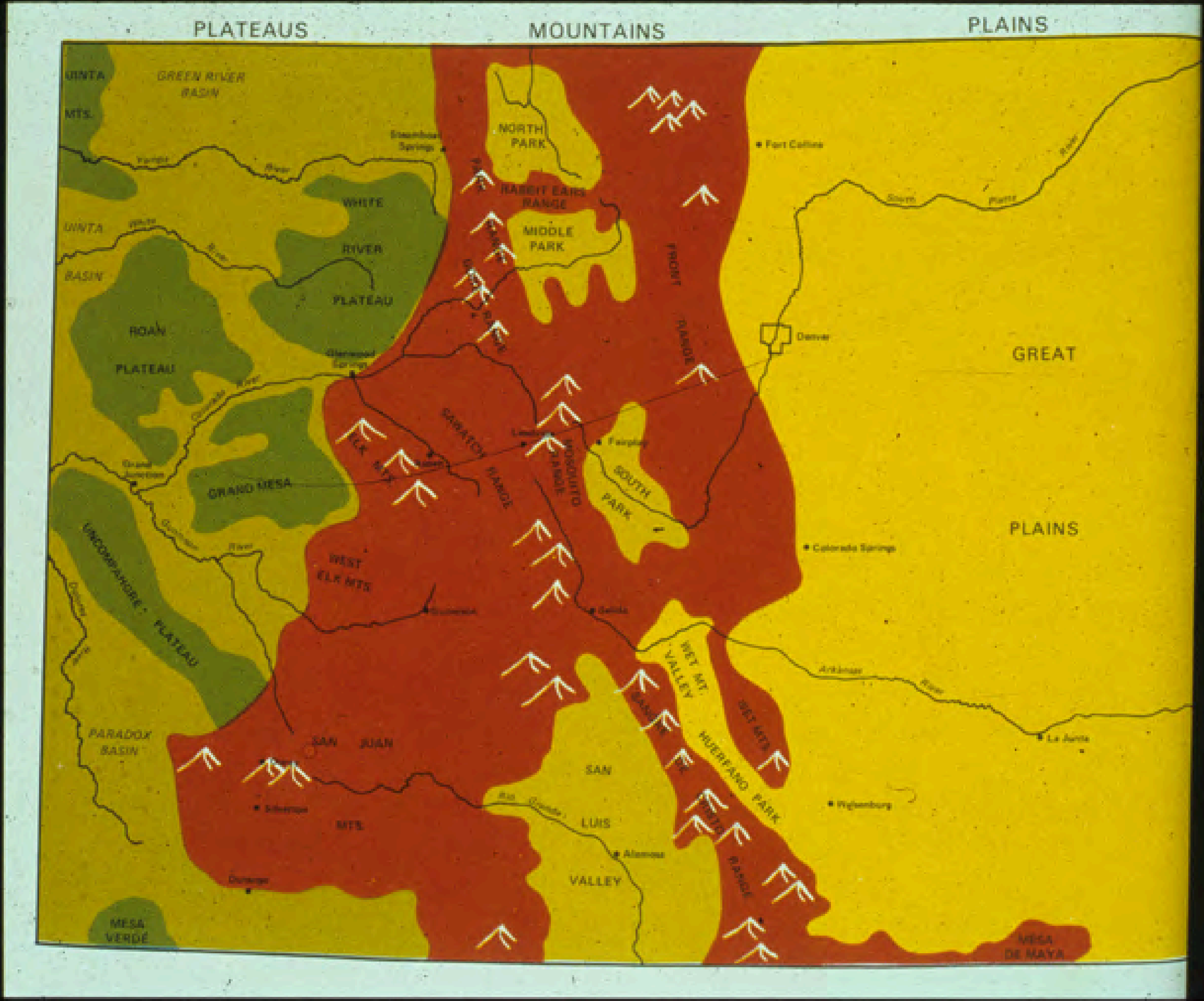
Coleoptera (Beetles)

Diptera (True Flies)

Lepidoptera (Moths and Butterflies)

Lentic or standing water habitats

Lotic or running water habitats


PLATEAUS
MOUNTAINS
PLAINS
UINTA MTS.
GREEN RIVER BASIN
NORTH PARK
RABBIT EARS RANGE
MIDDLE PARK
FRONT RANGE
WHITE RIVER PLATEAU
UINTA BASIN
ROAN PLATEAU
GRAND MESA
SAWATCH RANGE
MOSQUITO RANGE
SOUTH PARK
ELK MTS
WEST ELK MTS
UNCOMPAHGRE PLATEAU
PARADOX BASIN
SAN JUAN MTS.
SAN LUIS VALLEY
WET MT. VALLEY
WET MTS
HUERFANO PARK
MESA VERDE
MESA DE MAYA
GREAT PLAINS
Fort Collins
Denver
Colorado Springs
Fairplay
Salida
Alamosa
La Junta
Walsenburg
Durango
Silverton
Gunnison
Glenwood Springs
Steamboat Springs
Grand Junction
Leadville
Aspen
Colorado River
Gunnison River
Arkansas River
South Platte River
Rio Grande
Yampa River
White River

CLASSIFICATION OF THE HEXAPODA

Insecta

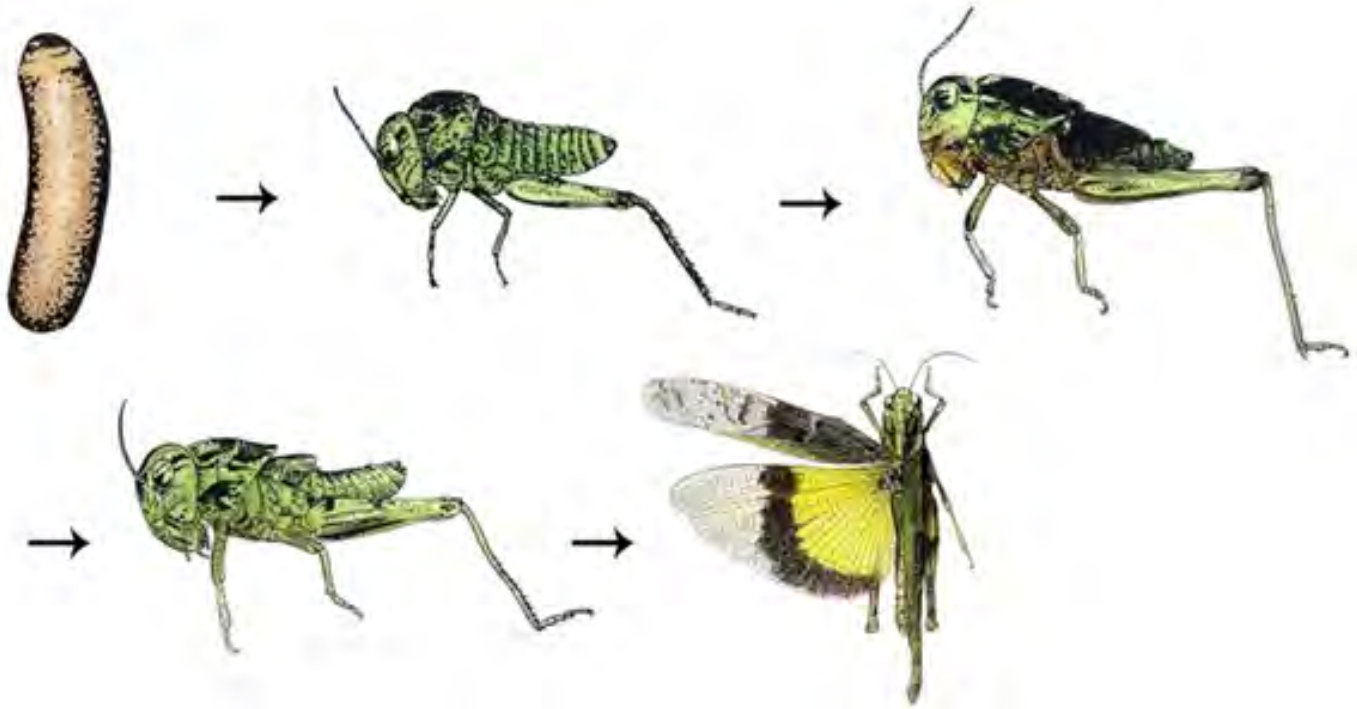
HEMIMETABOLOUS "NYMPHS"

Ephemeroptera – mayflies
Odonata – dragonflies and damselflies
Plecoptera – stoneflies
Hemiptera – bugs

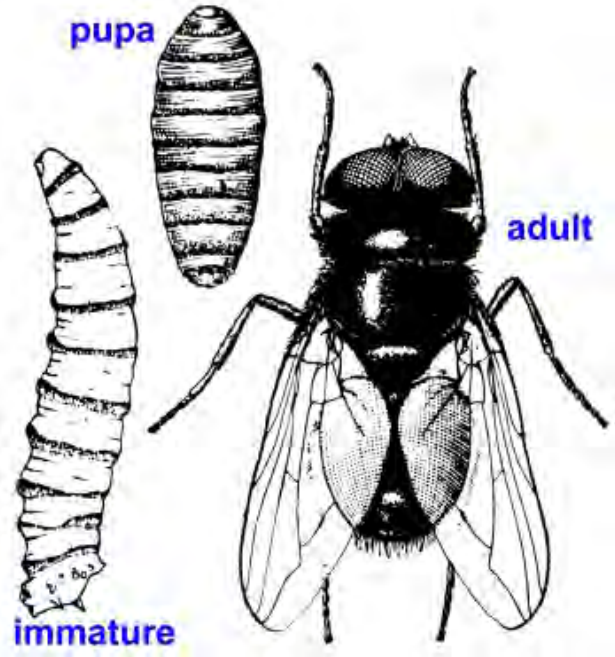
HOLOMETABOLOUS LARVAE

Coleoptera – beetles
Megaloptera – alderflies, dobsonflies, fishflies
Trichoptera – caddisflies
Lepidoptera – butterflies and moths
Diptera - flies

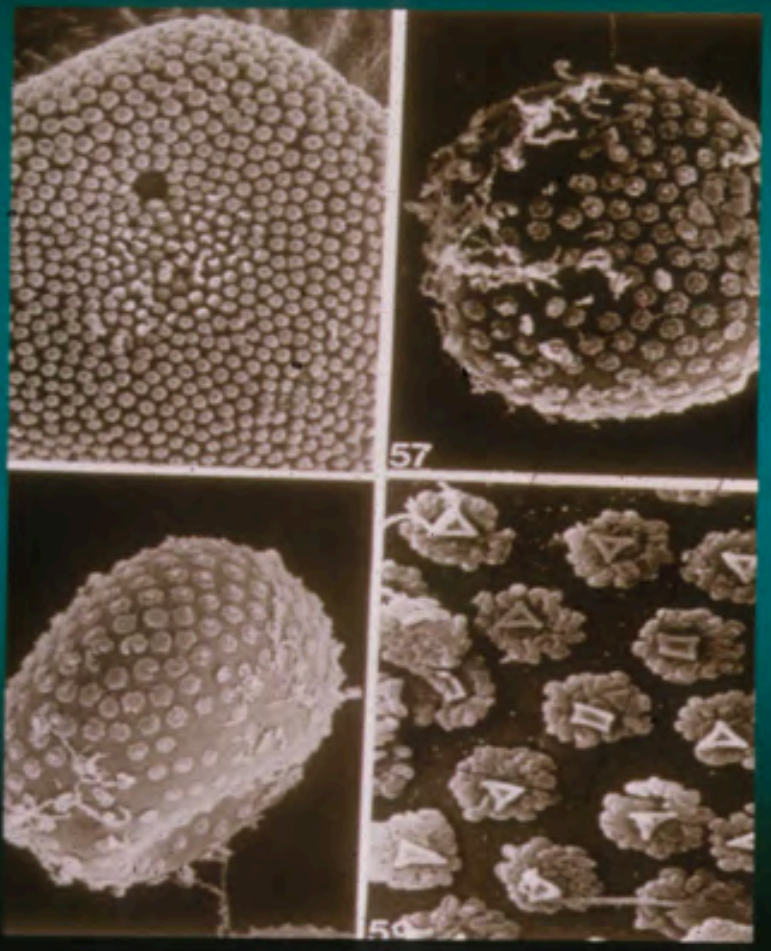
Hemimetabolous



Holometabolous

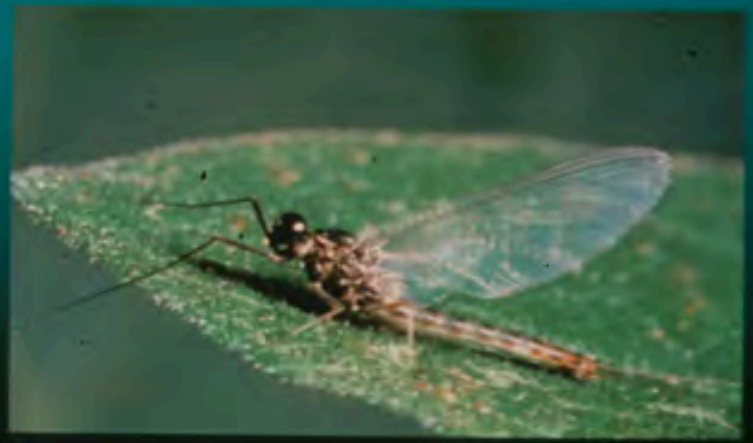


Ephemeroptera (Mayflies)



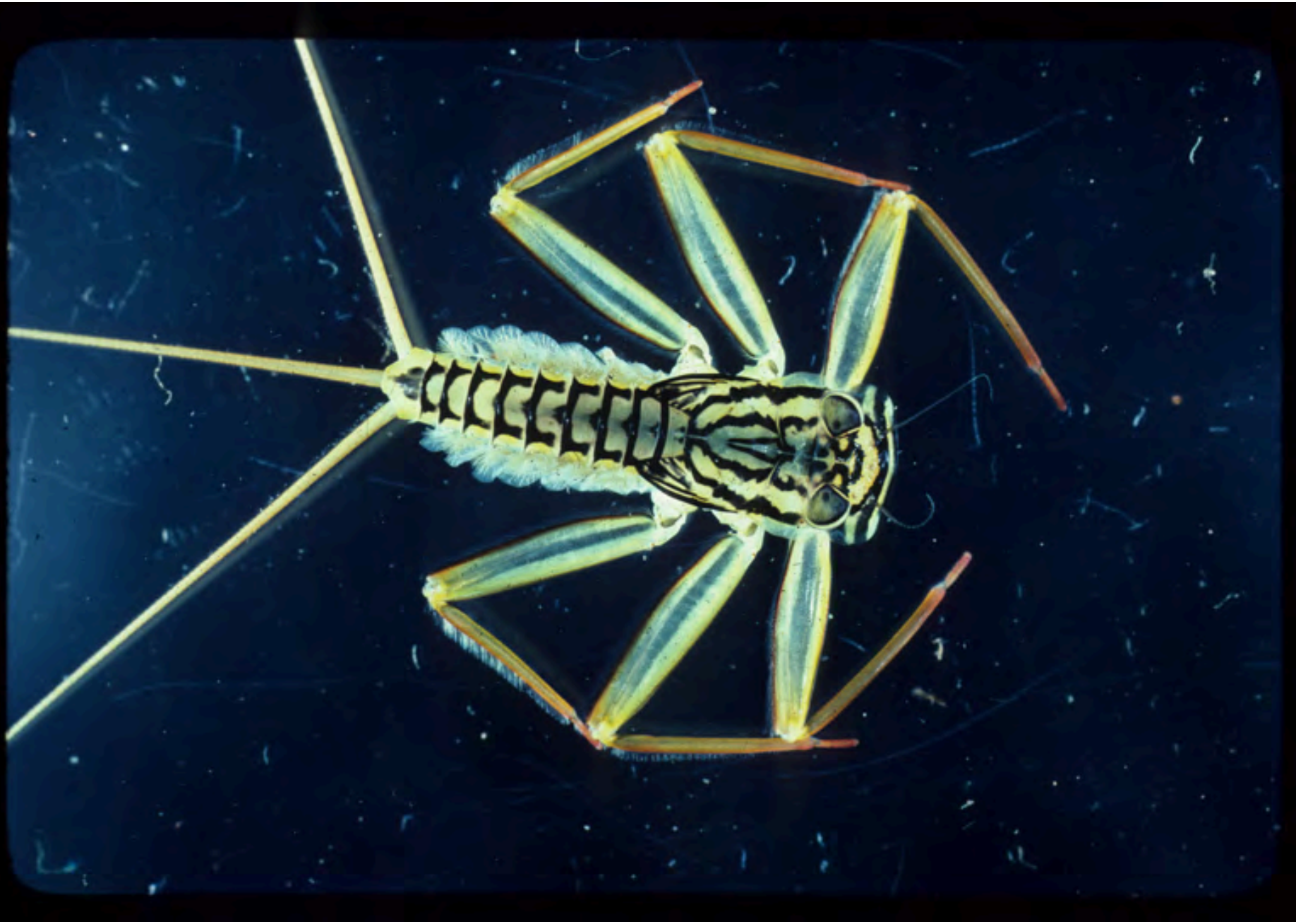
Ephemeroptera (Mayflies)

Adults have membranous wings that are held vertically at rest. Appear like small sailboats floating on the water. Two or three long tails with very short bristle-like antennae. Mouth parts are reduced. Males have extended front legs and enlarged eyes. Fly gracefully.



Ephemeroptera (Mayflies)

Nymphs have chewing mouth parts used for feeding on decayed plant material or algae. Two or three tails. One claw at the end of each leg. One set of obvious wing pads, usually two sets present. Plate-like, feather-like or tassel-like gills on 1 or more of 1-7 abdominal segments.



Ephemeroptera (Mayflies)

Life cycle: Incomplete. egg, nymph and adult.

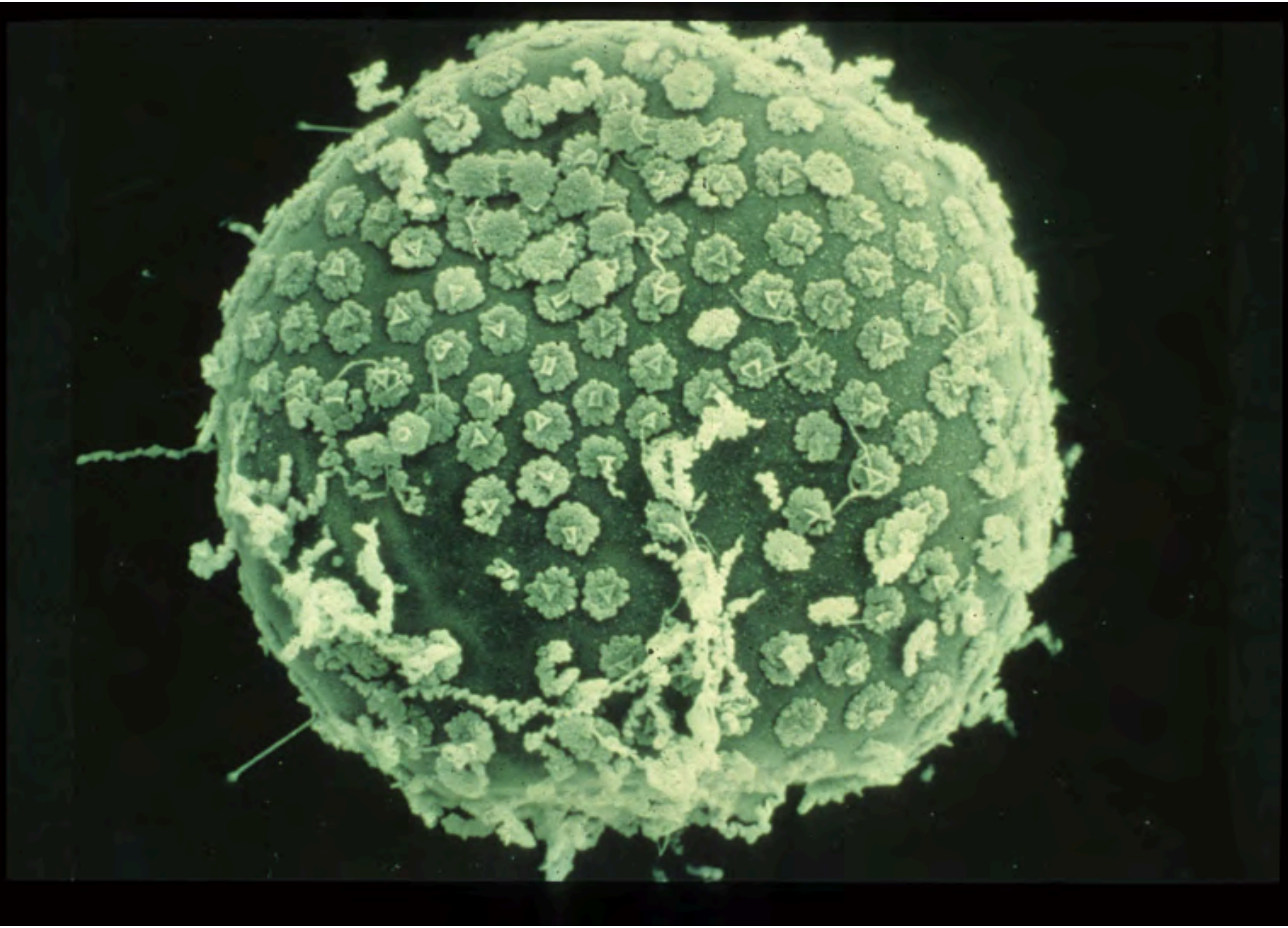
Life history: 1 generation / year, multiple generations / year, or several years / generation. Most common is 1 generation / year where nymphs hatch from eggs and live under water for approximately 1 year. Different species emerge from the water in different ways. After emergence the adult is called a subimago (dun). The subimago usually molts one more time and is then called an imago (spinner). Adult males form mating swarms and wait for females to fly near. Copulation occurs and females return to the water to lay eggs in different ways depending on species. Adults are short lived (hours to days).

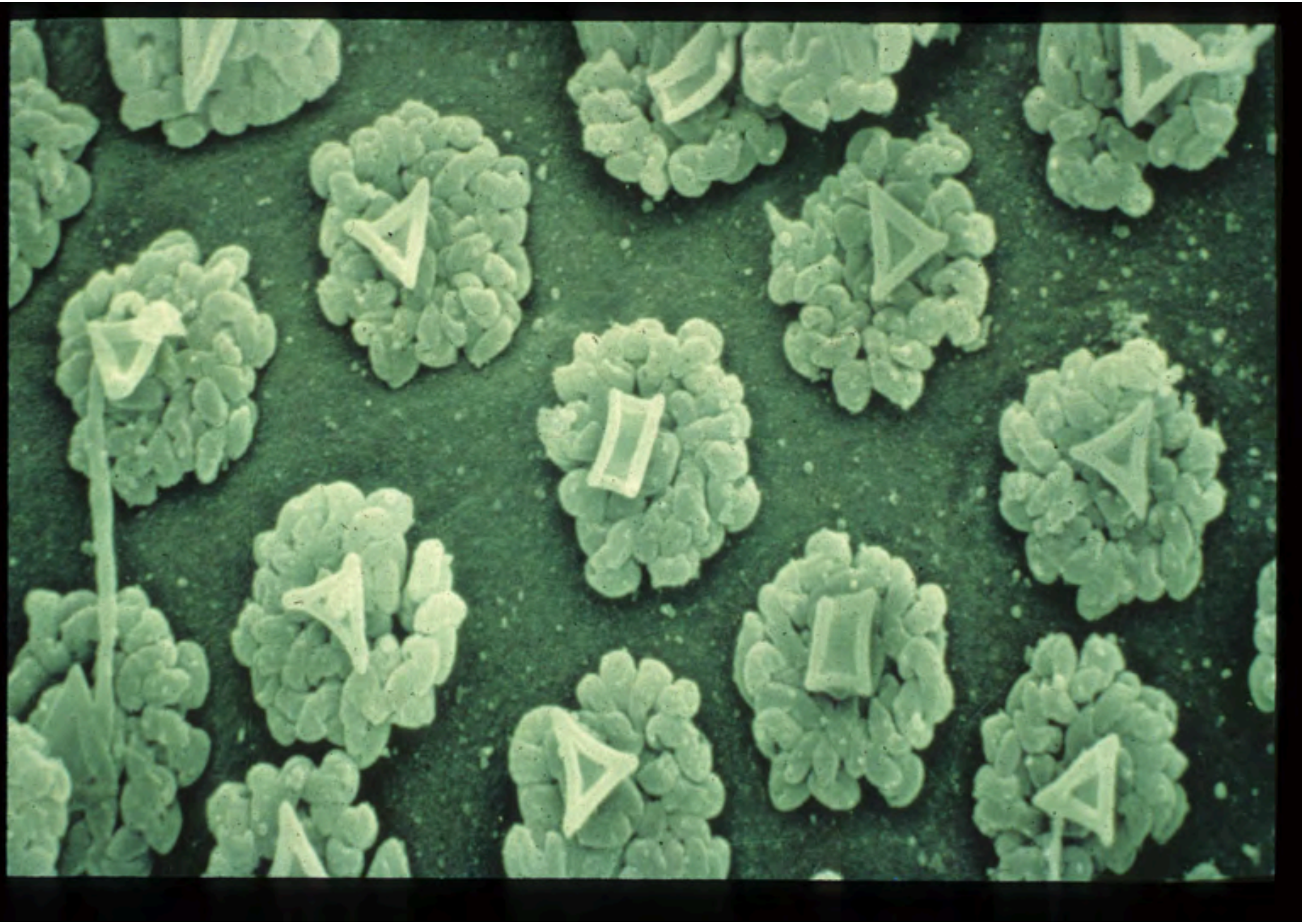
SPECIFIC COLORADO TAXA OF CONCERN

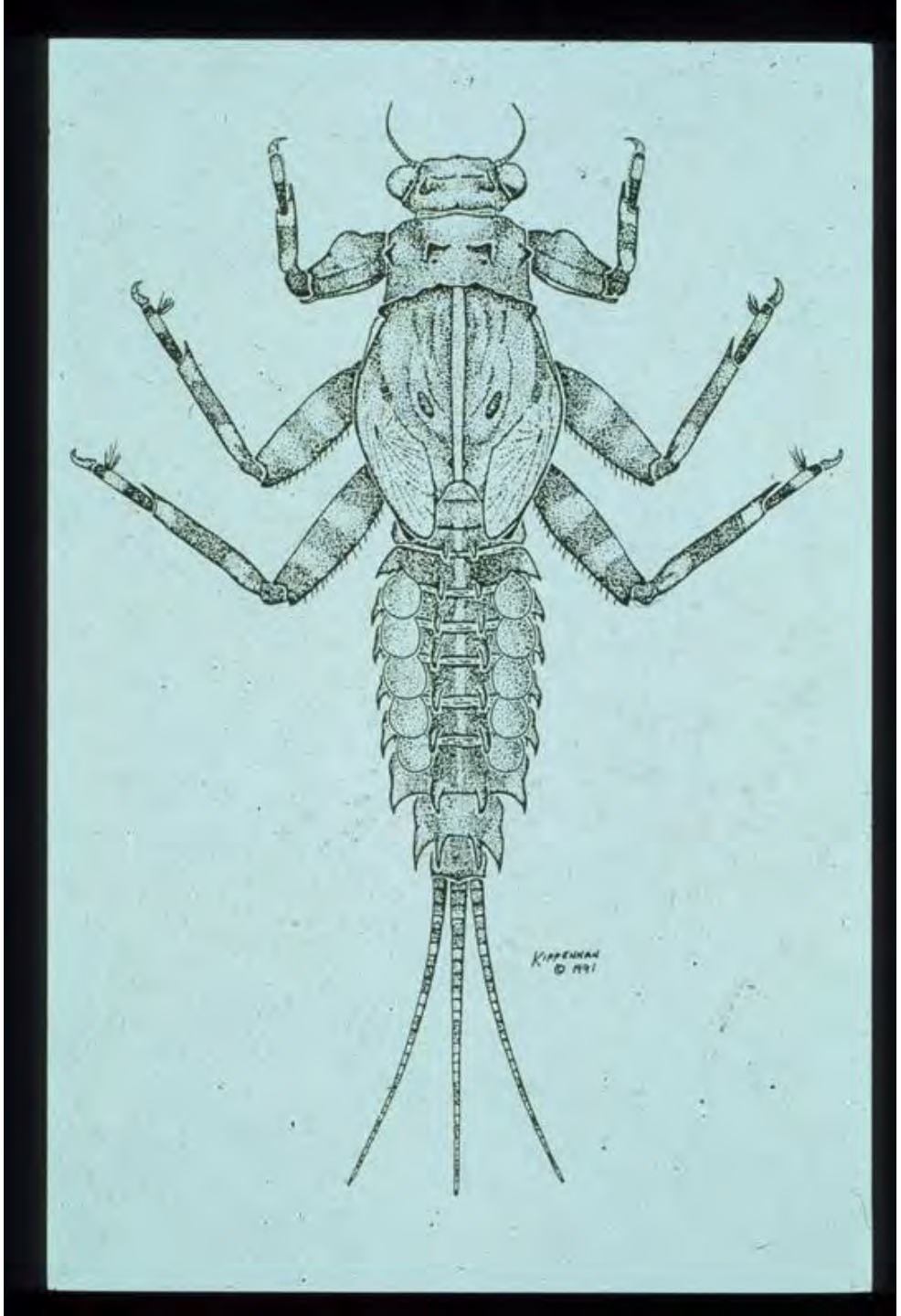
Mayflies

Apobaetis indeprenus	Green R.
Baetis armillatus	Chief Cr.
Barbaetis cestus	Roaring Fork, N Platte R.
Camelobaetidius warreni	White R., Chief Cr.
Camelobaetidius sp.	Yampa R.
Ametropus albrighti	Little Snake R., Yampa R.
Pseudiron centralis	Arkansas R., Green R.
Lachlania saskatchewanensis	Green R.,Yampa R., White R.
Macdunnoa persimplex	Poudre R. (historic?)
Rhithrogena flavianula	Gunnison R. (historic)
	Colorado R. (historic)
Ephemerella apopsis?	Chasm Lake, RMNP
Homoeoneuria alleni	Yampa R., Green R.

EXTINCT: Ephemera compar — "Foothills"






KIPPENHAN
© 1991

NYMPH

WET FLY

EMERGING
SUBIMAGO

WET FLY

UBIMAGO

DRY FLY
(DUN)

MAGO

DRY FLY
(SPINNER)

SPENT IMAGO

DRY FLY

	Size	**emergence**
Blue wing olive (*Baetis* & *Acentrella* spp.[3[)	18-22	April-October
Green Drake (*Drunella* spp. [3])	10-16	June-August
Pale Morning Duns (*Ephemerella dorothea infrequens*)	16-20	June-August
Brown Dun (*Epeorus longimanus*)	12-14	June-July

	Size	emergence
Blue Quills (*Paraleptophlebia* spp.)	16-18	June-July
Red Quills (*Rhithrogena* spp.)	14-16	June-Aug

Green Drake

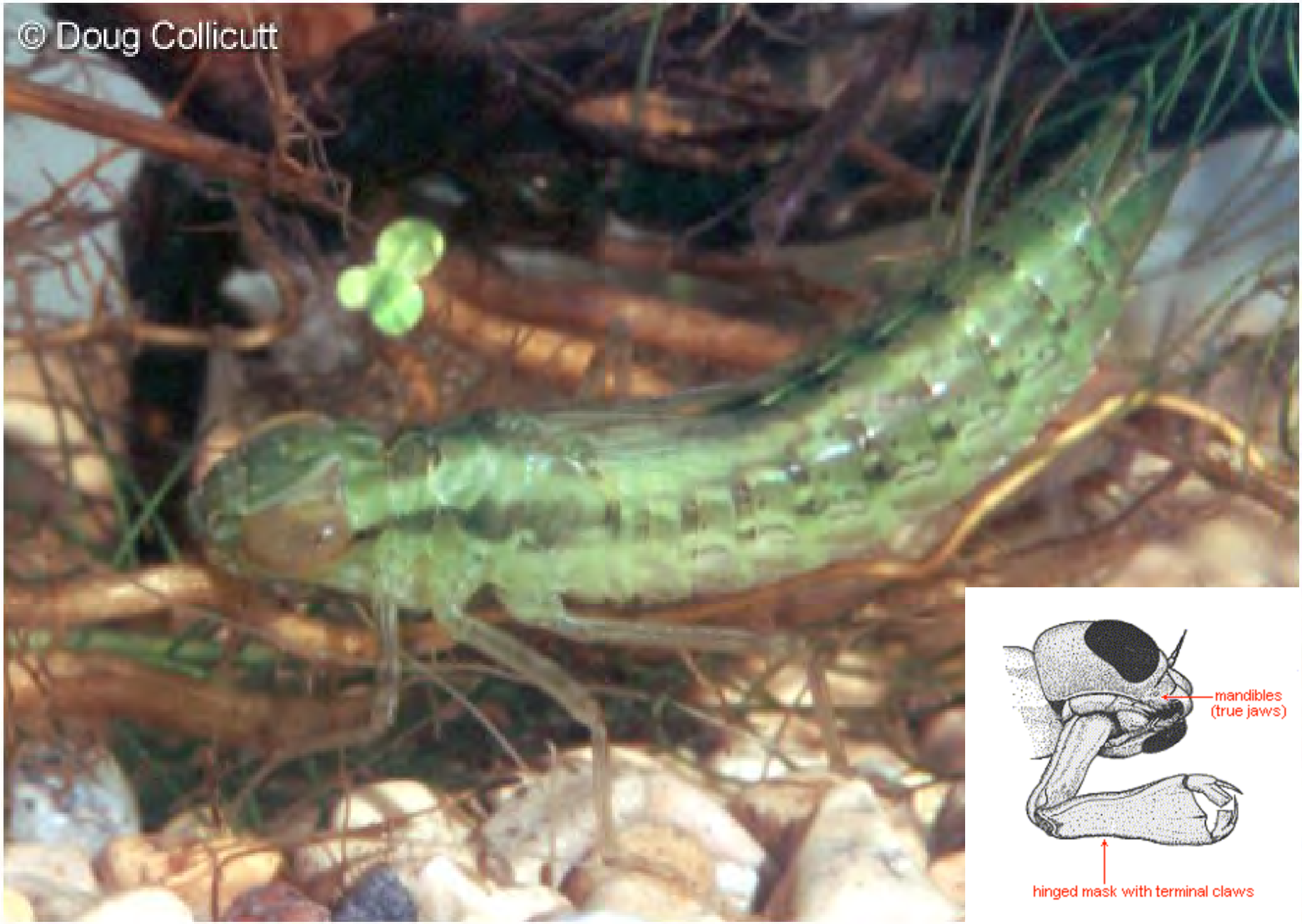
Brown Dun

Odonata (Dragonflies and Damselflies)

Adults have membranous wings with many veins. Wings out-stretched flat in dragonflies and held vertically in damselflies. Chewing mouth parts. Short antennae usually 3-7 segments. Both pairs of wings similar in shape.


© Cirrus Digital 2003
Green Darner Dragonfly ~ *Anax junius*


© 2004 Glenn Corbiere


© Doug Collicutt
mandibles
(true jaws)
hinged mask with terminal claws

Odonata (Dragonflies and Damselflies)

Life cycle: Incomplete. egg, nymph and adult.

Life history: 1 generation / year or several years / generation. Most common is 1 generation per year.

Nymphs crawl out of the water on plants or debris when they are ready to emerge. They then split their exuviae or shuck and crawl out. Adults are aerial predators and some species migrate long distances. Many females lay eggs by bouncing their abdomen on the water's surface or lay eggs directly in aquatic vegetation. Nymphs are voracious predators.

Habitat requirements for dragonflies and damselflies include: flow, permanency, size, depth, temperature of the water. The amount and type of vegetation present for protection, emergence and egg laying. The presence of fish predators, available food and bottom composition.

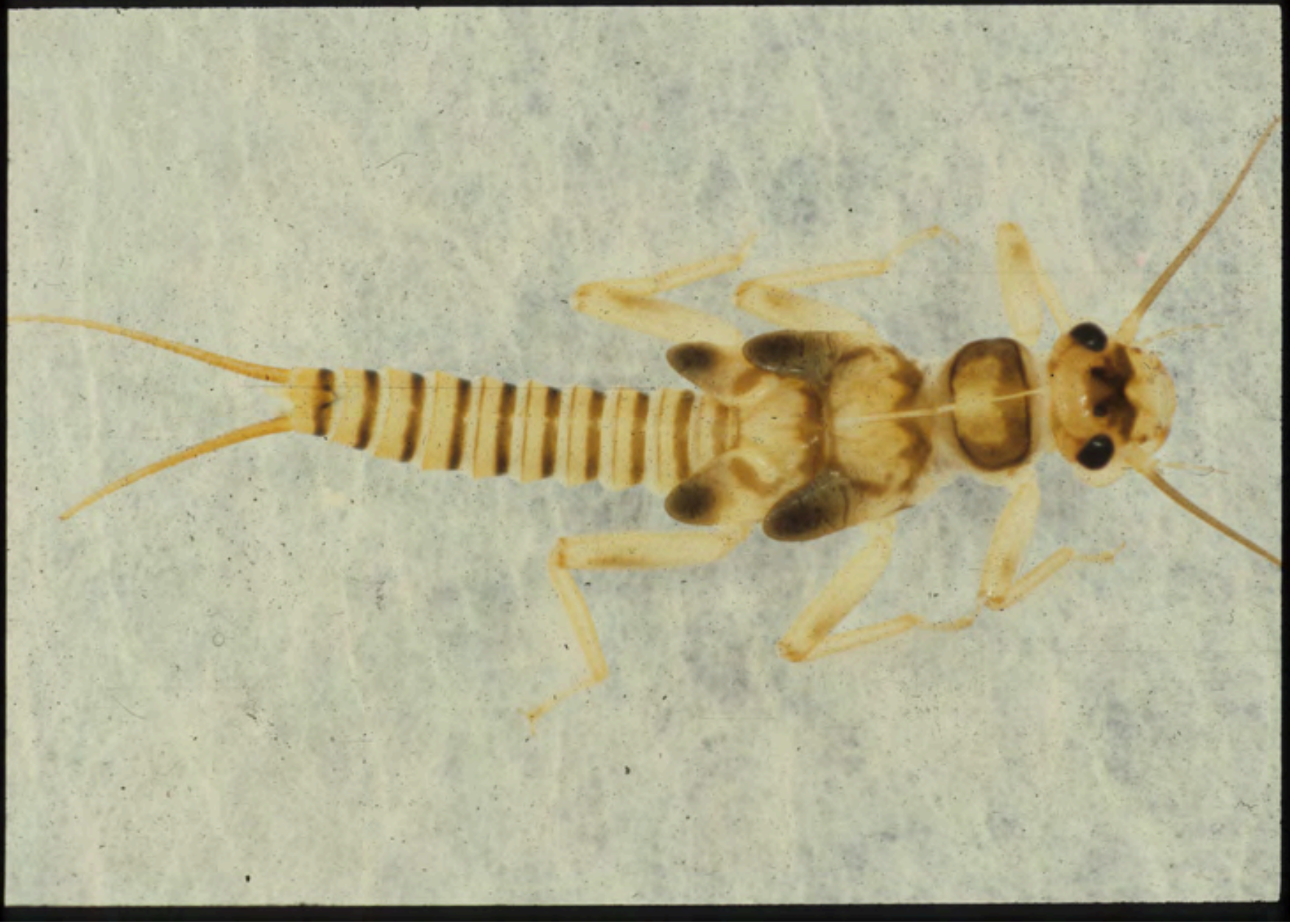
Odonata (Dragonflies and Damselflies)

Damselfly nymphs have chewing retractable mouth parts that are concealed at rest. Three plate-like gills on the end of the abdomen. Body shape is slender. Swim by moving body side to side.

Dragonfly nymphs also have chewing retractable mouth parts that are concealed at rest. No visible gill structures. Body shape more robust. Swim by propulsion expelling water from the anus.

PLECOPTERA (Stoneflies)

Capniidae (Slender Winter Stoneflies)
Chloroperlidae (Green Stoneflies)
Leuctridae (Rolledwinged Stoneflies)
Nemouridae (Nemourid Broadbacks)
Perlidae (Common Stoneflies)
Perlodidae (Perlodid Stoneflies)
Pteronarcyidae (Giant Stoneflies)
Taeniopterygidae (Taeniopterygid Broadbacks)



Plecoptera (Stoneflies)

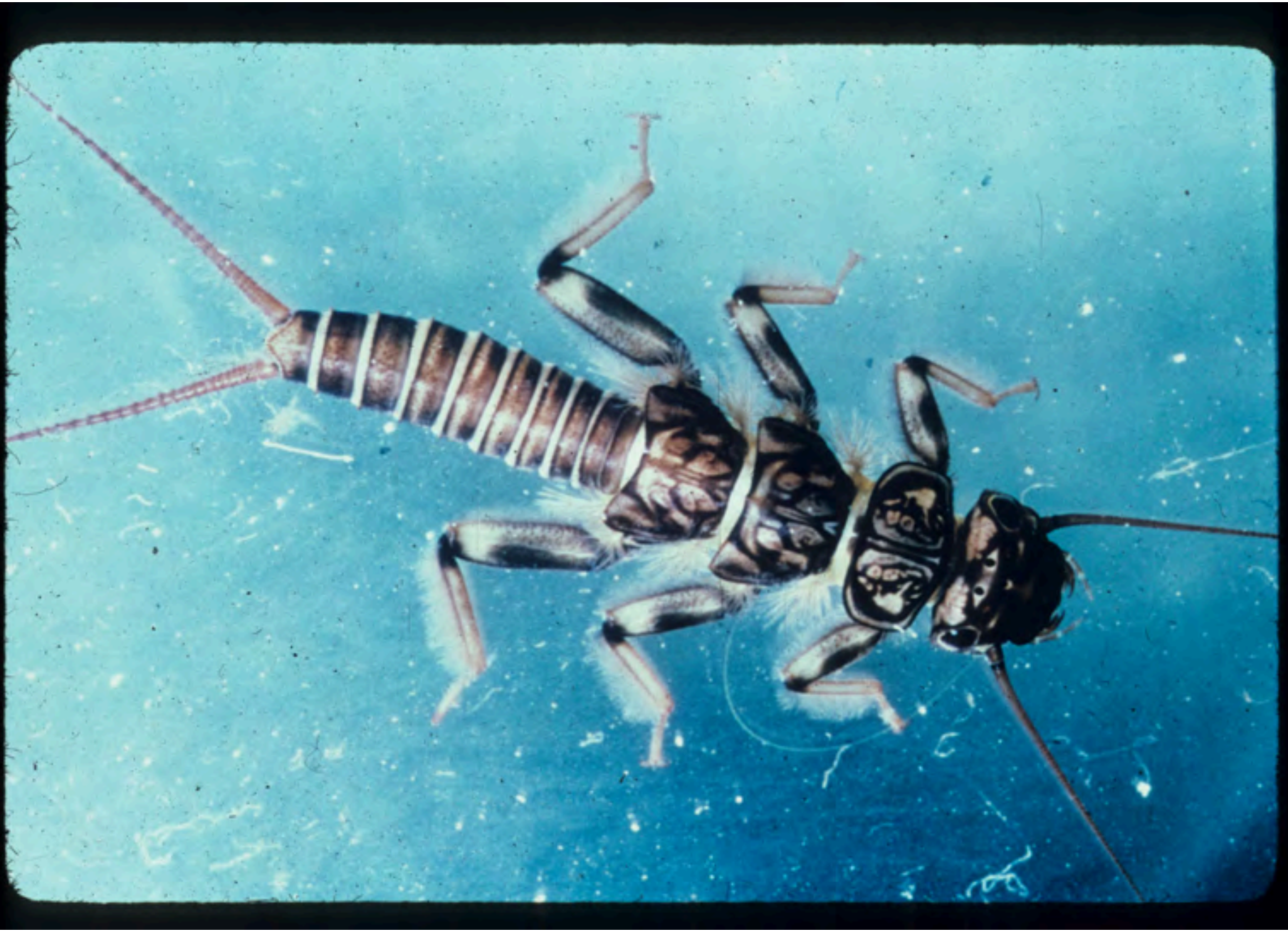
Adults have two sets of membranous wings that are held flat along the back. Hind wings have a large folded area. Adults also possess long antennae and may have two large tails at the end of the abdomen.

Nymphs have chewing mouth parts. Two claws at the end of each leg. Two tails and two obvious sets of wing pads.

Plecoptera (Stoneflies)

Life cycle: Incomplete. egg, nymph and adult.

Life history: 1 generation / year or several years / generation. Some groups live beneath the stream bed during nymphal development. Nymphs migrate to edges where they emerge from the water and crawl out of their shuck. Adults can be found along stream side vegetation. Most stoneflies are restricted to cold water streams. Some nymphs feed on other insects while most feed on plant material.



Salmonfly (*Pteronarcys californica*)	4-6	June
Golden stone (*Claassenia sabulosa*) *Hesperoperla pacifica*	8-10	June-Sept

Salmonfly

Golden stone

HEMIPTERA (Water Bugs)

Notonectidae (Backswimmers)
Corixidae (Water Boatman)

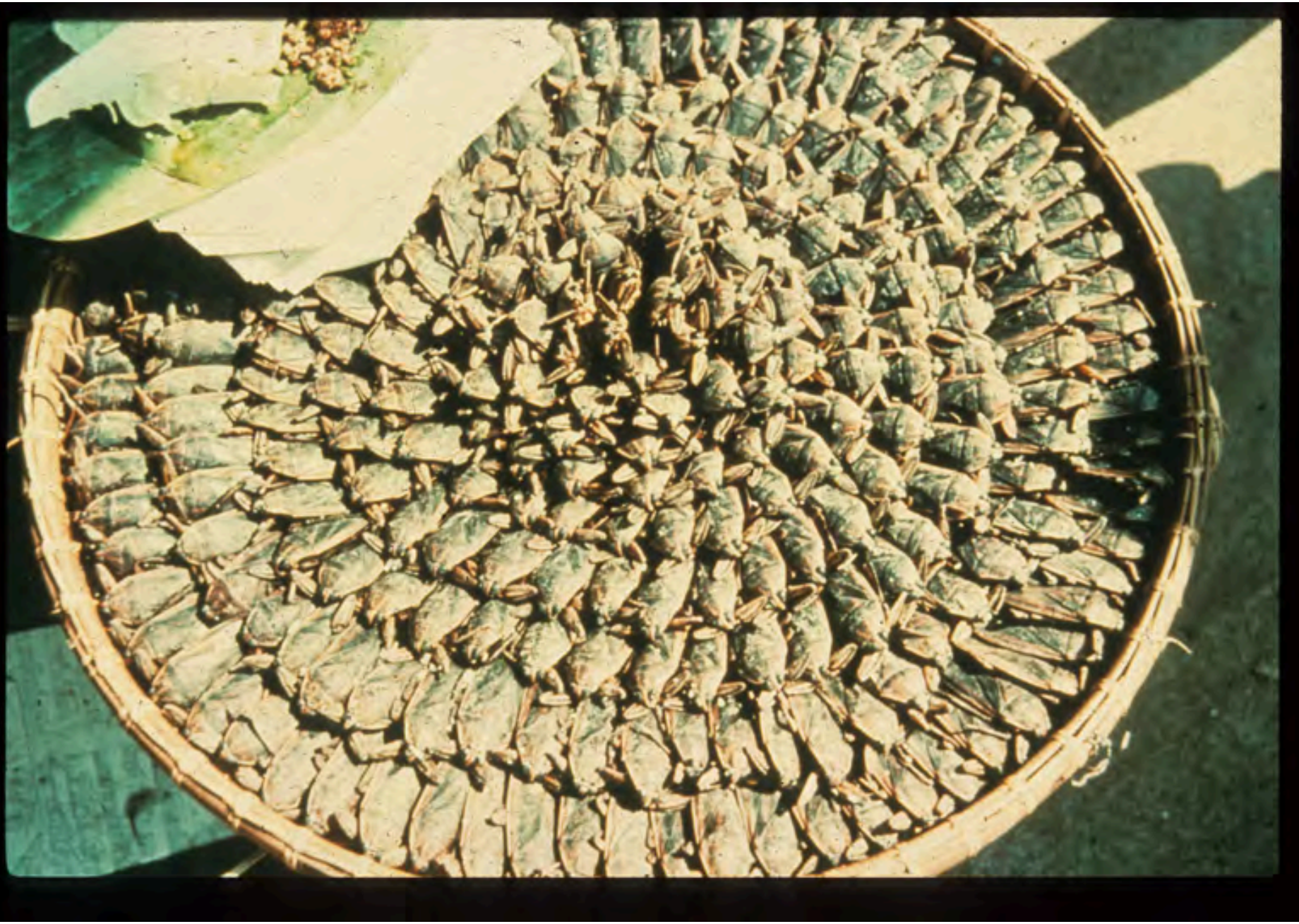
Hemiptera (True Bugs)

Life cycle: Incomplete. egg, nymph and adult.

Life history: Many over winter as adults and produce either 1 generation / year, multiple generations / year or several years / generation. All are predators except some water boatman which feed on plant material. Aquatic Hemiptera are adapted to a wide range of habitats. Some forms exist in hot springs, large rivers, saline marshes and even the ocean.

Hemiptera (True Bugs)

Nymphs closely resemble adults. Adult have wings that are half membranous and half leathery. Mouth parts are jointed and specialized for piercing and sucking. Some use digestive juices to liquefy the internal parts of prey.



Trichoptera (Caddisflies)

TRICHOPTERA (Caddisflies)

Brachycentridae (Humpless Case Makers)
Glossosomatidae (Saddlecase Makers)
Hydropsychidae (Common Netspinners)
Hydroptilidae (Micro Caddisflies)
Lepidostomatidae (Lepidostomatid Case Makers)
Leptoceridae (Longhorned Case Makers)
Limnephilidae (Northern Caddisflies)
Philopotamidae (Fingernet Caddisflies)
Rhyacophilidae (Freeliving Caddisflies)

Trichoptera (Caddisflies)

Free Living

Case Making

Shelter Making

Net Spinning

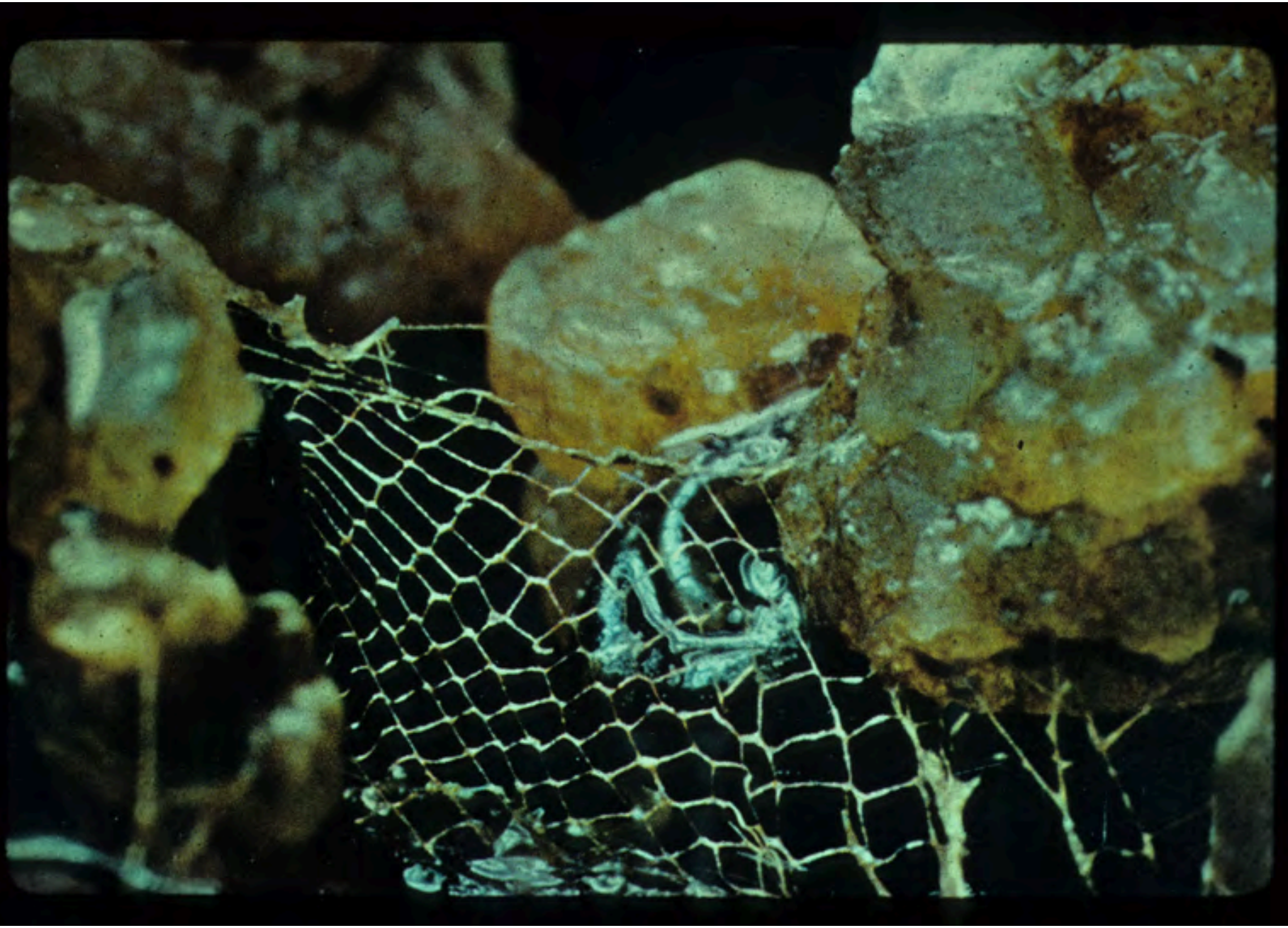
Trichoptera (Caddisflies)

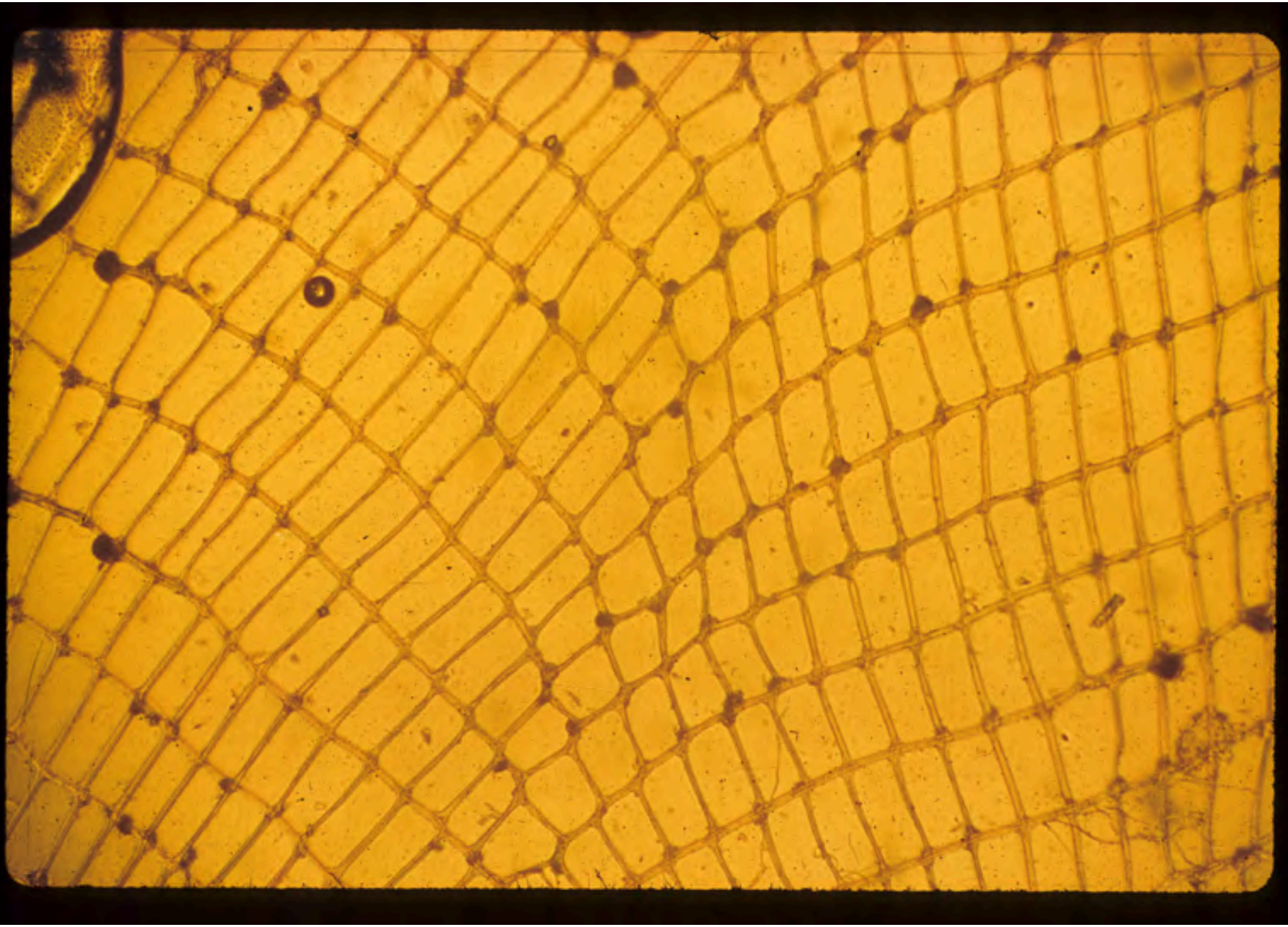
Life cycle: Complete. egg, larvae, pupae and adult.

Life history: 1 generation / year, multiple generations / year or several years / generation. Most common is one generation / year. Larvae pupate in cases attached to bottom substrate in quiet areas of streams and ponds. A few species pupate terrestrially. Some caddis flies ride gas bubbles to the surface during emergence. Females lay eggs by bouncing their abdomen on the water's surface or by entering the water and laying eggs directly on bottom substrate.

The ability to secrete silk has lead to a variety of portable and fixed shelters and food capturing devices. Caddisflies can be separated into four groups of silk utilization: free living, case making, shelter making and net spinning.


Anal prolegs





	size	emergences
Grannon caddis (*Brachycentrus occidentalis*)	14-16	May-Sept
Green Sedge (*Rhyacophila brunnea*)	14-16	April-May

Megaloptera (Dobsonflies, Fishflies and Alderflies)

Larvae have 3 pairs of legs on thorax and 7 or 8 pairs of lateral filaments on abdomen. Anal segment has a pair of pro-legs with 2 claws each or with a single anal filament.

Adults have membranous wings that are similar in shape and size. Wings held back and flat or in a tent like manner. Long antennae. No tails at the end of abdomen. Strong chewing mouth parts. Males have elongated mandibles.

Megaloptera (Dobsonflies, Fishflies and Alderflies)

Life cycle: Complete. egg, larvae, pupae and adult.

Life history: 1 generation / year or several years / generation. Pupation occurs on land. Females need suitable upstream sites to lay egg masses (bridge abutments or overhanging vegetation). Larvae hatch and fall into water. Common in eastern woodland streams and rivers. Local population occur in parts of Colorado. Larvae are voracious predators that feed opportunistically in riffles. Larvae of some species are known as hellgrammites.

COLEOPTERA (Beetles)

Dytiscidae (Predaceous Diving Beetles)
Hydrophilidae (Water Scavenger Beetles)
Elmidae (Riffle Beetles)

Coleoptera (Beetles)

Larvae have three pairs of jointed legs on the thorax. End of abdomen usually without anal prolegs or anal filaments.

Adults front wings without veins and very hard, covering hind wings. Chewing mouth parts.

Coleoptera (Beetles)

Life cycle: Complete. egg, larvae, pupae and adult.

Life history: 1 generation / year or several years / generation. Most common is one generation / year. Adults of most species leave the water temporally for dispersal flights. Associated with shallow ponds, wetlands, marshes, stream margins, slow flowing streams and aquatic vegetation. Typically adults are predators or scavengers. Larvae are predators of anything they can overpower. Some aquatic beetles carry their own air bubbles under water for breathing.

One out of every five different living things is a beetle.

DIPTERA (True Flies)

Tipulidae (Crane Flies)
Blephariceridae (Netwinged Midges)
Chironomidae (Midges)
Simuliidae (Black Flies)

Diptera (True Flies)

Larvae are often legless and maggot like. Adults possess one pair of membranous wings. Hind wings are reduced to small knobbed structures. Mouth parts are often used for sucking.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58-17


100.0 um

Stonefly Nymph

Caddisfly Larva

Mayfly Nymph

Aquatic Insect Orders

Ephemeroptera (Mayflies)

Odonata (Dragonflies and Damselflies)

Plecoptera (Stoneflies)

Hemiptera (True Bugs)

Megaloptera (Dobsonflies, Fishflies and Alderflies)

Trichoptera (Caddisflies)

Coleoptera (Beetles)

Diptera (True Flies)

Lepidoptera (Moths and Butterflies)

Bacteria	Fecal contamination Thermal pollution Toxic compounds Organic enrichment	Laboratory	Bacteria techniques	1
Algae	Nutrients Thermal pollution Sedimentation Toxic compounds	Microscopes Collecting gear Sample prep Counting slides	Taxonomy Field collection Lab prep	5
Macrophytes	Nutrients Thermal pollution Sedimentation Toxic compounds	Collecting gear Plant press Stero scope	Taxonomy Field collection Specimen mounts	2
Zooplankton	Nutrients Thermal pollution Sedimentation Toxic compounds	Microscopes Collecting gear Sample prep	Taxonomy Field collection Lab prep	4
Macroinvertebrates	Nutrients Thermal pollution Sedimentation Toxic compounds Organic enrichment	Stereo scope Collecting gear	Taxonomy Field collection Sample prep	3

POLLUTION PROBLEMS

- Eutrophication and organic enrichment
- Temperature alterations
- Heavy metals
- Oil and Related products
- Pesticides
- Acidification

Water Quality

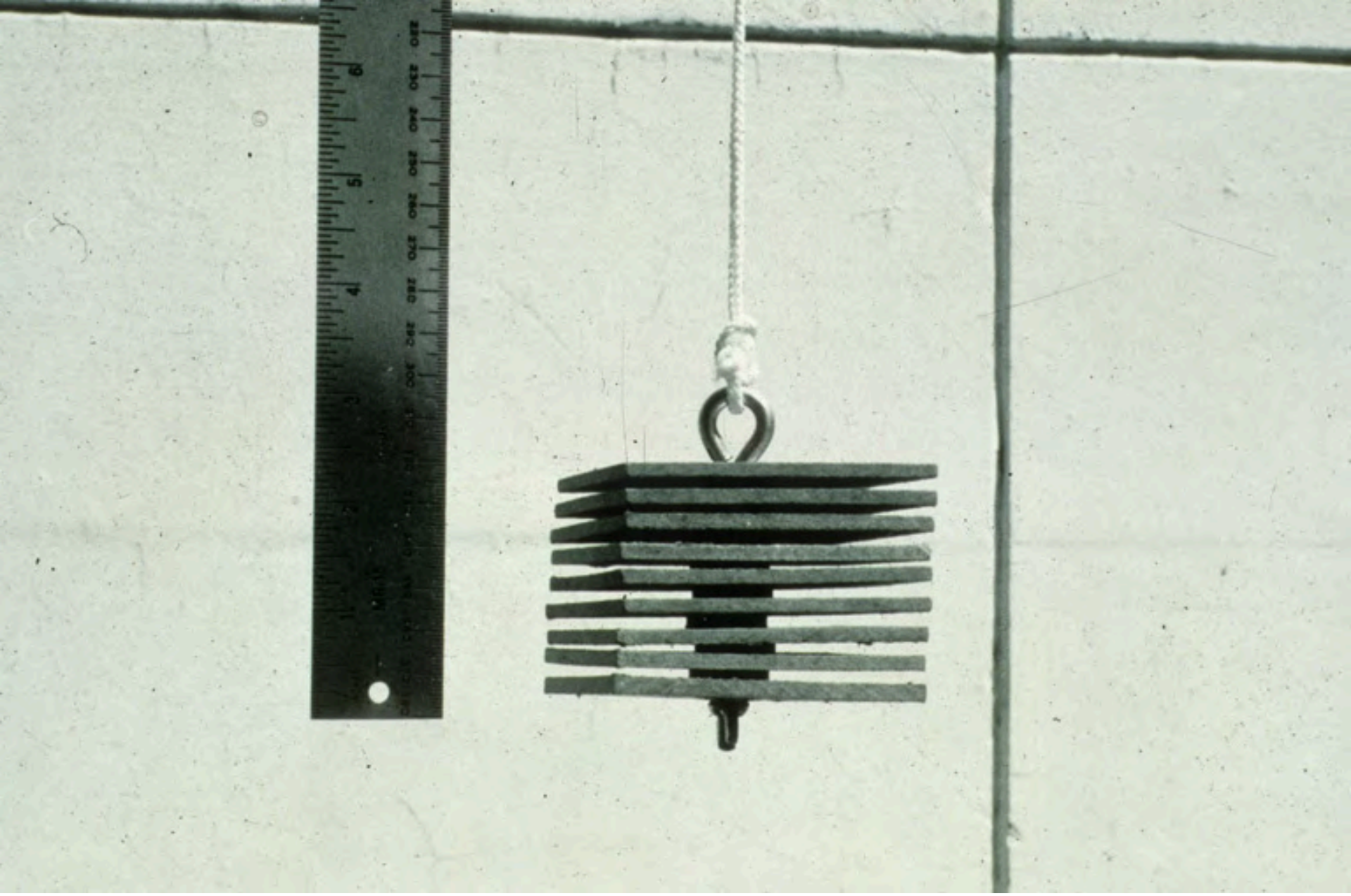
Discharge or streamflow - distribution
Temperature - controlling and limiting factor
Dissolved Oxygen - levels
Hydrogen Ion Activity - composition and abundance
Alkalinity - responsible for overall chemical environment
Conductivity - indicator of variety of impacts
Sulfate - plant growth
Nitrate - plant growth
Chloride - indicates a source of pollution
Calcium - well buffered systems - abundant and diverse fauna
Magnesium - important cation to flora and fauna

THREE TYPES OF SAMPLES

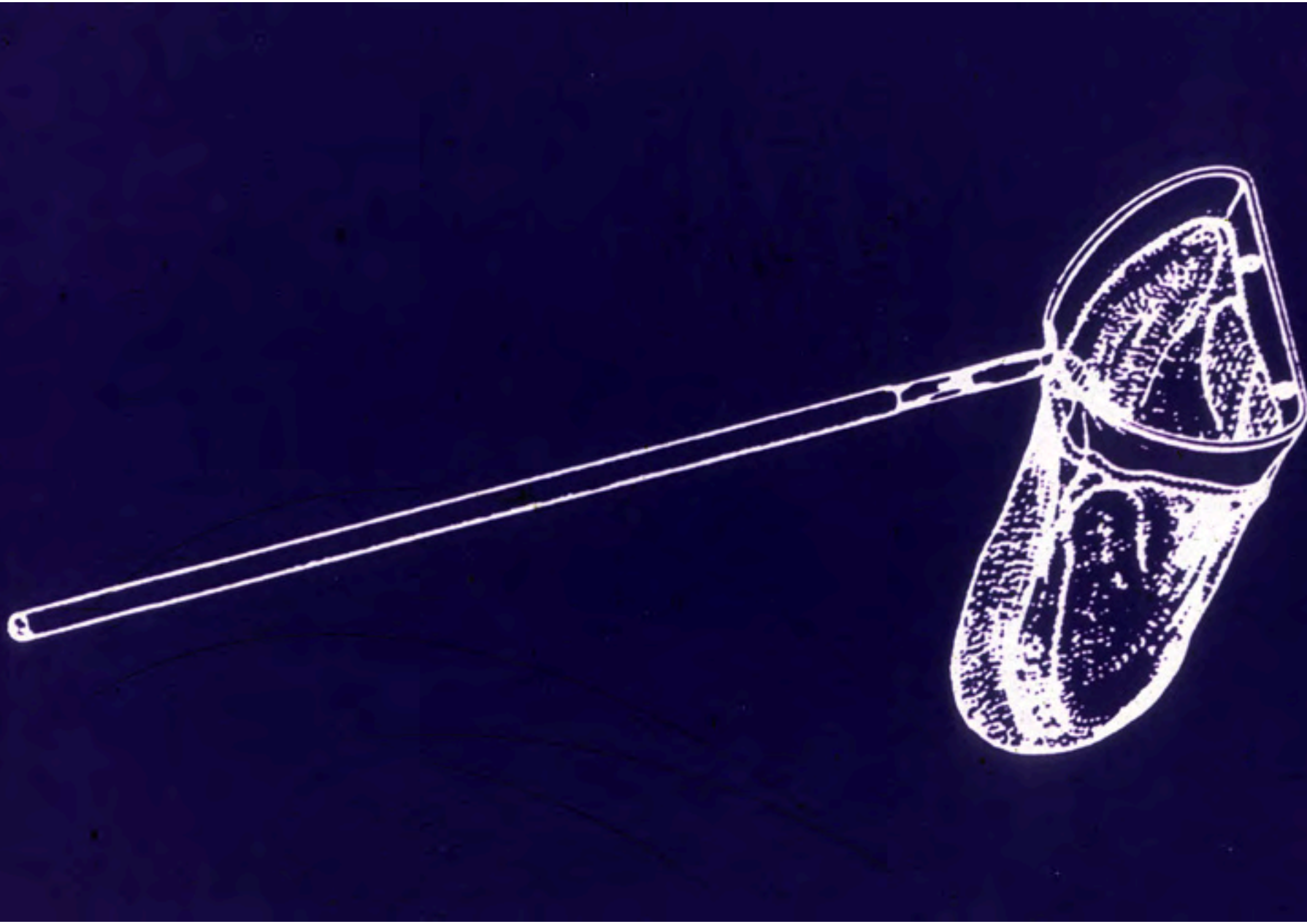
(1) quantitative benthic
(2) qualitative benthic
(3) aerial or light trap

SURBER SAMPLER

HESS SAMPLER



MULTIPLATE SAMPLER



Macroinvertebrate functional groups and their modes of feeding (Merritt and Cummins 1984).

Functional Group	Feeding Mode
Scrapers	Shear off attached perphyton and associated organims and detritus from underwater substrates
Collector-gatherers	"Vacuum" sedimented organic deposits from the substrate
Collector-filterers	Filter suspended particulate organic matter from water column
Shredders	Skeletonize whole leaves and leaf fragments
Predators (engulfers)	Capture and ingest animals

Organism Percentage in Feeding Guilds

Spring Creek #2