The Apterygota & Ephemeroptera

Insect Diversity & Evolution series

L 10

Original Classification: Insects

- Apterygotan orders
  - Diplura
  - Thysanura
  - Protura
  - Collembola

- Pterygota
  - Division: Exopterygota
    - Paleopteran orders: Ephemeroptera & Odonata
    - Orthopteroid orders
    - Hemipteroid orders
  - Division: Endopterygota

“Hexapoda”:
The tree of Life Project
- A collaborative effort of biologists from around the world. On more than 9000 World Wide Web pages, the project provides information about the diversity of organisms on Earth, their evolutionary history (phylogeny), and characteristics.
- ... ToIWeb - http://tolweb.org/Hexapoda
  (lecture & links on www.dropdata.org → entomology)

Arthropoda

Hexapoda: (insects, springtails, diplurans, and proturans)
- Crustacea (crabs, lobsters, shrimp, isopods, water fleas, barnacles, etc.)
- Pancrustacea
- Diplura
- Collembola
- Protura
- Odonata (dragonflies & damselflies)
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- Syntype
- Anapheidae (springtails, leafhoppers, loopers, scorpion flies, etc.)
- Dyptera (true bugs, stink bugs, plant bugs, etc.)
- Khepera (horseshoe crabs)
- Pycnogonida (sea spiders)
- Trilobites +

A symphyllan myriapod

Hexapoda

- Collembola (springtails)
- Protura
- Diplura
- Insecta

Silurian?

Rhyniella praecursor
(Devonian chert 400-412 mya)
www.abdn.ac.uk/rhynie

Order: Diplura

Position of Diplura in hexapoda is unclear; characteristics:
- eyeless
- tentorium absent
- unique muscles and pivots in legs

Other characteristics:
- mostly white
- long, slender antennae
- two prominent cerci, either long and filiform or short and forcep-like (Japygidae)
### Order: Protura

- eyeless
- antennae absent
- tentorium absent
- fore legs enlarged, with many sensilla; front legs serve role of antennae

Other characteristics:
- very small, less than 2 mm long
- cerci absent
- legs 5-segmented
- abdomen with 12 segments as adult
- anamorphic development (segments added at moults)

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### Order: Collembola (Springtails)

- Widest distribution of any hexapod group, occurring throughout the world, including Antarctica.
- Probably the most abundant hexapods on Earth, with up to 62,000 individuals per square M.
- Found in soil, leaf litter, logs, dung, cave, shorelines, etc.
- Approx. 6000 known species.

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### Collembolan characteristics

- ventral tube ("collophore") on segment 1 of abdomen (adhesive in some groups, but primarily involved with excretion and maintaining water balance)
- springing mechanism formed from retinaculum (catch mechanism) on segment 3, furcula on segment 4
- 4-segmented antennae (segments sometimes subsegmented, giving the appearance of more than 4 segments)
- 6 abdominal segments

Other characteristics:
- Indirect sperm transfer with globular stalked spermatophore
- Adults continue moulting throughout life (up to 50 moults)
- Reproductive instars alternate with feeding instars
- No Cerci

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### Some major groups of Collembola

- Poduroidea
- Entomobryoidea
- Sminthuridae
- Neelidae

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### Collembolan pests!

**The Lucerne Flea**  
*Sminthurus viridis*

In Australia:
- Invasive sp. From N. Europe
- Chemical sprays (resurgence?)
- Biological control (with predatory mites)

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### … but much more likely to be beneficial

**Springtails – Britain’s most abundant insects**

- Recycling nutrients (leaf litter *etc.*)

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**Frampton & Hopkin (2001)**  
*British Wildlife* **12** (6), 402
Class: Insecta

- Archaeognatha (bristletails)
- Thysanura (silverfish and firebrats)
- Pterygota (winged insects)

Styli on abdomen may be remnants of ancestral limbs.

... so what makes a true insect?
- lack of musculature beyond 1st antennal segment.
- Johnston's organ in pedicel (second segment) of antenna - detects movement.
- a transverse bar forming the posterior tentorium inside the head.
- tarsi sub-segmented.
- females with ovipositor formed by gonapophyses from segments 8 and 9.
- terminal filament (telson) extending out from end of segment 11 of abdomen (subsequently lost in most groups of insects).

Insect characters
- Tentorium: 2-3 fused apodemes giving rigidity to head and better articulation to mouthparts.
- Johnston’s organ - collection of sensory cells that detect movement of the flagellum.

first found in ...

Order: Archaeognatha (Bristletails)
- Originally combined with Thysanura; mandibles with only one condyle (the joint or socket-like attachment point to the head capsule).
  - ... feature gives the order its name (Archaeo - beginning, gnathos - jaw).
- compound eyes enlarged, medially contiguous.
- specialised musculature of abdomen, which allows them to jump by a rapid downward bending.
- abdominal segments bear styli.

Order: Thysanura (Silverfish and Firebrats)
- body flattened.
- long cerci and median filament.
- mouthparts - two condyles ("dicondylic").
- compound eyes separate.
- abdominal segments bear styli.

Insecta sub-class: Pterygota

How did wings evolve?
- Paleoptera ("old wing")
- Neoptera ("new wing")

Stenodictya (Carboniferous) showing prothoracic lateral expansions.

Petrobius maritimus (photo S. Trewhella)

Paleopterygota
- Brachypterygota (short-winged)
- Heteropterygota (diverse wings)
- Homopterygota (homogenous wings)
- Neuropterygota (nerve wings)

Stenodictya (Carboniferous)

Ephemeroptera (mayflies)
- Odonata (dragonflies and damselflies)
- Neoptera (bugs, beetles, wasps, moths, flies, etc.)
**Order: Ephemeroptera (Mayflies)**
- Ephemeros - short-lived, pteron - wing
- adults do not eat.
- immature stages aquatic with gills, usually herbivorous
- fore legs of male elongated, used to grasp female in flight.
- mouthparts of adults reduced, unsclerotised.
- hind wings reduced, smaller than fore wings.
- earliest fossils - Carboniferous

**Sub-imago and Imago**
- Sub-imago or anglers' "dun"
  - Dull (covered with fine hairs) - prevents wetting
  - Only insects to have flying immature stage
- Imago - "spinner"

**Life cycle**
- Eggs dropped singly (sometimes batches) onto water surface
- Nymphs:
  - usually feed on diatoms, algae, etc., sometimes carnivorous
  - plate-like tracheal gills on abdomen
  - always telson + 2 cerci
  - undergo up to 27 moults often taking 1 year (2 years for *Ephemera* spp.)
- Sub-imago finds resting place and moults within hours
- Imago: <1 day to 1 week (maximum).
- Males generally fly in swarms that undulate in the air 5-15 meters above the ground.

**Major families (esp. N European)**
1. Ephemeridae
2. Potamanthidae
3. Siphlonuridae
4. Ecydonuridae
5. Caenidae
6. Ephemerellidae
7. Isonychiidae
8. Baetidae
9.
10. Leptophlebiidae

(illustrations from Chinery, 1979)

NB: not all adults have central terminal filament

**Ecology**
- Immature & adult mayflies are an important part of food web near waterways: particularly for carnivorous fish e.g. trout in cold water streams, or bass and catfish in warm water streams.
- No apparent relationship species traits and habitat utilisation evident for Ephemeroptera.
- Baetidae use many habitat types and have diverse species traits;
- Leptophlebiidae, Heptageniidae, and Caenidae use many habitat types but each family has a rather uniform set of traits.
(see: Usseglio-Polatera & Tachet, 1994, *Freshwater Biology* 31: 357)
Conservation
- Little interest / knowledge of conservation status to date
- Alliance with anglers’ interests
- Southern iron blue mayfly (Nigrobaetis niger) now listed on UK BAP
- Indicator spp.

Macro invertebrates and their scores

Mayflies as indicator spp.
Biological Monitoring Working Party (BMWP) protocol

Scores for each family identified are totalled, which is the BMWP score. This figure is then divided by the number of taxa (each specific organism), to give the Average Score Per Taxon (ASPT); which is independent of sample size and perhaps less influenced by season than the BMWP (Sussex Ouse Conservation Society website)

Summary
- Apterygota: now not recognised as monophyletic; 3 orders now classed as Hexapoda, but not insects
- Collembola, protura etc. important leaf litter fauna recycling nutrients
- True insects mostly winged orders + old Thysanura (& Archaeognatha separate)
- Ephemeroptera - mayflies - Palaeopteran
  - aquatic larvae and unique pre-imago stage (dun)
  - ... important indicator species for quality of freshwater habitats