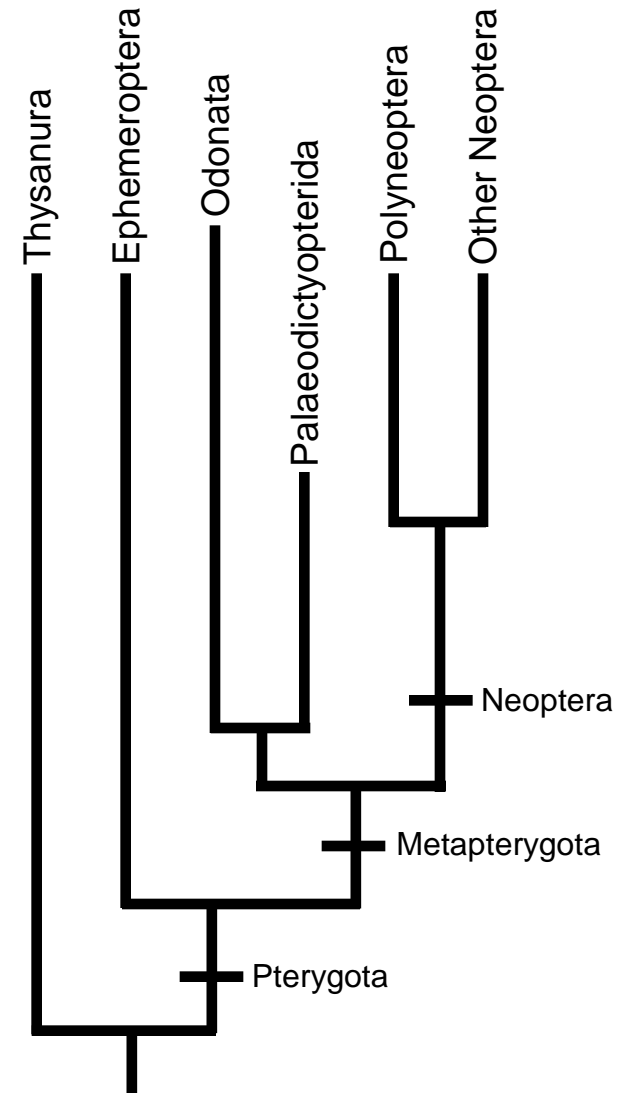


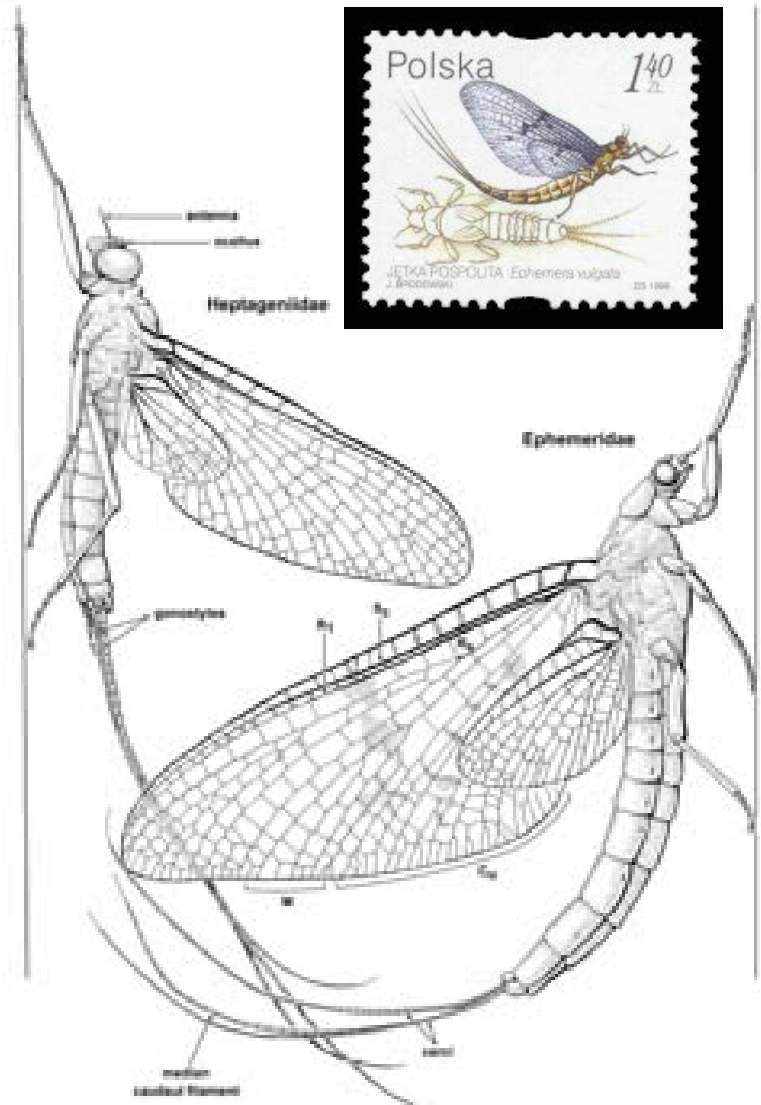
Insect Orders I: Paleoptera and Polyneoptera (in part)

- A single evolutionary origin of winged insects is now generally undisputed. This evolutionary lineage is referred to as the Pterygota.
- Traditionally, the Pterygota has been divided into two groups, the Palaeoptera (old wing) orders and the Neoptera (new wing) orders. The Neoptera has been universally supported as a monophyletic group based on the development of wing flexion that allows the wings to be folded over the back, among other characters.
- There is considerable debate regarding the status of the “Palaeoptera” due questions about the relationship of its two member orders, the Ephemeroptera and the Odonata. Recent evidence suggest that the Odonata is not the sister group of the Ephemeroptera, but is instead the sister group of the Neoptera, making the Palaeoptera paraphyletic.
- The Odonata and the Neoptera are now defined as members of the Metapterygota and are united by the absence of the subimago stage and the median caudal filament.



Ephemeroptera (Mayflies)

- **Classification.** 10-20 families divided into two suborders based on structure of immatures. Several hundred species worldwide.
- **Structure. Adults:** Mouthparts of adult are reduced and non-functional. Wings of adults have simple venation and strong fluting. Hind wings are absent in some groups. Alimentary canal of adult is reduced and functions as a reservoir for air which is pumped in and out through the mouth. Air aids in flying and it is the strong fluting of the wings and active pumping of air that gives mayflies their distinctive flight pattern. **Immature:** Nymphs respire by means of abdominal gills. Development of gills is related to habitat. Species living in standing water have large plumose gills. Species living in rapidly running water have smaller gills, some of which act as holdfasts to help maintain position on rocks. Strength and structure of legs also varies with habitat.



Ephemeroptera (Mayflies)

- **Natural history. Adults:** Adults live only a few hours or a few days at most. Mouthparts are reduced and non-functional and adults consequently do not feed. The alimentary canal in many species is filled with air. Synchronous emergence may satiate predators. Flight capabilities are poor, which limits dispersal and ability to escape predators. Up-and-down flight pattern very distinctive. Sperm transfer is direct with mating taking place in flight. Eggs are deposited in the water. Females of some species characteristically drop into the water during oviposition and drown. **Immatures:** Immatures of all species are aquatic. Nymphal period is relatively long, lasting 2 years or longer in some species. The number of larval molts varies with environmental conditions (poor conditions increase the number of molts). Nymphs of most species are herbivores or scavengers. Some species may be predaceous. Mayfly nymphs are an important source of food for freshwater fish. **Development:** Hemimetabolous (incomplete) metamorphosis. Unlike all other insects with hemimetabolous development, all mayfly species emerge from the water as a winged subimago, not as an adult. The subimago flies to vegetation and molts again to the adult or imago stage. Mayflies are the only order of pterygotes that molt again after acquiring functional wings. The subimago stages lasts from 5 mins to 4 days depending on the species. Some species reproduce and die in the subimago stage.



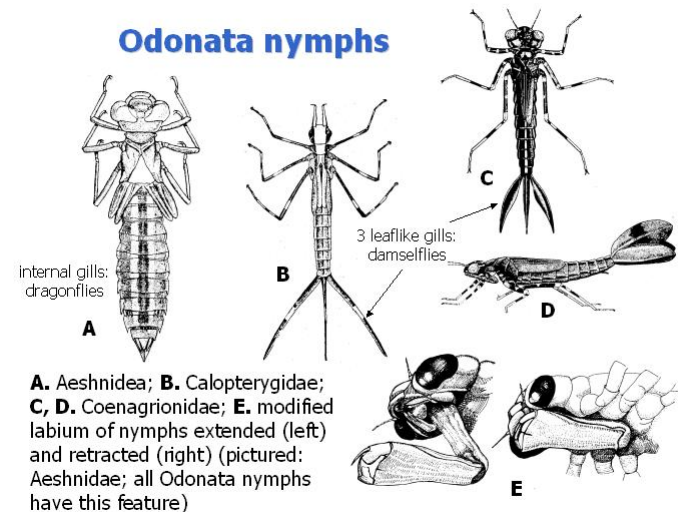
Odonata (Dragonflies & Damselflies)

- **Classification.** Two major suborders, the Zygoptera (Damselflies) with 16 families., and the Anisoptera (Dragonflies) with 7 families. 3500 species worldwide.
- **Structure. Adults:** Mandibles, eyes and head capsule are very well-developed. Legs are weak and not used for walking but for perching on vegetation and for seizing and holding prey. Legs form a basket when in flight. Copulatory organs of the male are located on the second and third abdominal segments. Males transfer their sperm from the 9th abdominal segment to these unique secondary genitalia. **Immatures:** Labium is highly modified as an extensible grasping organ with palps adapted for seizing prey. Legs are well-developed and used for walking, clinging to substrate and burrowing. Zygopteran nymphs respire through modified wing pads and through large caudal tracheal gills. Anisoptera respire through gills on the inside of the rectal area.



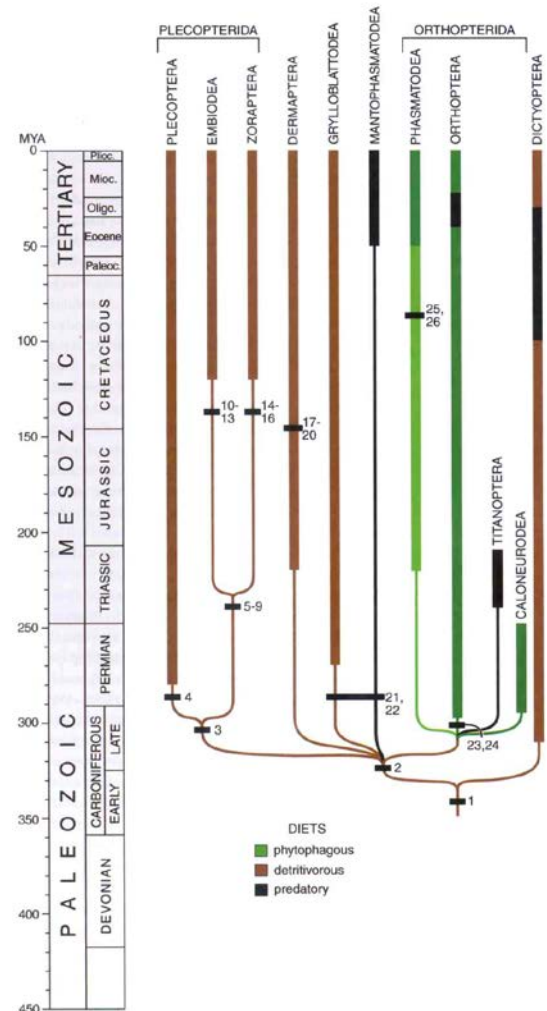
Odonata (Dragonflies & Damselflies)

- **Natural history. Adults:** Adults are strong fliers with large well-developed wings. Adults are relatively long-lived and therefore feed. Most species are active predators, capturing prey in flight and returning to defended perches to consume it. Different species exhibit different hunting techniques (sit-and-wait at territorial perch, or active hunting). Males use defended perches to locate and pursue females for mating. Sperm transfer is direct. Males grab females behind the neck in flight and sperm transfer takes place either in flight or after the mated pair alights on vegetation. Males frequently remain attached to females after sperm transfer is complete and the female proceeds to oviposit in water. **Nymphs:** Nymphs are almost always aquatic, inhabiting a variety of habitats (waterfalls, torrents, permanent and intermittent streams, lakes, ponds, temporary rain pools, tree holes, swamps, bogs, etc.). Nymphs are efficient sit-and-wait or stalking predators. The number of nymphal stages varies within and among species depending on the environmental conditions. Nymphal stage may last as long as 2-3 years. Nymphal stage diapauses in some species. **Development** is by hemimetabolous metamorphism.



The Polyneoptera

- The Polyneoptera consists of 11 extant orders. All orders except the Plecoptera have terrestrial wingless immature stages that resemble the adult stage (paurometabolous development). The Plecoptera have aquatic nymphs that do not resemble the adult stage (hemimetabolous development).
- Sister group relationships in the Polyneoptera are still unresolved in many respects, largely do to the lack of a sufficient number of derived characters shared among the members (synapomorphies).
- The order Orthoptera is by far the most diverse order in the Polyneoptera, followed by the Dictyopteran orders. At least two orders, the Grylloblattodea and the Mantophasmatodea appear to relict groups, widely distributed but of low diversity.
- The Zoraptera is a particularly difficult order to place phylogenetically, but it now appears to the sister group of the Embiidina.



Plecoptera (Stoneflies)

- **Classification.** Stoneflies are considered a pleisomorphic group because autapomorphies defining the group are not obvious. 1000 species worldwide.
- **Structure. Adults:** Well developed eyes in adult, weak mandibles. Abdomen soft, cylindrical or somewhat flattened. **Immatures:** Body form of immature resembles that of the adult. Nymphs may have external tracheal gills located on various body segments, or completely absent. Remnants of nymphal gills are retained in the adults, and are important in classification. Superficially resemble mayfly nymphs.
- **Natural history.** About 50% of the species are phytophagous and 50% are predaceous. Many species use acoustic signals during mating. These signals are produced by drumming the abdomen on the substrate. Important food source for freshwater fish.



Pteronarcyidae



Perlidae



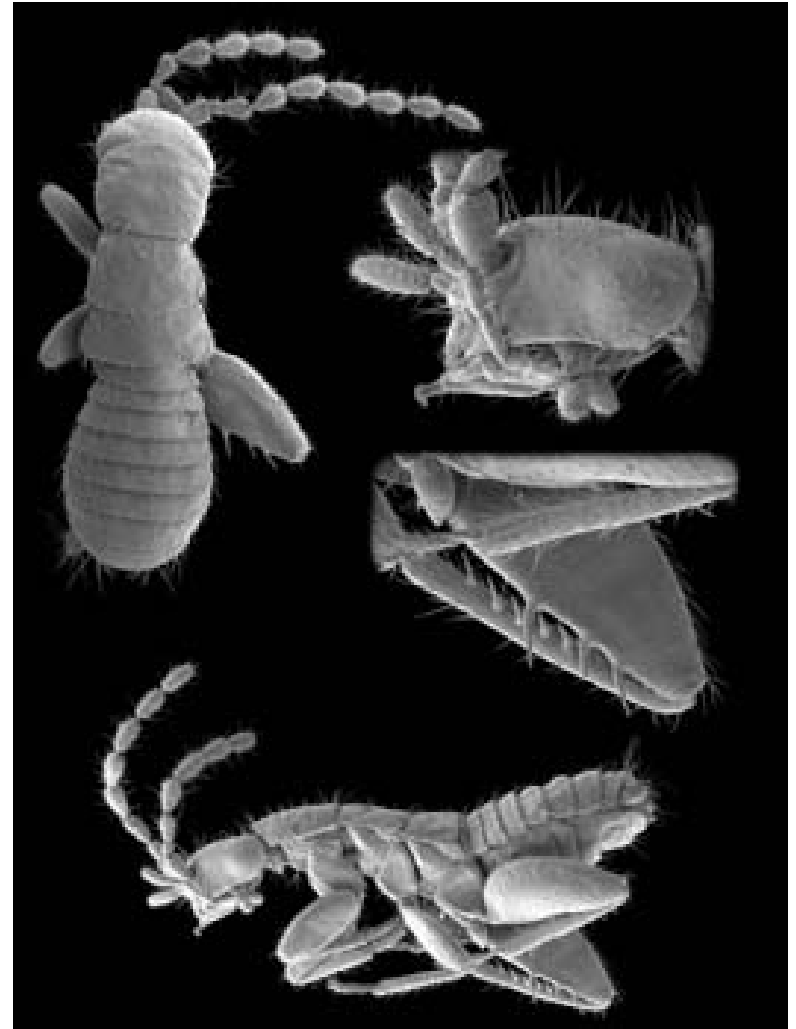
Embiidina (Webspinners)

- **Classification.** 360 described species segregated into 9 families. Occur principally in the tropics and warm temperate regions.
- **Structure.** Eyes often large in males, always small in females. Ocelli are absent. Males have large, specialized mandibles for grabbing female during mating. Special silk glands present on foretarsi and silk is spun during all nymphal instars and by male and female adults. Wings, when present have blood sinuses through which hemolymph is pumped. When hemolymph is withdrawn into the body the wings become flexible and collapse, making movement through galleries possible. When flight is necessary the wings are made more rigid by filling the sinuses with blood. Females are apterous, while males may have dehiscent wings.
- **Natural history.** Gregarious insects, which live in colonies consisting of 1-2 adult females and their offspring. Although females may share a composite gallery, they participate only in rearing their own young. In some species females routinely consume males after mating.



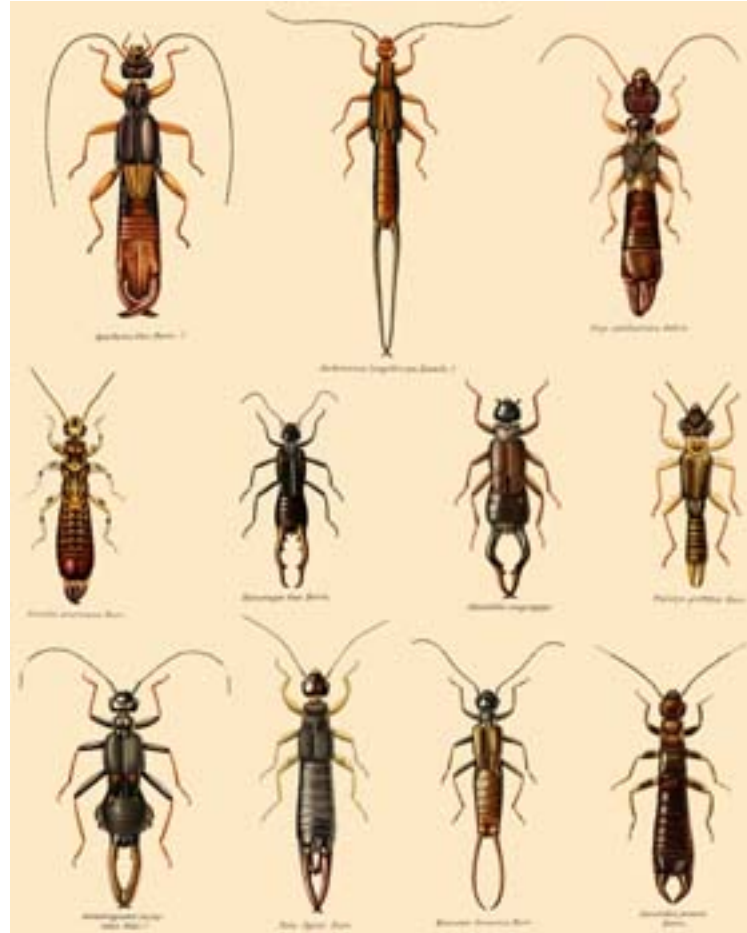
Zoraptera (Zorapterans)

- **Classification.** Comprise 32 extant species all classified into a single genus and family. Distributed pantropically. This order is difficult to place phylogenetically, because it has characters similar to the orthopteroid complex (chewing mouthparts), and others similar to the hemipteroid complex (internal structures). Current evidence suggest Zoraptera is the sister group to the Embiidina.
- **Structure.** Head with strong mandibulate mouthparts. Winged and wingless adult forms occur in both sexes in most species. The winged form is pigmented and has compound eyes and 3 ocelli, whereas the wingless form is pale and lacks both compound eyes and ocelli. Monophyly supported by 2- segmented tarsi and particular mating via a “mating hook” among other characters.
- **Natural history.** All species collected to date live communally under bark in rotting wood or in termite nests. Species are probably fungivores, but may also consume mites. Production of winged forms is triggered by resource limitation in the growing colony due to consumption or natural decomposition. Winged females start new colonies by colonizing new logs, shedding their wings and laying eggs, just as seen in termites and ants.



Dermaptera (Earwigs)

- **Classification.** Order divided into 3 suborders, only one of which occurs in the US, the Forficulina. The other two orders consist of species that are specialized ectoparasites of bats (*Arixenina*) or rodents (*Diploglossata*). 1900 described species, most occurring in tropical and warm-temperate habitats. Only 22 species found in the US, 12 of them introduced from Europe.
- **Structure.** Most distinctive feature is the highly modified cerci which take the form of terminal forceps. Forceps in males usually stronger and more curved than in females. Forceps form varies with species. Head with well developed eyes (no ocelli) and strong mandibles. Forewings form short tegmina.
- **Natural history.** Species typically found in crevices, under bark and in leaf-litter in moist habitats. Most species are omnivorous. Forceps used by males and females to capture prey, defend against predators, and in courtship and mating. Forceps also used in male-male competition for females. Females in many species remain with egg clutches and incubate, turn and protect eggs. Females continue to care for nymphs until the second instar after which they may turn cannibalistic.



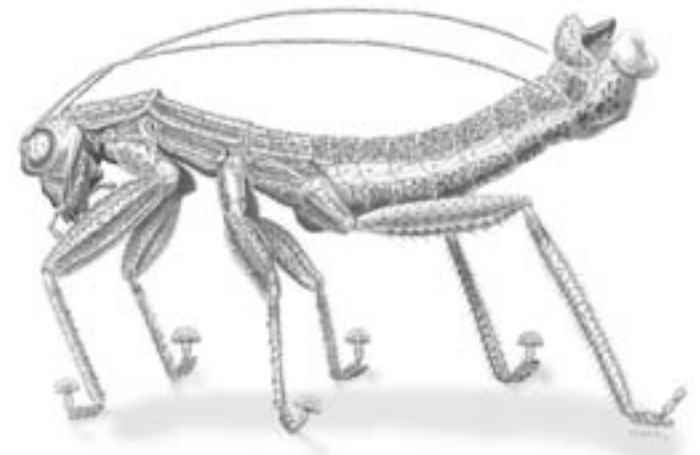
Grylloblattodea (snow crickets, rock crawlers)

- **Classification.** Single family with 5 genera. 26 species worldwide. Probably basal to other orders in the Orthopteroids.
- **Structure.** Eyes small or absent. Loss of ocelli. Wings absent. Toothed mandibles without a molar region. Primitive characters include enlarged coxae, 5-segmented tarsi, long multi-segmented cerci. Males have asymmetric genitalia.
- **Natural history.** Cryptozoic. Species found under rocks in cold, wet conditions at the edge of snow banks, talus slopes or in caves. Nocturnal foragers that take dead insects and other organic matter. Thin integument gives these insects a narrow temperature range. Adapted to very cold conditions. They will die of overheating in your hand.



Mantophasmatodea (African rock crawlers)

- **Classification.** Restricted to southern Africa. 15 species segregated into 3 families. First described in 2002. Probably the living sister group of the Grylloblattodea. Known from fossils before living species were found.
- **Structure.** Loss of ocelli, but large, well developed compound eyes present. Hypognathous head. Wings absent. Enlarged pretarsal arolium with a series of long setae.
- **Natural history.** Occur in xeric, rocky habitats in southern Africa. Nocturnally foraging, aggressive carnivores that pounce on prey and grasp them with the fore-legs and mid-legs. Prey include moths, silverfish and roaches.



Structural similarities between relict orders Grylloblattodea (above) and Mantophasmatodea (below)