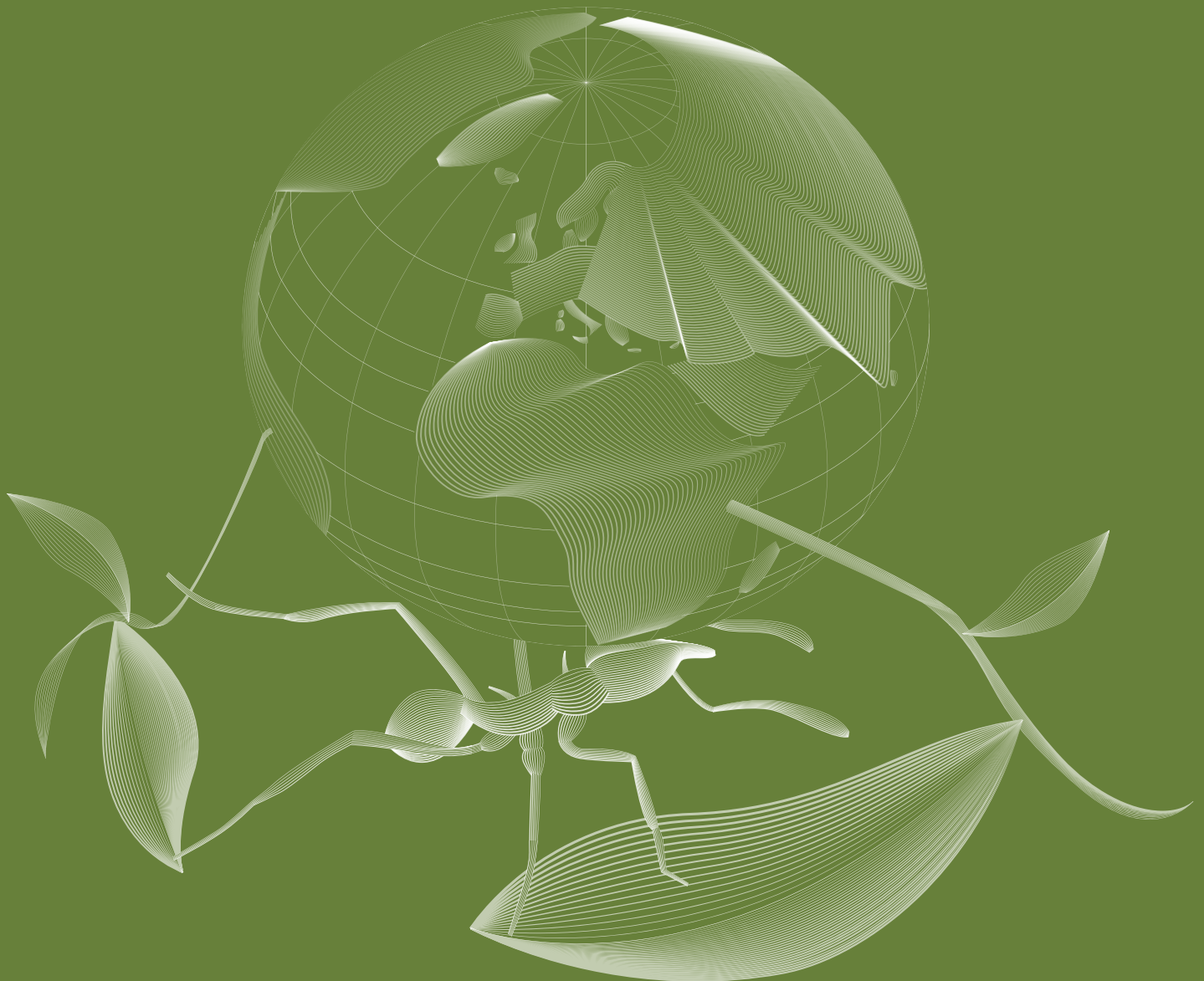




GLOBAL SOIL BIODIVERSITY ATLAS

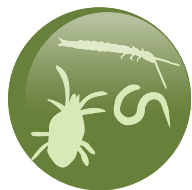


GLOBAL
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GLOBAL SOIL BIODIVERSITY ATLAS

Supporting the EU Biodiversity Strategy and the Global Soil Biodiversity Initiative: preserving soil organisms through sustainable land management practices and environmental policies for the protection and enhancement of ecosystem services



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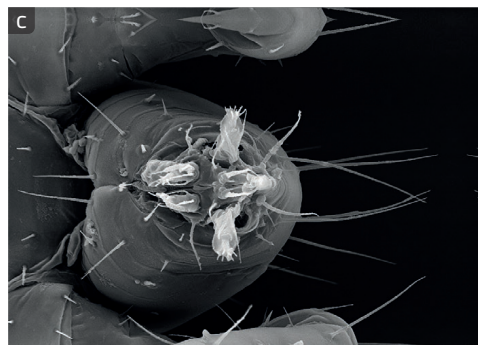
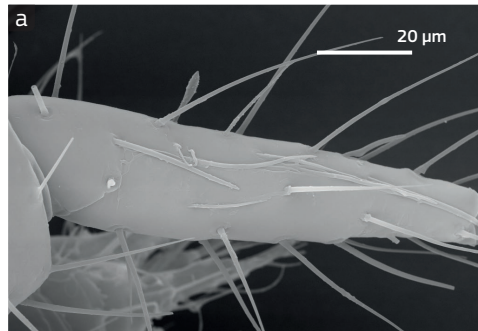
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Mesofauna – Protura

Morphology

Proturans are small soil-inhabiting primitive hexapods (ranging in size from 0.5 and 2.5 mm – see page 31) with no antennae and no eyes. The forelegs are used as sensory organs; they have many sensory organs ('sensilla') covering their posterior segments (tarsi). On the dorsal side of the head there are a pair of other important sensory organs (pseudoculi) whose functions are not well understood. Their bodies are cylindrical, pointed at both ends and generally unpigmented, pale or yellowish. Similar to the Collembola, they are wingless arthropods and their mouthparts are entognathous, meaning that they are retracted within the head capsule: the mandibles and maxillae are slender and their maxillary palps (mouthparts) are long, with setae and sensilla. They are born with nine abdominal segments and grow by successive moultings during which they add new distal segments. The adult has 12 abdominal segments. They have small pairs of lateral-ventral appendages on the first three abdominal segments. They lack cerci, the paired appendages on the rear-most segment of the body present in many other hexapods. Reproduction occurs with indirect fertilisation: the males deposit packets of sperm (spermatophores) and the females collect the spermatophores. [55, 56]



••• Morphological structures of the proturan *Acerentomon italicum*: (a) the sensory organs, sensilla and setae, on the exterior side of the legs; (b) pseudoculi, the eye-like structures that are not actually eyes, on the dorsal side of the head; (c) the mouthparts are entognathous, meaning that they are retracted within the head. (LGA)

Taxonomy

The class Protura (phylum Arthropoda, subphylum Hexapoda) includes three orders: Acerentomata (families Hesperentomidae, Protentomidae and Acerentomidae), Sinentomata (families Fujientomidae and Sinentomidae) and Eosentomata (families Eosentomidae and Antelientomidae).

The 'young' proturans

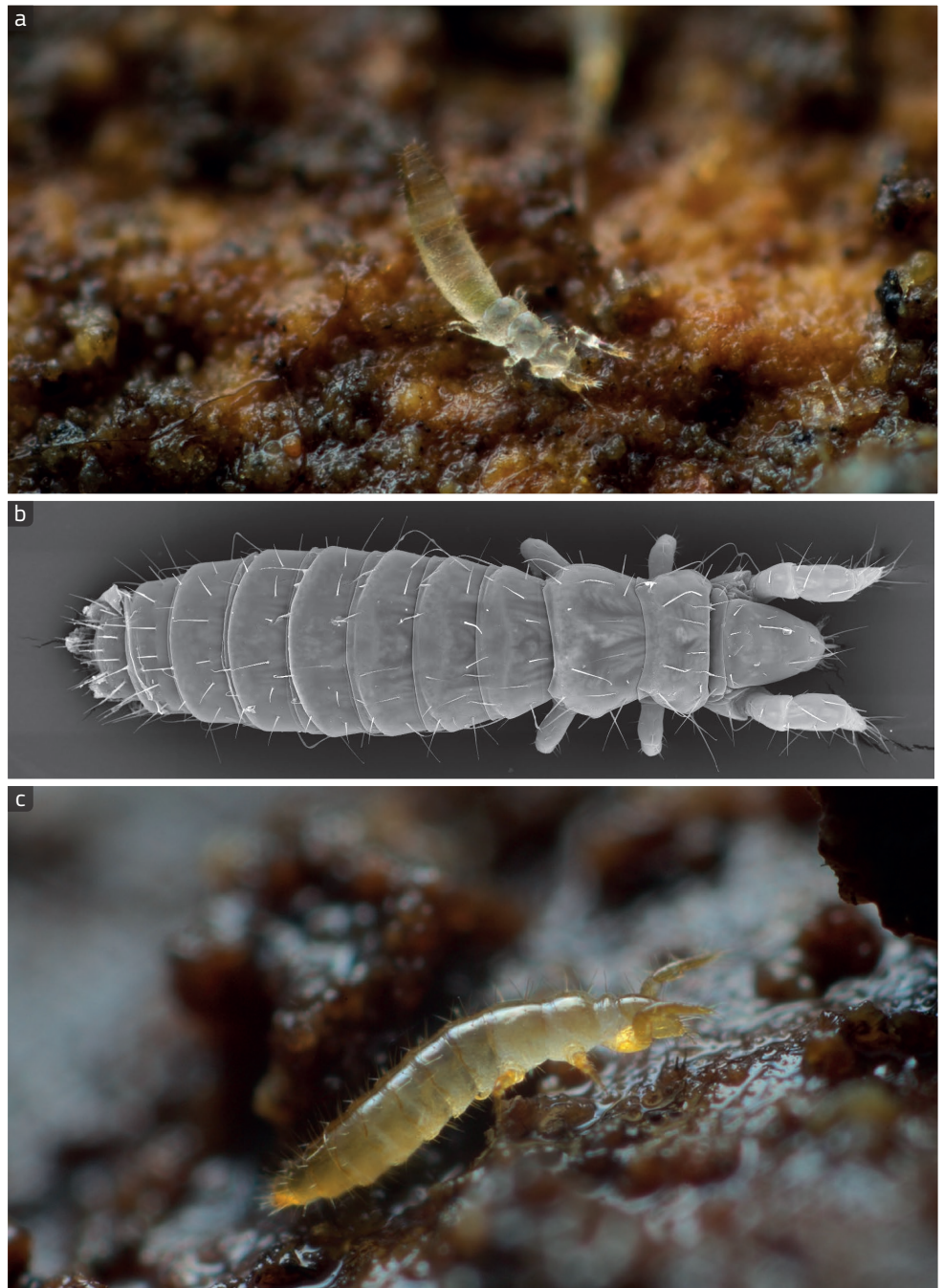
- Among hexapods (see page 31), Protura was the last class to be described. The first description of these minute soil arthropods was given in 1907.
- Filippo Silvestri and Antonio Berlese, two Italian entomologists, discovered proturans independently.
- The first species to be described was *Acerentomon doderoi*, found in soil near Syracuse, New York, USA.
- When disturbed, proturans seem to raise the end of the abdomen in a defensive posture similar to that adopted by scorpions.

Microhabitat

Protura are found in moist soils, leaf litter, humus, moss and decaying wood in woodland, grassland and agricultural soils. They do not thrive in very acid soils (e.g. coniferous woodlands). Usually, they are part of the decomposer community and help break down organic matter in soil and litter. In particular, proturans feed mainly on fungal hyphae (see box, page 39), but they are also important prey for small predators, such as spiders, mites (see page 49) and pseudoscorpions (see page 53).

Diversity, abundance and biomass

Proturans are found all over the world, with the exception of the polar regions. There are more than 700 described species. Their density is variable in relation to the characteristics of the soil and the content of organic matter. In disturbed and degraded soils they can be completely absent, while in undisturbed habitats, such as natural grasslands, there can be as many as 85 000 individuals per square metre.

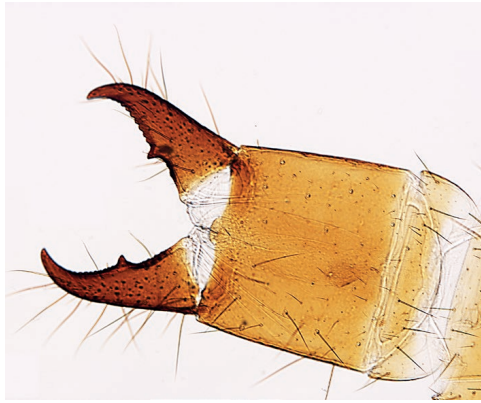


••• (a) and (c) Proturans in their natural environment in New Zealand and the UK, respectively. Proturans live mainly in soil, mosses and leaf litter in moist temperate forests. (b) Scanning electron microphotograph shows the dorsal part of the species *Acerentomon italicum*. (AM, LGA)

Mesofauna – Diplura

Morphology

Diplura are small wingless hexapods (see page 31), with body lengths ranging from 0.3 to 1 cm, although the largest species can be longer than 2 cm. Diplurans have a narrow and elongated body, and are generally white or colourless. The head has a pair of long and moniliform (a string formed of bead-like segments) antennae and no eyes. The abdomen ends with a pair of cerci, i.e. prominent abdominal appendages, which can contain silk glands. The cerci can have either a pair of pincers (Japygoidea) or can be filamentous (Campodeoidea). Some species of japygid Diplura are robust and darker in colour, and are often confused with earwigs (Dermaptera – see box to the right). However, Diplura have neither eyes nor wings. Fertilisation is similar to that found in proturans and collembolans (see pages 50-51): the males produce and deposit a large number of spermatophores, capsules containing spermatozoa, on the substrate that are then picked up by a female. The females lay eggs in clumps in the soil cavities or decomposing vegetation. Some species check the eggs and the larvae. Diplura are known to be able to regenerate lost body parts, such as legs, antennae and cerci. [57, 58]



Detail of the pincer-like structures of the dipluran *Catajapyx aquilonaris* belonging to the family of Japygidae. These abdominal appendages are scientifically known as cerci. (NS)

Taxonomy

The class Diplura (phylum Arthropoda, superclass Hexapoda) comprises nine extant families, the main ones being Japygidae and Campodeidae (each with more than 400 species).

Microhabitat

Diplura live in wood, leaf litter, under stones, rocks or logs, on the surface of, or in deeper layers of soil, in mosses or in termite and ant nests. Many species are herbivores and detritivores (feed on decomposing plant and animal parts) and feed on a wide range of plant material. However, some species have well-developed mandibles and eat nematodes (see pages 46-47), small arthropods, enchytraeids (see page 48), etc. They can also consume fungal mycelia (see box on page 39) and plant detritus. They are often part of the decomposer community, helping recycle dead plant material.

Diversity, abundance and biomass

There are approximately 1000 described species that are common inhabitants of most natural and human modified soils. They are distributed worldwide, from the tropics to temperate zones. They do not have specific habitat preferences and, generally, their population densities are not high (<50 individuals per square metre).

Maternal care of diplura

- Male diplurans produce large numbers of spermatophores (up to 200 per week), probably because sperm only remain viable in the spermatophore for about two days.
- The eggs of campodeid and japygid diplurans are normally laid in a mass of up to 40, in clumps or on small stalks in little cracks or cavities in the ground.
- Female campodeid diplurans abandon their eggs, but japygid species are known to remain in the brood chamber with the egg cluster, protecting the eggs and the newborn larvae.

Diplurans are not earwigs

- Some diplurans in the Japygidae family may be occasionally confused with earwigs. This confusion is due to the presence in both groups of pincer-like abdominal appendages, scientifically known as cerci.
- Diplurans are not insects. Earwigs are insects of the order Dermaptera and live in similar habitats: moist places beneath stones, boards, sidewalks, debris or in the soil.
- The forcep-like appendages, i.e. cerci, of some diplurans are designed to break off near the base if they are mishandled. This behaviour is probably an anti-predatory adaptation. It is known as autotomy and is typical also of reptiles, such as lizards, and amphibians, such as salamanders. Diplurans are among the few terrestrial arthropods known to be able to regenerate lost body parts (legs, antennae and cerci) over the course of several moults.



Despite having similar forcep-like structures, (a) earwigs and (b) japygid diplurans are very distinct animals. (MH, KSC)



Campodeidae diplurans. (a) A live specimen shows the typical shape of this group. They are pale, eyeless hexapods and have two long abdominal appendages and antennae. (b) A live specimen of *Campodea augens* on moss. They can be found also in moist soil, wood, leaf litter and under stones. (AM, NS)

Mesofauna – Pseudoscorpionida

Morphology

Pseudoscorpions are tiny arachnids known as 'false scorpions' because they look similar to scorpions but do not have an elongated postabdomen with a venomous sting at the end. Usually less than 5 mm in length, they are brownish arachnids with large pincer-like chela (pedipalps). The body is divided in two regions: the cephalothorax (or prosoma, a fused head and thorax) and the abdomen (or opisthosoma) clearly divided into 11 - 12 segments. The cephalothorax is covered dorsally by a shield (carapace) and bears the appendages. One to two pairs of simple eyes (ocelli) are sometimes present on the head, but many species are blind. The first pair of cephalic appendages, the chelicerae, are two-segmented, chelate (clawed) and used for feeding. Chelicerae have silk glands. Behind the chelicerae are the pedipalps, which are used to capture prey and for defence. Pseudoscorpions, like all arachnids, have four pairs of thoracic legs. The abdomen has no appendages. These animals have a long lifecycle (the course of developmental changes through which an organism passes from its birth to the mature state in which it may give birth to another organism), depending on the environment and the temperature. The males produce a spermatophore, and pull the female over it. The female carries a silken egg bag of about 12-40 eggs in a brood sac that is attached to the ventral surface of the opisthosoma. She can produce several broods each year. The young pseudoscorpions moult, passing from several larval instars (protonymph, deutonymph and tritonymph) before becoming adults that can live three to four years. [59]



Detail of the cephalic appendages of a pseudoscorpion. The smaller ones (dark red) are called chelicerae; the bigger ones (pale red) are the pedipalps and have a defensive function. (AM)



Female pseudoscorpion carries its brood sac. (MY)

Taxonomy

The Pseudoscorpionida or Pseudoscorpiones is a large group comprising 27 different families. They are found everywhere, but their highest diversity is found in the tropics.

A beetle for a house

- The dispersion of the tropical American pseudoscorpion *Cordylochemes scorioides* from one tree to another is mediated by the Harlequin beetle *Acrocinus longimanus*. The males show territorial behaviour on the back of the beetles and even mate with females there.
- *Nesticus birsteini* (today *Carpathonesticus birsteini*) distributed in Russia and Georgia, is the only pseudoscorpion to have appeared on a postage stamp.

Microhabitat

Pseudoscorpions live under bark and stones, in leaf litter, in caves, under rocks on the ground and in soil. They are also often found in moss and lichens, in ant and bee nests and in the burrows of ground-dwelling mammals. The cosmopolitan species *Chelifer cancroides* is often found in houses.

Diversity, abundance and biomass

Approximately 3400 species of Pseudoscorpions have been described. Their density, in general, is not high (<300 individuals per square metre). In some cases they are considered beneficial to humans as they prey on various pest species; for example, carpet beetle larvae, ants, mites and booklice. Occasionally Pseudoscorpiones may disperse attached to flying insects, birds and mammals (phoresy).



Diversity of pseudoscorpions: (a) *Chthonius delmastrai* was described the first time in 2009 in Italy; (b) *Rhacochelifer maculatus* was discovered by the famous entomologist and arachnologist Ludwig Carl Christian Koch in 1873; (c) *Roncus sardous* owes its name to the Italian island Sardinia where it was first discovered; (d) *Nebisium (Ommatoblathus) zoai* belongs to a genus of pseudoscorpions which includes over 230 different species. (SZO)