

Insect trait tool (ITT) v. 1.0 database

Supplement 1 - Trait categories (t1-t26) used for the expert classification of the family-taxa for the insect trait tool.
Explanations of the trait characters:

Terrestrial or aquatic environment (t1-t4)

larva terrestrial (t1)

Binding of larval stages to a terrestrial ecosystem. The majority of life occurs outside the water, notwithstanding potential brief entries into aquatic habitats to interact with other organisms. Larvae that can enter stems of aquatic plants within their tissue below the water surface are also included in this group as they would not be viable outside these stems due to their feeding requirements and regularly breathe gas mixtures within the stems. This group includes all riparian larvae that partially interact with the aquatic environment.

larva aquatic (t2)

Binding of larval stages to an aquatic ecosystem. These stages may have a complete adaptation of underwater respiration or may seek the water surface for respiration. The way of life and feeding takes place under water. This also includes all larvae that leave the water body as larvae for pupation or overwinter outside the water body. These groups do not include shore-dwelling larval stages that interact with organisms in the water, e.g. for feeding.

adult terrestrial (t3)

Binding of the adult stage to a terrestrial ecosystem. The majority of life occurs outside the water, although brief entry into aquatic habitats to interact with organisms or to lay eggs is possible. This group also includes all riparian insects that partially interact with the aquatic environment in terms of feeding. Included are the rarely appearing subadult flight stages as found in the Ephemeroptera. The group includes feeding modes that involve eating parts of aquatic plants that extend above the water surface (e.g. Pyralidae) or predators that dive to hunt (e.g. Carabidae) or parasitoids with aquatic hosts (e.g. Chalcididae).

adult aquatic (t4)

Adult stage binding to an aquatic ecosystem. Organisms can live permanently below the water surface, both those that leave it to breathe and those that can breathe there. They only leave the water to swarm in rare cases (e.g. Dytiscidae, Notonectidae). The predominant part of life and feeding takes place under water. In addition, this group includes insects that live on the water surface and rarely descend (e.g.

Gyrinidae). This group does not include riparian stages that partially interact with the aquatic environment in terms of feeding. These are found in the category "adult-aquatic".

Feeding behavior types of the larvae (t5-t10)

phytophagous (t5)

Feeding behavior based on the consumption of living plant parts, independent of the plant taxon consumed. Taxa such as lower algae, mosses, ferns and higher plants are considered, while the focus (>99%) is on higher plants. All vegetative plant parts are considered. Associated taxa of this group utilize various above-ground or underground plant parts (e.g. cells, juices, leaves, flowers or roots). The group also includes an exception of living plant parts with all life forms that consume woody plants and can be considered as xylophagous or deadwood organisms. The classification requires a more in-depth review, as many organisms are grouped together as xylobionts in the relevant literature. The "saprophagous" way of life is excluded, as fermentation for e.g. sap flows in deciduous trees is mostly caused by microorganisms and direct decomposition.

zoophagous (t6)

Lifestyles with animal-based diets. This category includes all lifestyles that depend on one or more individuals and consume parts or whole animals. This includes a wide variety of parasitic, predatory, and necrophagous lifestyles. Deliberately not included and considered completely separately is the diet of metabolic products such as feces, which is listed under "coprophagous" as a separate category.

mycetophagous (t7)

Diet based on the consumption of fungi. The grouping does not follow a systematic definition of fungi, so that different filamentous fungi are included as well as higher fungi with fruiting bodies. In some cases, the boundaries are fluid to the phytophagous category "saproxyllic", as some wood fungi certainly form the actual food of e.g. deadwood beetles. Binding to fungi was therefore only carried out for deadwood insects if the larva explicitly lives in fruiting bodies. For simplification, lichens were also included in this category, since the largest proportion (>99%) does not apply to them and the resolution is not fine enough.

saprophagous (t8)

Feeding behavior using fermenting moist situations such as sap flows on trees. The demarcation to other categories is basically fluid and difficult. We clearly limit ourselves to inhabitants of substrates with alcohol fermentation. These substrates can be, for example, sap flows, wet fermenting detritus situations, fermenting fruit or fermenting rotting mushrooms in leaf litter.

detritophagous (t9)

Feeding behavior in which detritus is decomposed. Here, the role of processing by microorganisms plays a major role. Detritus can be of plant, animal or fungal origin, with the plant part being the largest. The fineness of the substrate does not matter. The grazing of microfilm as well as fine organic material is also included in this category. While the distinction from carrion in the necrophorous category is simple, there is a difficulty in distinguishing it from decomposing foliage or other plant parts. Therefore, where very fresh and coarse structures are ingested, we categorize in the sub-categories of "phytophagous".

coprophagous (t10)

All diets that feed on animal feces. The size or systematic position of the animal does not matter. Likewise, it does not matter whether the feces are colonized when fresh or in varying degrees of decomposition. Or whether the droppings are freely available or are built up in nests (as in the case of urban pigeons, for example). A special case is faeces with extensive remains of chitin, hair, and bone parts. This case is classified in this category "necrophorous".

Phytophagous subtypes (t11-t20)**phyllophagous (t11)**

Leaf-feeding mode of life that consumes all living parts of the leaves as well as freshly dead leaves. The group includes both modes of life in which only individual cells of the underside of the leaf are eaten (e.g. Thysanoptera), those that eat whole leaves, and leaf-rolling taxa whose larvae develop in rolls or by eating killed and folded leaf parts, so-called cigars (e.g. Choreutidae, Rhynchitidae). Buds of leaves were also included. The transition is fluid here, especially in the category "detritophagous", as various leaf-eaters, for example, are also found here, which we delimit by the strong interaction of pre-processing microorganisms.

saproxylic (t12)

Feeding behavior in which woody plant parts are eaten, often in combination with fungi. The plant parts can be the woody body itself or bark, branches, woody fruit bodies or

seeds. In a few cases, living wood is eaten and dies as a result. The guilds of deadwood organisms are diverse; a rough distinction can be made between wood, bark, mulm, fungal wood and animal nests of cavity colonisers, all of which are grouped under this category here. The systematic classification of plants plays only a subordinate role. Deadwood occurs in both terrestrial and aquatic ecosystems.

sap-sucking (t13)

Special phytophagous way of life of the Hemiptera with unpaired sucking mouthparts, in which plant juices are ingested from a wide variety of plant parts. The distribution on plant parts does not play any further role for the classification. It does not matter whether saps are taken from leaves, stems, or roots. The category thus undifferentiatedly includes both xylem and phloem feeders. This category includes all honeydew producers that play an important ecological role in feeding other insects, especially in interaction with plant surfaces.

stem (t14)

Phytophagous diet that includes all living parts of stems. It does not matter whether the organisms consume outer parts of the stem in parts or completely or develop within them. Which tissues within the stem are consumed is also irrelevant. The boundary is drawn with woody plants such as trees and shrubs, whose stem inhabitants are placed in the "saproxylic" category.

flower (t15)

Diet in which all forms of flowers are consumed. This ranges from the consumption of flower buds to individual flower components (such as petals, sepals, or ovaries) including progressed fruit stalks.

seed (t16)

Diet in which all forms of seeds are consumed. This can be in the form of eating the whole fruit including seeds or eating the seeds within protective components such as pods or nutshells.

gall-inducing (t17)

Feeding type in which, in interaction with the plant, specific galls are formed with tissues in which feeding takes place. This group includes the clearly defined gall-forming insects. Purposely not included in this category are the diverse forms of secondary colonising parasitoids of various degrees of specialisation.

miners (t18)

This category contains mine-forming insects that develop within plant tissue as phytoparasites. In this process, plant tissue is consumed from within and the mine is left for pupation in some cases, in other cases only after hatching of the adult stage. The term "miners" is taken here to mean essentially leaf miners. Whenever a phytoparasitic lifestyle could be assigned to another plant part (e.g. seeds or stems), the classification is found there.

roots (t19)

A type of diet adapted to the consumption of underground plant parts. These may be living or dead roots of varying thickness, and in rare cases reservoirs such as tubers. Explicit deadwood organisms, whose biology essentially takes place in roots, are found within the category "saproxylic" due to their specialisation to wood as well as decomposing fungi.

not specified (phytophagous) (t20)

A summary category for diets that are either not yet fully elucidated or unspecific in terms of dietary intake of plant residues. In addition, all uncertainties that could not be assigned on the basis of the review carried out are also included here. The category thus combines a lack of biological knowledge and an error in processing.

Zoophagous subtypes (t21-t26)**predator (t21)**

A diet in which animal prey is killed for food. Feeding is not limited to one specimen of prey. The fitness of the prey animal is 0 after the predator has eaten. The size of the prey organism does not matter and there is only a limited time of co-existence between the prey specimen and the predator across a stadium. The predator is often larger than the prey, but this is only a tendency.

micropredator (t22)

Feeding behavior in which parts of one or more animals are eaten, but the prey is not killed. The fitness of the prey animal is present after the predator has eaten, although it may be weakened. The size of the prey organism does not matter and there is no co-existence between the prey and the predator across a stadium. The micropredator is often smaller than the prey, but this is only a tendency.

parasite (t23)

Feeding behavior in which parts of a single host animal are eaten but the host does not die to complete the life cycle

of the parasite or, in rare cases, does so due to secondary debilitation. The death of the host organism is therefore not a necessity for the development of the parasite. The number of parasites can be single or numerous per host. The ways of life are enormously varied. In Central Europe, there are only endoparasites within insects, which usually have a winged adult stage in at least one sex. When feeding, there is co-existence over a longer span between prey specimen and predator, often over one stage. A typical order is represented by the Strepsiptera.

parasitoid (t24)

Feeding behavior in which a single host animal is attacked and dies towards the end of the parasitoid's life cycle. The death of the host organism is decisive for the classification. The number of parasitoids can be single or numerous per host. The ways of life are enormously varied. For example, there are ectoparasitoids that eat into the host organism to pupate or endoparasitoids that pupate inside or outside the host. When feeding, there is co-existence over a longer time span between host specimen and parasitoid, often over a stadium. In Central Europe, hyperparasitoids and hyperhyperparasitoids have also been documented in the order Hymenoptera, whose host organisms are accordingly parasitoids or hyperparasitoids. An example of such assemblages are galls of the Cynipidae, which are secondarily colonised by various hyperparasitoids.

necrophorous (t25)

Diet in which dead animal material is consumed. This can either be the carrion of dead animals directly or individual components that come from an animal. In the latter case, this can be prey remains, hair remains, feathers, chitinous remains, or built-up material in nests or tunnels. The size of the animal or its systematic position does not matter. A special case is faeces or pellets with extensive remains of chitin, hair, and bone parts. In this case, they are classified in this category and not under "coprophagous".

not specified (zoophagous) (t26)

A summary category for diets that are either not yet fully elucidated or unspecific in terms of dietary intake of animal residues. In addition, all uncertainties that could not be assigned on the basis of the review carried out are also included here. The category thus combines a lack of biological knowledge and an error in processing.