TRICHOPTERA LARVAE OF FINLAND

AKI RINNE

PETER WIBERG-LARSEN

IDENTIFICATION KEY TO THE CADDIS LARVAE

OF FINLAND AND NEARBY COUNTRIES

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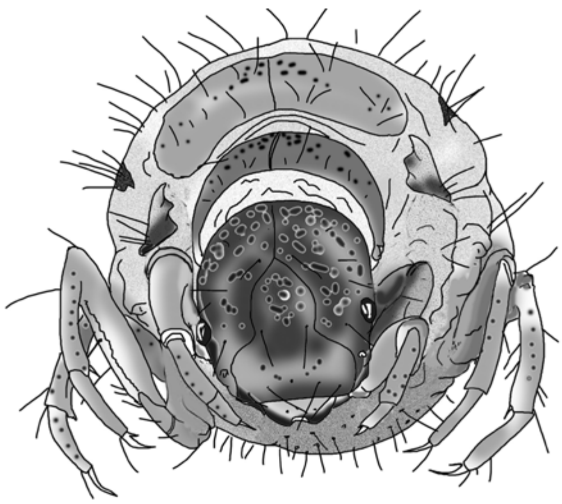
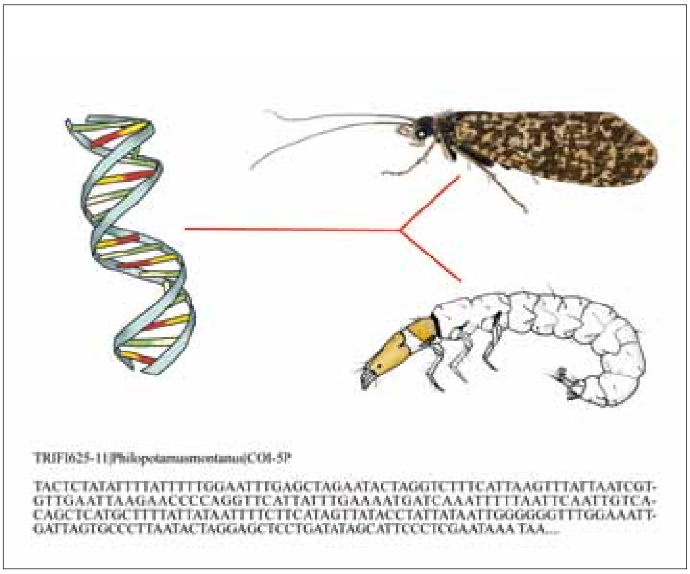


PREFACE

This is the first comprehensive key for identification of larvae of the Trichoptera species inhabiting northern Europe. Until now, identification of Trichoptera specimens sampled within this area has relied on the key to genera published by Solem & Gullefors (1996), supplemented with the key to species from the British Isles (Wallace et al. 2003), and on publications describing only specific species or presenting keys to single families or genera (e.g. Solem 1970, 1971, 1972, 1981, 1983, 1985; Wiberg-Larsen 1979, 1980; Wiberg-Larsen & Waringer 1998).

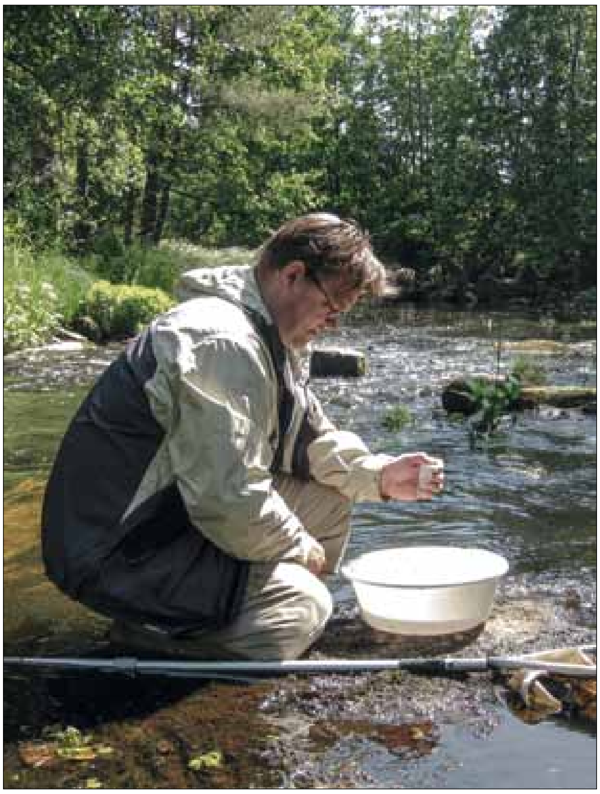
The relative scarcity of taxonomic literature on Trichoptera in northern Europe is somewhat surprising given the rather intensive interest from both amateurs and professionals during the last century, for instance A.J. Silfvenius/Siltala, O. Nybom (Finland), P. Esben-Pedersen, A. Nielsen, P. Wiberg-Larsen (Denmark), T. Andersen, J.O. Solem (Norway), G.M. Gislasson (Iceland), and B. Tjeder, B.W. Svensson, and B. Gullefors (Sweden).

Providing a key like this for Finland and its neighbouring countries has been a challenging task, requiring more than ten years of work involving field trips to collect material, microscopy, drawing or photographing details and, not least, constructing and testing the keys. Not only is the number of species relatively high, about 240 species being recorded in Finland and its neighbouring countries, but the book also includes 17 species for which the larvae have been unknown and several others hitherto only insufficiently described. Historically, association of larvae with their corresponding adults has relied on either rearing from larvae to pupae and adult or from eggs to mature larvae, a process that is both time-consuming and technically challenging.



However, recent barcoding techniques (using nuclei acid sequence analyses on mitochondrial DNA) have provided an important breakthrough in the work on Trichoptera identification, rendering association of adults with their larvae more reliable and easier. Despite this technical progress and sample efforts, the larvae of about 30 species (mostly Hydroptilidae) are still unknown or insufficiently described and therefore not included in the present keys for identification.

With this book we hope to make the biodiversity and fascinating life of Trichoptera larvae available to all – professionals as well as amateurs – with interest in our fresh and brackish waters.



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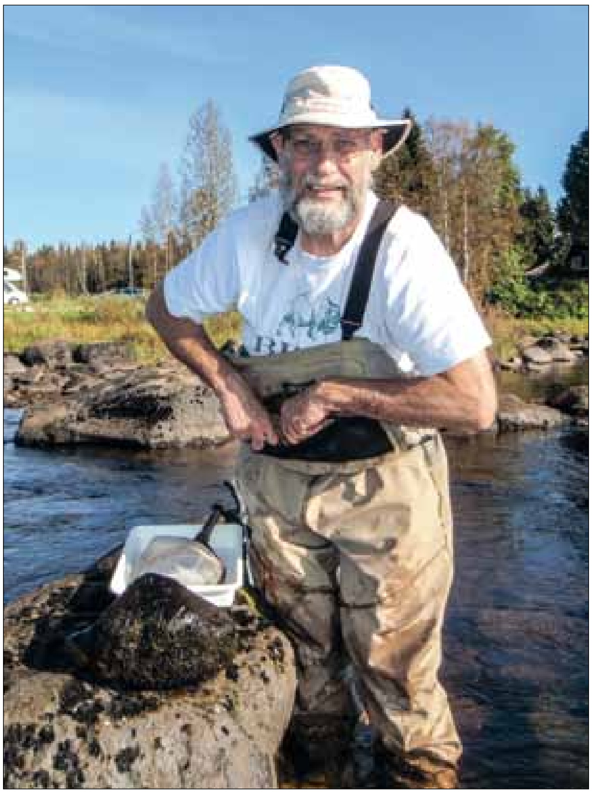

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BIODIVERSITY, BIOLOGY & ECOLOGY

World-wide, more than 14,500 species of Trichoptera belonging to 616 genera and 49 families are listed in the "Trichoptera World Checklist" (by September 2016). Although on a global scale, Trichoptera is one of the smaller insect orders compared with the big four orders (Coleoptera, Diptera, Lepidoptera and Hymenoptera) and only just qualifies to be in the "top ten", they are very prominent in freshwater bodies. Thus, world-wide, the order is more species-rich than other insect orders and arthropods in the freshwater environment.

In the Palearctic region (which includes Europe), there are more than 1500 species, belonging to 149 genera and 23 families. However, the species number decreases considerably towards the north to approx. 15% of the European fauna (Wiberg-Larsen 2005). At present, 218 Trichoptera species have been identified in Finland. Compared with the adjacent countries, this number is slightly lower than in Sweden where 224 species have been recorded so far (Gullefors 2015), but higher than in Norway (201 species: Kjærstad et al. 2010, Andersen & Hagenlund 2012, Ekrem et al. 2012) and Estonia (190 species: Viidalepp et al. 2011). The number of species in northern Europe are shown at the map below (data for Russian areas based on Ivanov (2011)).

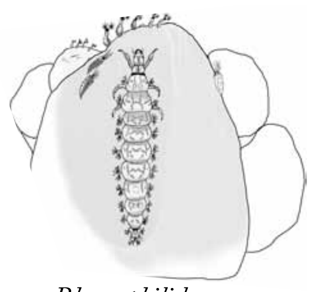
Overall, the number of Trichoptera species is expected to increase with the size of a water body. This has been nicely documented for near-pristine lowland Danish streams ranging from tiny brooks to small rivers (Wiberg-Larsen et al. 2000). The same pattern applies to the continuum of standing waters from the tiniest pools to the largest lakes. There are at least two reasons for this pattern that may also be observed for other groups of organisms. First of all, large water bodies may hold a larger number of individuals than small ones, which augments the chances of occurrence of more species. Furthermore, large-sized water bodies may contain more habitats than small ones, thereby offering favourable life conditions for more species.

Trichoptera are an important element in the biological structure of stagnant and running waters. In North-Europe, they belong to the top three, most species-rich animal groups, only being outnumbered by Chironomidae in streams and rivers and by Chironomidae and Coleoptera in pools, ponds and lakes. Not only do the larvae process dead or live organic matter, they also serve as food for top predators like dragonflies, amphibians, several fish species and a suite of birds, ranging from the dipper, grey wagtail, waders to grebes and ducks. Furthermore, their adult stages enter the terrestrial food webs where they act as prey for, for instance, spiders, predaceous beetles, numerous birds and bats.

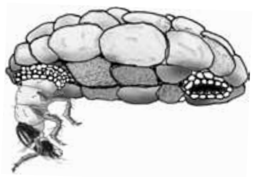
Constructions

Trichoptera are probably best recognised by nature-interested persons by their portable cases that are constructed from different materials such as fine gravel, sand, fresh or dead pieces of plant materials or of silky material only. Furthermore, the larvae have traditionally been classified as either case-bearing or free-living, although this is not a correct interpretation. Actually, only one family (Rhyacophilidae) includes truly free-living species that only construct a case of coarse mineral particles fixed to a stone when the larva is about to pupate. All other families without portable cases build either retreats on macrophytes, stones or logs (associated with capture nets – see below), or long tubes of fine mineral or organic particles that are fixed firmly to stones or logs.

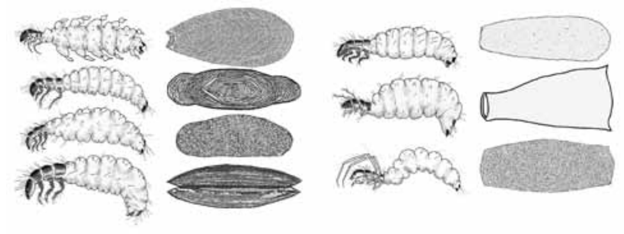
The ecological success of Trichoptera seems to be closely associated with their ability to produce strong silky treads that are used either to glue together case material or produce nets for filtering fine organic particles or capturing prey. As for Lepidoptera, the silk is produced by labial glands composed of a few tens or hundreds of large polyploid cells secreting polymerising proteins that are stored in the gland lumen as a semi-liquid gel (Sehnal & Sutherland 2008). The conversion (polymerisation) of this gel into



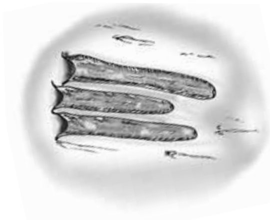
Rhyacophilidae



Glossosomatidae



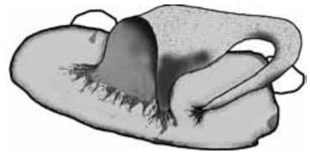
Hydroptilidae



Philopotamidae

Arctopsychidae & *Hydropsychidae*

Psychomyiidae



Polycentropodidae

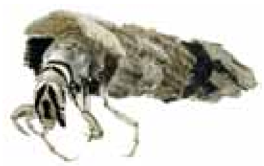
Brachycentridae

Lepidostomatidae

Goeridae

Molannidae

Odontoceridae



Phryganeidae

Leptoceridae

Beraeidae

Sericostomatidae

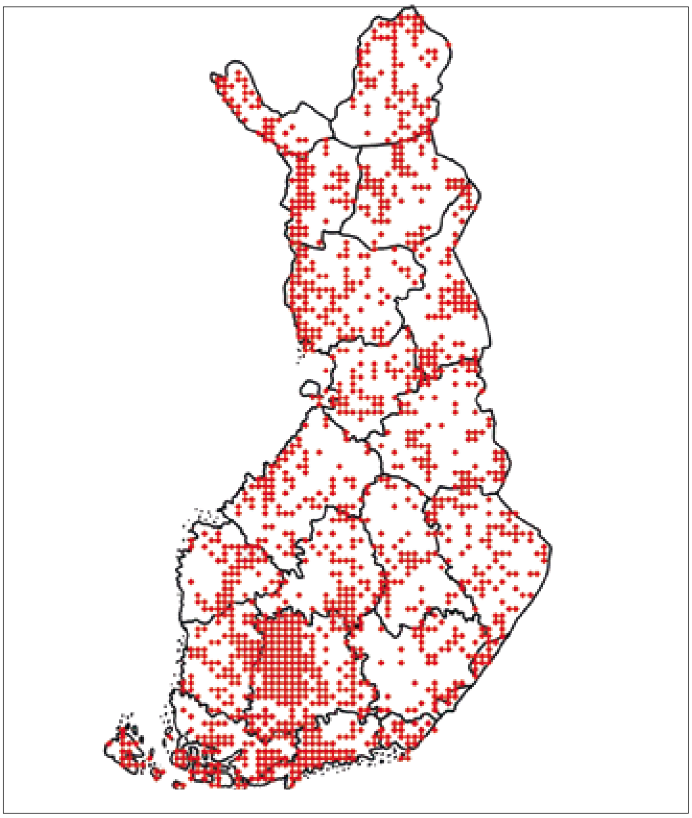
Apataniidae

Limnephilidae

TRICHOPTERA OF FINLAND

At present, a total of 218 Trichoptera species, belonging to 76 genera and 19 families, are recorded in Finland. A detailed checklist is presented on pages 123-129, including occurrences in the 21 Finnish provinces. This checklist also includes the recent assessment of their national conservational status, the so-called red-listing.

Suborder	Family	Genera	Species
Annulipalpia	Arctopsychidae	1	1
	Ecnomidae	1	1
	Hydropsychidae	2	9
	Philopotamidae	3	3
	Polycentropodidae	5	14
	Psychomyiidae	3	4
Integripalpia ("Spicipalpia")	Glossosomatidae	2	3
	Hydroptilidae	8	32
	Rhyacophilidae	1	3
Integripalpia	Apataniidae	1	8
	Beraeidae	2	2
	Brachycentridae	3	3
	Goeridae	2	2
	Lepidostomatidae	2	2
	Leptoceridae	8	30
	Limnephilidae	21	77
	Molannidae	2	5
	Phryganeidae	8	17
	Sericostomatidae	2	2



Maps (including 76 550 records / 636 876 specimens) in pp. 129-147 is based on Finnish YKJ coordinates with 10 km^2 accuracy.

REGIONAL BIODIVERSITY

The climate in Finland is overall continental but shows the characteristics of maritime influence when westerly winds prevail. The climate is therefore considerably milder than in areas situated at similar latitudes (e.g. South Greenland and Siberia). Due to the north-south orientation and size of the country, the temperature regime differs widely between its regions, the mean differences between north and south being about 12 and 5°C in January and July, respectively (see also figure D, page 13). Consequently, the country encompasses several ecoregions or vegetation zones (the boreo-nemoral zone and the northern, middle and southern boreal zones) with different climatic conditions. It is therefore not surprising that the distribution of the Trichoptera species shows a very distinct pattern, as also recognised for other groups of organisms.

Analyses of the data presented on pages 123-129 show that the number of species decreases significantly from south to north (according to latitude; see figure B, page 13). Similarly, the species composition change markedly with latitude and ecoregion (see figure C, page 13). The changes in both species number and composition are continuously, reflecting the gradient in climate and most prominently the differences in temperature regime.

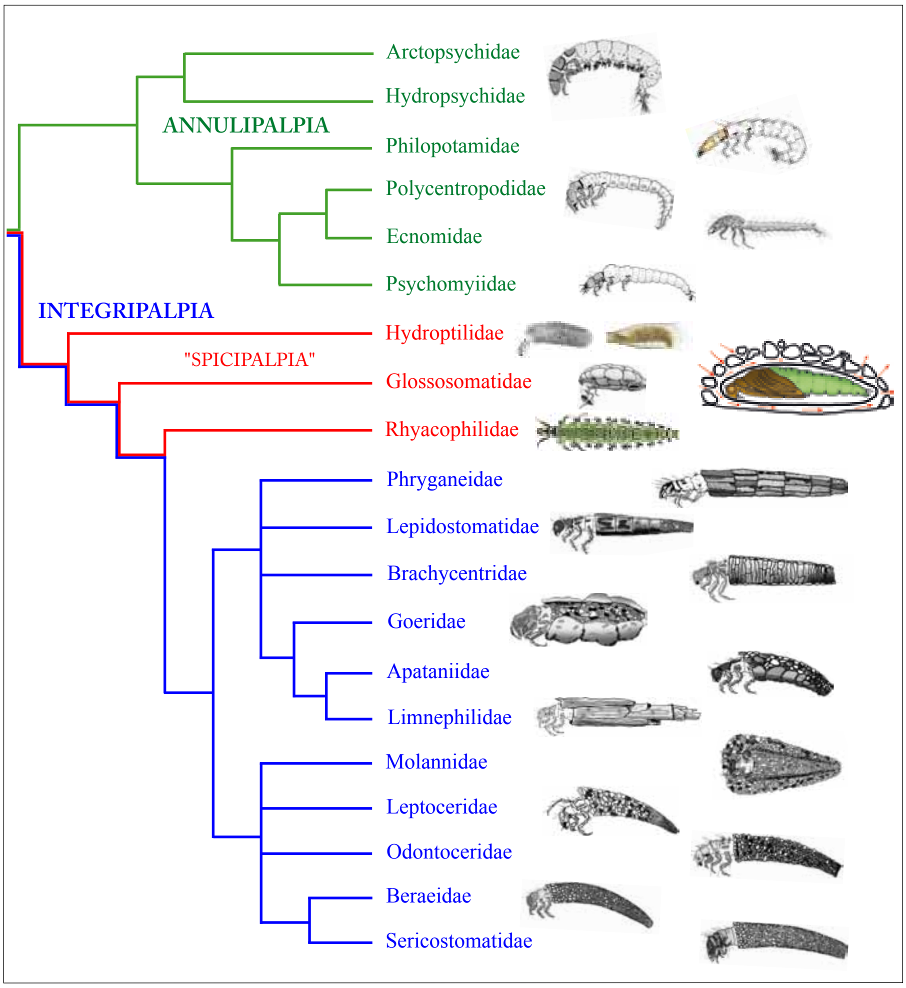
Despite the regional differences in species number and composition, many Trichoptera species have a very wide distribution and are found all over or almost all over the country. Thus, 40% of the species occur in 19-21 of the provinces, whereas approximately 75% of the species are found in half of the provinces. However, some species (about 15%) show limited distribution and are only found in five or fewer provinces. It is these species that are the primary responsible for the differences in species composition. Among this group of species some have a distinct northern distribution, others a predominantly southern distribution (see maps on pages 130-147).

Temperature influences the species in many ways by impacting all biological processes and their outcome (growth rate, size, initiation of diapause, success of egg laying, fecundity etc.). Low temperatures may affect and exclude species either directly (e.g. the species have higher temperature optima or are sensitive to bottom freezing of the habitats) or indirectly by reducing the availability of food resources. So, the simple explanation for the identified north-south patterns is that the harshening of the climate going northwards impoverishes the life conditions for the species. There is also a minor east-west gradient in species composition, maybe reflecting the influence of a milder marine climate. The patterns identified for Trichoptera are consistent with the findings in similar analyses of data for crane flies (Tipuliodea) (Salmela 2012) and probably apply to many other groups of plants and animals.

The biogeographical provinces are not of equal size, which may also influence species composition patterns. However, our data (see figure A) does not support any significant correlation between either number of species or species composition and province size, probably because the size range (3000-25 000 km^2) is not very big. The same conclusion could probably be drawn if only the area of the freshwater habitats is considered.

CLASSIFICATION

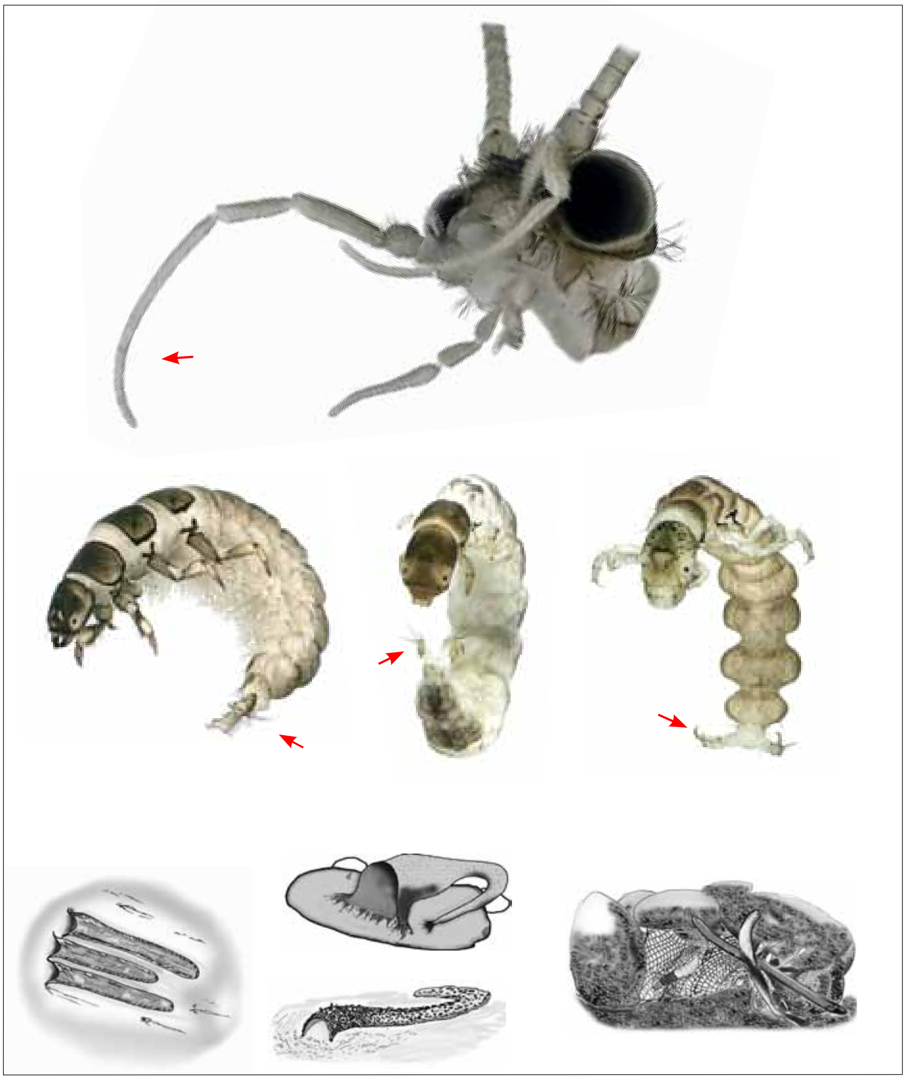
Although monophyly (i.e. a group of taxa consists of an ancestor and all its descendants) is well established for Trichoptera, there are still uncertainties about the relationships between suborders and families. Classification based on morphology and life history has overall identified three potential suborders: Annulipalpia, "Spicipalpia" and Integripalpia (Ross 1956, Ross 1967, Wiggins & Wichard 1989, Wiggins 1996). However, recent classification including molecular markers (rRNA, EF-α1, COI, and CPSase II (CAD protein)) as well as morphology have established Annulipalpia and Integripalpia as monophyletic suborders (Holzenthal et al. 2007, Malm et al. 2013, Kjer et al. 2016). It is also agreed that “Spicipalpia” is paraphyletic (i.e. the group includes some but not all the descendants of a common ancestor: the reason for using the term “Spicipalpia”), but its position and status is still questionable (Malm et al. 2013, Kjer et al. 2016). The most recent classification representing the hitherto most comprehensive dataset places “Spicipalpia” (known as "closed-cocoon makers") within Integripalpia. This classification is followed in the present book (see figure, redrawn from Kjer et al. 2016), although below we presents specific adult, larval characters, and biological traits for all three taxa (please consult "Morhology" for further explanations of the used terminology).



Annulipalpia

- The apical segment of the maxillary palps of adults is flexuous, multi-articulated, annulated and relatively long (sometimes longer than all the other segments together).

- 9th abdominal dorsum of larvae without sclerotized plate; anal prolegs are elongated, flexuous, with long lateral sclerites and down-directed terminal claws. 1st abdominal segment lacks dorsal and lateral protuberances.



Corresponding to the different ecological adaptations, larvae build (I) meandering tubes of sand grains or fine wooden particles glued together by silk and feed on bacteria, diatoms and fungi (scrapers), or (II) fixed retreats associated with spun silky nets for filtering fine organic particles or for capturing small invertebrate prey. Larvae occur, depending on family/species, in stagnant and/or running waters.

MORPHOLOGY

The larvae exhibit the general pattern of holometabolous insect larvae with a distinct head capsule, a thorax divided into three segments that each carries a pair of well-developed legs and ten abdominal segments including the most apical segment carrying the anal prolegs. The morphological terminology used in the following is mainly adopted from Wiggins (1996).

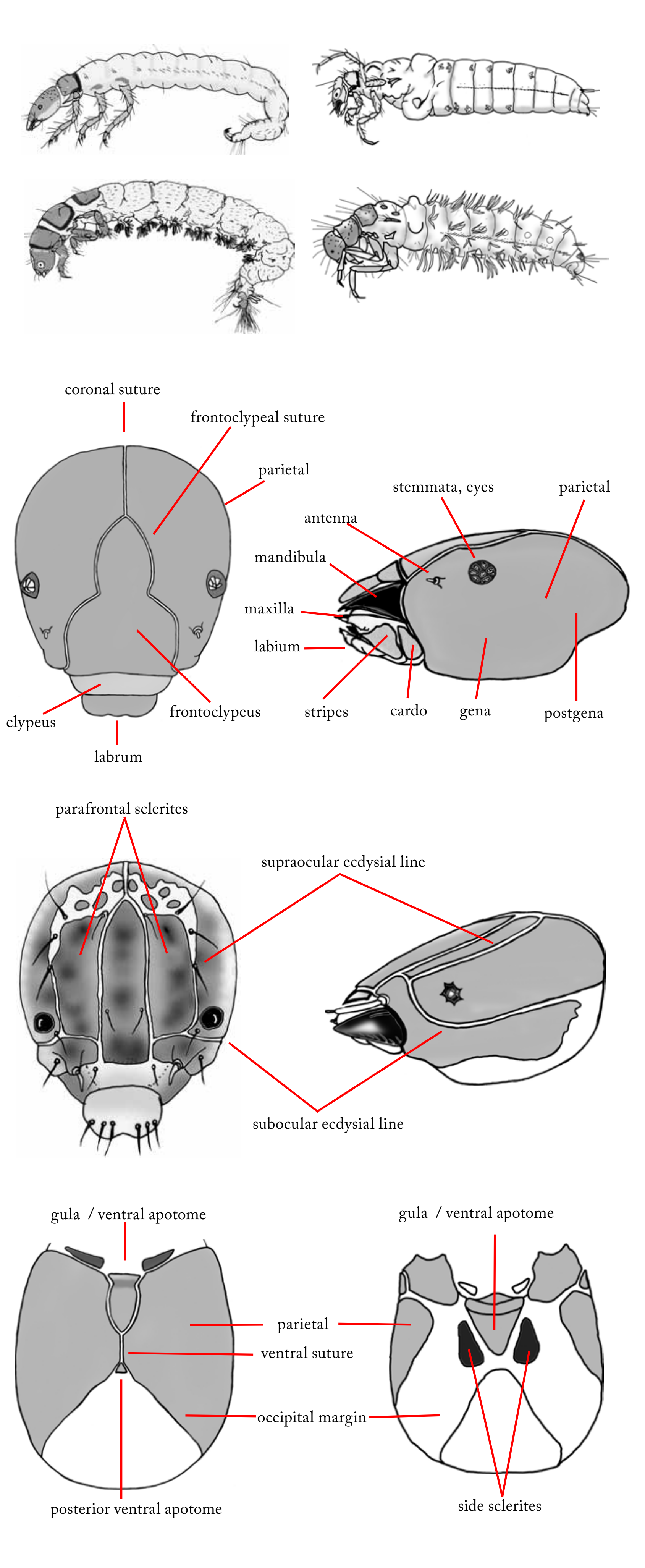
Head

This appears as a solid head capsule almost entirely made up of hard chitin plates (*sclerites*) separated by narrow sutures, whereas mouthparts like *maxillae* and *labium* are covered by elastic or semi-elastic *epithelia*. Dorsally, and placed central, is a more or less triangular *frontoclypeus* (or *frontoclypeal apotome*). The *coronal suture* (situated dorsally) and the *ventral ecdysial line* split the head capsule into two large parts called *parietals*. The ventral parts of the parietals are termed *genae*. A triangular or quadrangular sclerite *gula* (or ventral apotome) is located on the ventral side of the head between the genae, its dimensions being highly variable. The structures described above are shared by all species. However, some members of the family Leptoceridae have additional quadrangular *parafrontal* sclerites on their faces, which are separated by *supraocular ecdysial lines*. The lateral surface of the head may also be separated by a *subocular ecdysial line* in the middle of the genae.

Appearance of the head is highly variable. In the suborder Annulipalpia and taxon "Spicipalpia", the profile of the head is mostly elongated and somewhat flattened dorso-ventrally. Species of the suborder Integripalpia (ex. "Spicipalpia") have more round heads, their faces being concave, convex and sometimes furnished with ridges and spikes. This is an adaptation to prevent predation as the head may seal the circular "outdoor" of their cases tightly. Colouration of the head may also in combination with the case be seen as an adaptation to minimise predation, depending on the camouflage effect in the preferred habitats of the larvae.

Spines and setae

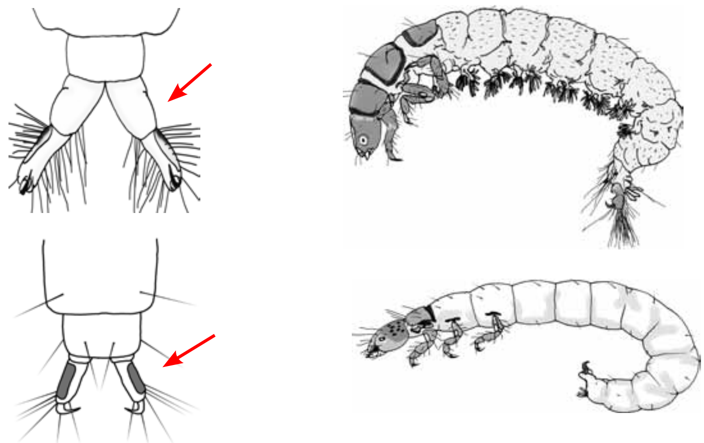
All species are furnished with *primary setae*. The distinction between *spines* and *setae* is in principle straightforward. However, use of other terms may cause confusion. Spines (processes, spikes, combs) are simple extensions of the cuticle, being an integrative part of this, and may take multiple forms: short and pointed, longer and bladelike, comp-shaped etc. They are primarily protective structures or facilitate feeding. Setae are articulated structures (bristles, hairs, flattened scale-setae or stout spurs) arising from alveoli



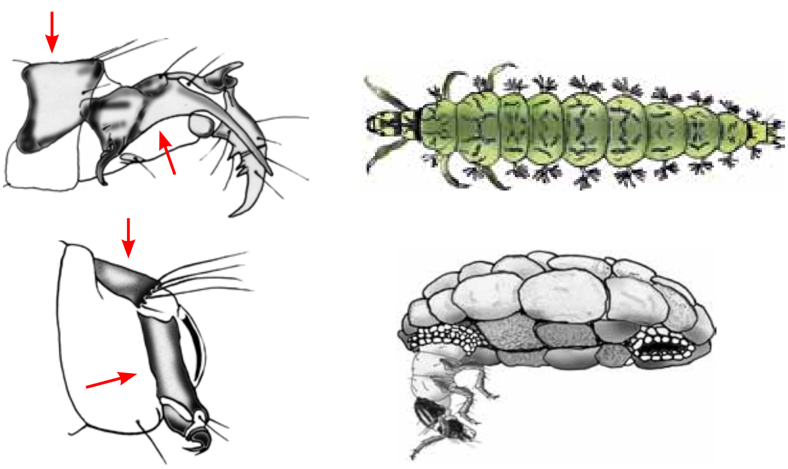
KEY TO FAMILIES

The key follows a traditional dichotomous form, following numbered steps. At each of these steps, the user has to choose between the 2 or occasionally 3 alternatives, and proceed to the next numbered step. The key generally applies to larvae at instar V unless other information is given. However, III-IV instar larvae may normally be identified as well.

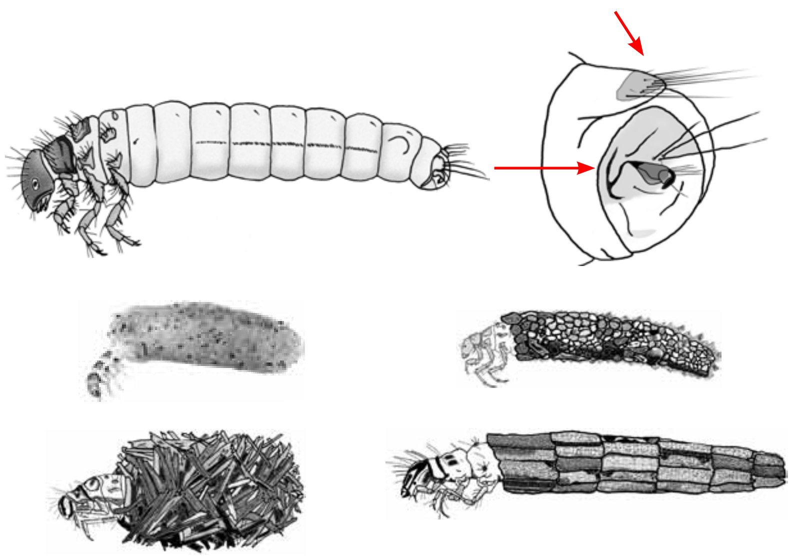
1 Anal prolegs predominantly long, free and flexuous, with longitudinal aligned lateral sclerite(s), **and no single** large sclerotized plate on 9th abdominal dorsum (a pair of very small sclerites may be present). Before metamorphosis larvae never build portable cases, but construct either (**a**) long slender tubes of fine debris/sand grains on stones or dead wood, or (**b**) retreats of coarse mineral/organic material fixed on wood, stones or plants, and associated with spun capture nets. **2**



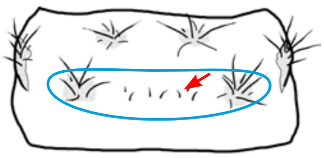
\- Anal prolegs predominantly long with longitudinal aligned lateral sclerite(s) **and** 9th abdominal dorsum with distinct **single** large sclerotized plate. Larvae either free living or build portable tortoise-like cases, constructed of sand grains. **6**



\- Anal prolegs short and squat, with a transversely aligned lateral sclerite(s) **and** 9th abdominal dorsum with **single** large sclerotized plate (or transverse row of setae group(s) where sclerite should have been located). Larvae build various types of portable cases, constructed of mineral and/or organic particles, fresh plant fragments, or of silky secretion only. **7**

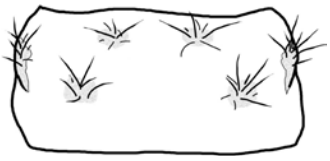


4 Metadorsum with at least 1 seta on soft cuticle between posterior setae areas (sa2). ....***Limnephilus sparsus***

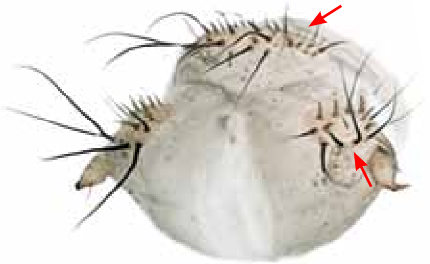


Case curved, usually of small plant pieces arranged tangentially (looking exactly like that of *Rhadicoleptus alpestris*). On sandy and gravelled beds the case may be constructed partly or entirely of sand grains. Very common, except in the extreme north. Temporary pools on rich fens, alongside lakes and rivers, and in mires.

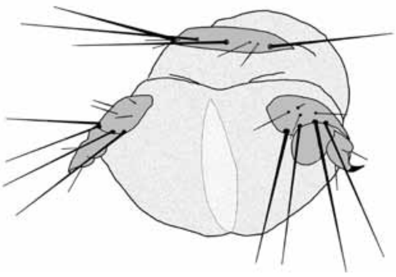
\- Metadorsum without setae on soft cuticle between posterior setae areas (sa2). **5**



5 Lateral sclerite of anal proleg and sclerite of 9th abdominal dorsum with at least few squat dagger-like yellow or brown setae on the faces. ....***Rhadicoleptus alpestris***

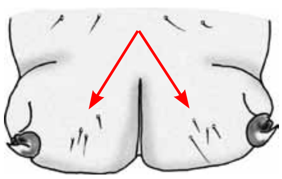


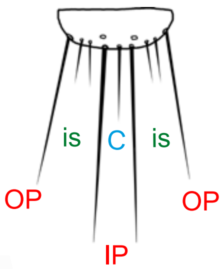
Case curved, of small plant pieces arranged tangentially (like in *Limnephilus sparsus*). Common in the mainland, relatively rare in the archipelago. In small temporary and permanent pools of mires and wetlands; usually among *Sphagnum* mosses and roots of *Eriophorum vaginatum*.

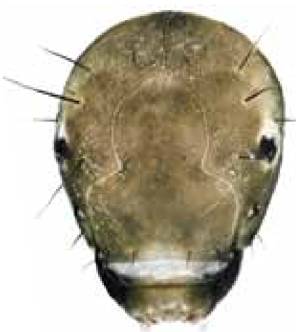


\- Lateral sclerite of anal proleg and sclerite of 9th abdominal dorsum without squat dagger-like setae on the faces. **6**

6 Small additional setae (as) present ventrally on soft cuticle between anal prolegs. Sclerite of 9th abdominal dorsum with 1 central seta C. All intermediate setae (is) between innermost and outermost primary setae (IP-OP) short, less than ¼ as long as outermost primary setae (OP). .... ***Limnephilus vittatus***

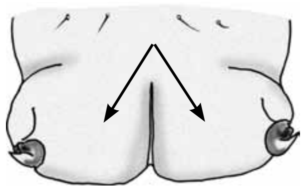


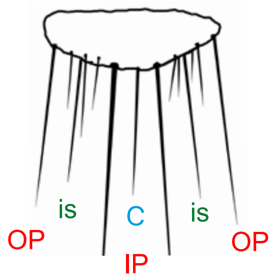




Case curved, of sand grains; anterior end dorsally notched. Stony, gravelled and sandy beds of open shallow fishless pools and ponds. In islands and islets of Baltic Sea the species inhabits small rock-pools filled mostly by rain, partly by spatters of waves. Widely distributed, but local.

\- Small additional setae absent on soft cuticle between anal prologs. Sclerite of 9th abdominal dorsum with 1 (exceptionally with 2) long central seta(e) C. At least 1 intermediate setae (is) between innermost and outermost primary setae (IP-OP) being ⅓ to nearly as long as outermost primary seta (OP). **7**

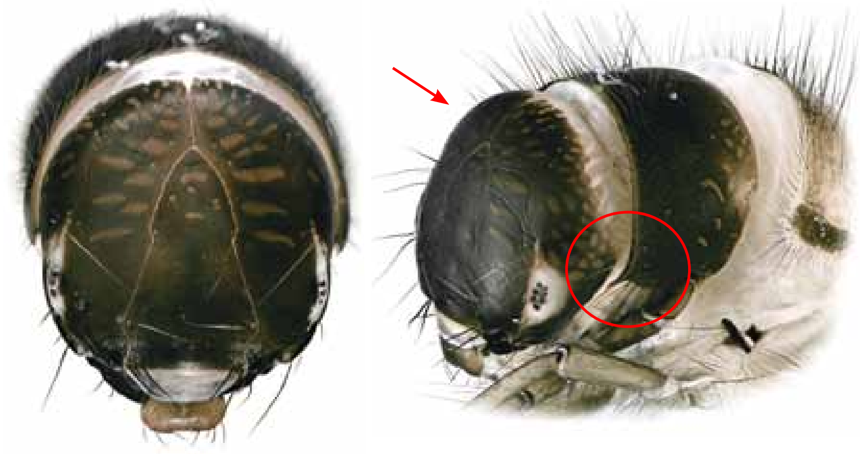




Limnephilidae Sub-key C

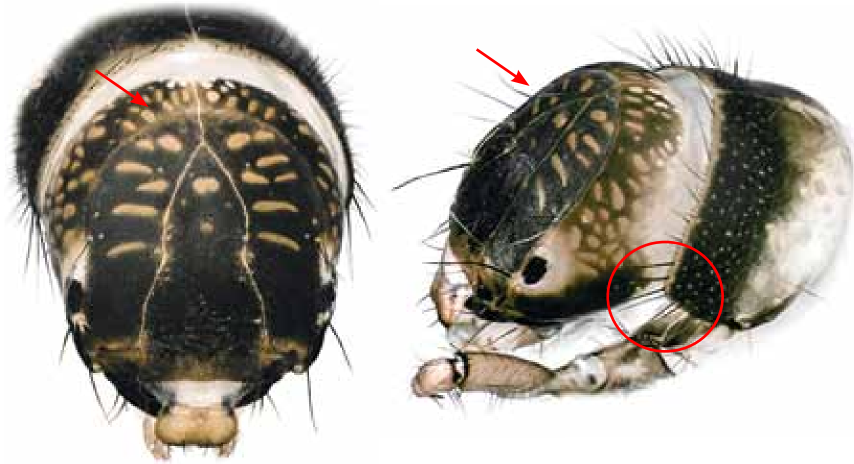
SERICOSTOMATIDAE

Larvae up to 17 mm. Antenna situated at or very close to anterior margin of the head capsule. Pronotum and mesonotum sclerotized, metanotum membranous with numerous bristles. Protrochantin large, with hook-shaped apex. Prosternal horn absent. 1st abdominal segment with small dorsal and lateral protuberances. Abdominal gills present, lateral fringe absent. Anal prolegs with dorsal clusters of at least 30 setae. Case of small equally sized flat sand grains, joined edge by edge creating a smooth case surface.



1 Anterior-lateral corner of pronotum with pointed apex. Ridge on lateral margin of dorsal surface of head prominent only on its anterior half. .... ***Sericostoma personatum***

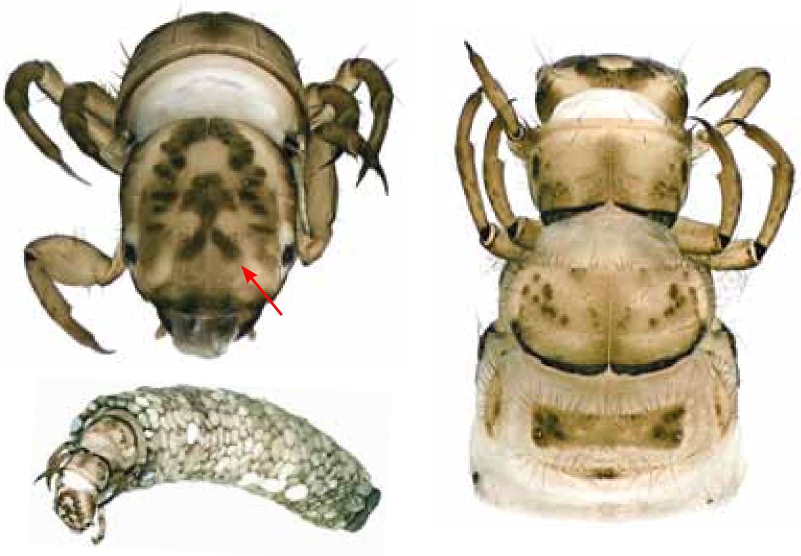
Sandy-silty beds of various size brooks and rivers; in southern provinces larvae live mainly in spring brooks. Larvae usually live out of sight within the sediment. Life cycle includes 7 instars and takes 2-3 years. Widely distributed, but local.



- Anterior-lateral corner of pronotum without pointed apex. Ridge on lateral margin of dorsal surface of head reaches to coronal suture and frames face anteriorly. ......***Notidobia ciliaris***

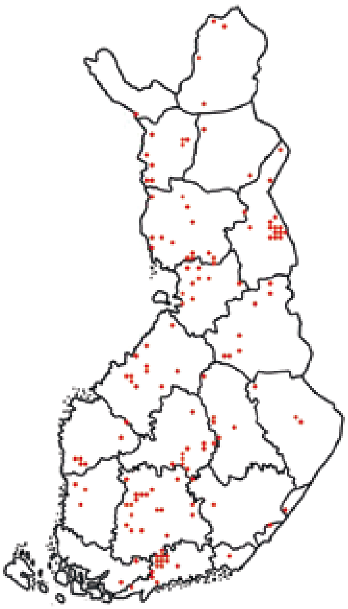
Sandy-silty beds of brooks and small rivers. Towards south (e.g. in Denmark) the species inhabits also littoral zone and outlets of lakes. Larvae usually live out of sight within the sediment. Life cycle probably univoltine. Relatively rare and local.

ODONTOCERIDAE

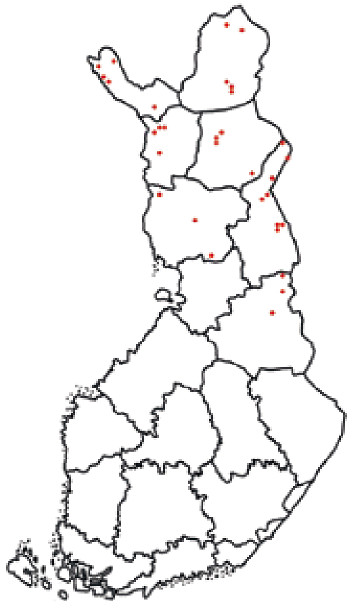


1 Frontoclypeus with characteristic dark anchor-shaped figure (Instars IV-V). Protrochantin small, apex not hook-shaped. Metanotum with large quadrangular anterior-median sclerite. Lateral sclerite of anal proleg with no more than 3-5 long setae; few small spines usually present. .... ***Odontocerum albicorne***

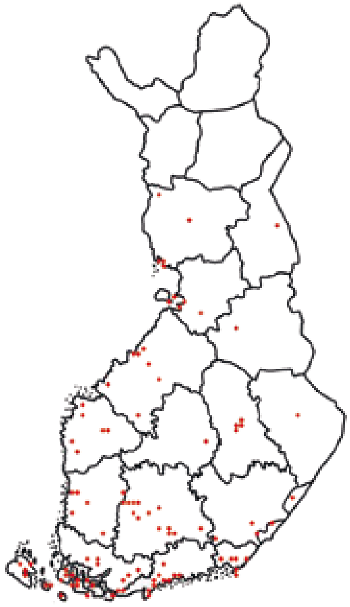
Not recorded from Finland, the nearest records are from Estonia, southern Sweden and St. Petersburg area. Case of coarse sand grains. In brooks and small rivers.



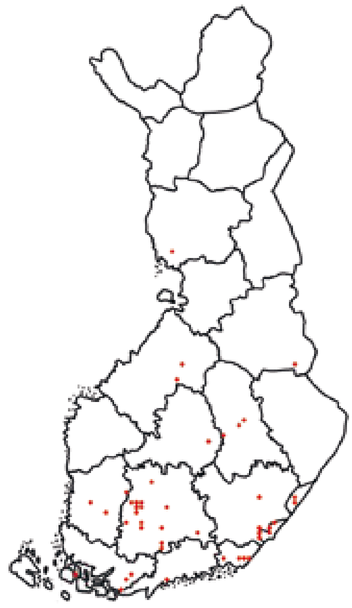
Agapetus ochripes



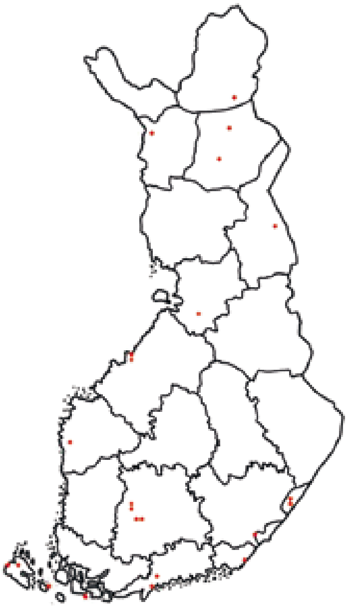
Agraylea cognatella



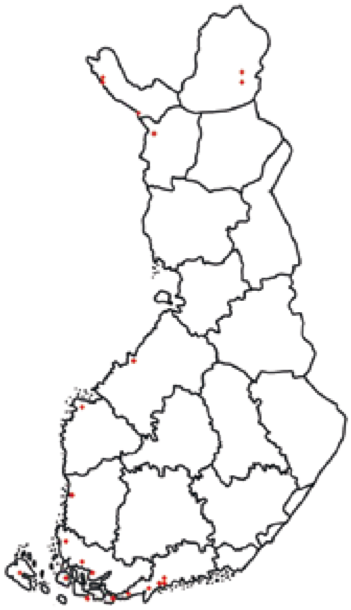
Agraylea multipunctata



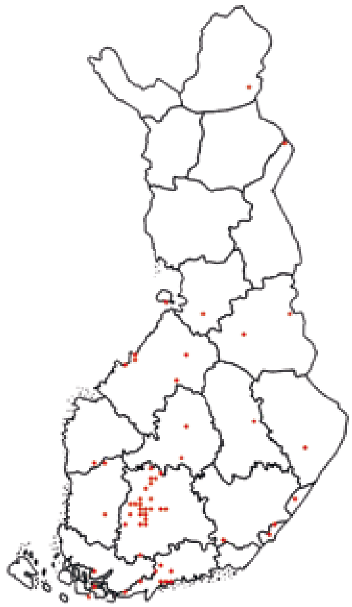
Agraylea sexmaculata



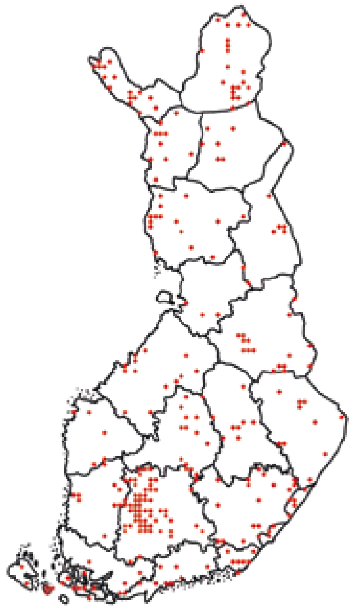
Agrypnetes colorata



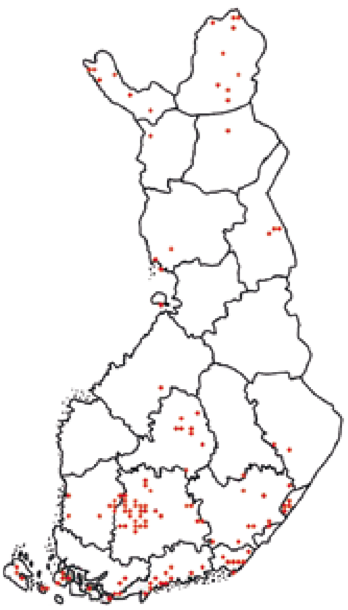
Agrypnetes crassicornis



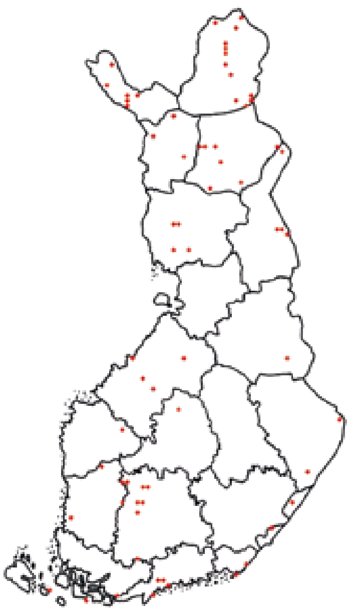
Agrypnia czerskyi



Agrypnia obsoleta

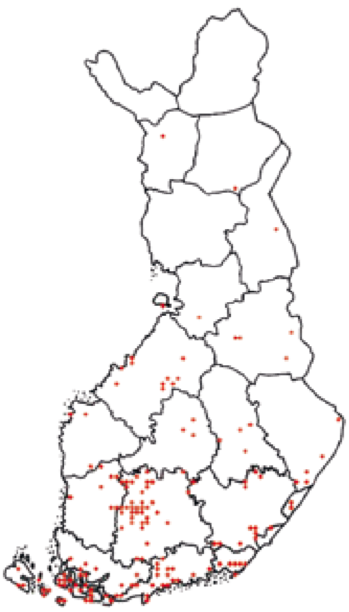


Agrypnia pagetana (+ p. hyperborea)



Agrypnia picta

Agrypnia sahlbergi



Agrypnia varia