

Characteristic and diagnostic features of the most frequently occurring species of the Thripidae family (Insecta, Thysanoptera) in crown canopies of Central European forests

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Abstract. The paper presents characteristic and morphological diagnostic features of females and second larval instar of six terebrantian species: *Oxythrips ajugae* Uzel 1895, *O. bicolor* (O. M. Reuter 1879), *Taeniothrips inconsequens* (Uzel 1895), *Thrips calcaratus* Uzel 1895, *T. minutissimus* Linnaeus 1758 and *T. pini* (Uzel 1895). The species are the most numerous and frequently caught in traps in the canopy layer of various Central European forests. Both adults and larvae of *Oxythrips* spp. may be easily recognized by features present at the end of their abdomen: the former by length of the abdominal segment X; the latter by differences in the length and position of spines. Adults of other the species mentioned above differ in the following features: number of antennal segments, number of setae in the distal part of their first pair of wings, presence or absence of additional setae on abdominal sternites and pleurites, presence or absence of a tooth on the tarsus of the first pair of legs. The main features differentiating larvae of these species (besides *T. pini* larva which have been hitherto undescribed) are body sclerotisation and length, and shape of the comb surrounding the IXth abdominal segment.

Key words: Thysanoptera, Terebrantia, morphology, second larval instar, canopy layer

1. Introduction

The thrips order divides into two suborders: Terebrantia, which includes smaller insects (measuring 1-3 mm), mainly connected with green plants, and Tubulifera converging slightly bigger species (3-15 mm), both herbivorous and mycetophagous. In both suborders, predatory species are poorly represented. Apomorphic feature which differentiates thrips from other insects is the asymmetric structure of piercing-sucking mouthparts which has no right mandible. Left mandible with jaws is used for puncturing tissues. The maxillary stylets create a tunnel, through which the salivary secretion runs down and is also used for sucking food. Two larval instars and adults present the highest alimentary activity. The propupa and pupa stages (in Tubulifera there are two pupa stages) are usually inactive and do not nourish themselves (Moritz 1997). The thrips, both in direct and indirect way, contribute to

the damage of plants and sometimes even to plant decay which causes economic loss. Due to sucking mesophyll cells by herbivorous species, discoloration occurs on leaves or flowers which subsequently leads to deformation, languishment, and early fall. Some of the species from Terebrantia suborder have the ability to convey plant viruses which are collected from the infected plants only by larval stages. Therefore, only imago stage is a virus vector for thrips (Whitfield et al. 2005).

In the age of global trade, it is easier for extraneous species to extend on new territories; not having natural enemies, they can become the invasive species. The ability for parthenogenetic reproduction facilitates thrips with the process of colonization and migration on new areas. An example is *Thrips calcaratus* (Uzel 1985), which were dragged to North America and now have become a major pest in forests, causing basswood tree defoliation (*Tilia americana* L.) (Raffa, Hall 1988; Raffa 1991).

In Poland, 226 species of thrips were found hitherto – 152 belong to Terebrantia and 74 to Tubulifera (Kucharczyk 2007; Plesz 2010 and verbal inf.). Among them 51 are connected alimentarily with trees and bushes. In this group, 23 species prey on leaves and on flowers in crown canopies and on bushes: 18 belong to the Thripidae family (Terebrantia) and 5 to Phlaeothripidae (Tubulifera). The remaining 28 species from Phlaeothripidae family are mycetophagous that live on decaying wood.

Despite numerous presence of thrips, it is because of their small sizes and often a hidden lifestyle that they are usually omitted in faunal and ecological research. Sometimes they are being treated as a group, without proper identification to species rank or at least a suborder, regardless of the fact that differences between representatives of both suborders are clear and visible when using a stereoscopic microscope with a low magnification (Schliephake, Klimt 1979; Moritz 1994, 2006; Mound, Kibby 1998). Usually adult specimens are identified from collected thrips, without the notification of larvae which are often much more numerous than imago and easier to collect due to their appearance on host plants. They also occur numerously in traps (Vierbergen et al. 2010).

The purpose of this research is to show distinctive morphological features of females and second larval instar of six, related with trees, terebrantian species from the Thripidae family: *Oxythrips ajugae* Uzel 1895, *O. bicolor* (O.M. Reuter 1879), *Taeniothrips inconsequens* (Uzel 1895), *Thrips calcaratus* Uzel 1895, *T. minutissimus* Linnaeus 1758 and *T. pini* (Uzel 1895). Selected features will allow (without making microscope slides) us to recognize species most numerously and frequently caught in traps and collected during shaking trees and bushes leafy branches in forest communities. Due to the fact that larvae of *T. pini* were hitherto undescribed in this research, only the features of imago were presented.

2. Material and methods

The thrips being the subject of this research were collected by the authors during long-term research in forest communities of south-eastern Poland (Lublin Upland, Roztocze, Sandomierz Forest, The Beskid Low Mts., Bieszczady Mts.) and preserved in AGA fluid (70% of ethyl alcohol, acetic acid analytically pure and gliceryne in proportions 9:1:1). Part of materials gathered in traps in Białowieża Forest, coming from Forestry Research Institute collections, was donated by Ph. D J. Gutowski. The microscope slides were made from all specimens before their identification by inundating them into Berlese's liquid or in Canadian balm (Mound, Kibby 1998). The specimens were identified to species rank with the use of a microscope (Olympus BX 61), using keys of zur Strassen (2003), Schliephake and Klimt (1979), and Vierbergen et al. (2010). The measurements were taken with the use of program for analysis called cellSens Dimension ver. 2010, and pictures were taken with Olympus DP 72. The evidence materials are placed in the Department of Zoology of Biology and Biochemistry Institute of Maria Curie-Skłodowska University in Lublin.

3. Characteristics of dendrophilous species from Thripidae family

The thrips from Thripidae family are herbivorous insects connected with herbaceous plants both mono- and dicotyledonous. Among 18 dendrophilous taxons occurring in Poland, *Thrips juniperinus* Linnaeus 1758, as is *Ankothrips niezabitoskii* (Schille 1910) from the Melanthripidae family, is an anthophilous species that feeds on Juniper Common pollen (*Juniperus communis* L.); its larvae and adults therefore can be seen only for a short period (May, June) on host plant, afterwards their growth runs in soil. In Poland only a few stations of the above mentioned species were found: in Roztocze, Lublin Upland, Wołyń Upland, and in Karpaty Mts. (Kucharczyk 2006; Kucharczyk, Kucharczyk 2008; Kucharczyk et al. 2008; Kucharczyk, Stanisławek 2010). Species from *Mycterothrips* Trybom genus occur in humid places, mainly on leaves and in willow inflorescences (*Salix* sp.). To less often and less frequently captured species, belong the species from *Dendrothrips* Uzel and *Drepanothrips* Uzel genera. The representatives of the first genus prey on ash tree (*Fraxinus* sp.), alder (*Alnus* sp.), lime (*Tilia* sp.), and privet (*Ligustrum* sp.); the second genus preys on a birch (*Betula* sp.), hazel (*Corylus* sp.), and oak (*Quercus* sp.). In western and southern Europe, *Drepanothrips*

reuteri Uzel 1895 is also considered to be a grapevine pest (*Vitis vinifera*) (Marullo 2003; Strassen zur 2003; Jenser et al. 2010).

Dendrophilous foliivores from Thripidae family most frequently occurring in forests of Central Europe are: *Oxythrips ajugae* and *O. bicolor*, *Taeniothrips inconsequens*, *Thrips calcaratus*, *T. minutissimus*, and *T. pini* (syn. *Taeniothrips laricivorus*; Kratochvil 1941). Their adult specimens and larvae are most frequently caught in May and June with Moericke's traps and screen traps placed in crown canopies or in bush coating, also with photoelectors placed on tree trunks and in soil cover, with entomological net during larval migration to soil and soil cover, where they undergo a further growth (Lewis 1973; Kucharczyk, Sęczkowska 1990; Kucharczyk 2004; Dubovský et al. 2010; Kucharczyk, Kucharczyk 2011). It is not yet known whether, during migration, larvae prey on herbaceous plants (Vierbergen et al. 2010).

The discussed species have only one generation a year; they winter in a pupa or imago stage. At the end of April and May, adult insects leave the wintering place, prey on the developing leaf buds and lay eggs within the easy reach of main veins on the underside of young leaves. Larvae incubate after approximately 2 weeks, intensively prey, and in June they migrate to soil and soil cover underneath a tree base. Propupas and pupas most frequently pass their growth on the depth of 5-20 cm; however they were also found below 50 cm (Skinner, Parker 1991). Adult specimen *T. minutissimus* and *T. pini* leave the place of metamorphosis and at the beginning of August, complete the prey and on autumn return for wintering to soil.

With conifers the European conifer thrips *T. pini* is connected, whose preying causes needle deformation of pine (*Pinus* sp.), spruce (*Picea* sp.), and larch

(*Larix* sp.) in addition to shoot's decay. At mass appearance it can cause major damage, especially in forest nurseries; and as other thrips, it facilitates penetration of fungus and bacteria to damaged cells. Also *O. bicolor* is more often found in coniferous forests (Kucharczyk 1994, 2004). The remaining discussed taxa, prey on deciduous trees. European species *T. calcaratus* and *T. inconsequens* were dragged on the beginning of XXth century to Canada and United States, where they have become serious pests of American linden (*Tilia americana* L.) and sugar maple (*Acer saccharum* Marshall) (Raffa, Hall 1988; Raffa 1991; Schultz 1991). In European conditions *T. inconsequens* can cause a significant damage in fruit tree cultivation and in ornamental plants from *Rosaceae* family, while in forest's edges it preys on maples, hawthorn, and blackthorn. The damages are mainly made by numerous occurring larvae which prey on trees and flower buds as well as on young leaves, causing their decay (Zawirska 1994).

4. Diagnostic features of the thrips of crown canopies

Thrips from *Oxythrips* genus are characterized by bright color (from yellow to light brown), antennae compound of 8 segments, and the presence of only one pair of very long setae at the hind edge of pronotum. Back edge of abdominal tergite VIII is deprived of row of bristles (without comb). *O. ajugae* and *O. bicolor* can be easily distinguished by the shape of abdominal segment X which in latter species is highly elongated (fig. 1A-D). Males of both species are smaller than females, have two pairs of short spines on IXth abdominal tergite and are more difficult to differentiate.

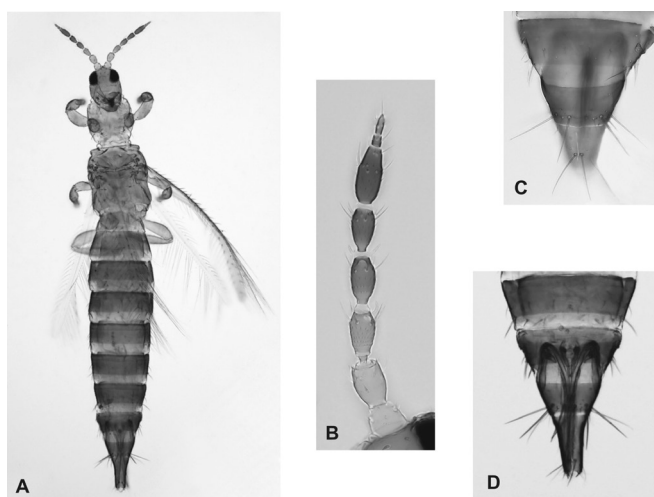


Figure 1. Body shape and characteristics of *Oxythrips* sp. adults: A – *O. bicolor*, B – antenna of *O. ajugae*; end of abdomen: C – *O. ajugae*, D – *O. bicolor*.

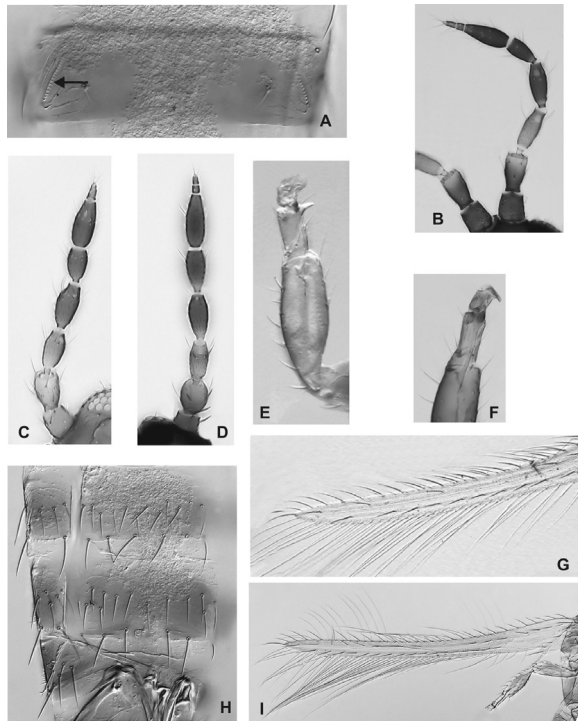


Figure 2. Characteristics of adults: A – ctenidium on tergite VI of *T. minutissimus*; antennae: B – *Taeniothrips inconsequens*, C – *Thrips minutissimus*, D – *T. pini*; tooth on foretarsus: E – *T. calcaratus*, F – *Taeniothrips inconsequens*; G – distal part of forewing of *T. pini*, H – additional setae on sternites and pleurites of *T. minutissimus*; I – forewing of *T. minutissimus*.

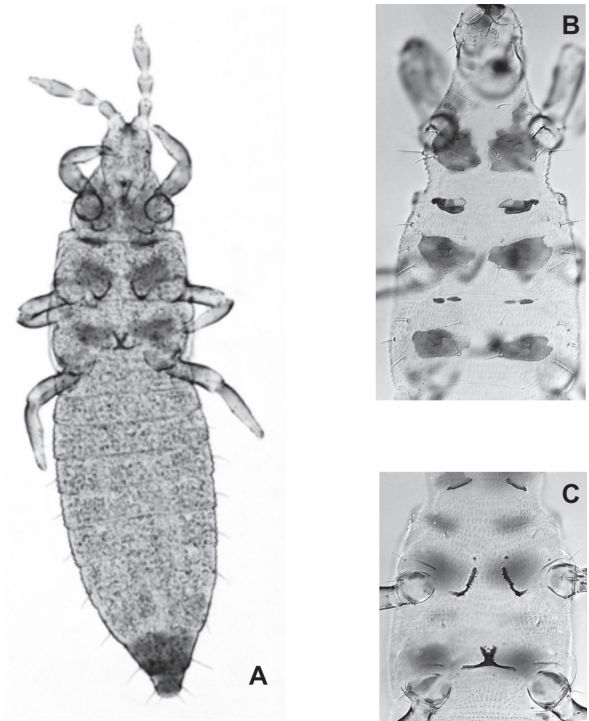


Figure 3. Body shape – A, and characteristics of second larval instar of *Thrips minutissimus*: B – pro-, meso-, and metanotum sclerotization, C – spinula on meso- and metasternite.

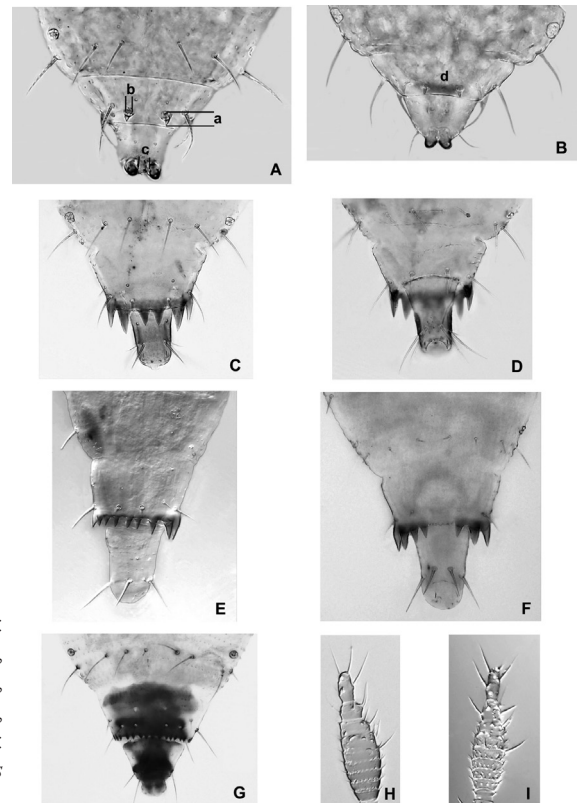


Figure 4. Characteristics of second larval instar. End of abdomen: A – *Oxythrips ajugae*, B – *O. bicolor*, C – *Taeniothrips inconsequens*, dorsal side, D – *T. inconsequens*, ventral side, E – *Thrips calcaratus*, dorso-lateral side, F – *T. calcaratus*, ventral side, G – *T. minutissimus*, dorsal side; antennal segments IV–VII: H – *T. minutissimus*, I – *Taeniothrips inconsequens* (features a–d explained in tab. 1).

Table 1. Distinguishable characteristics of the second larval instar of *Oxythrips ajugae* and *O. bicolor* (letters a-d marked on figures 4A, B)

Feature	<i>Oxythrips ajugae</i>	<i>Oxythrips bicolor</i>
Length of spines on tergite IX (a)	10–12,5 μm	$\sim 7,5 \mu\text{m}$
Basal width of spines (b)	$\geq 5 \mu\text{m}$	3–4 μm
Distance between spines at the end of segment X (c)	$\sim 10 \mu\text{m}$	spines close together
Sclerotization between spines (d)	absent	present

Table 2. Distinguishable characteristics of second larval instar of *T. inconsequens*, *T. calcaratus* and *T. minutissimus*

Feature	<i>T. inconsequens</i>	<i>T. calcaratus</i>	<i>T. minutissimus</i>
Range of comb teeth on segment IX	terga and pleura	terga, pleura and part of sterna	terga
Number of teeth in the comb	8	17–18	~ 15
Length of comb teeth	the longest lateral ones $\geq 30 \mu\text{m}$	the longest lateral ones $\sim 30 \mu\text{m}$	all in similar length $\sim 10 \mu\text{m}$
Length/width ratio of antennal segment VII	≥ 3	~ 2	~ 2

In thrips from *Thrips* genus, there is a pair of lateral ctenidia on sides of V-VIII tergites (fig. 2A) which is not present in *Taeniothrips* species (Mound 2003). Taking into consideration the antennae structure, the discussed thrips can be divided into 2 groups: adult specimens of *T. pini* and *T. inconsequens* have 8-segmented antennae (on this basis the former was earlier assigned to *Taeniothrips* genus), and *T. calcaratus* and *T. minutissimus* 7-segmented antennae (figs. 2B-D).

T. pini is characterized by the presence of additional setae on abdominal sternites which *T. inconsequens* lacks. The latter species has a visible tooth on tarsus of foreleg (fig. 2F) and its forewings are pale at the base and darker in the distal section. At the end of first vein of this wing in *T. inconsequens* there are 4-6 setae, while in *T. pini* on uniformly dark wing are only 3 setae (fig. 2G).

In second species group, a visible tooth on tarsus of first leg pair can be found in *T. calcaratus* (fig. 2E), while it is missing in *T. minutissimus*. The latter species is characterized by the presence of numerous setae both on abdominal sternites and pleurites and 7-11 setae in row at the end of forewings primary vein (fig. 2H, I).

In *T. calcaratus* (fig. 2E), additional setae are present only on sternites, and the distal part of wing vein is equipped with only 3 setae.

Wingless thrips larvae from the Terebrantia sub-order are usually creamy white or yellowish, older before pupation adopt a light-brown tone. Their antennae are 7-segmented and number and location of setae on body are permanent for all Terebrantia; differences in chaetotaxy are expressed mainly in setae length and the shape of their apex. Essential features that will allow larvae identification are cuticle sculpture and the sclerotization degree on particular parts of the body, presence or absence of spines on IXth and Xth abdominal segment, and shape and length of teeth forming comb at the end of IXth abdominal segment (Kucharczyk 2010, Vierbergen et al. 2010). At second larval instar from *Oxythrips* genus there is no stronger sclerotization, and the sculpture of cuticle is indistinct. Both above mentioned species can be recognized by their characteristic features, e.g., spines present on IXth and Xth abdominal segment, and they differentiate by their length and mutual location (tab.1, fig. 4A, B) (Kobro 2002; Vierbergen et al. 2010).

Larva of second instar of *T. minutissimus* is characterized by very strong head, thorax, and abdominal end sclerotization (fig. 3A-C, 4G), which is missing in *T. inconsequens* and *T. calcaratus* (fig. 4C-F) (larva of *T. pini* is hitherto undescribed). The remaining features of IXth abdominal segment differentiating the described species are listed in table 2 and illustrated in figure 4 (tab. 2, figs. 4C-I) (Kucharczyk 2010; Vierbergen et al. 2010).

5. Summary

Dendrophilous thrips from Thripidae family occur most frequently in spring and early summer during leaf and flower development. Most often they are representatives of six species: *Oxythrips ajugae*, *O. bicolor*, *Taeniothrips inconsequens*, *Thrips calcaratus*, *T. minutissimus*, and *T. pini*. Besides adult specimen, their larvae occur numerously both in crown canopies and in shrub layer on host plants. They are often found in traps of different kind, where they are caught after being passively precipitated by wind or during migration for further metamorphosis to soil or soil cover. Larvae of described species can be distinguished by their characteristic features, which are: strongly developed abdominal spines (*Oxythrips* spp.) or teeth surrounding the IXth segment of abdomen (other species). Those elements can perform defensive functions against predatory mites and insects during preying on leaves and soil where thrips spend majority of their lives and where their development from larvae to propupa and pupa to imago takes place. In Central Europe two of the described species – *T. inconsequens* and *T. pini* – are considered to be tree and bush pests. Remaining species, despite mass occurrence during spring in their natural range, do not cause direct loss; however, they facilitate phytopathogens penetration into tissues which were damaged during the prey. Understanding the characteristics of most frequently occurring imago and larvae of thrips in forests, will allow the identification of species and potential vermin recognition.

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