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Research Article

Dipteran (Bibionomorpha and Tipulomorpha) diversity in dead wood in Lithuania

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Abstract

The aim of this study is to compile the species list of Bibionomorpha and Tipulomorpha flies associated with dead wood in Lithuania. Saproxylic nematocerans were studied from 2014 to 2020 in four protected areas and in five different tree species *(Populus tremula, Quercus robur*, *Tilia cordata*, *Fraxinus excelsior* and *Alnus glutinosa*) of the second stage of decay by using emergence traps. In total, 113 species were identified with Mycetophilidae, Sciaridae and Limoniidae being the most species-rich families. The compiled list of species emerging from dead wood in Lithuania is presented. Fourteen species were reared from dead wood for the first time.

Keywords

Diptera, Lithuania, dead wood, aspen, oak, ash, small-leaved lime, alder

Introduction

Nematoceran flies – especially the species of infraorders Bibionomorpha (*sec.* Ševčík et al. 2016) and Tipulomorpha (*sec.* Wiegmann et al. 2011) – are a megadiverse group of insects and one of the most common groups associated with dead wood (Hövemeyer 1998). Infraorder Bibionomorpha consist of 17 extant families, most being mycetophagous or

saprophagous (Ševčík et al. 2016). These families are the largest Diptera groups associated with fungal fruiting bodies and, in many cases, they are found in moist dead wood or under the bark of a trunk penetrated by fungal mycelia (Irmler et al. 1996, Hövemeyer 1998, Rotheray et al. 2001, Alexander 2002, Jakovlev 2011, Mlynarek et al. 2018, Ulyshen 2018). The infraorder Tipulomorpha is one of the largest groups in the suborder Nematocera, with five families Cylindrotomidae, Limoniidae, Pediciidae, Tipulidae and Trichoceridae (Wiegmann et al. 2011). They are found in various habitats, ranging from aquatic to terrestrial environments (Gelhaus and Podėnienė 2019). Some genera or species are obligatorily saproxylic, whereas for others, wood is just one possible habitat for their development (Krivosheina 1991, Hövemeyer and Schauermann 2003, Krivosheina 2006, Krivosheina and Zaitzev 2008, Podėnienė et al. 2012, Polevoi and Salmela 2014).

There is a large knowledge gap about the diversity of Bibionomorpha and Tipulomorpha in various tree species. Nematoceran diversity has, so far, been studied in only a few tree species, beech (*Fagus sylvatica*) and aspen (*Populus tremula*) being the most common (Hövemeyer 1998, Schiegg 2001, Hövemeyer and Schauermann 2003, Halme et al. 2012, Polevoi et al. 2018). The economic value of the aspen is very low; however, it holds a great diversity of saproxylic insects and is associated with rare species (Polevoi et al. 2018). Evidence related to the importance of the aspen for saproxylic insect diversity has also been provided by Finnish scientists (Halme et al. 2012). According to Irmler et al. (1996), in a study comparing beech, alder (*Alnus glutinosa*) and spruce (*Picea abies*) dead wood, Sciaridae was most abundant in alder, while Mycetophilidae species were numerous in beech wood. A study of saproxylic Diptera in Scotland involving approximately 22 different tree species showed that birch (*Betula pubescens*), pine (*Pinus sylvestris*) and aspen had the most diverse Diptera assemblage; however, only a few species of Tipulomorpha and none of Bibionomorpha were mentioned in the study (Rotheray et al. 2001). Study of dipterans in five tree species (*Fagus sylvatica, Fraxinus excelsior, Picea abies, Populus tremula* and *Quercus robur*) by Økland (1999) showed microhabitats that are usually used by different species – logs, stumps, logs with different species of fungi etc. Although these studies present data on adults of many saproxylic species, many of these species still have unknown biology because it is unclear exactly where their larvae develop – this is especially true for those of the infraorder Bibionomorpha.

A decreased amount of dead wood in forest ecosystems because of forest clearance and habitat fragmentation can have a great impact on species, which can be put under threat. This paper compiles a list of nematoceran species in Lithuania reared from different tree species.

Methods

The research was conducted in four nature reserves in Lithuania in 2014, 2016 and 2018 to 2020 (Fig. 1). In total, 40 traps were installed on tree trunks; however, six of them were empty. Five tree species were chosen – small-leaved lime (*Tilia cordata*), aspen (*Populus tremula*), ash (*Fraxinus excelsior*), alder (*Alnus glutinosa*) and oak (*Quercus robur*) (Table 1). Saproxylic insects were reared using trunk-emergence traps (Gorban and Podėnienė

2021). Tent-like traps covered 1 m of fallen tree trunks, so a comparable section of every tree was used in the research. Traps were set in spring (April-May) and were kept until autumn (October-November); they were emptied every 10-14 days. As we do not know the exact time of tree death or fall, a classification table of wood decay was used. The wood of the second decay stage still has attached bark and fungal mycelia has penetrated 3 cm into the wood. We intentionally chose this decay stage because nematoceran larvae are common under the bark of the wood. Only males of the families Sciaridae and Mycetophilidae were included in the Table as the females are difficult to identify; the family Cecidomyiidae was also excluded.

Table 1.

Emergence traps localities.

Year	Nr. in the map	Reserve	Coordinates	Traps	Trap nr.
2014	1	Dūkštų Ąžuolynas, Neries Regioninis Parkas Reserve	54°50'30.5"N 24°58'12.8"E	Aspen, Oak, Ash,	1 1 1
2016	2	Būda Botanical-Zoological Reserve	54°52'51.1"N 24°21'36.1"E	Ash, Aspen	4 1
2018	2	Būda Botanical-Zoological Reserve	54°52'51.1"N 24°21'36.1"E	Ash, Aspen	3 3
	3	Biržų Giria Botanical Reserve	56°15'03.6"N 24°57'40.4"E	Alder, Ash	2 2
2019	2	Būda Botanical-Zoological Reserve	54°52'51.1"N 24°21'36.1"E	Ash, Aspen	2 3
	3	Biržų Giria Botanical Reserve	56°15'03.6"N 24°57'40.4"E	Alder, Ash	1 1
2020	2	Būda Botanical-Zoological Reserve	54°52'51.1"N 24°21'36.1"E	Linden, Oak	1 3
	4	Punia Šilas strict Nature Reserve	54°31'48.8"N 24°04'50.4"E	Linden, Oak	2 3

Results

In total, 808 specimens belonging to 113 species were identified (Table 2). The most abundant families were Sciaridae (204 specimens), Anisopodidae (179) and Mycetophilidae (150). The most species-rich families were Mycetophilidae (43 species), Sciaridae (26) and Limoniidae (22). Out of eight aspen trunks, 31 species and 338 specimens were collected; however, 158 specimens belonged to one species, *Sylvicola cinctus* (Anisopodidae). Out of seven oak trunks, 29 species and 99 specimens were reared, with Bibionidae being the most abundant (41 specimens). Out of 13 ash trunks, 54 species and 288 specimens were collected and Sciaridae was the most abundant (154 specimens). Out of three alder trunks, three species and four specimens were collected. Out of three linden tree trunks, 31 species and 79 specimens were collected, with

Mycetophilidae being the most abundant and species-rich. In total, 17 species were reared from dead wood for the first time (Table 2, marked with an asterisk).

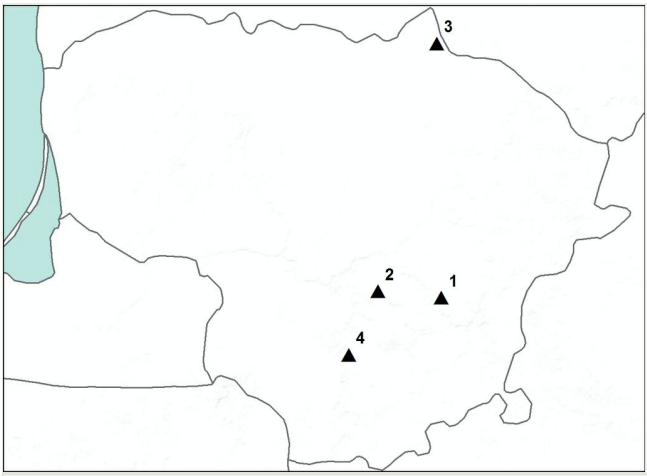

Figure 1. doi

Nature Reserves in Lithuania. 1 - Dūkštų Ąžuolynas, Neries Regioninis Parkas Reserve, 2 – Būda Botanical-Zoological Reserve, 3 – Biržų Giria Botanical Reserve, 4 – Punia Šilas strict Nature Reserve.

Table 2.

List of Bibionomorpha and Tipulomorpha species reared from different tree species (species reared from dead wood for the first time marked with asterisks).

	Populus tremula	*Quercus robur*	*Fraxinus excelsior*	*Alnus glutinosa*	*Tilia cordata*
Number of traps	8	7	13	3	3
Family Anisopodidae					
Sylvicola cinctus (Fabricius, 1787)	158	1	20		
Family Bibionidae					
Bibio marci (Linnaeus, 1758)		1			1
Bibio nigriventris (Haliday, 1833)	1	28			11
Bibio reticulatus (Loew, 1846)		12	3		11
Family Cylindrotomidae					
**Diogma glabrata* (Meigen, 1818)					7
Family Ditomyidae					
Ditomyia fasciata (Meigen, 1818)	19				
Symmerus annulatus (Meigen, 1830)					2
Symmerus nobilis (Lackschewitz, 1937)			2		
Family Keroplatidae					

	Populus tremula	*Quercus robur*	*Fraxinus excelsior*	*Alnus glutinosa*	*Tilia cordata*
Keroplatus testaceus (Dalman, 1818)					1
Neoplatyura flava (Macquart, 1826)			1		
Orfelia fasciata (Meigen, 1804)					2
Orfelia nemoralis (Meigen, 1818)	1			2	1
Family Limoniidae					
Achyrolimonia decemmaculata (Loew, 1873)					1
*Atypoptht*h*almus* (*Atypophthalmus*) *inustus* (Meigen 1818)					1
Austrolimnophila (*Austrolimnophila*) *ochracea* (Meigen, 1804)					2
Dicranomyia (*Dicranomyia*) *modesta* (Meigen, 1818)			3		
**Dicranomyia* (*Glochina*) *tristis* (Schummel, 1829)					1
**Dicranophragma* (*Brachylimnophila*) *nemorale* (Meigen, 1818)		1			
Discobola caesarea (Osten Sacken, 1854)	1	1		1	
Discobola parvispinula (Alexander, 1947)		2			
Epiphragma ocellare (Linnaeus, 1761)		1			
Gnophomyia viridipennis (Gimmerthal, 1847)	72				
Idioptera pulchella (Meigen, 1830)			1		
Limonia nubeculosa (Meigen, 1804)		1	1		
Limonia phragmatidis (Schrank, 1781)					1
Limonia trivittata (Schummel, 1829)			3		
Metalimnobia (*Metalimnobia*) *quadrimaculata* (Linnaeus, 1760)	11				
**Metalimnobia* (*Metalimnobia*) *quadrinotata* (Meigen, 1818)					1
**Ormosia* (*Ormosia*) *staegeriana* (Alexander, 1953)			1		
Rhipidia (*Rhipidia*) *maculata* (Meigen, 1818)			1		
**Rhypholophus bifurcatus* (Goetghebuer, 1920)		2			
Rhypholophus varius (Meigen, 1818)			2		
Family Mycetophilidae					
**Allodia* (*Brachycampta*) *grata* (Meigen, 1830)					1
Allodia lugens (Wiedemann, 1817)					1
Allodia subpistillata (Ševčik, 1999)			1		
**Allodia truncata* (Edwards,1921)			1		

	Populus tremula	*Quercus robur*	*Fraxinus excelsior*	*Alnus glutinosa*	*Tilia cordata*
**Boletina cincticornis* (Walker, 1848)		1			
Brachypeza (*Brachypeza*) *armata* (Winnertz, 1864)	1				
Brevicornu serenum (Winnertz, 1863)	1				
Brevicornu sericoma (Meigen, 1830)					3
Coelophthinia thoracica (Winnertz, 1863)			1		
Cordyla brevicornis (Staeger, 1840)	1				
Cordyla pusilla (Edwards, 1925)	1				
Diadocidia ferruginosa (Meigen, 1830)					1
Dynatosoma nigromaculatum (Lundström, 1913)	2				
Dynatosoma reciprocum (Walker, 1848)	26				2
Exechia confinis (Winnertz, 1863)			1		
Exechia dizona (Edwards, 1924)		1	7		
Exechia dorsalis (Staeger, 1840)		1	1		
Exechia exigua (Lundstrom, 1909)			1		
Exechia fusca (Meigen. 1804)	1	1			6
Exechia nigroscutellata (Landrock, 1912)			1		
Exechia unifasciata (Lackschewitz, 1937)			3		
Exechia parva (Lundström, 1909)		1	7		
Exechia parvula (Zetterstedt, 1852)			22		
Exechia seriata (Meigen, 1830)			2		
Exechia repandoides (Caspers, 1984)			1		
Exechiopsis fimbriata (Lundstrom, 1909)			9		
Gnoriste bilineata (Zetterstedt, 1852)			1		
Leia bilineata (Winnertz, 1863)			2		
**Leia bimaculata* (Meigen, 1804)					4
Leptomorphus forcipatus (Landrock, 1918)	1				
Mycetophila alea (Laffoon, 1965)					4
Mycetophila fungorum (De Geer, 1776)		1			2
Mycetophila uliginosa (Chandler, 1988)		1			
Mycomya (*Mycomyopsis*) *permixta* (Vaisanen, 1984)	1				
Mycomya tenuis (Walker, 1856)			2		1
Notolopha cristata (Staeger, 1840)			1		
Phronia biarcuata (Becker, 1909)					1
Rymosia bifida (Edwards, 1925)	2		9		

	Populus tremula	*Quercus robur*	*Fraxinus excelsior*	*Alnus glutinosa*	*Tilia cordata*
Rymosia fasciata (Meigen, 1804)		1	1		
Rymosia placida (Winnertz, 1863)			1		
Saigusaia flaviventris (Strobl, 1894)	1				1
Sciophila limbatella (Zetterstedt, 1852)		1			
Sciophila lutea (Macquart, 1826)	1				
Family Sciaridae					
Bradysia fungicola (Winnertz, 1867)		4			
Bradysia pectoralis (Staeger, 1840)			2		
Bradysia placida (Winnertz, 1867)		2			1
Bradysia strenua (Winnertz, 1867)	1				
**Bradysia trivittata* (Staeger, 1840)		1			
**Corynoptera bulgarica* (Mohrig & Mamaev, 1992)		1			
Corynoptera dentata (Bukowski and Lengersdorf, 1936)			5		
Corynoptera deserta (Heller and Menzel, 2006)			3		
Corynoptera flavicauda (Zetterstedt, 1855)					1
Corynoptera forcipata (Winnertz, 1867)			1		
Corynoptera furcifera (Mohrig and Mamaev, 1987)	1				
Corynoptera irmgardis (Lengersdorf, 1930)			3		
Corynoptera polana (Rudzinski, 2009)			2		
Corynoptera subtilis (Lengersdorf, 1929)	3		8		
Cratyna nobilis (Winnertz, 1867)	4		23		
Epidapus detriticola (Kratochvil, 1936)	1	3	1		
Epidapus gracilis (Walker, 1848)		1			
Epidapus lucifuga (Mohrig, 1970)	1				
Leptosciarella rejecta (Winnertz, 1867)			1		
Peyerimhoffia vagabunda (Winnertz, 1867)					2
Scatopsciara atomaria (Zetterstedt, 1851)	2		20		
Scatopsciara calamophila (Frey, 1948)	3		70		
Scatopsciara pusilla (Meigen, 1818)			12		
Xylosciara heptacantha (Tuomikoski, 1960)	1			1	
Zygoneura bidens (Mamaev, 1968)	9		2		
Zygoneura sciarina (Meigen, 1830)	7		1		
Family Tipulidae					
Dictenidia bimaculata (Linnaeus, 1760)		2			1

	Populus tremula	*Quercus robur*	*Fraxinus excelsior*	*Alnus glutinosa*	*Tilia cordata*
Nephrotoma quadrifaria (Meigen, 1804)			1		
Tipula (*Pterelachisus*) *apicispina* (Alexander, 1934)		21			4
Tipula (*Platytipula*) *autumnalis* (Loew, 1864)			12		
Tipula (*Lunatipula*) *humilis* (Staeger, 1840)			1		
Tipula (*Pterelachisus*) *irrorata* (Macquart, 1826)			2		
**Tipula* (*Pterelachisus*) *luridorostris* (Schummel, 1833)		1			
**Tipula* (*Beringotipula*) *unca* (Wiedemann, 1817)		4			
Tipula (*Schummelia*) *variicornis* (Schummel, 1833)	3				
Tipula (*Pterelachisus*) *varipennis* (Meigen, 1818)			1		
Family Trichoceridae					
Trichocera forcipula (Nielsen, 1920)			3		
Trichocera inexplorata (Dahl, 1967)			1		
Total number of species	31	29	54	3	31

Discussion

Our results show that communities of nematoceran flies in dead wood at the second stage of decay are species-rich and highly variable; however, more than half of the species were represented by a single specimen. Fourteen species were recorded from the dead wood for the first time.

Our study shows that dead wood is chosen by groups with a very different biology: obligate saproxylic species (*Gnophomyia viridipennis*, *Austrolimnophila* (*Austrolimnophila*) *ochracea*, *Epiphragma ocellare*), mycetophagous species (*Atypoptht*h*almus* (*Atypophthalmus*) *inustus*, *Achyrolimonia decemmaculata*, *Discobola caesarea, Metalimnobia* (*Metalimnobia*) *quadrinotata*, *M. quadrimaculata, Rhipidia* (*Rhipidia*) *maculata* and most species of the families Mycetophilidae, Ditomyiidae and Keroplatidae), species with a typical development habitat in moist soil or leaf litter (*Dicranomyia* (*Glochina*) *tristis*, *Limonia nubeculosa*, *Limonia phragmitidis*, *Dicranophragma* (*Brachylimnophila*) *nemorale*, *Ormosia (Ormosia) staegeriana, Rhypholophus bifurcatus*, *Rhypholophus varius*, *Nephrotoma quadrifaria*, *Tipula* (*Beringotipula*) *unca*, *Trichocera forcipula*, *Sylvicola cinctus* and most species of the families Bibionidae and Sciaridae) and species that develop under mosses (*Diogma glabrata*, *Tipula* (*Pterelachisus*) *apicispina*, *Tipula* (*Pterelachisus*) *luridorostris*, *Tipula* (*Pterelachisus*) *variicornis*) (Irmler et al. 1996, Podėninė 2003, Nielsen and Nielsen 2007, Ševčík 2010, Jakovlev 2011, Jakovlev 2012,

Seeber et al. 2012, Podėnienė 2012, Skartveit et al. 2013, Imada 2020). Once again, this shows the importance of dead wood not only for typical saproxylic insects, but also for other forest-dwelling species that choose wood only as a random site of development.

Previous studies of aspen (Halme et al. 2012, Polevoi et al. 2018, Gorban and Podėnienė 2021) showed a great variety of nematoceran species that depend on this tree species. In our study, *Sylvicola cinctus* (Anisopodidae) was the most abundant species in aspen, with some records from ash and oak wood. *S. cinctus* larvae is saprophagous and develops in decaying organic matter, also previously having been reared from aspen (Økland 1999). The second most abundant was *Gnophomyia viridipennis* (Limoniidae). *Gnophomyia* is one of the first groups colonising dead trees and *G. viridipennis* specimens are repeatedly reared from aspen wood (Hancock 2008, Krivosheina 2008). *Dynatosoma reciprocum* (Mycetophilidae) was reared mostly from aspen wood as well, with few specimens emerging from small-leaved lime trees. This species was previously reared from under the bark of spruce (Jakovlev 2011). *Ditomyia fasciata* (Ditomyiidae) specimens were reared from aspen trunks; however, it is common in various fungi species (Kurina and Ševčík 2006) and has previously been reared from alder wood (Irmler et al. 1996). *Zygoneura sciarina* (Sciaridae) and *Metalimnobia quadrimaculata* (Limoniidae) also were reared only from aspen trunks. The larvae of *M. quadrimaculata* previously have been reared from decaying wood and from various fungi species (Ševčík 2003, Podėnienė 2012, Polevoi et al. 2018). Some species were reared only from small-leaved lime, for example, *Diogma glabrata* (Cylindrotomidae), which is a well-known phytophagous species common in mosses in soil or dead wood (its larvae feed on mosses) and *Leia bimaculata* and *Mycetophila alea* (Mycetophilidae), which are usually associated with different fungi species (Podėninė 2003, Krivosheina 2008, Kramer and Langlois 2019, Imada 2020). *Bibio nigriventris* and *B. reticulatus* (Bibionidae) mostly were reared from oak and small-leaved lime. Adults of *B. reticulatus* are common in woodlands, where they usually occur in large numbers (Skartveit et al. 2013). Their larvae develop in strongly decomposed friable wood, decaying wood roots or forest litter (Krivosheina 2006). *Tipula* (*Pterelachisus*) *apicispina* specimens were mostly reared from oak as well. Usually, this species is found under moss cushions (Podėninė 2003).

Some species were reared only from ash wood. The most abundant species reared from ash wood was *Scatopsciara calamophila* (Sciaridae), which previously had only been known from beech (Irmler et al. 1996, Schiegg 2001). Many specimens of Mycetophilidae family, also both Trichoceridae species (*Trichocera forcipula* and *T. inexplorata*) were reared from ash trunks as well, although most of these species develop in fungi or decaying organic matter. The diversity in alder wood was the lowest and was represented only by four specimens and three species. Alder has been shown to have a much higher diversity in previous studies; for example, Irmler et al. (1996) reared many Mycetophilidae and Sciaridae from this tree species.

Although most of the species are known from different habitats, it appears that many of them use dead wood as one of their possible habitats, for example, *Exechia fusca* (Mycetophilidae) is known to develop in agarics (Jakovlev 1994) or soil and litter (Irmler et al. 1996); however, they also have been reared from strongly decayed pine wood (Jakovlev

2011). Decayed wood is penetrated by fungal mycelia and also can be covered with small patches of moss, providing suitable habitat for many species to develop. Since many species are represented by only one specimen, their preference for certain tree species needs to be studied further.

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