Int. J. Dipterol. Res. 10(3)
21 November 1999
ISSN 1021-1020

New rearing records of forest-dwelling Diptera

BJORN ØKLAND

Økland, B. 1999. New rearing records of forest-dwelling Diptera. *Int. J. Dipterol. Res.*, **10**(3): 133—146.

Information about larval ecology is fundamental in entomological research; however, in many insect species the larval habitat is still unknown. In the present project, Diptera insects were reared from various microhabitats and substrates of coniferous and deciduous forests of southern Norway. The material included 54 species that have not been reared earlier and 213 new species-microhabitat relationships. Many new records were found in dead wood of common tree species, such as Picea abies, Populus tremula and Fraxinus excelsior. Microhabitats associated with the root zone of windfelled trees showed the highest number of new species-microhabitat relationships.

B. Økland, Norwegian Forest Research Insititute, Hogskoleveien 12, 1432 As, Norway. Phone: + 47 64 94 90 41, Fax: + 47 64 94 29 80.

Key words. Rearing, eclector, Diptera, forest.

Introduction

The insects constitute the most species-rich group of organisms in forests. Increased knowledge about this group is necessary for several purposes, such as biodiversity management in forestry, control of forest pests and improved understanding of fundamental processes in the forest ecosystems. However, it is a considerable task to fill gaps in basic knowledge about this group. In many countries, there is a lack of taxonomic and faunistic information to clarify what species of insects are found within the borders. Species new to the country appear frequently, especially in the two most species-rich insect orders Diptera and Hymenoptera, which include several poorly researched groups. For instance in Norway, Recent records of Diptera are 160 new species of Mycetophiloidea (Økland & Zaitzev 1997), 17 new species of Lestremiinae (Økland & Mamaev 1997) and five species of Milichiidae (Økland 1998), and in Hymenoptera Riedel & Berg (1997) published 78 new species of Ichneumonidae. In 1993, the total number of documented species in Norway was 14768 (Ottesen 1993). Based on records in neighbouring countries, the number of insect species in Norway has been estimated to 23222 (Ottesen 1993), however, the number may show to be even higher. More distributional and ecological knowledge is required to improve the Norwegian red-list, which has considered only a quarter of the species due to lack of information (see Table 16 in Gundersen & Rolstad 1998).

Larval habitat is unknown in many species of forest insects, especially in the species-rich insect orders Diptera and Hymenoptera. Knowledge about larval ecology may for instance be essential when a drop in distributional records over time should be interpreted during red-list evaluation of a species. Furthermore, revealing the substrate of the larvae may be a first step towards finding the life cycle and the habitat requirements of an insect species. Larval information is necessary for understanding the ecological role of the various species and groups of insect, and the ecological impacts induced by changes of species composition of the insect fauna.

Table 1. Forest localities, trapping periods and number of eclector traps used in each locality. Label data for each locality consists of a county code (see Økland 1981), community name and local name. BØ = eastern part of Buskerud county, AK = Akershus county, OS = southern part of Oppland county, and VE = Vestfold county.

locality (label data)	period	traps
BØ, Ringerike: Spålen	8 July – 20 Sept. 1995	14
AK, Ås: Vardåsen	9 July – 10 Nov. 1995	1
OS, Gausdal: Ormtjernkampen	16 June – 8 Sept. 1995	8
AK, Rælingen: Tappenberg	8 May – 29 Aug. 1996	39
VE, Larvik: Middagskollen	6 May – 20 Aug. 1997	25
AK, Ås: Danemark	13 May – 26 Aug. 1997	25
AK, Ås: Syverud	15 May – 27 Aug. 1997	25
AK, ÅS: Smihagen	13 May – 26 Aug. 1997	25

The present report is a contribution to increase our knowledge about larval habitats of insect species. The results are based on rearing records from various forest substrates, including material from ten families of Diptera. The specific goals have been to:

(1) find the microhabitat of species for which the biology is unknown.

(2) find new species-microhabitat relationships.

(3) compare frequencies of new rearing records between the various substrates and microhabitats.

Material and methods

The rearing records were performed by altogether 162 eclector traps in eight forest localities in south-eastern Norway (Table 1). The eclector traps were mounted on a variety of microhabitats (Table 2).

Each eclector trap enclosed a section of dead wood or other substrates by means of a black cotton cloth. Space between the substrate and the textile was formed by arches of 3-mm wire inserted

Table 2. Substrates, microhabitats and number of eclector traps included in the present rearing study.

substrate	microhabitat	traps
Fagus sylvatica	bark crevices of living tree	4
	dead wood infected by and *Hypoxylon multiforme*	7
	dead wood infected by *H. multiforme* and *Ganoderma applanatum*	4
	decayed log	2
	dry, dead wood inhabited by Anobiidae beetles	2
	nearly decomposed log	4
	newly dead log	3
Fraxinus excelsior	log without bark	22
	log with bark	1
	stump	3
ground vegetation	patch of Eu-Piceetum ground vegetation	12
	wet moss carpet on steep rock in Eu-Piceetum woodland	3
Picea abies	bark-free dead wood with Myxomycetes	1
	carpophore of *Fomitopsis pinicola* with insect web	4
	carpophore of *Phellinus chrysoloma*	1
	carpophore of *Phellinus chrysoloma* with insect web	3
	log end with carpophore of *Fomitopsis pinicola*	1
	Phlebia centrifuga	1
	rotten log inhabited by *Lasius brunneus*	1
	under root plate of wind-felled tree	12
Populus tremula	log with bark	1
	basis of wind-broken tree	2
	cleft between branches of dead tree	1
	dead wood infected by *Oxyporus corticola*	1

	deeply decayed tall stump	4
Populus tremula	in cavity of wind-broken tree	3
	log without bark	10
	Phellinus tremula on tall stump	1
	stump with bark	2
	under loose bark on tall stump	1
Quercus robur	dead wood without bark	4
	part on living trunk without bark	1
	big branch hole	1
	big dead branch with bark	7
	cleft at base of living trunk	3
	crevices at base of living trunk	1
	dead wood infected by *Stereum hirsutum*	1
	dead wood infected by *Stereum hirsutum* and red rot fungi	1
	moss-covered dead branch	4
	soil-filled cavity inhabited by *Lasius* ants	1
	under loose bark on living trunk	1
soil	mineral soil exposed by windfelling of *Picea abies*	12

Table 3. The number of species reared in total, the number of species reared for the first time, and the number of new species-microhabitats relationships.

Family	species	first rearing			new microhabitat		
		likely	uncertain	sum	likely	uncertain	sum
Nematocera:							
Anisopodidae	1	1		1	1		1
Bolitophilidae	1					4	4
Keroplatidae	8	1	4	5	6	20	26
Diadocidiidae	3	1	0	1	1		1
Mycetophilidae	30	9	5	14	19	55	74
Brachycera:							
Empididae	13	1	10	11	5	23	28
Hybotidae	26	10	9	19	32	25	57
Dolichopodidae	7	3		3	7	3	10
Syrphidae	8				1	6	7
Milichiidae	3				5		5
Total	100	26	28	54	77	136	213

into the substrate surface. The ends of the cotton cylinder were closed by thin wire. Glass collecting vials were attached to the lower part of each trap. Ethylene-glycol with a small amount of detergent was used as preservative in all trap models. A photo of the trap model is found as Figure 1C in Okland (1996). All traps were emptied twice during the trapping periods, with exception of the traps in the localities Spålen, Vardåsen, Gausdal and Ormtjernkampen (Table 1) which were emptied once.

Results

The rearing records yielded altogether 100 species in ten families of Diptera. The material was compared to rearing records known from publications (a long list not cited here) and experts (see preview). For 54 species which have not been reared before, rearing records are presented for the first time (Tables 3, 6—12). Furthermore, the present material includes 213 new microhabitats for the species (Tables 3, 6—12). However, the

majority of the new records were considered uncertain because it could not be decided wether they were really new larval microhabitats or not (Tables 3, 6—12). In several cases, it could nor be excluded that the eclector had trapped imago individuals being present in the microhabitat before mounting the trap.

The new species — microhabitat relationships were sorted by tree species or substrate type. The largest number of new rearing records was found in ground vegetation followed by spruce (*Picea abies*) and soil, however, most of these records were uncertain (Table 4). The broad-leaved tree species gave less new species — microhabitat relationships, with the lowest number in oak (*Quercus robur*).

Microhabitats created by windstorms in the forests were on the top of the ranking list of new records, i.e. «rootplate of wind-felled *Picea abies*» and «mineral soil exposed by windfelling of *Picea abies*». Microhabitats associated with windstorms were also found with frequent records further down in the list, such as «in cavity of wind-broken *Populus tremula*» and «basis of wind-broken *Populus tremula*» (Table 5). However, the top-ranking microhabitats of wind-felled *Picea abies* contained only uncertain records. Excluding the uncertain records, the largest number of new records were associated with dead wood, such as "log without bark", "in cavity of windbroken *Populus tremula*, "log with bark" and "dead wood infected by *Hypoxylon multiforme*".

The tables 6 and 7 present rearing records of species within the nematoceran families. The only

Table 4. The various tree species/substrates ranked in descending order according to the number of new species — microhabitat relationships.

Substrate	new records		
	likely	uncertain	sum
ground vegetation	0	58	58
Picea abies	8	38	46
soil	0	36	36
Populus tremula	23	4	27
Fraxinus excelsior 15	0	15	
Fagus sylvatica	22	0	22
Quercus robur	9	0	9
Total	77	136	213

Table 5. The various microhabitats ranked in descending order according to the number of new species — microhabitat relationships.

Microhabitat	new records		
	likely	uncertain	sum
under root plate of wind-felled *Picea abies*		38	38
mineral soil exposed by windfelling of Picea abies		36	36
patch of Eu-Piceetum ground vegetation		36	36
log without bark	26	1	27
wet moss carpet on rock in Eu-Piceetum woodland		22	22
in cavity of wind-broken *Populus tremula*	7	1	8
log with bark	7		7
dead wood infected by *Hypoxylon multiforme*	5		5
basis of wind-broken *Populus tremula*	2	1	3
big dead branch with bark	3		3
sporocarp of *Fomitopsis pinicola* with insect web	3		3
nearly decomposed log	3		3
soil-filled cavity inhabited by *Lasius* ants	3		3
decayed log	2		2
newly dead log	2		2
stump with bark	2	1	3
bark-free dead wood with Myxomycetes	1		1
sporocarp of *Phellinus chrysoloma*	2		2
crevices at base of living trunk	1		1
deeply decayed tall stump	1		1
log end with sporocarp of *Fomitopsis pinicola*	1		1
moss-covered dead branch	1		1
Phlebia centrifuga	1		1

Table 6. Rearing records of species in Anisopodidae, Bolitophilidae, Diadocidiidae and Keroplatidae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. Brackets around the asterisks denote uncertain records. The percent of traps on each microhabitat including the respective species is given in the far right column.

Species	substrate	microhabitat	%
Anisopodidae			
Sylvicola cinctus Fabr., 1787*	*Populus tremula*	log with bark*	100
Bolitophilidae			
Bolitophila (B.) austriaca (Mayer, 1950)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Diadocidiidae			
Diadocidia ferruginosa (Mg., 1830)	*Fraxinus excelsior*	log without bark	9
Diadocidia spinosula Tollet, 1948*	*Fraxinus excelsior*	log without bark*	9
Diadocidia valida Mik, 1874	*Fraxinus excelsior*	log without bark	5
Keroplatidae			
Keroplatus testaceus Dalman, 1818	*Picea abies*	sporocarp of *Fomitopsis pinicola* with insect web*	50
	Picea abies	log end with sporocarp of *Fomitopsis pinicola**	100
	Picea abies	*Phlebia centrifuga**	100
Neoplatyura flava (Mcq., 1826)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Orfelia discoloria (Mg., 1818)	*Fraxinus excelsior*	log without bark	5
	Quercus robur	dead wood with Stereum hirsutum and red rot fungi*	100
Pyratula zonata (Ztt., 1852)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Macrocera aterrima Stack., 1945(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Macrocera parva Lundström, 1911(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Macrocera pilosa Landrock, 1917*	*Fraxinus excelsior*	stump*	33
	Picea abies	bark-free dead wood with Myxomycetes*	100
Macrocera stigma Curtis, 1837	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83

Table 7. Rearing records species in Mycetophilidae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. Brackets around the asterisks denote uncertain records. The percent of traps on each microhabitat including the respective species is given in the far right column.

Species	substrate	microhabitat	%
Acnemia nitidicollis (Meigen, 1818)*	*Fraxinus excelsior*	log without bark*	32
Anatella gibba Winnertz, 1863(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Apolephthisa subincana (Curtis, 1837)	*Fagus sylvatica*	dead wood with *Ganoderma applanatum* and *Hypoxylon multiforme*	25
Boletina basalis (Meigen, 1818)*	*Fraxinus excelsior*	log without bark*	5
	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Boletina nigricans Dziedzicki, 1885(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	50
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	50
	Picea abies	under root plate of wind-felled tree(*)	60
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	60
Coelophthinia thoracica (Winnertz, 1863)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Coelosia fusca Bezzi, 1892	*Fraxinus excelsior*	log without bark*	5
Coelosia truncata Lund., 1909	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	50
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	50
	Picea abies	under root plate of wind-felled tree(*)	60
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	60
Cordyla murina Winnertz, 1863	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Ectrepesthoneura colyeri Chandler, 1979*	*Fraxinus excelsior*	log without bark*	9
	Quercus robur	crevices at base of living trunk*	100
	Quercus robur	soil-filled cavity inhabited by *Lasius* ants*	100

Eudicrana nigriceps (Lund., 1909)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Exechiopsis membranacea (Lund., 1912)*	*Fraxinus excelsior*	log without bark*	5
Gnoriste longirostris Siebke, 1864	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Leia bifasciata Gimmerthal, 1846	*Fagus sylvatica*	dead wood with Ganoderma applanatum and Hypoxylon multiforme*	25
	Fagus sylvatica	dead wood infected by *Hypoxylon multiforme**	14
	Fraxinus excelsior	log without bark	9
Leptomorphus (L.) quadrimaculatus (Mats., 1916)	*Picea abies*	carpophore of *Fomitopsis pinicola* with insect web*	25
Mycetophila fungorum (De Geer, 1776)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Mycetophila sordida van der Wulp 1874*	*Picea abies*	carpophore of *Fomitopsis pinicola* with insect web*	25
Mycetophila sumavica (Lastovka, 1963)*	*Fraxinus excelsior*	log without bark*	5
Mycomya denmax Väisänen, 1979	*Fraxinus excelsior*	log without bark	5
Mycomya levis (Dziedzicki, 1885)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Palaeodocosia janickii (Dziedzicki 1923)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Phthinia humilis Winnertz, 1863	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Polylepta guttiventris (Zett., 1852)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	100
	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	100
	Picea abies	under root plate of wind-felled tree(*)	83
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	83
Sciophila interrupta (Winnertz, 1863)	*Fraxinus excelsior*	log without bark*	14
Sciophila nonnisilva Hutson, 1979	*Fraxinus excelsior*	log without bark*	5
Sciophila rufa Meigen, 1830	*Fagus sylvatica*	newly dead log*	33
Sciophila spinifera Zaitzev, 1982*	*Picea abies*	carpophore of *Phellinus chrysoloma**	100
	Picea abies	carpophore of *Phellinus chrysoloma* with insect web*	100
Synapha vitripennis (Meigen, 1818)*	*Quercus robur*	soil-filled cavity inhabited by *Lasius* ants*	100

Table 8. Rearing records species in Dolichopodidae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. Brackets around the asterisks denote uncertain records. The percent of traps on each microhabitat including the respective species is given in the far right column.

Species	substrate	microhabitat	%
Achalcus melanotrichus Mik, 1878	*Populus tremula*	in cavity of wind-broken tree*	33
Dolichopus discifer Stannius, 1831	ground vegetation	wet moss carpet on steep rock in Eu-Piceetum woodland(*)	33
Medetera belgica Parent, 1936*	*Quercus robur*	moss-covered dead branch*	25
Medetera pseudoapicalis Thun., 1955*	*Fagus sylvatica*	dead wood infected by *Hypoxylon multiforme**	14
Medetera seguyi Parent, 1926*	*Fraxinus excelsior*	log with bark*	100
	Populus tremula	log without bark*	20
Medetera tristis (Zett., 1838)	*Fraxinus excelsior*	log with bark*	100
	Populus tremula	log without bark*	10
Systenus pallipes (Von Roser, 1840)	*Populus tremula*	in cavity of wind-broken tree(*)	67
	Populus tremula	stump with bark(*)	50

Table 9. Rearing records species in Empididae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. Brackets around the asterisks denote uncertain records. The percent of traps on each microhabitat including the respective species is given in the far right column.

Species	substrate	microhabitat	%
Anthepiscopus oedalinus (Zett., 1838)*	*Populus tremula*	deeply decayed tall stump*	25
Heleodromia immaculata Haliday, 1833(*)	*Picea abies*	under root plate of wind-felled tree(*)	8
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	8
Hilara abdominalis Zett., 1838(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	8
	Picea abies	under root plate of wind-felled tree(*)	25
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	17
Hilara intermedia (Fall., 1816)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	17
	Picea abies	under root plate of wind-felled tree(*)	8
Hilara interstincta (Fall., 1816)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	25
	Picea abies	under root plate of wind-felled tree(*)	8
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	33
Hilara litorea (Fall., 1816)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	8
Iteaphila nitidula Zett., 1838(*)	*Picea abies*	under root plate of wind-felled tree(*)	8
Rhamphomyia (L.) hybotina (Zett., 1838)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	33
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	25
Rhamphomyia (M.) anomalina (Zett., 1838)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	8
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	8
Rhamphomyia (P.) albidiventris Strobl, 1898	*Fraxinus excelsior*	log without bark*	5
	Picea abies	under root plate of wind-felled tree(*)	17
	Populus tremula	in cavity of wind-broken tree*	33
	Populus tremula	log without bark*	10
Rhamphomyia (P.) fuscipennis (Zett., 1838)(*)	*Picea abies*	under root plate of wind-felled tree(*)	17
Rhamphomyia (P.) lividiventris (Zett., 1838)(*)	*Picea abies*	under root plate of wind-felled tree(*)	17
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	17
Rhamphomyia (P.) pilifer Meig., 1838	ground vegetation	wet moss carpet on rock in Eu-Piceetum woodland(*)	33
	Picea abies	under root plate of wind-felled tree(*)	8
	Populus tremula	in cavity of wind-broken tree*	33
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	25

Table 10. Rearing records species in Hybotidae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. Brackets around the asterisks denote uncertain records. The percent of traps on each microhabitat including the respective species is given in the far right column

Species	substrate	microhabitat	%
Bicellaria austriaca Tuomik., 1955(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	17
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	17
Bicellaria intermedia Lundb., 1910(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	33
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	42
Bicellaria nigra (Meig., 1824)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	42
	Picea abies	under root plate of wind-feiled tree(*)	42
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	25
Drapetis parilis Collin, 1926*	*Populus tremula*	basis of wind-broken tree*	50
Drapetis stackelbergi Kovalev, 1972*	*Populus tremula*	log without bark*	10
Euthyneura albipennis Zett., 1842	*Fraxinus excelsior*	log without bark*	9
	Fraxinus excelsior	log with bark*	100
	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	8
	Picea abies	under root plate of wind-felled tree(*)	25
	Populus tremula	log without bark*	40
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	8
Euthyneura gyllenhali (Zett., 1838)*	*Fagus sylvatica*	nearly decomposed log*	25
Euthyneura myrtilli Macq., 1836	*Fagus sylvatica*	dead wood with *Ganoderma applanatum* and *Hypoxylon multiforme**	25
	Fraxinus excelsior	log without bark*	9
	Picea abies	under root plate of wind-felled tree(*)	8
	Populus tremula	log without bark*	10
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	8
Hybos grossipes (L., 1767)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	42
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	8
Leptopeza borealis Zett., 1842*	*Populus tremula*	log without bark*	10
Leptopeza flavipes (Meig., 1820)*	*Fagus sylvatica*	nearly decomposed log*	25
Ocydromia glabricula (Fall., 1816)*	*Populus tremula*	log without bark*	20
Oedalea ringdahli Chvála, 1983*	*Quercus robur*	big dead branch with bark*	14
Oedalea stigmatella Zett., 1842	*Fagus sylvatica*	newly dead log	33

	Fraxinus excelsior	log without bark	5
	Picea abies	under root plate of wind-felled tree(*)	8
	Populus tremula	basis of wind-broken tree*	50
	Populus tremula	in cavity of wind-broken tree*	67
Oedalea zetterstedti Collin, 1926*	*Fagus sylvatica*	dead wood infected by Hypoxylon multiforme*	14
	Fraxinus excelsior	log without bark*	27
	Fraxinus excelsior	stump*	33
	Populus tremula	log without bark*	30
	Quercus robur	big dead branch with bark*	14
Platypalpus macula (Zett., 1842)*	*Fagus sylvatica*	dead wood with Ganoderma applanatum and Hypoxylon multiforme*	25
Platypalpus nigritarsis (Fall., 1816)(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	17
Platypalpus scandinavicus Chvála, 1972(*)	*Picea abies*	under root plate of wind-felled tree(*)	8
Platypalpus stigmatellus (Zett., 1842)(*)	*Picea abies*	under root plate of wind-felled tree(*)	8
Tachypeza fennica Tuomik., 1932*	*Fagus sylvatica*	dead wood infected by Hypoxylon multiforme*	14
	Fagus sylvatica	decayed log*	50
	Fraxinus excelsior	log without bark*	9
Tachypeza fuscipennis (Fall., 1815)	*Fraxinus excelsior*	log with bark*	100
Tachypeza heeri Zett., 1838	*Fraxinus excelsior*	log with bark*	100
	Populus tremula	log without bark	10
Tachypeza nubila (Meig., 1804)	*Fagus sylvatica*	dead wood infected by Hypoxylon multiforme*	14
	Fagus sylvatica	decayed log*	50
	Fagus sylvatica	nearly decomposed log*	25
	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	33
	Picea abies	under root plate of wind-felled tree(*)	33
	Populus tremula	log without bark*	20
	Quercus robur	big dead branch with bark	14
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	25
Tachypeza truncorum (Fall., 1815)	*Fagus sylvatica*	newly dead log*	33
	Fraxinus excelsior	log with bark*	100
	Picea abies	under root plate of wind-felled tree(*)	8
Trichina clavipes Meig., 1830(*)	ground vegetation	patch of Eu-Piceetum ground vegetation(*)	33
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	25
Trichinomyia flavipes (Meig., 1830)(*)	*Picea abies*	under root plate of wind-felled tree(*)	8

Table 11. Rearing records species in Syrphidae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. Brackets around the asterisks denote uncertain records. The percent of traps on each microhabitat including the respective species is given in the far right column.

Species	substrate	microhabitat	%
Brachyopa pilosa Collin, 1939	*Populus tremula*	log without bark(*)	10
Melanostoma scalare (Fabr., 1794)	ground veg.	patch of Eu-Piceetum ground vegetation(*)	8
	Picea abies	under root plate of wind-felled tree(*)	8
	soil	mineral soil exposed by windfelling of *Picea abies*(*)	17
Meliscaeva cinctella (Zett., 1843)	ground veg.	patch of Eu-Piceetum ground vegetation(*)	8
Myathropa florea L., 1758	*Populus tremula*	in cavity of wind-broken tree	33
Xylota coeruleiventris Zett., 1838	*Populus tremula*	in cavity of wind-broken tree*	33
Xylota segnis L., 1758	*Populus tremula*	in cavity of wind-broken tree	33
Xylota sylvarum L., 1758	*Fagus sylvatica*	dead wood with *Ganoderma applanatum* and *Hypoxylon multiforme*	25
Xylota tarda Meig., 1822	*Populus tremula*	basis of wind-broken tree(*)	100

Table 12. Rearing records species in Milichiidae. Asterisks denote species without previous rearing records (first column), and microhabitats without previous rearing records (third column) of the respective species. The percent of traps on each microhabitat including the respective species is given in the far right column.

Species	substrate	microhabitat	%
Milichia ludens Wahl., 1847	*Quercus robur*	soil-filled cavity inhabited by *Lasius* ants	100
Neophyllomyza acyglossa Vill., 1920	*Populus tremula*	in cavity of wind-broken tree*	33
	Populus tremula	log without bark*	40
Phyllomyza equitans Hend., 1919	*Populus tremula*	in cavity of wind-broken tree*	33
	Populus tremula	log without bark*	10
	Quercus robur	big dead branch with bark*	14
	Quercus robur	soil-filled cavity inhabited by *Lasius* ants	100

species of Anisopodidae in the present material is a first rearing record of this species (Table 6). The only reared species of Bolitophilidae has previously been reared from fungi (*Tricholoma focale*, Yakovlev 1994). It is unclear whether the various microhabitat records here are habitats of fungi used for larval development or they are resorts for imago of *Bolitophila austriaca*. In both cases, a high percent of traps including this species (83—100%, Table 6) indicates a regular use of these microhabitats. A similar uncertainty about how the microhabitat is used is also found for many of the fungi-associated species of the families Keroplatidae (Table 6) and Mycetophilidae (Table 7). In addition, many of the species in these families are net spinners, suggesting that the records represent microhabitats for larval nets. One of the Diadocidiidae species has been reared for the first time (Table 6). "Log without bark" is plausible larval habitat for this species, as well as the two species of Diadocidiidae which are previously known to scrape mycelium on surfaces of dead wood (see ref. in Yakovlev 1994).

The rearing records of species within the brachyceran families are presented in the Tables 8—12. A large proportion of new rearing records was found in the families Empididae (85% of species reared), Hybotidae (73%) and Dolichopodidae (43%). However, the majority of the Empididae records and about half of the Hybotidae records are considered uncertain (Tables 9 and 10). None of the species in Syrphidae and Milichiidae have not been reared before, however, some of the microhabitats are probably new for the respective species (Tables 11 and 12).

Discussion

Rearing records by eclectors do not give exact information about how the microhabitats are used by each species. However, this method may be useful for screening possible habitats before performing more focused studies to state the exact larval habitat. The eclectors may be advantageous compared to direct observations which depend on being present in right time, and because the larvae may be small and hidden. In situ rearing may be successful when laboratory rearing fails to copy natural conditions necessary for the larval development. On the other hand, eclectors fail when the larvae do not find a proper pupal habitat within the eclector (for instance fungi-inhibiting larvae with pupation in soil), and for some species oviposition may be prevented by the eclector itself, depending on the time of mounting the eclector.

There is a comprehensive literature on insect fauna associated with dead wood and wood-inhabiting fungi (see for instance Palm 1951 and 1959, Hilt & Ammer 1994, Ferrar 1987, Koch 1989—1992, Smith 1989, Kaila et al. 1994, Ehnström & Waldén 1986, Samuelsson et al. 1994, Siitonen 1994, Irmler et al. 1996, Økland et al. 1996). However, the large number of new records in the present study may indicate that there is still a lot to find out about ecology of insects in microhabitats related to dead and dying trees. There are many types of micro-niches connected with the various types of dead wood. The broad-leaved tree species are considered to be hosts for a diverse fauna of insects, such as beetles (Jonsell et al. 1998) and Diptera (Ferrar 1987, Smith 1989). The relatively low number of new records from broad-leaved trees compared to other habitats in the present study may be correlated with differences in research activity on these tree species in the past. Apparently, it has been a considerable research activity on Diptera of deciduous trees in the Continental Europe and on the British Isles (Ferrar 1987, Smith 1989). In contrast, several microhabitats of boreal forests have received little attention, giving a bigger potential for doing new rearing records of Diptera. For instance microhabitats of wind-blown trees ranked on the top of the list of new rearing records. These records were not made in the dead trunk of the wind-thrown trees, but in microhabitats that probably have been overlooked in previous studies, such as under rootplates and in the patch of mineral soil exposed by wind-felling. Similar habitats have been found to be important for the diversity of bryophytes in Boreal spruce forests (Jonsson & Esseen 1990).

Acknowledgements

The project was financially supported by the Norwegian Research Council and Norwegian Forest Research Institute. Thanks for species identifications and verifications are given to Lene Martinsen and Dr. Geir Söli (Mycetophiloidea), Terje Jonassen (Empidoidea), Tore R. Nielsen (Syrphidae) and Dr. Irina Brake (Milichiidae). Thanks to Dr. Graham Rotheray, Dr. Mc Gowan, Dr. Peter Chandler and Dr. Alexander Zaitzev for comments

on species in the rearing list, and to Torfinn Sæther and Camilla Bergkvist for technical assistance.

References

Ehnström, B. & H. W. Waldén. 1986. Faunavård i skogsbruket. Del 2 - Den lägre faunan. Skogsstyrelsen, Jönköping. (in Swedish with English summary).

Ferrar, P. 1987. A guide to the Breeding Habits and Immature Stages of Diptera Cyclorrhapha. E.J. Brill/Scandinavian Science Press, Copenhagen., *Entomonograph*, 8(1): 478 p.

Gundersen, V. & J. Rolstad. 1998. Truete arter i skog [Threatened species in forests]. Oppdragsrapport nr. 6/98 (in Norwegian).

Hilt, M. & U. Ammer. 1994. Totholzbesiedelnde Käfer im Wirtschaftswald — Fichte und Eiche im Vergleich. Forstw. Cbl. **113**: 245—255. (In German with English summary).

Irmler, U., Heller, K. & J. Warning. 1996. Age and tree species as factors influencing the populations of insects living in dead wood (Coleoptera, Diptera: Sciaridae, Mycetophilidae). *Pedobiologia*, **40**: 134—148.

Jonsell, M., Weslien, J. & B. Ehnström. 1998. Substrate requirements of red-listed saproxylic invertebrates in Sweden. *Biodiversity & Conservation*, 7(6): 749—764.

Jonsson, B. G. & P.-A. Esseen. 1990. Treefall disturbance maintains high Bryophyte diversity in a Boreal spruce forests. *Journal of Ecology*, **78**: 924—936.

Kaila, L., Martikainen, P., Punttila, P. & E. Yakovlev. 1994. Saproxylic beetles (Coleoptera) on dead birch trunks decayed by different polypore species. *Ann. Zool. Fennici*, **31**: 97—107.

Koch, K. 1989—1992. Die Käfer Mitteleuropas Ökologie 1—III. Krefeld: Goecke & Evers.

Økland, K. A. 1981. Division of Norway for use in biogeographic work — a revision of the Strand-system. *Fauna*, **34**: 167—178. (In Norwegian).

Økland, B. 1996. A comparison of three methods of sampling saproxylic beetles. *European Journal of Entomology*, **93**: 195—209.

Økland, B. 1998. A review of species and new rearing habitats of the family Milichiidae (Diptera) in Norway. *Fauna norv., Ser. B*, **45**: 121—123.

Økland, B. and I. Zaitzev. 1997. Mycetophilids (Diptera, Sciaroidea) from southeastern Norway. *Fauna norv., Ser. B*, **44**: 27—37.

Økland, B. & B. M. Mamaev. 1997. Fennoscandian records of Lestremiinae (Diptera: Cecidomyiidae). *Fauna norv., Ser. B*, **44**: 123—128.

Økland, B., Bakke, A., Hågvar, S. & T. Kvamme. 1996. What factors influence the diversity of saproxylic beetles? A multiscaled study from a spruce forest in southern Norway. *Biodiversity & Conservation*, **5**: 75—100.

Ottesen, P. (1993). Norske insektfamilier og deres artsantall [Norwegian insect families and their species numbers]. *Norsk Institutt for Naturforskning utredning*, **55**: 1—40. (In Norwegian with English summary).

Palm, T. 1951. Die Holz- und Rinden-käfer der nord-schwedischen Laubbäume. *Medd. från Statens Skogforskn. -inst.*, 40(2): (In German).

Palm, T. 1959. Die Holz- und Rinden-käfer der süd- und mittelschwedischen Laubbäume. *Opuscula Entomologica* Suppl. XVI, Lund. (In German).

Riedel, M. & Ø. Berg. 1997. Faunistic remarks on Norwegian Ichneumonidae (Hymenoptera). *Fauna norv., Ser. B*, **44**: 39—53.

Samuelsson, J., Gustafsson, L. & T. Ingelög. 1994. Dying and dead trees. A review of their importance for biodiversity. *SLU Info*, Swedish University of Agricultural Sciences, Uppsala: 109 p.

Siitonen, J. 1994. Decaying wood and saproxylic Coleoptera in two old spruce forests: a comparison based on two sampling methods. *Ann. Zool. Fennici*, **31**: 89—95.

Smith, K. G. V. 1989. An introduction to the immature stages of British flies. *Handbooks for the Identification of British Insects*, Royal Entomological Society of London, **10**(14): 280 p.

Yakovlev, E. B. 1994. *Palaearctic Diptera associated with fungi and myxomycetes*. Karelian Research Center, Forest research institute, Russian Academy of Sciences: 128 pp.

Received 13.X.1999