Checklist of primary parasitoids and hyperparasitoids (Hymenoptera, Apocrita) on aphids (Hemiptera, Aphididae) from Norway

KARIN WESTRUM, INGEBORG KLINGEN, TROND HOFSVANG & ELINE BENESTAD HÅGVAR

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A Norwegian checklist of naturally occurring parasitoids and hyperparasitoids that are known to emerge from aphid species is presented. The checklist consists of both old records and species new to Norway. When available, host plant, host aphid and host parasitoid are given. The primary parasitoids *Binodoxys angelicae* (Haliday, 1833), *Lipolexis gracilis* Förster, 1862, *Lysiphlebus cardui* (Marshall, 1896), *Trioxys auctus* (Haliday, 1833) (Aphidiinae) and the hyperparasitoids *Alloxysta pleuralis* (Cameron, 1879) (Alloxystidae) are reported for the first time in Norway. In total we list 27 primary parasitoid species (24 Aphidiinae and 3 Aphelinidae) and 27 hyperparasitoids from Norway that are known to emerge from aphids. In Sweden about 125 species (114 Aphidiinae and 11 Aphelinidae) are known as primary parasitoids on aphids, whereas about 70 hyperparasitoid species are known. Obviously, this checklist does not include all parasitoids and hyperparasitoids that may emerge from aphids in Norway and only more studies may give us a more complete list. The checklist should therefore be updated periodically to assist researchers and policy makers within the field of biodiversity (mapping), natural resource management and applied entomology.

Keywords: parasitoids, hyperparasitoids, aphids, Norway, natural enemies, biodiversity, Hymenoptera, Aphidiinae, Aphelinidae, Pteromalidae, Encyrtidae, Megaspilidae, Alloxystidae, Hemiptera, Aphididae.

Karin Westrum, Ingeborg Klingen & Trond Hofsvang, Norwegian Institute for Agricultural and Environmental Research (Bioforsk), Plant Health and Plant Protection Division. Høgskoleveien 7, NO-1432 Ås, Norway.

Eline Benestad Hågvar, Norwegian University of Life Sciences, Høyskoleveien 12, NO-1432 Ås, Norway.

E-mail corresponding author: ingeborg.klingen@bioforsk.no

Introduction

Previous and more recent studies from Norway have revealed new species of naturally occurring insect parasitoids and hyperparasitoids (Hymenoptera, Apocrita) known to emerge from aphids (Hemiptera, Aphididae), but it is difficult to trace their records. In this paper we have therefore attempted to collect records, both published and unpublished, and present them in a checklist. Most faunistic publications on Norwegian insects have dealt with a specific taxon, whereas the focus of this checklist is the parasitoid and hyperparasitoid guild on aphids. It is our intention to update this checklist periodically to assist researchers and policy makers within the field of biodiversity (mapping) and applied entomology. We may have missed records, however, and would therefore

welcome all records of primary parasitoids and hyperparasitoids known to emerge from aphids.

Primary insect parasitoids on aphids are known from the following two Hymenoptera groups: 1) All species in Aphidiinae (Ichneumonoidea: Braconidae) 2) Some species in Aphelinidae (Chalcidoidea). Hyperparasitoids on aphids exist in nine different genera belonging to 5 different families (Table 1). In some genera all species are hyperparasitoids, as in *Alloxysta, Lytoxysta* and *Phaenoglyphis* (Quinlan & Evenhuis 1980), however in other genera, e.g. *Syrphophagus*, only very few species use already parasitized aphids as hosts (Noyes 2003).

TABLE 1. Genera (Hymenoptera) with known hyperparasitoids on aphids (Sullivan & Völkl 1999).

Superfamily	Family	Genera
Chalcidoidea	Pteromalidae	*Asaphes*
		Coruna
		Euneura
		Pachyneuron
Chalcidoidea	Encyrtidae	*Syrphophagus*
Ceraphronoidea	Megaspilidae	*Dendrocerus*
Cynipoidea	Alloxystidae	*Alloxysta*
		Lytoxysta
		Phaenoglyphis

Materials and methods

All parasitoid and hyperparasitoid species referred to as unpublished in the checklist (Table 2) were obtained from collected aphids (*Myzus cerasi* Fabricius, 1775, *Aphis pomi* DeGeer, 1773, *Dysaphis plantaginea* (Passerini, 1860), *Rhophalosiphum padi* (Linné, 1758)) that was identified down to species level and then placed individually on a leaf, suitable to the aphid. The leaf with aphids was embedded in 1.5% water agar in a 30 ml vial closed with a lid with 8 needle thick holes for aeration. The vials were then incubated at 20°C, 70% RH and 16:8 L:D. Aphids were recorded daily for mortality resulting in mummification or growth of insect pathogenic fungi. Mummified aphids were then recorded twice a week for emergence of parasitoids and hyperparasitoids. Also unidentified aphid mummies found at collection were placed individually as described above and observed for emergence of parasitoids and hyperparasitoids. Collected specimens from *M. cerasi* were obtained as a part of the project "Beneficial fungi and viruses for the control of pest insects in fruit", specimens from *A. pomi* and *D. plantaginea* were obtained as part of a master thesis (Westrum 2004), and specimens from *R. padi* were obtained as a part of the project "Forecasting aphids in cereals". Parasitoid and hyperparasitoid specimens hatched from mummies were placed in a small vial with 70% alcohol and sent for identification to species level to: Dr. Petr Starý (Institute of Entomology, Academy of Science, Czech republic) who identified parasitoids in the Apidiidinae hatching from *M. cerasi*, *A. pomi, D. plantaginea* and *R. padi* in 2003 and 2010; Dr. George Melika (Systematic Parasitoid Laboratory, Köszeg, Hungary) who identified hyperparasitoids in the family Alloxystidae from *M. cerasi* and *A. pomi* in 2003; Dr. Hannes Baur (Departement of Invertebrates, Natural History Museum, Bern Switzerland) who identified hyperparasitoids from the Pteromalidae from *A. pomi*; Dr. A. Polazek (Natural History Museum, London) who identified hyperparasitoids from the Megaspilidae from *M. cerasi* and *A. pomi* in 2003. After identification to species level, all specimens were labeled and stored in 70% alcohol in the collection of Bioforsk, The Norwegian Institute of Agriculture and Environment Research, Plant Health and Plant Protection Division. They might be viewed upon request. For earlier published material please see references given in Table 2.

Results

Table 2 presents a Norwegian checklist of primary parasitoid and hyperparasitoid species known to emerge from aphids. Both published and some unpublished materials are included. One of the species, *P. dolichocera*, is considered a synonym of *P. villosa* (Evenhuis & Bartotin 1977) and we

TABLE 2. Norwegian checklist of primary parasitoid and hyperparasitoid species known to emerge from aphids. The species of primary parasitoids, hyperparasitoids and host aphids are listed alphabetically after primary parasitoid. Hyphen (-): indicates lack of information or not relevant. County: refers to the "Strand-system" (Økland, 1981): AAY=Aust-Agder costal, AK=Akershus, BØ=Buskerud eastern, FV=Finnmark western, HEN=Hedmark northern, HES=Hedmark southern, HOI=Hordaland interior, NTI=Nord-Trøndelag interior, ON=Oppland northern, VE=Vestfold, SFI=Sogn og Fjordane interior, Ø=Østfold. EIS: European Invertebrate Survey (Endrestøl, 2005). Date: date/period of collected aphid(s).

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
Aphelinus abdominalis (Dalman, 1820)	-	-	-	SFI	60	Jostedalen, Myklemyr/ Vigdalen	-	11.VIII.1979	Compton 1981
Aphelinus abddominalis (Dalman, 1820)	-	-	-	NTI	101/102	Overhalla	-	17.VIII.1903	Strand 1913
Aphelinus chaonia Walker, 1839	-	-	-	SFI	60	Jostedalen, Fossen	-	24.VII.1979	Compton 1981
Aphelinus chaonia Walker, 1839	-	-	-	SFI	60	Jostedalen, Myklemyr/ Vigdalen	-	11.VIII.1979	Compton 1981
Aphelinus varipes (Förster, 1841)	-	-	-	SFI	60	Jostedalen, Gaupne	-	16.VII.1979	Compton 1981
Aphelinus varipes (Förster, 1841)	-	*Myzus persicae*/ *Aphis gossypii*	*Capcicum*/ *Cucumis*	AK	28	Ås	-	1994/1995	Røhne 2002
Aphidius colemani Viereck, 1912	-	*Myzus persicae*	-	AK	28	Ås	NM997160	1973	Hofsvang & Hågvar 1983
Aphidius colemani Viereck, 1912	-	-	*Capsicum*	AK	28	Ås	NM997160	27.XI.1975	Hofsvang & Hågvar 1983
Aphidius ervi Haliday, 1834	-	-	-	AK	28	Asker	-	1968	Hofsvang & Hågvar 1983
Aphidius ervi Haliday, 1834	-	*Myzus persicae*	-	AK	28	Ås	NM997160	10.IX.1973 10.VIII.1976	Hofsvang & Hågvar 1983
Aphidius ervi Haliday, 1834	-	-	*Trifolium*	AK	28	Ås	NM997160	27.V.1982	Hofsvang & Hågvar 1983
Aphidius matricariae Haliday, 1834	-	*Myzus persicae*	-	Ø	19	Jeløy	NL919892	24.VIII.1973	Hofsvang & Hågvar 1983
Aphidius matricariae Haliday, 1834	-	*Myzus persicae*	-	AK	28	Ås	NM997160	09.VIII.1982	Hofsvang & Hågvar 1983
Aphidius matricariae Haliday, 1834	*Dendrocerus carpenteri* (Curtis, 1829)	*Myzus persicae*	-	AK	28	Ås	NM997160	09.VIII.1982	Hofsvang & Hågvar 1983
Aphidius matricariae Haliday, 1834	*Asaphes suspensus* (Nees, 1834)	*Myzus persicae*	-	AK	28	Ås	NM997160	09.VIII.1982	Hofsvang & Hågvar 1983
Aphidius matricariae Haliday, 1834	*Asaphes vulgaris* Walker, 1834	*Myzus persicae*	-	AK	28	Ås	NM997160	09.VIII.1982	Hofsvang & Hågvar 1983
Aphidius rhopalosiphi De Stephani, 1902	-	*Rhopalosiphum* sp.	-	AK	28	Ås	NM997160	IV.1978	Hofsvang & Hågvar 1983
Aphidius rhopalosiphi De Stephani, 1902	-	-	*Hordeum*	NTI	101	Steinkjer	PR2297	27.VI. – 02.VII.2007	Klingen, I. & Westrum, K. unpublished
Aphidius rhopalosiphi De Stephani, 1902	-	-	-	-	-	-	-	-	Starý 1981

TABLE 2. continued

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
Aphidius rosae Haliday, 1834	-	*Macrosiphum rosae*	-	AK	28	Ås	NM997160	18.VI.1976	Hofsvang & Hågvar 1983
Aphidius uzbekistanikus Luzhetzki, 1960	-	-	-	-	-	-	-	-	Starý 1981
Binodoxys angelicae (Haliday, 1833)	-	*Aphis pomi*	*Malus*	BØ	28	Hurum	NM899135	26.VI. - 02.VII.2002	Westrum, K. unpublished
Diaeretiella rapae (M'Intosh, 1855)	-	*Myzus persicae*	-	AK	28	Ås	NM997160	23.VIII.1975 25.IX.1976 08.XI.1976	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Asaphes suspensus* (Nees, 1834)	*Myzus persicae*	-	AK	28	Ås	NM997160	05.X.1977 11.X.1978 3,17.X.1980	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Asaphes suspensus* (Nees, 1834)	*Myzus persicae*	*Capsicum*	AK	28	Ås	NM997160	22.VII. - 02.IX.1982	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Asaphes vulgaris* Walker, 1834	*Myzus persicae*	-	AK	28	Ås	NM997160	03.X.1980	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Asaphes vulgaris* Walker, 1834	*Myzus persicae*	*Capsicum*	AK	28	Ås	NM997160	12.VIII. – 15.X.1982	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Dendrocerus aphidium* (Rondani, 1877)	*Myzus persicae*	-	AK	28	Ås	NM997160	-	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Dendrocerus laticeps* (Hedicke, 1929)	*Myzus persicae*	-	AK	28	Ås	NM997160	19.VIII-1977 11.X.1978 07.X.1981	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Dendrocerus laticeps* (Hedicke, 1929)	*Myzus persicae*	*Capsicum*	AK	28	Ås	NM997160	29.VI.1982	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	*Dendrocerus* sp. Ratzeburg, 1852	*Myzus persicae*	*Capsicum*	AK	28	Ås	NM997160	22.VII.1982	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	-	*Myzus persicae*	-	Ø	19	Jeløy	NL919892	VII.1973	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	-	*Myzus persicae*	-	AK	28	Ås	NM997160	VII.1974	Hofsvang & Hågvar 1983
Ephedrus cerasicola Starý, 1962	-	*Myzus persicae*	*Capsicum*	AK	28	Ås	NM997160	22.VII. – 09.IX.1982	Hofsvang & Hågvar 1983
Ephedrus lacertosus (Haliday, 1833)	-	-	-	-	-	-	-	-	Mackauer, 1968
Ephedrus persciae Frogatt, 1904	-	-	-	-	-	-	-	-	Mackauer 1968
Ephedrus persciae Frogatt, 1904	-	*Myzus cerasi*	-	AAY	6	Grimstad	MK7266	19.VII.1975	Hofsvang & Hågvar 1983
Ephedrus persciae Frogatt, 1904	-	*Dysaphis plantaginea*	*Malus*	AK	28	Ås	NM994162	29.VII. – 30.VII.2002	Westrum, K. unpublished

TABLE 2. continued

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
Ephedrus persciae Frogatt, 1904	-	*Myzus cerasi*	*Prunus*	AK	28	Ås	NM990158	21.V. – 19.V.II.2002	Klingen, I. & Westrum, K. unpublished
Ephedrus persciae Frogatt, 1904	-	*Myzus cerasi*	*Prunus*	HOI	32	Ullensvang	LM707904	19.VI.2002 24.VI. – 08.VII.2004	Klingen, I. & Westrum, K. unpublished
Ephedrus plagiator (Nees, 1811)	-	-	-	-	-	-	-	-	Mackauer 1968 Starý 1981
Ephedrus plagiator (Nees, 1811)	-	*Hyalopterus pruni*	*Prunus*	AK	28	Asker,Sem	-	04.VII.1974	Edland 1976
Ephedrus plagiator (Nees, 1811)	-	*Myzus cerasi*	*Prunus*	AK	28	Ås	NM990158	22.V. – 09.VII.2001 21.V. – 13.VI.2002	Klingen, I. & Westrum, K. unpublished
Ephedrus plagiator (Nees, 1811)	-	*Myzus cerasi*	*Prunus*	HOI	32	Ullensvang	LM707904	25.VI. – 30.VI.2004	Klingen, I. & Westrum, K. unpublished
Ephedrus plagiator (Nees, 1811)	-	*Rhopalosiphum padi*	*Hordeum*	NTI	101	Steinkjer	PR2297	27.VI. – 11.VII.2007	Klingen, I. & Westrum, K. unpublished
Ephedrus plagiator (Nees, 1811)	-	*Rhopalosiphum padi*	*Hordeum*	HES	54	Brumunddal	PN0254	26.VI.2007	Klingen, I. & Westrum, K. unpublished
Ephedrus sp.	-	*Aphis pomi*	*Malus*	VE	19	Gjennestad	NL726667	08.XI.2003	Westrum, K. unpublished
Ephedrus sp.	-	*Myzus cerasi*	*Prunus*	AK	28	Ås	NM990158	21.V. – 12.VII.2002	Klingen, I. & Westrum, K. unpublished
Falciconus pseudoplatani (Marshall, 1896)	*Dendrocerus carpenteri* (Curtis, 1829)	-	*Acer*	AK	28	Ås	NM997160	26.X.1974	Hofsvang & Hågvar 1983
Falciconus pseudoplatani (Marshall, 1896)	-	-	*Acer*	AK	28	Ås	NM997160	26.X.1974 19.VIII.1976	Hofsvang & Hågvar 1983
Lipolexis gracilis Förster, 1862	-	*Aphis pomi*	*Malus*	BØ	28	Hurum	NM899135	29.VII. – 30.VII.2002	Westrum, K. unpublished
Lysiphlebus cardui (Mashall, 1896)	-	-	*Viburnum*	VE	19	Sandefjord	NL65035211	21.VIII.2005	Westrum, K. unpublished
Lysiphlebus confusus Tremblay&Eady, 1978	-	-	*Matricaria*	AK	28	Ås	NM997160	08.VII.1970	Hofsvang & Hågvar 1983
Monoctonus caricis (Haliday, 1934)	-	-	-	-	-	-	-	-	Mackauer & Starý 1967
Praon abjectum (Haliday, 1833)	-	-	-	-	-	-	-	-	Starý 1981
Praon gallicum Starý, 1971	-	-	-	-	-	-	-	-	Starý 1981
Praon myzophagum Mackauer, 1959	-	*Myzus persicae*	-	AK	28	Ås	NM997160	24.VII.1974	Hofsvang & Hågvar 1983
Praon silvestre Starý, 1971	-	-	*Brassicae*-field	AK	28	Ås	NM997161	31.X.1975	Hofsvang & Hågvar 1983

TABLE 2. continued

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
Praon volucre (Haliday, 1833)	-	-	Capsicum	AK	28	Ås	NM997160	IX.1975	Hofsvang & Hågvar 1983
Praon volucre (Haliday, 1833)	-	Hyalopterus pruni	Prunus	AK	28	Asker, Sem	-	13.VIII.1973 04.VII.1974	Edland 1976
Praon volucre (Haliday, 1833)	-	-	-	-	-	-	-	-	Starý 1981.
Praon sp. (unhatched mummy)	-	Aphis pomi	Malus	BØ	28	Hurum	NM899135	01.VII. – 30.VII.2002	Westrum, K. unpublished
Praon sp. (unhatched mummy)	-	Aphis pomi	Malus	AK	28	Ås	NM994162	03.IX.2003	Westrum, K. unpublished
Trioxys auctus (Haliday, 1833)	-	-	Hordeum	NTI	101	Steinkjer	PR2297	27.VI. -29. VI.2007	Klingen, I. & Westrum, K. unpublished
Trioxys sp.	-	Rhopalosiphum padi	Hordeum	NTI	101	Steinkjer	PR2297	04.VII. – 09.VII.2007	Klingen, I. & Westrum, K. unpublished
Toxares deltiger (Haliday, 1833)	-	Myzus persicae	-	Ø	19	Jeløy	NL919892	24.VIII.1973	Hofsvang & Hågvar 1983
-	*Alloxysta erythrothorax* (Hartig, 1840)	-	-	-	-	-	-	-	Hellén 1963, 1966
-	*Alloxysta filicornis* (Cameron, 1889)	-	-	SFI	42/51	Aurlandsdalen, Vassbygdi,	-	15.VIII.1965	Hellén 1966
-	*Alloxysta filicornis* (Cameron, 1889)	-	-	SFI	41/42	Vatnahalsen	-	16.VIII.1965	Hellén 1966
-	*Alloxysta filicornis* (Cameron, 1889)	-	-	-	-	-	-	-	Hellén 1963
-	*Alloxysta flavicornis* (Hartig, 1841)	-	-	SFI	42/51	Aurlandsdalen, Vassbygdi	-	15.VIII.1965	Hellén 1966
-	*Alloxysta flavicornis* (Hartig, 1841)	-	-	-	-	-	-	-	Hellén 1963
-	*Alloxysta forticornis* (Giraud, 1860)	-	-	-	-	-	-	-	Hellén 1963, 1966
-	*Alloxysta fuscipes* (Thomson, 1862)	-	-	SFI	41/42	Vatnahalsen	-	16.VIII.1965	Hellén 1966
-	*Alloxysta fuscipes* (Thomson, 1862)	-	-	-	-	-	-	-	Hellén 1963
-	*Alloxysta fulviceps* (Curtis, 1838)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004
-	*Alloxysta macrophadna* (Hartig, 1841)	-	-	SFI	42/51	Aurlandsdalen, Vassbygdi	-	15.VIII.1965	Hellén 1966
-	*Alloxysta macrophadna* (Hartig, 1841)	-	-	SFI	41/42	Vatnahalsen	-	16.VIII.1965	Hellén 1966

TABLE 2. continued

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
-	*Alloxysta macrophadna* (Hartig, 1841)	-	-	-	-	-	-	-	Hellén 1963
-	*Alloxysta macrophadna* (Hartig, 1841)	-	-	HEN	72	Alvdal, Tronfjeld	-	29. VIII.1903	Strand 1914
-	*Alloxysta macrophadna* (Hartig, 1841)	-	-	NTI	101/102	Overhalla	-	11-22. VII.1903	Strand 1914
-	*Alloxysta maxima* Hedicke, 1914*	-	-	NTI	101/102	Overhalla	-	21.VIII.1903 24.VIII.1903	Strand 1914
-	*Alloxysta obscurata* (Hartig, 1840)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004
-	*Alloxysta pallidicornis* (Curtis, 1838)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004
-	*Alloxysta pedestris* (Curtis, 1838)	-	-	SFI	42/51	Aurlandsdalen, Vassbygdi	-	15.VIII.1965	Hellén 1966
-	*Alloxysta pleuralis* (Cameron, 1879)	*Aphis pomi*	*Malus*	BØ	28	Hurum	NM899135	28.VII.2003	Westrum, K. unpublished
-	*Alloxysta rubriceps* (Kieffer, 1902)	*Hyalopterus pruni*	*Prunus*	AK	28	Asker, Sem	-	04.VII.1974	Edland 1976
-	*Alloxysta victrix* (Westwood, 1833)	*Myzus cerasi*	*Prunus*	AK	28	Ås	NM990158	21.V. – 22.VII.2002	Klingen, I. & Westrum, K. unpublished
-	*Alloxysta victrix* (Westwood, 1833)	-	-	SFI	42/51	Aurlandsdalen, Vassbygdi	-	15.VIII.1965	Hellén 1966
-	*Asaphes hirsutus* Gibson & Vikberg, 1998	-	-	ON	71	Dovre, Fokstua	-	13.VII.1953	Gibson & Vikberg 1998
-	*Asaphes suspensus* (Nees, 1834)	*Aphis pomi*	*Malus*	VE	19	Gjennestad	NL726667	11.IX.2003	Westrum, K. unpublished
-	*Asaphes suspensus* (Nees, 1834)	*Hyalopterus pruni*	*Prunus*	AK	28	Asker, Sem	-	13.VIII.1973	Edland 1976
-	*Asaphes suspensus* (Nees, 1834)	-	-	SFI	60	Jostedalen, Gaupne	-	19.VII.1979	Compton 1981
-	*Asaphes suspensus* (Nees, 1834)	-	-	HOI	41	Ulvik, Osastøl	-	03.IX.1970	Hedquist 1982
-	*Asaphes vurgaris* Walker, 1834	*Hyalopterus pruni*	*Prunus*	AK	28	Asker, Sem	-	13.VIII.1973	Edland 1976
-	*Asaphes vurgaris* Walker, 1834	-	-	SFI	60	Jostedalen, Gaupne	-	16.VII.1979	Compton 1981

TABLE 2. continued

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
-	*Asaphes vurgaris* Walker, 1834	-	-	HOI	41/42	Måbødalen	-	-	Hedquist 1982
-	*Asaphes vulgaris* Walker, 1834**	-	-	Ø	12	Halden, Kornsjø	-	23.V.1903	Strand 1913
-	*Asaphes vurgaris* Walker, 1834**	-	-	HES	55/56	Elverum	-	3.-5.V.1903	Strand 1919
-	*Dendrocerus aphidum* (Rondani, 1877)	-	-	SFI	42/51	Aurlandsdalen, Vassbygdi	-	15.VIII.1965	Hellén 1966 (se Fergusson 1980)
-	*Dendrocerus carpenteri* (Curtis, 1829)	*Aphis pomi*	*Malus*	AK	28	Ås	NM994162	18.IX.2003	Westrum, K. unpublished
-	*Dendrocerus carpenteri* (Curtis, 1829)	*Aphis pomi*	*Malus*	VE	19	Gjennestad	NL726667	11.IX.2003	Westrum, K. unpublished
-	*Dendrocerus carpenteri* (Curtis, 1829)	-	*Rosa*	AK	28	Ås	NM997160	14.VI.1974	Hofsvang & Hågvar 1983
-	*Dendrocerus carpenteri* (Curtis, 1829)	*Hyalopterus pruni*	*Prunus*	AK	28	Asker, Sem	-	13.VIII.1973 04.VII.1974	Edland 1976
-	*Dendrocerus dubiosus* (Kieffer, 1907)	-	-	SFI	42/51	Vassbygda Flom	-	15.VIII.1965	Dessart 1972 (see Fergusson 1980)
-	*Dendrocerus laevis* (Ratzeburg, 1852)	-	-	ON	71	Dovre	-	-	Fergusson 1980
-	*Dendrocerus* sp. Ratzeburg, 1852	*Aphis pomi*	*Malus*	VE	19	Gjennestad	NL726667	11.IX.2003	Westrum, K. unpublished
-	*Dendrocerus* sp. Ratzeburg, 1852	*Aphis pomi*	*Malus*	AK	28	Ås	NM994162	08.IX.2003	Westrum, K. unpublished
-	*Dendrocerus* sp. Ratzeburg, 1852	*Myzus cerasi*	*Prunus*	AK	28	Ås	NM990158	12.VI. – 20.VI.2001	Klingen, I. & Westrum, K. unpublished
-	*Euneura sopolis* (Walker, 1844)	-	-	FV	173	Alta	-	-	Walker 1844, Noyes 2003
-	*Phaenoglyphis heterocera* (Hartig, 1841)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004
-	*Phaenoglyphis salicis* (Cameron, 1883)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004
-	*Phaenoglyphis villosa* (Hartig, 1841)	*Aphis pomi*	*Malus*	VE	19	Gjennestad	NL726667	11.IX.2003	Westrum, K. unpublished
-	*Phaenoglyphis villosa* (Hartig, 1841)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004

TABLE 2. continued

Primary parasitoid species	Hyperparasitoid species	Host aphid species	Host plant	County	EIS	Locality	UTM WGS84 32V	Date	Reference
-	*Phaenoglyphis villosa* (Hartig, 1841)***	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004
-	*Phaenoglyphis xanthochroa* (Forster, 1869)	-	-	-	-	Norwegian mainland	-	-	Fauna Europaea Web Service. 2004

* Not any confirmed observation that this species hatch from aphids but still included. See discussion.
** In these references it is originally reported as *Isocratus vulgaris* Walker, 1834 which is a synonym of *Asaphes vulgaris* Walker,1834 (Gibson & Vikberg 1998, Fauna Europaea Web Service 2004)
*** In this reference it is originally reported as *Phaenoglyphis dolichocera* (Cameron, 1889) which is a synonym of *Phaenoglyphis villosa* (Evenhuis & Barbotin 1977, Fauna Europaea Web Service 2004).

have therefore listed it as *P. villosa* in Table 2. *A. maxima* is included in Table 2 even though we have not found any confirmed aphid host for this species in the literature. The reason we are still listing it is that, to our knowledge, it is the only report of this species worldwide. The types are stored in Humbolt University Museum in Berlin (Strand 1914, Andrews 1978). In addition to confirmed observations of Norwegian parasitoid and hyperparasitoid species known to emerge from aphids in Table 2, Strand (1919) also gives reports on parasitoids identified to only genus level from several Norwegian locations. Genera he is mentioning are: *Aphidius* spp. and *Praon* sp.

Discussion

In this checklist (Table 2) we list 27 primary parasitoid species (24 Aphidiinae and 3 Aphelinidae) and 27 hyperparasitoids (4 Pteromalidae, 5 Megaspilidae and 18 Alloxystidae) that are known from aphids in Norway. In Sweden about 125 species (114 Aphidiinae and 11 Aphilinidae) are reported as primary parasitoids on aphids, whereas about 70 hyperparasitoid species are reported (Gärdenfors unpublished, Noyes 2003). In Table 3, the number of primary parasitoids and hyperparasitoids documented to have aphids as hosts in Sweden and Norway is compared. The total number of species worldwide in each of the current genera is also given. Based on these comparisons, it is obvious that the Norwegian parasitoid fauna is poorly investigated. The primary parasitoids *B. angelicae, L. gracilis, L. cardui, T. auctus* (Aphidiinae) and the hyperparasitoid *A. pleuralis* (Alloxystidae) are reported for the first time in Norway. The parasitoids *B. angelicae*, *L. gracilis* and the hyperparasitoid *A. pleuralis* were observed as confirmed hatchings from *A. pomi* on apples from Hurum in the South Eastern part of Norway. The parasitoids *L. cardui* and *T. auctus* were observed from confirmed hatchings from unidentified aphid mummies from *Viburum* in Sandefjord and *Hordeum* in Steinkjer respectively. All species reported as new to Norway have, however, also been reported in Sweden according

TABLE 3. Numbers of primary parasitoid and hyperparasitoid species known to emerge from aphids reported for Norway compared to reports for Sweden. Last column present numbers of primary parasitoid and hyperparasitoid known to emerge from any hosts worldwide.

Family *Genus*	Numbers of primary parasitoid and hyperparasitoid species known to emerge from aphids reported for Norway (Table 2)	Numbers of primary parasitoid and hyperparasitoid species known to emerge from aphids reported for Sweden (references)	Numbers of primary parasitoid and hyperparasitoid species reported worldwide (references)
PRIMARY PARASITOIDS			
Braconidae (Aphidiinae)	24	114 (Gärdenfors pers. comm.)	Less than 600 described species (Stary pers. comm.)
Aphelinidae			
*Aphelinus**	3	11 (Noyes 2003)	89 (Noyes 2003)
HYPERPARASITOIDS			
Encyrtidae			
Syrphophagus	0	2 (Noyes 2003)	84 (Noyes 2003)
Pteromalidae			
Asaphes	3	4 (Noyes 2003)	17 (Noyes 2003)
Coruna	0	1 (Noyes 2003)	2 (Noyes 2003)
Euneura	1	2 (Noyes 2003)	5 (Noyes 2003)
Pachyneuron	0	5 (Noyes 2003)	59 (Noyes 2003)
Megaspilidae			
Dendrocerus	5	24 (Gärdenfors pers. comm.)	19** (Fergusson 1980)
Alloxystidae			
Alloxysta	14	27 (Gärdenfors pers. comm.)	146 (Andrews 1978)
Lytoxysta	0	0	1*** (Andrews 1978)
Phaenoglyphis	4	5 (Gärdenfors pers. comm.)	30 (Andrews 1978)

** A few species in related genera are known to parasitize aphids, ** Europe, *** North America*

to Gärdenfors (pers. comm.). The old record of *A. maxima* from Overhalla in Norway is to our knowledge still the only record of this species worldwide.

Parasitoids are important in population dynamics and regulation of several aphid species. They may cause high levels of mortality, and are therefore used in biological control (Powell & Pell 2007). The impact of hyperparasitoids on biological control is debated (Rosenheim 1998, Sullivan & Völkl 1999) since several studies show that aphidiids are able to regulate aphid populations in spite of high levels of hyperparasitoids (Hougardy & Mills 2009). According to Mackauer & Völkl (1993) the overall impact of hyperparasitoids on aphid-aphidiid population dynamics is probably limited by the low average fecundity of most hyperparasitoids. The use of parasitoids in conservation biological control can be difficult to perform in practice due to lack of knowledge of the biology of the species and their taxonomical status. Exact information about the host is often

lacking and the expression "associated with aphids" is often used without specifying whether this has been confirmed by observed hatching from an aphid species. We suggest that only isolated aphid mummies or parasitized living aphids should be used for subsequent hatching to identify a true host of an aphid parasitoid or hyperparasitoid. This is the case for the new material we present in this checklist (Table 2).

The relation between aphids, parasitoids and their hyperparasitoid species are important not only in population dynamics and biological control but also in relation to conservation and biodiversity. Many parasitoids and hyperparasitoids are host-specific and therefore dependent on the presence of their host. Should the host aphid and its host plant(s) become extinct, it is likely that the parasitoids and hyperparasitoids will also become extinct (Petermann et al. 2010). In additions to contribute to the general knowledge about the biodiversity among parasitoids and hyperparasitoids of aphids in Norway, the present checklist (Table 2) gives an overview of parasitoid and hyperparasitoid species that should be considered for their importance in integrated and biological control strategies in different crops in Norway. For example, we now know that the following parasitoid and hyperparasitoid species might be important for the control of pest aphids in apples (*A. pomi* and *D. plantaginea*): Parasitoids: *B. angelicae, Ephedrus* sp., *L. gracilis* and *Praon* sp. from *A. pomi* and *E. persicae* from *D. plantaginea*. Hyperparasitoid: *A. pleuralis, A. suspensus* and *D. carpenteri* from *A. pomi*. In this paper we have started to collect records of insect parasitoids and hyperparasitoids on aphids in Norway. Since the checklist (Table 2) is still far from complete it should be updated periodically to assist researchers and policy makers within the field of biodiversity (mapping), natural resource management and applied entomology.

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References

Andrews, F.G. 1978. Taxonomy and host specificity of Nearctic Alloxystinae with a catalog of the world species (Hymenoptera: Cynipidae). *Occasional Papers on Entomolgy State Calif, Department of Food and Agriculture* No. 25, 1978, 128 pp.

Compton, C. 1981. The chalcid fauna of the Jostedalen (Hym., Chalcidoidea). *Fauna norvegica Serie B* 28, 83–89.

Dessart, P. 1972. Révision des espèces européennes de genre *Dendrocerus* Ratzeburg, 1852 (Hymenoptera, Ceraphronoidea). *Mémoires de la Société royale belge d'Entomologie* 32, 1–310.

Edland, T. 1976. Verknad av insektmiddel i ulike konsentrasjoner på bladlus og nyttedyr. *Forskning og forsøk i landbruket* 27, 683–699.

Endrestøl, A. 2005. A new version of the EIS-system for Norway. *Fauna* 58, 92–97.

Evenhuis, H.H. & Barbotin, F. 1977. Studies on Cynipidae Alloxystinae. 6. *Phanenoglyphis villosa* (Hartig) and *Alloxysta arcuata* (Kieffer). *Entomologische Berichten (Amsterdam)* 37, 184–190.

Fauna Europaea Web Service. 2010. *Fauna Europaea version 2.2*, Available online at http://www.faunaeur.org [accessed Oct-2010]

Fergusson, N.D.M. 1980. A revision of the British species of *Dendrocerus* Ratzeburg. (Hymenopthera: Ceraphronoidea) with a review of their biology as aphid hyperparasites. *Bulletin of the British Museum (Natural History) Entomology* 41, 255–314.

Gibson, G.A.P. & Vikberg, V. 1998. The species of *Asaphes* Walker from America North of Mexico, with remarks on extralimital distributions and taxa (Hymenoptera: Chalcidoidea, Pteromalidae). *Journal of Hymenoptera Research* Vol. 7, 209–256.

Hedquist, K.-J. 1982. Chalcid flies (Chalcidoidea) from Hardangervidda. *Fauna of the Hardangervidda* 16, 1–16.

Hellén, W. 1963. Die Alloxystinen Finnlands

(Hymenoptera: Cynipidae). *Fauna fennica* 15, 1–23.
Hellén, W. 1966. Cynipiden- and Proctotrupoidenfunde aus Norwegen (Hympenoptera). *Norsk Entomologisk Tidsskrift* 13, 393.
Hofsvang, T. & Hågvar, E. 1983. Primary parasitoids (Hym., Aphidiidae) and hyperparasitoids on aphids from Norway. *Fauna norvegica Serie B* 30, 60–62.
Hougardy, E. & Mills, N.J. 2009. Factors influencing the abundance of *Trioxys pallidus*, a successful introduced biological control agent of walnut aphid in California. *Biological Control* 48, 22–29.
Mackauer, M. 1968. Die Aphidiiden (Hymenoptera) Finnlands. *Fauna fennica* 22, 1–40.
Mackauer, M. & Starý, P. 1967. *Hym. Ichneumonoidea. World Aphidiidae.* Index of Entomophagous Insects. Le Francois. Paris. 195 pp.
Maukauer, M. & Völkl, W. 1993. Regulation of aphid populations by aphidiid wasps: does parasitoid foraging behaviour or hyperparasitism limit impact? *Oecologia* 94, 339–350.
Noyes, J.S. 2003. *Universal Chalcidoidea Database.* World Wide Web electronic publication. www.nhm.ac.uk/entomology/chalcidoids/index.html [accessed Oct-2010]
Økland, K.A. 1981. Inndeling av Norge til bruk ved biogeografiske oppgaver - et revidert Strand-system. *Fauna* 34, 167–178.
Quinlan, J. & Evenhuis, H.H. 1980. Status of the subfamily names Charipinae and Alloxystinae (Hymenoptera: Cynipidae). *Systematic Entomology* 5, 427–430.
Petermann, J.S., Müller, C.B., Weighelt, A., Weisser, W.W. & Schmid, B. 2010. Effect of plant species loss on aphid-parasitoid communities. *Journal of Animal Ecology* 79, 709–720.
Powell, W. & Pell, J.K. 2007. *Biological control*. Pp. 469–513 in van Emden, H.F. & Harrington, R. (eds.), Aphids as crop pests. CABI, Wallingford, UK.
Rosenheim, J.A. 1998. Higher-order predators and the regulation of insect herbivore populations. *Annual Review of Entomology* 43, 421–447.
Røhne, O. 2002. Effect of temperature and host stage on performance of *Aphelinus varipes* Förster (Hym., Aphelinidae) parasitizing the cotton aphid, *Aphis gossypii* Glover (Hom., Aphididae). *Journal of Applied Entomology* 126, 572–576.
Starý, P. 1981. Biosystematic synopsis of parasitoids on cereal aphids in the western Palaearctic (Hymenoptera, Aphidiidae; Homoptera, Aphidoidea). *Acta Entomologica Bohemoslovaca* 78, 382–396.
Strand, E. 1913. XX. Hymenoptera Parasitica. *Nyt Magazin for Naturvidenskaberne* 51 IV, 337–361.
Strand, E. 1914. Neue Beiträge zur Arthopodenfauna Norwegens nebst gelegentlichen Bemerkungen über deutche Arten. XXI. Cynipidae. Bearbeitet von Hans Hedicke. *Nyt Magazin for Naturvidenskaberne* 52 IV, 353–356.
Strand, E. 1919. Neue Beiträge zur Arthopodenfauna Norwegens nebst gelegentlichen Bemerkungen über deutche Arten. XXII–XXVI. *Nyt Magazin for Naturvidenskaberne* 56, 107–127.
Sullivan, D.J. & Völkl, W. 1999. Hyperparasitism: multitrophic ecology and behaviour. *Annual Review of Entomology* 44, 291–315.
Walker, F. 1844. On the species of Chalcidites inhabiting the Arctic Region. *Annual Magazine of Natural History* 14, 331–342.
Westrum, K. 2004. Natural occurrence of insect pathogenic fungi and parasitoids on rosy apple aphid (*Dysaphis plantaginea*) and green apple aphid (*Aphid pomi*) (Homoptera: Aphididae). M.Sc. Thesis, Agricultural University of Norway. (In Norwegian).

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