Cimex pipistrelli complex new to Norway and additional records of bed bug species (Cimicidae, Heteroptera) from Norway and Sweden

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Cimex pipistrelli complex is recorded for the first time from Norway. Recent records of *Cimex pipistrelli* complex and of *Cimex hirundinis* (= *Oeciacus hirundinis*) Lamarck, 1816 are presented for Norway and Sweden. Species occurrence, species status and taxonomy of European Cimicidae are discussed with respect to Northern Europe.

Key words: Heteroptera, Cimicidae, *Cimex pipistrelli* complex, new records, Norway.

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Introduction

The bed bug family Cimicidae (Heteroptera) constitutes a group of specialized haematophagous ectoparasitic insects. About two-thirds of the cimicid species are associated primarily with bats, which have been suggested to be the ancestral hosts of the family (Horváth 1913). The remaining species are associated with birds and only a very few of all cimicid species, among which the famous common bed bug *Cimex lectularius* Linnaeus, 1758, are parasites of humans (Usinger 1966, Reinhardt & Siva-Jothy 2007).

The family Cimicidae contains about 110 species classified into 6 subfamilies and 24 genera (Henry 2009), and has a worldwide distribution. There are 17 species listed in Europe (Péricart 1996, Simov *et al.* 2006, Quetglas *et al.* 2012). The status of the species of the *Cimex pipistrelli* species complex (containing *C. pipistrelli* Jenyns, 1839, *C. singer* China, 1938, *C. dissimilis* (Horvath, 1910), *C. stadleri* (Horvath, 1935) and *C. japonicus* Usinger 1966) was long under debate (e.g. Hedicke 1935, Wendt 1941, Stichel 1959, Lansbury 1961, Usinger 1966, Wagner 1967, Péricart 1972, Kerzhner 1989, Péricart 1996, Melzer 2007, Balvín *et al.* 2013). The discrimination of different species of the so called

C. pipistrelli species complex is mainly based on morphological characters (see e.g. Usinger 1966). Recent studies, however, revealed significant morphological variation within *Cimex*-species depends on their host species (Balvín *et al.* 2013). Together with the results of recent molecular analysis (Balvín *et al.* 2015) it is very likely that all former and recent records of the *C. dissimilis* and *C. pipistrelli* (Coulianos & Ossiannilson 1976) from Sweden are in fact *C. pipistrelli* sensu lato (see below). Moreover, based on molecular data, the genus *Oeciacus* Stål, 1873 has been proposed as a synonym of *Cimex* (Balvín et al. 2015). We are aware of that neither the current catalogues of the Palearctic Heteroptera (Péricart 1996, Aukema *et al.* 2013) nor the taxonomic index of the Fauna Europaea are in concordance with the suggestions of Balvín *et al.* (2015). Final assessments, however, require further studies on the European Cimicinae species (Aukema pers. com. and see also a recent publication for *Cimex lectularius*; Hornok *et al.* 2017). Therefore we use the names *Cimex* (= *Oeciacus*) *hirundinis* Lamarck, 1816 and *C. pipistrelli* complex in this publication.

The following cimicid species are known from the five Nordic countries (Péricart 1996): *C.* (= *Oeciacus*) *hirundinis* Lamarck, 1816 and *C. lectularius* Linnaeus, 1758 (from all five countries), *C. pipistrelli* complex – (Demark and Sweden) and *C. columbarius* Jenys, 1839 (Finland: Usinger 1966, Albrecht et al. 2015). Recently, the tropical human bed bug *C. hemipterus* (Fabricius, 1803) was found both in Finland (Helsinki in 2010: Rintala & Rinne 2011) and in Sweden (in 1981, 2015, 2016: Persson Vinnersten 2017). To our knowledge, there are only a few more published records of this species in Europe, i.e. Russia (Gapon 2016), The Netherlands (Aukema & Hermes 2006), United Kingdom (Péricart 1996, Reinhardt & Siva-Jothy 2007) and Germany (Lederer 1950). The taxonomic status of *C. columbarius* has been under debate since the 1930ies (see e.g. Usinger 1966). This species was previously widespread in the heydays of pigeon breeding in Europe (the Finnish records are from 1949–1954), but more recent records are scarce; e.g. no record after 1950 in Germany (Hoffmann & Melber 2003) or after 1938 in the Netherlands (Aukema & Hermes 2006). Since no fresh material of *C. columbarius* was available for recent genetic studies (Balvín et al. 2015), the long debated question whether *C. columbarius* is a valid species, subspecies or just a variety of *C. lectularius* (see e.g. Usinger 1966 and references therein) remains unanswered.

The common bed bug, *C. lectularius*, had almost become extinct after the 1950–1960s, probably due to highly effective, but environmentally hazardous, insecticides. Today, the situation is very different with a remarkable resurgence of the common bed bug in Europe and worldwide over the last 10–15 years (Williams & Willis 2012, Reinhardt & Seidel 2012, Koganemaru & Miller 2013). In Norway, between 2007–2016, the number of pest control operations against the common bed bug increased with more than 600% resulting in a total of 3037 operations in 2016 (Norwegian Institute of Public Health 2018).

Here we present and discuss new data for *Cimex pipistrelli* complex and *C.* (= *Oeciacus*) *hirundinis* Lamarck, 1816 from Norway and Sweden.

First records of *Cimex pipistrelli* complex in Norway

The database of the Norwegian Institute of Public Health (FHI) contains several reports (N=6, June 2017) of bed bugs living in or close to bat roosts, that attacked humans in their houses (Norwegian Institute of Public Health, unpubl. data). The collection material of the FHI was checked in June 2017 (SR) and *C. pipistrelli* complex could be confirmed for two localities in Vestfold and Aust-Agder Counties (see Table 1). A third record will be presented in more detail.

Easy come, easy go: *Cimex pipistrelli* complex new to Hordaland County but (perhaps) immediately lost?

The bed bug *C. pipistrelli* complex was discovered

TABLE 1. Overview of all known records from *Cimex pipistrelli* complex (published as *C. pipistrelli* or *C. dissimilis*) from Norway and Sweden. For all records not mentioned in Coulianos (1998) and Coulianos & Ossiannilsson (1976), respectively, coordinates are given. Unpublished data from Sweden are from the Swedish Species Information Center (ArtDatabanken 2018) and/or Coulianos (unpubl. data). Leg. Norwegian Institute of Public Health (FHI)/Anticimex means that material was sampled or sent to these institutions. ZMBN= University Museum Bergen Norway. Annotations: [1] Material Anticimex: determination not approved by one of the authors, [2] Leg. FHI/Coll. FHI TBV= T. Person Vinnersten

Country	Province/County	Locality	Date	Coordinates	Leg./coll.	Comments/Publication
Norway	Vestfold	Stavern	1 July 2013	58.998° N 10.033° E	[2]	Material sent to FHI
Norway	Aust-Agder	Tromøya	1 July 2013	58.462°N 8.892° E	Leg. FHI/Coll. ZMBN	Material sent to FHI
Norway	Hordaland	Voss-Rekve	May 2015	60.628°N 6.3073°E	Leg. Anticimex/ Coll. ZMBN	
Sweden	Blekinge	Karlskrona	9 Jan 2015	56.1612° N 15.5869°E	Leg. Anticimex	Det. TBV, specimen was sitting on a bat's wing
Sweden	Skåne	Öved	July 1934		Leg. N.A. Kemner	Kemner 1937 in Coulianos & Ossiannilsson (1976)
Sweden	Skåne	Lomma	19 July 1959		Leg. F. Ossiannilsson	Ossiannilsson 1947 in Coulianos & Ossiannilsson (1976)
Sweden	Småland	Bjurkärr, sjön Åsnen	25 June 1985	56.641°N 14.669° E	Leg. R. Baranowski	
Sweden	Småland	Kalmar	19 Dec 2014	56.66°N 16.35°E	Leg. Anticimex	Det. Anticimex [1]
Sweden	Småland	Kalmar	3 Dec 2015	56.66°N 16.35°E	Leg. Anticimex	Det. Anticimex [1]
Sweden	Småland	Kalmar	20 Sep 2016	56.66°N 16.35°E	Leg. Anticimex	Det. Anticimex [1]
Sweden	Småland	Jönköping	28 April 2017	57.782°N 14.163° E	[2]	Det. TBV, 1 specimen sitting on a bat's wing
Sweden	Småland	Kalmar	27 July 2017	56.66°N 16.35°E	[2]	Det. TBV
Sweden	Småland	Kalmar	July 2017	56.66°N 16.35°E	[2]	Det. TBV, 2 different localities in Kalmar
Sweden	Öland	Resmo, Lilla Frö	23 May 2016	56.559° N 16.424° E	Leg. Anticimex & T. Knutsson	Det. Anticimex [1], Artdatabanken (2018): 10 specimens
Sweden	Östergötland	Hävla	7 June 2016	58.914°N 15.868° E	Leg . C-E. Ström	
Sweden	Östergötland	Norrköping	1 July 2010	58.587° N 16.192° E	Leg. Anticimex	Det. Anticimex [1]
Sweden	Södermanland	Valen, Hjälmaren	17 July 2015	59.253°N 15.756°E	Leg. L. Simonsson	
Sweden	Södermanland	Stockholm, Dalarö	Sept 1995	59.135°N 18.410° E	[2]	Det. TBV
Sweden	Södermanland	Stockholm, Värmdö, Fåglebrolandet	20 Nov 2014	59.274° N 18.627° E	Leg. Anticimex	Det. Anticimex [1]
Sweden	Södermanland	Viggaren (Albrostugan), Katrineholmen	7 July 2015	58.876°N 16.364°E	Leg. Anticimex	Det. Anticimex [1]
Sweden	Södermanland	Nyköping	20 July 2015	58.752°N 17.009°E	[2]	Det. TBV, 3-4 specimens
Sweden	Södermanland	Eskilstuna	7 Sep 2017	59.371°N 16.509°E	[2]	Det. TBV, 3-4 specimens
Sweden	Södermanland	Stockholm (South)	7 Nov 2017	59.27° N 18.04° E	[2]	Det. TBV
Sweden	Uppland	Boo, Saltsjö-Bo	July 2018	59.325°N 18.267°E	Leg. A. Johnsson	
Sweden	Uppland	Harg, Myrtorp	1 April 1985	59.35°N 16.49°E	Leg. R. Brock	Exact locality in the Myrtorp area is uncertain
Sweden	Uppland	Skokloster	19 April 1987	59.703°N 17.621°E	Leg. B. Åsberg	
Sweden	Uppland	Ekerö	1 April 1993	59.359°N 17.669°E	Leg. L. Jönsson	
Sweden	Värmland	Karlstad	21 Jan 1999	59.402° N 13.511° E	Leg. Anticimex	Det. Anticimex [1]

TABLE 1. *Continued*.

Country	Province/County	Locality	Date	Coordinates	Leg./coll.	Comments/Publication
Sweden	Dalarna	Mora, Alderängarna	October 2016	61.051° N 14.434° E	Leg. C.U. Eliasson	Artdatabanken (2018): 1 specimen
Sweden	Dalarna	Falun	2 July 1981	60.606°N 15.635°E	[2]	Det. TBV
Sweden	Gästrikland	Gävle	29 June 2018	60.674°N 17.141°E	[2]	Det. TBV
Sweden	Hälsingland	Söderhamn	25 July 2018	61.305° N 17.062°E	[2]	Det. TBV

when some specimens entered the loft of an inhabited house near Voss (see table 1) from a roost of the soprano pipistrelle *Pipistrellus pygmaeus* (Leach, 1825) in February 2015, most likely woken up from winter hibernation on a warm day. When the pest control company Anticimex AS examined the site in April and May 2015 several specimens were collected for further investigation (4♀♀, leg. Anticimex AS May 2015; 6♂♂, leg. Olav Overall April 2015, coll. University Museum Bergen (ZMBN). For two individuals, species identity was confirmed by DNA barcoding according to Hebert *et al.* 2003 (for results see BOLD:AAM2800). After consultation with the County Governor (Fylkesmannen) of Hordaland County a securing of the roof in order to prevent the bats from returning to their roost was made, but the measures taken were not sufficient and the bats returned in summer 2015. However, in June 2015 no bed bugs were found in those areas of the house used by humans, indicating that the bed bugs left this part of the building and stayed only in the roosts. Later a completely new roof was constructed, and since 2016, the bat roost did not exist anymore.

As compensation for the lost bat roost bat nest boxes were put up in the surroundings since artificial bat nest boxes as roosting places might stabilize bat populations in the long run (e.g. Brittingham & Williams 2000). In theory, the bed bugs might have been moved together with their host to the new roosting place. Even if bat nest boxes frequently are occupied by bed bugs (e.g. Morkel 1999, Bartonička & Gaisler 2007) it is not certain that at least parts of the first recorded population of the *Cimex pipistrelli* complex in Norway had survived that way. First of all, bed bugs usually stay only on its hosts shortly whilst feeding (Hase 1917, Usinger 1966) but may stay on the body of their hosts for longer time for the purpose of dispersal (Heise 1988). Bed bugs are wingless and all long range dispersal depends on "travel with their hosts". Transportation of bed bugs by the soprano pipistrelle, however, has been found to be rare (Balvín *et al.* 2012). Moreover, the bed bugs would have to stay on the hibernating bat the whole winter, which is not very likely. Consequently, the first recorded population of the *C. pipistrelli* complex from Norway probably became extinct. This is a classic example how biodiversity loss affects coexisting species, a phenomenon called "the sixth mass coextinction" (Dunn *et al.* 2009).

When examining the material from the FHI two more records of the *C. pipistrelli* complex were found (see table 1), indicating that there are more existing populations in Norway. It is more likely that such populations will be detected if bed bugs attack humans than from the relative scare studies on bats. Colonization of different bed bug species from bat roosts into rooms used by humans and subsequently biting of humans has been regularly reported (e.g. Kolb *et al.* 2009). Since the common bed bug (*C. lectularius*) also frequently parasites bats in human buildings, further investigations of such cases would be needed.

The status of the *Cimex pipistrelli* complex in Sweden

Previous records of the *C. pipistrelli* complex from Skåne and Uppland (Coulianos & Ossiannilson 1976) and new records are presented in table 1. The species complex is now recorded from 11 provinces ranging a period from 1789–2016.

Coulianos & Ossiannilsson (1976) mention that according to Péricart (1972) Swedish specimens seem to be intermediary between *C. dissimilis* and *C. pipistrelli,* which just reflects the uncertainty about the *C. pipistrelli* complex as discussed above. Again, there are several reports to Anticimex Sweden about Cimicidae living in buildings with bats or swallows/martins that attacked humans (Persson Vinnersten, unpubl.) where the actually species is unknown.

New records of the swallow *bug Cimex* (= *Oeciacus*) *hirundinis* in Sweden and Norway

The swallow bug is a parasite of different bird species but swallows in particular. The house martin *Delichon urbicum* (Linnaeus, 1758) is the principal host (Usinger 1966). Table 2 summarizes published (Coulianos & Ossiannilsson 1976) and unpublished older and recent records of the swallow bug showing a relatively widespread occurrence in 12 Swedish provinces.

The records of *Cimex* (= *Oeciacus*) *hirundinis* in the annotated catalogue of Heteroptera of Norway (Coulianos 1998) are older ones (1897–1952) from Oslo (Kristiania) and Bærum Municipalities (see Artsdatabanken 2018 for details), whereas more recent records are all based on material sent to the FHI (Table 2).

All records from Norway and Sweden are restricted to the Southeastern part of the countries, which is surprising as its main host, the house martin, has a nationwide distribution in both countries. Interestingly, *Cimex* (= *Oeciacus*) *hirundinis* records from the Finnish provinces Ostrobottnia media and Lapponia enontekiensis (north of 65°) (Rintala & Rinne 2011, Rinne 2012) indicate a more Northern distribution of the species.

Despite a widespread distribution of its main host, the house martin, (Avibirds-Bird Online Guide 2018), data from other European countries shows that the swallow bug seems to be found only occasionally (e.g. only 113 records in total from the whole Europe: GBIF database).

TABLE 2. Overview of all known records from *Cimex* (= *Oeciacus*) *hirundinis* from Norway and Sweden. For all records not mentioned in Coulianos (1998) and Coulianos & Ossiannilsson (1976), respectively, coordinates are given. Unpublished data from Sweden are from the Swedish Species Information Center (ArtDatabanken 2018) and/or Coulianos (unpubl. data). Leg. Norwegian Institute of Public Health (FHI)/Anticimex means that material was sampled or sent to these institutions. NISK= Norwegian Institute for Forest Research (now Norwegian Institute of Bioeconomy Research (NIBIO). Annotations: TBV= T. Person Vinnersten [1] Coulianos & Ossiannilsson (1976).

Country	Province/County	Locality	Date	Coordinates	Leg./coll.	Comments/Publication
Norway	Oslo	Kristiania	1897		Leg. Thomas Georg Münster	Coulianos (1998)
Norway	Oslo	Oslo	5 July 1950	59.93°N 10.83°E	Leg. Thor Hiorth Schøyen/Coll. NISK	seen and det. by Coulianos 2018
Norway	Oslo	Oslo, Alnabru	20 Apr 2007	59.932°N 10.835°3E	Leg. FHI/Coll. FHI	
Norway	Akershus	Bærum, Jar	July 1938	10,502°N 59,951°E	Leg. Thor Hiorth Schøyen/Coll. NISK	seen and det. by Coulianos 2018
Norway	Akershus	Bærum	June 1952	10,502°N 59,951° E	Leg. Thor Hiorth Schøyen/Coll. NISK	seen and det. by Coulianos 2018
Norway	Akershus	Skedsmo, Lahaugmoen	16 Sep 1978	59.975°N 10.962° E	Leg. FHI	
Norway	Akershus	Eidsvoll	7 June 1978	60.331° N 11.261° E	Leg. FHI	
Norway	Akershus	Rælingen	14 May 1987	59.921° N 11.083° E	Leg. FHI	
Norway	Buskerud	Sylling	1903			Schøyen 1903 in Coulianos (1998)
Norway	Buskerud	Drammen	11 Nov 1975	59.7438° N 10.204° E	Leg. FHI	
Norway	Telemark	Seljord	26 June 1974	59.484°N 8.6301° E	Leg. FHI	

TABLE 2. *Continued*.

Country	Province/County	Locality	Date	Coordinates	Leg./coll.	Comments/Publication
Norway	Oppland	Lunner	1914			Schøyen 1915 in Coulianos (1998)
Norway	Oppland	Lillehammer	6 June 2017	61.115° N 10.446° E	Leg. FHI/Coll. FHI	
Sweden	Skåne	Malmö	1919			Kemner 1925 in [1]
Sweden	Skåne	Arlöv	June 1945		Leg. T. Malmgren	[1]
Sweden	Skåne	Åkarp	24 Apr 1950		Leg. O. Kristensson	[1]
Sweden	Skåne	Falsterbo fyrhus	24 Aug 2015	55.383°N 12.816°E	Leg. Raul Vicente & Michael Tholin	Artdatabanken (2018): 15 specimens
Sweden	Skåne	Malmö	12 May 2015	55.59°N 13.01°E	Leg. Anticimex/ Coll. Anticimex	Det. TBV
Sweden	Småland	Loftahammar, Jungfrusund	15 Aug 1977	57.957°N 16.811°E	G. Sjödin	Artdatabanken (2018): 8 specimens, Det. Coulianos
Sweden	Öland	Torslunda, Skogsby	15 June 1970		Leg. C-C. Coulianos	[1]
Sweden	Öland	Högby, SV Hornsjön	3 Aug 2013	57.181°N 16.954° E	Leg. H-E. Wanntorp	
Sweden	Gotland	Bunge, Bungenäs	June 1947		F. Ossiannilsson	[1]
Sweden	Gotland	Stora Karlsö, Fyren	15 April 2006	57.289 °N 17.959°E	Leg. H. Elmqvist	Artdatabanken (2018): 15 specimens
Sweden	Gotland	Visby	July 2015	57.634°N 18.294° E	Leg. Anticimex/ Coll. Anticimex	Det. TBV
Sweden	Östergötland					Kemner 1937 in [1]
Sweden	Västgötland					Kemner 1937 in [1]
Sweden	Dalsland		ca. 1940		Leg. L. Fredberg	[1]
Sweden	Södermanland		ca. 1860			Reuter 1871 [1]
Sweden	Uppland	Runmarö	1902		Leg. Hoffstein	[1]
Sweden	Uppland	Älvkarleö	July 1925			Kemner 1925 in [1]
Sweden	Uppland	Uppsala	Ca. 1935			Kemner 1937 in [1]
Sweden	Uppland	Uppsala	15 Oct 1937			[1]
Sweden	Uppland	Bergshamra, Solna	15 Sep 1941			Ossiannilsson 1942 in [1]
Sweden	Värmland					Kemner 1937 in [1]
Sweden	Dalarna	Långsjön, Stora Skedevi Socken, Socken,	17 Aug 1952	60.513°N 15.916°E		
Sweden	Hälsingland	Tönnånger, Skogs kommune (now Söderhamns muncipality)	4–12 March 1964	61.118°N 16.797°E		

As an example, the Netherlands had between 60 000–80 000 pairs of house martins between 1990 and 2006 (Dijk 2013), but only one single record of the swallow bug has been reported since 1990 (Aukema & Hermes 2006). However, the swallow bug has been regularly found when nests of the house martin (including artificial breeding facilities; Berend Aukema, pers. com.) have been checked specifically for bugs (Orzágh *et al.* 1990, Frieß & Brandner 2014), indicating a more frequent occurrence of *Cimex* (= *Oeciacus*) *hirundinis*. Both nymphs and adults

of the swallow bug seem to hibernate within the bird nest (Wachmann et al. 2006), waiting for the spring and arrival of the house martins. Thus, the investigations for swallow bugs could easily be done without any harm to the birds during post breeding season. To gain more knowledge about the distribution of the swallow bug in Norway, and the other Scandinavian countries, we would like to plea ornithologists, birders and nature lovers in general to report any findings of this species to the authors or to biodiversity databases.

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