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Contribution to the Fennoscandian distribution of *Chionea* Dalman, 1816 (Diptera, Limoniidae), with notes on the ecology

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Updated information is given on the distribution of *Chionea araneoides* Dalman, 1816 and *C. crassipes* Boheman, 1846 in Norway. While *C. araneoides* is very common in southern Norway, there are only two records in northern Norway. *C. crassipes* has been taken numerously and in several localities in Finnmark, but in southern Norway, only a few individuals have been found in three alpine sites. These may represent relict populations. *C. lutescens* Lundström, 1907 is reported new to Sweden. Three samples of *C. crassipes* from Oulanka national park in Finland confirm the few earlier records from this country. Information is given on phenology, temperature and weather conditions, as well as some ecological aspects for *C. araneoides* in southern Norway, based on long term data.

Key-words: *Chionea*, Limoniidae, Diptera, distribution, Norway, Sweden, Finland, ecology, winter, snow

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Introduction

The wingless, "spider-like" *Chionea*-species (Diptera, Limoniidae) are winter active and can be seen walking on the snow surface (Fig. 1) at temperatures down to about –6 °C (e.g. Svensson 1966, Hågvar 1971). However, there has long been confusion both about their taxonomy and their distribution in Fennoscandia. Svensson (1966) wrote that three species had been reported from Sweden: *C. crassipes* Boheman, 1846 (he referred to Dalman as author), *C. araneoides* Dalman, 1816, and *C. minuta* Tahvonen, 1932. However, he assumed that the two latest probably were synonyms. Later, Svensson (1969) concluded that *C. araneoides* was a good species, and that both *C. minuta* and *C. brevirostris* Tahvonen, 1932 were synonyms. An extensive material sampled in northern Sweden and Finland contained three species: *C. araneoides*, *C. crassipes*, and *C. lutescens* Lundström, 1907 (Mendl et al. 1977). While *C. araneoides* occurred in both countries, *C. crassipes* was found only in the Swedish material and *C. lutescens* only in the Finnish. Later, Krzeminski (1982) presented a generalized map of Europe, where all the three last mentioned species were indicated by symbols to occur both in Norway, Sweden and Finland. This is, however, not correct for *C. lutescens*. Recently, Oosterbroek & Reusch (2008) presented a review of the European species of the genus *Chionea*. They concluded as follows: *C. araneoides* occurs widespread in all

FIGURE 1. A female of *Chionea araneoides* walking on snow. The long legs and tarsi make walking on even coarse snow an easy task. Photo: Niels Sloth.

three countries, but in Norway not further south than Oslo, and in Sweden not further south than Västra Götaland. *C. crassipes* has also been found in all three countries, widespread in Sweden south to Dalarna in the middle part of the country, in a few localities in Finland, and in only two sites in Norway (Finmarkia according to Siebke (1877) and Norefjell in Buskerud according to Tjeder (1965)). The distribution of *C. lutescens* covers large parts of Europe, but is not yet fully understood due to taxonomical confusions. It has not yet been confirmed from Norway and Sweden, but is widespread in Finland south of the Arctic Circle.

This paper adds information on the distribution of *Chionea* species in Norway, and has remarks to the distribution in Sweden and Finland. We also present some data on the ecology of *C. araneoides*, which adds to previous studies (e.g. Hågvar 1971, 1976, 2010).

Material and methods

This paper presents new material which was not included in the European survey given by Oosterbroek & Reusch (2008). Most data from Norway have been collected by two of the authors (SH and EØ) during several decades. Among other contributors, valuable material from Finnmark was collected by Geir Hågvar in 1971–72 and by persons from Øytun Folkehøyskole in 2009. In addition, material from the Zoological museums in Oslo (NHMO), Bergen (ZMB) and Tromsø (TM) were studied. From Sweden, the material in Lund museum (LM) was studied, which revealed a new species to Sweden. Data confirming known distribution in Sweden has not been included here. From Finland, material from Oulanka National Park was studied. The specimens were identified, or confirmed, by Stefano Vanin.

Results

Figs 2–3 show the known distribution of *C. araneoides* and *C. crassipes* in Norway. The records below are listed according to the revised Strand-system (Økland 1981). Among more than 600 *Chionea* specimens recorded in southern Norway, only 5 were *C. crassipes*. These were collected at high altitudes in western Buskerud (BV), northern Hedmark (HEN) and northern Oppland (ON). Among the 64 *Chionea* specimens recorded in northern Norway, only 6 were *C. araneoides*. This indicates a southern main distribution of *C. araneoides*, and a northern main distribution of *C. crassipes*. In the total material, the percentage of males was 59 in *C. araneoides*, and 44 in *C. crassipes*. *C. lutescens* was absent in the Norwegian material.

Records of *Chionea araneoides* in Norway

AK, Nannestad: Tømte, Steinsgård, EIS 37, 1 December 1966, 2♀♀, leg. Østbye, E.; Nannestad: Engelstadtjernet, EIS 36, 18 January 2009, 1♂1♀, leg. Elven, H.; Hurdal: Skrukkelia, EIS 45, December 1973 and January & March 1974, 16♂♂1♀, leg. Sørensen, O.J.; Eidsvoll: Netsjøen, EIS 37, 13 January 1974, 2♂♂, leg. Sørensen, O.J.; Eidsvoll: EIS 37, 26 December 1973, 1♂, leg. Sørensen, O.J.; Bærum: Bærumsmarka, Ila-Kampen, EIS 28, 22 January 1968, 3♂♂3♀♀, leg. Østbye, E.; Bærum: Lake Dælivann and Kolsåsen, EIS 28, December 1967–January 1968, 127 specimens, among which 50♂♂43♀♀, leg. Hågvar, S.; Bærum: Lake Dælivann and Kolsåsen, EIS 28, 1970–1990, 20♂♂5♀♀, leg. Hågvar, S.; Bærum: Burudvann-Vensåsseter-Skytterkollen,

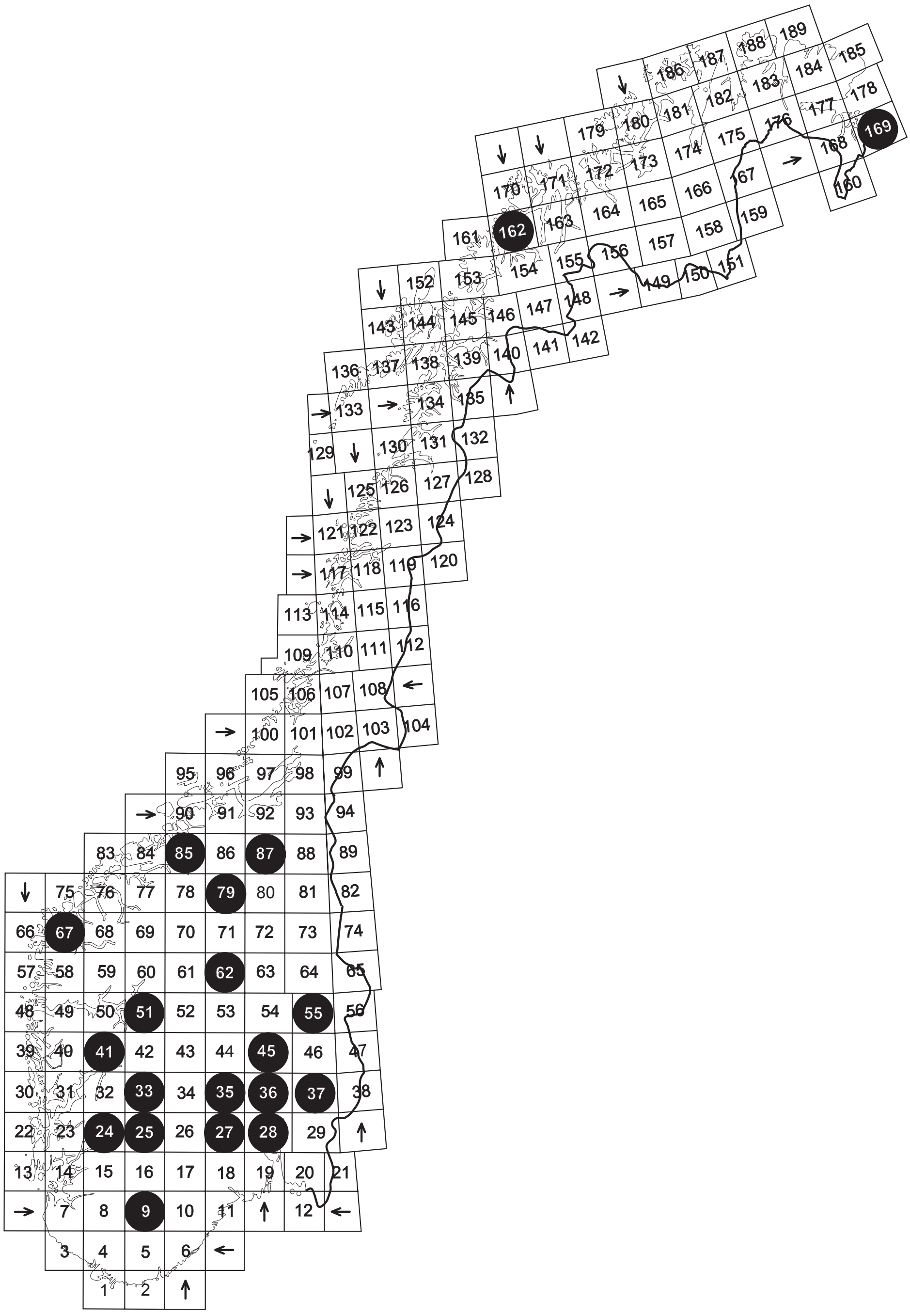

FIGURE 2. Known distribution of *Chionea araneoides* in Norway, illustrated by the EIS system (Endrestøl 2005).

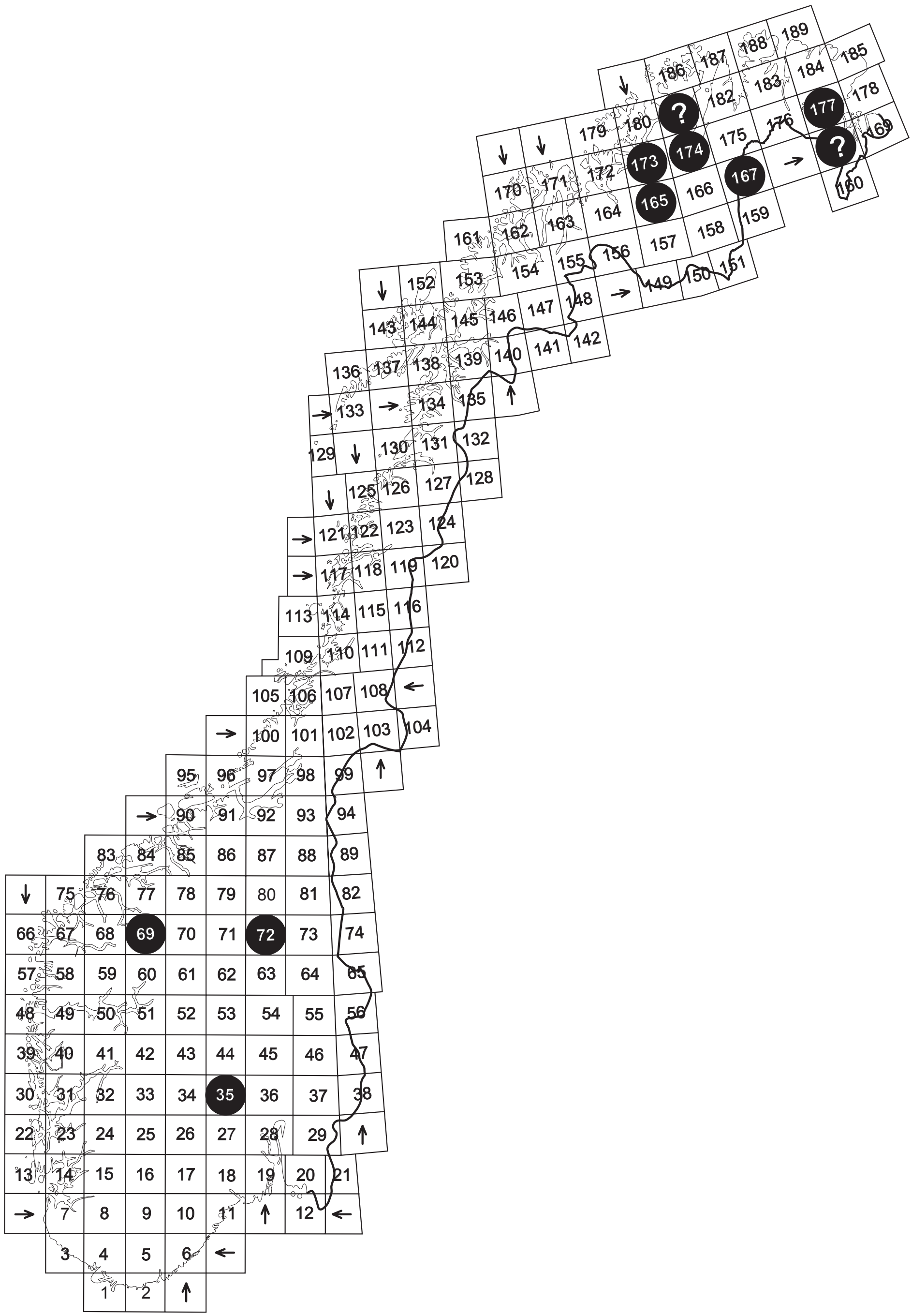

Figure 3. Known distribution of *Chionea crassipes* in Norway, illustrated by the EIS system (Endrestøl 2005).

EIS 28, 25 January 1970, 3♂♂3♀♀, leg. Østbye, E.; Oslo: Østmarka, EIS 28, 1970–2009, 24♂♂15♀♀, leg. Hågvar, S.; Oslo: Ullevålseter, EIS 28, 31 January 2009, 1♂, leg. Hågvar, S.; Ski: Ski, EIS 28, 20 February 1972, 1♀, leg. Selmer.; **BØ**, Hurum: Grytnes, EIS 28, 10 November 1997, 1♂, leg. Engdal, J.; Lier: Sylling, EIS 28, 1 December 1970, 1♂, leg. Østbye, E.; Drammen: Sunesetra, EIS 28, 21 January 1968, 1♂1♀, leg. Melåen, J. (NHMO).; Ringerike: Nordmarka, EIS 36, 1970–2000, 102♂♂81♀♀, leg. Hågvar, S.; Ringerike: Nordmarka, EIS 36, 17 February 2007, 22♂♂21♀♀, leg. Hågvar, S.; Kongsberg: Ravalsjøen, Haugmyrene, EIS 27, 24 January 1971, 1♂1♀, leg. Østbye, E.; Kongsberg: Ravalsjøen, EIS 27, 4 February 1968, 5♂♂13♀♀, leg. Østbye, E.; Kongsberg: Ravalsjøen, EIS 27, 24 January 1971, 7♂♂3♀♀, leg. Østbye, E.; Kongsberg: Ravalsjøen, EIS 27, 12 January 1975, 4♂♂4♀♀, leg. Østbye, E.; **BV**, Rollag: Votnedalen, Vegglifjell, 850 m a.s.l., EIS 35, 1982–2009, 51♂♂26♀♀, leg. Hågvar, S.; **TEI**, Vinje: Raulandsheiene 950 m a.s.l., EIS 25, 23 December 1971, 2♀♀, leg. Østbye, E.; Vinje: Rauland, EIS 25, 4 October 1975, 1♂, leg. Hågvar, S.; Fyresdal: Birtedalen, EIS 9, 27 December 2002, 3♂♂2♀♀, leg. Olsen, K.M.; **HES**, Elverum: Svartholtet, EIS 55, 29 December 1968, 14♂♂2♀♀, leg. Østbye, E.; **ON**, Nord-Fron: Skåbu, 940 m a.s.l., EIS 62, 3 April 1972, 2♂♂2♀♀, leg. Selmer.; **OS**, Lunner: Grua, Tveitmarkhøgda, EIS 36, 6 February 2000, 1♂1♀, leg. Antal, A. & Starholm, T.; **RI**, Suldal: Sandvatnet, EIS 24, 3 April 1966, 1♀, leg. Kjos-Hansen (ZMB); **HOI**, Voss: 4 km E of Mjølfjell station, 670 m a.s.l., EIS 41, 8 January 1990, 1♂, leg. Jensen, L.G. (ZMB); Eidfjord: 400 m NE of Maurset, EIS 33, 11 December 1971, 1♀, leg. Rosenlund (ZMB); **SFI**, Sogndal: Barsnes, EIS 51, 1 January 1967, 1♂, leg. Hågvar, S.; Sogndal: Barsnes, EIS 51, 30 December 1968, 1♂1♀, leg. Hågvar, S.; **MRI**, Surnadal: Vindøla, EIS 85, 20 December 1967, 1♂, leg. Røv, N.; **MRY**, Volda: Folkestadbygd, EIS 67, 11 January 1967, 1♀, leg. Solem, J.O.; **STI**, Midtre Gauldal: Budal, Endal, EIS 87, 1977, 1♂, leg. Engdal, J.; Oppdal: Near Heimtjørni, EIS 79, (pitfall, September 1994–June 1995, 1200 m a.s.l.)1♂3♀♀, leg. Skartveit, J. (ZMB); Oppdal: S. Knutshø, EIS 79, (pitfall, September 1994–June 1995, 1150 m a.s.l.) 1♂, leg. Skartveit, J. (ZMB); Oppdal: Kongsvoll 900 m a.s.l., EIS 79, 3 October 1984, 1♀, leg. Fjeldså, A. (ZMB).; **TRY**, Tromsø: Ørndalen, EIS 162, 31 October 1982, 1♂, leg. Fjellberg, A. (TM).; **FØ**, Sør-Varanger: Svanhovd, Svanvik, EIS 169, 2 November 1983, 3♂♂1♀, (TM).

Records of ***Chionea crassipes*** in Norway

BV, Norefjell, EIS 35, 20 February 1963, 1♀, leg. Bergsten, F. (Tjeder 1965, not seen by us); Norefjell, EIS 35, 10 March 1965, 1♀, leg. Benssen, G. (LM).; **HEN**, Tynset: Auma, Tyldalskjølen, EIS probably 72, 12 April 1968, 1♂, leg. Lillehammer, A. (NHMO); **ON**, Skjåk: Northern end of Liavatn, EIS 69, 12 March 1978, 2♂♂, leg. Fjellberg, A. (ZMB); **FV**, Alta: Eibydalen 13 km S of Alta, EIS 173, 20 February 1972, 1♂1♀, leg. Hågvar, G.; Alta: Skoadduvarri, EIS 173, 7 March 1971, 1♂, leg. Hågvar, G.; Alta: Skoadduvarri, EIS 173, 2 April 1972, 1♂, leg. Hågvar, G.; Alta: Tverrelvdalen, Stilla, EIS 173, 25 May 1971, 1♀, leg. Hågvar, G.; Alta: At main road 2 km S of Eiby, EIS 173, 19 March 1972, 4♀♀, leg. Hågvar, G.; Alta: Øytun, EIS 173, 29 March 2009, 1♀, leg. Krempig, L.; Alta: Talvik, EIS 173, 24 April 2009, 3♂♂1♀, leg. Dalsgaard, L.H.V.; Alta: Between Gampvann and Garrejokka 17 km S of Alta, EIS 165, 19 March 1972, 1♀, leg. Hågvar, G.; Alta: 3–8 km NE of Vuossogalvarri, EIS 165, 31 March 1972, 11♂♂22♀♀, leg. Hågvar, G.; Alta: Gargia, EIS 165, 1 April 2009, 2♂♂1♀, leg. Krempig, L.; **FN**, Nesseby: Varangerbotn, EIS 177, 20 March and 20 November 1967, 3♂♂, leg. Andersen, J.; Porsanger: Stabbursdalen, EIS 174, 12 March 2009, 1♀, leg. Dalsgaard, L.H.V.; **FI**, Karasjok: Karasjok, EIS 167, 29 April 1967, 1♀, leg. Hove. (NHMO).; Kautokeino: Vesterelvdalen, EIS 165, 27 February 2009, 1♂, leg. Krempig, L.; **FØ**, Sør-Varanger: ”S. Varanger, Sandberg”, 1♂ (dry specimen NHMO). Remark: EIS uncertain, but placed in 168 with a question mark.

Finnmark: “Finmark 7.74 Siebke”, 1♂ (dry specimen NHMO). *Remark*: The specimen has been identified to cfr. crassipes. We assume that it belongs to the following sample listed in Siebke (1877) as *C. araneoides*: "Kistrand ad Porsangerfjord 1874, cons. R. Collett". FN and EIS 181, but question mark on map due to uncertain identification.

Finnmark: "Finmarken 4, Siebke", 1♂ (dry specimen NHMO). *Remark*: We assume that it belongs to the following sample listed in Siebke (1877) as *C. crassipes*: "Nordri in Finmarkia mense April, Siebke". Further location is unknown, not indicated on map.

Chionea lutescens new to Sweden

One sample from Lund museum contained interesting information, as *Chionea lutescens* was recorded new to Sweden:

Material: Östergötland: Åtvidaberg 31 January 1966, 1♂2♀♀, leg. Gaunitz. (LM).

Chionea crassipes confirmed in Finland

Chionea crassipes was confirmed in three samples from coniferous forest in Oulanka National Park, NE Finland:

Material: 20 March 1968, 1♂1♀, leg. Svensson, S.A.; March 1968, 2♂♂1♀, leg. Wiger, R.; 15-20 March 1971, 15♂♂19♀♀, leg. Hågvar, S.

Notes on ecology and behaviour

C. araneoides.

Based on material from south Norway, Fig. 4 illustrates that specimens have been taken from October to April, but with maximum numbers observed in January. It means that this species uses the snow surface mainly during the coldest part of the year. Closer information about weather conditions at samplings are given in Fig. 5. Active animals were observed down to -6°C, which corresponds to the chill-coma temperature measured by Sømme & Østbye (1969). Most animals were sampled at subzero temperatures, but also often at zero and in one case up to 5°C. Temperatures were measured partly 1 cm above the snow level, and partly at 1,5 m height. Control measurements showed that at subzero temperatures, the difference between these two levels was never more than 0.3°C, while the 1 cm level tended to be about two degree colder when the 1.5 m level showed 2–5°C. The great majority of the observations were made in completely overcast weather, without wind. It was often snowing or foggy.

It is characteristic that the animals are constantly walking, and Hågvar (1971) showed that each individual walks near its top speed. Walking speeds from 26-80 cm per minute were recorded (Fig. 6), with approximately half a meter as a mean value. Even at -5.5°C, a female walked 46 cm per minute. Since the freezing temperature of the haemolymph is around -0.7°C (Sømme & Østbye 1969), it means that the animals move easily in a super cooled state. Several cases of directional migration were observed, indicating efficient dispersion (Fig. 7). The routes A and B were observed at 0°C, and C at about -3.5°C. Migrations A and C ended under spruce trees, where the animal partly stopped and gradually crept downwards in air channels to reach stable temperature conditions. Half an hour after animal C had escaped, the temperature had dropped to at least -4.5°C.

If you move too close to a migrating animal (a few dm), its directional movement may be disturbed. This is illustrated in Fig. 7D. First the animal stopped. When the observer moved it actively to avoid it to fall into a hare's footprint, its course became random.

C. crassipes.

The 41 specimens recorded in Alta, Finnmark, 1971–1972 were found in pine and/or birch forest. Some were taken close to open, treeless areas 350-400 m a.s.l., with only a few, small birches. Highest catches were taken in spruce and birch forest, in overcast weather at -3°C, partly under light snowfall. A few individuals were taken in sunny weather, but without wind. Except for one animal taken on wet snow at 4.5°C, the snow was dry and temperatures varied between -0.5 and -4.8°C. The specimen observed at the colder temperature moved only slowly. Five animals were found dead on snow, but temperature at death was unknown. All temperatures were measured 1 cm above the snow surface. Most specimens of *C. crassipes* were taken in May and April, and even one individual in late May. May be this species, usually living in colder areas than *C. araneoides*, has a somewhat later activity period on snow than *C. araneoides*.

Discussion

Distribution of *C. araneoides.*

The species is common and widespread in south Norway, and is typically found on snow in boreal forests. However, it has even been found above the tree limit, even up to 1200 m a.s.l. in the Dovre Mountains at Oppdal, STI. In North Norway there are only two records, and the Finnmark material is dominated by *C. crassipes*. While Oosterbroek & Reusch (2008) did not know records south of Oslo, the present material shows a southern record in EIS 9. In Fig. 2, there is a lack of records in the outer coastal areas of south Norway. Maybe this could be due to a lack of a permanent, insulating snow cover during winter, so that animals would be killed during cold periods. Further investigations should be done along the south-Norwegian coast, but also in middle- and northern Norway where large areas are without records. According to Oosterbroek & Reusch (2008), *C. araneoides* is distributed in northern Europe and in the mountains of Central Europe and Romania, while it is lacking in the intermediate lowlands.

Distribution of *C. crassipes*.

While Oosterbroek & Reusch (2008) only mentioned two records from Norway (Finmarkia according to Siebke (1877) and Norefjell in Buskerud according to Tjeder (1965)), the present data shows several locations in Finnmark, including a number of records in the Alta area. Two new localities in south Norway were in EIS 69 and 72. The northern main occurrence in Norway is mirrored by the presence in the northern half of Sweden. Also the few Finnish records are from the northern part (Oosterbroek & Reusch 2008). While high mountains are lacking in southern Sweden and Finland, the species has been confirmed in three high altitude sites in south Norway. These may be relict populations, and the species may have a bicentric distribution in Norway. It should be looked for more closely in mountains of south Norway, as well as in the middle part of the country. According to Oosterbroek & Reusch (2008), the nominotypical subspecies has been found only in Norway, Sweden, Finland and the Kola Peninsula in Russia.

Distribution of *C. lutescens*.

The record from Åtvidaberg, Östergötlands län in SE Sweden, which is new to the country, conforms to the southern distribution in Finland (Oosterbroek & Reusch 2008). The species has been reported from large parts of Europe, but the distribution is not yet fully understood (Oosterbroek & Reusch 2008). Also, taxonomical studies, both morphological and molecular, to clarify the difference between *C. lutescens*, *C. belgica* (Becker, 1912) and other southern species, are needed.

We may conclude that *C. lutescens* is the most southern of the three species, and *C. crassipes* the most northern. *C. araneoides* is widespread in Europe, but is rare far north and avoids lowland middle Europe. The European distribution is disjoint.

Ecology and behaviour of *C. araneoides*.

The phenology of *C. araneoides* in south Norway differs from *Boreus* sp. (Mecoptera), which is another typical wingless insect on snow. *Boreus* is not so cold tolerant, occurs on snow mainly at temperatures close to zero, and is mainly seen during the milder parts of the winter, in November/December and March/April (Sømme

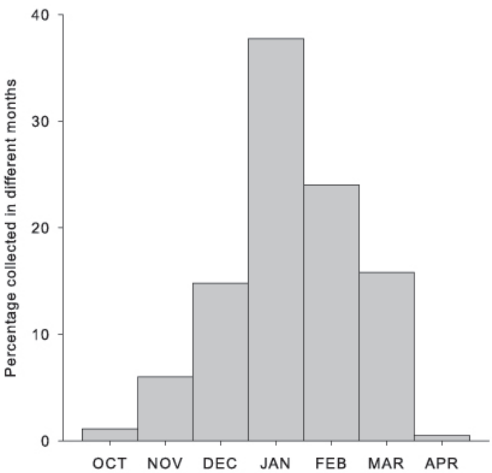

FIGURE 4. Phenology of *Chionea araneoides* in south Norway, based on 366 collected animals on snow. The main activity of the species occurs in the coldest winter months. Data compiled from many years.

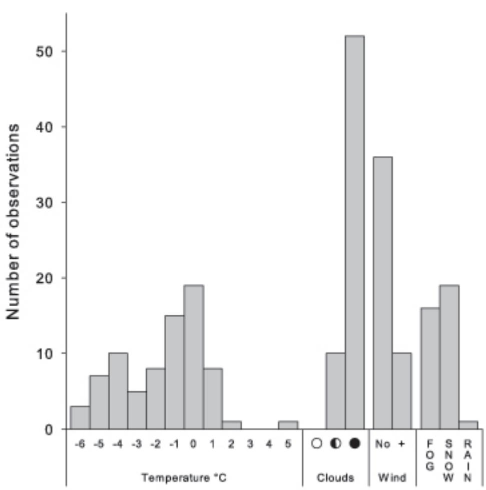

FIGURE 5. Weather conditions at different cases when *Chionea araneoides* was collected on snow in south Norway. Cloud conditions are indicated as no clouds, partly cloudy or completely cloudy, and wind conditions as no wind or faint wind (+). Cases of foggy, snowy or rainy weather are also indicated.

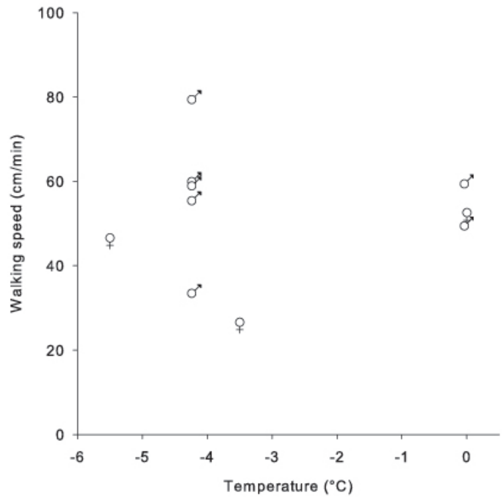

FIGURE 6. Walking speed of *Chionea araneoides* individuals at different temperatures. The slowest animals had lost a leg. Males and females are indicated.

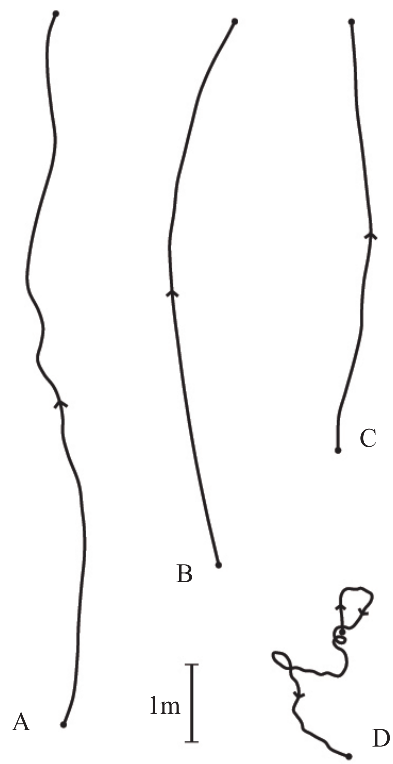

FIGURE 7. Routes on snow of four individuals of *Chionea araneoides*. Animal D was disturbed by the observer. More explanation in text.

& Østbye 1969, Hågvar 2001, 2010). During cold periods, both *Chionea* and *Boreus* stay below the snow where the temperature is close to 0°C (Coulianos & Johnels 1962), and migration between this subnivean environment and the snow surface occurs along air channels which are naturally created along stems, bushes and other vegetation which penetrate the snow layers. Both *Chionea* and *Boreus* lay eggs during the snow-covered period, but their phenology of egg-laying is different. Because *Boreus* eats moss, the ovaries continuously produce ripe eggs, and egg-laying occurs throughout the winter (Hågvar 2001). Adult *C. araneoides*, however, probably do not eat, have a shorter life, and have to lay their single batch of eggs during the cold part of the winter. This may explain their higher cold tolerance. By dissecting females, Hågvar (1976) showed that females hatch with undeveloped eggs, and lay most of their eggs in December and January. Each female has a capacity of about 100 eggs, and these are laid in portions on soil. Obviously, the smooth and predator-free snow surface is an ideal arena for migration, and with a speed of about 30 m per hour, the eggs from one *Chionea* female can be spread over a considerable area. We assume that the main purpose of snow surface activity in this wingless insect is migration and spreading of the eggs.

Hågvar (1971) assumed that one purpose of snow surface activity in *C. araneoides* was to allow the sexes to meet. However, copulating animals are very rarely seen on snow (Hågvar 2010). May be copulation to a large degree occurs just after hatching in late autumn. The ability to copulate at subzero temperatures have, however, been documented since animals put artificially together on snow often mate spontaneously (Fig. 8). The behaviour at copulation was described by Hågvar (1971).

While hibernating, inactive arthropods can use antifreeze agents that make the haemolymph viscous, winter active species like *Chionea* have to use antifreeze agents which allow the haemolymph to circulate easily. Vanin et al. (2008) showed that both *Chionea* and *Boreus* use the sugar trehalose as antifreeze agent.

C. araneoides is sensitive to even faint wind, and the great majority of the observations were made on windless days (Fig. 5). May be this is due to the danger of dehydration and/or lowered body temperature. Strong winds may even blow the animal away, or animals could be killed by snow falling down from trees.

Nearly all observations of *C. araneoides* were done in overcast weather (Fig. 5). This may seem strange, since solar radiation would obviously increase their body temperature. However, activity under a clear sky could be dangerous since temperature may fall rapidly during evening. Animals could be killed before they were able to find a way down to the subnivean environment. Since *C. araneoides* is active at temperatures only a few degrees above its chill-coma temperature, a stable temperature during migration is highly favourable. As seen in Fig. 5, it is often snowing or foggy when *C. araneoides* is active. A high air moisture is probably positive. Fig. 9 illustrates a typical *Chionea*-weather in a mid-Norwegian spruce forest: It is overcast, calm and a little foggy. The temperature is stable, slightly below zero.

In contrast, *Boreus* may be active on snow in bright sunshine (Hågvar 2001). However, this occurs mainly during late winter with air temperatures well above zero, so that the animals have sufficient time to escape if temperature drops towards a critical point.

Even heavy snowfall has no negative influence on the activity of *C. araneoides*. On the contrary, snowy, calm weather seems to induce surface activity. Maybe the animals can sense that the weather is changing to a stable, cloudy condition. Zettel (1984) concluded that the snow surface activity of the springtail *Isotoma hiemalis* was triggered by falling barometric pressure. May be this is also the case for *Chionea*. Walking on fresh snow may also have the advantage that footprints of mammals, which may act as pitfalls, are more or less wiped out.

Acknowledgments. We thank the Zoological museums in Oslo, Bergen, Tromsø and Lund for loan of material, Niels Sloth and Hallvard Elven for photographs of *C. araneoides*, and Lars Ove Hansen for producing the EIS maps.

FIGURE 8. Copulation of *Chionea araneoides* on snow is rarely observed, but if the sexes are brought together on snow, they often mate spontaneously. Photo: Hallvard Elven.

FIGURE 9. A calm, overcast and partly foggy winter day. Such stable weather conditions, with a temperature slightly below zero, are favoured by *Chionea araneoides* for migration on snow. Not rarely, the animals are active while it is snowing. Photo: Sigmund Hågvar.

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