

Four new records of limoniid crane flies (Diptera: Limoniidae) from forests in East Denmark using a standardized sampling design

Fire nye registreringer af limoniid stankelben (Diptera: Limoniidae) fra øst danske skove ved brug af et standardiseret forsøgsdesign

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Abstract

Knowledge of the fauna of Danish deciduous forests is important in order to conserve and stop the decline in biodiversity. Crane flies represent an important, but often neglected, group of insects in forests because of their abundance and diversity. Crane flies were collected from 10 forests with managed and unmanaged sites in East Denmark. Sampling was done with a sweep net in 125 different 706 m² circles. Each circle was sampled for 10 minutes at three intervals during the summer of 2015, totalling 62.5 hours. A total of 4814 specimens including 101 species of crane flies were collected, and four species were found as new to Denmark: 24 specimens of *Achyrolimonia decemmaculata* (Loew, 1873) were collected from eight forests; four specimens of *Dicranomyia lucida* Meijere, 1918 were collected from one forest (Suserup); 12 specimens of *Gonomyia bifida* Tonnoir, 1912 were collected from five forests; and 12 specimens of *Thaumastoptera calceata* Mik, 1866 were collected from one forest (Suserup). 34 of 125 circles investigated had one or more new species record. The habitat in which the species were collected is described, and their presence in Denmark is discussed.

Dansk sammendrag

Viden om faunaen i danske løvskove er vigtig i forbindelse med at bevare og stoppe reduktionen af biodiversiteten. Stankelben repræsenterer en vigtig, men ofte overset, gruppe af insekter i skov på grund af deres forekomst og diversitet. Stankelben blev indsamlet fra 10 danske skove med både forstligt drevne områder og urørt skov. Indsamlingen blev foretaget med fangstnet i 125 forskellige 706 m² cirkler. Dette blev gjort i 10 minutter af tre omgange i løbet af sommeren 2015, i alt 62,5 timer. Totalt blev 4814 individer fordelt på 101 arter af stankelben indsamlet, og fire arter kunne konstateres som nye for Danmark: 24 individer af *Achyrolimonia decemmaculata* (Loew, 1873) blev indsamlet i 8 skove; fire individer af *Dicranomyia lucida* Meijere, 1918 blev indsamlet i en skov (Suserup); 12 individer af *Gonomyia bifida* Tonnoir, 1912 blev indsamlet i 5 skove; og 12 individer af *Thaumastoptera calceata* Mik, 1866 blev fundet i en skov (Suserup). 34 ud af 125 undersøgte

cirklér havde et eller flere nye artsfund for landet. Arternes indsamlingshabitat beskrives og deres tilstedeværelse i Danmark diskuteres.

Introduction

The deciduous forests of Denmark cover 6 % of the total land area and represent an important biome for conservation of biodiversity (Nord-Larsen et al. 2014). Insects are especially important in Danish forests in relation to biodiversity, and approximately 25 % of all red list classified insects are associated with deciduous forests (Petersen et al. 2016). However, only 16 % of all Danish insect species has been evaluated on the red list, and especially the order Diptera has been neglected with only species of two families assessed for their status, i.e., Asilidae with 30 species and Syrphidae with 267 species (Wind & Pihl 2004). Diptera is considered one of the largest orders of insects in Denmark, including approximately 5000 recorded species (Petersen & Meier 2001). However, many families of Diptera have been poorly studied in Denmark, under-representing the actual number of species (Petersen & Meier 2001). Knowledge on Danish forest Diptera is limited, but very important in regard to conserving species and stopping the decline in biodiversity.

Crane flies are usually divided into four families, Limoniidae, Tipulidae, Pediciidae and Cylindrotomidae (Stary 1992). A checklist of Danish Diptera listed 261 species of crane flies with proper documentation (Petersen & Meier 2001). The checklist of Danish Diptera is based on material in the Natural History Museum of Denmark, University of Copenhagen as well as the pinned specimens in Natural History Museum in Aarhus, and with additional records from the relevant chapters in the Palearctic Catalogue (Soós et al. 1992). From distributional patterns and expert opinions the authors behind the list estimated the total number of crane fly species existing in Denmark at 330. This left an estimated 69 species from three of the four families [Limoniidae (48), Tipulidae (16), Pediciidae (5)] still to be found in Denmark (Petersen & Meier 2001). Since then, another four species have been added to the list by Salmela (2012), Bygebjerg & Munk (2005), and Pape in litt. in Oosterbroek (2014).

Most adult crane flies in Europe are active between May and September, where they emerge from their pupa and rapidly mate. The female oviposits and ends its lifecycle shortly afterwards. The eggs are laid in a variety of environments, including aquatic, semiaquatic and terrestrial habitats, where they hatch after a few weeks depending on temperature (Pritchard 1983). The larval stage is associated with many different habitats, including most types of marginal zones in wetland, soil and dead wood. Most temperate

crane flies overwinter in the third or fourth larval instar (Pritchard 1983). Some species of crane flies have several generations per year, whereas others only have one (Pritchard 1983).

Because of their diverse ecology, Diptera can serve as good indicators of the quality of ecosystems in biodiversity studies (Disney 1986, Frouz 1999). Crane flies in Denmark are represented by a large number of species with a diverse ecology, adults are relatively easy to sample, and detailed identification keys are available. Therefore, they are suitable for biodiversity and ecology studies comparing habitats and management strategies. During a biodiversity study comparing crane fly diversity in managed and unmanaged forests in Eastern Denmark, four species of crane flies previously not recorded from Denmark were discovered. We here present the findings with a short description of the habitats in which they were encountered.

Materials and methods

A total of 10 forests divided into a total of 17 parts including both managed and unmanaged areas in eastern Denmark were investigated as part of a larger study (coordinated by Inger Kappel Schmidt, University of Copenhagen). Similar areas in close proximity, size and age were paired for comparison so that ideally only the degree of management was separating the two sites (Fig. 1). The different areas, ranging from 2.0 ha to 19.3 ha, were divided into 100 x 100 m grids. Grid points were chosen from UTM coordinates with northings and eastings ending on 00 m. Each grid point was sampled. In the sites Farum Lillevang and Jonstrupvang where only a few grid points were present, additional grid points were chosen at random from a 50 x 50 m grid to ensure a proper sampling size. This yielded 3 to 20 grid points to be sampled from each site, totaling 125 grid points.

Crane flies were collected using a sweep net with a diameter of 38 cm in a circle with a radius of 15 m around each of the chosen grid points, giving a total sampling area of 8.84 ha. Sampling was done in low and high vegetation and around dead and live tree trunks, and was done with the aim to cover the entire circle. Sweeping was conducted in one- to two-minute intervals followed by quickly emptying the net. This was done for 10 minutes at each point (62.5 hours in total), including placing the crane flies into collecting tubes with 70 % alcohol. Sampling was conducted in mid-June, mid-July and early September 2016 over a span of maximum 11 days. Sampling was done in dry weather between 8 am and 6 pm and with dry ground vegetation. Crane flies were transferred to glass vials, labelled, and

identified to species using a stereo microscope Leica M205 C and the identification key by Stubbs & Kramer (2016).

Locations on Zealand, Denmark

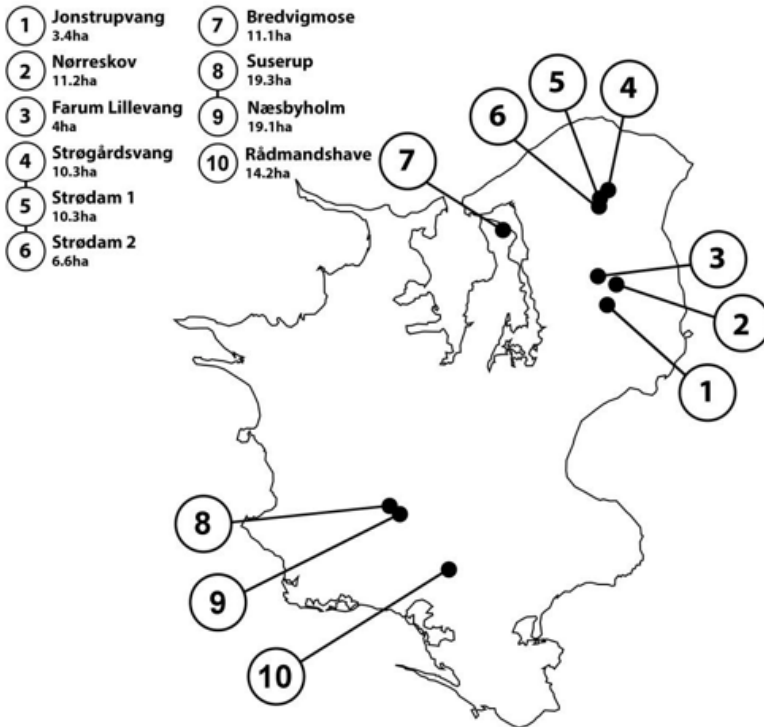


Fig. 1. Localities sampled in this study. Forest 1, 2, 3 & 7 each has a managed and an unmanaged part. Forest 4 is managed and paired with the unmanaged forests 5 & 6. Forest 8 is unmanaged and paired with managed forest 9. Forest 10 has two managed parts and two unmanaged parts.

Results

A total of 4814 specimens including 101 species of crane flies were collected and identified to species from a total of 373 samples (two samples were missing). Records new to Denmark and the collecting site(s) are presented in Table 1. From the 373 samples, 34 samples had one or more new records, and all of the forests had at least one new record. Two of the grid points in Suserup (forest 8) had the same two new species records, and one of them also included a third new record (*Achyrolimonia decemmaculata*).

Table 1: New records of crane flies species found in this project. Each row is connected and shows the forest with number of specimens, number of catch sites within the forest, date and specimens found in unmanaged sites. Number of individuals (Ind.), number of grid point circles (GPC), and number of individuals in unmanaged forests (Ind. in un.).

Species	Forest	Ind. (n)	GPC (n)	Date	Ind. in un. (n)
<i>Achryolimonia decemmaculata</i>	Rådmandshave	3	3	16/06/2015, 01/09/2015	1
	Strøgårdsvang	5	3	11/06/2015, 02/09/2015	0
	Nørreskoven	2	2	12/09/2015	2
	Strødam1,2	4	4	11/06/2015, 10/09/2015	4
	Farum Lillevang	3	2	08/06/2015, 11/09/2015	3
	Jonstrupvang	2	2	11/09/2015	1
	Suserup	5	4	15/06/2015, 04/09/2015	5
<i>Dicranomyia lucida</i>	Suserup	4	2	15/06/2015	4
<i>Gonomyia bifida</i>	Næsbyholm	2	2	10/06/2015, 01/09/2015	0
	Nørreskoven	2	2	15/07/2015	2
	Strøgårdsvang	4	3	02/09/2015	0
	Strødam2	3	2	11/06/2015, 10/09/2015	3
	Bredvigmosse	1	1	10/06/2015	0
<i>Thaumastoptera calceata</i>	Suserup	12	2	15/06/2015	12

1. *Achryolimonia decemmaculata* Loew, 1873

Material examined: DENMARK: **Rådmandshave:** 16.vi.2015, 1 ♀, 01.ix.2015, 2 ♂. **Strøgårdsvang:** 11.vi.2015, 3 ♂, 02.ix.2015, 2 ♂. **Nørreskoven:** 12.ix.2015, 1 ♀ 1 ♂. **Strødam1,2:** 11.vi.2015, 1 ♀, 10.ix.2015, 3 ♂. **Farum Lillevang:** 08.vi.2015, 1 ♀, 11.ix.2015, 2 ♂. **Jonstrupvang:** 11.ix.2015, 1 ♀ 1 ♂. **Suserup:** 15.vi.2015, 1 ♀, 04.ix.2015, 3 ♀ 1 ♂. D. Byriel & M. Justesen, Natural History Museum of Denmark.

Achryolimonia decemmaculata is distributed throughout the West Palaearctic and has been recorded from Sweden, Finland, Lithuania, Great Britain and Ireland in North Europe (Oosterbroek 2014). Because of its distribution in neighbouring countries, the species was classified as likely to occur in Denmark (Petersen & Meier 2001). The species lives in woodland and is associated with decaying wood where the larvae feed on fungi (Stubbs 2003).

The species was initially found in 1993 by Line Sørensen in a project similar to the present, sampling the same forests with the addition of Krenkerup Haveskov. From a total of 56 hours of quantitative sweeping self-selected areas in the 18 different sites one specimen was collected in Krenkerup Haveskov, one specimen in Suserup and two specimens in Bredvigmosse. All specimens were collected in unmanaged sites. Sampling was conducted

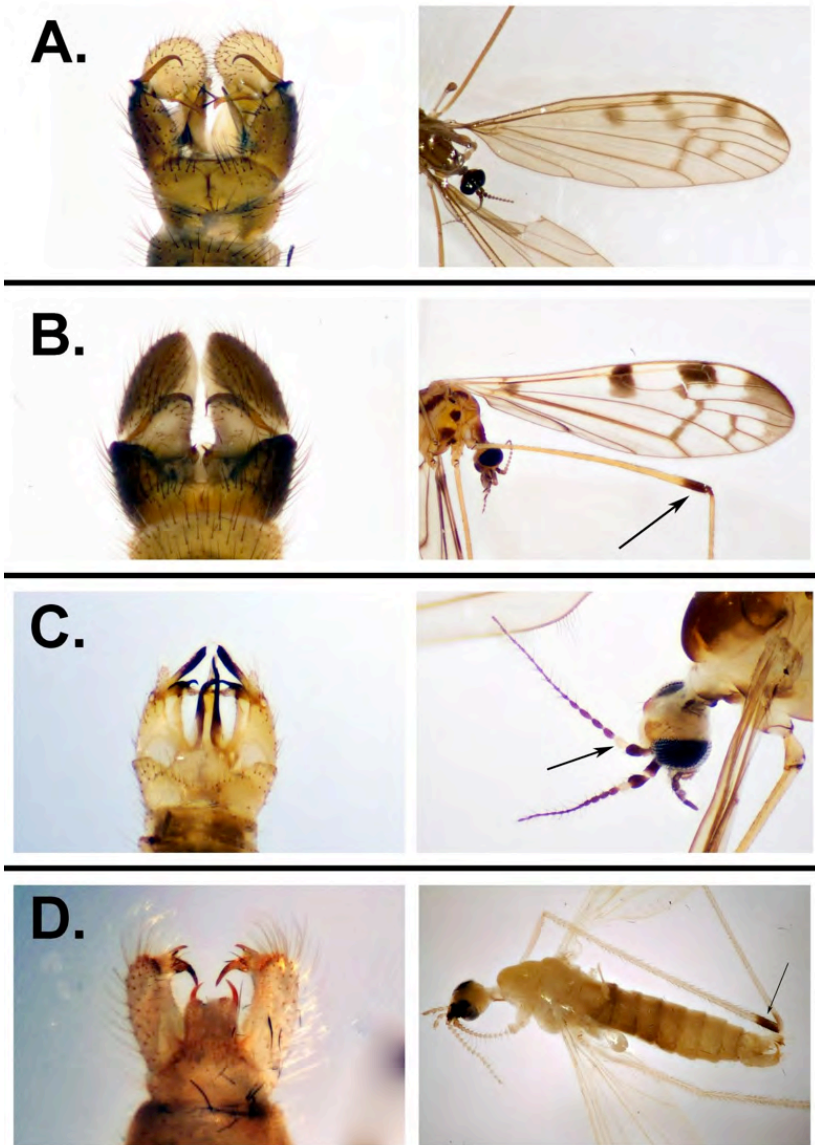


Fig. 2. Hypopygium and selected characters for identification of (A) *Achyrolimonia decemmaculata* with five distinct spots on each wing. (B) *Dicranomyia lucida* with distinct wing pattern and black-tipped femora. (C) *Gonomyia bifida* with basal flagellar segment yellowish. (D) *Thaumastopectera calceata*, general habitus with black-tipped femora.

every other week, with a total of 7 visits in each forest. This was done from 9 am to 22 pm using a sweep net with a diameter of 38 cm. Furthermore one specimen was found in Strødam using water trays (Møller 1997). The material was not preserved.

Achyrolimonia decemmaculata was collected also on the 5th and 10th September 2012 in Kongelunden, Amager (by W. Gritsch). A small number of specimens were observed swarming around highly decayed logs on the forest floor. Only males were found and a single specimen was collected using a sweep net (currently in coll. W. Gritsch). This find has been reported on the Danish webpage www.fugleognatur.dk.

In the present study, 24 specimens were collected from seven different forest parts, with 17 being collected from unmanaged areas. The species was collected in the first and last sampling period, which implies at least two generations in Denmark. This species was primarily sampled around larger pieces of deadwood, but also in areas with small amounts of deadwood.

As the name implies, *Achyrolimonia decemmaculata* can be recognized by its five distinct spots on each wing (Fig. 2 A). It is a modest-sized species with silvery frons.

2. *Dicranomyia lucida* de Meijere, 1918

Material examined: DENMARK: Suserup: 15.vi.2015, 2♀2♂. D. Byriel & M. Justesen, Natural History Museum of Denmark.

Dicranomyia lucida is distributed throughout the West Palaearctic and is recorded in North Europe from Great Britain and Ireland (Oosterbroek 2014). The species was not expected to occur in Denmark by expert opinion (Petersen & Meier 2001). It is found in wet woodland, woodland seepages and carr, and the larvae are found in rich mud seepages (Godfrey 2000, Bloxham 2014).

In this study four specimens were collected in Suserup forest, in close proximity (<50m) to the big lake Tystrup in wet woodland. In both of the grid points a spring overflow was present leaving most of the areas wet. Areas had a total vegetation cover of 90% and 35% and were dominated by *Carex* sp., *Carex elata*, various grasses, common nettle (*Urtica dioica*) and young trees of beech and ash. Both grid points had large amounts of deadwood in all stages of decay.

Dicranomyia lucida can be recognized by its distinctly patterned wings. It can be separated from *Dicranomyia ornata* by the shining orange thorax with a

black median band dorsally. Femora are black-tipped, and wing vein m-cu is located at the base of the discal cell (Fig. 2 B).

3. *Gonomyia bifida* Tonnoir, 1920

Material examined: DENMARK: Næsbyholm: 10.vi.2015, 1♂, 01.ix.2015, 1♀. Nørreskoven: 15.vi.2015, 2♀. Strøgårdsvang: 02.ix.2015, 1♀ 3♂. Strødam: 11.vi.2015, 1♂, 10.ix.2015, 2♀. Bredvigmosse: 10.vi.2015, 1♂. *D. Byriel & M. Justesen, Natural History Museum of Denmark.*

Gonomyia bifida is distributed throughout the West Palaearctic and is recorded in the neighbouring countries Norway, Sweden, Germany and Great Britain (Oosterbroek 2014). By expert opinion it was considered likely to occur in Denmark (Petersen & Meier 2001). It is found in marginal habitats along flowing as well as standing waters (Cranston & Drake 2010).

In this study 12 specimens were found in five different forests (Table 1). *Gonomyia bifida* was generally found in close proximity (<100 m) to lakes, small ponds, mires and ditches. It was caught in areas with a high percentage of vegetation cover (75–85%) dominated by common nettle and grasses, and in areas with lower vegetation cover (≤40%) dominated by the fern *Polypodium vulgare* and tufted hairgrass (*Deschampsia cespitosa*).

Gonomyia bifida is easily recognized by the basal flagellar segment which is yellowish and in strong contrast to the brownish remaining segments (Fig. 2 C).

4. *Thaumastoptera calceata* Mik, 1866

Material examined: DENMARK: Suserup: 15.vi.2015, 5♀ 6♂ 1?. *D. Byriel & M. Justesen, Natural History Museum of Denmark.*

Thaumastoptera calceata is distributed throughout the West Palaearctic and has been recorded from Great Britain and Ireland in North Europe (Oosterbroek 2014). Because of its distribution in neighbouring countries, the species was classified as likely to occur in Denmark (Petersen & Meier 2001). The larva of this species is associated with woody debris, but is considered non-xylophagous and probably saprophagous (Godfrey 2003). Most records are from wet woodland, at shaded seepages where calcareous conditions are preferred (Stubbs 2003).

In this study 12 specimens from Suserup forest were found at the same date and location as *Dicranomyia lucida*.

Thaumastoptera calceata is a small, fragile, lemon-yellow species with distinct black tips to femora and tibia (Fig. 2 D).

Discussion

The total area of the deciduous forests in East Denmark, excluding Bornholm, is 66 623 ha (Nord-Larsen et al. 2014). In the present study the total area sampled was 8.84 ha, and only 62.5 hours were spent catching crane flies with sweep nets. This suggests that there are many more new crane flies to be found in the forests of East Denmark, and it shows the large gap in our knowledge on Danish crane fly forest faunas.

This study found four new records, but *Dicranomyia lucida* was not expected to occur in Denmark. Therefore, the current number of crane flies expected to occur in Denmark are 62 species (Petersen & Meier 2001). Of these, at least 26 species are associated with forest and over half of them are associated with wetland habitats or wetland marginal zones (Oosterbroek 2014). Forest wetland areas can therefore be considered valuable habitats for finding new Danish records of crane flies. Rare habitats in forests such as springs or dead wood submerged in water could be of special interest as observed from Suserup in this study. Using other methods for sampling such as UV-traps for crepuscular and night active crane flies, Malaise traps for longer periods of trapping, and collection of larvae could also be of value. These sampling methods are of interest since no specimens of the saproxylic genus *Ctenophora* were caught during this project. This suggests that some species are unlikely to be caught with sweep nets due to their biology.

Whether the four species found in this study have been present in Denmark for a long time or have recently arrived is difficult to assess. Crane flies have been poorly studied in Denmark within the last century, and traditions for collecting crane flies are poor compared to, e.g., hover flies, beetles, butterflies and moths. *Achyrolimonia decemmaculata*, which is dependent on polyporous fungi on old dead wood, had been found in 1993 in different unmanaged areas. As a result of extensive forestry until the 1967 windfall, dead wood was almost nonexistent in Denmark (Johannsen et al. 2015). This event together with a changing attitude towards forest use and a high increase in unmanaged areas in 1992 (Johannsen et al. 2013) have probably enhanced the presence of *Achyrolimonia decemmaculata*, and might explain why the species has not been found until recently.

12 specimens of *Gonomyia bifida* were found from five different areas in this study. It also occurs in all neighbouring countries. It was discovered in Devon, Great Britain, in 1885 and described in 1920. It was first rediscovered in Great Britain in 1968 (Stubbs 1970). It is possible that the presence of this species is based on annual favourable climatic conditions as mentioned by

Stubbs (1970). Therefore, it is possible that *Gonomyia bifida* has become more abundant during the last decades or particular climatic conditions in 2015 could have enhanced its presence. This could be tested by future resampling the same areas in which *Gonomyia bifida* was found.

Dicranomyia lucida and *Thaumastoptera calceata* were found at the same two gridpoints in Suserup. Both areas had a spring overflow in most parts of the circle, large amount of dead wood, tree species in all ages, and a calcareous soil. The combination of these parameters makes a varied environment for crane flies and belongs to a rare type of habitat in Denmark. This might explain why these two species have not been found before now. *Dicranomyia lucida* was not expected to occur in Denmark. It occurs in Germany and Great Britain but in no other neighboring countries. This is the first finding from Scandinavia, and since the species is on the brink of its northern distribution, it is possible that the species arrived recently with the current warmer climate.

Whether unmanaged areas hold a greater potential for finding new records of crane flies compared to managed areas is difficult to assess based on the present data. Many of the crane flies expected to occur in Denmark are associated with specific wetland areas, and a few of them are associated with dead wood. Therefore, it is likely that drainage of wetlands and removal of deadwood result in destruction of unique forest habitats, thus lowering the potential of new records in managed areas. However, as observed, managed areas can also be valuable habitats for new records of crane flies. Studies on crane flies and their habitats in Denmark will most likely be a useful tool in conservation management.

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