The Danish Piesmatidae – Distribution and identification (Hemiptera, Heteroptera)

Danske Piesmatidae – Udbredelse og identifikation (Hemiptera, Heteroptera)

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Abstract

The distribution of the four Danish species of Piesmatidae are described illustrated an mapped, and an key for their identification is presented. Danish records of *Parapiesma variabile* (Fieber, 1844) are shown to refer to *P. salsolae* (Becker, 1867), and *P. variabile* can no longer be assumed to be a Danish species. Detailed records of Danish piesmatids have been uploaded to www.gbif.org.

Sammendrag

Udbredelsen af de fire danske arter af Piesmatidae er beskrevet, illustreret og kortlagt, og en nøgle til identifikation af disse er forelagt. Danske registreringer af *Parapiesma variabile* (Fieber, 1844) har vist sig at være *P. salsolae* (Becker, 1867), og *P. variabile* kan dermed ikke længere formodes at være en dansk art. Detaljerede registreringer af danske piesmatider er blevet uploaded til www.gbif.org.

Introduction

Piesmatidae is a family belonging to the hemipteran suborder Heteroptera (true bugs). About 40 species of Piesmatidae are known worldwide (Grimaldi & Engel, 2008). Four of these are known to occur in Denmark. The family is especially characterized by its punctuated network of cells on pronotum and hemelytra, and the species are all relatively small with a body length ranging from 2-4 mm (Grimaldi & Engel, 2008). Piesmatids are not particularly prominently coloured and are often referred to as ash-grey leaf bugs (Ghahari & Moulet, 2012).

Piesmatids can appear similar to the species of the family Tingidae (lace bugs). Earlier both families were classified in the same infraorder, Cimicomorpha. It was later discovered that they are not as closely related as first assumed, and the two families are now placed in separate infraorders, with the Tingidae remaining in Cimicomorpha and the Piesmatidae moved to Pentatomomorpha (Leston et al., 1954; Miller, 2004; Grimaldi & Engel, 2008). The main characteristic that distinguish Tingidae and Piesmatidae and the primary reason why the families are now classified in separate infraorders is the lack of ocelli in the species of Tingidae (Miller, 2004). Whereas ocelli are often present in adult macropterous specimens of Piesmatidae (Grimaldi & Engel, 2008).

The similarity between the species of Piesmatidae makes it difficult to identify the Danish species. One aim of this paper is therefore to construct an identification key including updated names as well as an extended set of characters relative to the 'classical' identification key for the Danish species of this family (Jensen-Haarup, 1912). Moreover, succinct descriptions of species and diagnoses of genera are included. These descriptions provide information on morphology, most similar species, host plant(s) and general distribution. Maps of the known distribution in Denmark are also included. These records on which the maps are based have been incorporated in Global Biodiversity Information Facility (www.gbif.org).

Material and methods

Identification and descriptions

It is possible to identify Danish Piesmatidae solely by their outer morphological characteristics. Some of the most important characteristics to look for include the shape of pronotum and paranota, as well as the number of keels on pronotum. A microscope is often necessary for identification due to the small body size.

To ease identification the key includes scanning electron microscope (SEM) pictures illustrating tiny significant details. This have been done by using a JEOL JSM-6335F scanning electron microscope. In preparation for SEM specimens were purified with 96% ethanol, followed by acetone. The cleaned insects were then placed on aluminium stubs, coated with platinum and palladium, and finally inserted into the vacuum chamber of the SEM. Additionally, optical pictures were taken with a macro lens to illustrate colour patterns.

The identification key and species descriptions are build on the original key in "Danmarks fauna 12 – Tæger by A. C. Jensen-Haarup" (Jensen-Haarup, 1912) as well as identification keys from England (Southwood & Leston, 1959), Germany (Wagner, 1959; Wagner, 1966) and France (Heiss & Péricart, 2007). The characters described in these identification keys were compared, and new characters were added. Additional information of the species was obtained from Fauna Europaea (2017), Global Biodiversity Information Facility (2017), Hurd (1946), Jorigtoo et al. (1998) and Allearter.dk (2017).

Data and processing

The distribution maps are based on 1.278 specimens of Piesmatidae from Denmark. These specimens primarily come from the collection of the Natural History Museum of Denmark and from the collection of the Natural History Museum Aarhus. Remaining specimens have come from collectors around the country. The information on the specimens was used to construct a data sheet in Microsoft Excel™ with information on species name, collection locality and date, host plant, name of collector and name of identifier.

Results

Data set

The dataset (1.278 records) is available through the Global Biodiversity Information Facility, GBIF: http://doi.org/10.15468/51dpya. The information available on the label for each specimen has been of varying degree. GPS coordinates have been found for the locations by using www.mapper.acme.com, www.google.dk/maps and www.fugleognatur.dk. Because of differences in the precision noted for the locations of the various specimens, coordinate uncertainties in meters have been created around the GPS coordinates. These coordinate uncertainties have the purpose of including the uncertainty for locations of specimens that have little information about the place of collection. Few specimens have very unprecise locations noted on their labels such as Jutland or Zealand. For these locations, coordinate uncertainties have not been created because of their size that would dominate the distribution maps and thereby overshadow other coordinate uncertainties. Although the locations of these specimens do not have coordinate uncertainties, they are marked on the maps around the centre of the region noted on their labels, to include some information on where the specimens have been found.

Family Piesmatidae (Amyot & Audinet-Serville, 1843)

Six genera worldwide, two in Denmark. About 40 species worldwide, four in Denmark.

Morphology

The species of Piesmatidae are characterized by their punctuated network of cells on pronotum and hemelytra, their two-segmented tarsi, their four-segmented antennae and their likewise four-segmented rostrum (Heiss, & Péricart, 2007). In addition, the Piesmatidae are characterized by having elongated juga, mandibular plates, that are pointing forward and reach at least to the apex of clypeus (Fig. 1a, b) (Schuh & Slater, 1995). Furthermore, the scutellum is exposed, the hemelytra have a distinct membrane area and the bucculae, which are flanges on each side of labium, are well developed (Schuh & Slater, 1995). The species are similar to each other in size and colours, around 2-4 mm in body length and with grey-brown colours.

An important character that distinguish the Danish species of Piesmatidae is the number of keels at pronotum, which is either two or three (Fig. 1a, b). Furthermore, the shape of pronotum and the relative length of their four antennal segments is important for identification.

Ecology

Piesmatids are phytophagous and often host specific. They often feed on species of Chenopodiaceae, but are also found at other plant families, for example Caryophyllaceae, Amaranthaceae and Cistaceae (Schuh & Slater, 1995; Southwood & Leston, 1959). In addition, species of the family have been found on *Corynephorus canescens*, *Jasione montana*, *Salsola kali* and Portulacaceae spp.

Description

Piesmatidae are characterized by a network of small cells that are similar in size and shape. Ocelli are often present in adult macropterous specimens. Juga are elongated as they reach at least to the apex of clypeus. In addition tarsi are two-segmented and both the antennae and rostrum are four-segmented. Furthermore, scutellum is exposed, the bucculae are well developed and the hemelytra membrane area is distinct. Body length is around 2-4 mm and the species are with grey-brown colours.

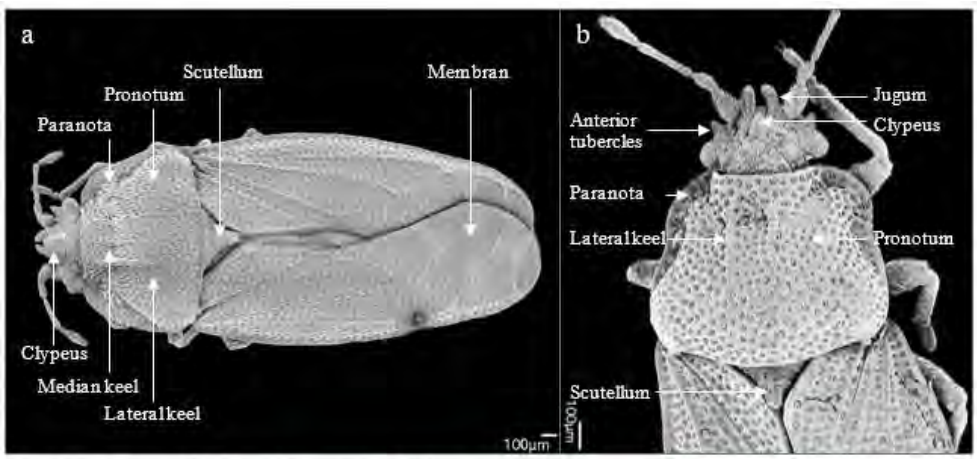

Fig. 1 Dorsal view of habitus of Piesmatidae: (a) *Parapiesma quadratum* and (b) *Piesma maculatum*

Key for identification of Danish species of Piesmatidae

The key only applies to adult specimens.

1 Pronotum with 2 keels (Fig. 2a); anterior tubercles simple (Fig. 2c, 3a); Scutellum with dark tip 2

- Pronotum with 3 keels (Central keel often vague) (Fig. 2b); anterior tubercles double (Fig. 2b, 3b); Scutellum with pale tip 3

2 Pronotum narrowed in front (Fig. 2c); Paranota with 1 row of cells; Paranota not indented; L. 2.0-3.0 mm ..... *Piesma capitatum* (p. 5)

- Pronotum not narrowed in front (Fig. 2a); Paranota with 2-3 rows of cells; Paranota indented; L. 2.3-3.1 mm ..... *Piesma maculatum* (p. 6)

3 Paranota indented; On *Salsola kali*; L. 3.0-3.4 mm ..... *Parapiesma salsolae* (p. 7)

- Paranota not indented; On species of *Chenopodium* or Portulacaceae L. 2.3-3.5 mm ..... *Parapiesma quadratum* (p. 8)

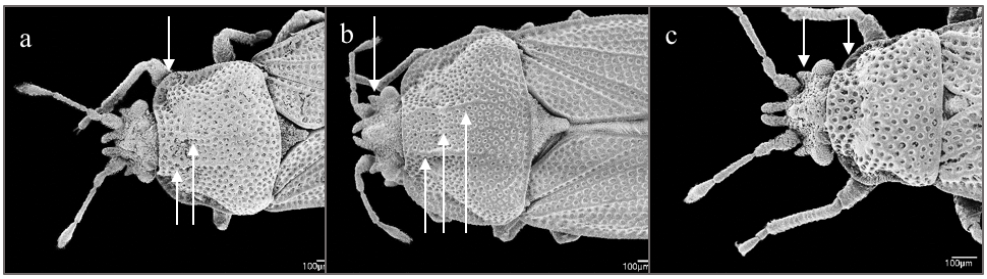

Fig. 2. Dorsal view of pronotum of *Piesmatidae*: (a) *Piesma maculatum*, (b) *Parapiesma quadratum* and (c) *Piesma capitatum*.

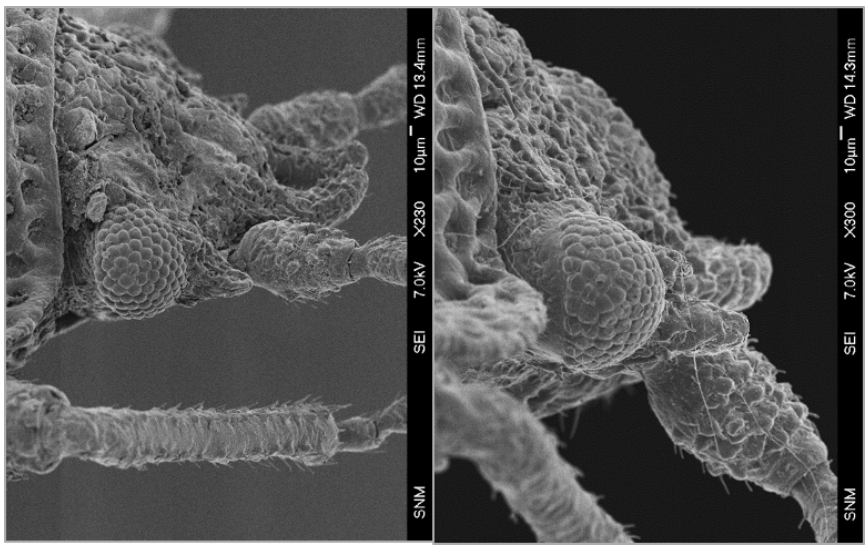

Fig. 3. Lateral view of anterior tubercles of *Piesmatidae*: (a) *Piesma maculatum*, (b) *Parapiesma quadratum*.

Danish species of Piesmatidae
Genus *Piesma* Lepeletier & Serville, 1828
Genus *Piésma*: Jensen-Haarup, 1912

Diagnosis. Colours variable, usually with shades of grey and brown. Pronotum with 2 keels, anterior tubercles simple. Head with ocelli, antennae and rostrum four-segmented. Legs with two-segmented tarsi. Membrane of hemelytra with 4 veins. Juga longer in males than in females.

Piesma capitatum (Wolff, 1804)
Piésma capitáta: Jensen-Haarup, 1912

Fig. 2c; 4a, b

Description
Length. 2.0-3.0 mm. Macropterous forms 2.4-3.0 mm; Brachypterous forms 2.0-2.5 mm.

Colours. Head dark-brown to black. Pronotum, paranota, hemelytra, antennae and legs grey-brown to yellow-brown. Scutellum including its tip dark-brown (Fig. 4a).

Habitus. Pronotum narrowed in front, with 2 keels. Paranota with 1 row of cells, not indented (Fig. 4a, b).

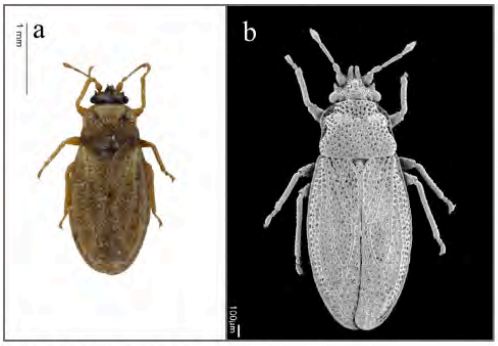

Fig. 4. Dorsal view of *Piesma capitatum*: (a) Colour photo and (b) SEM image.

Fig. 5. Distribution map of *Piesma capitatum* in Denmark. Based on 115 specimens.

Similar species
Similar to *Piesma maculatum*. Agrees with this species in having 2 keels at pronotum. Differs by having a narrower pronotum which is relatively long (Fig. 12).

Host plants
Corynephorus canescens and *Jasione montana*.

Distribution
Adults occur throughout the year.

Present in. Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Central European Russia, Croatia, Czech Republic, Denmark, East European Russia, Estonia, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Kaliningrad Region, Latvia, Liechtenstein, Luxembourg, Macedonia, Moldova, North European Russia, Northwest European Russia, Norwegian mainland, Poland, Romania, Slovakia, Slovenia, South

European Russia, Spanish mainland, Sweden, Switzerland and Yugoslavia (Péricart & Golub, 1996).

Notes
Piesma capitatum occurs in Jutland, Fyn, Langeland and Zealand (Fig. 5). The distribution map is based on 115 specimens.

Piesma maculatum (Laporte, 1833)
Piésma maculáta: Jensen-Haarup, 1912

Fig. 1b; 2a; 3a; 6a, b

Description
Length. 2.3-3.1 mm. Macropterous or submacropterous.

Colours. Colours variable. Head brown. Pronotum, paranota and hemelytra usually white-grey, yellow-brown or yellow-grey with brown spots. Antennae and legs yellow-brown. Scutellum including its tip dark-brown (Fig. 6a).

Habitus. Pronotum wide, with 2 keels. Paranota with 2-3 rows of cells, indented (Fig. 6a, b).

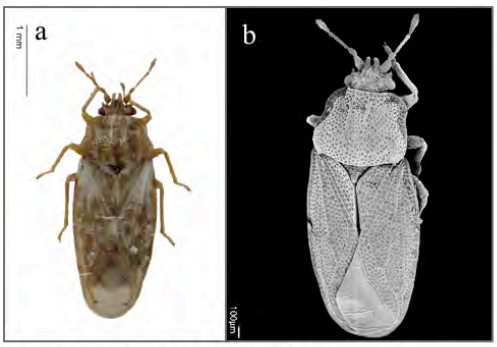

Fig. 6. Dorsal view of *Piesma maculatum*: (a) Colour photo and (b) SEM image.

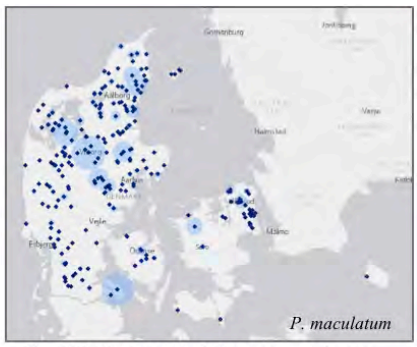

Fig. 7 Distribution map of *Piesma maculatum* in Denmark. Based on 867 specimens.

Similar species
Similar to *Piesma capitatum* (See *Piesma capitatum*) and *Parapiesma quadratum*. Differs from the latter species in having 2 keels at pronotum (Fig. 12).

Host plants
Chenopodium spp.

Distribution
Adults occur throughout the year.

Present in. Austria, Belarus, Belgium, Bosnia and Herzegovina, Britain I., Bulgaria, Central European Russia, Croatia, Czech Republic, Denmark, East European Russia, Estonia, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Latvia, Lithuania, Luxembourg, Macedonia, Malta, Moldova, North European Russia, Northwest European Russia, Norwegian mainland, Poland, Portuguese mainland, Romania, Slovakia, Slovania, South European Russia, Spanish mainland, Sweden, Switzerland, The Netherlands and Yogoslavia (Péricart & Golub, 1996).

Notes
Piesma maculatum is the most abundant Danish species of the Piesmatidae. It is also the species that has the greatest distribution as it is found in most of the country (Fig. 7). The distribution map is based on 867 specimens and the species is found at 223 locations.

Genus *Parapiesma* Pericart, 1974
Genus *Piésma*: Jensen-Haarup, 1912

Diagnosis. Colours variable, usually with shades of grey and brown. Pronotum with 3 or 5 keels, anterior tubercles double. Head with ocelli, antennae and rostrum four-segmented. Legs with two-segmented tarsi. Membrane of hemelytra with 4 veins.

Parapiesma salsolae (Becker, 1867)
Fig. 8a, b

Description
Length. 3.0-3.4 mm. Macropterous only known.

Colours. Head yellow-brown. Pronotum, paranota, hemelytra grey-brown to whitish with pale brown spots. Antennae and legs pale yellow-brown. Scutellum brown with pale tip (Fig. 8a).

Habitus. Pronotum with 3 keels. Paranota with 1-2 rows of cells, indented. 3. antennal segment 1.55-1.67 times as long as the 4. antennal segment and almost 3 times as long as the 2. antennal segment (Fig. 8a, b).

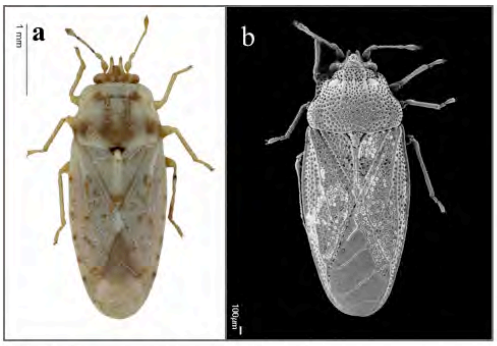

Fig. 8. Dorsal view of *Parapiesma salsolae*: (a) Colour photo and (b) SEM image.

Fig. 9. Distribution map of *Parapiesma salsolae* in Denmark. Based on 16 specimens.

Similar species
Similar to *Parapiesma quadratum*. Agrees with this species in having 3 keels at pronotum and a pale tip at scutellum. Differs by having paranota indented (Fig. 12).

Host plant
*Salsola kali***.**

Distribution
Adults occur throughout the year.

Present in. Austria, Belarus, Bulgaria, Czech Republic, Denmark, East European Russia, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland, Moldova,

North European Russia, Northwest European Russia, Romania, Slovakia, South European Russia, Spanish mainland, The Netherlands and Yugoslavia (Péricart & Golub, 1996).

Notes
Parapiesma salsolae is known from Samsø, Randers, Northern Zealand and Lolland (Fig. 9). The first specimens were found in Randers in 1878. The species was registered as a Danish species based on the first specimens found on Samsø in 1983 (Skipper & Tolsgaard, 2013). The distribution map is based on 16 specimens.

In "Danmarks fauna 12 – Tæger" (Jensen-Haarup, 1912) *Parapiesma variabile* (Fieber, 1844) was included as a Danish species, but *P. salsolae* was not. The description of *P. variabile* in Jensen-Haarup (1912) matches the description of *P. variabile* in other keys as the body length is described to be around 2.5 mm (Wagner, 1959; Wagner, 1966; Heiss & Péricart, 2007; Wachmann et al., 2007), whereas *Parapiesma salsolae* has a body length around 3.0-3.4 mm. Furthermore, *P. variabile* was described by Jensen-Haarup (1912) as having paranota indented and having spots on pronotum and hemelytra, however these two characteristics are also present in *Parapiesma salsolae*.

No specimens of *P. variabile* are present in the studied collections; it seems that the species was confused with *P. salsolae* by Jensen-Haarup (1912).

In 1974 *P. vaiabile* was still listed as a Danish species in "Fortegnelse over Danmarks tæger (Hemiptera-Heteroptera)" (Andersen & Gaun, 1974), but *P. salsolae* was not included. This species was registered as Danish for the first time by Skipper & Tolsgaard (2013), based on specimens found on Samsø in 1983. *Parapiesma variabile* was, however, also included in Skipper & Tolsgaard's list.

By looking further at the specimens identified as *P. variabile* or *P. salsolae* in the collections, it was discovered that all were *P. salsolae*. The two species are extremely similar, which probably has led to the difficulties in identifying the specimens to the correct species (Heiss & Péricart, 2007). The main character that distinguishes *P. salsolae* and *P. variabile* is the length of the antennal segments compared to each other: in *P. salsolae* the 3rd antennal segment is 1.55-1.67 times as long as the 4th and almost 3 times as long as the 2nd, whereas in *P. variabile* has the 3rd antennal segment 1.3 times as long as the 4th and 2.5 times as long as the 2nd. Furthermore, *P. salsolae* has a body length around 3.0-3.4 mm, while *P. variabile* has a body length of 2.4-2.8 mm. In addition, the two species can be distinguished by their host plant preferences: *Parapiesma salsolae* feeds on *Salsola kali*, whereas *P. variabile* is known to feed on *Herniaria glabra* (Heiss & Péricart, 2007); Wachmann et al., 2007).

Due to the absence of preserved specimens of *P. variabile* in the collections, this species cannot be regarded as a Danish species as previously assumed.

Parapiesma quadratum (Fieber, 1844)
Piésma quadráta: Jensen-Haarup, 1912

Fig. 1a; 2b; 3b; 10a, b

Description
Length. 2.3-3.5 mm. Macropterous or submacropterous.

Colours. Colours and pattern variable. Pronotum, paranota and hemelytra usually white-grey, yellow-brown or yellow-grey with brown spots. New developed insects often reddish. Antennae and legs yellow-brown. Scutellum black with pale tip (Fig. 10a).

Habitus. Pronotum with 3 keels. Paranota not indented and with 3-4 rows of cells (Fig. 10a, b).

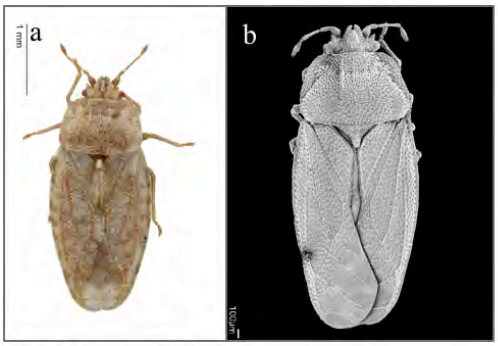

Fig. 10. Dorsal view of *Parapiesma quadratum*: (a) Colour photo and (b) SEM image

Fig. 11. Distribution map of *Parapiesma quadratum* in Denmark. Based on 280 specimens.

Similar species
Similar to *Piesma maculatum* and *Parapiesma salsolae* (See *Piesma maculatum* and *Parapiesma salsolae*) (Fig. 12).

Host plants
Chenopodium spp. and Portulacaceae spp.

Distribution
Adults occur throughout the year.

Present in. Austria, Belarus, Belgium, Bosnia and Herzegovina, Britain I., Bulgaria, Croatia, Czech Republic, Denmark, East European Russia, Estonia, Finland, French mainland, Germany, Greek mainland, Hungary, Ireland, Italian mainland, Kaliningrad Region, Liechtenstein, Luxembourg, Macedonia, Moldova, North European Russia, Northwest European Russia, Norwegian mainland, Poland, Romania, Slovakia, Slovenia, South European Russia, Spanish mainland, Sweden, Switzerland, The Netherlands and Yugoslavia (Péricart & Golub, 1996).

Notes
Parapiesma quadratum occurs in most of the country, but is less present in Western Jutland (Fig. 11). Moreover, it is the most abundant species of *Parapiesma*. The distribution map is based on 280 specimens.

Discussion
Distribution
The species known most places in Denmark is *Piesma maculatum* with a count of 223 locations (Fig. 7). With 863 collected specimens this is also the most abundant Danish species of Piesmatidae. The least abundant species which also has been found in the fewest places is *Parapiesma salsolae*, of which only 16 specimens have been found at 4 distinct locations in Denmark (Fig. 9).

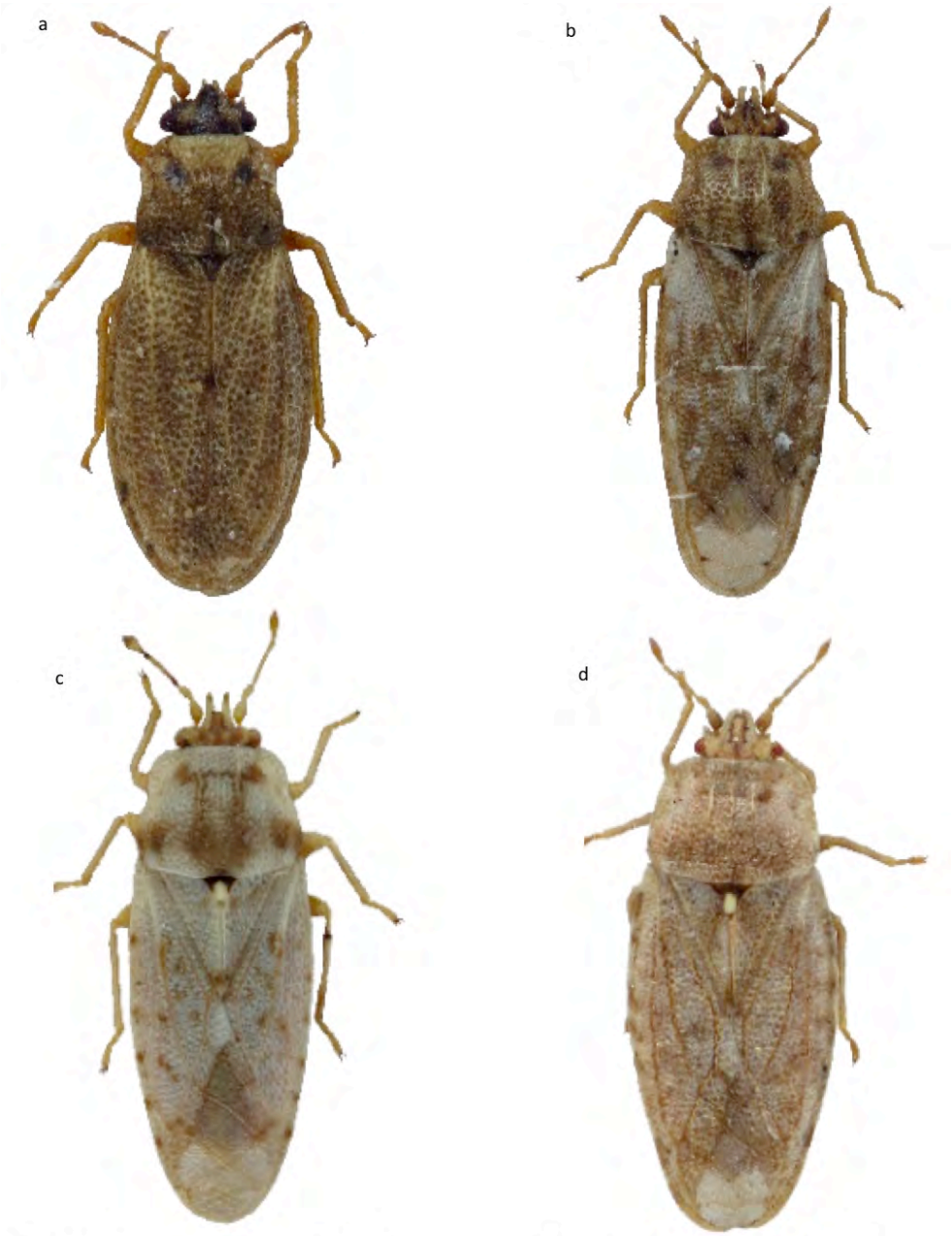

Fig. 12. Danish Piesmatidae: (a) *Piesma capitatum*, (b) *Piesma maculatum*, (c) *Parapiesma salsolae* and (d) *Parapiesma quadratum*.

Challenges of georeferencing

There can be some bias in the distribution maps due to the fact that some areas are more likely to be visited by collectors, such as forests and nature areas near cities. This might make the maps a bit unprecise as the species could exist in places where no collections have been made. Furthermore, there is a tendency that newly found specimens have more accurate locality information (often with GPS-coordinates), while older specimens differ more in the accuracy of the noted localities. This has been considered by marking coordinate uncertainties around locations that have limited georeferencing information.

Conclusion

The morphological diversity among the Danish piesmatid species is poor and they are plain in colours and around the same size. These simple characteristics can induce difficulties in the identification of Piesmatidae and has earlier led to the wrong identification of *Parapiesma salsolae*, as specimens of this species have been identified as *Parapiesma variabile*. Due to this confusion *Parapiesma variabile* was earlier assumed to be a Danish species, but as none of the specimens in the collections belong to this species it can no longer be classified as a Danish species.

There is great variation in the distribution of the distinct species of Danish Piesmatidae, where some are widely spread around the country like *Piesma maculatum* in contrast to *Parapiesma salsolae*, which only has been found at few locations in Denmark.

Hopefully this work will be a useful tool in identifying Piesmatidae and may contribute to the discovery of new species of this family of true bugs.

Acknowledgements

I wish to thank Curator Henrik Enghoff at Natural History Museum of Denmark for his expert advices throughout this project and for making this work possible by providing specimens for observation and georeferencing. Thanks are due to Isabel Calabuig because of her help with the construction of data to make them usable for this project and available for GBIF. I wish to express my appreciation to Curator Thomas Simonsen for providing specimens of the collection at Natural History Museum Aarhus, which contribute to the making of realistic illustrations of the distribution of the studied family, and thereby improving the results of this project. I wish to offer my gratitude to Jan Pedersen and Anders Alexander Illum for their extraordinary support throughout the creation of this thesis. Furthermore, I wish to thank Sree Gayathree, Cecilie Svenningsen, Arn Rytter Jensen, Line Kræmer and Frederik Vad for their assistance in realising this project. Thanks are also due to Lars Skipper, Otto Buhl, Lars Thomas, Linda Kjær-Thomsen and the Biowide-project for the supply of specimens, which increases the amount of data and thereby improving the results. My thanks are given to Rune Møenbo Jensen, Christian Lerche Neergaard and Marine Delahaye for proofreading this thesis and to my friends and family for their encouragement throughout the creation of this thesis.

Litterature

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