Aphids in nests of *Lasius flavus* F. in Denmark. I: Faunistic description

(Aphidoidea, Anoeciidae & Pemphigidae; Hymenoptera, Formicidae)

Lone Godske

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This paper presents the results of a survey of the aphids found in association with *Lasius flavus* in four separated localities in Denmark. Eleven species of subterranean aphids belonging to 2 families and 6 genera were recorded: *Anoecia corni* (Fabricius, 1775); *Anoecia major* Börner, 1950; *Anoecia zirnitsi* Mordvilko, 1931; *Anoecia pskovica* Mordvilko, 1916; *Tetraneura ulmi* (Linné, 1758); *Baizongia pistaciae* (Linné, 1767); *Geoica utricularia* (Passerini, 1856); *Geoica setulosa* (Passerini, 1860); *Forda formicaria* v. Heyden, 1837; *Forda marginata* Koch, 1857; *Smynthurodes betae* Westwood, 1849. *F. formicaria* was the most common species. *A. major* and *B. pistaciae* are recorded for the first time in Denmark. The morphological and behavioural adaptations of the aphids to a subterranean life, and their association with ants, are discussed.

Lone Godske, Institute of Zoology and Zoofysiology, University of Aarhus, DK-8000 Aarhus, Denmark.

Introduction

It has long been known that a special association exists between certain ant species and certain aphid species. Detailed reviews on these trophobiotic associations have been published by Nixon (1951), Way (1963), and Pontin (1978).

The ants utilise the aphids as a source of food and at the same time protect them against predators and parasitoids and increase their fecundity (Banks, 1962).

Lasius flavus F. is a small yellow ant living subterraneanly in grasslands. The nutrient supply of *L. flavus* is thought to consist almost exclusively of the excrements of root-sucking aphids. Their need for carbonhydrates is satisfied by honey dew, a rich source of sugars as well as other minor nutrients, excreted by the aphids. Other food requirements are met by eating some of the aphids.

The aphids associated with *L. flavus* have a number of interesting morphological characteristics which make them distinct from free-living forms. Their morphology is, of course, determined by both the adaptations to the association with the ants and to the requirements of underground life. For example, the small size and short legs and antennae might be adaptations to a subterranean life, while the lack of functional siphunculi, which are used to ward off predators, the dorsal position of anus, and the short cauda, which can no longer be used for throwing the honey dew away from the aphid, could be consequences of association with the ants.

The aim of this paper is to describe the aphid species found in nests of *L. flavus* at four different locations in Denmark and to discuss their interdependence of *Lasius flavus*.

The list of aphids contain two species found for the first time in Denmark.

Localities

The aphids were collected from nests of *L.*

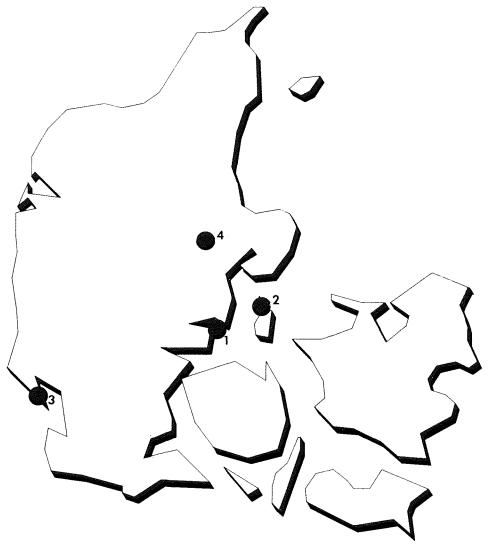

Fig. 1. Location of collections. 1 = Alrö, 2 = Samsø, Stavns fjord, 3 = Skallingen, 4 = south of Randers.

flavus on four different locations in Denmark in 1987-89 (Fig. 1). Location No. 1 was a saltwater tidal meadow on Alrö, an island in Horsens Fjord where the nests were scattered and the soil was clayey. This meadow was grazed by cattle in the summertime. Location No. 2 was a saltwater tidal meadow on the island of Samsø where the nests were closely packed (number of nests/100 m^2 = 30,5; Nielsen, 1986) and 11.6% of the meadow was covered by nests (Nielsen et al., 1976). The soil seemed more sandy than on Alrø. This meadow was grazed by cattle during the whole year. The vegetation on these two sites were dominated by *Festuca rubra* L., *Agrostis tenuis* Sibth. and *Juncus gerardi* Lois. In addition to these, *Deschampsia flexuosa* L., *Plantago maritima* L. and *Armeria maritima* (Mill.) were common on both meadows. Location No. 3 was a saltwater tidal meadow on the Skallingen peninsula. 17.7% of the meadow was covered by nests (Nielsen et al., 1976). This meadow was flooded more frequently than the others in fall, winter and spring, so the vegetation was dominated by salt-tolerant plants. The vegetation was short because of grazing by sheep and cattle.

A few collections were made in an old pasture south of Randers (location No. 4). This pasture was hilly with slopes so steep that cultivation is impossible. The pasture was not so intensively grazed by cattle, and consequently the vegetation was higher than on the three saltwater meadows (locations Nos 1-3).

Cylindrical soil samples (7 cm in diametre) from ants' nests were taken in the wintertime (November to March) on locations Nos 1 and 2, in October on location No. 4 and in the summertime (June) on location No. 3. The samples never reached deeper than 22 cm. The aphids where extracted from the soil samples in a Berlese funnel (40 W bulb; distance from sample: 10 cm.; extraction time: 6-10 days depending on soil structure). The aphids were driven into a tube containing 70% ethanol, and the species were identified after preparation and mounting as described by Heie (1980).

Results

Eleven species of subterranean aphids belonging to 6 genera and 2 families were found in association with *L. flavus* in and around the nests.

Descriptions of apterous viviparous females, which was the morph most frequently found, are given below.

Family ANOECIIDAE

1. *Anoecia corni* (Fabricius, 1775)

A. corni is common in Denmark, but because of its holocyclic life cycle with obligatory host-alternation it was only found in the autumn on location No. 2. Its primary host is *Cornus*.

A. corni is dark because of heavy sclerotization, and this colour persists when kept in 70% ethanol. The large compound eyes are recognized without use of microscope.

2. *Anoecia major* Börner, 1950

First record of *A. major* in Denmark. It has only been found once in October on location No. 4 of this study.

This species has not earlier been described as being visited by ants (Heie, 1980).

A. major is dark like *A. corni,* and the single specimen found is smaller than previously described (O. Heie, pers. com.). *A. major* has been found on *Cornus* in nature and is perhaps monoecious.

3. *Anoecia zirnitsi* Mordvilko, 1931
Previously found only on Samsø by M. Gissel Nielsen. One adult specimen found on location No. 3 in June was determined as *Anoecia zirnitsi. A. zirnitsi* is greyish green with 6-segmented antennae. Aphid eggs were found in *L. flavus* nests on location No. 2 in December. The eggs were kept for one months at 5°C, then at 20°C, and they hatched after 14 days. Eggs kept only at 20°C became mouldy after a few weeks. The aphids were mounted and recognized as *Anoecia* probably *zirnitsi.* Eggs collected by *L. flavus* can be found in masses of 4000 or more (Nielsen, pers. com.).

A. zirnitsi is holocyclic and monoecious with different grasses as hostplants.

4. *Anoecia pskovica* Mordvilko, 1916
A. pskovica has previously only been found on two locations in Denmark (Femmøller and Samsø), and in this survey it was found again on Samsø on location No. 2.

It is mealy light red in life, but turns grey or white after a few hours in 70% ethanol. *A. pskovica* is recognized by its extremely short processus terminalis.

A. pskovica is holocyclic, monoecious, and lives on roots of *Carex.*

Family PEMPHIGIDAE

5. *Tetraneura ulmi* (Linné, 1758)
T. ulmi is common in Denmark and was found on locations Nos 1 and 2.

T. ulmi is recognized by its dark brown or red colour when adult and its light yellow or orange colour when nymph. The colours fade only slightly in 70% ethanol. The antenna is shorter than the antenna of *A. pskovica.*

T. ulmi is holocyclic and forms characteristic galls on *Ulmus,* its primary host, but the species overwinters anholocyclicly on roots of grasses, its secondary hosts, in nests of *L. flavus* as well.

6. *Baizongia pistaciae* (Linné, 1767)
First record in Denmark. The species was found on location Nos 1 and 2.

B. pistaciae is mealy white, with head, prothorax, antennae, legs and anal region brown; the colour fades only slightly in 70% ethanol. Nymphs are often lighter than adults. The species can be recognized by its extremely short antenna and its wax gland plates.

The species is anholocyclic in Denmark, and the host-plants are grasses.

7. *Geoica utricularia* (Passerini, 1856)
G. utricularia is common in Denmark and was found on all four locations.

When alive *G. utricularia* can be recognized by the small, broadly oval body. The colour is white or yellow but some specimens have more or less brownish colours on legs, rostrum and cauda. *G. utricularia* is recognized when mounted by the presence of small hairs surrounding the primary rhinarium and a large number of short hairs on the anal plate.

The species is anholocyclic on grass roots in Denmark.

8. *Geoica setulosa* (Passerini, 1860)
This species has earlier only been found once in Denmark, but it has probably been overlooked. During these investigations it was found to be quite common and was found on three different locations: Nos 1, 2 and 3.

G. setulosa is similar to *G. utricularia.* When mounted it can be recognized by the presence of a few long hairs on the anal plate, arranged in two rows, unlike the many short, more scattered hairs in *G. utricularia.*

G. setulosa is anholocyclic in Denmark.

9. *Forda formicaria* v. Heyden, 1837
This species is common and widespread in Denmark and was found together with *L. flavus* to be the most common aphid on all locations.

The colour of *F. formicaria* ranges from pale yellow and pale green to darker green. Zwölfer (1957) has studied the colour variation and correlated it with variation in host plants, temperature and altitude. After a few days in 70% ethanol the colours fade, and the aphids become light grey. The adults of *F. formicaria* are the largest aphids found in *L. flavus* nests.

The species is anholocyclic on grass roots in Denmark.

10. *Forda marginata* Koch, 1857
F. marginata was found on locations Nos 1 and 2. It seems to prefer drier and warmer soil than *F. formicaria* (Heie, 1980).

This species is easily confounded with *F. formicaria* because the two species have an identical colour pattern, but *F. marginata* differs from *F. formicaria* in the smaller size of the primary rhinarium on the ultimate antennal segment.

The species is anholocyclic in Denmark.

11. *Smynthurodes betae* Westwood, 1849
Previously only a few records from Denmark. In this collection it was found on locations Nos 1 and 2. It was quite abundant in some nests and almost absent from others. *S. betae* is found on herbaceous dicotyledones only, while other Fordinae infest monocotyledones.

When alive, *S. betae* is dark green to light green, and the colour fades only slightly in 70% ethanol. When this species is mounted it is easily recognized because the 2nd antennal segment is as long as the 3rd antennal segment.

The species is anholocyclic in Denmark.

Conclusion

Some of the characters of the aphids associated with *Lasius flavus* are morphological adaptations to a subterranean life. These include the pale colour (except in *Anoecia* spp.), the short antennae and in some cases probably also the reduced eyes. Reduction of siphunculi and cauda, a dorsal position of the anus, and presence of hairs for keeping a drop of excrement outside the anus until removed by an ant, are morphological adaptations to a strong association with ants. Also the behaviour of the aphids demonstrates adaptations. They accept contact with ants and react positively by facilitating the removal of honeydew. The short legs may just as well be an adaptation to a subterranean life as to an association with ants.

None of the aphids found in connection with this survey could survive without ants, whether they are heteroecious (as e.g. *Anoecia corni* and *Tetraneura ulmi*) or monoecious (as most of the species), holocyclic or anholocyclic or both. Several species among the holocyclic ones are able to live anholocyclicly, e.g. *Forda* spp. (which are holocyclic and heteroecious in warmer climates, where *Pistacia* grows). Their occurrence in ants' nests during the winter will be treated in a later paper.

Different species of aphids were often found in the same chamber of a nest. This indicate, that competition between the species is limited.

Clearly, it would be interesting to know more of the biology and distribution of the species found in this survey. Further studies of aphids in ants' nests will undoubtedly show, that certain species are more common than previously assumed.

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Dansk sammendrag

Bladlus i tuer af gul engmyre (*Lasius flavus* F.) i Danmark

Den underjordiske bladlusfauna i tuer af gul engmyre er beskrevet fra 4 lokaliteter (tre strandenge og et overdrev). Følgende 11 arter af bladlus er fundet: *Anoecia corni* (Fabricius, 1775); *Anoecia major* Börner, 1950; *Anoecia zirnitzi* Mordvilko, 1931; *Anoecia pskovica* Mordvilko, 1916; *Tetraneura ulmi* (Linné, 1758); *Baizongia pistaciae* (Linné, 1767); *Geoica utricularia* (Passerini, 1856); *Geoica setulosa* (Passerini, 1860); *Forda formicaria* v Heyden, 1837; *Forda marginata* Koch, 1857; *Smynthurodes betae* Westwood, 1849. Af disse er *F. formicaria* den almindeligste art på alle 4 lokaliteter. *A. major* og *B. pistaciae* er registreret for første gang i Danmark.

Bladlusenes specielle morfologiske og adfærdsmæssige tilpasninger til livet i jorden og med myrerne er diskuteret.

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