

Exotic ants in Denmark (Hymenoptera: Formicidae)

Eksotiske myrer i Danmark (Hymenoptera: Formicidae)

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Abstract

The number of exotic and invasive tramp organisms is increasing rapidly in the age of global trade. Ants can be particularly problematic when introduced into new ecosystems by human activities. Here we present a list of 30 exotic ant species so far introduced to Denmark. A total of 16 species temporarily established colonies inside heated buildings. Another 14 species were only sporadically introduced to the country with cargo, without documented establishment. In a search for exotic ants in five Danish hothouse complexes in the years 2013-2015, we recorded a total of ten species (*Anochetus mayri*, *Gnamptogenys striatula*, *Hypoponera ergatandria*, *H. punctatissima*, *Linepithema angulatum*, *Neoponera unidentata*, *Strumigenys rogeri*, *Technomyrmex albipes*, *T. vitiensis* and *Solenopsis* sp.). Of these, only *H. punctatissima* and *Technomyrmex* spp. have previously been found in Denmark and *A. mayri* was to our knowledge not reported from Europe before. We conclude that exotic ant communities in greenhouses are subject to turnover and that the number of exotic ant species distributed with plants likely increased in recent time. Finally, we discuss the potential of the observed species to become pests outside their native ranges.

Dansk sammendrag

Antallet af eksotiske og invasive organismer er stærkt stigende i takt med globaliseringen og den stigende internationale handel. Myrer kan være særlig problematiske, når de bliver introduceret i nye økosystemer af menneskelige aktiviteter. Her præsenterer vi en liste med 30 eksotiske myrearter som er indført til Danmark. I alt har 16 af de eksotiske myrearterne midlertidigt etableret kolonier i opvarmede bygninger, mens de resterende 14 kun er blevet sporadisk introduceret til Danmark med fragt. I en periode fra 2013 til 2015 undersøgte vi fem store opvarmede driv- og tropenhuse i Danmark og indsamlede i alt 10 eksotiske myrearter (*Anochetus mayri*, *Gnamptogenys striatula*, *Hypoponera ergatandria*, *H. punctatissima*, *Linepithema angulatum*, *Neoponera unidentata*, *Strumigenys rogeri*, *Technomyrmex albipes*, *T. vitiensis* og *Solenopsis* sp.). Kun *H. punctatissima* og *Technomyrmex* spp. er tidligere fundet i Danmark og *A. mayri* er ifølge vores viden ikke rapporteret fra Europa før. Vi konkluderer, at artssammensætningen af eksotiske myrer i drivhuse er omskiftelig og at der sandsynligvis er et stigende antal af eksotiske myrearter som bliver transporteret rundt med planter. Tilslut diskuterer vi potentialet for at de observerede arter bliver skadedyr uden for deres oprindelige udbredelses område.

Introduction

Introduced species are increasingly causing problems in ecosystems worldwide (Clavero et al. 2005). Ants can be particularly harmful when introduced into non-native ecosystems: no less than five ants are considered to be among the 100 worst invasive alien species (Lowe et al. 2000). More than 40 ants have already become pan-tropical tramp species (Wetterer 2015) and some of them are responsible for economical damage and loss of biodiversity in fragile ecosystems (e.g., O'Dowd et al. 2003, Hoffmann and Parr 2008). With the increase of global trade, the number of these tramp-ant species seems to rise rapidly. Generally, organisms can become introduced into non-native ecosystems by human activities in two ways:

Unintended transport in or on vehicles or with cargo such as plants, food and substrates (Aguin-Pombo 2012).

Intended transport of exotic species as pets, domestic or laboratory organisms (Brown 2006).

Unintended introduction by global trade has been identified as the most likely cause of introduction in a few particularly severe and well-studied cases of invasive alien species (e.g., Suarez et al. 2001, Tschinkel 2006, Ascunce et al. 2011) and is likely the primary cause of dispersal of tramp-ants. The existence of online shops selling ants as pets has also been mentioned as a possible source of introductions (Buschinger 2004).

The minimum requirement for the establishment of an exotic ant species in a new locality is a fertile female reproductive (queen), arriving in a place that offers suitable environmental conditions for the species. Exotic ants do not only become introduced into natural ecosystems but are also often found in greenhouses and hothouses belonging to zoos and botanical gardens, in places with otherwise unsuitable natural conditions for the species (Boer and Vierbergen 2008). Such artificial indoor-habitats tend to be colonized by a characteristic ant fauna comprising many species also present as exotic or invasive species somewhere in the wild (Boer and Vierbergen 2008, Jucker et al. 2008). Tramp species inside buildings are sometimes neglected by scientists because they are “only” found indoors. However, those populations are potential stepping stones for the worldwide dispersal of tramp organisms. Thus, greenhouses offer an opportunity to identify new circulating species with a relatively high potential of successful introduction into new habitats.

Here we present an overview of to our knowledge all exotic ants found in Denmark to date. Besides gathering records from the literature and identifying old museum specimens we searched for exotic ants in five hothouse complexes in Denmark between 2013 and 2015 and compare the results to literature records. Finally, we discuss the potential of the observed species to become pests outside their native ranges.

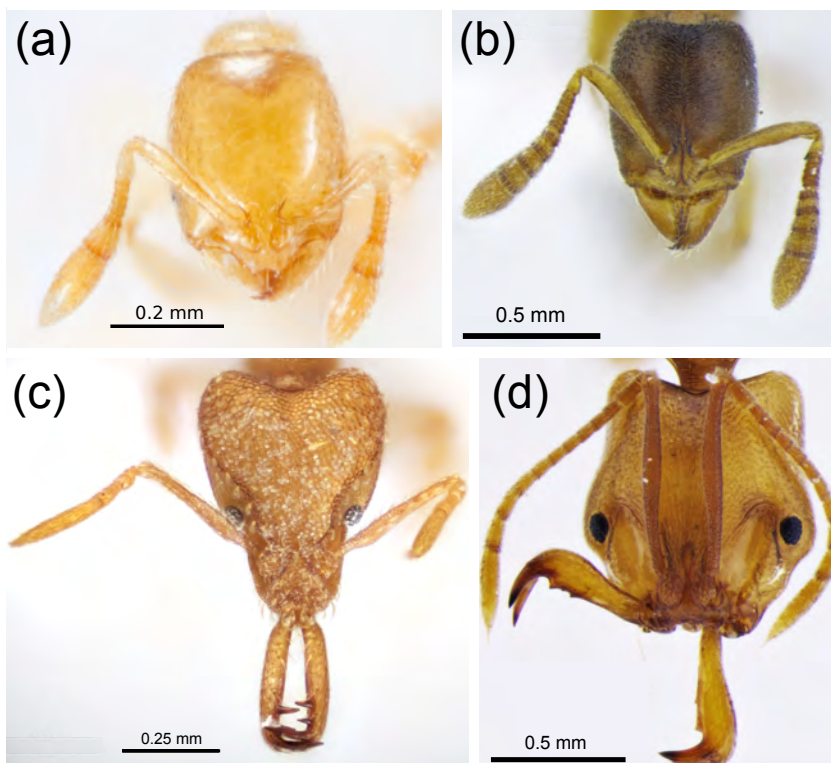


Fig. 1: Full face view of workers of *Solenopsis* sp. (a), *Hypoponera ergatandria* (b), *Strumigenys rogeri* (c) and *Anochetus mayri* (d) collected in Denmark.

Materials and Methods

We searched for ants in five hothouse-complexes in Denmark (Table 1). Specimens from the ground, plants, trees, in soil, rotten wood and insect traps installed by the institutions were manually collected in $\geq 95\%$ ethanol. Some previously unidentified exotic ants collected in the Danish harbour of Frihavn in the 1950's, deposited at the Zoological Museum of Copenhagen (ZMUC) by collector D. Th. Skovgaard, were identified. The following literature was used for identification: *Anochetus* spp: Fernández and Arias-Penna (2008); *Aphaenogaster* spp: Boer (2013), *Hypoponera* spp: Seifert (2003, 2013), *Pheidole* spp: Sarnat et al. (2015), *Strumigenys* spp: Brown (1962), *Technomyrmex* spp: Bolton (2007), *Tetramorium* spp: (Bolton 1977, 1980). All plants in the rainforest house of The Blue Planet Kastrup were imported from Costa Rica (Lars Skou Olsen, personal communication). We therefore used the keys in Longino (2010) for identifications of all specimens collected there (Table 1). Specimens have been deposited at ZMUC and can be borrowed from the authors upon request.

Table 1: Exotic ants established in heated buildings in Denmark. *BA = Aarhus Botanical Gardens, BCPH = Botanical Garden University of Copenhagen, TBPK = The Blue Planet Kastrup, NA/other = unknown or other locations, RT = Randers Tropical Zoo, ZCPH = Copenhagen Zoo. **NR = new records, REF. 1 = Nielsen (2011), REF. 2 = Danish Ants (Formicidae) dataset (GBIF.org), REF. 3 = www.fugleognatur.dk., REF. 4 = Wetterer and Hita Garcia (2015).

Species	Location*					NA/ other	Source**
	Botanical gardens		Zoos				
	BA	BCPH	TBPK	RT	ZCPH		
PONERINAE							
<i>Anochetus mayri</i> Emery, 1884				2015			NR
<i>Hypoponera ergatandria</i> (Forel, 1893)	2015	2013-14					NR
<i>Hypoponera punctatissima</i> (Roger, 1859)			2015		2013	1908-1988	REF. 1, 2, NR
<i>Ponera coarctata</i> (Latreille, 1802)						1958	REF. 1, 2
<i>Neoponera unidentata</i> Mayr, 1862			2015				NR
DOLICHODERINAE							
<i>Linepithema angulatum</i> (Emery, 1894)			2015				NR
<i>Technomyrmex albipes</i> (Smith F., 1861)				2015		(1986)	REF. 1, 2, NR
<i>Technomyrmex vitiensis</i> Mann, 1921	2015	2013					REF. 1, NR
ECTATOMMINAE							
<i>Gnamptogenys striatula</i> Mayr 1884			2015				NR
MYRMICINAE							
<i>Monomorium pharaonis</i> (Linnaeus, 1758)						1921-1986	REF. 1, 2
<i>Pheidole anastasioi</i> Emery, 1896		1929				1985	REF. 1, 2
<i>Pheidole pallidula</i> (Nylander, 1849)						2015	REF. 1, 3
<i>Pheidole punctatissima</i> Mayr, 1870						2005	REF. 1, 2
<i>Solenopsis</i> sp.				2015	2013		NR
<i>Strumigenys rogeri</i> Emery, 1890			2015	2015			NR
<i>Tetramorium caldarium</i> (Roger, 1857)						1858	REF. 1, 4

Results

A total of 30 species of exotic ants have so far been found in Denmark, 16 of which were established inside heated buildings (Table 1). Another 14 species became introduced to Denmark sporadically for example with cargo, without documented establishment (Table 2).

During our search in hothouses between 2013 and 2015, one ant species was found for the first time in Europe and another six species were recorded for the first time in Denmark. Only three ant species found in this survey have been reported from Denmark before: *Hypoponera punctatissima*, *Technomyrmex albipes* and *T. vitiensis*. Another five species not previously reported from Denmark were found in the collection of D. Th. Skovgaard deposited at ZMUC. Those, among other species (Table 2) were collected at the harbour of Frihavnen (Copenhagen) in the 1950's and did to our knowledge not become established anywhere in Denmark.

Table 2: Non-established exotic ants sporadically introduced to Denmark. *NR = new record, REF. 1 = Nielsen (2011), ZMUC = specimens deposited at the Zoological Museum University of Copenhagen.

Species	Year	Location	Source*
DOLICHODERINAE			
<i>Tapinoma melanocephalum</i> (Fabricius, 1793)			REF. 1
FORMICINAE			
<i>Camponotus vagus</i> (Scopoli, 1763)		Frihavnen, Copenhagen	REF. 1, ZMUC
<i>Colobopsis truncata</i> (Spinola, 1808)			REF. 1
<i>Nylanderia vividula</i> (Nylander, 1846)			REF. 1
<i>Oecophylla smaragdina</i> (Fabricius, 1775)			REF. 1
<i>Paratrechina longicornis</i> (Latreille, 1802)		Frihavnen, Copenhagen	REF. 1, ZMUC
MYRMICINAE			
<i>Aphaenogaster senilis</i> Mayr, 1853	1955	Frihavnen, Copenhagen	ZMUC, Fig. 3c
<i>Crematogaster scutellaris</i> (Olivier, 1792)		Frihavnen, Copenhagen	REF. 1, ZMUC
<i>Monomorium</i> sp.	1955	Frihavnen, Copenhagen	ZMUC, Fig. 4a
<i>Pheidole megacephala</i> (Fabricius, 1773)			REF. 1
<i>Pheidole noda</i> Smith F., 1874	1951	Frihavnen, Copenhagen	ZMUC, Fig. 3a
<i>Temnothorax recedens</i> (Nylander 1856)	2014	Jagtvej, Copenhagen	NR, Fig. 4b
<i>Temnothorax</i> sp.	1953	Frihavnen, Copenhagen	ZMUC, Fig. 4c
<i>Tetramorium bicarinatum</i> (Nylander, 1846)	1954	Frihavnen, Copenhagen	ZMUC, Fig. 3b

Exotic ant species first recorded in Denmark (indoors)

Anochetus mayri Emery, 1884: Denmark (greenhouse), Randers, Randers Tropical Zoo, South American Biome (56°27' N, 10°01' E), 07.VI.2015 leg. A. A. Illum, R. S. Larsen, S. Schär, 3w, 1dQ, Fig. 1d. One medium sized colony in rotten log in the "South American dome".

Aphaenogaster senilis Mayr, 1853: Denmark (port of entry), Copenhagen, Frihavnen (55°42' N, 12°35' E), 26.VI.1955, leg. D. Th. Skovgaard, 1w (Fig. 3c).

Gnamptogenys striatula Mayr 1884 (= *G. wheeleri* Santschi, 1929): Denmark (greenhouse), Kastrup, The Blue Planet Kastrup (55°38' N, 12°39' E), Rainforest house, 19.I.2015, leg. A. A. Illum, R. S. Larsen, S. Schär, 2w, 1aQ, 1m, Fig. 2d. At least two colonies containing alates, in rotten logs.

Hypoponera ergatandria (Forel, 1893): Denmark (greenhouse), Copenhagen, Botanical Garden – University of Copenhagen (55°40' N, 12°31' E), 03.III.2013, leg. A. A. Illum, R. S. Larsen, S. Schär, 2w; Aarhus, Aarhus Botanical Gardens (56°10' N, 10°11' E), 06.VI.2015, leg. A. A. Illum, R. S. Larsen, S. Schär, 3w, Fig. 1b. Abundant in soil and rotten wood of both botanical gardens.



Fig. 2: Lateral aspect of a queen of *Solenopsis* sp. (a), a worker of *Linepithema angulatum* (b), *Neoponera unidentata* (c) and *Gnamptogenys striatula* (d) collected in Denmark.

Linepithema angulatum (Emery, 1894): Denmark (greenhouse), Kastrup, The Blue Planet Kastrup, (55°38' N, 12°39' E), Rainforest house, 19.I.2015, leg. A. A. Illum, R. S. Larsen, S. Schär, 3w, Fig. 2b. On trees, plants and on walls.

Monomorium sp.: Denmark (port of entry), Copenhagen, Frihavnen (55°42' N, 12°35' E), 23.VIII.1955, leg. D. Th. Skovgaard, 4w (Fig. 4a).

Neoponera unidentata Mayr, 1862: Denmark (greenhouse), Kastrup, The Blue Planet Kastrup (55°38' N, 12°39' E), Rainforest house, 19.I.2015, leg. A. A. Illum, R. S. Larsen, S. Schär, 2w, Fig 2c. On a small tree.

Pheidole noda Smith F., 1874: Denmark (port of entry), Copenhagen, Frihavnen (55°42' N, 12°35' E), 06.X.1951, leg. D. Th. Skovgaard, 1w major (Fig. 3a).

Solenopsis sp.: Denmark (greenhouse), Copenhagen Zoo, Bird house (55°40' N, 12°31' E), 23.II.2013, leg. A. A. Illum, R. S. Larsen, S. Schär, 1dQ, >50w, Fig. 1a, 2a. Foraging on plants and butterfly feeding stations; Randers, Randers Tropical Zoo (56°27' N, 10°01' E), 07.VI.2015 leg. A. A. Illum, R. S. Larsen, S. Schär, 5w. On the ground.

Strumigenys rogeri Emery, 1890: Denmark (greenhouse), Kastrup, The Blue Planet Kastrup, (55°38' N, 12°39' E), Rainforest house, 19.I.2015, leg. A. A. Illum, R. S. Larsen, S. Schär, 3w, Fig. 1c. One subterranean colony in the rainforest house; Randers, Randers Tropical Zoo (56°27' N, 10°01' E), 07.VI.2015 leg. A. A. Illum, R. S. Larsen, S. Schär, 1w, 1aQ. Abundant in rotten logs, ground and leaf litter in all heated buildings.

Temnothorax recedens (Nylander, 1856): Denmark (in house), Jagtvej, Copenhagen. 2014 leg. R. S. Larsen, 1w, Fig. 4b. Found in terrarium, probably introduced with substrate.

Temnothorax sp.: Denmark (port of entry), Copenhagen, Frihavnen (55°42' N, 12°35' E), 23.III.1953, leg. D. Th. Skovgaard, 1w (Fig. 4b).

Tetramorium bicarinatum (Nylander, 1846): Denmark (port of entry), Copenhagen, Frihavnen (55°42' N, 12°35' E), 04.VIII.1954, leg. D. Th. Skovgaard, 4w, 1dQ (Fig. 3b).

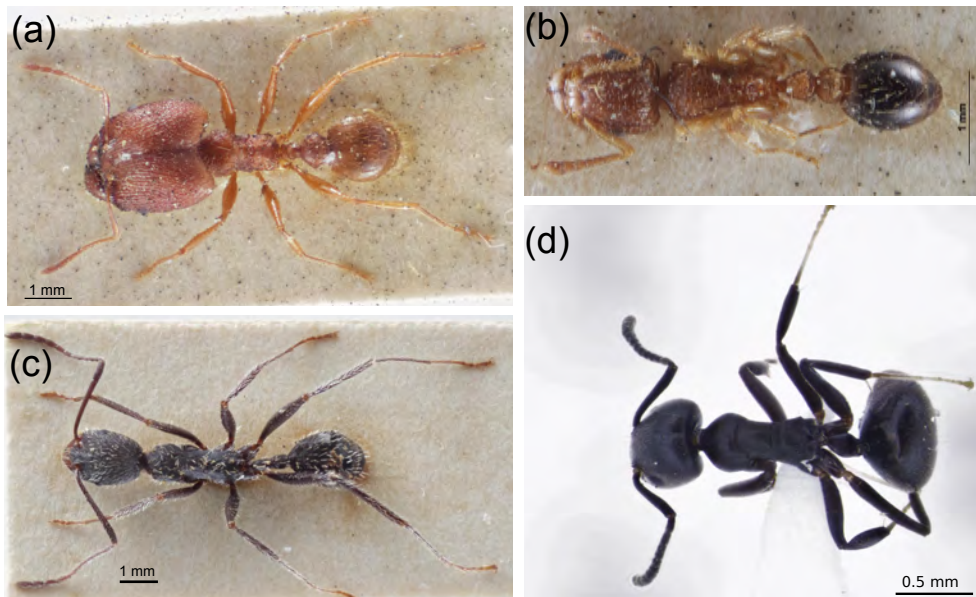


Fig. 3: Dorsal aspect of workers of *Pheidole noda* (a), *Tetramorium bicarinatum* (b), *Aphaenogaster senilis* (c) and *Technomyrmex albipes* (d) collected in Denmark.

Discussion

All established exotic ant species in Danish greenhouses have been found outside their native distribution range before. *Anochetus mayri* is present as an exotic species in Florida (Deyrup 2002). *Linepithema angulatum* was imported to the United States with orchids at several ports of entry (Wild 2007) and has also been found indoors in Norway in 2015 (Gjershaug et al. 2016). The new records of this species from Norway and Denmark show that *L. angulatum* is now transported into the Old World as well. Given the invasiveness of the congeneric *L. humile* it seems obvious that especially *L. angulatum* could become a severe pest when accidentally introduced to places with suitable tropical climate. *Gnamptogenys striatula* and *Neoponera unidentata* are already known from buildings in The Netherlands (Boer and Vierbergen 2008). *Strumigenys rogeri* is a pantropical tramp species and was also discovered in hothouses in Scotland, England, Germany, Norway, the US and Canada (Wetterer 2012, Gjershaug et al. 2016). *Hypoconeropsis punctatissima* and *H. ergatandria* have even cosmopolitan distributions (Seifert 2013). *Monomorium pharaonis*, *Technomyrmex albipes*, *T. vitiensis*, *Tetramorium caldarium* are again successful and widespread tramp species, as are some of the species only collected at the port of entry: *Paratrechina longicornis*, *Pheidole megacephala*, *Tapinoma melanocephalum* and *Tetramorium bicarinatum* (Wetterer 2015). The Asian tramp ant *Pheidole noda* collected in the 1950's at the harbour in Frihavn has been found in Europe before, in a glasshouse in Italy (Sarnat et al. 2015). A small number of Mediterranean European ants has been collected at Frihavn: *Aphaenogaster senilis*, *Camponotus vagus*, *Colobopsis truncata* and *Crematogaster scutellaris*. These sporadically introduced species originating from relatively close Southern Europe are most likely not capable of establishing in Denmark outdoors, as they did not colonize the country despite the absence of major natural barriers. Ants originating from places with tropical or subtropical climate are certainly not capable of surviving in Denmark outside heated buildings. On the other hand, in hothouses they can probably not resist the competition of cosmopolitan tramp species. It is possible that with global warming, species of Central European origin might increasingly find suitable conditions in Denmark. However, the impact of climate change will



Fig. 4: Dorsal aspect of workers of *Monomorium* sp. (a), lateral aspect of *Temnothorax recedens* (b) and dorsal aspect of *Temnothorax* sp. (c) collected in Denmark.

likely not affect the establishment of tramp species which are typically adapted to tropical and subtropical conditions. The number of ant species introduced to Denmark without establishment is likely much higher than the 14 species reported here, because perhaps most temporary introductions remain unnoticed. Finally, two unidentified species (*Temnothorax* sp. and *Monomorium* sp.) of unknown origin were found at Frihavn (Fig. 4). We find it interesting that the ant fauna in zoos and botanical gardens were somewhat different: we discovered *H. ergatandria* and *T. vitiensis* only in both botanical gardens and *H. punctatissima*, *S. rogeri* and *Solenopsis* sp. only in zoos (Table 1). However, future studies involving a higher number of buildings are required to draw a conclusion whether this difference is meaningful or not. The community of exotic ants in Denmark has changed over time: from the species collected prior to 2010 we only recollected *H. punctatissima* and *T. albipes* during our recent survey carried out between 2013-2015, while most species found during this assessment were new records (Table 1). This suggests that Denmark is relatively robust against introductions of exotic ants, since most species do not seem to be capable of maintaining long term populations, even after becoming established.

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