Exotic ants in The Netherlands (Hymenoptera: Formicidae)

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Exotic ants in The Netherlands are examined, mainly based on interceptions by the Plant Protection Service, recent investigations in botanical gardens and zoos, and revision of collection material. A total of 76 species could be identified. At ports of entry, 39 species have been intercepted, that are not reported from any establishment in the country. Thirty-seven species got established indoors, 23 temporarily and fourteen locally. Most frequently encountered is *Monomorium pharaonis*, followed by *Linepithema humile*, and the third in order is *Tapinoma melanocephalum* or *Technomyrmex albipes*. The latter is now the most common species in botanical gardens and zoos, where it replaced *Paratrechina longicornis* and *L. humile*. Many exotic species are 'temporary', due to pest control or environmental changes. Better hygiene in houses and increased pest control prevented local establishment in the last decades, despite the increasing number of introductions. Moreover, most exotics are poor colonizers and not able to settle and/or spread after arrival. Up till now, all these introductions did not have any influence on the outdoor ant fauna. The only exotics rarely encountered outdoors are *Camponotus vagus, Crematogaster scutellaris*, *Plagiolepis taurica* and *Lasius emarginatus*. They settled locally and give no indication of spread to other locations.

Introduction

In the period 1926 to 1944, Stärcke reported regularly on the occurrence of exotic ants in The Netherlands (Stärcke 1926a, 1926b, 1933, 1943, 1944). A motivation was given in his report: "It seemed me good to draw up the account of this period, before a new period of increasing central heating and plane traffic creates new possibilities" (Stärcke 1943). Since then, publications on exotic ant occurrences were published only incidentally.

Exotic ant species are currently given considerable worldwide attention, reflecting the increasing economic and agricultural impact, health effects on humans, displacement of native species, and disruption of natural ecosystems (Ward *et al.* 2006). Knowledge of exotic ants is nevertheless limited. Therefore, acquiring data on them is important in order to understand why some species become successful biological invaders. McGlynn (2002) published a list of 137 ants that have been transported to new regions around the world. Nineteen of them were recorded from Europe, especially from the Iberian Peninsula. For most European countries there are no published records, or only incomplete lists or outdated records. For example, from Slovenia one species is recorded to have established (Bračko 2000), from Belgium three (Dekoninck *et al.* 2006a, b), from Austria eight (Steiner *et al.* 2002), and from Switzerland nine species (Wittenberg 2005, UGZ 2006), while the early list of exotic taxa of Great Britain counted 56 species (Donisthorpe 1927). In most of these cases the observations are only incidental and information on establishments is scarce. The list for The Netherlands in this paper counts 76 exotic species.

The term 'exotic' is used to indicate non-native or alien origin (McGlynn 2000, Anonymous 2006a). All species considered in the following lists are exotic and predominately from (sub-)tropical origin. All were accidentally introduced by human activity.

Entry pathways

Non-plant products

The exotic ants introduced in The Netherlands before 1945 (Stärcke 1944), almost exclusively arrived by boat or by the exchange of plant material from tropical greenhouses. Until today, opportunistic ants occur on ships, sometimes even on empty ships, without cargo (Ward *et al.* 2006). However, some species survive the long journeys only because of the presence of specific cargo, like cork from Southern Europe and North Africa, or cocoa from Togo. Occasionally cargo enables ants to hide and survive the travel time without food supply, for example in wooden boxes with machine components, or in wooden pallets under non-food import products.

The chances of ants to survive a journey have increased, because of the enhanced speed of transport. Moreover, the diversity of products has increased, as well as the number of countries they originate from. Increased tourism plays a role as well (Anonymous 2005b). Therefore it is not surprising that new exotic ant species have turned up during the last decades.

Transport companies are aware of the problem of their stowaways and have taken measures. Wooden pallets and containers are treated with methyl-bromide to prevent the spread of exotic insects. Food is often packed and the humidity and temperature on board are usually low. On the other hand, many ant species can survive extreme circumstances for a long time.

Plant products

Stärcke (1926b, 1943, 1944) already reported the interception of several ant species from plant products, e.g., bananas, orchids and flower bulbs. In The Netherlands the import of plant products has increased rapidly since Stärcke's records, and today the amount is enormous; several times more than in any other European country (Anonymous 2006b). The number of imported ants is high as well, because ants easily hide in plant material or penetrate into package material.

Quarantine inspectors of the Plant Protection Service (Wageningen) often find a few individual ants, usually of the worker caste, during their import inspection. However, they rarely focus on them during their searches. From a phytosanitary viewpoint, ants are not that important. However, when complete nests are being found, they are always collected and sent to the diagnostic department of the service for identification. The identification is often hampered by the high number of ant species in the tropics, the availability of queens and/or males only, polymorphic workers, and the occurrence of undescribed species. At present, hygiene is high in the nurseries of import companies and detected ants are eliminated quickly. A small part of imported fertile ants slip through and are able to settle. Only when the presence of exotic ants gives inconvenience, growers will take action with, e.g., pesticides or poisoned baits. Consequently, most imported ant species on plant material will remain undiscovered.

Tourism

Dutch citizens travel frequently to southern Europe for holidays with tents, caravans, etc. Nests of ants can be taken home and successively leave the carrier and settle in houses. Other species enter houses with luggage, e.g., in 2000 *Tapinoma melanocephalum* became a plague in a house at Capelle a/d IJssel, as a result of an accidentally 'infested' football shoe after a soccer competition in Brazil.

Material, sources & definitions

Most of the older material is situated in the collections of the Zoological Museum of Amsterdam (ZMA) and of the National Museum of Natural History Naturalis, Leiden (NMNH). It is investigated by the first author from 2002-2006. A large part of this material originates from the original collection of A. Stärcke. The smaller collections of the Museum of Natural History Maastricht and the Wageningen University were examined as well. Other data on exotic ants were derived from the Health Service Amsterdam (GGD, Amsterdam), the Plant Protection Service (PPS) and 'Kennis- en Adviescentrum Dierplagen' (KAD, Wageningen). The GGD Amsterdam has been collecting ants since 1978, which are curated partly in the collection of the ZMA.

For this paper, we also used annual reports of the GGD Amsterdam over the period 1961-1967, 1973-1976 and 1978-2005. The PPS has stored exotic ants since 1950. These ants originate mostly from imported plant material, but also from organizations and private persons that asked the PPS for advice. The KAD occasionally stored ants; data on non-curated ants are available in the archives (1988-2006).

Since 2000 several heated greenhouses in botanical gardens have been investigated: Delft University of Technology, Utrecht University, and Hortus Botanicus in Amsterdam. We also collected in greenhouses in zoos: Burgers' Bush of Burgers' Zoo in Arnhem and some greenhouses of Artis Zoo in Amsterdam. Zoos in Rotterdam and in Emmen, and Groningen University (the greenhouse in Haren) sent us ants for investigation.

We divided the exotic species into four groups:

(1) intercepted exotics non-native species found during import inspection. These species can also belong to one of the other three groups.

(2) temporary exotics non-native species having temporary populations after accidental introduction from abroad. These species are found in or near the 'transportation medium' (think of, for

Table 1. Ant species found during import inspection and not known from any local settlement in The Netherlands. The first year of interception and the collection in which the species is present are given (or a reference if the collection is unknown).
Tabel 1. Mierensoorten die zijn gevonden tijdens importinspecties en waarvan geen vestigingen in Nederland bekend zijn. Het eerste jaar dat de soort is aangetroffen en de collectie waar de soort is ondergebracht worden gegeven (of een referentie indien de collectie onbekend is).

Species	First year	collection/ reference
Two – five interceptions		
Camponotus atriceps (Smith)	1931	NMNH
C. bugnioni Forel	1923	Stärcke 1926b
C. pennsylvanicus (De Geer)	<1950	NMNH
C. planatus Roger	2003	PPS
C. truncatus Spinola	<1933	Stärcke 1943
Cardiocondyla wroughtonii (Forel)	1997	PPS
Crematogaster algirica (Lucas)	<1935	Stärcke 1943
C. sordidula (Nylander)	<1935	Stärcke 1943
Odontomachus haematodes (L.)	1926	ZMA
O. monticola Emery	1978	PPS
Oecophylla longinoda Latreille	1984	PPS
O. smaragdina (Fabricius)	1985	PPS
Pheidole susannae Forel	1999	PPS
Wasmannia auropunctata (Roger)	1988	PPS
One interception		
Acromyrmex coronatus (Fabricius)	1937	NMNH
A. lundi (Guérin-Méneville)	1989	PPS
Anoplolepis gracilipes (Smith)	1934	NMNH
Camponotus aegyptiacus Emery	2004	ZMA
C. fastigatus Roger	2008	PPS
C. herculeanus (L.)	1995	PPS
C. mitis (Smith)	1938	NMNH
Cardiocondyla nuda (Mayr)	2003	PPS
Cephalotes curvistriatus (Forel)	1991	PPS
Gnamptogenys striatula Mayr	2008	PPS
Hypoponera eduardi (Forel)	1990	PPS
Lasius lasioides Emery	1973	NMNH
Lepisiota obtusa (Emery)	2005	PPS
Monomorium latinode Mayr	2002	PPS
M. salomonis (L.)	1995	PPS
Odontomachus brunneus (Patton)	1998	PPS
Pachycondyla unidentata Mayr s.s.	2004	PPS
Pheidole dossena Wilson	2005	PPS
P. laticornis Wilson	2003	PPS
Plagiolepis schmitzii Forel	2004	PPS
Prenolepis nitens (Mayr)	<1950	NMNH
Solenopsis gayi (Spinola)	1966	PPS
Strumigenys minutula Terayama & Kubota	2006	PPS
Technomyrmex foreli Emery	2005	PPS
Temnothorax subditivus (Wheeler)	2006	PPS

Table 2. Survey of temporary and local exotic ant species in The Netherlands.
Tabel 2. Overzicht van tijdelijke en lokale exotische mierensoorten in Nederland.

Genus	Species	First record	Last record [1]	Interception(s)	Temporary (T) or Local (L)	Number of observations/locations	First record in collection of ...[2]
subfamily Dolichoderinae							
Iridomyrmex	sp.	1982	[3]		T	1	PPS
Linepithema	*humile* (Mayr)	1976	-	+	L	>10	PPS
Linepithema	*iniquum* (Mayr)	1926	1943		T	2-5	(NMNH)
Tapinoma	*melanocephalum* (Fabricius)	1917	-	+	L	>10	ZMA
Tapinoma	*sessile* (Say)	1996	-		T	2-5	PPS
Technomyrmex	*albipes* (Smith)	1988	-	+	L	>10	PPS
subfamily Formicinae							
Camponotus	*canescens* Mayr	1950			T	1[4]	ZMA
Camponotus	*vagus* (Scopoli)	<1975	-		L	>5	(PPS)
Brachymyrmex	*obscurior* Forel	1942	1942		T	2-5	NMNH
Brachymyrmex	*patagonicus* Mayr	1990			T	1	PPS
Lasius	*emarginatus* (Olivier)	1980	-		L	2	PPS
Paratrechina	*bourbonica* (Forel)	1937	-	+	T	>5	NMNH
Paratrechina	*flavipes* (Smith)	1980	-	+	T	2-5	PPS
Paratrechina	*longicornis* (Latreille)	1909	-	+	T	>10	(NMNH)
Paratrechina	*steinheili* (Forel)	1980	-	+	T	2-5	PPS
Paratrechina	*vividula* Nylander	1921	-		T	>10	NMNH
Plagiolepis	*alluaudi* Emery	1921	-		L	>10	NMNH
Plagiolepis	*pygmaea* (Latreille)	1997			T	1	KAD
Plagiolepis	*taurica* Santschi	2000			L	1	KAD
subfamily Myrmecinae							
Crematogaster	*scutellaris* (Olivier)	1933	-	+	L	>10	NMNH
Pheidole	*anastasii* Emery	1917	-		L	>10	ZMA
Pheidole	*fervens* Smith	1924	1978		T	>5	NMNH
Pheidole	*megacephala* (Fabricius)	1977	-	+	T	2-5	PPS
Pheidole	*pallidula* Nylander	2004			T	1	P. Boer
Pheidole	*punctatissima* Mayr	1994	-	+	T	2-5	PPS
Monomorium	*destructor* (Jerdon)	1991		+	T	1	
Monomorium	*floricola* (Jerdon)	1975	-		L	2-5	PPS
Monomorium	*pharaonis* (Linnaeus)	1877	-	+	L	>10	NMNH
Solenopsis	*geminata* (Fabricius)	1992	-	+	T	2-5	PPS
Solenopsis	*invicta* Buren	1957	-	+	T	2-5	ZMA
Tetramorium	*bicarinatum* (Nylander)	1909	-	+	L	>10	(NMNH)
Tetramorium	*insolens* (Smith)	1978	-		L	local	PPS
Tetramorium	*lanuginosum* Mayr	1984	?		T	2-5	PPS
Tetramorium	*pacificum* Mayr	?			T	1	PPS
Tetramorium	*simillimum* (Smith)	1978	1994	+	T	2-5	PPS
subfamily Ponerinae							
Hypoponera	*schauinslandi* (Emery) [5]	1923	-		L	>10	NMNH
subfamily Pseudomyrmecinae							
Pseudomyrmex	*gracilis* Fabricius	1936			T	1 [6]	NMNH

[1] - observed after 1996; [2] between brackets: not first record; [3] half a year established in- and outdoors in Katwijk; [4] found on the island of Ameland; [5] McGlynn and others referred to *H. punctatissima*, but this could in many cases be *H. schauinslandi*; [6] additionally in 1995 a *Pseudomyrmex* sp. nest in an imported *Acacia* sp. in the butterfly house in the zoo of Emmen

example, pot plants and/or wooden pallets.

(3) local exotics non-native species having temporary populations. These species have moved away from the entry medium and have (been) dispersed to other locations.

(4) permanent exotics non-native species having permanent populations. These species are able to spread to other locations by themselves. None of the species in this paper could be placed in this category.

The nomenclature adopted here is according to Bolton *et al.* (2006).

Table 3. Survey of the local exotic ant species in The Netherlands in the period before 1945 and in the period 2000–2006. ↓: decreasing compared with the period before 1945; (+) incidentally imported.
Tabel 3. Overzicht van de lokale exotische mierensoorten in Nederland in de periode voor 1945 en van 2000-2006. ↓: afname vergeleken met de periode voor 1945; (+) incidenteel aangevoerd.

Species / Soort	<1945	2000-2006
Camponotus vagus	-	+
Crematogaster scutellaris	(+)	+
Hypoponera schauinslandi	+	+
Linepithema humile	-	+
Lasius emarginatus	-	+
Monomorium floricola	-	+
Monomorium pharaonis	+	+↓
Paratrechina longicornis	+	(+)
Pheidole anastasii	+	+↓
Plagiolepis alluaudi	+	+↓
Plagiolepis taurica	-	+
Tapinoma melanocephalum	+	+
Technomyrmex albipes	-	+
Tetramorium insolens	-	+
Tetramorium bicarinatum	+	+↓

1. *Tapinoma melanocephalum* is one of the most damaging exotics. Photo: April Nobile, www.antweb.org.
1. Het spookdraaigatje *Tapinoma melanocephalum* is één van de exoten met economisch gezien de meeste impact.

Results

Intercepted exotics

Fifty-five exotic species were identified to species level, and 39 are exclusively known from import interception in The Netherlands (table 1 & 2). For the latter no establishments are known. The total number of species would have been much higher if all intercepted species could have been identified. Especially in the collection of the PPS many specimens are 'waiting' for identification to species level.

Temporary, local and permanent exotics

Thirty-seven temporary and local exotics could be identified (table 2, including their first record for The Netherlands). Populations of 24 species survived for a longer time, of which nine in houses. Most of the temporary exotics are so-called tramp species: widespread by human activity and permanently established in one or more non-native continents (Passera 1994, McGlynn 2002). From the fourteen local exotics it is unknown if one of these species can disperse on own strength. Except for four species, all local exotics are exclusively found indoors. A very rough occurrence trend could be derived from the gathered data (table 3). Permanent exotics do not exist in The Netherlands. The Dutch Atlantic climate and strong competition by other ants – especially by representatives of *Formica*, *Lasius* and *Myrmica* – prevents settlement of species from foreign temperate areas.

The local exotics

Dolichoderinae

Linepithema humile

Is since 1989 very numerous in the large greenhouse of Burgers' Bush in Burgers' Zoo, Arnhem. After control measures it is undetectable there at present. It occurs regularly in houses, nesting in various places. Since 1994 this ant is found four times during import interceptions. This species is difficult to control and is established for many years in several blocks of houses.

Tapinoma melanocephalum (figure 1)

This is one of the exotic species with highest economical impact (Vierbergen 1997). It is found regularly during import inspections from 1990-2005 (e.g., Taiwan, Thailand, Costa Rica) and settles commonly in houses.

Technomyrmex albipes (figure 2)

Is of Indo-Australian origin and was found twice during import inspections: in 1992 on *Codiaeum* ('croton'), imported from Sri Lanka, and in 1997 on *Citrus* from Thailand. It is the most remarkable newcomer of all exotics because in a short time it became a permanent indoor colonizer, preferring habitats with rather constant humidity, temperature, food supplies and nesting possibilities (Vierbergen 2003). These circumstances can be found in heated greenhouses and animal residences in zoos. *Technomyrmex albipes* was deliberately released into the greenhouses in the botanical garden of Leiden, to eliminate *Paratrechina longicornis*. The action was effective, the latter disappeared, but *T. albipes* became a new plague (M Kole, personal communication). The speed at which *T. albipes* conquered the heated greenhouses in The Netherlands is nevertheless unprecedented. This is partly due to an infestation in cultures of stingless bees at Utrecht University, which were used for pollination of tropical plants in the greenhouses, and the exchange of plants between the botanical gardens and zoos (M Kole, personal communication). Nineteen years after the first observation it is a serious pest.

Nests are situated aboveground in all possible places, like double synthetic glass, electric installations, cavities in branches and leaf sheaths of big plants. After disturbing a nest, the ants remove at once carrying their brood with them. Half of the worker-like ants are fertile females, which produce offspring, a very rare phenomenon amongst ants (Warner 2003). The traditional ant pest control methods – killing off the fertile queen through the workers by feeding her with poisoned matter – does not work effectively on *T. albipes*. Toxic bait can also kill other, non-target ant species in greenhouses. As a result, *T. albipes* can take possession of the entire aboveground greenhouse. The soil-living *Hypoponera schauinslandi* is not decreasing when *T. albipes*

2. *Technomyrmex albipes* is a widespread but relatively new exotic in The Netherlands, which might spread even further. Photo: April Nobile, www.antweb.org.
2. De witvoetmier *Technomyrmex albipes* is een wijdverbreide maar relatief nieuwe exoot, die zich waarschijnlijk nog verder zal verspreiden.

3. *Paratrechina longicornis* was common in the botanical gardens of Leiden and Utrecht, but disappeared there. Photo: April Nobile, www.antweb.org.
3. De superlangsprietmier *Paratrechina longicornis* was algemeen in de hortus van Leiden en Utrecht, maar is daar verdwenen.

increases. This species is not attracted to baits and does not compete with the aboveground living *T. albipes*. Stärcke (1943) already noticed that *T. albipes* is extraordinarily aggressive against other ant species. *Technomyrmex albipes* is certainly not at its peak; at some locations it is possible that this ant is still replacing other species.

Formicinae

Camponotus vagus

Is known to be introduced with wood and railway sleepers from France and Eastern Europe (Mabelis 2007). However, spread on own strength to other locations has not been observed, but locally the species can survive for several years. In 1972 in a dune area at Bloemendaal (Noord-Holland) a colony of *C. vagus* was introduced artificially, and it stayed here for 25 years (Boer & De Gruijter 1999). Because of the poor dispersal, natural spread from Belgium and Germany is unlikely. Its 'habitat' in The Netherlands – wooden railway sleepers – is slowly disappearing, because these sleepers are replaced by concrete ones.

Lasius emarginatus

Found in a house in Huizen (Noord-Holland, 1980) and Hengelo (Overijssel, 1996). In Hengelo the ants were observed outside the house as well. The species occurs in Central Europe south from 52.5° N (Seifert 2007). In Belgium the species is regularly found on old brick walls in the western part of Flanders, approximately 20 km from the Dutch border (Vankerckhoven 2006). An alate gyne was caught in Tilburg on 28.vii.2006 (Boer *et al.* 2007), 7 km of the Belgian border. Very likely permanent establishment seems to be a matter of time.

Paratrechina longicornis (figure 3)

Of Asian and Afro-tropical origin. From 1909 until at most 1942, this species occurred in the Hortus Botanicus of Utrecht. It was a pest in the Hortus Botanicus of Leiden until ca. 1990, when it was replaced by *Technomyrmex albipes* (see above). At present this species can be considered a temporarily establisher.

Plagiolepis alluaudi

Is probably of Afro-tropical origin. The number of records is slightly decreasing.

Plagiolepis taurica

Has established since 2000 in and around one complex of houses in Utrecht. The nearest outdoor populations are situated in Belgium (Boer 2007).

Myrmecinae

Crematogaster scutellaris

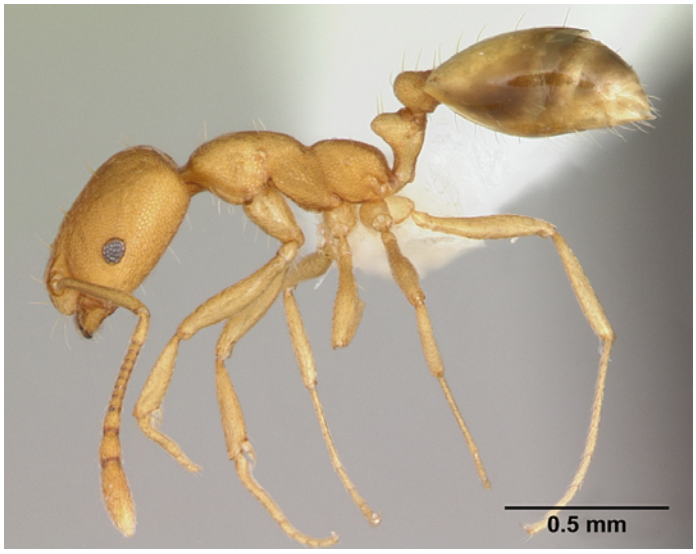
Is regularly imported and often established, but is never expanding. In 1993 it had settled in a house in Zoetermeer (Zuid-Holland), where it was tending aphids in the adjacent garden (Vierbergen 1994, Brink 1995). This colony was introduced by a caravan from Spain, indicating entry via tourist traffic. Also in Germany a nest was found to be introduced by a caravan from Italy (Sellenschlo 1993). Alate gynes have been seen outdoors, in the vicinity of a colony at Mook (Limburg). This colony previously lived indoors (B Baartman, personal communication). Additionally nests can survive the winter outdoors in bark on the stem of imported *Quercus ilex* trees (A Sonnemans, personal communication).

Monomorium floricola

Is regularly intercepted on plant material imported from the Philippines, Thailand and Costa Rica. Often introduced with pot plants in greenhouses, but also incidentally occurring in houses.

Monomorium pharaonis (figure 4)

Is broadly established and widely distributed. Before 1886 the pharaoh ant was already a pest in a bakery in Amsterdam and in houses in The Hague (Bos 1886). In 1926 *M. pharaonis* was present in all major cities – sometimes as pest – in bakeries, houses and other buildings with central heating (Stärcke 1926b, 1944). In the period 1967 to 1979, the species was annually



4. *Monomorium pharaonis* is the most often encountered and the first local exotic ant of The Netherlands. Photo April Nobile, www.antweb.org.
4. De faraomier *Monomorium pharaonis* is de meest aangetroffen en oudste exoot van Nederland.

5. *Hypoponera schauinslandi* is the most successful exotic ant species in Dutch greenhouses. Photo: April Nobile, www.antweb.org.
5. De tropische staafmier *Hypoponera schauinslandi* is de meest succesvolle mierenexoot in kassen.

recorded more than 100 times in Amsterdam (data of GGD Amsterdam). In 2005 the number of records of the KAD in Amsterdam was only seven. This number is not high, but this does not mean that the pharaoh ant has nearly disappeared; in 2004 and 2005 a large-scale pest control program in the centre of Arnhem was performed. It proved to be an obstinate species, and control was only successful when all citizens cooperated (Anonymous 2005a).

The impression is that pharaoh ants are not as common as before 1945. An important reason is the obligation of house owners to perform pest control against ants. Of all exotic ants, this species preferably resides closer to human residences. It rarely occurs on plant material, as is also indicated by the single known interception on plant material in The Netherlands (in 2006 found on *Momordica* fruit, imported from Surinam). Remarkably, pathways other than import with pot plants and vegetables have not been reported yet. In the ZMA a worker was found, erroneously identified as *Leptothorax nylanderi* (Förster), which was labeled "Kijfhoek, Meijendel, 20-iv-1960, leg. Lefeber". This *M. pharaonis* record is included in a geographical map of *L. nylanderi* on page 247 in Peeters *et al.* (2004). Additionally we found a worker of *M. pharaonis* in the NMNH, labeled "Castricum, PWNduinen, 13-viii-1984, leg. AC&WA Ellis". Remarkably, both locations are in a dune area far from urban settlements. However, it is doubtful that both records indicate the presence of outdoor nests. It is well possible these ants have been mislabelled, or samples may have stayed open for a longer time at the site of preparation, resulting in secondary contamination of samples with this common house pest.

Pheidole anastasii

Initially, only two *Pheidole* species were reported in Europe, The Netherlands included, namely *P. anastasii* and *P. megacephala*. After checking the collections, *P. anastasii* proved to be most abundant, the second was often misidentified. The number of records is decreasing. It is known from Artis Zoo in Amsterdam since 1936, where it is still common.

Tetramorium bicarinatum

In 1943 the most common ant in Dutch greenhouses (Stärcke 1943). The number of records is decreasing in the last decades.

Tetramorium insolens

Is from Indo-Australian origin. This species never lives in sympatry with *T. bicarinatum*. *Tetramorium insolens* occurs in Burgers' Zoo in Arnhem, where it is known from Burgers' Bush (from 1989 on) and Burgers' Mangrove (from 1993 on).

Ponerinae

Hypoponera schauinslandi (figure 5)

Is of tropical origin. Common in all investigated tropical greenhouses and (sub-)tropical zoo/animal houses. This species is apparently the most successful exotic ant in Dutch greenhouses and is also known from houses. It gives nuisance to greenhouse staff by its painful sting.

Tropical gardens and zoos

In the period 2000-2006 we investigated greenhouses in botanical gardens and heated animal residences in zoos. During this period, we found five species in the botanical gardens, although other species had been present in the years before (table 4). Four of the currently found species were absent in the past and one – *Pheidole anastasii* – was established in more than one period and at more than one location. In the animal residences we recorded seven species, although other species were present in the years before. *Brachymyrmex patagonicus*, *Paratrechina bourbonica*, *Pheidole megacephala* and *P. fervens* were found to be present temporarily. Competition most likely plays an important role in the presence/absence of species. *Monomorium pharaonis*, for example, was replaced from animal residences by *P. anastasii* in the Amsterdam zoo (Anonymous 1936), where the latter is still dominant. In another part of that zoo, *M. pharaonis* was replaced by *Paratrechina vividula*, which established here in 1926 (Stärcke 1943). In the large greenhouse in Burgers' Zoo at Arnhem, *Linepithema humile* was very numerous in the

Table 4. Occurrence of exotic indoor ant species in greenhouses and tropical gardens in botanical gardens and zoos, in three periods: x/x/x = before 1945/1946-1999/2000-2006; + present, - no observations. We only mention species that have been found in more than one period or at more than one location.
Tabel 4. Voorkomen van exotische mieren in kassen en tropische tuinen in botanische tuinen en dierentuinen. Periode: x/x/x = voor 1945/1946-1999/2000-2006; + aanwezig, - geen waarnemingen. We hebben alleen die soorten opgenomen die in meer dan een periode of op meer dan een locatie zijn waargenomen.

	Botanical gardens					Zoos			
Species	**Leiden**	**Amsterdam**	**Utrecht/Baarn**	**Groningen/Haren**	**Delft**	**Amsterdam**	**Rotterdam**	**Arnhem**	**Emmen**
anno	1594	1638	1723	1628-2006	1917	1838	1857	1913	1935
Hypoponera schauinslandi	+/-/+	-/-/+	-/-/+		-/-/+	-/+/+		-/+/-	
Technomyrmex albipes	-/+/+	-/-/+	-/-/+	-/-/+	-/-/+	-/-/+	-/-/+	-/-/+	
Pheidole anastasii		-/+/-	+/-/-			+/+/+			
Pheidole fervens	+/-/-						-/+/-		
Pheidole megacephala						-/-/+	-/+/-		
Tetramorium bicarinatum		+/-/-	+/-/-	-/+/-	+/-/+	+/+/+	+/+/-		
Tetramorium insolens				-/-/+				-/+/+	
Plagiolepis alluaudi	-/+/-			-/-/+	-/+/+			-/+/-	-/+/-
Pseudomyrmex gracilis									-/+/+

beginning. Because of starting nuisance, control measures were taken and successively *L. humile* was accidentally (almost) completely replaced by *Technomyrmex albipes* (JAB Wensing, Burgers' Zoo, personal communication). In this context, it is interesting to know that ants living indoors are not always experienced as a nuisance. They can even be beneficial. In orchid greenhouses at Loosdrecht and Aerdenhout *Tapinoma melanocephalum* and *Linepithema iniquum* were recognized as useful in the period 1926 to 1932, because these species controlled all kinds of vermin (Stärcke 1943).

Discussion and conclusion

Since the reports on Dutch ant exotics by Stärcke seven species were added to the local exotics (table 2 & 4), of which three species are indigenous in Northwest-Europe (*Camponotus vagus*, *Lasius emarginatus* and *Plagiolepis taurica*). Sixteen of the temporary species were not recorded by Stärcke and, with the exception of the Mediterranean *Plagiolepis pygmaea* and *Pheidole pallidula*, these are of non-European origin. Thus, the 'new possibilities' Stärcke detected in his time, did not result in the establishment of high numbers of new exotics in our time. Despite the increased speed of transport, tourism and trade all over the world, an invasion of exotic ants in The Netherlands has not yet occurred. Especially a better hygiene in houses and an increased control prevented local establishment in the last decades.

Owing to the large import of plant material in The Netherlands, relatively many non-native ant species are being found, compared to surrounding countries. The total species number of intercepted, temporary and local exotics found in The Netherlands exceeds 76, because not all intercepted ants are identified to species level. The number of identified intercepted non-native ant species in New Zealand is 114 (Ward *et al.* 2006) and in the USA (inclusive non-identified species) 232 (Suarez *et al.* 2005). The trade in plant products is not as intensive in The Netherlands as in the USA (Anonymous 2007b), but it is more intensive than in New Zealand. Moreover, the import of plant material in The Netherlands is the highest (74.053 tons in 2005) of all of Europe (in total 106.395 tons in 2005).

The only two indoor species able to survive outdoors for years (*Crematogaster scutellaris* and *Plagiolepis taurica*) are of central or southern European origin, just like the only outdoor exotic establisher *Camponotus vagus*. These three species are not known as tramp species. Here, they live at the border of their distribution area and must be considered as regularly accidentally introduced species, which may become permanent exotics in the future due to global warming. At present, the most common and difficult to control Dutch indoor exotic ant is *Monomorium pharaonis*, but the second is *Linepithema humile*, which was absent in Stärcke's time. The third in order is *Tapinoma melanocephalum* or *Technomyrmex albipes* (T Brink, personal communication). The newcomer *T. albipes* started to spread and settle worldwide in the beginning of the nineties of the previous century (Deyrup 1991). Since October 2007, the insecticide hydramethylnon may no longer be used (Anonymous 2007a), so nowadays no effective formicide is permitted in The Netherlands. Maybe this will result in new opportunities for exotic ants.

The question remains how local exotics disperse from the one indoor settlement to another. Or, alternatively, will all indoor establishments be caused by new entries? We suppose that this is nearly always the case in temporary establishment of ants in resident housings. Exchange of plants explains the dispersal of part of the species in greenhouses of botanical gardens, but dispersal of *Monomorium pharaonis* must have taken place by other means, such as transport of goods of different (household) kinds (Passera 1994).

The indoor ant populations in greenhouses of zoos and botanical gardens show similarities in species composition. *Hypoponera schauinslandi* and *Tetramorium bicarinatum* have been inhabitants there for a long time. The presence or absence of species is evidently influenced by inter-specific competition. The way in which the greenhouses are equipped plays an important role. Modern greenhouses with a minimum of soil and humus contain fewer species in lower densities than old greenhouses with all kinds of cavities and with relatively much soil and humus. When hygienic and control measures increase, the number of local exotics will decrease in The Netherlands. *Paratrechina longicornis* is likely to be the first ant to have disappeared for this reason.

Observations of indoor exotic ants settling outdoors permanently are completely absent, while in warmer regions invasions of gardens and fields are common. Even the settlement of species originating from a temperate climate from other continents will be hampered, because of the strong competition by the Dutch native species. All in all, exotics do not influence the outdoor ant fauna of The Netherlands.

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Samenvatting

Exotische mieren in Nederland (Hymenoptera: Formicidae)

Stärcke heeft van 1926 tot 1944 herhaaldelijk melding gemaakt van exotische mierensoorten in Nederland. In de periode daarna zijn door de Plantenziektenkundige Dienst (Wageningen) niet-inheemse mieren verzameld en gedetermineerd. In de periode 2002-2006 is onderzoek gedaan naar de aanwezigheid van (vaak ongedetermineerde) exotische mieren in collecties en in kassen van botanische tuinen en dierentuinen. Hoewel nog niet al het materiaal op naam is gebracht, zijn er nu 76 exotische mierensoorten voor Nederland vastgesteld. Negenendertig soorten zijn alleen 'onderschept' tijdens inspecties van de Plantenziektekundige dienst, 23 soorten hebben kans gezien zich tijdelijk te vestigen en twaalf soorten komen thans lokaal in allerlei gebouwen in Nederland voor. In vergelijking met de jaren voor 1945, zijn er in de jaren 2000-2006 zeven soorten bijgekomen die zich in binnenmilieus gevestigd hebben, een is verdwenen, terwijl van vier soorten veel minder waarnemingen werden gedaan. Onder de nieuwkomers bevindt zich de witvoetmier *Technomyrmex albipes*, die nu zelfs de meest algemene mier is in botanische tuinen en dierentuinen. De 'oudste' exoot is de faraomier *Monomorium pharaonis*. Deze is nu nog steeds wijdverbreid in verwarmde gebouwen en is daar met een zekere regelmaat een plaag. Andere succesvolle binnenmilieus in gebouwen zijn de Argentijnse mier *Linepithema humile*, het spookdraaigatje *Tapinoma melanocephalum* en de tropische staafmier *Hypoponera schauinslandi*. Van alle waargenomen tijdelijke en lokale exotische soorten is het overgrote deel wereldwijd bekend. Door biologische bestrijdingsmaatregelen kunnen lokaal gevestigde exotische mieren vervangen worden door andere. Zo is in de Hortus in Leiden *Paratrechina longicornis* verdrongen door *Technomyrmex albipes*, die als natuurlijke vijand werd ingezet. Door de toepassing van een breed scala aan bestrijdingsmethoden in Burgers' Bush te Arnhem halverwege de negentiger jaren van de vorige eeuw is *Linepithema humile* door de onopzettelijk geïntroduceerde *T. albipes* vervangen. De zwarte reuzenmier, *Camponotus vagus*, die regelmatig wordt geïmporteerd met houten spoorbielzen wordt bedreigd door vervanging door betonnen bielzen. De schorpioenmier *Crematogaster scutellaris* en de dwergschubmier *Plagiolepis taurica* kunnen zich zowel binnen als buiten vestigen. Er is echter nog geen sprake van uitbreiding op plaatsen waar zij zich tijdelijk hebben gevestigd. Dit zelfde geldt voor de muurmier *Lasius emerginatus*, hoewel er sterke aanwijzingen zijn dat deze soort zich binnenkort definitief in Nederland zal vestigen. Anders dan bij veel andere insecten, hebben mierenexoten ondanks het hoge aantal introducties en locale vestiging geen enkele invloed op de sterk competitieve inheemse (mieren)fauna van Nederland.

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