

## ***Technomyrmex vitiensis* Mann, 1921 (Hymenoptera, Formicidae, Dolichoderinae), a new exotic tramp ant in Finland**

Simo Väänänen, Kari Vepsäläinen & Ville Vepsäläinen

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Globalisation and urbanisation have steadily increased the occurrence and establishment of exotic ant species around the world. Even though native Finnish ants are well-studied, knowledge about introduced exotic ants living indoors in Finland is scanty. We report here a new exotic tramp ant, *Technomyrmex vitiensis*, found in 2016 the first time in Finland. The species lives in the two tropical houses of the Helsinki Zoo. The species is known to have, in addition to normal alate reproductives, wingless ergatoid queens and males. Ergatoid queens made around 15% of the individuals in the studied nests, but we were unable to find ergatoid males. Ergatoid queens were also found among foragers, outside nests; a behaviour that has not been recorded earlier in *Technomyrmex* species. Alate males were present only in nests sampled in late autumn. Nests that were sampled in early spring contained dealate queens, but queens were not found in the late autumn.

Globalisaatio ja kaupungistuminen ovat lisänneet vieraslajien, myös eksoottisten muurahaisten, leviämistä kautta maailman. Vaikka Suomen luonnossa elävät muurahaislajit tunnetaan suhteellisen hyvin, sisätiloissa tavattavista tulokasmuurahaisista ei tiedetä kovinkaan paljon. Kirjoituksessamme kerromme Suomesta ensi kerran vuonna 2016 löytyneestä uudesta eksoottisesta tulokasmuurahaisesta *Technomyrmex vitiensis*. Ehdotamme lajille suomenkielistä nimeä sorjateknomyrahainen. Se elää Helsingissä, Korkeasaaren eläintarhan trooppisissa taloissa. Lajilla on sekä normaaleja siivellisiä että ergatoidisia eli siivettämiä kuningattaria ja koiraita. Ergatoidisia kuningattaria oli 15 % tutkittujen pesien yksilöistä, mutta ergatoidisia koiraita emme löytäneet. Aikaisemmista tutkimuksista poiketen tapasimme ergatoidisia kuningattaria myös pesän ulkopuolella, työläisten parista. Siivellisiä koiraat löysimme vain loppuvuodesta otetuista pesänäytteissä. Siipensä pudottaneita kuningattaria oli vain alkuvuodesta otetuissa näyteissä.

Simo Väänänen, ORCID 0000-0003-1113-6539. Email: svaanan2@welho.com

Kari Vepsäläinen, ORCID 0000-0002-9712-9323. Jokipuistonkaari 8 E 32, Sipoo, Finland. Email: kari.vepsalainen@helsinki.fi

Ville Vepsäläinen, Helsinki Zoo, P.O. Box 1000, FI-00811 Helsinki, Finland. Email: ville.vepsalainen@korkeasaari.fi

### Introduction

Ants are an important component in numerous biotic interactions, and they shape the structure and function of ecosystems all around the world (Hölldobler & Wilson 1990, Lach et al. 2010). The total number of described ant species is over 13380 (Bolton 2018). Of these, around 150 species worldwide were estimated by McGlynn (1999) to have been introduced into new areas by man. Today, the total number of introduced ant species is considered to be much higher (Miravete et al. 2014). The increase and spread of exotic ant species around the world are attributed to globalisation and urbanisation (Klotz et al. 2008). When referring to ant species that are distributed widely by human commerce and live in close association with man in countries where they are introduced to, the term tramp ant is often applied (Hölldobler & Wilson 1990, Holway 2002, Klotz et al. 2008). Many of the exotic tramp ant species are adapted to tropical and subtropical conditions, and thus in Europe, where the climate is too harsh for them, the species are confined to indoors (Pospischil 2015).

*Technomyrmex* Mayr, 1872 is a moderately large dolichoderine genus with 94 extant and 4 fossil species (Bolton 2018).

*Technomyrmex vexatus* (Santschi, 1919) in Gibraltar is the only *Technomyrmex* species living in the wild in the European mainland (Guillem & Bensusan 2008). Several well-known and widespread tramp species are classified in the *Technomyrmex albipes* group: *T. pallipes* (Smith, F., 1876), *T. albipes* (Smith, F., 1861), *T. difficilis* Forel, 1892 and *T. vitiensis* Mann, 1921 (Bolton 2007). Tramp species of *Technomyrmex* occur sporadically across all biogeographic regions and in hothouse environments in the Holarctic (Bolton 2007).

Ants normally have alate (winged) female and male reproductive castes, and a wingless female worker caste (Hölldobler & Wilson 1990). Because workers have no spermatheca, they are at the most capable of producing males from unfertilised eggs. Nevertheless, also wingless true reproductives occur in ants. There are at least 77 ant genera with at least one species that has either wingless ergatoid (superficially worker-like) queens or other functionally similar wingless female reproductives (Peeters 2012). Wingless ergatoid queens are known in 25 species of *Technomyrmex* (Bolton 2007). Also wingless ergatoid males have evolved in several ant genera, and such males are known in seven *Technomyrmex* species, including *T. vitiensis* (Pech & Bezděk 2016).

Here, we report the first find of *Technomyrmex vitiensis* in Finland. We also provide information on worker, ergatoid queen and other castes in the Finnish *T. vitiensis* colonies.

## Materials and methods

A strange new ant was first noticed in late November 2016 by the staff of the Helsinki Zoo, on the island Korkeasaari, Helsinki. The ant was living in the two tropical houses of the Zoo (Africasia and Amazonia) (WGS84: 60.1755° N, 24.9830° E). These buildings—heated and kept at suitable temperatures for many exotic animals and plants—have many large animal closures and terraria. The new ant was conspicuously different from *Monomorium pharaonis* (Linnaeus, 1758), which had been living in the Helsinki Zoo for many years and was well known to the zoo staff. They described in March 2017 the visibility and abundance of the new ant as follows: boxes with food (vegetables and fruit) to culture crickets and cockroaches, teemed with ants that covered the pieces of food under a black mat. The ant species was identified (from a preliminary sample, not included in this study) by Kari Vepsäläinen and later confirmed by Barry Bolton as *Technomyrmex vitiensis*.

Ville Vepsäläinen (VV) collected two whole nests of *T. vitiensis* from the Africasia house in early 2017. The first nest (Nest1), collected on 21.3.2017, came from a carton box that contained dried moss bricks. The other one (Nest2) was taken in 26.3.2017 from under decorative bricks and within bottom substrate of a terrarium for a corn snake. On 21.11.2017 Simo Väänänen (SV) collected a nest sample (Nest3) from under a thin placard placed on the wall next to the animal terrarium in the Africasia house. Further, from various places within Ama-

zonias and Africasia, SV took some additional small samples of nest material with a few ants (Nest4). Finally, he took a forager sample of ants covering a large piece of banana (Foragers1), in an arthropod terrarium in the hallway between the Amazonia and Africasia houses. On 9.3.2018, VV took two large forager samples, one from a beetle (*Smaragdesthes africana*) terrarium, the other one from a cockroach (*Gromphadorhina portentosa*) terrarium, where food (pieces of orange and pear) was covered black with ants (Foragers 2-3). Samples were preserved in 80% ethanol or stored in a freezer. The samples are kept in the private collection of SV and in the Finnish Museum of Natural History, University of Helsinki, Finland (MZH).

We (SV) used a binocular microscope with 6-40x magnification to identify and count the proportions of *Technomyrmex vitiensis* castes in the samples. An individual female was counted as ergatoid queen if it had at least one ocellus and showed more or less conspicuous queen-like modifications in the mesosoma. Extra care was applied when checking for the existence of possible wingless ergatoid males, which should have e.g. conspicuously shorter antennal scapes than do female castes. All nest samples included innumerable brood, which were not studied closer.

We used version 1.7 of package 'Exact' (Calhoun 2016) in R (version 3.4.3) (R Core Team 2017), to test the proportions of castes between the samples. To test the independence of rows and columns in our 2 x 2 tables, we applied Barnard's exact test, a version of unconditional exact tests (all tests were two-sided and used the binomial model with CSM approximation).



**Figure 1.** *Technomyrmex vitiensis*, dorsal view; from left to right: worker, ergatoid queen, dealate queen. Note different scales. Collated from photos by Pekka Malinen.

## Results

Table 1 documents our samples by castes, month of collecting and source of sample (nest or forager sample). The percentage of ergatoid queens in our pooled nest samples of workers and ergatoid queens was 15.4%. The proportion of ergatoid queens did not differ in the March samples or in the November samples (test results not shown). Neither did the combined nest samples of March versus November differ for the proportion of ergatoid queens ( $p = 0.82$ , sample sizes 2575 vs 104, difference in the proportion of ergatoid queens = 0.04).

Ergatoid queens were found in two of the three samples taken outside nests. Their proportion in the pooled forager samples of workers and ergatoid queens was 2.2%. This is substantially less than in the nests (15.4%). The difference between the combined nest versus forager samples is statistically significant ( $p = 3.4 \times 10^{-10}$ ).

The small number of males (13) and dealate queens (8) were found in November (in both nest samples) and March (in both nest samples), respectively. The different seasonal distribution of males and dealate queens is statistically significant ( $p = 10^{-6}$ ). The only alate queen was also collected in March, but outside the nest, on food in the cockroach terrarium.

Of the males, one in the Nest3 and another in the Nest4 sample had a deformed left antenna, similar to the “hockey-stick” antenna described by Pech & Bezděk (2016); furthermore, the other of these males had short forewings. The wings of all the other males were fully developed. None of the samples had ergatoid males.

## Discussion

Even though the native Finnish ants are fairly well-studied, the knowledge about introduced exotic ants living indoors in Finland is sporadic. The checklist of Finnish ants contains 54 native outdoors-living species (Paukkunen 2018). The list of outdoor species is often supplemented with *Hypoponera punctatissima* (Roger, 1859), which sometimes settles in compost mounds—it lives, however, in Finland mainly indoors. Strictly indoors-living species are few: the by far most common is *Monomorium pharaonis* (Linnaeus, 1758), whereas *Tapinoma melanocephalum* Fabricius, 1793 and *Nylanderia vividula* (Nylander, 1846) have been reported occasionally (Paukkunen 2018). *Anoplolepis gracilipes* (Smith, F., 1857) has once invaded in abundance logistic centres for imported furnitures, where it was (as far as we know) successfully eradicated soon after it was noted (K. Vepsäläinen, unpublished). Save for a few short, mostly old, reports (e.g. Nylander 1846, Savas 1937, Silfverberg 1978, Rosengren 1992, Sorvari 2002), almost nothing is known about the biology and distribution of introduced ant species in Finland. Consequently, *Technomyrmex vitiensis*



**Figure 2.** *Technomyrmex vitiensis*, lateral view; from top to bottom: worker, ergatoid queen, dealate queen. Note different scales. Collated from photos by Pekka Malinen.

reported here is one of the very few strictly indoors-living introduced, exotic ant species that have succeeded in establishing itself in Finland. Clearly, an intensive survey—preferably in cooperation with pest-control companies and the personnel of hothouses, and botanical and zoological gardens—would be welcome in order to update the state of imported, exotic ants in Finland.

Although the identification to the species of the several *Technomyrmex* tramp species requires care (see the key by Bolton (2007)), *T. vitiensis* (Figures 1.-3.) is moderately easy to distinguish from the other Finnish ant species, whether native or introduced. *Technomyrmex* belong to the subfamily Dolichoderinae, and thus they have only one petiolar segment or node between the alitrunk and gaster like the formicine ants. The circular nozzle-like acidopore of Formicinae at the posterior end of the abdomen, fringed with setae (coronula), is however, lacking in Dolichoderinae. Furthermore, *Technomyrmex* do not have the petiolar scale universal in Formicinae and their peti-



ole is overlapped by the gaster. In Finland, these dolichoderine traits are shared only by the ghost ant *Tapinoma melanocephalum*. However, whereas *Technomyrmex* have five dorsally visible gastral tergites and the anal orifice is situated at the tip of the gaster, *Tapinoma* have four dorsally visible tergites and a ventrally located anal orifice (Bolton 2007, Czechowski et al. 2012).

*Technomyrmex vitiensis* probably originates from South-East Asia and it is widespread in South-East Asia, on islands in the Indian Ocean and Polynesia. It is known from numerous Palaearctic and Nearctic tropical greenhouses (Bolton 2007). In Europe records come from the United Kingdom, Germany, Belgium, the Netherlands, Switzerland, Austria, Denmark and Finland (Bolton 2007, Pospischil 2015, Schär et al. 2018, this study). *T. vitiensis* started to spread in European tropical greenhouses at the end of the last century and is now considered the most common exotic ant species in buildings with tropical environmental conditions in continental Europe (Pospischil 2015, Pospischil personal communication). Overall, the number of tropical and subtropical ant species that are transported and become established in tropical greenhouses in Europe is growing (Boer & Vierbergen 2008, Pospischil 2011, Pospischil 2015).

*Technomyrmex vitiensis* is versatile in its choice of nest sites. It nests in various cavities as long as they are sufficiently undisturbed and covered—though, in specific situations (see Oettler & Heinze 2009) groups of workers, intermorphs (called here ergatoid queens) and brood may be found on the inner side of large leaves and other highly unstable nest sites. *Technomyrmex* colonies are polydomous and nests exchange workers (Warner 2003), and it is possible that *T. vitiensis* forms one large polydomous colony within every hothouse they have invaded. Although *Technomyrmex* workers do not sting or bite humans or cause damage to human-made structures, they may be a nuisance and pest inside heated greenhouses (Warner 2003). In the tropical houses of the Helsinki Zoo, *T. vitiensis* is considered a nuisance as its nests and foragers are ubiquitous and abundant, e.g. workers are commonly seen foraging even inside the refrigerator of the staff's coffee room. They also prey on eggs and instars of insects cultured to feed species on exhibition. Owing to the abundance of these ants and their tendency to occupy even small spaces, they may be a risk to e.g. electrical appliances—for such realised risks by *Lasius neglectus*, see Espadaler & Bernal (2008). Hence, efforts to exterminate *T. vitiensis* from the Helsinki Zoo are now ongoing, but it is unlikely that the population there can ever be completely eradicated. In such efforts, trophallaxis—also observed between adults of *T. vitiensis*—can be taken advantage of, as the exchange of liquids by trophallaxis among the individuals also spreads pest control agents (e.g. boric acid) used in baits (Oettler & Heinze 2009).

Like many species in the *T. albipes* group, *T. vitiensis* has both alate sexuals and wingless ergatoid queens and ergatoid males



**Figure 3.** A male of *Technomyrmex vitiensis*. It had a deformed left antenna. For further information, see text. Photo by Pekka Malinen.

(Pech & Bezděk 2016). Whereas true workers lack ocelli and their mesosoma is very simplified, the ergatoids have one to three ocelli and their mesosomal morphology is intermediate between that of workers and the mesosoma of queens or males (the winged sexuals need space and special structure for the flight muscles). Bolton (2007, p.105) provides a good description of the morphology of worker–queen intercastes (called here ergatoid queens) along the continuum from worker-like to notably queen-like. Ergatoid and alate queens have a spermatheca, which is lacking in workers. Moreover, whereas workers have only four ovarioles, ergatoid queens of *T. vitiensis* have 10–24 (Oettler & Heinze 2009). Ergatoid males share the basic morphological syndrome with ergatoid females, as noted by Pech & Bezděk (2016), who were the first to report ergatoid males in *T. vitiensis*.

In the colonies studied by Pech & Bezděk (2016), ergatoid males seem to be present throughout the year. In contrast, neither we nor Oettler and Heinze (2009) found any ergatoid males, which implies substantial variation among colonies due to unknown factors. On the other hand, in the pooled nest data, the proportion of ergatoid females was ca. 15%. In earlier studies the proportion of ergatoid queens of *T. vitiensis* has varied

**Table 1.** Number of individuals in castes found in *Technomyrmex vitiensis*, documented by samples. Nest1-Nest2 were collected in March 2017, Nest3-Nest4 in November 2017, Foragers1 in November 2017, and Foragers2-Foragers3 in March 2018. Ergatoid queen percentages (%) were calculated from combined worker and ergatoid queen samples. Weighted means ( $\bar{x}$ ) are given for the percentages of ergatoid queens in nest vs forager samples (on row "Total")

| Sample    | Worker | Ergatoid queen | Alate queen | Dealate queen | Ergatoid male | Male | Total | Ergatoid queen<br>% (nests) | Ergatoid queen<br>% (foragers) |
|-----------|--------|----------------|-------------|---------------|---------------|------|-------|-----------------------------|--------------------------------|
| Nest1     | 842    | 161            | 0           | 2             | 0             | 0    | 1005  | 16.0                        | —                              |
| Nest2     | 1341   | 231            | 0           | 6             | 0             | 0    | 1578  | 14.7                        | —                              |
| Nest3     | 64     | 16             | 0           | 0             | 0             | 10   | 90    | 20.0                        | —                              |
| Nest4     | 20     | 4              | 0           | 0             | 0             | 3    | 27    | 16.7                        | —                              |
| Foragers1 | 24     | 0              | 0           | 0             | 0             | 0    | 24    | —                           | 0.0                            |
| Foragers2 | 102    | 2              | 0           | 0             | 0             | 0    | 104   | —                           | 1.9                            |
| Foragers3 | 96     | 3              | 1           | 0             | 0             | 0    | 100   | —                           | 3.0                            |
| Total     | 2489   | 417            | 1           | 8             | 0             | 13   | 2928  | $\bar{x} = 15.4$            | $\bar{x} = 2.2$                |

between 3.6% and 32% (Oettler & Heinze 2009, Pech & Bezděk 2016), and in the nests of *T. brunneus* colonies it has been on average 40% (Tsuji et al. 1991). A substantial proportion of ergatoid females is essential for the growth and spread of *Technomyrmex* colonies. Although normal nuptial flight of alate males and females, and subsequent dispersal of inseminated gynes are needed for independent founding of new colonies, ergatoid females take over reproduction after the original queen dies (Warner 2003). As colonies with ergatoid queens multiply by budding, establishment of new nests by groups of workers and ergatoid reproductives allows *T. vitiensis* to quickly spread locally over suitable habitats (Oettler & Heinze 2009). Seasonally such colonies also produce normal alate queens and males (Warner 2003).

The lack or rarity of ergatoid males in the colony studied by Oettler & Heinze (2009) might explain the low proportion of ergatoid females there that were inseminated. Our suggestion is stimulated by Ogata et al. (1996), who found that—in *T. brunneus*—the mismatch between the size of genitalia of males and females across the castes allows mating of ergatoid females only with ergatoid males. A similar size difference occurs in *T. vitiensis*, in which the genitalia of wingless males are smaller than those of winged males (Pech & Bezděk 2016). This raises an additional question: could the occurrence and frequency of ergatoid males correlate with the quality of the environment for the species? Furthermore, if ergatoid females are not inseminated, their reproductive function will be hampered—at the most males would be produced, which would affect the colony dynamics. In spite of their epithet, ergatoids (worker-like), they are not supposed to work—indeed, ergatoid queens have not been reported from outside nests, which is in accordance with observations on the behaviour of *T. difficilis* and *T. brunneus* (Warner 2003). Against this background, our findings of ergatoid queens among foragers, on food outside nests, are new, although the function of such foraging by ergatoids is not known.

The rapid spread of *T. vitiensis* to and in heated greenhouses in many European countries, and the many peculiarities of social organisation and reproduction of the species, seem to include interesting questions. Comparison of colonies over their known existence in Europe could answer part of the questions: How much do the colonies differ for the seasonal distribution of the castes? Or the production of alate males and females? What is the role of unmated ergatoid females versus mated ones, in the production of various castes? Could the frequency of ergatoid males in the colony be used as a measure of quality of the colony's environment? Could *Technomyrmex* through competition with some other invasive ants help to control them? Indeed, in the Helsinki Zoo the numbers of *Monomorium pharaonis* may have declined after the invasion of *T. vitiensis*, although the relations between the two species there have not been studied (V. Vepsäläinen, pers. observation). And of course, the permanent question actual with all pest species: can an effective but environmentally friendly means be found to eradicate colonies of *T. vitiensis* from where they are not welcome?

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