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First record of *Pheidole indica* Mayr, 1879 (Hymenoptera, Formicidae) in Algeria (North Africa) and its relationships with local Hemipterans

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Abstract

First record of Pheidole indica *Mayr, 1879 (Hymenoptera, Formicidae) in Algeria (North Africa) and its relationships with local Hemipterans.* Algeria has a rich ant fauna with more than 340 known species, but the full extent of this diversity is little known. In this study, *Pheidole indica* Mayr, 1879 is recorded for the first time from Algeria. It is considered non-native for the country, taking the number of exotic ants in Algeria to 12. Data concerning its ecology is briefly extended through its relationship with local Hemipterans species and host plants. Three Hemipteran species were found as food sources for *P. indica*: *Icerya purchasi* (Maskell, 1878), *Saissetia oleae* (Olivier, 1791), *Aspidiotus hederae* (Bouché) Vallot, 1829.

Key words: Tramp ants, Algeria, *Pheidole indica*, Cohabitation ant–Hemipterans

Resumen

Primer registro de Pheidole indica *Mayr, 1879 (Hymenoptera, Formicidae) en Argelia (norte de África) y sus relaciones con los hemípteros locales.* Argelia posee una rica fauna de hormigas, con más de 340 especies conocidas, aunque la misma está todavía insuficientemente estudiada. En este trabajo se registra por primera vez *Pheidole indica* Mayr, 1879 en Argelia, que se considera una especie no nativa del país. Este registro eleva a 12 el número de hormigas exóticas. Sus datos ecológicos se amplían brevemente a través de su relación con las especies locales de hemípteros y la planta huésped. Se han encontrado tres especies de hemípteros como fuentes de alimento para *P. indica*: *Icerya purchasi* (Maskell, 1878), *Saissetia oleae* (Olivier, 1791) y *Aspidiotus hederae* (Bouché) Vallot, 1829.

Palabras clave: Hormigas vagabundas, Argelia, *Pheidole indica*, Cohabitación hormiga–hemípteros

Resum

Primer registre de Pheidole indica *Mayr, 1879 (Hymenoptera, Formicidae) a Algèria (nord d'Àfrica) i les seves relacions amb els hemípters locals.* Algèria té una rica fauna de formigues, amb més de 340 espècies conegudes, tot i que encara està insuficientement estudiada. En aquest treball es registra per primera vegada *Pheidole indica* Mayr, 1879 a Algèria, que es considera una espècie no nativa del país. Aquest registre eleva a 12 el nombre de formigues exòtiques. Les seves dades ecològiques s'amplien breument a través de la relació amb les espècies locals d'hemípters i la planta hoste. S'han trobat tres espècies d'hemípters com a fonts d'aliment per a *P. indica*: *Icerya purchasi* (Maskell, 1878), *Saissetia oleae* (Olivier, 1791) i *Aspidiotus hederae* (Bouché) Vallot, 1829.

Paraules clau: Formigues vagabundes, Algèria, *Pheidole indica*, Cohabitació formiga–hemípters

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Introduction

The term exotic does not directly imply invasiveness. It is undeniable that invasive species belong to a subset of exotic species (Williamson and Fitter, 1996). However, some researchers believe that native species of a region can also qualify as invasive when they colonize and dominate an adjacent or nearby habitat following diffusion dispersal (Thompson et al., 1995; Davis et al., 2000).

Three phases are necessary for a successful biological invasion: introduction, establishment, and expansion or spread (Sakai et al., 2001). Detailed knowledge of the presence or arrival of an exotic species in different countries is useful for precautionary management of possible invasion. Prediction of invasiveness uses convergent morphological and life history characteristics to identify potential invaders (Forcella et al., 1986; Mack, 1996; Reichard and Hamilton, 1997). Detection of a transferred species may only occur after it becomes locally abundant. Translocations may pass unnoticed, particularly when a reproducing population is not established. Furthermore, they may disappear from such areas if followed by another competitor. For example, *Linepithema humile* (Mayr) and *Pheidole megacephala* (Fabricius) periodically displace one another in Bermuda (Haskins and Haskins, 1965; Lieberburg et al., 1975). Also, the species composition of transferred ‘tramp' (human commensal) ants on islands in Polynesia changes over time, with some tramp species disappearing from specific islands (Wilson and Taylor, 1967).

Invasions have complex and often immense, long-term, direct and indirect impacts. In many cases, such impacts become apparent or problematic only when invaders are well established and have large ranges (Pyšek et al., 2020). According to Lach et al. (2010), ants are among the most devastating invasive species because of their enormous impact on biodiversity. They reduce the diversity of native ants, displace many invertebrate 'arthropods' and negatively affect many vertebrate populations (Lach et al., 2010). This impacts on ecosystem functions such as seed dispersal (Lach, 2003) and soil chemistry (Lach and Hooper–Bùi, 2010; Stanley and Ward, 2012) and also affects flowering plants by displacing

pollinators (Lach, 2007). In addition, invasive ants may damage electrical equipment, invade homes, transmit diseases, and constitute a major problem in agricultural areas (Pimentel et al., 2005; Moreira et al., 2005; Wielgoss et al., 2014). Plants with extra-floral nectar, however, generally benefit from the association with invasive ants because these ants are abundant and aggressive, making them better plant guards than native ant species (Lach et al., 2010). Plants hosting aphids also profit in some cases from the presence of invasive ants. One study found that Argentine ants reduced damage to plants by means of skeletonising insects by 50 % (Nygard et al., 2008).

Due to their small size and nesting habits ants are easily transported by humans (Bertelsmeier et al., 2018; Fournier et al., 2019). More than 200 species are known to have established populations outside their native area (Bertelsmeier et al., 2018) and more than 600 species have been introduced outside their native area (Miravete et al., 2013). Exotic ants are often intercepted at ports of entry, frequently detected on plants (Suarez et al., 2005). Currently, the invasive specialist group of the International Union for Conservation of Nature (IUCN) lists 19 ant species as highly problematic, and five species are even on the list of 'The 100 worst invasive species': the Argentine ant (*Linepithema humile* Mayr, 1868), the yellow crazy ant (*Anoplolepis gracilipes* Smith, 1857), the electric ant (*Wasmannia auropunctata* Roger, 1863), the imported fire ant (*Solenopsis invicta* Buren, 1972), and the big-headed ant (*Pheidole megacephala* Fabricius, 1793) (Holway et al., 2002).

Ants can be found everywhere in Algeria, in forests and in open areas, close to water courses and in dry areas, on clay and on rocks (Cagniant, 1973). Unfortunately, knowledge of ants in Algeria remains poor. This is relatively unsurprising given the remarkable diversity of the eco-systematic, where marine, coastal, forest, mountain, steppe, desert, humid, arid environments and Mediterranean vegetation can all be found (Abdelguerfi et al., 2009). All these factors contribute to the high diversity of insect fauna, and the high degree of endemisms and exotic species. In this setting, the myrmecofauna is no exception (Cagniant, 2006).

The checklist generated in Antmap.org (2021) lists 340 ant species native to Algeria. Moreover, there are 11 exotic species considered non-native to Algeria, according to the literature: (1) *Trichomyrmex destructor* (Jerdon, 1851), mentioned by André (1883) as *Monomorium gracillimum* (Mayr, 1868) without locality name, and by Bernard (1968) as *M. gracillimum* from Tassili n'Ajjer; (2) *Monomorium pharaonis* (Linnaeus, 1758), recorded in Oran by Bernard (1968); (3) *Linepithema humile* (Mayr, 1868) by Frisque (1935), Barech et al. (2015), Slimani et al. (2020); (4) *Paratrechina longicornis* (Latreille, 1802) by Cagniant (1970) and Slimani et al. (2020); (5) *Pheidole megacephala* (Fabricius, 1793) by Chopard (1919); (6) *Tetramorium bicarinatum* (Nylander, 1846), noted by Bernard (1960) in the Gardens at Djanet; (7) *Tetramorium simillimum* (Fr. Smith, 1851), in oases at Djanet (Bernard, 1968); (8) *Tetramorium lanuginosum* (Mayr, 1870) reported by Barech et al. (2011) in an irrigated garden at Higher National Agronomic School Algiers; (9) *Lioponera longitarsus* (Mayr, 1879) by Barech et al. (2017) in an olive grove at Nouara, M'sila; (10) *Strumigenys membranifera* (Emery, 1869) recorded in Aïn Moussa, Ouargla (wild ecosystem) for the first time in Algeria by Chemala et al. (2017) and Oussalah et al. (2019) in the citrus orchard at ITMAS (Institute of Technology on Specialized Agriculture) Heuraoua Rouïba; and (11) *Nylanderia jaegerskioeldi* (Mayr, 1904) noted by Oussalah et al. (2019) in the citrus orchard at ITMAS Heuraoua Rouïba. Furthermore, Salata et al. (2021) have suggested that *Aphaenogaster splendida* might be an exotic species in the Western Mediterranean region.

These publications have provided information and knowledge about invasive species in Algeria but a more thorough investigation and more details are needed. In the present study, we provide the first records of *Pheidole indica* Mayr, 1879 for Algeria, collected in an urban ecosystem, and we include some ecological data about host plants and Hemipteran species associated with this species.

Pheidole Westwood, 1839 is one of the largest ant genera worldwide with approximately 980 described species and 142 subspecies (Longino, 2009; Bolton, 2012). The large number

of species is to be expected as *Pheidole* is the dominant taxon of the New World ground ant assemblages (Fowler, 1994). However, some species are also arboreal and others have symbiotic relationships with myrmecophytes. Indeed, *Pheidole* is now the most species-diverse group of New World organisms after beetles.

Wilson (2003) proposed 19 species groups within the New World *Pheidole* based on overall similarity. Of these species groups, 17 are of New World origin and two are of Old World origin. The two Old World groups are each represented in the New World by a single introduced species (*P. megacephala* and *P. indica*).

Fischer and Fisher (2013) reported that *Pheidole indica* (= *P. teneriffana*) is an invasive species with collection records scattered over several continents and islands across the globe. The spread of this species, like other introduced species, is often associated with the commercial trade of plants (Sarnat et al., 2015). *Pheidole indica* is placed in the category D2 of the classification of Blackbourne et al. (2011). This category includes species that are able to adapt to local environments after introduction in a new place. The success of the adaptation of *P. indica* mostly depends on its polygyny (true or facultative) and polydomy (Sarnat et al., 2015). It seems to be common in dry habitats (Wetterer, 2011), especially along coasts and in urban areas (Collingwood et al., 1997; Gómez and Espadaler, 2006). Furthermore, it has been described as aggressive toward other ant species, locally abundant, and spreading in urban areas (Collingwood, 1985; Gómez and Espadaler, 2006).

Material and methods

Two worker specimens (soldiers) of *Pheidole* sp. were collected from a building in a suburb of Algiers, from a private indoor pot plant *Chlorophytum* in November 2019. After an extensive search in the surroundings of the building, an outdoor population was found in October 2021. The nearby streets within a range of 50 m^2, centred round the previously mentioned building, were surveyed and a general appraisal was undertaken by identifying trees on which ant workers were present. We examined 25 sidewalk trees of three varieties, *Morus alba* L., *Ficus retusa* L., and *Cupressus sempervirens* L.) and found all were visited by *P. indica*. We counted the ants crossing a virtual horizontal line at breast height for ten minutes each afternoon at 1:00 p.m., once a week, right throughout the month of October 2021.

We also checked the identity of the host tree and the presence of possible food sources, in particular, the sugar liquids of the Hemipterans, which are very attractive for ants.

Sampling of Hemipterans was also carried out once a week during the same month. Three replicate trees were sampled for each of the three tree species. From each tree we took: two twigs of 10 to 20 cm long, and two leaves, those that were most infested by mealybugs.

Mealybugs were counted in the laboratory under a binocular magnifying glass. We counted the total number of individuals of each species of Hemipterans and also the ants that may be associated with these insects. Ants were identified using Sarnat et al. (2015) and available keys (Cagniant, 1966). However, identification of Hempiterans was based on the aspect of the shield (shape, diameter) and its coloration (Benassy, 1961). A guide of crop protection (Paternelle et al., 2000) was used for confirmation. Digital images were prepared using Keyance digital with 4x microscope objective and were taken by Julien Lalanne/(RBINS). Voucher specimens are deposited in the Royal Belgium Institute of Natural Sciences and at the Higher National Agronomic School Algiers.

Anova–one way analysis was performed to assess any differences between the presence of insects in the species trees. Statistical differences were considered as significant when p–value was below 0.05 (confidence interval of 95 %). Pearson coefficient was performed to calculate the correlation between the ant and the Hemipteran insects. All statistical analyses were conducted in IBM® SPSS® STATISTICS, 20.

Fig. 1. Image of study area (Algiers, Algeria) *Morus alba* where *Pheidole indica* was detected.

Fig. 1. Imagen del área de estudio (Argel, Argelia). Morus alba*, donde se localizó* Pheidole indica*.*

Results

The study revealed the presence of *Pheidole indica* (fig. 1, 2) in Djebel Bouzegza Street, an urban area in Belfort in El-Harrach, approximately 14 km East of Algiers, and 2.5 km from the coast. The area is situated in the center of the Mitidja plain in north Algeria.

This presence of this exotic species on the three trees was highly significant in *M. alba* (mean = 94.67 ± 5.158, p = 0.00), followed respectively by *F. retusa* and *C. sempervirens* (mean = 25.25 ± 3.646, p = 0.00; 4.17 ± 3.186, p = 0.00).

Three Hemipterans were exclusively observed on mulberry tree (table 1): *Icerya purchasi* (Maskell, 1878), *Saissetia oleae* (Olivier, 1791), *Aspidiotus hederae* (Bouché) Vallot, 1829. The mealybug *I. purchasi* was mainly present in *M. alba,* with the average approximate value of 6 (5.8 ± 1.682). The Coccidae *S. oleae* was only relatively frequent (3.2 ± 1.305) and Diaspididae *A. hederae* was poorly represented (1.33 ± 1.118). These figures do not reflect a strong infestation by Diaspididae and Coccidae (fig. 3).

It is worth pointing out that the presence of this exotic ant species associated with the Hemipterans complexes and host plant shows strong variation. *P. indica* is very important (there might be more than 90 individuals per ten minutes) in association with *I. purchasi* in which the correlation was the highest (Pearson coefficient = 0.902, p = 0.00), followed by *S. oleae* (Pearson coefficient = 0.832, p = 0.00) and finally *A. hederae* (Pearson coefficient = 0.860, p = 0.00).

In one tree an *M. alba* worker of *Plagiolepis schmitzii* (Forel, 1895) was also foraging but in low numbers.

Fig. 2. Soldier worker of *Pheidole indica.*

Fig. 2. Pheidole indica *obrera soldado.*

Discussion

Sarnat et al. (2015) considered *P. indica* as native to the Indomalayan bioregion and belong to the *fervens* clade. In most publications from the References section, this species is mentioned with its junior synonym *Pheidole teneriffana* Forel, 1893.

P. indica is an introduced species, reported from several areas across the world: Africa, Arabic Peninsula, Australia, California, Caribbean islands, China, India Bangladesh, Japan, Korea, Mediterranean region, Malagasy region, Pakistan, Peru, Sri Lanka, West Indian Ocean islands (Wetterer, 2011; Fisher and Fisher, 2013; Sarnat et al., 2015). Described from the Canary Islands and found widely distributed throughout the greater Mediterranean region, its native range (Wilson, 2003; Wetterer, 2011). Recently, Scupola (2021) recorded *P. indica* for the first time in the Middle East, in Jordan. Compared with other countries of the Maghreb (Oussalah et al., 2019), the first records of *P. indica* in the Maghreb were in Tunisia by Santschi (1908) and in Morocco by Delabie (2007). In the present study this exotic species is recorded for the first time in Algeria. These data show *P. indica* was present in the Maghreb the last century but observed in Algeria only recently, in 2019. Ants are often inconspicuous immigrants, and may remain unnoticed for many years after their arrival in a new area. In addition to Morocco and Tunisia, it also occurs in Iberia (Acosta and Martinez, 1983), Greece (Legakis, 2011) and Sicily (Schifani and Alicata, 2018), and smaller islands such as the Canary Islands (Forel, 1893), Pantelleria (Mei, 1995) and the Maltese Islands (Baroni Urbani, 1968).

P. indica has been found in sunny environments rather than from shadyplaces, as was reported by Sarnat et al. (2015). They pointed out that *P. indica* usually nests in sunny and arid places, under stones or pavement tiles, and it is abundant in places rich in food remains and animal corpses. Very often, main nest chambers contain deed workers of the genera *Camponotus* and *Messor*. It is a species that is closely related with anthropogenic habitats. Colonies are facultatively polygynous (Sarnat et al., 2015).

The abundance of *P. indica* in association with various mealybugs in *M. alba* tree seems to be of interest with these Hemipterans. The diet and biology of the genus *Pheidole* could explain these associations. For example, a similar case was observed by Campbell (1994) on host plant Cocoa in Ghana in which *Pheidole megacephala* attended mealybugs, mainly *Planococcoides njalensis* (Laing), and *Planococcus citri* (Risso) (both Pseudococcidae). Concerning others ants, Powell and Silverman (2010) also noted in their study on host

Table 1. Tree hosts and the average of Hemipterans tended by *Pheidole indica* in Algiers from mid October to 1st November 2021.

Tabla 1. Árboles huésped y media de hemípteros relacionados con Pheidole indica *en Argel desde mediados de octubre hasta el 1 de noviembre de 2021.*

	Mean ± SD		
Insect species / trees species	*Morus alba* L.	*Ficus retusa* L.	*Cupressus sempervirens* L.
Icerya purchasi (Maskell) / per leaf	5.8 ± 1.682	0	0
Saissetia oleae (Olivier) / per twig	3.2 ± .305	0	0
Aspidiotus hederae (Bouché) / per twig	1.33 ± 1.118	0	0
Pheidole indica / per ten minutes	94.67 ± 5.158	25.25 ± 3.646	4.17 ± 3.186

plant cotton in North America that invasive ant species, such as the Argentine ant, *L. humile,* established mutualisms with the aphid species *Aphis gossypii* (Glover) and are generally regarded as more aggressive than native ants *Tapinoma sessile* (Say, 1836). Consequently, they may be more effective at protecting honeydew–producing hemipterans from natural enemy attack. Furthermore, both native and invasive ants are capable of form-

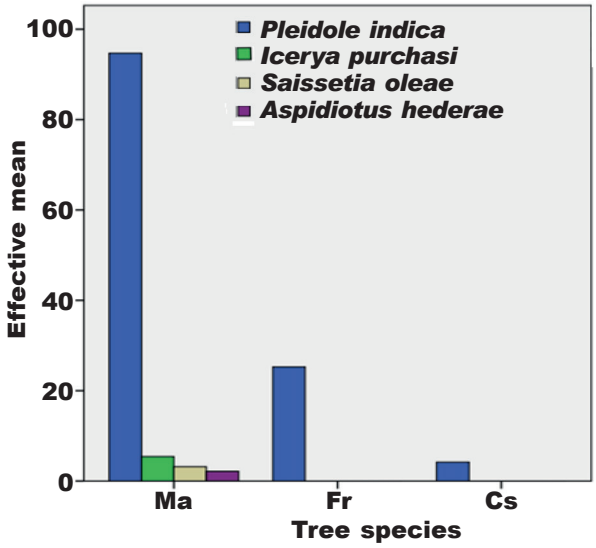

Fig. 3. Fluctuation of the population of Hemipterans species and the ant *P. indica* in three trees species (Ma, *Morus alba*; Fr, *Ficus retusa*; Cs, *Cupressus sempervirens*).

Fig. 3. Fluctuación de la población de especies de hemípteros y de la hormiga P. indica *en tres especies de árboles (Ma,* Morus alba*; Fr,* Ficus retusa*; Cs,* Cupressus sempervirens).

ing mutualisms with hemipteran insects. The ecological dominance of invasive ants is often facilitated by hemipteran insects. This association requires invasive ant control strategies to expand beyond ants to consider mutualists (Wang et al., 2021).

Here, we showed that *P. indica*, in much lower number, were foraging on *F. retusa* and *C. sempervirens*. Other plants were present in the street though at the precise date of this survey, they were not recorded as visited by the ants: *Schefflera arboricola* (Hayata) Merr., *Yucca elephantipes* Baker in Regel, *Populus nigra* L. and *Phoenix canariensis* Hort. Ex Chabaud. Since many aphids and scales have been mentioned on all of them (Blackman and Eastop, 1994, 2006; Howard et al., 2001), it remains to be explored whether other plant species from the streets may be visited by *P. indica* in spring or summer. The presence of the species *P. indica* seems to be limited to urban habitats throughout the region, but it does not currently appear to be of concern. Nevertheless, the impact of exotic ants may only be observable after a certain period of time. It is important to emphasise that the ecology and the impacts of this species are poorly studied and require further research.

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