Ant species (Hymenoptera, Formicidae) associated to eucalyptus plantations in Portugal

[Formigas (Hymenoptera, Formicidae) associadas ao eucaliptal, em Portugal]

[Hormigas (Hymenoptera, Formicidae) asociadas al eucaliptal en Portugal]

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Abstract
The presence of ants in forest ecosystems is influenced by the available food resources and the interactions that they establish with other arthropods (e.g., predation, mutualism). The economic importance of eucalypts in Portugal and the exponential introduction of exotic insect pests, namely honeydew-producing hemipteran species, justify the need to clarify the role of ants in this ecosystem. In this paper, we present the results of a meta-analysis based on surveys carried out between 1990 and 2015 in 68 *Eucalyptus* plantations, distributed among the districts of Aveiro, Lisbon, Portalegre, Évora, Beja and Faro. Samples were collected based on visual observation and pitfall traps. In total, 541 specimens were identified, including 25 species, raising to 44 the number of ant species found in *Eucalyptus* spp. in Portugal, which corresponds to ca. 30% of total number of ant species reported for Portugal.

Keywords: Ants, *Eucalyptus*, interactions, survey, honeydew

Resumo
A presença das formigas nos ecossistemas florestais é influenciada pelos recursos alimentares disponíveis e pelas interações que estas estabelecem com outros artrópodes (e.g., predação, mutualismo). A importância económica do eucalipto em Portugal e o crescimento exponencial do número de espécies exóticas de insetos, em particular hemípteros excretores de melada, justificam a necessidade de se esclarecer o papel das formigas neste ecossistema. Neste trabalho, apresentam-se os resultados de uma meta-análise feita com base em prospeções realizadas, entre 1990 e 2015, em 68 parcelas de *Eucalyptus*, distribuídas pelos distritos de Aveiro, Lisboa, Portalegre, Évora, Beja e Faro. As amostragens foram feitas através de observação visual e armadilhas *pitfall*. No total, foram identificados 541 exemplares, compreendendo 25 espécies, elevando para 44 o número de espécies de formigas referenciadas em eucaliptais, no país, o que corresponde a cerca de 30% do número total de espécies assinaladas para Portugal.

Palavras-chave: *Eucalyptus,* formigas, interações, inventário, melada

Resumen
La presencia de hormigas en ecosistemas forestales está influenciada por la disponibilidad de recursos tróficos y por las interacciones que éstas establecen con los demás artrópodos (p.ej. depredación, mutualismo). La importancia económica de los eucaliptos en Portugal, así como la introducción exponencial de plagas de insectos exóticos, particularmente de especies de hemípteros productores de melaza, justifican la necesidad de esclarecer el rol de las hormigas en este ecosistema. En este trabajo presentamos los resultados de un meta-análisis basado en muestreos llevados a cabo entre el 1990 y el 2015 en 68 plantaciones de *Eucalyptus* distribuidas entre los distritos de Aveiro, Lisboa, Portalegre, Évora, Beja y Faro. Los muestreos se llevaron a cabo mediante observación visual y trampas de caída. En total, se identificaron 541 especímenes, incluidas 25 especies, elevando a 44

el número de especies de hormigas encontradas en *Eucalyptus* spp. en Portugal, lo que corresponde a cerca del 30% del número total de especies de hormigas registradas en Portugal.

Palabras clave: *Eucalyptus*, hormigas, interacciones, melaza, muestreo

Introduction

Eucalyptus species are the most planted trees worldwide, particularly known for its great use for paper production (Paine *et al.*, 2011). *Eucalyptus* plantations showed an average annual rate of increase of 3.1 million ha, between 2010 and 2015. In fact, the production/ consumption of wood/paper, in general, also increased throughout this period and demand for more wood products is expected to continue growing (FAO, 2015). The Mediterranean basin holds much of the commercial cellulose fiber production. In Portugal, *Eucalyptus* plantations represents 26% of the national forestry, corresponding to 812 000 ha (ICNF, 2013).

As *Eucalyptus* spread around the world, a number of insect species from its native range also began to appear, colonizing new environments (Paine *et al.,* 2011). For nearly a century, no phytosanitary problems occurred in these plantations, in Portugal. The first concern arose in 1971, with the accidentally introduction of *Ctenarytaina eucalypti* (Maskell), a psyllid (Hemiptera, Psyllidae) that assumed pest status in *Eucalyptus globulus* Labill nurseries (Azevedo & Figo 1979). The eucalyptus longhorned borer, *Phoracantha semipunctata* (Fabricius), assumed great economic importance in the 1980s and 1990s. Later, the eucalyptus weevil *Gonipterus platensis* Marelli, a defoliating insect, caused major losses on wood production, assuming a key pest status in many *Eucalyptus* plantations worldwide (Reis *et al.,* 2012). The increasing rates of introduction and establishment of non-native insects, in *Eucalyptus* plantations, have become an important management issue, particularly in the last decade, corresponding to 11 invasive insect species.

Ants are bio-indicators of habitat disturbance and transformation, agents of biological pest control, seed dispersal, soil modification and stakeholders in mutualistic interactions with honeydew-producing hemipteran insects, such as psyllids. Interactions between psyllids and ants are known to occur in *Eucalyptus* habitats (Jones & Paine, 2012, Barton *et al.,* 2013). Four species of invasive psyllids have been recorded in Portugal, as pests of eucalypts, which may facilitate or enhance the abundance of invasive ant species in these ecosystems (Jones & Paine, 2012): *C. eucalypti* (Azevedo & Figo 1979), *Ctenarytaina spatulata* Taylor (Valente et al. 2004), *Glycaspis brimblecombei* Moore (Valente & Hodkinson 2009) and *Blastopsylla occidentalis* Taylor (Pérez-Otero et al. 2011).

About 20 years ago, Cammell *et al.,* (1996) studied the diversity of ant communities in eucalyptus plantations of central Portugal, recording 35 ant species. Knowledge on species composition of ant communities is of critical importance for pest management. For example, some ant species, as the Argentine ant, *Linepithema humile* Mayr, may exacerbate pest impacts and interfere in the success of the biological control of eucalyptus lerp psyllids, and on the other hand act as an egg predator of the eucalyptus long-horned borer (Way *et al.,* 1992, Jones & Paine, 2012). Yet, the role of ants in *Eucalyptus* ecosystems and their impacts on biological control remain unclear.

This work brings together the results of surveys carried out on *Eucalyptus* plantations in Portugal, in order to characterize species composition of ant communities in this forest ecosystem, expecting to contribute with new insights for pest management strategies.

Material and methods

Data source

Samples were collected from 68 sites on *Eucalyptus* plantations, distributed among seven districts, in Portugal, by Cammell *et al.,* (1996), Garcia et al. (unpublished data), Vasques & Valente (2008), and Zina & Franco (2015), (Fig. 1, Table 1). Ant specimens were kept in the laboratory of entomology (Faculty of Agronomy, University of Lisbon) and identified according to Collingwood & Prince (1998) and Gómez & Espadaler (2007).

Results

Identification of ant species

A total of 541 ants were identified, comprising 13 genera and 25 species (Fig. 2), raising to

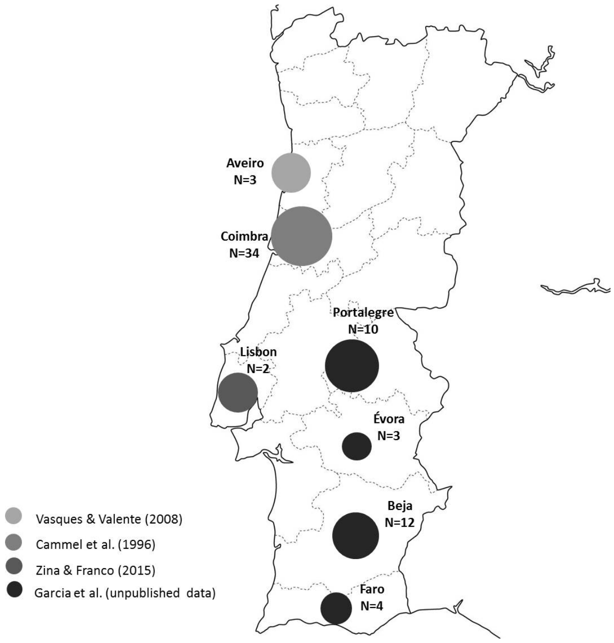

Fig. 1 Location of the study sites (N) where samples were collected in Eucalyptus *habitats at seven districts, in Portugal.*
Fig.1 Localización de las zonas de estudio (N) donde se recolectaron las muestras en hábitats de Eucalyptus *de siete distritos en Portugal.*

44 the ant species found on *Eucalyptus* spp., in Portugal (Table 2). The most frequent ant species were *Lasius grandis* Forel and *Formica fusca* Linnaeus occurring in 85% and 82% of the sampled sites, respectively (Fig. 2).

Discussion

Ant species richness

This work focused on the ant fauna associated to *Eucalyptus* spp., in Portugal. A total of 44 ant species are present in *Eucalyptus* ecosystems, which represents about 30% of the national referenced species. It is a high diverse ecosystem despite its relatively recent introduction, when compared to ant communities of other perennial forest and agricultural habitats, in Portugal, such as oaks (28 ant species), pines (25), citrus (26) and olive (34) (Cammell *et al.,* 1996, Zina, 2008, Gonçalves, 2013).

Ant composition patterns

The considered studies showed few similarities in ant assemblages. Four ant species were shared at least in three surveys, namely *Plagiolepis pygmaea* Latreille, *Plagiolepis schmitzii* Forel, *L. grandis* and *Camponotus piceus* (Leach); 14 species were found in two studies; and a much higher number of species (26) appeared in a single study (Fig. 3). These results suggest that species composition of ant communities associated with *Eucalyptus* in a certain region is much influenced by the pool of species present on that region. Nevertheless, the different sampling size of the studies may have also influenced the results.

Table 1 Summary of the studies conducted in Eucalyptus *habitats of Portugal, in recent years, gathered in this work.*
Tabla 1 Resumen de los estudios realizados en los últimos años en hábitats de Eucalyptus *de Portugal recopilados en este trabajo.*

	Cammell et al. (1996)	**Vasques & Valente (2008)**	**Zina & Franco (2015)**	**Garcia et al. (unpublished data)**
Aim	Diversity and structure of ant communities	*Ctenarytaina spatulata* and its potential predators	Diversity and structure of ant communities	Survey/ dispersion patterns of *Eucalyptus* pests
Date	May to August 1990-1993	March to July 2007	May 2015	July 2012/ May 2014
District	Coimbra	Aveiro	Lisbon	Évora, Portalegre, Beja and Faro
Sampling method	Baits/ Visual observation	Visual observation	Visual observation/ Pitfall traps	Visual observation
Sampling sites	34	3	2	29
Host	*Eucalyptus globulus* *Eucalyptus maidenii*	2-year *Eucalyptus globulus* plantations	*Eucalyptus* spp. arboreta	*Eucalyptus* spp. on road sides
No. ant specimens identified	-	408	68	65

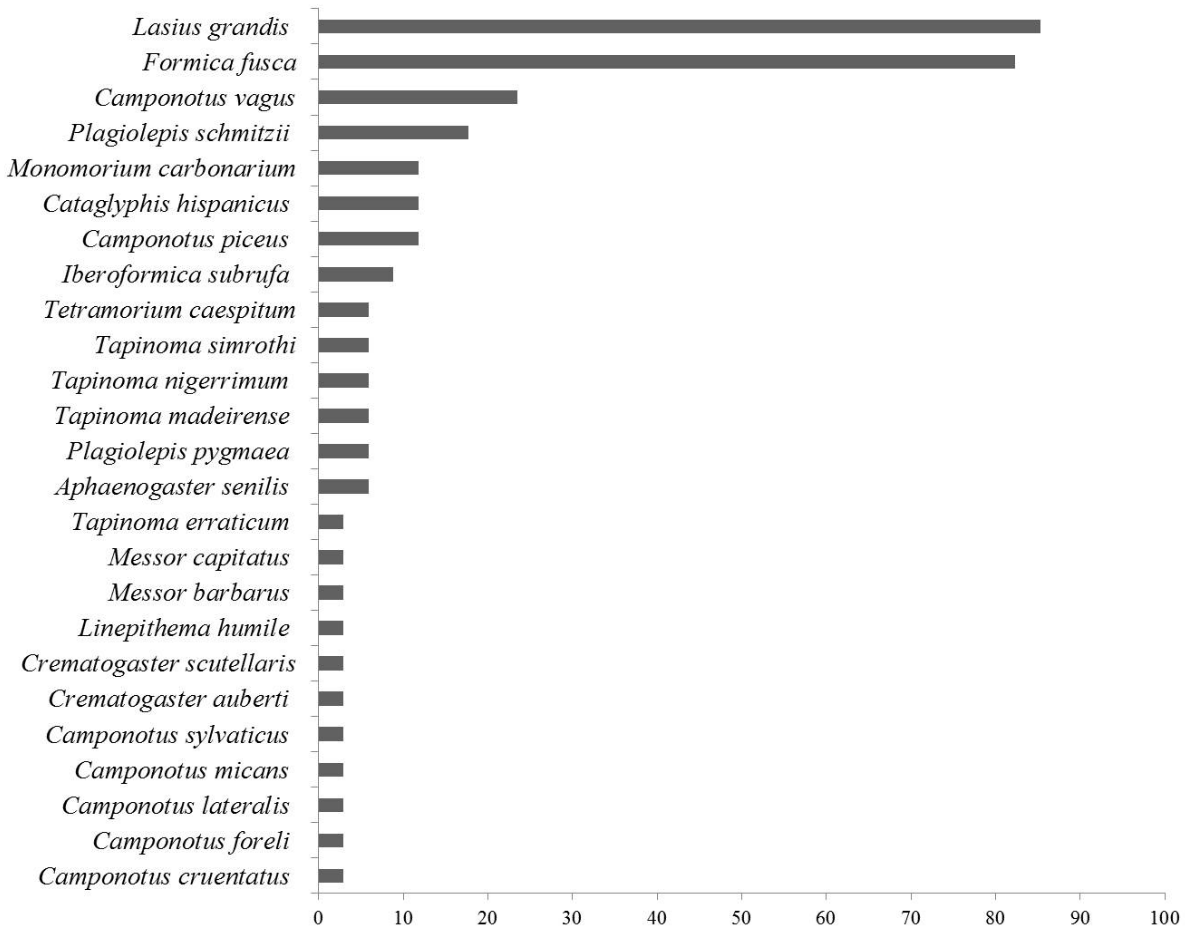

Fig. 2 Frequency distribution of the compiled ant species identified in this work, in function of the 34 sampled sites, carried out in Eucalyptus *spp., between 2007 and 2015, in Portugal.*
Fig. 2 Distribución de las frecuencias de las especies de hormigas recopiladas e identificadas en este trabajo en función de las 34 zonas de muestreo en Eucalyptus *spp. entre 2007 y 2015 en Portugal.*

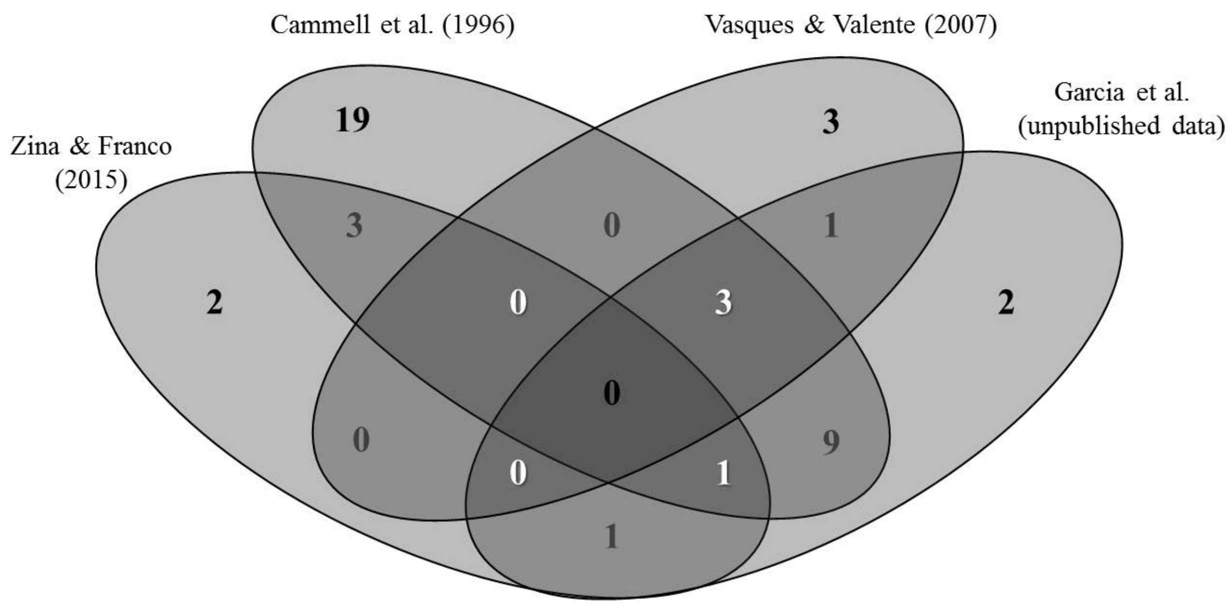

Fig. 3 Venn diagram representing ant species richness and shared species of four studies carried out in Eucalyptus *spp., in Portugal.*
Fig. 3 Diagrama de Venn representando la riqueza de especies de hormigas y las especies compartidas en 4 estudios llevados a cabo en Eucalyptus *spp. en Portugal.*

Table 2 List of the ant species recorded on Eucalyptus *spp., at seven municipalities of Portugal.*
Tabla 2 Listado de las especies de hormigas registrado en Eucalyptus *spp. en los siete municipios de Portugal.*

Municipality	**Aveiro**	**Coimbra**	**Lisbon**	**Évora**	**Beja**	**Portalegre**	**Faro**	
Ant species Reference:	Vasques & Valente (2008)	Cammell et al. (1996)	Zina & Franco (2015)	Garcia et al. (unpublished data)				**Total**
Aphaenogaster gibbosa		X						
Aphaenogaster iberica		X						
Aphaenogaster senilis		X	X					
Camponotus barbaricus		X						
Camponotus cruentatus		X				X		
Camponotus fallax		X						
Camponotus figaro		X						
Camponotus foreli		X			X			
Camponotus lateralis		X				X		
Camponotus micans					X			
Camponotus piceus	X	X			X	X		
Camponotus pilicornis		X						
Camponotus sylvaticus		X			X			
Camponotus vagus	X							
Cataglyphis viatica hispanica		X		X	X		X	
Crematogaster auberti		X			X			
Crematogaster scutellaris		X	X					
Crematogaster sordidula		X						
Formica cunicularia		X						
Formica fusca	X							
Formica gerardi		X						
Formica rufibarbis		X						
Iberoformica subrufa		X			X		X	
Lasius grandis	X	X		X		X		
Linepithema humile		X				X		
Messor barbarus			X					
Messor bouvieri		X						
Messor capitatus			X					
Monomorium carbonarium	X							
Pheidole pallidula		X						
Plagiolepis pygmaea	X	X				X		
Plagiolepis schmitzii		X	X		X	X	X	
Solenopsis lusitanica		X						
Tapinoma erraticum						X		
Tapinoma madeirense	X					X		
Tapinoma nigerrimum			X				X	
Tapinoma simrothi		X			X	X		
Temnothorax corticalis		X						
Temnothorax racovitzai		X						
Temnothorax recedens		X						
Temnothorax unifasciatus		X						
Tetramorium caespitum		X	X					
Tetramorium forte		X						
Tetramorium semilaeve		X						
Species richness	**7**	**35**	**7**	**17**				**44**

Two alien ant species were identified among the community of ants occurring in *Eucalyptus*: *Monomorium carbonarium* (Smith), native from Azores and Madeira, and the Argentine ant, *L. humile* (Wetterer et al. 2004, Wetterer et al. 2007). These species, established in many Mediterranean areas were not detected as often as expected. On the other hand, *M. carbonarium* was the fifth most frequent species, occurring in Aveiro *Eucalyptus* plantations.

The native dominant ant species *L. grandis* appears well adapted to *Eucalyptus* plantations, contrarily to the other native dominants, such as *Pheidole pallidula* (Nylander) and *Crematogaster scutellaris* (Olivier) which were absent or occurred rarely on this ecosystem, respectively. *Formica fusca* was the second most frequent species, due to its abundance in the samples collected in Aveiro, as this species was absent in other sites.

Further investigation is required to understand ant interactions with *Eucalyptus* pests, and native ant species, in particular honeydew-producing hemipteran species.

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Ecological diversity of ants (Hymenoptera, Formicidae) in *Tapada da Ajuda*, Portugal

[Ecologia e diversidade de formigas (Hymenoptera, Formicidae) na Tapada da Ajuda, Portugal]

[Ecología y diversidad de hormigas (Hymenoptera, Formicidae) en *Tapada da Ajuda*, Portugal]

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Abstract

Tapada da Ajuda is a 100 ha campus of the Faculty of Agronomy, University of Lisbon, situated near Monsanto area, in Lisbon. It is composed of both agricultural and forest landscape, as well as a few urbanized areas. It includes also the Natural Botanical Reserve D. António Xavier Pereira Coutinho, the oldest in Portugal. In this paper we evaluated the disturbance level of habitats exposed to different anthropogenic pressure, using ants as bio-indicators of ecosystem health, in *Tapada da Ajuda*. A first inventory of the ant species of *Tapada da Ajuda* is presented. Each species was classified according the functional groups used for Iberian Peninsula. Sampling was carried out in May 2015, by visual search and hand collecting at 20 sites and by installing pitfall traps in eight different habitats. In total, 25 ant species were identified. Species indicators of disturbance (generalists, opportunists and invasive) were present in more than 90% of sampling sites.

Keywords: Bio-indicators, disturbance, functional groups, habitat, pitfall

Resumo

A Tapada da Ajuda, com cerca de 100 ha, é um espaço florestal e agrícola, que integra a Reserva Botânica Natural D. António Xavier Pereira Coutinho, a mais antiga de Portugal, e inclui o *campus* do Instituto Superior de Agronomia, Universidade de Lisboa, no qual existem algumas áreas urbanizadas. Neste trabalho é avaliado o grau de perturbação de habitats submetidos a maior ou menor pressão antropogénica, utilizando as formigas como bioindicadores de qualidade ambiental, na Tapada da Ajuda. Apresenta-se, pela primeira vez, um inventário das espécies de formigas presentes na Tapada da Ajuda. Cada espécie foi classificada de acordo com os grupos funcionais usados para a Península Ibérica. As amostragens foram realizadas em Maio de 2015, através de recolha directa por observação visual em 20 locais e através da instalação de armadilhas *pitfall* em oito habitats diferentes.

No total, foram identificadas 25 espécies de formigas. As espécies indicadoras de perturbação (generalistas, oportunistas e invasoras) estiveram presentes em mais de 90% dos pontos de amostragem.

Palavras-chave: Bioindicadores, grupos funcionais, habitat, perturbação, *pitfall*

Resumen

Tapada da Ajuda es un espacio forestal y agrícola de 100 ha de extensión que integra la Reserva Botánica Natural D. António Xavier Pereira Coutinho, la más antigua de Portugal, e incluye el campus del Instituto Superior de Agronomía de la Universidad de Lisboa, en el cual existen algunas áreas urbanizadas. En este trabajo hemos evaluado el grado de perturbación de hábitats sometidos a distintas presiones antropogénicas en *Tapada da Ajuda* utilizando las hormigas como bioindicadoras de la calidad ambiental. Se presenta un primer inventario de las especies de hormigas en *Tapada da Ajuda*. Cada especie se ha clasificado de acuerdo a los grupos funcionales usados para la península ibérica. El muestreo se llevó a cabo en Mayo de 2015, mediante observación visual y recolección manual en 20 localidades y mediante la instalación de trampas de caída *pitfall* en 8 hábitats distintos. En total, se identificaron 25 especies de hormigas. Las especies indicadoras de perturbación (generalistas, oportunistas e invasoras) se hallaron presenten en más del 90% de localidades muestreadas.

Palabras clave: Bioindicadores, grupos funcionales, hábitat, perturbación, *pitfall*

Introduction

Ants are particularly important in the functioning of ecosystems (Folgarait, 1998). They contribute to the regulation and survival of many organisms as a result of being involved in numerous interactions through herbivory, predation and/ or mutualisms with other organisms, such as bacteria, plants, fungi, arthropods and vertebrates (Guénard, 2013). Their ability to modify abiotic conditions, change local structure and soil composition, due to the nesting habits, assigns ants the role of 'ecosystem engineers' (Jones et al. 1994). Ants have been classified into functional groups and thus used as bio-indicators of habitat disturbance, often associated with human activities and land uses (Majer, 1983; Andersen, 1995; Lobry de Bruyn, 1999; Roig & Espadaler, 2010). Generally, human and natural disturbance have different impacts. For example, urbanization and agricultural intensification may originate major changes in species composition of ant communities, by favouring invasive, opportunistic or generalist species. In contrast, in the case of natural disorders, such as fires and floods, invasive species have more difficulty to establish and dominate, due to competition with native species which seem to be better adapted to those events (Philpott et al. 2010). Until recently, it was thought that urban areas were not interesting for biodiversity studies. However, there is much research on ant diversity in green areas within urban landscapes worldwide (Clarke *et al.,* 2008; Guénard, *et al.,* 2015). In fact, urban ecosystems can ensure a high diversity of native ant species and contribute to their preservation (Guénard *et al.,* 2015). At the basis are the specific ecological niches created by diverse habitats (McKinney, 2008).

Tapada da Ajuda is a 100 ha urban park, located nearby Monsanto park (the largest green patch in Lisbon and one of the massive parks in the world, covering almost 1000 ha). It is characterized by different land uses and high heterogeneity of habitats, including the Natural Botanical Reserve D. António Xavier Pereira Coutinho (the oldest in Portugal), agricultural and forest areas, gardens, sports facilities, water plans, roads and human activities associated with the campus of the Faculty of Agronomy, University of Lisbon. Few biodiversity studies have been carried out *at Tapada da Ajuda* mostly related to plants (Vasconcelos *et al.,* 2013) and birds (Ferreira, 2011). The present study was aimed at providing a baseline data on ant species diversity in Tapada da Ajuda and evaluating the disturbance level of habitats exposed to different anthropogenic pressure, using ants as bio-indicators of ecosystem health.

Material and methods

Study site

The study was conducted at *Tapada da Ajuda* (38°42'27.5''N; 9°10'56.3''W), in Lisbon (Fig. 1). Habitats exposed to different anthropogenic pressure were selected for ant sampling, as explained in Figure 1.

Field sampling

Ants were surveyed in May 2015 by visual search and hand collecting at 20 sites stratified among 14 plots within *Tapada da Ajuda*, corresponding to different habitats (Fig. 1), and by installing pitfall traps at eight different habitats. Pitfall traps consisted of 7 cm cylindrical containers partially filled with propylene glycol and a few drops of detergent. The ants falling into traps were collected after a week and preserved in 96% ethanol. Identification was based on Collingwood & Prince (1998) and Gómez & Espadaler (2007).

Data analysis

Records from both sampling methods were combined in order to cover a larger number of species. Species richness was determined for each sampled habitat. Ant species were assigned to functional groups and

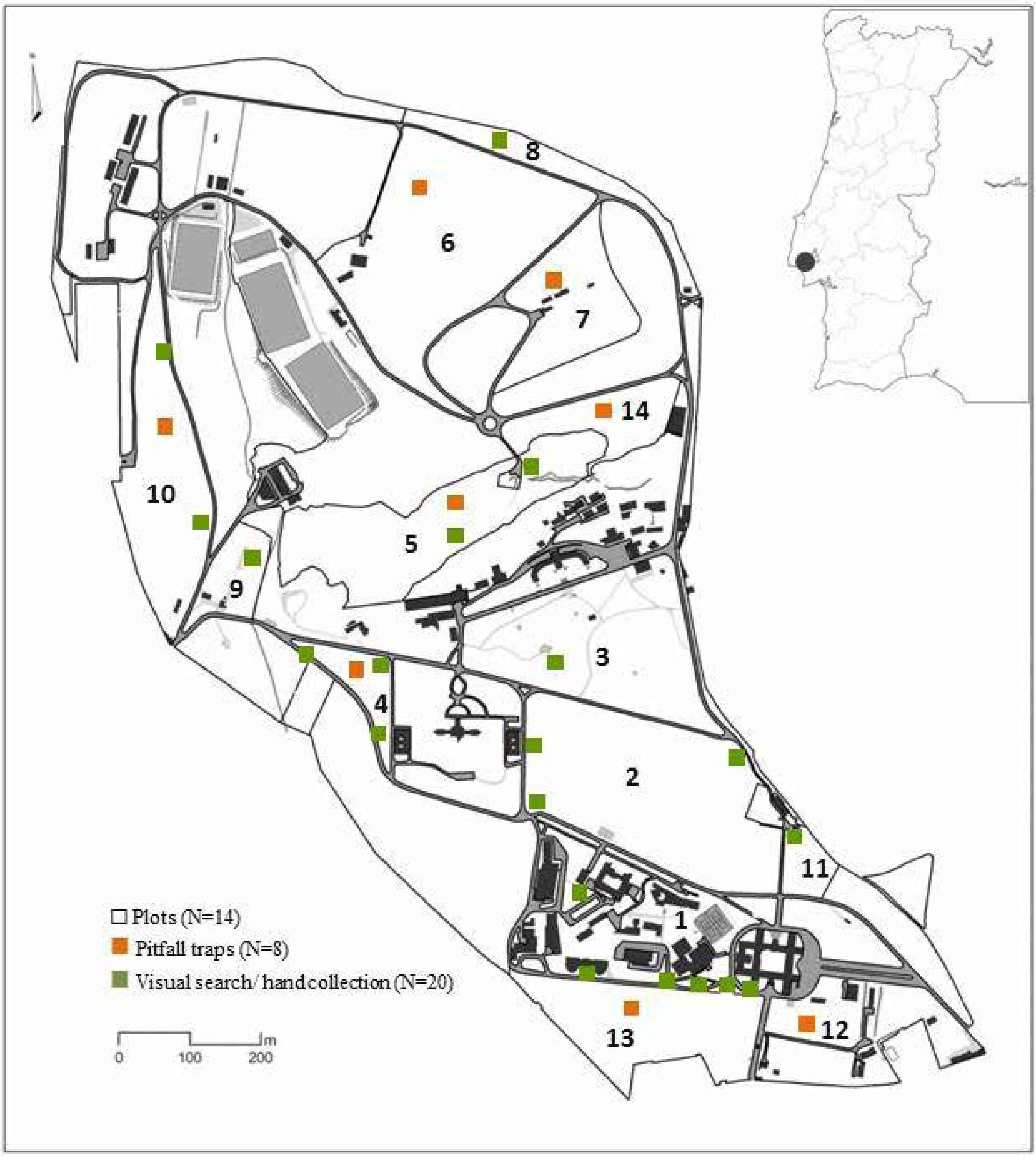

Fig. 1. Location of the sampling sites within the 14 plots in Tapada da Ajuda, Lisbon, Portugal: 1. Garden, buildings, paths; 2. Arable crops, uncultivated areas; 3. Garden, buildings, paths; 4. Pine stand; 5. Reserve, natural vegetation; 6. Grassland, uncultivated areas; 7. Apiary, natural vegetation; 8. Eucalyptus, other trees and bushes; 9. Forest nurseries; 10. Eucalyptus plantations; 11. Paths, vegetables, aromatic and ornamental species, uncultivated areas; 12. Citrus orchard; 13. Vineyards; 14. Olive orchard (adapted from Vasconcelos et al.*, 2013).*

Fig. 1. Ubicación de las localizaciones de muestren en 14 parcelas de Tapada da Ajuda, Lisboa: 1. Jardín, edificios, caminos; 2. Cultivos, áreas no cultivadas; 3. Jardín, edificios, caminos; 4. Masa de pinos; 5. Reserva, vegetación natural; 6. Prado, áreas no cultivadas; 7. Colmenar, vegetación natural; 8. Eucalipto, otros árboles y arbustos; 9. Viveros forestales; 10. Plantaciones de eucaliptos; 11. Caminos, vegetales, especies aromáticas y ornamentales, áreas no cultivadas; 12. Huerta de cítricos; 13. Viñedos; 15. Huerto de olivos (adaptación de Vasconcelos et al.*, 2013).*

global disturbance indices were determined accordingly to Roig & Espadaler (2010): a) Species indicators of disturbance: invasive/ exotic, generalist and/or opportunist species; b) Species indicators of stability: cold climate/ shadow habitats specialists, hot climate/open habitats specialists; and c) Cryptic species: small sized and inconspicuous species. The corresponding indices of disturbance, stability and cryptic species were calculated as the percentage of ant species indicators of disturbance, stability and cryptic species, respectively, in relation to the total number of collected ant species.

The number of ants species collected in *Tapada da Ajuda* was compared with a general survey done during the X Iberian Congress of Myrmecology - Taxomara on July 2015.

Results

Ant community structure

A total of 743 specimens were identified in this study, comprising 22 ant species from 12 genera (Table 1). Twenty ant species were collected by visual search and 13 by pitfall traps. In terms of shared species, 11 ant species were detected by both sampling methods (Fig. 2). *Aphaenogaster senilis* Mayr was the most frequent species found in pitfall traps (62.5%), whereas *Plagiolepis schmitzii* Forel occurred in 70% of visual search sites (Fig. 2).

Functional groups and habitat disturbance

Generalist and opportunistic species were present in all plots and in 93% of the sampled sites (12 ant species) (Fig. 3). Cryptic species were collected in 43% and 64% of the sampled sites and plots, respectively, being the highest number of *Temnothorax* species collected in the natural reserve (plot 5) (Table 1). Cold climate specialists occurred in 43% of both plots and sampled sites, while hot climate specialists were present in 32% of the sampled sites and 50% of the plots. Two invasive species were recorded on 11% of the sampled sites and 21% of the plots (Fig. 3).

Disturbance index in each plot ranged from 50 (plots 2, 4 and 8) to 100 in agricultural habitats (citrus and olive trees; plots 12 and 14 respectively) (Table 1). Functional groups, considering only species sampled by pitfall traps, representing specific habitats with a single sampling site, are shown in Fig 4.

Discussion

Combining the data obtained in the present study (22 species) with the addition of two species, out of 14, collected during the X

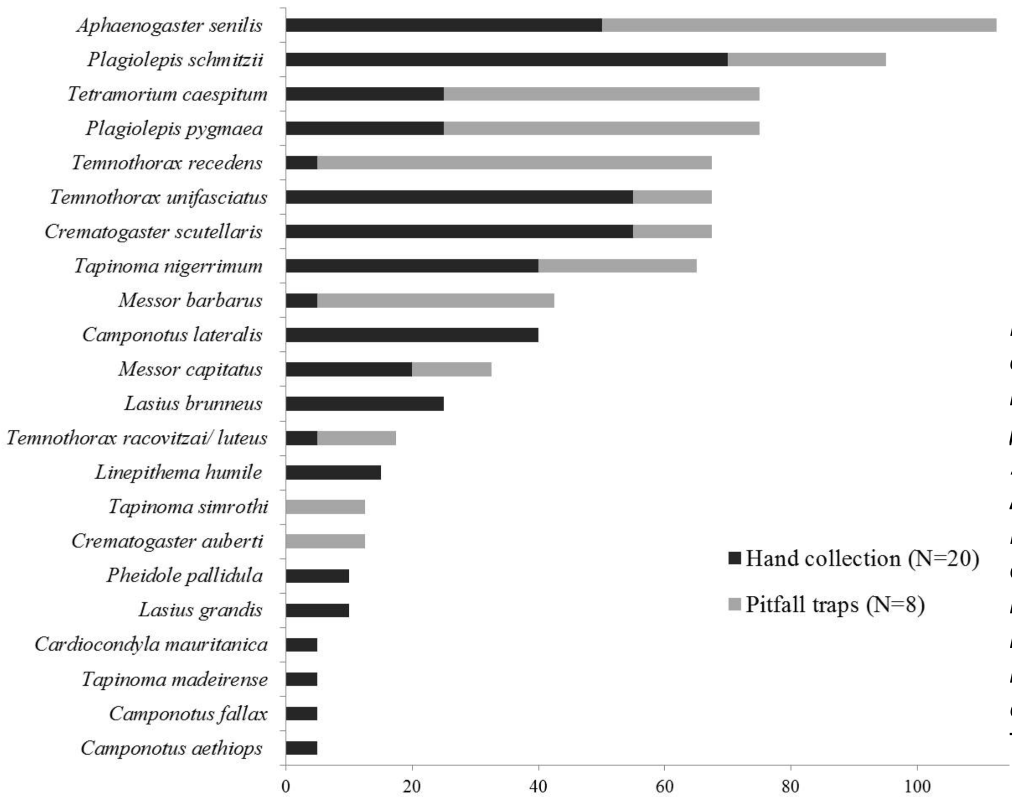

Fig. 2. Frequency (%) of ant species collected by hand collection and pitfall traps, in May 2015, at Tapada da Ajuda.

Fig. 2. Frecuencia (%) de las especies de hormigas recolectadas mediante recolección manual y trampas de caída en Mayo 2015 en Tapada da Ajuda.

Table 1. Ant species and corresponding functional groups identified at the 14 plots sampled in Tapada da Ajuda*, Lisbon.*
Tabla 1. Especies de hormigas y grupos funcionales correspondientes identificadas en las 14 parcelas muestreadas en Tapada da Ajuda*, Lisboa.*

Ant species	Functional groups[1]	Plots														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Aphaenogaster senilis	GO	+	+	+	+	+/□	□	□	+		+/□	+			□	
Camponotus aethiops	HCS/OH	+														
Camponotus fallax	CCS/SH				+											
Camponotus lateralis	CCS/SH	+	+	+	+	+					+					
Cardiocondyla mauritanica	IE									+						
Crematogaster auberti	GO							□								
Crematogaster scutellaris	GO	+	+	+	+	+					+				□	
Lasius brunneus	CCS/SH	+	+	+	+											
Lasius grandis	CCS/SH	+														
Linepithema humile	IE	+		+						+						
Messor barbarus	HCS/OH					+	□				□			□		
Messor capitatus	HCS/OH	+					□		+		+	+				
Pheidole pallidula	GO	+			+											
Plagiolepis pygmaea	GO	+				+/□			+		+		□	□	□	
Plagiolepis schmitzii	GO	+	+	+	+	+				+	+/□	+			□	
Plagiolepis xene[2]	P															
Solenopsis sp.[3]	C															
Tapinoma madeirense	GO	+														
Tapinoma nigerrimum	GO	+				+	□			+	+	+		□		
Tapinoma simrothi	GO						□									
Temnothorax racovitzai/ luteus	C					+/□										
Temnothorax recedens	C	+				+/□		□								
Temnothorax unifasciatus	C	+	+	+	+/□	+			+	+	+					
Tetramorium caespitum	GO	+				+	□	□		+	+/□			□		
Tetramorium semilaeve[2]	GO															
No. sites		6	3	1	4	3	1	1	1	1	3	1	1	1	1	**28**
Species richness		16	6	7	8	11	6	4	4	6	10	4	1	4	4	**22**
Disturbance Index		56	50	57	50	55	67	75	50	83	60	75	100	75	100	**55**
Stability Index		31	33	29	38	18	33	0	25	0	30	25	0	25	0	**32**
Cryptic species Index		13	17	14	13	27	0	25	25	17	10	0	0	0	0	**14**

Legend:[1]Functional groups: GO - Generalists/ opportunists; IE - Invasive/ exotic; CCS/SH - Cold climate specialists/ shadow habitats; HCS/OH - Hot climate specialists/ open habitats; C - Cryptic species; P - Social parasites; [2] Record within the X Iberian Congress of Myrmecology -Taxomara on July 2015; [3] Record on October 2015; + Presence by hand collection; □ Presence in pitfall traps.

Iberian Congress of Myrmecology - Taxomara on July 2015 and by the time of writing this article (October 2015), a total of 25 ant species have been reported from *Tapada da Ajuda*. This study revealed a relatively high number of ant species, which is within the range of ant richness reported in other studies carried out in urban parks (0-78 species), such as in Madrid

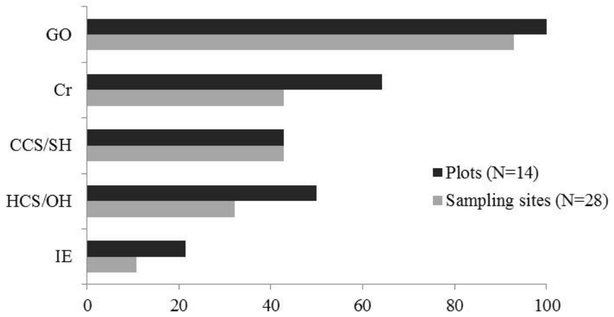

Fig. 3. Frequency distribution (%) of functional groups composition (species occurrence data) by plot and sampling site, carried in May 2015, at Tapada da Ajuda*. Functional groups: GO - Generalists/ opportunists; C - Cryptic species; CCS/ SH - Cold climate specialists/ shadow habitats; HCS/OH - Hot climate specialists/ open habitats; IE - Invasive/ exotic.*

Fig. 3. Distribución de frecuencias (%) de la composición de grupos funcionales (datos de especies encontradas) por parcela y localización de muestreo llevado a cabo en Mayo 2015 en Tapada da Ajuda*. Grupos funcionales: GO – Generalistas/ oportunistas; C – Especies crípticas; CCS/SH – Especialistas de climas fríos/ hábitats sombreados; HCS/ OH – Especialistas de climas cálidos/ hábitats abiertos; IE – Invasoras/ exóticas.*

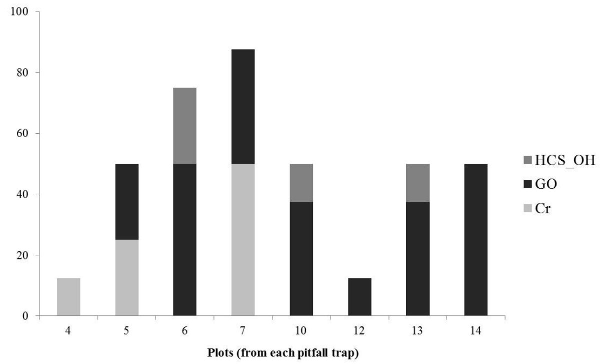

Fig. 4. Frequency distribution (%) of functional groups composition (species occurrence data) in May 2015, at Tapada da Ajuda*, for each pitfall trap, corresponding to different habitats, Plots: 4. Pine stand; 5. Reserve, natural vegetation; 6. Grassland; 7. Apiary, natural vegetation; 10. Eucalyptus plantations; 12. Citrus orchard; 13. Vineyards; 14. Olive orchard.*

Fig. 4. Distribución de frecuencias (%) de la composición de grupos funcionales (datos de especies encontradas) en Mayo 2015 en Tapada da Ajuda *para cada trampa de caída, correspondiente a diferentes hábitats. Parcelas: 4. Masas de pino; 5. Reserva, vegetación natural; 6. Prado; 7. Colmena, vegetación natural; 10. Plantaciones de eucalipto; 12. Huerto de cítricos; 13. Viñedos; 14. Huerto de olivos.*

(Heras et al. 2011), Cordoba and Seville (Carpintero & Reyes-López, 2013), in Spain, San Francisco (Clarke *et al.,* 2008), Raleigh (Guénard *et al.,* 2015), and New York (Savage *et al.*, 2015), in the USA. The differences in the number of ants species identified in urban parks by different authors may reflect the influence of different factors, including sampling effort, habitat diversity, park size, age and shape, existing pool of ant species in each region, and presence of exotic ant species (Carpintero & Reyes-López, 2013; Touyama *et al.,* 2003; Guénard *et al.,* 2015).

Surprisingly, invasive ants, namely the argentine ant, *Linepithema humile* (Mayr) and *Cardiocondyla mauritanica* Forel were only found in three plots, with intermediate to high levels of disturbance (56-83%). The same two species were also found by Carpintero & Reyes-López (2013) in urban parks of Cordoba and Seville. However, a highest occurrence would be expected for *L. humile*, which is a ubiquitous urban pest, with high capacity of competing and displacing native ant species worldwide (Touyama *et al.,* 2003; Roura-Pascual *et al.,* 2011). On the other hand, a recent study showed that exotic ants across different levels of stressed habitats revealed no significant impact on species richness (Savage *et al.,* 2015). One explanation could be the fact that exotic ants are limited to park edges, and thus do not have much effect on native ant fauna (Clarke *et al.,* 2008).

The lowest level of disturbance (50%) was found on arable crops (plot 2), pine stand (plot 4) and *Eucalyptus* (plot 8), while the highest one (100%) was observed in orchards, such as citrus (plot 12) and olives (plot 14). Ant species indicators of disturbance (generalists, opportunists and invasive) dominated in plots and sampling sites. Cryptic species, being sensible to habitat change, were particularly important in the natural reserve (plot 5), where the number of *Temnothorax* species was the highest.

Interestingly, the most urbanized area (plot 1) was not the most disrupted one, showing the highest number of ant species. Nevertheless, plot 1 was also composed by a diverse number of plant species (>150), which may provide diverse niches for ants (McKinney, 2008; Coutinho, 2014).

Acknowledgments

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Primera cita para Cataluña de *Myrmica lemasnei* Bernard, 1967(Hymenoptera: Formicidae)

[First record for Catalonia of *Myrmica lemasnei* Bernard, 1967 (Hymenoptera: Formicidae)]

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Myrmica lemasnei Bernard, 1967 (Fig. 1) es una parásita social carente de obreras conocida hasta el momento del departamento francés de Pyrénées-Orientales y del Pirineo de Huesca (Radchenko & Elmes, 2010).

Se añade a la lista de localidades conocidas de esta especie la primera de Cataluña:

- *Torrent de les Comes Xiques*, *Toses*, *Girona*. 42º19'N 2º00'E. 1580m. 14-V-2014. Fede García *leg*. Bosque de *Pinus sylvestris* con *Buxus sempervirens*. Bajo piedra en un camino, única zona algo abierta de un bosque denso (Fig. 2). Capturadas tres reinas (Fig. 3). Una en la colección de Xavier Espadaler, dos en la colección del autor, de las cuales una en seco, la otra en etanol 96%. No se excavó el nido por lo que el número total de reinas parásitas no se conoce.

En las localidades anteriormente conocidas la altitud a que se encontró fue de 800 y 900 metros, y por tanto con la presente cita se amplia notablemente la amplitud altitudinal conocida para *M. lemasnei*.

Dentro del nido, *M. lemasnei* es reconocible por ser de inferior tamaño que las reinas y obreras de la especie hospedadora.

Figura 2: Biotopo donde fueron encontrados los especímenes.
Figure 2: Biotope where the specimens were found.

De *Myrmica karavajevi* (Arnoldi, 1930), especie parásita social también presente en la península ibérica y perteneciente al mismo grupo de especies que *M. lemasnei* (Radchenko & Elmes 2010), se distingue por el pospeciolo reticulado y la pilosidad del primer segmento del gaster de *M. lemasnei* (Fig. 4),

Figura 1: Reina de Myrmica lemasnei*, vista lateral. Escala: 1mm*
Figure 1: Myrmica lemasnei *queen, lateral view. Scale bar: 1mm*

Figura 3: Myrmica lemasnei *en el nido.*
Figure 3: Myrmica lemasnei *in the nest.*

Figura 4: Cabeza de Myrmica lemasnei*, vista frontal.*
Figure 4: Myrmica lemasnei *head, frontal view.*

Figura 5: Cabeza de obrera de Myrmica spinosior, vista frontal.
Figure 5: Myrmica spinosior worker head, frontal view.

mientras que en *M. karavajevi* el pospeciolo es liso y carece de pelos en el primer segmento gastral.

La especie hospedadora en *Toses* es *Myrmica spinosior* Santschi, 1931 (Fig. 5). Se capturaron diez obreras y una reina. Índices biométricos de obreras siguiendo a Radchenko & Elmes (2010) (n=4) FI: 0.36, FLI: 1.32.

En la vecindad inmediata del nido parasitado no se encontró otra colonia de *M. spinosior*, seguramente debido a lo cerrado del bosque que rodeaba el lugar, donde la única especie del género presente era *Myrmica ruginodis* Nylander, 1846.

M. spinosior ha sido reconocida sólo recientemente como especie (Seifert, 2005), aunque ya había sido detectada como una población de *Myrmica sabuleti* Meinert, 1861 con particularidades morfológicas (Collingwood & Yarrow, 1969) y biométricas (Seifert, 1988). Por tanto sería interesante revisar si en Francia la especie hospedadora es realmente *M. sabuleti*, como fue citada en su momento, o bien *M. spinosior.* En Huesca la especie hospedadora era *M. spinosior* (García et al. 2008). Ambas especies son muy similares morfológicamente, y ambas se encuentran en la zona pirenaica (obs. pers.).

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