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The Journal of Basic and Applied Zoology (2024) 85:21
https://doi.org/10.1186/s41936-024-00375-9

The Journal of Basic and Applied Zoology

RESEARCH

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Confirmed presence of the enigmatic ant *Aphaenogaster gemella* (Hymenoptera: Formicidae) in Iberia

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Abstract

Background While the Iberian Peninsula has been relatively well-studied from a myrmecological standpoint, the true presence of certain ant species has remained obscure for decades. In this context, the case of *A. gemella* (Roger, 1862) stands out as one of the most intriguing examples. Initially described from the Balearic Islands, this conspicuous species seemingly vanished from the archipelago by the 1980s, confining its current distribution to the Maghreb region. However, lingering doubt has persisted regarding its potential presence in Iberia, based on some old bibliographic records from Spain and Portugal.

Results This study confirms the first known established population of *A. gemella* in the Iberian Peninsula (Tarifa, Southern Iberia). Two colonies were detected in an urban grass patch within the city center. The validity of other Iberian records regarding the species and its status as an exotic species are also discussed.

Conclusions The presence of *A. gemella* in Southern Iberia highlights the need for targeted sampling efforts to delineate its actual range and distinguish it from morphologically similar species in the region.

Keywords Exotic species, Iberian Peninsula, Alien ants

Background

The Iberian Peninsula harbors one of Europe's richest and most unique ant faunas (Arcos & Garcia, 2023; Janicki et al., 2016; Wang et al., 2023), and its composition has been the subject of several recent papers addressing regional and national species checklists (e.g., Arcos et al., 2022; Catarineu et al., 2018; García & Cuesta-Segura, 2017). Despite this attention, the presence of certain species within the Iberian territory remains unclear. It is the case, for instance, of *Temnothorax clypeatus* (Mayr, 1853), once recorded in 1983, or *Crematogaster fuentei* Menozzi, 1922, never found again since its description over a century ago. While some of these could represent simple misidentifications, others could be potentially existing species awaiting rediscovery (Pérez-Delgado et al., 2023; Schifani et al., 2020).

In this manuscript, we address one such case, presenting the first confirmed record of the elusive *A. gemella* (Roger, 1862) in Iberia after 70 years. Roger (1862) described *A. gemella* based on specimens collected from Algeria and Mallorca (Balearic Islands), including a male from each location and a worker from Mallorca. Subsequently, it has been recorded in Morocco (Saunders, 1890), mainland Spain (Collingwood & Yarrow, 1969), Portugal (Collingwood & Yarrow, 1969), and France (Bernard, 1983). Its native range, however, is believed to be confined to the Maghreb region (Cagniant, 1990). Workers of this species are grayish, middle-sized (6–8 mm), and show a slender appearance, similar to other members of the *A. sardoa* species group to which it belongs (Schifani et al., 2022). The other two Iberian members of the group are *Aphaenogaster iberica* Emery, 1908, and

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Aphaenogaster senilis Mayr, 1853, from which it differs by the much shorter propodeal spines.

In the Balearics, *A. gemella* was once a common ant that inhabited the three major islands (Mallorca, Menorca, and Eivissa). However, its population declined significantly during the 1960s and 1970s, likely due to the establishment of the invasive ant *Linepithema humile* (Mayr, 1868) (Cagniant, 1994; Gómez & Espadaler, 2006). In its extensive samplings in the Balearics, Del Río (1988) only found *A. gemella* in the city of Inca (Mallorca) and stated it was "about to disappear" from the archipelago. Indeed, the specimens he found in 1983 were the last to be seen in the region. Since then, some authors have considered *A. gemella* to be eradicated from the Balearics (Gómez & Espadaler, 2005). In Morocco, although the species is rare (Cagniant, 1996), recent studies have reported its local abundance (Taheri et al., 2017).

While the presence of *A. gemella* in the Balearics and the Maghreb region is well documented, the validity of the reports from mainland Spain and Portugal is debatable. Collingwood (1978) mentioned the species from North Iberia, Portugal, and the Balearics, but without giving any precise locations. These records are based on two papers according to Collingwood, one being Ceballos (1956) and the other Collingwood and Yarrow (1969). Ceballos (1956) only listed *A. gemella* from the Balearics (Mallorca, Menorca, and Eivissa) based on prior literature. Collingwood and Yarrow (1969) also noted *A. gemella* from the Balearics and inferred that observations by Goetsch (1942) of *Aphaenogaster* workers carrying leaves to the nest in Blanes (NE Iberia) should be attributed to *A. gemella*, as it was supposedly the only vegetarian species within the group as stated by Bernard (1958). However, this assertion, relying solely on the feeding behavior of the ants and lacking examination of material from the locality, is difficult to substantiate. Furthermore, the illustrations of the *Aphaenogaster* workers from Blanes made by Goetsch (1942) (page 214) depict long propodeal spines, a characteristic shared by either *A. iberica* or *A. senilis*, both common ants in Iberia with similar appearances that are often observed gathering vegetal material along with small invertebrates (pers. obs.). Therefore, Collingwood's (1978) report of *A. gemella* in North Iberia likely results from misidentification. Even more dubious is the mention of *A. gemella* in Portugal, since it does not appear in either of the two papers in which Collingwood (1978) based this record. Schifani et al. (2022) also mention this species from Portugal, but without newly studied material.

A second controversial, unpublished record of *A. gemella* in Spain comes from a biodiversity survey conducted across 20 olive groves distributed throughout Andalusia (Southern Iberia) as part of the "LIFE Olivares Vivos" project (https://www.olivaresvivos.com/life-olivares-vivos/), spanning from 2015 to 2020. On its website, it is stated that *A. gemella*, "a species that was considered extinct in Spain since the 60 s," was discovered in several olive groves. There are no other data available regarding the location of the samples or any information on how the individuals were identified. A post on the platform X (https://twitter.com/olivaresvivos/status/1338431066940563456/photo/1) by the official page of the project appears to show a photographed individual of "A. gemella" found during the survey. Notably, the propodeum of this worker seems rounded, without a trace of propodeal spines, which diverges from the typical characteristics of *A. gemella*. According to Schifani et al. (2022), "the lack of propodeal spines […] is very rare in *Aphaenogaster* (about 2%, as it is only seen in *A. inermita* and *A. pallida*)" in the West-Palearctic context. Given the informal character of this record, the lack of precise locality information, and the particular propodeum shape observed in the single available photograph of a specimen, we regard this "A. gemella" record as invalid until verified by a myrmecologist or published in a peer-reviewed journal.

Finally, in his review of the *A. testaceopilosa* species group (currently the *A. sardoa* species group following Schifani et al., 2022), Boer (2013) examined 4 workers from Tarifa (Cádiz, S Iberia) collected by Bosschoert on August 15, 1954, almost 70 years ago. This constitutes the only reliable bibliographic record of *A. gemella* in the Iberian Peninsula. To our knowledge, no further myrmecological studies have been conducted in the town of Tarifa. Although some neighboring areas have been surveyed over the years (Guillem & Bensusan, 2019; Tinaut, 1989), there has been no sign of *A. gemella*. Consequently, the status of this population has remained obscure since its initial documentation.

Methods

On May 16, 2023, the first author discovered workers of *A. gemella* in the city center of Tarifa (Cádiz, Spain) during a brief cultural visit to the town. Two colonies were located within irrigated patches of grass situated alongside the historic Arrabal Defensive Wall (first nest, 36°00′52.7"N 5°36′08.1″W; second nest, 36°00′49.2″N 5°36′03.8″W) (Fig. 1). These colonies, separated by approximately 150 m, had a single circular entrance and were located on the ground. Other ants present in the area were *A. senilis* and *Pheidole pallidula* (Nylander, 1849). It is worth mentioning that the appearance of

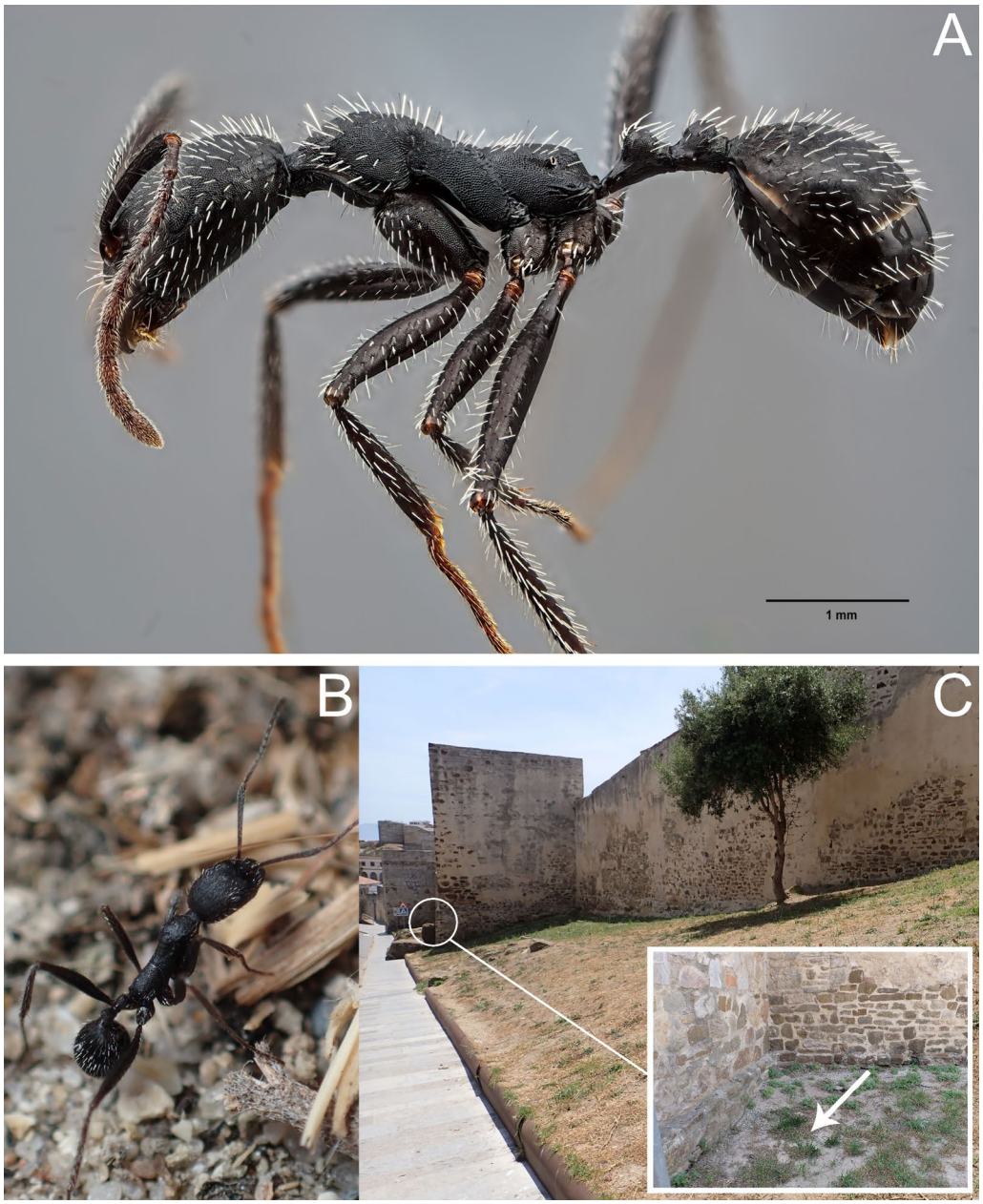

Fig. 1 **A** Lateral view of a worker of *A. gemella*. **B**: aspect of *A. gemella* in the field. **C**: habitat of *A. gemella*, with a closeup view of one of the nest locations (arrow)

A. gemella and *A. senilis* is identical in the field, which makes it impossible to differentiate them unless workers are inspected one by one with a hand magnifier or stereomicroscope. On the same day, the first author sampled ants along a 2-km transect within the Estrecho Natural Park, commencing near the site of *A. gemella* discovery and actively searching for the species. However, only workers of *A. senilis* were abundantly found during the search.

Results

The samples were identified as *A. gemella* following the keys provided by Boer (2013). According to the author, this species represents the sole European member of the *A. sardoa* species group with a 5-segmented antennal club, alongside *A. senilis* (Fig. 2). From the latter, it is distinguished by the length of the propodeal spines, which are notably shorter in *A. gemella* (Fig. 3). Cagniant (1990, 1996) recognizes two distinct subspecies, based on

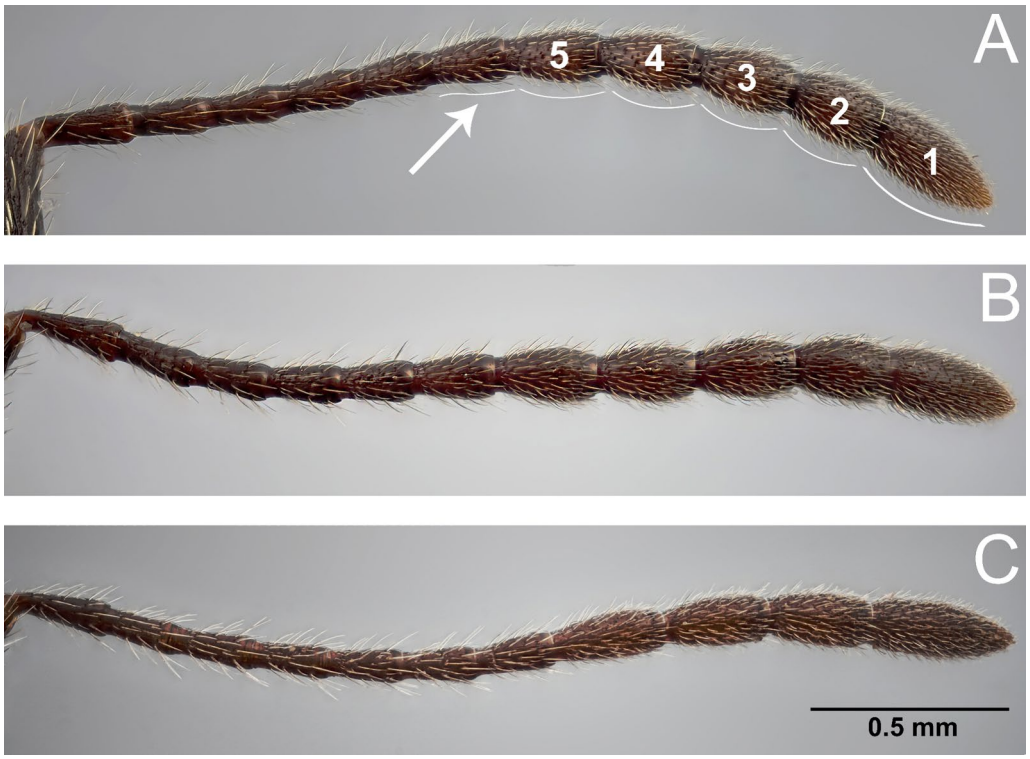

Fig. 2 Antennas of *A. gemella* (**A**), *A. senilis* (**B**) and *A. iberica* (**C**). The five segments (1→5) that conform the antennal club of *A. gemella*, and *A. senilis* have a curved profile, while the sixth (arrow) and the subsequent have a slightly sinuous profile. The antennal club of *A. iberica* possesses four segments

differences in propodeal spine length and male genitalia: *A. gemella gemella*, ranging from Ceuta to Tetouan, and *A. gemella marocana* (Forel, 1903), found in the Tanger region. The examined workers from Tarifa exhibit a dentiform propodeum, rather than thin but distinct propodeal spines, which matches the description of *A. gemella gemella*. The latter was also the subspecies that inhabited the Balearics, according to Cagniant (1990, 1996). Moreover, Cagniant (1994) outlines morphological variations between Balearic and Moroccan populations of *A. gemella gemella*, showing that insular workers have nearly absent propodeal spines, while continental ones have a dentiform propodeum. Interestingly, the specimens from Tarifa seem to resemble the Balearic population more closely than the Moroccan population in terms of propodeal spine morphology.

Discussion

The presence of *A. gemella* in Tarifa, merely 14 km away from Morocco, raises the question on whether this ant could have naturally crossed the Gibraltar Strait and be considered as native, or whether it has been anthropogenically introduced. We lean towards the exotic hypothesis most likely, based on the following considerations:

(a) Queens of *A. gemella* are brachypterous (Cagniant, 1990) and unable to fly, a trait shared with other similar species within the group (Cagniant, 1996). This would prevent fertilized females from crossing the Strait of Gibraltar by air. Floating logs and vegetation are also potential vehicles for maritime ant translocations, but *A. gemella* is a soil-nesting species that would rarely establish its colonies in wood.

(b) The presence of *A. gemella* in a small urban enclave of Tarifa, juxtaposed with its apparent absence in the nearby, more preserved natural surroundings, suggests a probable anthropogenic origin. In fact, a similar distribution pattern was previously observed in the Balearic population, where *A. gemella* tended to thrive in urban areas (Gómez & Espadaler, 2006) rather than mountainous or Mediterranean shrub landscapes. This is the reason why there is consensus about the exotic origin of *A. gemella* in the Balearics (Cagniant, 1990; Gómez & Espadaler, 2006). Other myrmecological studies conducted throughout the years in the proximity of Tarifa have not been able to locate it (Tinaut, A. 1989; Guillem & Bensusan, 2019), which reinforces the idea that

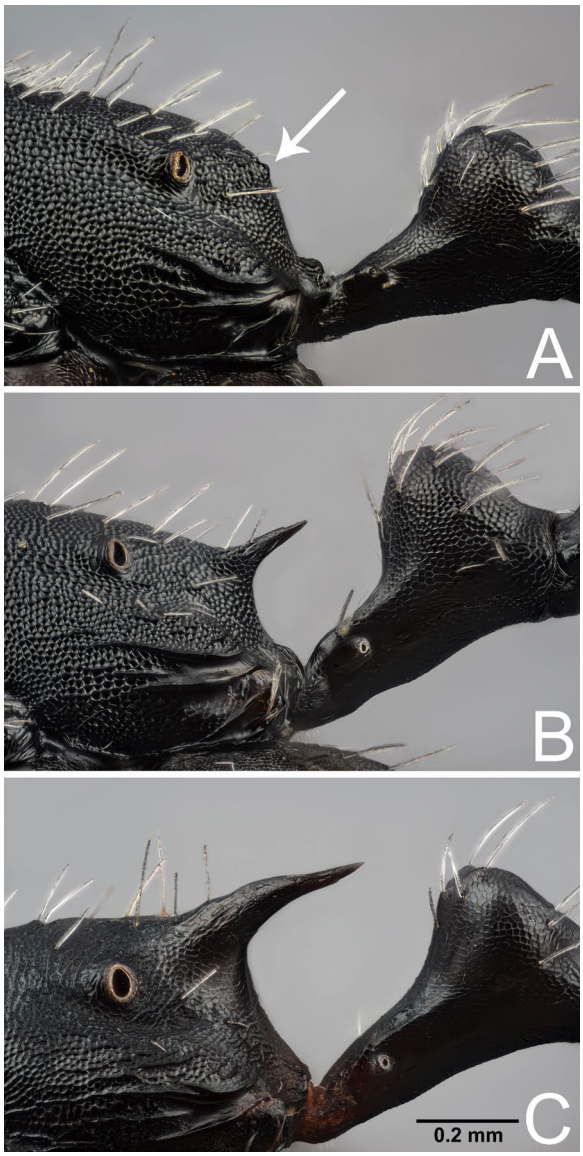

Fig. 3 Closeup view of the propodeum of *A. gemella* (**A**), *A. senilis* (**B**), and *A. iberica* (**C**), the three Iberian members of the *A. sardoa* species group, where the distinct development of the propodeal spines can be seen. The arrow in A points to the small dentiform, almost absent, propodeal spine

the population of *A. gemella* is restricted to the city center.

(c) The species has the potential to become an alien species in other Mediterranean regions, as evidenced by its endurance in the Balearics for a period spanning at least 121 years (from the original description in 1862 to its last recorded sighting in 1983). In France, it was also reported as introduced in two localities by Bernard (1983), although it has not been found again in the country (Blatrix et al., 2018). Furthermore, other morphologically and biologically similar species such as *A. iberica* and *A. senilis* have also successfully established alien populations in Mediterranean regions beyond their native ranges (Gómez & Espadaler, 2006; Wetterer et al., 2004). In light of these precedents, the survival of an exotic *A. gemella* population in Tarifa is not surprising.

With the available data, it is not possible to say if the *A. gemella* population now established in Tarifa is the same as the one found by Bosschoert in 1954 (Boer, 2013). Its extension in the city also remains unknown, since the present finding of the specimens near the historical Arrabal Defensive Wall was not accompanied by a comprehensive survey of the urban area. As previously mentioned, the morphology of the propodeal spines observed in the Iberian specimens bears closer resemblance to the Balearic form than the Moroccan form of *A. gemella gemella*, which also questions the precedence of the Tarifa's population from a supposed North African origin.

Conclusions

Since its first mention by Collingwood and Yarrow (1969), the occurrence of *A. gemella* in Iberia has remained ambiguous. Although a reliable record from Tarifa (Southern Iberia) previously existed (Boer, 2013), based on specimens collected in 1954, its status as an established species has never been assessed. As a result, subsequent papers either include *A. gemella* in the Iberian species checklist (Borowiec, 2014; Schifani et al., 2022) or omit it (Gómez et al., 2018). The confirmed presence of *A. gemella* in Southern Iberia represents the sole known live population outside the Maghreb region. A natural translocation of the species from Morocco to Southern Iberia is very unlikely, as queens lack the ability to fly, and colonies are not located in vegetation material that could float from one shore to the other. Additionally, the length of the propodeal spines in the studied workers from Tarifa more closely resembles those described for the Balearic population, which are considerably rudimentary compared to the short denticles found in the Moroccan population according to Cagniant (1994). It is also clear that *A. gemella* has the potential to become an exotic ant outside the Maghreb region, even maintaining stable introduced populations for extended periods, as in the case of Mallorca (Balearic Islands). Consequently, *A. gemella* should be regarded as native in the Maghreb region (Morocco, Algeria), and most probably introduced in the Balearics (here presumably eradicated), mainland

Spain (confirmed established population in Tarifa), and France (here presumably eradicated). Bibliographic records of *A. gemella* from other localities in mainland Spain are highly likely misidentifications, and its presence in Portugal is dubious, as the origin of the record cannot be traced. Targeted sampling efforts will be necessary in order to precisely delineate the range of *A. gemella* in Tarifa and Southern Iberia as a whole, with a focus on distinguishing it from the common and morphologically similar species *A. senilis* and *A. iberica*, which are indistinguishable in the field. With its confirmed presence, the checklist of Iberian ants now comprises 296 species (Arcos & Garcia, 2023).

Acknowledgements
We thank the three anonymous reviewers for comments on the manuscript.

Author contributions
JA helped in conceptualization, writing, review and editing. PA was involved in photography, review and editing.

Funding
The authors are not funded and did not receive any support.

Availability of data and materials
Not applicable.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

Received: 22 April 2024 Accepted: 20 June 2024
Published online: 03 July 2024

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