



RESEARCH ARTICLE - ANTS

First record of *Temnothorax convexus* (Forel, 1894) in Portugal (Hymenoptera: Formicidae) with an updated checklist of the ants from the country

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Abstract

The Iberian Peninsula holds one of the richest myrmecofauna of the Mediterranean basin, but some regions such as Portugal remain comparatively undersampled. Although new unrecorded species have been regularly found and published during the last two decades, the sum is still far from approaching the more than 300 species known to occur in the Iberian Peninsula. In this context, the arboreal ant *Temnothorax convexus* (Forel, 1894) is reported here for the first time in Portugal. A complete society was found nesting inside an abandoned gall of *Andricus quercustozae* (Bosc, 1792) near Lisbon. A full morphometric evaluation of the specimens is provided, including a small sample from the recently discovered population in South Iberia. High-definition photographs of the worker caste are presented, together with a comparison with the most similar species in Iberia. Finally, a critical update of the Portuguese ant checklist is provided, discussing the most recent nomenclatural changes and taxonomic issues, rising the final species number to 132.

Introduction

The ant species richness in Iberia is among the largest in the Mediterranean basin, including a high rate of endemic taxa (Borowiec, 2014; Janicki et al., 2016; Guénard et al., 2017). However, only few species are ubiquitous in the whole region, with a great number of taxa being only present in one of the six recognized refugia (Tinaut & Ruano, 2021). These originated during the Pliocene and Pleistocene, and are delimited according to its general fauna and flora composition, and also by the mountain ranges that serve as dispersal barriers for ants (Gómez & Lunt, 2007; Tinaut & Ruano, 2021). In this sense, targeting undersampled refugia appears to be vital in order to produce a final checklist of the Iberian myrmecofauna. The Atlantic refugium, which includes Portugal and extends along

the western Iberian coast, is an example of a poorly known region (Borowiec & Salata, 2017), as the continuous finding of previously unrecorded species suggests. The most recent critical checklist of the ant fauna of Portugal listed a total of 106 species (Salgueiro, 2002a), which is far from being close to the more than 300 species currently known to inhabit Iberia (Sánchez-García et al., *in prep.*).

During a myrmecological survey conducted by the second author on the outskirts of Lisbon, in the small village of Lousa (municipality of Loures), a colony of a blackish *Temnothorax* species was recovered from an abandoned gall of *Quercus faginea* Lam., containing the gyne and approximately 30 workers, together with some female pupae and recently emerged individuals. After a thorough analysis of the workers, we identified the sample as *Temnothorax convexus* (Forel,



1894), representing the first record of this arboreal species in Portugal and the second population known to occur in Iberia. This finding constitutes also the most northern and western location of the species.

Material and methods

Measurements were taken using a Nikon SMZ-U stereomicroscope with a magnification between 70 and 225x depending on the character. A cross-scaled ocular micrometer with 100 divisions was used, with an estimated error of 0.01 mm. Specimens were dried and temporarily mounted before measuring and later preserved in ethanol. To minimize measuring errors, characters present on each side of the specimen were both measured and the arithmetic mean was then calculated; when percentual differences greater than 5% were detected for a specific character pair in the same individual this was remeasured to assess whether discordant values represented an occasional recording error or an asymmetry. True asymmetric characters are here defined as characters with a mean percentual asymmetry equal or greater than 3% for all of the worker specimens in the dataset. When any structure is absent, for example a scape, only one side is considered. The following characters were identified as true asymmetric, requiring the evaluation of both sides of the specimens for a reliable interpretation ($n = 10$): EL (4.35% \pm 4.15%); LMH (9.19% \pm 8.73%); MGr (7.50% \pm 23.72%); SPST (6.42% \pm 7.62%); PEL (3.21% \pm 4.72%); PPL (4.77% \pm 3.90%). The variation of the rest of the measured characters is: SL (1.17% \pm 1.76%); L1F (0.95% \pm 1.80%); ML (1.74% \pm 1.32%); MH (1.46% \pm 1.32%); PEH (1.02% \pm 1.60%); PPH (1.95% \pm 2.97%). Measured characters and indexes are those usually used in the genus *Temnothorax* (Seifert, 2006; Csősz et al., 2015). An illustrated photograph with most of the measurements used is provided by Csősz et al. (2015). For each individual, 25 characters were recorded (41 primary measurements considering bilaterally present characters). All measurements are in millimeters and follow the format “mean \pm standard error (lowest measurement – highest measurement)”. The photographic material consisted of a Sony A6000 camera equipped with a Laowa 25mm ultra-macro lens with 2.5 to 5X magnifications, a Plan APO 10X and Nikon Mplan 20X ELWD microscope objectives. For the focus stacking technique, an electronic macro rail with a resolution $< 1 \mu\text{m}$ per photo was used. Lighting was provided by two 1W LEDs of adjustable intensity. The map presenting the localities of *T. convexus* (Fig 1) was created using Natural Earth (<https://www.naturalearthdata.com/downloads/>) and QGIS Geographic Information System (<http://www.qgis.org>).

Measurements and indexes

– HL: maximum cephalic length in the median line, measured in frontal view. The cephalic capsule must be carefully tilted to the position with the true maximum. Excavations of the posterior margin of the head and/or clypeus reduce HL.

– HWb: maximum cephalic width just posterior to the eyes, measured in frontal view.

– CS: cephalic size. The arithmetic means of HL and HWb $[(HL/HWb)/2]$.

– PoOC: postocular distance, measured in frontal view., To measure it, position the head as in HL and measure PoOC using as reference (1) the perpendicular projection of the posterior margin of the eye to the median line of head and (2) the median point of the posterior head margin.

– EL: maximum length of the eye, measured in lateral view. Not pigmented ommatidia should also be measured.

– FRS: distance of the frontal carinae immediately caudal of the posterior intersection points between frontal carinae and the lamellae dorsal to the torulus, measured in frontal view (Fig 2A). If these dorsal lamellae do not laterally surpass the frontal carinae, the deepest point of scape corner pits may be taken as a reference line. These pits take up the inner corner of the scape base when the scape is fully switched caudad and produce a dark triangular shadow in the lateral frontal lobes immediately posterior to the dorsal lamellae of the scape joint capsule.

– SL: maximum straight-line scape length excluding the articular condyle, measured in frontal view.

– L1F: length of distal funiculus segment, measured in frontal view (Fig 2B). Note that the segment may be caudally or ventrally curved; in this case, it should be measured in lateral view.

– ML: mesosoma length, measured in lateral view. Take as reference points (1) the transition point between anterior pronotal slope and anterior propodeal shield and (2) the caudalmost point of the propodeal lobe, which is usually rounded. In gynes: length from caudalmost point of the propodeal lobe to the most distant point of the steep anterior pronotal face.

– MH: mesosoma height, measured in lateral view. To measure it, use as reference (1) the lowest point of katapistemum and (2) the perpendicular projection to a line connecting the dorsal most points of promesonotum and propodeum.

– MGr: maximum depth of metanotal groove, measured perpendicularly to the tangent connecting the dorsalmost points of promesonotum and propodeum, given as per cent ratio of CS (%) $[(MGr/CS)*100]$.

– PronW: maximum pronotal width, measured in dorsal view. In gynes, width is measured immediately frontal of the tegulae.

UHM: count of unilateral hairs on mesosoma excluding those on propodeal spines. To achieve a correct count, the mesosoma must be positioned in fronto-dorsal view to correctly establish its median longitudinal axis. Appressed and/or laterally positioned hairs should also be counted. Not measured in gynes, since they are very hairy and UMH in this case is not efficient to measure.

– LMH: length of longest hair on pronotum, from base to tip.

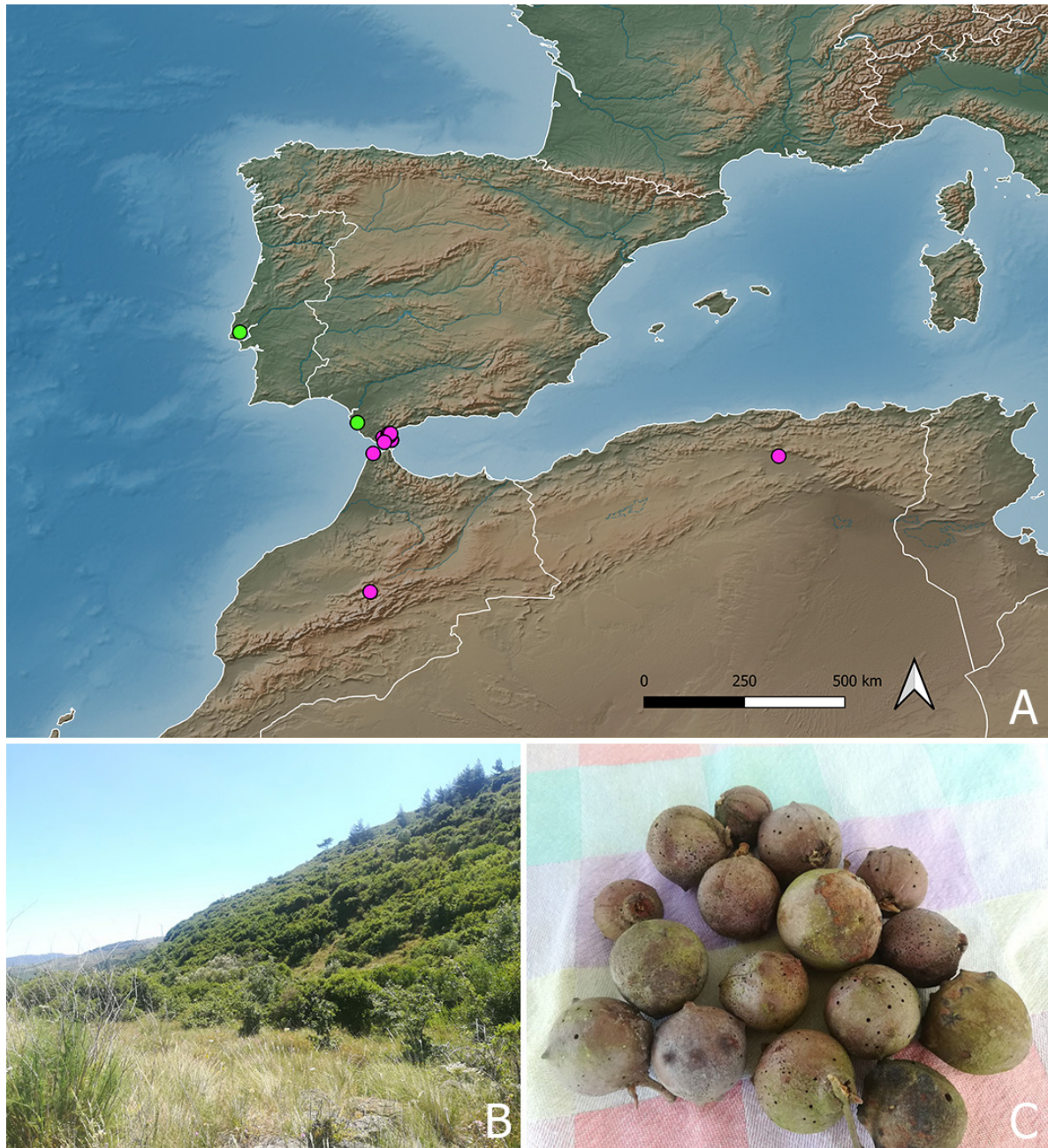


Fig 1. A: known records of *T. convexus* (pink circles) and new locations (green circle). B: general view of the habitat where the sample from Lisbon was found. C: galls from the same place where the sample was located.

– PEL: petiolar length, measured in lateral view. To measure it, take as reference (1) the point where the anterior corner of the subpetiolar process meets the ventral petiole margin and (2) the dorsal and caudalmost point of the caudal cylinder (Fig 2D).

– PEH: petiole height, measured in lateral view. Measure the maximum height of the perpendicular projection of a line that extends from (1) the point where the anterior corner of the subpetiolar process meets the ventral petiole margin and (2) the lowermost point of the caudal cylinder.

– PPL: postpetiole length, measured in lateral view. The maximum distance of the postpetiole is measured from the anterior margin to the posterior margin, perpendicular to the dorsal profile line of the postpetiole.

– PPH: maximum height of postpetiole, measured in lateral view (Fig 2D). It is the longest distance from the deepest point of the subpetiolar process to the superior profile of postpetiole.

– SPBA: the smallest distance between the lateral margins of the spines at their base; it should be measured in dorsofrontal view so that the wider parts of the ventral propodeum do not interfere with the measurement in this position (Fig 2C); if the lateral margins of spines diverge continuously from the tip to the base, the smallest distance at the base is not defined; in this case, SPBA is measured at the level of the bottom of the interspinal meniscus.

– SPST: distance between the center of propodeal stigma and spine tip; the stigma center refers to the midpoint defined by

the outer cuticular ring but not to the center of the real stigma opening that may be positioned eccentrically.

– SPWI: maximum distance between the outer margins of the propodeal spines, measured in dorsal view.

– PEW: maximum petiole width, measured in dorsal view.

– PPW: maximum postpetiole width, measured in dorsal view.

Results

A single colony was found nesting in an abandoned gall of *Quercus faginea* Lam., containing the gyne and approximately 30 workers, together with some female pupae that were reared in the laboratory. The cynipid gall wasp was identified as *Andricus quercustozae* (Bosc, 1792). The gall was located on the ground and had a single, minute entrance to the interior. The habitat was an open, sun-exposed shrubland with scattered *Q. faginea* and *Q. suber* L. trees. The investigated sample was identified as *T. convexus* according

to the original description, the morphologic description provided by Guillem and Bensusan (2019) and by comparison with the imaged syntype of the species in Antweb.org (CASENT0909022). *T. convexus* belongs to the *angustulus* group according to the literature (Cagniant & Espadaler, 1997; Galkowski & Cagniant, 2017). This is mainly integrated by arboreal species with the following character combination: (1) petiole shape triangular in lateral view, (2) pronounced sculpture on mesosoma consisting on ground reticulation with superimposed longitudinal striae and (3) dark coloration of mesosoma with occasional reddish pronotum in some bicoloured species. However, one of the main diagnostic features of the group (1) does not fit the characteristics found in *T. convexus*, since the petiole in this species is low and rounded. Species-groups in *Temnothorax* are informally used and few have been properly characterized, and so we are not here proposing a new redefinition of the *T. angustulus* group as we understand that a wider revision of this species is needed in order to determine its diagnostic features.

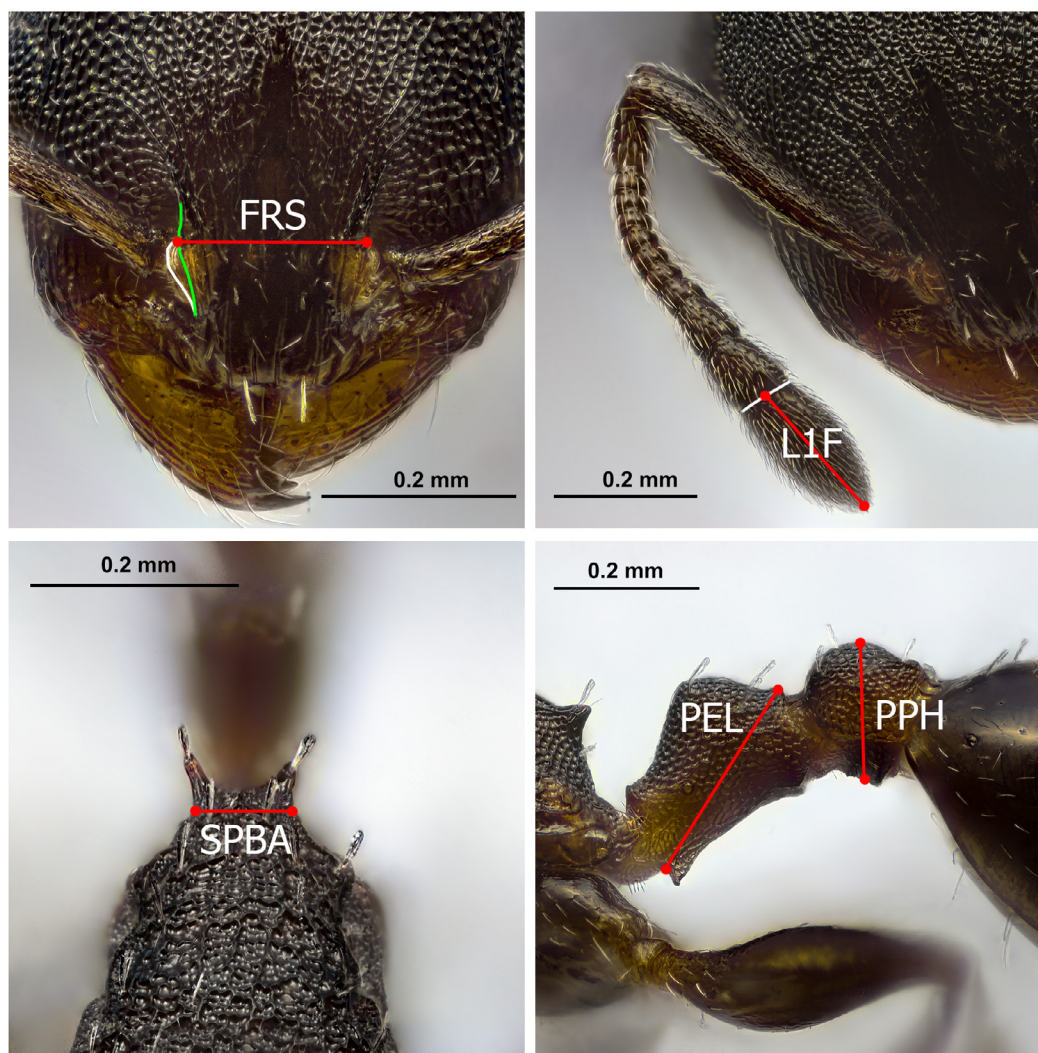


Fig 2. Worker of *T. convexus*. A: frontal view showing how to measure FRS; the white line follows the profile of the dorsal lamellae and the green line follows the profile of the frontal carinae, with the measuring point starting at the intersection between both lines. B: frontal view showing how LIF is measured. C: detailed view of the mesosoma in dorso-frontal view, the position in which SPBA is measured. D: lateral view of the petiole and postpetiole, with the measuring points for PEL and PPH.

Worker diagnosis

Investigated material: seven workers from Lousa (Portugal), 38.880889, -9.213500 (error range ± 7 m), V.2021, 230 m, Diogo Chaves leg., nest in gall; 3 workers from El Puerto de Santa María (Cádiz, Spain), 36.571500, -6.216583 (error range ± 7 m), 25.V.2019, 2 m, Rafael Obregon leg., nest in fallen branch in an open mastic shrubland with scattered *P. pinea* L. trees. Measurements in millimeters (n = 10): HL: 0.635 ± 0.031 (0.570–0.693) mm; HWb: 0.499 ± 0.032 (0.453–0.564) mm; PoOC: 0.246 ± 0.015 (0.222–0.268) mm; EL: 0.126 ± 0.007 (0.111–0.139) mm; FRS: 0.192 ± 0.013 (0.176–0.213) mm; SL: 0.472 ± 0.029 (0.425–0.527) mm; L1F: 0.222 ± 0.008 (0.208–0.236) mm; LMH: 0.062 ± 0.009 (0.048–0.083) mm; ML: 0.714 ± 0.039 (0.656–0.786) mm; MH: 0.292 ± 0.024 (0.254–0.333) mm; MGr: 0.001 ± 0.002 (0–0.007) mm; SPST: 0.174 ± 0.014 (0.157–0.194) mm; SPL: 0.112 ± 0.015 (0.083–0.139) mm; PEL: 0.236 ± 0.025

(0.208–0.287) mm; PEH: 0.204 ± 0.015 (0.179–0.231) mm; PPL: 0.141 ± 0.010 (0.129–0.157) mm; PPH: 0.168 ± 0.012 (0.152–0.194) mm; USH: 9.385 ± 1.293 (6–10.5) mm; SPTI: 0.180 ± 0.019 (0.153–0.213) mm; SPWI: 0.191 ± 0.018 (0.159–0.224) mm; SPBA: 0.132 ± 0.019 (0.110–0.166) mm; PronW: 0.341 ± 0.022 (0.313–0.383) mm; PEW: 0.139 ± 0.013 (0.116–0.166) mm; PPW: 0.188 ± 0.014 (0.162–0.213) mm. See Table 1 for the indexes.

Big and robust species (mean CS 0.634 mm); polymorphism more pronounced than other Palearctic species, with a notable size difference between smaller and bigger specimens. Slightly bicolored species with brownish mesosoma and darker head, with slightly darkened antennal clubs and femora. Scapes relatively short (mean SL/CS 0.694). Eyes moderately large (mean EL/CS 0.244). Standing hairs on mesosoma relatively short (mean LMH/CS 0.081). Promesonotal groove distinct in dorsal view, especially in the bigger specimens (Fig 3D). Metanotal groove absent to

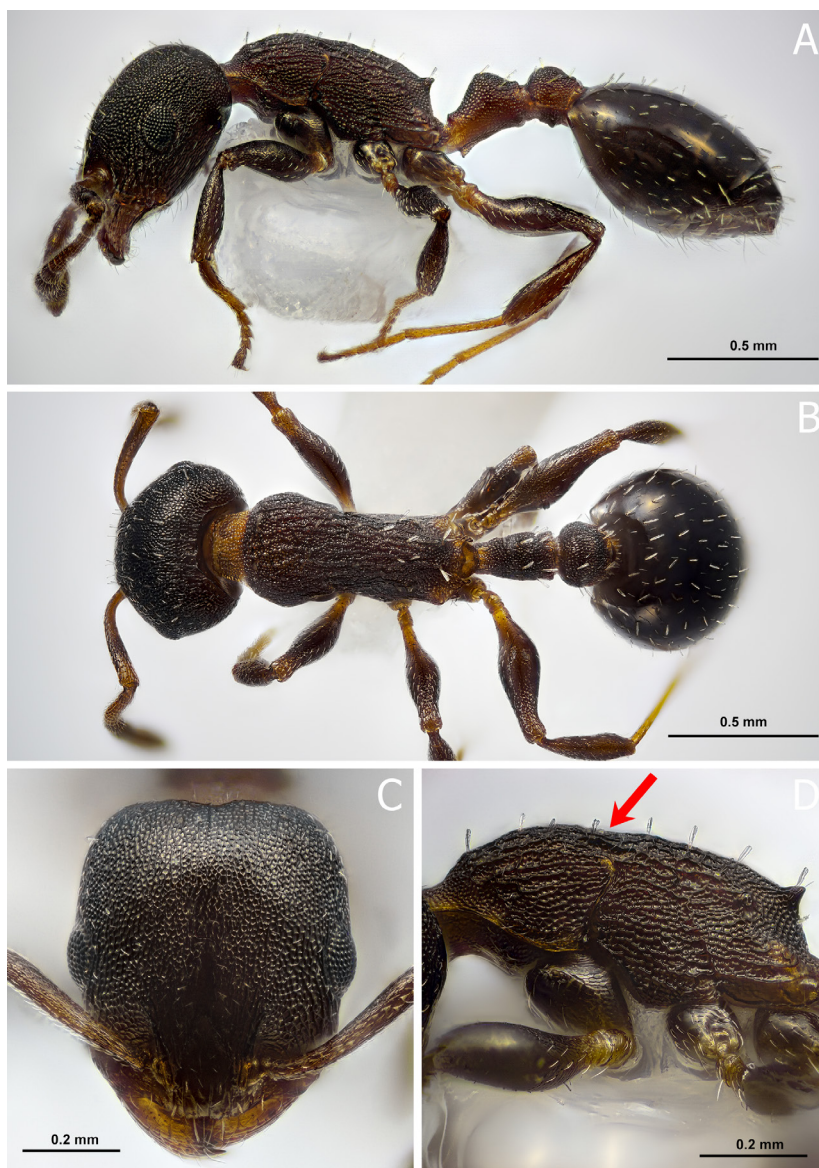


Fig 3. Worker of *T. convexus*. A: lateral view. B: dorsal view. C: frontal view. D: detail of mesosoma, with the distinct short pilosity and pronounced promesonotal furrow (red arrow).

very shallow (mean MGr/CS 0.104%). Mesosoma profile concave, with a pronounced decline of the dorsal profile line near the propodeal spines (see Fig 3A). Propodeal spines strongly reduced to triangular teeth (mean SPST/CS 0.205) and relatively close in dorsal view (mean SPWI/CS 0.187) (see Fig 3B). Subpetiolar process short but distinct. Petiole long (mean PEL/CS 0.408) and low (mean PEH/CS 0.339), with rounded apex; some specimens may show a slightly truncated apex. Sculpture of head consisting of reticulate ground sculpture with shallow superimposed longitudinal striae, with absent or very narrow smooth median region on frons (Fig 3C). Mesosoma with reticulate ground sculpture and strong longitudinal striae, especially pronounced on sides of pronotum and dorsum. When comparing the measured individuals from Lisbon and Cádiz, mean indexes are concordant. The morphologic coincidence of these two samples with the imaged syntype of *T. convexus* from Forêt de Msila (Algeria) (CASENT0909022) is also complete. Note that a noticeable difference in propodeal spine length is found between both sides of an important number of workers, which highlights the necessity of measuring both spines in this species.

Gyne diagnosis

Two specimens from Lisbon were available for measuring (same collection data as workers) and indexes are presented in Table 1. Measurements (n = 2): 0.695 ± 0.013; HL 0.709 ± 0.020 (0.695, 0.723) mm; HWb 0.681 ± 0.007 (0.677, 0.686) mm; PoOC 0.265 ± 0.005 (0.262, 0.269) mm; FRS 0.232 ± 0.000 (0.232, 0.232) mm; SL 0.459 ± 0.013 (0.450, 0.468) mm; EL 0.197 ± 0.003 (0.195, 0.199) mm; L1F 0.199 ± 0.013 (0.190, 0.209) mm; LMH 0.079 ± 0.000 (0.079, 0.079) mm; ML 1.129 ± 0.003 (1.126, 1.131) mm; MH 0.637 ± 0.029 (0.616, 0.658) mm; SPST 0.139 ± 0.000 (0.139, 0.139) mm; PEL 0.311 ± 0.007 (0.306, 0.315) mm; PEH 0.229 ± 0.003 (0.227, 0.232) mm; PPL 0.204 ± 0.013 (0.195, 0.213) mm; PPH 0.248 ± 0.010 (0.241, 0.255) mm; SPWI 0.209 ± 0.007 (0.204, 0.213) mm; SPBA 0.209 ± 0.007 (0.204, 0.213) mm; PronW 0.649 ± 0.000 (0.649, 0.649) mm; PEW 0.199 ± 0.007 (0.195, 0.204) mm; PPW 0.287 ± 0.000 (0.287, 0.287) mm.

Gynes are visually bigger than other Palearctic species of the genus (mean CS 0.120 mm). Head dorsum brownish with slightly darkened antennal clubs and femora; mesosoma brownish with yellowish areas. Note that gynes can be both uniformly dark or bicolored according to Guillem and Bensusan (2019). Our specimens have yellowish pronotum and the rest of the mesosoma brownish. Mesosoma curved, with convex scutum and scutellum in lateral view. Scape relatively short (mean SL/CS 0.660). Standing hairs on mesosoma short (mean LMH/CS 0.113). Mesosoma profile slightly concave. Propodeal spines strongly reduced to two obtuse angles, without distinct denticles. Subpetiolar process short but distinct. Petiole very long (mean PEL/CS 0.447) and low (mean PEH/CS 0.330), with rounded apex. Sculpture of head consisting

of reticulate ground sculpture with shallow superimposed longitudinal striae. Mesosoma with reticulate ground sculpture and strong longitudinal striae, especially pronounced on sides of pronotum and scutum.

Discussion

T. convexus was originally described from Algeria (Forel, 1894). Emery (1915) described *Leptothorax submuticus* from Tangier (Morocco), which was later synonymized with *T. convexus* (Cagniant & Espadaler, 1997). Recently, Guillem and Bensusan (2019) recorded it from several locations in Gibraltar and Cádiz (South Iberia). A map with all known records of *T. convexus* is presented in Figure 1. In its revision of the *Temnothorax* from Morocco, Cagniant and Espadaler (1997) couldn't find any *T. convexus* sample in the region and raised the possibility of the species representing a teratogenic form of *T. atlantis* (Santschi, 1911). According to Galkowski and Cagniant (2017), *T. convexus* has not been located again in the type locality. The population from Cap Espartel (Morocco), described as *Leptothorax convexus* var. *timida* (Santschi, 1912), was synonymized under *T. algiricus* (Forel, 1894) by Cagniant and Espadaler (1997); however, the imaged worker holotype (CASENT0912920) strongly recalls the general appearance of *T. convexus* and does not match the concept of *T. algiricus*, a taxon with long propodeal spines and triangular petiole, instead of short propodeal spines and rounded petiolar node as seen in the mentioned type.

In Iberia, its closest relatives based on the morphology of the worker and gyne castes are *T. angustulus* (Nylander, 1856), *T. aveli* (Bondroit, 1918), *T. continentalis* Galkowski and Cagniant, 2017, *T. corticalis* (Schenck, 1852) and *T. nadigi* (Kutter, 1925). These are mostly arboreal species that have coarse sculpture on the mesosoma and short to medium length propodeal spines. A comparison between all five species and *T. convexus* is presented in Table 2. In general terms, the length of the propodeal spines, which are extremely reduced in *T. convexus*, could exclude *T. angustulus* and *T. continentalis* from the differential diagnosis of the worker caste, since they are usually longer and curved; the petiolar shape is also very different in *T. convexus*. The workers of the species *T. aveli* and *T. corticalis* are typically of yellowish mesosoma, thus differentiating them easily from the dark brown mesosoma of *T. convexus*. Furthermore, in this species the petiole is short and triangular, while in *T. convexus* it is long and of rounded apex. It should be noted that the presence of the species *T. corticalis* in Iberia is dubious, since it has not been found in the region in the last 30 years (since De Haro & Collingwood, 1991), which raises the possibility of a misidentification with *T. aveli* or other closely-related arboreal species, especially since some records are based on the gyne caste only (Collingwood & Yarrow, 1969), which is very similar in both taxa. Interestingly, *T. convexus* and *T. nadigi* are two apparently unrelated species that share some uncommon traits within the Iberian members of the genus

Table 1. Indexes of *T. convexus* workers and gynes.

	<i>T. convexus</i> from Portugal (n = 7)	<i>T. convexus</i> from Cádiz (n = 3)	All worker specimens (n = 10)	Gynes from Portugal (n = 2)
CS	0.638 ± 0.056 [0.577, 0.742]	0.626 ± 0.025 [0.598, 0.644]	0.634 ± 0.048 [0.577, 0.742]	0.695 ± 0.013 [0.686, 0.704]
CL/CWb	1.130 ± 0.031 [1.078, 1.172]	1.145 ± 0.061 [1.075, 1.186]	1.135 ± 0.039 [1.075, 1.186]	1.041 ± 0.019 [1.027, 1.054]
PoOC/CL	0.377 ± 0.010 [0.364, 0.392]	0.361 ± 0.012 [0.351, 0.375]	0.373 ± 0.013 [0.351, 0.392]	0.374 ± 0.003 [0.372, 0.377]
FRS/CS	0.318 ± 0.013 [0.304, 0.337]	0.341 ± 0.010 [0.331, 0.350]	0.325 ± 0.016 [0.304, 0.350]	0.333 ± 0.006 [0.329, 0.338]
SL/CS	0.690 ± 0.008 [0.681, 0.702]	0.704 ± 0.015 [0.691, 0.721]	0.694 ± 0.012 [0.681, 0.721]	0.660 ± 0.031 [0.638, 0.682]
EL/CS	0.245 ± 0.013 [0.233, 0.269]	0.241 ± 0.010 [0.233, 0.252]	0.244 ± 0.012 [0.233, 0.269]	0.283 ± 0.001 [0.283, 0.284]
L1F/CS	0.338 ± 0.021 [0.294, 0.361]	0.336 ± 0.007 [0.331, 0.341]	0.337 ± 0.019 [0.294, 0.361]	0.287 ± 0.024 [0.270, 0.304]
LMH /CS	0.081 ± 0.006 [0.076, 0.091]	-	0.081 ± 0.006 [0.076, 0.091]	0.113 ± 0.002 [0.112, 0.115]
ML/CS	1.269 ± 0.031 [1.221, 1.325]	1.264 ± 0.014 [1.255, 1.281]	1.267 ± 0.027 [1.221, 1.325]	1.264 ± 0.035 [1.559, 1.649]
MH/CS	0.554 ± 0.009 [0.540, 0.563]	0.544 ± 0.015 [0.527, 0.558]	0.551 ± 0.011 [0.527, 0.563]	0.917 ± 0.060 [0.875, 0.959]
MGr/CS	0.149 ± 0.124 [0.070, 0.402]	0.000 ± 0.000 [0.000, 0.000]	0.104 ± 0.125 [0.070, 0.402]	-
SPST/CS	0.202 ± 0.009 [0.193, 0.219]	0.212 ± 0.010 [0.201, 0.219]	0.205 ± 0.010 [0.193, 0.219]	0.200 ± 0.004 [0.197, 0.203]
PEL/CS	0.408 ± 0.015 [0.389, 0.426]	0.407 ± 0.027 [0.388, 0.438]	0.408 ± 0.018 [0.388, 0.438]	0.447 ± 0.018 [0.434, 0.459]
PEH/CS	0.338 ± 0.009 [0.327, 0.351]	0.340 ± 0.018 [0.326, 0.360]	0.339 ± 0.011 [0.326, 0.360]	0.330 ± 0.011 [0.322, 0.338]
PEW/CS	0.272 ± 0.026 [0.248, 0.325]	0.261 ± 0.013 [0.248, 0.273]	0.269 ± 0.022 [0.248, 0.325]	0.287 ± 0.004 [0.284, 0.289]
PPL/CS	0.241 ± 0.004 [0.232, 0.244]	0.257 ± 0.006 [0.252, 0.264]	0.246 ± 0.009 [0.232, 0.264]	0.294 ± 0.024 [0.276, 0.311]
PPH/CS	0.319 ± 0.017 [0.304, 0.350]	0.318 ± 0.022 [0.295, 0.338]	0.319 ± 0.017 [0.295, 0.350]	0.357 ± 0.007 [0.351, 0.362]
PPW/CS	0.363 ± 0.030 [0.335, 0.425]	0.365 ± 0.009 [0.357, 0.374]	0.364 ± 0.025 [0.335, 0.425]	0.413 ± 0.008 [0.408, 0.419]
SPWI/CS	0.191 ± 0.022 [0.171, 0.238]	0.178 ± 0.009 [0.171, 0.187]	0.187 ± 0.020 [0.171, 0.238]	0.300 ± 0.004 [0.297, 0.303]
PronW/CS	0.623 ± 0.027 [0.589, 0.675]	0.622 ± 0.023 [0.605, 0.647]	0.622 ± 0.024 [0.589, 0.675]	0.933 ± 0.018 [0.921, 0.946]
USH/CS	18.435 ± 3.054 [15.142, 0.223]	-	18.435 ± 3.054 [15.142, 24.948]	-
SPBA	0.185 ± 0.017 [0.171, 0.223]	0.165 ± 0.013 [0.155, 0.180]	0.179 ± 0.018 [0.155, 0.223]	0.300 ± 0.004 [0.297, 0.303]

Temnothorax, including greatly reduced propodeal spines, coarse striation on mesosoma and low petiole, and to some extent the characteristic convex mesosoma. However, they are easily separated based again on the typical yellowish aspect of

the mesosoma of *T. nadigi* and its long-standing hairs on the mesosoma, compared to the very short hairs of *T. convexus*, and also by the low and truncated petiole of *T. nadigi* against the rounded and massive petiolar node of *T. convexus*.

Table 2. Morphological differences between the worker caste of *T. convexus* and its most similar species in Iberia.

<p><i>Temnothorax convexus</i> (Forel, 1894) Head entirely reticulated, with superficial superimposed longitudinal striae on frons. Propodeal spines reduced to short denticles. Petiolar apex rounded. Metanotal groove absent to shallow. Mesosoma convex in lateral view. Bicolored with lighter mesosoma and slightly reddish pronotum.</p>	vs.	<p><i>Temnothorax angustulus</i> (Nylander, 1856) and <i>Temnothorax continentalis</i> Galkowski & Cagniant, 2017 Posterior half of the head mostly smooth and shiny, with superimposed longitudinal striae on frons. Propodeal spines triangular and distinct. Petiolar apex distinctly triangular. Metanotal groove usually distinct in profile view. Mesosoma flat in lateral view. Concolorous mesosoma in the case of <i>T. angustulus</i> and markedly reddish in <i>T. continentalis</i>.</p>
<p><i>Temnothorax convexus</i> (Forel, 1894) Petiole apex rounded. Hairs on mesosoma short. Workers of dark coloration and lighter brownish mesosoma.</p>	vs.	<p><i>Temnothorax aveli</i> (Bondroit, 1918) Petiole apex triangular. Hairs on mesosoma long. Workers usually bicolored, with a dark brown head and yellowish mesosoma.</p>
<p><i>Temnothorax convexus</i> (Forel, 1894) Petiole in lateral view long and rounded. Species of dark brown coloration, with brownish mesosoma and occasional reddish pronotum.</p>	vs.	<p><i>Temnothorax corticalis</i> (Schenck, 1852) Petiole in lateral view short and triangular Bicolored species with yellowish mesosoma and darker head.</p>
<p><i>Temnothorax convexus</i> (Forel, 1894) Antennal club not markedly darkened. Sculpture of head uniform, frons included. Hairs on mesosoma short. Bicolored with brownish mesosoma and darker head and gaster, occasionally with reddish pronotum. Petiole apex usually rounded.</p>	vs.	<p><i>Temnothorax nadigi</i> (Kutter, 1925) Antennal club clearly darkened. Sculpture of frons reduced, with a smooth and shiny medium strip. Hairs on mesosoma longer. Bicolored with yellowish mesosoma and darker head. Petiole apex usually truncated.</p>

The gyne caste of *T. convexus* is also very distinct. Gynes of *T. angustulus* and *T. continentalis* have well developed propodeal spines, of triangular aspect and wide base, and the shape of the petiole is high and triangular, contrasting with the almost absent propodeal spines and low and rounded petiolar node of *T. convexus*. On the other hand, gynes of *T. aveli*, *T. convexus*, *T. corticalis* and *T. nadigi* have very reduced propodeal spines. From *T. aveli*, the gyne of *T. convexus* is distinguished by the overall darker coloration (usually light brown mesosoma in *T. aveli*) and the reduction of the propodeal spines to two very obtuse angles (small denticles in *T. aveli*). The gyne of *T. convexus* is easily separated from *T. corticalis* based on the low and long petiole of the first in contrast with the high and short triangular petiole of the later (Seifert, 2018). The most similar gyne is found in the species *T. nadigi*, but the pilosity is significantly longer and the antennal clubs are darkened in the case of *T. nadigi*, while they are not distinctly darkened in *T. convexus*. The curved mesosoma is also found to some extent in the gyne caste of *T. convexus*, which is a very prominent feature within the Iberian *Temnothorax* gynes.

We suspect that the record of *T. atlantis* (Santschi, 1911) from Portugal that appears in Henin et al. (2000) could actually be *T. convexus*. We base this assumption on the following facts: (1) the locality where *T. atlantis* was found is at some 60 km from our new record of *T. convexus*, (2) the species *T. atlantis* is similar to *T. convexus* based on the morphology of the worker caste and a misidentification with the latter is plausible, especially when *T. convexus* was apparently not considered in the differential diagnosis by these authors, (3) the authors of the paper state that the shape

of the petiole is not coincident with the original description of *T. atlantis* since it is “more concave”, a feature that matches the petiole shape of *T. convexus*, (4) the fact that *T. atlantis* is a North African species and its dubious presence in Iberia is solely based on the Portuguese record and (5) there is no other Iberian species similar to *T. atlantis* apart from *T. convexus* and so the possibility of a third species being involved in the differential diagnosis is very unlikely. A visit by the second author (3.VI.21) to the area where *T. atlantis* was originally recorded did not provide any sample of *Temnothorax*. On the contrary, the area was found to be infested by *Linepithema humile* (Mayr, 1868), an invasive exotic species which could have in fact eradicated any *Temnothorax* population inhabiting the locality. However, more effort is needed to assess this possibility, as *T. convexus* appears to be an uncommon species even in the areas where it is present (Guillem & Bensusan, 2019).

Since the checklist published by Salgueiro (2002a), who recognized 106 species of ants in continental Portugal, the discovery of new species in the country has not stopped. The addition of *T. convexus* to the Portuguese ant fauna follows this trend. The species that have been located in the country are summarized in Table 3, raising the final number of continental Portuguese ants to 132. Note that the list presented by Salgueiro (2002a) would currently contain 105 species instead of 106, since *Camponotus figaro* Collingwood & Yarrow, 1969 was synonymized by Seifert (2019) under the species *C. piceus* (Leach, 1825), which was also recorded in the region. Other new nomenclatural changes affecting the Portuguese fauna are worth mentioning here. The identity of the species integrating the *Tapinoma*

nigerrimum species-complex should be carefully studied, as the old records of *T. nigerrimum* (Nylander, 1856) could actually represent more than one species and not necessarily the true *T. nigerrimum* (see Seifert et al., 2017); thus, the only confirmed species of the complex in Portugal for the time being is *T. ibericum* Santschi, 1925. The recorded species *T. ambiguum* Emery, 1925 is currently considered a junior synonym of *T. madeirense* Forel, 1985 (see Seifert, 2012a). The Iberian records of *C. sicheli* Mayr, 1866 should be treated as *C. ruber* Emery, 1925 according to Cagniant (1996). The species *Camponotus truncatus* (Spinola, 1808) is now named *Colobopsis truncata* (Spinola, 1808) (see Ward et al., 2016); however, note that after the description of the similar species *Colobopsis imitans* (Schifani et al., 2021) there are no reliable records of *C. truncata* in the territory, and although its presence in Portugal is most plausible, we have preferred to exclude it from the checklist until its existence in the region is confirmed. The species *Bothriomyrmex saundersi* Santschi, 1922, recorded by Espadaler et al. (2008), was considered as *incertae sedis* by Seifert (2012b), since neither types nor terra typica were known. However, the latter author overlooked the types of its junior synonym *B. rogeri* Emery, 1924, which was described from Benaolán (Málaga); until this typical material is not examined, we have decided to maintain *B. saundersi* in the checklist. The *Proformica* sp. record in Tinaut and Ruano (1994) could represent a new species for Iberia based on the male genitalia and the worker and queen morphology according to these authors, so we have listed it as a potential species different from the other two *Proformica* species recorded in Portugal. The species *Formica subrufa* Roger, 1859 now belongs to the genus *Iberoformica* (see Gómez et al., 2018). The species *Pyramica argiola* (Emery, 1869) is currently inside the genus *Strumigenys* (see Baroni Urbani & De Andrade, 2007). The majority of the *Leptothorax* species recorded from Portugal in Salgueiro (2002a) were later transferred to the genus *Temnothorax* (see Bolton, 2003), with the exception of *L. acervorum* (Fabricius, 1793). The recently described *T. alfacarensis* (Tinaut & Reyes-López, 2020) was already recorded as *Temnothorax* sp. in Espadaler et al. (2008). Previous records of *T. specularis* (Emery, 1916) should now be treated as *T. exilis* (Emery, 1869) according to Salata et al. (2018). The species *T. rabaudi* (Bondroit, 1918) was synonymized under *T. aveli* (Bondroit, 1918) (see Casevitz-Weulersse & Galkowski, 2009). The species *Leptothorax caparica* (described by Henin et al., 2001) is currently considered a junior synonym of *Cardiocondyla mauritanica* Forel, 1890 according to Henin et al. (2003). The ant *Messor structor* (Latreille, 1798) was split into five species, with only *M. ibericus* Santschi, 1925 being so far reported from Iberia and a very low probability of the true *M. structor* occurring in Portugal; we therefore provisionally assign the old records to *M. ibericus* and exclude *M. structor* from the checklist. The species *Tetramorium caespitum* (Linnaeus, 1758) was recently discovered to represent a cryptic group

containing several species in Iberia (Wagner et al., 2017); until the identity of these samples is confirmed, we treat the records of *T. caespitum* and *T. impurum* (Forster, 1950) as *Tetramorium* sp. (*caespitum* complex). The species *T. ruginode* Stitz, 1917 was synonymized under *T. forte* Forel, 1904 by Güsten et al. (2006). The following species are noted from Portugal in Borowiec and Salata (2012) and Radchenko (2004) but the original reference or record has not been found in the present paper and are therefore not counted in our updated checklist: *Aphaenogaster subterranea* (Latreille, 1798), *A. testaceopilosa* (Lucas, 1849), *Cataglyphis cursor* (Fonscolombe, 1846), *Cryptopone ochracea* (Mayr, 1855), *Lasius neglectus* Van Loon, Boomsma & Andrasfalvy, 1990, *Liometopum microcephalum* (Panzer, 1798), *Pheidole indica* Mayr, 1879 and *T. subboreale* Seifert, 2012. Finally, it should be noted that the record of *Stenammina sardoum* Emery, 1915 from Portugal probably represents a misidentification with *S. debile* (Foerster, 1850) or *S. westwoodi* Westwood, 1839, as the first is apparently a Sardinian endemic (Rigato, 2011), and is therefore excluded from the checklist.

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Table 3. Complete checklist of continental Portuguese ant fauna, combining that of Sagueiro (2002a) and posterior additions. Nomenclatural changes proposed after 2002 have been applied to the names.

Subfamily	Species	Added species after Sagueiro (2002a)
Amblyoponinae	<i>Stigmatomma gaeticum</i> (Baroni Urbani, 1978)	Boieiro et al. (2002)
	<i>Bothriomyrmex meridionalis</i> (Roger, 1863)	
	<i>Bothriomyrmex saundersi</i> (Santschi, 1922)	Espadaler et al. (2008)
	<i>Dolichoderus quadripunctatus</i> (Linnaeus, 1771)	
Dolichoderinae	<i>Linepithema humile</i> (Mayr, 1868)	
	<i>Tapinoma erraticum</i> (Latreille, 1798)	
	<i>Tapinoma ibericum</i> (Santschi, 1925)	Seifert et al. (2017)
	<i>Tapinoma madeirense</i> (Forel, 1895)	
	<i>Tapinoma simrothi</i> (Krausse, 1911)	
	<i>Camponotus aethiops</i> (Latreille, 1798)	
	<i>Camponotus barbaricus</i> (Emery, 1905)	
	<i>Camponotus cruentatus</i> (Latreille, 1802)	
	<i>Camponotus fallax</i> (Nylander, 1856)	
	<i>Camponotus foreli</i> (Emery, 1881)	
	<i>Camponotus gestroi</i> (Emery, 1878)	
	<i>Camponotus lateralis</i> (Olivier, 1792)	
	<i>Camponotus micans</i> (Nylander, 1856)	
	<i>Camponotus piceus</i> (Leach, 1825)	
	<i>Camponotus pilicornis</i> (Roger, 1859)	
	<i>Camponotus ruber</i> (Emery, 1925)	
	<i>Camponotus sylvaticus</i> (Olivier, 1792)	
	<i>Camponotus vagus</i> (Scopoli, 1763)	
	<i>Cataglyphis hispanica</i> (Emery, 1906)	
	<i>Cataglyphis iberica</i> (Emery, 1906)	
Formicinae	<i>Colobopsis imitans</i> (Schifani et al., 2021)	Schifani et al. (2021)
	<i>Formica cunicularia</i> (Latreille, 1798)	
	<i>Formica decipiens</i> (Bondroit, 1918)	
	<i>Formica frontalis</i> (Santschi, 1919)	
	<i>Formica fusca</i> (Linnaeus, 1758)	
	<i>Formica gerardi</i> (Bondroit, 1917)	
	<i>Formica pratensis</i> (Retzius, 1783)	
	<i>Formica rufa</i> (Linnaeus, 1761)	
	<i>Formica rufibarbis</i> (Fabricius, 1793)	
	<i>Formica sanguinea</i> (Latreille, 1798)	
	<i>Iberoformica subrufa</i> (Roger, 1859)	
	<i>Lasius alienus</i> (Foerster, 1850)	
	<i>Lasius brunneus</i> (Latreille, 1798)	
	<i>Lasius emarginatus</i> (Olivier, 1792)	
	<i>Lasius flavus</i> (Fabricius, 1782)	

Table 3. Complete checklist of continental Portuguese ant fauna, combining that of Sagueiro (2002a) and posterior additions. Nomenclatural changes proposed after 2002 have been applied to the names. (Continuation)

Subfamily	Species	Added species after Sagueiro (2002a)
	<i>Messor ibericus</i> (Latreille, 1798)	
	<i>Messor lusitanicus</i> (Tinaut, 1985)	
	<i>Messor maroccanus</i> (Santschi, 1927)	
	<i>Monomorium carbonarium</i> (Smith, 1858)	
	<i>Monomorium pharaonis</i> (Linnaeus, 1758)	
	<i>Monomorium subopacum</i> (Smith, 1858)	
	<i>Myrmecina graminicola</i> (Latreille, 1802)	
	<i>Myrmica aloba</i> (Forel, 1909)	
	<i>Myrmica rubra</i> (Linnaeus, 1758)	
	<i>Myrmica ruginodis</i> (Nylander, 1846)	
	<i>Myrmica sabuleti</i> (Meinert, 1861)	
	<i>Myrmica scabrinodis</i> (Nylander, 1846)	
	<i>Myrmica specioides</i> (Bondroit, 1918)	
	<i>Myrmica wesmaeli</i> (Bondroit, 1918)	Salgueiro (2002b)
	<i>Myrmoxenus kraussei</i> (Emery, 1915)	Borowiec & Salata (2017)
	<i>Oxyopomyrmex saulcyi</i> (Emery, 1889)	Boieiro et al. (2002)
	<i>Pheidole pallidula</i> (Nylander, 1849)	
	<i>Solenopsis fugax</i> (Latreille, 1798)	
	<i>Solenopsis latro</i> (Forel, 1894)	
	<i>Solenopsis lusitanica</i> (Emery, 1915)	
Myrmicinae	<i>Solenopsis monticola</i> (Bernard, 1950)	
	<i>Solenopsis oraniensis</i> (Forel, 1894)	
	<i>Stenammas debile</i> (Forster, 1850)	Salgueiro (2002b)
	<i>Stenammas westwoodii</i> (Westwood, 1839)	Garcia et al. (2015)
	<i>Strongylognathus caeciliae</i> (Forel, 1897)	Gonçalves et al. (2014)
	<i>Strongylognathus huberi</i> (Forel, 1874)	
	<i>Strumigenys silvestrii</i> (Emery, 1906)	Boieiro et al. (2009)
	<i>Temnothorax affinis</i> (Mayr, 1855)	
	<i>Temnothorax albipennis</i> (Curtis, 1854)	Boieiro et al. (2009)
	<i>Temnothorax alfacarensis</i> (Tinaut & Reyes-López, 2020)	Espadaler et al. (2008)
	<i>Temnothorax angustulus</i> (Nylander, 1856)	Peira et al. (2002)
	<i>Temnothorax atlantis</i> (Santschi, 1911)	
	<i>Temnothorax aveli</i> (Bondroit, 1918)	
	<i>Temnothorax clypeatus</i> (Mayr, 1853)	
	<i>Temnothorax convexus</i> (Forel, 1894)	Present work
	<i>Temnothorax corticalis</i> (Schenck, 1852)	
	<i>Temnothorax exilis</i> (Emery, 1916)	
	<i>Temnothorax formosus</i> (Santschi, 1909)	Salgueiro (2003)
	<i>Temnothorax luteus</i> (Forel, 1874)	Borowiec & Salata (2017)
	<i>Temnothorax nylanderi</i> (Foerster, 1850)	
	<i>Temnothorax pardoii</i> (Tinaut, 1987)	

Table 3. Complete checklist of continental Portuguese ant fauna, combining that of Salgueiro (2002a) and posterior additions. Nomenclatural changes proposed after 2002 have been applied to the names. (Continuation)

Subfamily	Species	Added species after Salgueiro (2002a)
Myrmicinae	<i>Temnothorax parvulus</i> (Schenck, 1852)	Espadaler et al. (2008)
	<i>Temnothorax racovitzai</i> (Bondroit, 1918)	
	<i>Temnothorax recedens</i> (Nylander, 1856)	
	<i>Temnothorax tuberum</i> (Fabricius, 1775)	
	<i>Temnothorax tyndalei</i> (Forel, 1909)	Gonçalves et al. (2014)
	<i>Temnothorax unifasciatus</i> (Latreille, 1798)	
	<i>Tetramorium biskrense</i> (Forel, 1904)	Espadaler & Gómez (2014)
	<i>Tetramorium forte</i> (Forel, 1904)	
Ponerinae	<i>Tetramorium semilaeve</i> (André, 1883)	
	<i>Tetramorium sp. (caespitum complex)</i>	
	<i>Hypoponera abeillei</i> (André, 1881)	Boeiro et al. (2002)
	<i>Hypoponera eduardi</i> (Forel, 1894)	
	<i>Hypoponera punctatissima</i> (Roger, 1859)	
	<i>Ponera coarctata</i> (Latreille, 1802)	

References

- Baroni Urbani, C. & De Andrade, M.L. (2007). The ant tribe Dacetini: limits and constituent genera, with descriptions of new species (Hymenoptera, Formicidae). *Annali del Museo Civico di Storia Naturale "Giacomo Doria"*, 99: 1-191.
- Boeiro, M., Espadaler X., Azedo A.R., Collingwood C. & Serrano A.R.M. (2009). One genus and three ants species new to Portugal (Hymenoptera, Formicidae). *Boletín de la Sociedad Entomológica Aragonesa*, 45: 515-517.
- Boeiro, M.R.C., Espadaler, X., Azedo, A.R. & Serrano, A.M. (2002). Four new species to the ant fauna of Portugal (Hymenoptera, Formicidae). *Boletim da Sociedade Portuguesa de Entomologia*, 7: 253-259.
- Bolton, B. (2003). Synopsis and classification of Formicidae. *Memoirs of the American Entomological Institute*, 71:1-370.
- Borowiec L. & Salata S. (2012). Ants of Greece - Checklist, comments and new faunistic data (Hymenoptera: Formicidae). *Genus (Wroclaw)*, 23: 461-563.
- Borowiec L. & Salata S. (2017). New records of ants (Hymenoptera: Formicidae) from southern Portugal. *Acta Entomologica Silesiana*, 25: 1-10. doi: 10.5281/zenodo.834177
- Borowiec L. (2014). Catalogue of ants of Europe, the Mediterranean Basin and adjacent regions (Hymenoptera: Formicidae). *Genus (Wroclaw)*, 25: 1-340.
- Branstetter M.G. (2012). Origin and diversification of the cryptic ant genus *Stenammina* Westwood (Hym.: Formicidae), inferred from multilocus molecular data, biogeography and natural history. *Systematic Entomology*, 37: 478-496.
- Cagniant H. & Espadaler X. (1997). Les *Leptochothorax*, *Epimyrmica* et *Chalepoxenus* du Maroc (Hymenoptera: Formicidae). Clé et catalogue des espèces. *Annales de la Société Entomologique de France (n.s.)*, 33: 259-284.
- Cagniant, H. (1996). Étude des populations d'*Aphaenogaster* (supersp.) *praedo* Em. du Maroc. Nouvelles localités d'*Aphaenogaster* marocaines. *Camponotus ruber* Forel, 1894 bona species. (Hymenoptera, Formicidae). *Bulletin de la Société Zoologique de France*, 121: 237-254.
- Casevitz-Weulersse, J., Galkowski, C. (2009). Liste actualisée des fourmis de France (Hymenoptera, Formicidae). *Bulletin de la Société Entomologique de France*, 114: 475-510.
- Collingwood, C.A. & Yarrow, I.H.H. (1969). A survey of Iberian Formicidae (Hymenoptera). *EOS. Revista Española de Entomología*, 44: 53-101.
- De Haro, A. & Collingwood, C.A. (1991). Prospección mirmecológica en la Cordillera Ibérica. *Orsis*, 6: 129-126.
- Emery, C. (1915). Contributo alla conoscenza delle formiche delle isole italiane. Descrizione di forme mediterranee nuove o critiche. *Annali del Museo Civico di Storia Naturale*, 46: 244-270.
- Espadaler, X. & Franch, J. (1978). *Leptochothorax nadigi* Kutter, 1925 (Hym. Formicidae) en España. *Boletín de la Asociación Española de Entomología*, 1:161-162.
- Espadaler, X. & Gomez, K. (2014). *Tetramorium biskrense* Forel, 1904 in peninsular Spain and Portugal (Hymenoptera, Formicidae). *Boletín de la Sociedad Entomológica Aragonesa*, 55: 303-305.

- Espadaler, X., Boieiro, M., Azedo, R., Bernardes, C., Figueiredo, D. & Serrano, A.R.M. (2008). Additions to the ant Fauna of Portugal (Hymenoptera: Formicidae). *Boletín de la Sociedad Entomológica Aragonesa*, 42: 349-351.
- Forel, A. (1894). Les Formicides de la Province d'Oran (Algérie). *Bulletin de la Société Vaudoise des Sciences Naturelles*, 30: 1-45.
- Galkowski, C. & Cagniant, H. (2017). Contribution à la connaissance des fourmis du groupe *angustulus* dans le genre *Temnothorax* (Hymenoptera, Formicidae). *Revue de l'Association Roussillonnaise d'Entomologie*, 26: 180-191.
- García, F., Espadaler, X., Serrano, A. & Boieiro, M. (2015). New records for *Stenammina westwoodii* Westwood, 1839 (Hymenoptera: Formicidae) from the Iberian Peninsula. *Boletín de la Sociedad Entomológica Aragonesa (S.E.A.)*, 56: 203-206.
- Gómez, A. & Lunt, D.H. (2007). Refugia within Refugia: Patterns of Phylogeographic Concordance in the Iberian Peninsula. In: S. Weiss & N. Ferrand (Eds.), *Phylogeography of Southern European Refugia: Evolutionary perspectives on the origins and conservation of European biodiversity* (pp. 155-188). Dordrecht: Springer Netherlands. doi: 10.1007/1-4020-4904-8_5
- Gómez, K., Lorite, P., García, F., Tinaut, A., Espadaler, X., Palomeque, T., Sanlloriente, O., Trager, J. (2018). Differentiating *Iberoformica* and *Formica* (*Serviformica*) with description of the sexual castes of *Formica* (*Serviformica*) *gerardi* Bondroit, 1917 stat. rev. *Sociobiology*, 65: 463-470. doi: 10.13102/sociobiology.v65i3.3315
- Gonçalves, C., Espadaler, X., Pereira, J.A., Santos, S. & Patanita, M.I. (2014). Primeiros registos das espécies *Strongylognathus caeciliae* Forel, 1897 e *Temnothorax tyndalei* (Forel, 1909) (Hymenoptera, Formicidae) em Portugal Continental. *Boletín de la Sociedad Entomológica Aragonesa (S.E.A.)*, 54: 402.
- Guénard, B., Weiser, M., Gomez, K., Narula, N. & Economo, E.P. (2017). The Global Ant Biodiversity Informatics (GABI) database: a synthesis of ant species geographic distributions. *Myrmecological News*, 24: 83-89.
- Guillem, R. & Bensusan, K. (2019). Two new species of ants (Hymenoptera: Formicidae) for Europe from southern Iberia. *Revista de la Sociedad Gaditana de Historia Natural*, 13: 5-10.
- Güsten, R., Schulz, A., Sanetra, M. (2006). Redescription of *Tetramorium forte* Forel, 1904 (Insecta: Hymenoptera: Formicidae), a western Mediterranean ant species. *Zootaxa*, 1310: 1-35.
- Henin, J.M., Collingwood, C.A., Paiva, M.R. (2003). Synonymy between *Leptothorax caparica* Henin, Paiva & Collingwood, 2001 and *Cardiocondyla mauritanica* Forel, 1890 (Hymenoptera, Formicidae). *Boletim da Sociedade Portuguesa de Entomologia*, 211: 377-378.
- Henin, J.M., Paiva, M.R. & Collingwood, C.A. (2001). The Iberian *Leptothorax* Mayr, 1855 (Hymenoptera, Formicidae): Discovery of a new species and first record of *L. atlantis* Santschi, 1911. *Boletim da Sociedade Portuguesa de Entomologia*, 7: 161-166.
- Janicki, J., Narula, N., Ziegler, M., Guénard, B. & Economo, E.P. (2016). Visualizing and interacting with large-volume biodiversity data using client-server web-mapping applications: The design and implementation of antmaps.org. *Ecological Informatics*, 32: 185-193.
- Obregón, R. & Reyes, L. (2012). New contribution of exotic ants from Portugal (Hymenoptera: Formicidae). *Boletín de la Asociación Española de Entomología*, 36 (3/4): 279-284.
- Pereira, J.A., Bento, A., Sousa, D., Campos, M. & Torres, L. (2002). Estudo preliminar sobre as formigas (Hymenoptera: Formicidae) associadas ao olival da Terra Quente Transmontana (Nordeste de Portugal). *Boletín de Sanidad Vegetal Plagas*, 28: 357-365.
- Radchenko, A. (2004). Fauna Europaea: Formicidae. In: Noyes, J. (Ed.): *Fauna Europaea: Hymenoptera*. – Fauna Europaea version 1.1: <<http://www.faunaeur.org>>, retrieved on 29 January 2021.
- Rigato, F. (2011). Contributions to the taxonomy of West European and North African *Stenammina* of the *westwoodii* species-group. (Hymenoptera Formicidae). *Memorie della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, 37: 1-56.
- Salata, S., Borowiec, L. & Trichas, A. (2018). Taxonomic revision of the Cretan fauna of the genus *Temnothorax* Mayr, 1861 (Hymenoptera: Formicidae), with notes on the endemism of ant fauna of Crete. *Annales Zoologici (Warsaw)*, 68: 769-808. doi: 10.3161/00034541ANZ2018.68.4.004
- Salgueiro, J. (2002a). Catálogo dos formicídeos de Portugal continental e ilhas. *Boletín de la Sociedad Entomológica Aragonesa*, 31: 145-171.
- Salgueiro, J. (2002b). Variação anual em três comunidades de formicídeos da Serra da Estrela. Adição de um género novo e de duas espécies novas para Portugal. *Boletín de la Asociación Española de Entomología*, 26: 121-131.
- Salgueiro, J. (2003). Primeiros registos de Formicídeos (Hymenoptera) para duas áreas protegidas portuguesas. Adição de duas novas espécies à mirmecofauna de Portugal. *Boletín de la Sociedad Entomológica Aragonesa*, 32: 109-110.
- Sánchez-García, D., Cuesta-Segura, D.A., Trigos-Peral, G., Arcos, J., Catarineu, C., García-García, F., Herraiz, J.A., Espadaler, X., Gómez, K. & Tinaut, A. Checklist of the Iberian Myrmecofauna, in preparation.
- Schifani, E., Giannetti, D., Csösz, S., Castellucci, F., Luchetti, A., Castracani, C., Spotti, F. A., Mori, A., Grasso, D. A. (2021). Is mimicry a diversification-driver in ants? Biogeography, ecology, ethology, genetics and morphology define a second

- West-Palaeartic *Colobopsis* species (Hymenoptera: Formicidae). Zoological Journal of the Linnean Society XX: 1-27. doi: 10.1093/zoolinnean/zlab035/6323347
- Seifert, B. (2003). The ant genus *Cardiocondyla* (Insecta: Hymenoptera: Formicidae) - A taxonomic revision of the *C. elegans*, *C. bulgarica*, *C. batesii*, *C. nuda*, *C. shuckardi*, *C. stambuloffi*, *C. wroughtoni*, *C. emeryi*, and *C. minutior* species groups. Annalen des Naturhistorischen Museums in Wien Serie B Botanik und Zoologie, 104: 203-338.
- Seifert, B. (2018). The ants of Central and North Europe. Boxberg, Lutra, 407 p.
- Seifert, B. (2012a). Clarifying naming and identification of the outdoor species of the ant genus *Tapinoma* Förster, 1850 (Hymenoptera: Formicidae) in Europe north of the Mediterranean region with description of a new species. Myrmecological News, 16: 139-147.
- Seifert, B. (2012b). A review of the West Palaeartic species of the ant genus *Bothriomyrmex* Emery, 1869 (Hymenoptera: Formicidae). Myrmecological News, 17: 91-104.
- Seifert, B. (2019). A taxonomic revision of the members of the *Camponotus lateralis* species group (Hymenoptera: Formicidae) from Europe, Asia Minor and Caucasia. Soil Organisms, 91: 7-32. doi: 10.25674/so-91-1-02
- Seifert, B., D'Eustacchio, D., Kaufmann, B.E., Centorame, M., Lorite, P. & Modica, V.M. (2017). Four species within the supercolonial ants of the *Tapinoma nigerrimum* complex revealed by integrative taxonomy (Hymenoptera: Formicidae). Myrmecological News, 24: 123-144.
- Tinaut, A. & Reyes-López, J.L. (2020). Descripción de una nueva especie para la península ibérica: *Temnothorax alfacarensis* n. sp. (Hymenoptera, Formicidae). Boletín de la Asociación Española de Entomología, 44: 359-378.
- Tinaut, A. & Ruano, F. (1994). Contribución al conocimiento de los formicidos de la Sierra de la Estrella (Portugal). Boletín de la Asociación Española de Entomología, 18: 97-99.
- Tinaut, A. & Ruano, F. (2021). Biogeography of Iberian Ants (Hymenoptera: Formicidae). Diversity, 13: 88. doi: 10.3390/d13020088.
- Wagner, H.C., Arthofer, W., Seifert, B., Muster, C., Steiner, F.M., Schlick-Steiner, B.C. (2017). Light at the end of the tunnel: Integrative taxonomy delimits cryptic species in the *Tetramorium caespitum* complex (Hymenoptera: Formicidae). Myrmecological News, 25: 95-129.
- Ward, P.S., Blaimer, B.B., Fisher, B.L. (2016). A revised phylogenetic classification of the ant subfamily Formicinae (Hymenoptera: Formicidae), with resurrection of the genera *Colobopsis* and *Dinomyrmex*. Zootaxa, 4072: 343-357.
- Zina, V. & Franco, J.C. (2015). Ecological diversity of ants (Hymenoptera, Formicidae) in Tapada da Ajuda, Portugal. Iberomyrmex, 7: 17-23.

