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Description of *Temnothorax estel* sp. nov. (Hymenoptera: Formicidae), with a review of the Iberian species of the *sordidulus* species-complex

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Abstract

A characteristically bicolored ant belonging to the *Temnothorax sordidulus* species-complex is described from mountainous habitats in Iberia and named *T. estel* **sp. nov.** Three additional and closely-related taxa are newly recognized as members of the complex, including the Iberian endemics *T. ibericus* (Menozzi, 1922) and *T. platycephalus* (Espadaler, 1997) and the Pyrenean *T. conatensis* Galkowski & Lebas, 2016. The taxonomy of all four species is reviewed and discussed within the Palearctic context. Images and an identification key are provided.

Key words: morphometry, new species, taxonomy, biogeography, Iberian Peninsula

Introduction

Temnothorax is a hyper-diverse genus of small and cryptically colored ants that tend to nest in preformed cavities (Prebus 2017). It represents the most speciose genus in the Palearctic region (Seifert 2006), but is still largely unexplored under modern taxonomic approaches. Recent revisions of some European species-groups (Csősz *et al*. 2014; Seifert *et al*. 2014; Csősz *et al*. 2015; Csősz *et al*. 2018) have revealed a significant number of previously unrecognized cryptic species, but more effort is needed targeting Iberian diversity: only 6.9% of the total samples examined in the previous papers were Iberian, and the Iberian material was mostly from NE Iberia. As a result, the taxonomic identity of many *Temnothorax* species from this territory remains obscure and disconnected from the Palearctic context.

Progress has been made establishing species groups and species complexes among the Palearctic *Temnothorax*. One of these is the *Temnothorax sordidulus* species-complex, which was originally conceived by Seifert (2006) and included species characterized by the presence of a distinct mesonotal depression; petiolar shape showing a high node with a small dorsal plane; head, scape and mesosoma more elongated than in the *T. nylanderi* group (CL/CW 1.08–1.22, SL 0.75–0.81, ML/CS 1.180–1.27 [metrics of Seifert]); sculpture on vertex without the densely arranged, regular and linear carinulae of the *T. nylanderi* group; spines usually shorter and more erect than the *T. nylanderi* and the *T. parvulus* / *lichtensteini* group; spine axis in lateral view deviating by 40–55 ° from longitudinal axis of mesosoma; coloration of head and gaster always rather dark, varying from medium orange brown to blackish brown, never light yellowish as frequently found in the *T. parvulus* / *lichtensteini* group; and mesosoma varying from distinctly lighter or as dark as head and mesosoma. Seifert originally recognized five species in the *sordidulus* species-complex: *T. artvinensis* Seifert, 2006, *T. melas* (Espadaler *et al*., 1984), *T. schoedli* Seifert, 2006, *T. sordidulus* (Müller, 1923) and *T. saxonicus* (Seifert, 1995). In a revision of the Ponto-Mediterranean *T. nylanderi* species-group, Csősz *et al*. (2015) gave a definition of the *T. sordidulus* species-complex that helped separate it from other complexes in the *T. nylanderi* species-group: "workers of the *Temnothorax sordidulus* species-complex can be distinguished from those other complexes treated in this revision by the combination of the following salient features: brown to black color; slightly longer than broad head (CL/CWb [1.143, 1.278)], sculpture of head dorsum dull: with areolate ground sculpture combined with conspicuous parallel costulate or irregular reticulate main sculpture; moderately long to long propodeal spines (SPST/CS [0.220, 0.335]), deviating from longitudinal axis of mesosoma by 40–50°; petiolar node in lateral view with a concave frontal profile meeting occasionally indistinct truncate dorsum in an obtuse angle (110–120°) with a narrowly rounded transition, without a conspicuous sharp fronto-dorsal ridge on the petiolar node" (metrics of Csősz *et al*., 2015). Csősz *et al*. (2015) included four species in the *T. sordidulus* species-complex: *T. artvinensis*, *T. schoedli*, *T. sordidulus* and *T. tergestinus* (Finzi, 1928) (= *T. saxonicus* according to the authors). In the present study, the *T. sordidulus* species-complex is characterized by having an elongated head (HL/HWb typically >1.20; metrics defined below), dull surface due to reticulated ground sculpture, distinct metanotal groove, medium to long propodeal spines and high petiole with an anterior concave face and short posterior face.

Beyond Iberia, members of the complex include *T. artvinensis* and *T. schoedli* endemic to the Black Sea coast, *T. melas* endemic to Corsica and the more widespread *T. sordidulus* and *T. tergestinus* (Finzi, 1928) (Seifert, 1995; Seifert, 2006; Csősz *et al*. 2015). *Temnothorax sordidulus* occurs from Turkey to SE France, and *T. tergestinus* occurs from Bulgaria to SE France (Csősz 2001; Borowiec 2014). In the present paper, four Iberian species match the concept of this complex based on morphometric data; three are previously described endemic species (*T. conatensis* Galkowski & Lebas, 2016, *T. ibericus* [Menozzi, 1922] and *T. platycephalus* [Espadaler, 1997]) and a fourth is a new species from South Iberia described here (*T. estel* **sp. nov.**). The taxonomy of the four species is reviewed and an identification key is provided.

Material and methods

Measurements were taken using a Nikon SMZ-U with a magnification between 70 and 225x depending on the character. A cross-scaled ocular micrometer with 100 divisions was used and specimens were mounted and dried before measuring. To minimize measuring errors, characters present on each side of the specimen were both measured and the arithmetic mean was then calculated; when percent differences greater than 5% were detected for a specific character pair in the same individual, this was remeasured in order to assess whether discordant values represented an occasional recording error or an asymmetry. True asymmetric characters are here defined as characters with a mean percent asymmetry greater than 3% for all of the specimens in the dataset. The following characters were identified as asymmetric, requiring the evaluation of both sides of the specimens for a reliable interpretation: PoOC, SL, LFF, LMH, MGr and SPST. Measured characters and indexes are those usually used in the genera *Temnothorax* (Seifert 2006; Csősz *et al*. 2015), but some modifications and new characters have been introduced. For each individual, 27 characters were recorded (46 primary measurements considering bilaterally present characters), representing a total of 3496 unique measurements across the 76 workers. All measurements are in millimeters and follow the format "mean ± standard error (lowest measurement—highest measurement)".

The indexes of *T. sordidulus* and *T. tergestinus* presented in Table 2 were calculated based on the dataset of morphometrics given in Csősz *et al*. (2015). Notice that some characters are recorded by these authors under different definitions from the ones used here. The measurements of *T. normandi* were kindly given by Sándor Csősz.

The holotype and 4 paratypes of *T. estel* **sp. nov.** have been deposited in the Museu de Ciències Naturals de Barcelona (MCNB), 5 paratype workers in the National Museum of Natural History (MNHN) and 5 paratypes in the California Academy of Sciences (CASC). The rest of the material is in the personal collection of the author, excluding loaned specimens.

Measurements

HL: maximum cephalic length in median line, measured in frontal view (Fig. 1E). The cephalic capsule must be carefully tilted to the position with the true maximum. Excavations of posterior margin of head and/or clypeus reduce HL.

HW: maximum cephalic width across the eyes, measured in frontal view. Not measured in all specimens, just for comparison purposes in the case of *T. platycephalus*.

HWb: maximum cephalic width just posterior to the eyes, measured in frontal view (Fig. 1E).

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

PoOC: postocular distance, measured in frontal view (Fig. 1E). Using a cross-scaled reticle, 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.

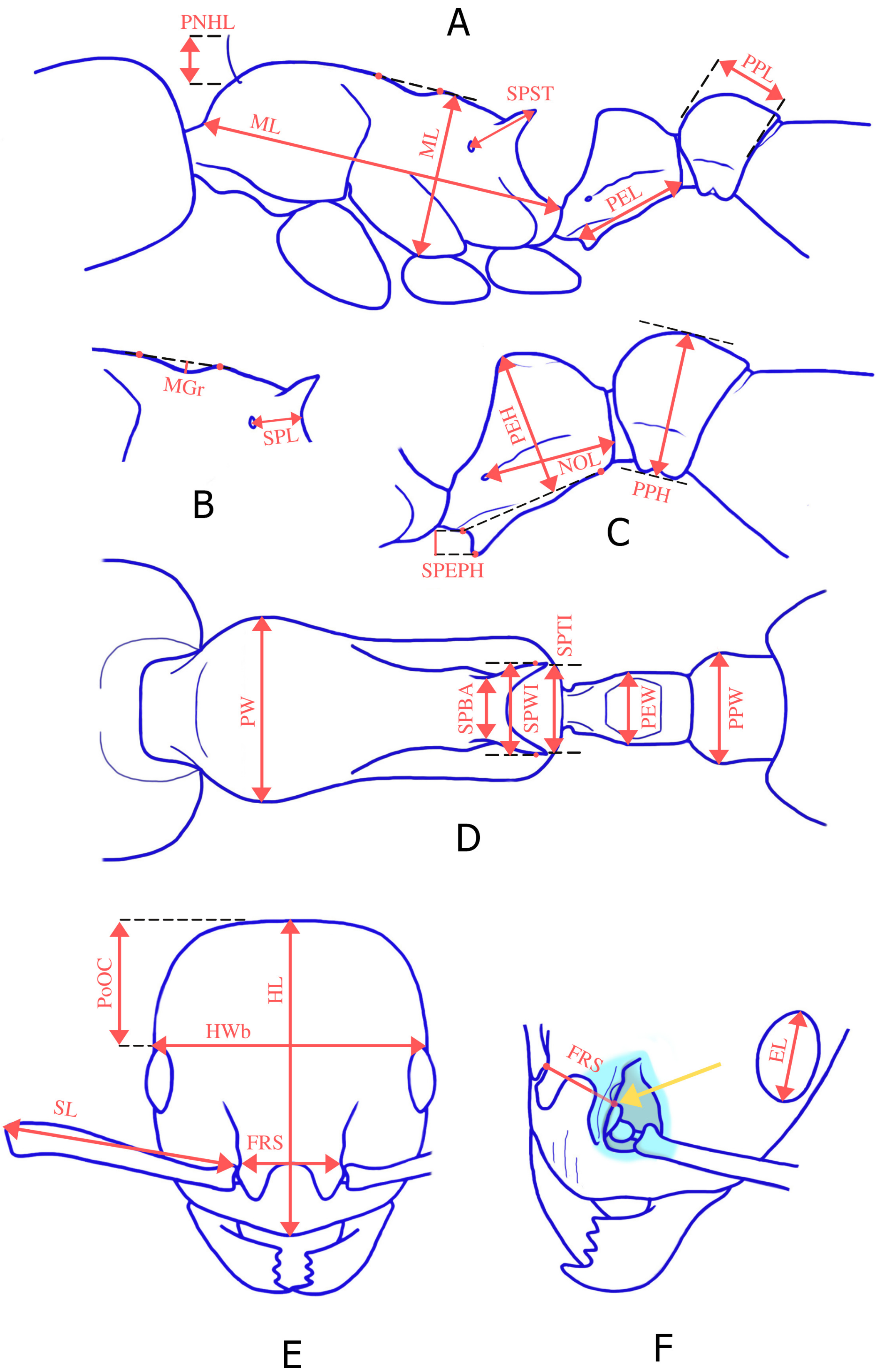

FIGURE 1. Measurements in workers. Continuous red lines indicate the length that should be measured for each character. Discontinuous lines indicate auxiliary lines from which perpendicular measurements are performed. A: lateral view of worker. B: mesosoma section for a detailed view of MGr and SPL in lateral view. C: petiole and postpetiole in lateral view. D: mesosoma, petiole and postpetiole in dorsal view. E: head in frontal view. F: tilted head in latero-frontal view showing a complementary view of the measurement endpoints of FRS and EL.

EL: maximum length of the eye, measured in lateral view (Fig. 1F). 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. 1E and 1F). If these dorsal lamellae do not laterally surpass the frontal carinae, the deepest point of scape corner pits may be taken as reference line. These pits take up the inner corner of scape base when the scape is oriented caudad and produce a dark triangular shadow in the lateral frontal lobes immediately posterior to the dorsal lamellae of scape joint capsule.

SL: maximum straight-line scape length excluding the articular condyle, measured in frontal view (Fig. 1E).

LDFS: length of distal funiculus segment, measured in frontal view. 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 (Fig. 1A). Take as reference points (1) the transition point between anterior pronotal slope and anterior pronotal shield and (2) the caudalmost point of propodeal lobe, which is usually rounded. In gynes: length from caudalmost point of propodeal lobe to the most distant point of steep anterior pronotal face.

MH: mesosoma height, measured in lateral view (Fig. 1A). Use a cross-scaled reticle and measure the height using as reference (1) the ventralmost point of katepisternum and (2) the perpendicular projection to a line connecting the dorsalmost points of promesonotum and propodeum.

MGr: depth of metanotal groove (Fig. 1B), measured perpendicularly to the tangent connecting the dorsalmost points of promesonotum and propodeum, given as per cent ratio of CS (%): (MGr/CS)*100.

PW: maximum pronotal width, measured in dorsal view (Fig. 1D). In queens, width is measured immediately in front 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 frontal view to correctly establish its median longitudinal axis. Appressed and/or laterally positioned hairs should also be counted.

LMH: length of longest standing hair on mesosoma excluding those on propodeal spines, measured in lateral view (Fig. 1A).

SPEPH: maximum subpetiolar process height, measured in lateral view (Fig. 1C). Take as reference (1) the point where the anterior corner of the subpetiolar process meets the ventral petiole margin and (2) the lowermost point of the structure.

PEL: petiolar length, measured in lateral view (Fig. 1A). Take as reference (1) the point where the anterior corner of the subpetiolar process meets the ventral petiole margin and (2) the lowermost point of caudal cylinder.

PEH: petiole height, measured in lateral view (Fig. 1C). Use a cross-scaled reticle to measure the maximum height of the perpendicular projection of an imaginary 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 caudal cylinder. The auxiliary line does not always correspond to the ventral profile line, as shown on the figure.

NOL: length of the petiolar node, measured in lateral view from petiolar spiracle to dorso-caudal corner of caudal cylinder (Fig. 1C). Do not erroneously take as reference point the dorso-caudal corner of the helcium, which is sometimes visible.

PPL: postpetiole length, measured in lateral view (Fig. 1A). It is the maximum distance of the petiole measured from the anterior margin to the posterior margin, perpendicular to the superior profile line.

PPH: maximum height of postpetiole, measured in lateral view (Fig. 1C). It is the longest distance measured perpendicularly to a line defined by the ventral profile of postpetiole.

PECW: petiolar cylinder width, measured in lateral view. Use a cross-scaled reticle and take as reference (1) the uppermost point of petiolar cylinder and (2) the perpendicular projection of the lowermost point of petiolar cylinder.

SPL: minimum distance between the center of propodeal spiracle and the subspinal excavation, measured in lateral view (Fig. 1B).

SPBA: the smallest distance between the lateral margins of the spines at their base (Fig. 1D); it should be measured in dorsofrontal view, in order that the wider parts of the ventral propodeum do not interfere with the measurement in this position; if the lateral margins of spines diverge continuously from the tip to the base, a smallest distance at 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 (Fig. 1D); 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.

SPTI: the distance between spine tips in dorsal view (Fig. 1D); if spine tips are rounded or truncated, the centers of spine tips are taken as reference points.

PEW: maximum petiolar width, measured in dorsal view (Fig. 1D).

PPW: maximum postpetiolar width, measured in dorsal view (Fig. 1D).

Results

Temnothorax conatensis Galkowski & Lebas, 2016

(Fig. 2A and 6A)

Material. 6 workers, Spain, Mont-Rebei (Lleida), IIX.2008, 42°03’51.0”N 0°41’16.0”E, 1300 m, Fede García leg. One individual with a right hypoplasic propodeal spine.

Diagnosis. Dark brown to black coloration with infuscate antennal funiculus and femora, head and mesosoma with reticulated ground sculpture, inconspicuous to moderately-impressed metanotal groove (mean MGr/CS 0.797%), moderately long propodeal spines and long petiole (mean PEL/CS 0.417). Larger than other Iberian taxa in the *sordidulus* species-complex (mean CS 0.636 mm).

Comments. The investigated material, the original description and the imaged holotype of *T. conatensis* in Antweb (ANTWEB1032082) match the concept of the *sordidulus* species-complex in coloration, head and mesosoma sculpture, metanotal groove depth, length of propodeal spines, concave anterior face of petiole and body proportions. In the Palearctic context, workers show intermediate characteristics between *T. sordidulus* and *T. tergestinus*, but *T. conatensis* is easily differentiated by its larger size (CS > 0.600), shorter mesosoma (mean ML/CS 1.227), inconspicuous to poorly developed metanotal groove and lower petiole (mean PEH/CS 0.342). The petiole is usually longer, with rounded apex and slightly convex dorsal surface, while in *T. sordidulus* and *T. tergestinus* it is shorter and usually truncated.

Temnothorax conatensis is most similar to *T. platycephalus* from Iberia and *T. melas* from Corsica, together forming a sub-complex of very robust and slender species hardly differentiated from each other. Workers of all three species are of dark brown coloration, elongated head, small FRS/CS, inconspicuous to poorly-developed metanotal groove and well developed subpetiolar process. The petiole shape of *T. conatensis* and *T. platycephalus* varies from triangular to truncated with distinct concave posterior face, as seen also in some specimens of *T. melas* (see below). Undoubtably, *T. conatensis* and *T. platycephalus* constitute a pair of cryptic species, with >70% of the characters measured showing overlapping ranges and nearly identical appearance. However, a striking difference is found in the HL/HWb parameter, with *T. platycephalus* having a much longer head (HL/HWb 1.295–1.345) than *T. conatensis* (HL/HWb 1.222–1.226); the postpetiole is also narrower in the first (mean PPW/CS 310 vs. 330). Both species share the same habitat and nesting preferences and may co-occur in North Iberia.

The case of *T. melas* is intriguing. The imaged specimens in Antweb (CASENT0915390, CASENT0911189) are visually indistinguishable from the workers of *T. platycephalus* here evaluated, both sharing the characteristically elongated head feature, which separates them from *T. conatensis*. Seifert (1995) stated that the “frontal and dorsal profile lines of the petiole meet in a sharp angle” in *T. melas*, but the petiolar profile appears to be highly variable in this complex of species, and short and peaked petioles are also found in *T. platycephalus* and *T. conatensis*. On the other extreme of the spectrum, distinctly truncated petioles are seen in *T. conatensis* and *T. platycephalus*, and an imaged specimen of *T. melas* suggests it is also the case of this species (CASENT0906689). A preliminary comparison of my data of *T. platycephalus* and the indexes presented by Seifert (2006) for *T. melas*, measuring head width as HW instead of HWb, demonstrates their overall morphometric similarity and points to a cryptic identity of both species (Table 1). However, the isolation of *T. melas* in Corsica makes their separation easy based on a geographic criterion.

TABLE 1. Morphometric indexes of *T. platycephalus* considering HW instead of HWb, compared to the indexes of *T. melas* given by Seifert (2006) (5 nest samples with 11 worker individuals). Mean ± standard error is shown, followed by the range in brackets.

	T. platycephalus (n = 10)	*T. melas* (n=11)
CS	0.665 ± 0.015	0.654 ± 0.021
	[0.629, 0.663]	[628, 673]
HL/HW	1.227 ± 0.035	1.206 ± 0.015
	[1.191, 1.270]	[1.184, 1.220]
SL/CS	0.801 ± 0.024	0.783 ± 0.009
	[0.764, 0.825]	[0.766, 0.790]
FRS/CS	0.331 ± 0.013	0.329 ± 0.005
	[0.309, 0.343]	[0.322, 0.335]
SPBA/CS	0.238 ± 0.002	0.279 ± 0.018
	[0.236, 0.242]	[0.260, 0.303]
SPTI/CS	0.270 ± 0.013	0.307 ± 0.008
	[0.257, 0.287]	[0.299, 0.318]
PEW/CS	0.239 ± 0.009	0.258 ± 0.011
	[0.228, 0.252]	[0.247, 0.274]
PPW/CS	0.341 ± 0.006	0.364 ± 0.021
	[0.336, 0.350]	[0.338, 0.385]

García *et al*. (2018) examined the same material from Mont-Rebei and offered a comparison with *T. grouvellei* (Bondroit, 1918), but this is a very different species belonging to the *exilis* group that has coarse striation without reticulated ground sculpture and distinctly long and domed petiole. Finally, the black photo-stacked specimen from France that appears in Blatrix (2013) is morphometrically concordant with *T. sordidulus* and not with *T. conatensis* nor *T. platycephalus*, but it shows an atypical short petiole that would be worth investigating.

Nests of *T. conatensis* were found in rock crevices and on the ground, in an altitude between 600–1500 meters (Galkowski & Lebas 2016; García *et al*. 2018).

***Temnothorax estel* sp. nov.**

(Fig. 2B and 6B, worker; Fig. 3, queen)

Type material. Holotype worker: Spain, Serra d'Aitana (Alacant), 20.VI.2020, 38°39'05.6"N 0°14'13.7"W, 1282 m (MCNB code MZB 2021-0727). Paratypes: 4 workers, same nest and date as holotype (MCNB codes MZB 2021-0728, MZB 2021-0729, MZB 2021-0730 and MZB 2021-0731); 5 workers, same nest and date as holotype (will be deposited in MNHN); 5 workers, same nest and date as holotype (will be deposited in CASC).

Additional studied material. 2 workers, Serra d'Aitana (Alacant), 09.IV.2012, 38°39'00.4"N 0°13'28.7"W, 1247 m; 14 workers, 1 queen, 13 males, Siles, Sierra de Cazorla (Jaén), 30.VI.2016, 38°22'38.7"N 2°31'03.7"W, 1425 m; 10 workers, 10 males, Serra d'Aitana (Alacant), 20.VI.2020, 38°39'05.6"N 0°14'13.7"W, 1282 m; 20 workers from 2 nests, Sierra de Cazorla (Jaén), 26.IX.2020, 37°48'48.1"N 2°57'36.6"W, 1796 m; 30 workers from 2 nests, Sierra de Cazorla (Jaén), 26.IX.2020, 37°48'10.4"N 2°58'14.4"W, 1649 m.

Diagnosis. Characterized within the Iberian *sordidulus* species-complex by being bicolored, with yellowish mesosoma and darker head dorsum; sculpture of frons entirely reticulated; head elongate (mean HL/HWb 1.275); metanotal groove inconspicuous to very shallow; and with the longest propodeal spines of the complex (mean SPST/CS 0.313).

Description of worker (n=50). 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; LDFS: 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; NOL: 0.161 ± 0.014 (0.139–0.185) mm; SPEPH: 0.038

± 0.006 (0.028–0.046) mm; PECW: 0.130 ± 0.008 (0.120–0.139) 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; PW: 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 2 for the indexes.

Size. Small species in the *sordidulus* species-complex (mean CS 0.567 mm).

Coloration pattern. Bicolored species. Dorsum of head dark brown, contrasting with yellowish mesosoma. Antennal club not darkened. Ventral side of head, mandibles, antennae and legs yellowish. Femora occasionally darkened. Tergites of gaster with a dark and diffuse band on their distal third; rest of gaster yellow.

Head. Antenna of 12 segments. Head strongly elongated (mean HL/HWb 1.275). In frontal view, sides of head parallel, converging posteriorly. Posterior margin of head straight. Anterior margin of clypeus rounded. Eyes small (mean EL/CS 0.223 mm). Postocular distance similar to the rest of species (PoOC/HL 0.387). Frontal carinae very narrow (mean FRS/CS 0.339). Scape long, but not reaching the posterior margin of head (mean SL/CS 0.831). Mandible of five teeth. Frons with reticulated ground sculpture and distinct but not strong superimposed longitudinal striae, with very narrow and smoother median region. Clypeus surface smooth and shiny, with 9–11 longitudinal carinae; a median and two paramedian carinae are often more pronounced. Concentric rugae visible on genae.

Mesosoma. Indistinct to shallowly impressed metanotal groove (mean MGr/CS 0.220%). Pronotum narrow (mean PW/CS 0.601 mm). Propodeal spines longer than any other species in the complex (mean SPST/CS 0.308 mm), curved and deviating from longitudinal axis of mesosoma by 45°; in smaller individuals, spines may be much thinner and longer. Declivity before propodeal spines usually present in lateral view. Whole surface of mesosoma with reticulated ground sculpture and superimposed longitudinal striae, which are more developed on lateral margins of pronotum. Setae on mesosoma short (mean LMH/CS 0.110).

Petiole and postpetiole. Petiole high, with concave anterior face and truncated apex. Usually, a transverse and pronounced carina crosses the petiole in lateral view. Petiolar cylinder narrow than any other species in the complex (mean PECW/PEH 0.229). Subpetiolar process well developed (mean SPEPH/CS 0.067), with rounded apex and occasional concave anterior face. Postpetiole subquadrate in dorsal view, getting narrower towards the base. Petiole and postpetiole narrow in dorsal view (mean PEW/CS 0.245; mean PPW/CS 0.332).

Description of queen (n=1). HL: 0.730 mm; HWb: 0.675 mm; PoOC: 0.290 mm; EL: 0.185 mm; FRS: 0.268 mm; SL: 0.536 mm; LDFS: 0.231 mm; LMH: 0,066 mm; ML: 1.282 mm; MH: 0.656 mm; SPST: 0.259 mm; SPL: 0.139 mm; PEL: 0.324 mm; PEH: 0.287 mm; NOL: 0.213 mm; SPEPH: 0.046 mm; PECW: 0.194 mm; PPL: 0.194 mm; PPH: 0.250 mm; SPTI: 0.287 mm; SPWI: 0.305 mm; SPBA: 0.277 mm; PW: 0.804 mm; PEW: 0.203 mm; PPW: 0.277 mm. Indexes: CS: 0.703; HL/HWb: 1.080; PoOC/HL: 0.397; FRS/CS: 0.382; SL/CS: 0.763; EL/CS: 0.263; LDFS/CS: 0.329; LMH/CS: 0.092; ML/CS: 1.825; MH/CS: 0.934; SPST/CS: 0.368; SPL/CS: 0.197; PEL/CS: 0.461; NOL/CS: 0.303; PEH/CS: 0.408; PPL/CS: 0.276; PPH/CS: 0.355; SPEPH/CS: 0.066; PECW/CS: 0.276; PEW/CS: 0.289; PPW/CS: 0.395; SPWI/CS: 0.434; SPTI/CS: 0.408; SPBA/CS: 0.395; PW/CS: 1.145.

Head and mesosoma brown, with yellowish appendages; abdomen brown with a yellowish macule on the base of the first gastral tergite. Head with reticulated ground sculpture and coarse superimposed longitudinal striae. Scutum longitudinally striated, without median shiny region. Scutellum with a median smooth and shiny region, sides longitudinally striated. Propodeal spines well developed. Petiole high and long, with concave anterior face and triangular apex. Subpetiolar process medium-sized. Sides of postpetiole on dorsal view converging posteriorly.

Variability. Some workers (7% of all examined individuals) may exhibit a darker coloration pattern, with black to dark brown head dorsum contrasting with brown mesosoma and dark brown gaster with a basal yellowish macule on the first tergite. The mesosoma declivity preceding propodeal spines may be pronounced (18% of individuals), present but not pronounced (54%) or absent (27%). The absolute length of the propodeal spines may be bigger in the smaller specimens of the colony. The petiolar apex appears rounded instead of truncated in 25% of individuals. A poorly-developed mesopropodeal depression is present in 23% of individuals, while it appears as inconspicuous in the rest. Subpetiolar process may be reduced in smaller specimens (12%).

Etymology. Catalan for star, in reference to the color of the mesosoma in contrast with the dark head and gaster, which resembles a star in the sky.

Comments. *T. estel* **sp. nov.** is easily distinguished from any other taxa of the Iberian *sordidulus* species-complex by the unique combination of bicolored body, long head (mean HL/HWb 1.275), inconspicuous to poorly-developed metanotal groove (mean MGr/CS 0.297%) and longest propodeal spines of the complex (mean SPST/CS 0.313).

FIGURE 2. Head (left) and lateral view (right) of the workers of (A) *T. conatensis* (Mont-Rebei, Lleida), (B) *T. estel* **sp. nov.** (Sierra de Cazorla, Jaén), (C) *T. ibericus* (Sierra de Javalambre, Teruel), and (D) *T. platycephalus* (Sierra de Cazorla, Jaén).

FIGURE 3. Head (left) and lateral view (right) of the queen of *T. estel* **sp. nov.** Individual from Sierra de Cazorla, Jaén (see "additional studied material" under the *T. estel* **sp. nov.** description above).

FIGURE 4. A: Nest of *T. estel* **sp. nov.** in a rock crevice in Serra d'Aitana, Alacant. B: Worker of *T. platycephalus* from Sierra de Cazorla, Jaén. C: big rocks where both *T. estel* **sp. nov.** and *T. platycephalus* establish their nest in Sierra de Cazorla, Jaén. D: general view of the habitat of *T. estel* **sp. nov.** in Serra d'Aitana, Alacant.

The most closely related species to *T. estel* **sp. nov.** is *T. tergestinus*, from Central Europe. The first has much longer head (mean HL/HWb 1.252 vs. 1.206), narrower frontal carina (mean FRS/CS 0.343 vs. 0.361), longer scape (mean SL/CS 0.826 vs. 0.799), inconspicuous to poorly-developed metanotal groove (vs. poorly to well-developed metanotal groove in *T. tergestinus*) and longer and more diverging propodeal spines (mean SPST/CS 0.313 vs. 0.276; SPWI/CS 0.342 vs. 0.333). Both species exhibit the same coloration pattern, but *T. tergestinus* can also show extreme dark forms (Csősz *et al*. 2015; Borowiec & Salata 2018). *Temnothorax tergestinus* has a wide Palearctic distribution from Bulgaria to France, but has not been yet recorded from Iberia. It is unknown whether a contact zone between *T. estel* **sp. nov.** and *T. tergestinus* could exist somewhere in North Iberia or South France.

MGr is probably one of the best discriminant characters between *T. estel* **sp. nov.** and *T. tergestinus*, but it has not been measured for the latter species in this paper. Queens of both taxa appear very similar, and the only available queen of *T. estel* **sp. nov.** does not allow a safe separation with the queens of *T. tergestinus*. Males of the *sordidulus* species-complex are largely unknown and rarely described, since the external morphology is very variable within the same nest and the study of the genitalia is not routinely used in the genus.

Biology. Mostly unknown. Nests were found at high altitude in rock crevices and once under a plain stone, and populations were located from stony open habitats to semi-open pine forests (Fig. 4). All colonies were monogynous. Nest densities were always low. Two colonies kept in an artificial nest were fed with insects and nectar and produced reproductive individuals in early July. The elongated head may be an adaptation to move into rock crevices and nest in narrow spaces.

Distribution. Known from SE Iberia (Fig. 5).

FIGURE 5. Distribution of the southern species in the *sordidulus* species-complex, including the French records of *T. tergestinus* and *T. sordidulus*. Colors: *T. conatensis* (dark blue circles), *T. estel* **sp. nov.** (gold circles), *T. ibericus* (purple circles), *T. platycephalus* (red circles), *T. sordidulus* (green circle) and *T. tergestinus* (yellow circle).

***Temnothorax ibericus* (Menozzi, 1922)**
(Fig. 2C and 6C)

Material. 2 workers, Spain, Sierra de Javalambre (Teruel), 5.VI.2015, 1648 m, Daniel Sánchez leg.; 4 workers, Jaén, J. Reyes-López leg.; 5 workers, Lamiana-Escuaín (Huesca), 29.VII.2008, 42°35'01.9"N 0°10'06.0"E, 1080 m, Ramón Antor leg.

Diagnosis. Characterized within the Iberian *sordidulus* species-complex by its dark coloration, prominent superimposed longitudinal striae of head, well-defined metanotal groove, short propodeal spines and relatively wide postpetiole (PPW/CS usually >0.400). Smallest species of the complex (mean CS 0.548 mm).

Comments. *T. ibericus* is most similar to *T. sordidulus*; they both show dark coloration with infuscate antennal clubs, elongated head, developed metanotal groove, short propodeal spines, rounded petiolar apex and short subpetiolar process. Its status as a differentiated species is justified by its more pronounced superimposed longitudinal striae on head, less developed reticulated ground sculpture of frons, less impressed metanotal groove and wider postpetiole of the complex. *T. ibericus* has been classically considered a member of the *exilis* species-group, but the reticulated ground sculpture, visible metanotal groove and petiolar shape perfectly match the concept of the *sordidulus* species-complex. The queen also shows the typical aspect of the *T. sordidulus* queens, with uniform dark coloration and short propodeal spines. Description of nest preferences and morphology of the queen can be found in Espadaler *et al*. (2017).

***Temnothorax platycephalus* (Espadaler, 1997)**
(Fig. 2D and 6D)

Material. 50 workers from 2 nests, Spain, Sierra de Cazorla (Jaén), 26.IX.2020, 37°48'48.1"N 2°57'36.6"W, 1796m.

Diagnosis. Characterized within the Iberian *sordidulus* species-complex by its dark brown coloration, extremely elongated head (mean HL/HWb 1.318), whole surface of head and mesosoma reticulated, inconspicuous to shallowly-impressed metanotal groove (mean MGr/CS 0.485%), moderately long propodeal spines (mean SPST/CS 0.267) and long mesosoma (mean ML/CS 1.310). Larger species in the *sordidulus* species-complex (CS mean 0.644 mm).

Comments. It is readily separated from darker forms of *T. tergestinus* by its long head and less developed metanotal groove, from *T. ibericus* by the reticulated sculpture of head, poorly developed metanotal groove and narrow postpetiole, from *T. sordidulus* by its long head and poorly developed metanotal groove, and from *T. estel* **sp. nov.** by the different coloration pattern and shorter propodeal spines. *Temnothorax platycephalus* is most similar to *T. conatensis*, from which it is differentiated by its longer head and shorter propodeal spines, sharing the characteristic shape of petiole and robust appearance. Nests are monogynous and located in rock crevices at high altitudes. The only known records are from Jaén and Cuenca (Espadaler 1997).

Key for workers of the Iberian species of the *sordidulus* species-complex

For a reliable interpretation of the mean values used in the keys, at least 2–3 workers should be measured.

1. Median region of frons mostly smooth and shiny, without reticulated ground sculpture; rest of frons with pronounced longitudinal striae and reticulated ground sculpture (Fig. 6B). Concolorous black to dark brown with infuscate antennal clubs and femora; some specimens slightly bicolored with darker head dorsum and gaster. Postpetiole wide (mean PPW/CS 0.403, usually > 0.400). Characteristic morphometric combination: head elongated (HL/HWb >1.250), metanotal groove poorly to well-developed (mean MGr/CS 1.21%), shortest propodeal spines of the Iberian complex (mean SPST/CS 0.244), subpetiolar process small (mean SPEPH/CS 0.041) . . . . *ibericus*

\- Whole frons with reticulated ground sculpture and poorly to well-developed longitudinal striae, without distinct smooth and shiny median region (Fig. 6A, 6C–D). Concolorous black to dark brown or bicolored forms with yellowish mesosoma. Postpetiole narrower (mean PPW/CS 0.344, always <0.400). Metanotal groove less developed (mean MGr/CS 0.449%), propodeal spines larger (mean SPST/CS 0.290), subpetiolar process longer (mean SPEPH/CS 0.073). 2

2. Bicolored with head black to dark brown contrasting with yellowish mesosoma (Fig. 6A). Characteristic morphometric combination: medium-sized species (mean CS 0.400), head elongated (mean HL/HWb 1.275), metanotal groove inconspicuous to

poorly developed (mean MGr/CS 0.297%), propodeal spines well developed (mean SPST/CS 0.340), subpetiolar process well developed (mean SPEPH/CS 0.065) . . . . *estel* **sp. nov.**

- Concolorous black to dark brown (Fig. 6C–D); some specimens slightly bicolored with lighter brownish mesosoma. Larger species (mean CS 0.600), propodeal spines shorter (mean SPST/CS 0.269). 3

3. Head elongated (mean HL/HWb 1.318), mesosoma longer (mean ML/CS 1.310), subpetiolar process well developed (mean SPEPH/CS 0.087). . . . . *platycephalus*

- Head shorter (mean HL/HWb 1.224), mesosoma shorter (mean ML/CS 1.227), subpetiolar process developed (mean SPEHP/CS 0.069) . . . . *conatensis*

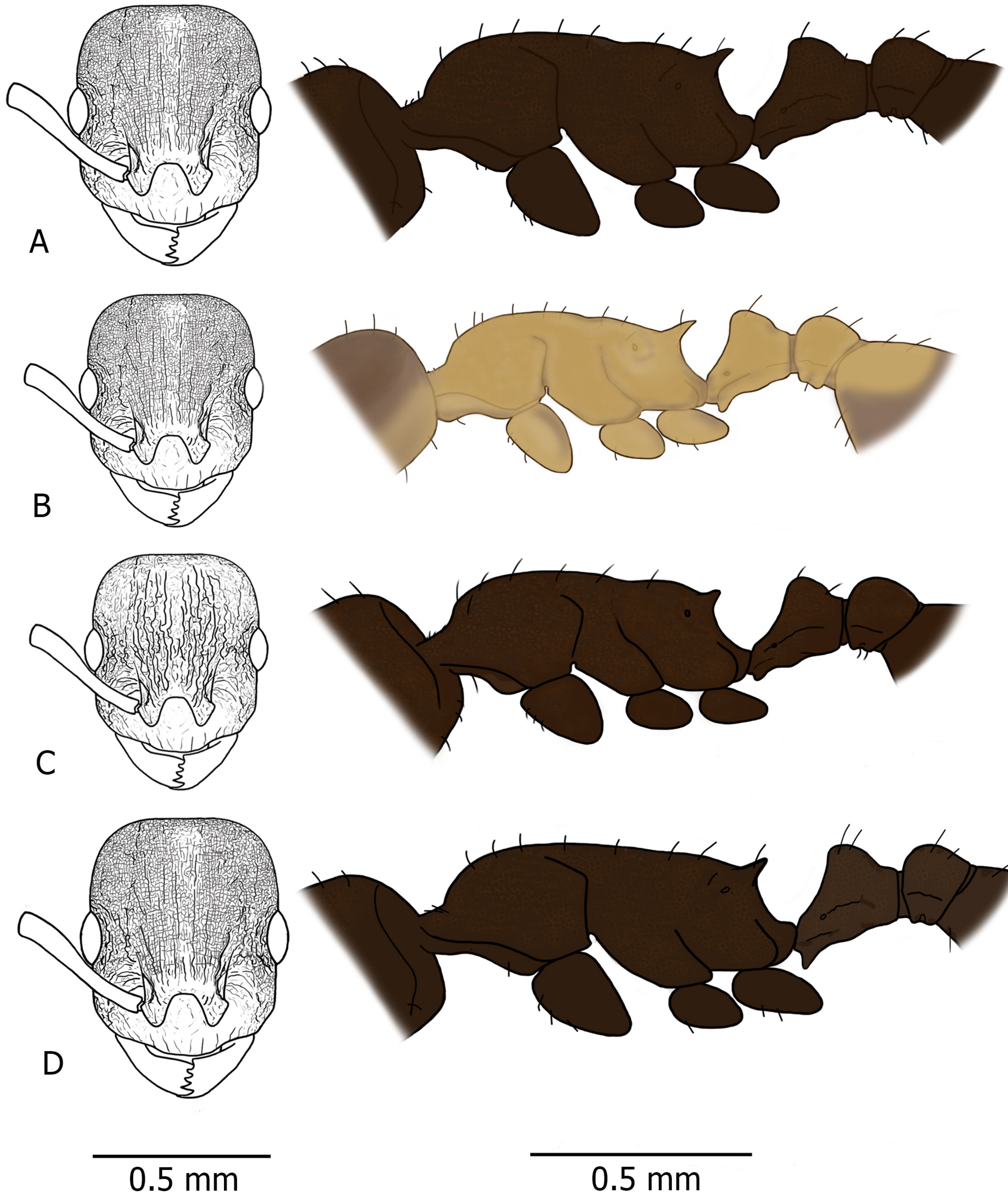

FIGURE 6. Typical coloration and morphological appearance of the species in the Iberian *sordidulus* species-complex. Sculpture of frons (left column) and lateral view of workers (right column); *T. conatensis* (A), *T. estel* **sp. nov.** (B), *T. ibericus* (C) and *T. platycephalus* (D).

TABLE 2. Measurements for Iberian species of the *Temnothorax sordidulus* complex. Mean ± standard error is shown, followed by the range in brackets. If a species has the largest or smallest mean among the species, the mean is in bold. If two species are tied for largest or smallest, they both appear in bold. Values for *T. sordidulus* and *T. tergestinus* are extracted from Csősz *et al*. (2015) using measurements of individuals from the supplementary material (not the reported nest means).

	T. estel **sp. nov.** (n = 50)	*T. tergestinus* (n = 132)	*T. ibericus* (n = 10)	*T. conatensis* (n = 6)	*T. sordidulus* (n = 43)	*T. platycephalus* (n = 10)	*T. normandi* (n = 2)
CS	0.567 ± 0.031 [0.511, 0.629]	0.592 ± 0.033 [0.523, 0.665]	**0.548** ± 0.033 [0.503, 0.606]	0.636 ± 0.013 [0.622, 0.647]	0.573 ± 0.030 [0.518, 0.607]	**0.644** ± 0.014 [0.629, 0.663]	0.622
HL/HWb	1.275 ± 0.030 [1.220, 1.314]	**1.206** ± 0.021 [1.169, 1.253]	1.261 ± 0.011 [1.259, 1.276]	1.224 ± 0.002 [1.222, 1.226]	1.238 ± 0.022 [1.192, 1.278]	**1.318** ± 0.022 [1.295, 1.345]	1.152
PoOC/HL	0.387 ± 0.012 [0.355, 0.403]	0.384 ± 0.006 [0.373, 0.400]	**0.395** ± 0.015 [0.380, 0.415]	0.385 ± 0.010 [0.375, 0.395]	**0.374** ± 0.006 [0.363, 0.390]	0.379 ± 0.006 [0.372, 0.386]	0.387
FRS/CS	0.339 ± 0.011 [0.311, 0.351]	0.361 ± 0.008 [0.347, 0.380]	0.351 ± 0.006 [0.344, 0.359]	0.351 ± 0.010 [0.342, 0.362]	**0.366** ± 0.008 [0.353, 0.378]	**0.342** ± 0.013 [0.321, 0.354]	0.375
SL/CS	0.831 ± 0.015 [0.809, 0.859]	0.799 ± 0.010 [0.781, 0.824]	**0.768** ± 0.023 [0.745, 0.795]	**0.833** ± 0.003 [0.830, 0.836]	0.785 ± 0.011 [0.763, 0.809]	0.827 ± 0.024 [0.787, 0.847]	0.782
EL/CS	**0.223** ± 0.012 [0.197, 0.237]	0.258 ± 0.009 [0.237, 0.280]	0.227 ± 0.008 [0.221, 0.238]	0.247 ± 0.008 [0.238, 0.254]	**0.266** ± 0.007 [0.258, 0.280]	0.264 ± 0.008 [0.255, 0.272]	0.250
LDFS/CS	0.392 ± 0.016 [0.368, 0.425]	-	0.389 ± 0.018 [0.374, 0.414]	**0.385** ± 0.014 [0.372, 0.400]	-	**0.402** ± 0.009 [0.393, 0.414]	-
LMH/CS	**0.110** ± 0.015 [0.088, 0.132]	-	0.129 ± 0.019 [0.107, 0.154]	0.126 ± 0.005 [0.121, 0.130]	-	**0.144** ± 0.012 [0.132, 0.160]	-
ML/CS	1.259 ± 0.021 [1.218, 1.289]	1.252 ± 0.019 [1.209, 1.290]	1.251 ± 0.026 [1.225, 1.282]	**1.227** ± 0.014 [1.212, 1.239]	1.276 ± 0.011 [1.261, 1.298]	**1.310** ± 0.016 [1.285, 1.328]	1.221
MH/CS	0.515 ± 0.021 [0.477, 0.550]	-	**0.521** ± 0.011 [0.508, 0.531]	0.494 ± 0.014 [0.480, 0.507]	-	**0.487** ± 0.011 [0.475, 0.500]	-
MGr/CS (%)	**0.220** ± 0.387 [0.000, 1.271]	-	**1.036** ± 0.283 [0.656, 1.298]	0.797 ± 0.301 [0.595, 1.143]	-	0.485 ± 0.211 [0.294, 0.836]	-
SPST/CS	**0.308** ± 0.018 [0.286, 0.343]	0.276 ± 0.024 [0.220, 0.335]	**0.244** ± 0.015 [0.222, 0.256]	0.273 ± 0.024 [0.250, 0.297]	0.258 ± 0.016 [0.227, 0.281]	0.267 ± 0.013 [0.250, 0.286]	0.256
SPL/CS	**0.197** ± 0.021 [0.151, 0.222]	0.171 ± 0.007 [0.154, 0.184]	0.194 ± 0.015 [0.183, 0.216]	**0.170** ± 0.020 [0.171, 0.188]	0.176 ± 0.009 [0.162, 0.191]	0.194 ± 0.010 [0.176, 0.202]	0.165

......continued on the next page

TABLE 2. (Continued)

	T. estel **sp. nov.** (n = 50)	*T. tergestinus* (n = 132)	*T. ibericus* (n = 10)	*T. conatensis* (n = 6)	*T. sordidulus* (n = 43)	*T. platycephalus* (n = 10)	*T. normandi* (n = 2)
PEL/CS	0.415 ± 0.028 [0.381, 0.469]	-	**0.399** ± 0.009 [0.389, 0.410]	**0.417** ± 0.017 [0.401, 0.435]	-	0.405 ± 0.010 [0.393, 0.419]	0.425
NOL/CS	0.283 ± 0.018 [0.261, 0.317]	**0.259** ± 0.008 [0.244, 0.275]	0.272 ± 0.027 [0.239, 0.303]	0.282 ± 0.007 [0.275, 0.290]	0.271 ± 0.009 [0.255, 0.285]	**0.293** ± 0.028 [0.272, 0.343]	0.256
PEH/CS	0.359 ± 0.012 [0.344, 0.391]	0.384 ± 0.012 [0.353, 0.410]	0.363 ± 0.003 [0.359, 0.366]	**0.342** ± 0.006 [0.338, 0.349]	**0.388** ± 0.006 [0.380, 0.397]	0.353 ± 0.008 [0.343, 0.365]	0.381
PPL/CS	**0.250** ± 0.016 [0.221, 0.270]	0.254 ± 0.007 [0.239, 0.268]	0.270 ± 0.016 [0.248, 0.282]	**0.288** ± 0.027 [0.259, 0.312]	0.264 ± 0.009 [0.250, 0.276]	0.278 ± 0.014 [0.263, 0.296]	0.267
PPH/CS	0.297 ± 0.013 [0.279, 0.321]	**0.352** ± 0.010 [0.327, 0.370]	0.339 ± 0.009 [0.328, 0.350]	0.290 ± 0.011 [0.283, 0.303]	0.349 ± 0.011 [0.333, 0.375]	**0.281** ± 0.007 [0.275, 0.292]	0.349
SPEPH/CS	0.067 ± 0.009 [0.050, 0.082]	-	**0.041** ± 0.007 [0.035, 0.051]	0.069 ± 0.005 [0.063, 0.072]	-	**0.087** ± 0.003 [0.084, 0.091]	-
PECW/CS	**0.229** ± 0.008 [0.220, 0.242]	-	**0.255** ± 0.005 [0.248, 0.261]	0.238 ± 0.007 [0.231, 0.244]	-	0.238 ± 0.008 [0.226, 0.248]	-
PEW/CS	**0.245** ± 0.017 [0.217, 0.272]	0.266 ± 0.008 [0.252, 0.291]	**0.276** ± 0.012 [0.260, 0.291]	0.265 ± 0.020 [0.250, 0.287]	0.264 ± 0.009 [0.254, 0.280]	0.247 ± 0.010 [0.237, 0.263]	0.254
PPW/CS	**0.332** ± 0.015 [0.304, 0.353]	0.367 ± 0.013 [0.341, 0.390]	**0.403** ± 0.012 [0.386, 0.449]	0.364 ± 0.011 [0.357, 0.377]	0.363 ± 0.007 [0.350, 0.374]	0.352 ± 0.007 [0.346, 0.365]	0.385
SPWI/CS	**0.336** ± 0.021 [0.299, 0.369]	0.333 ± 0.024 [0.283, 0.372]	0.309 ± 0.006 [0.300, 0.313]	0.325 ± 0.011 [0.312, 0.333]	0.306 ± 0.015 [0.280, 0.331]	**0.293** ± 0.013 [0.277, 0.307]	0.309
SPTI/CS	**0.317** ± 0.021 [0.286, 0.352]	0.312 ± 0.021 [0.270, 0.346]	0.294 ± 0.013 [0.276, 0.308]	0.310 ± 0.011 [0.297, 0.319]	0.288 ± 0.014 [0.266, 0.312]	**0.278** ± 0.011 [0.265, 0.293]	0.294
SPBA/CS	**0.232** ± 0.023 [0.208, 0.281]	**0.273** ± 0.011 [0.248, 0.295]	0.257 ± 0.012 [0.246, 0.274]	0.242 ± 0.013 [0.232, 0.257]	**0.273** ± 0.011 [0.257, 0.291]	0.245 ± 0.004 [0.243, 0.251]	0.264
PW/CS	**0.601** ± 0.011 [0.587, 0.625]	0.620 ± 0.013 [0.588, 0.652]	0.624 ± 0.019 [0.606, 0.650]	**0.625** ± 0.014 [0.610, 0.638]	0.615 ± 0.011 [0.599, 0.640]	0.620 ± 0.007 [0.613, 0.629]	-
USH/CS	16.5 ± 2.2 [9.908, 18.244]	-	**17.0** ± 1.9 [15.071, 18.887]	**14.8** ± 0.62 [14.943, 16.154]	-	18.3 ± 0.6 [17.369, 18.843]	-

Discussion

With the addition of the Iberian endemics *T. estel* **sp. nov.**, *T. ibericus* and *T. platycephalus*, together with the South Palearctic *T. conatensis*, the geographic distribution of the *sordidulus* species-complex is significantly extended 1000km to the south. After a taxonomic evaluation of the newly included taxa, the species-complex is redefined as follows: concolorous to bicolored species, elongated head (HL/HWb 1.142–1.36, typically >1.20), sculpture of head dorsum and mesosoma consisting of reticulate ground sculpture and poorly to well-developed longitudinal striae, with or without reticulated ground sculpture on median region of frons, inconspicuous to well-developed metanotal groove, short to long propodeal spines (SPST/CS 0.220–0.343), deviating from longitudinal axis of mesosoma by 40–50º, and petiole with a concave anterior face and usually truncated or rounded apex. *Temnothorax normandi* (Santschi, 1912), a North African species described from Tunisia, could be a good candidate to be considered in the *sordidulus* species-complex (Csősz S., *personal communication*); the measurements kindly provided by Csősz point to this possibility (see Table 2), but more material is needed to make a decision

Nests of these species are usually located in rock crevices, but *T. ibericus* appears to be of ground nesting habits. This habitat preference suggests that workers spend most of the time foraging on big rocks and rarely descend to the ground; this may be the explanation for the fact that *T. ibericus* has numerous pitfall-collection records while the rest of the species have not been recovered in any study using this technique. In fact, intensive pitfall samplings in an area of Sierra de Cazorla where both *T. estel* **sp. nov.** and *T. platycephalus* exist were unsuccessful in recovering individuals of any species (J. Reyes *comm. pers.*). This interesting behavior may also explain the elongated appendages that most species exhibit, which could be a useful trait in order to penetrate into small crevices and establish their colonies in reduced spaces. These four species also seem to prefer colder climate and inhabit mountains over 1000 meters high.

The state of knowledge regarding geographic distributions is yet immature for most of the species, with perhaps the exception of *T. ibericus*, which has been consistently collected during the last decades and shows a more or less homogenous distribution in the East half of the region. *Temnothorax estel* **sp. nov.** and *T. platycephalus* are probably distributed throughout Iberia, considering the wide geographic range of *T. ibericus* and other European taxa of the *sordidulus* species-complex; they should be expected in mountain ranges >1000 meters with open and stony habitats, although its nesting habits may make its collection intrinsically rare. Targeted samplings searching in rock crevices seem to be the most effective method to find workers.

Although no additional taxa in the *sordidulus* species-complex is suspected to occur in Iberia based on the examined specimens, further material will be needed to investigate if cryptic species, a common phenomenon in the genus, is present within the four recognized species. Future samplings in SE France will be critical to understand species limits and possible reproductive interactions between South European and Iberian species, since hybridization has been already hypothesized for two of them (*T. saxonicus* x *T. tergestinus*) (Seifert, 2018). This revision, of preliminary nature due to the limited specimens available for measuring, will hopefully serve as a basis to construct future taxonomic work and favor early characterization of undiscovered species.

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