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Strumigenys emmae (Emery, 1890) (Myrmicinae) new to Britain, with an updated key to the known *Strumigenys* of the West Palaearctic

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Abstract

The ant genus *Strumigenys* is a hyper diverse pantropical group of specialised predatory leaf litter dwelling ants. Species richness peaks within tropics, with few species extending into the West Palaearctic realm. A significant proportion of *Strumigenys* species known from the West Palaearctic are non-native, spread via human commerce, and predominately establishing populations within artificially heated greenhouses. In Britain, two *Strumigenys* species were previously known, *S. rogeri* Emery, 1890 and *S. perplexa* (Smith, 1876). Here we add a third species, *S. emmae* (Emery, 1890) based upon specimens from the humid tropical biomes at the Eden Project, Cornwall (UK). A single record outlined here is noted as the earliest known record of *S. emmae* from Europe thus far, pre-dating previous records by four years. We provide high resolution images, measurements, and discussion on the ecology of the species. In addition, an updated key to the *Strumigenys* of the Europe is supplied.

Key words: Non-native, ants, Formicidae, greenhouse, cryptobiotic

Introduction

The hyper diverse ant genus *Strumigenys* (Myrmicinae) currently comprises over 850 species worldwide (Janicki *et al*., 2016; Bolton 2023). Colonies are predominately leaf-litter dwelling, and often difficult to find due to their slow movement and diminutive size. Species feed upon soft bodied leaf litter arthropods in which they ambush and capture using various mandibular ensnaring methods, from simple gripping mandibles to high-power, latch-mediated snapping jaws (Booher *et al*., 2021). *Strumigenys* species richness peaks within the tropical regions with, significantly fewer species known from the West Palaearctic (Janicki *et al*., 2016; Guénard *et al*., 2017; Hamer *et al*., 2021; Tang & Guénard 2023; Hamer *et al*., 2023). Of the species that are known from the West Palaearctic, a significant number are non-native, being now distributed across the world by human-mediated transportation (Tang *et al*., 2019; Hamer *et al*., 2021). This spread is not exclusive to *Strumigenys*, with many other ant species from different genera known to be adventive, including over 500 species to date, but with hypogaeic and cryptobiotic (i.e. challenging to collect and sample without specialised techniques) species remaining largely undetected (Wong *et al*., 2023). Ant introductions have varying ecological consequences from benign, mostly non-destructive introductions (such as many species within greenhouses) to more significant, highly detrimental, biological invasions (Tercel *et al*., 2023). Some *Strumigenys* species have characteristics that favour successful introductions such as polygynous colonies and parthenogenic reproduction. A recent assessment by Booher *et al*., (2023) found *S. eggersi* Emery, 1890 became very common post-introduction, likely at the detriment of native *Strumigenys* species. Few, if any other *Strumigenys* species have been evaluated for their impact on native communities post-invasion however.

One such adventive *Strumigenys* species is *S. emmae*, which is one of the most well redistributed *Strumigenys* species, with a near pantropical distribution (Wetterer 2012). In the Britain, currently only two *Strumigenys* species are recorded, *S. rogeri* and *S. perplexa*, with only the latter recorded outdoors (Guernsey, Channel Islands) (Donisthorpe 1908; Donisthorpe 1915; Hamer *et al*., 2021, Hamer *et al*., 2023). Here we add a third species, *S.*

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emmae to Britain on the basis of specimens collected from the indoor humid tropical biomes at the Eden Project, Cornwall (UK)—a set of climatically controlled greenhouses which accommodate numerous tropical plants from across the globe. Measurements, high resolution images and a brief discussion concerning the species ecology is provided. In addition, the dichotomous key to the known *Strumigenys* species from Europe is updated, with *S. emmae* now included.

Materials and methods

Site Information and Collection Methods

The Rainforest Biome at the Eden Project (figure 1) mimics rainforest conditions by maintaining humidity around a mean of 90 % and temperature at a mean of 24 °C (range 18 to 35 °C). The biome is the largest indoor rainforest in the world with a maximum height of 55 m and length of 240 m which include a range of paths, pools, streams, waterfalls and tree top walkways all with an engaging variety of themed exhibits. It contains over 1,000 species of plant which are divided into zones: Tropical Islands, South East Asia, West Africa, Tropical South America and Crops. The care of the plants and replanting of smaller species is very active, constant and includes regular substrate renewal. Whilst excellent for plants this dynamic system of management has proved challenging for entomologists attempting to relocate species that have moved to different zones, declined to a very low density or seemingly undetectable for multiple years only to reappear in good numbers. All successful sampling was carried out at the edge of the biome dominated by bamboo, ferns and grasses. The substrate was a mix of gravel, decomposing plant material and dark organic soil. The habitat can be seen in figure 2 with the interception trap in action, the pitfall trap had been set in the same location but is hidden. This particular area is without public access and is not actively cultivated. Specimens were collected by two methods – a cheese baited pitfall trap and in a flight interception trap (FIT) both placed in the West Africa zone (figure 2). The traps were set close together in the upper extremities of the biome next to the external boundary where they were left in place for extended periods of more than a year. Their purpose was to sample long term coleopteran diversity. The unlidded pitfall trap comprised of a 300 ml wide mouthed jar set in the ground with 100 ml of 50% propan-1,2-diol and finished off with a generous shake of extra hot chilli powder to deter mammals. The cheese bait comprised of a fermented soft cheese mix (developed and cultured by CRT for its long lasting strong aroma of organic decomposition) which stood inside the pitfall in a 30 ml universal tube with numerous 0.4 mm holes melted through the lid to allow the smell to dissipate. The FIT comprised of 4 inverted two litre clear plastic bottles attached upside down to a central pole forming an almost continuous trapping perimeter, each bottle had a large window cut in it to allow flying insects in whereupon touching the sides they dropped into the preservative below. The preservative was 50% propan-1,2-diol with extra hot chilli powder added to deter mammals. The FIT was hung from the supporting arms of the biome dome to hang freely just above the ground. Both trap types are an effective way to sample mobile insect faunas and used in this way at low density can provide useful long term monitoring data on species colonisations as exemplified by the current discovery.

Morphometrics

Commonly used morphometric diagnosis were used to validate our identification of *S. emmae* (Bolton, 1983). Linear morphometric values included total length (TL), head length (HL), head width (HW), mandible length (ML), antennal scape length (SL), pronotal width (PW) and mesosomal length (WL) Indices; cephalic index (CI = HW / HL × 100), mandible index (MI = ML / HL × 100), and scape index (SL / HW × 100).

Results

A total of two specimens were collected (figure 3 A–F), comprising one worker (figure 3 A–C) and one queen (figure 3 D–F) from the West Africa zone in the upper biome where the wall meets the ground (figure 1, figure 2). This area is without public access and is not actively cultivated. Specimens were identified by comparing morphological characters to the description provided by Bolton (2000), satisfying all diagnostic characters, as well as queen and worker images on AntWeb.org.

FIGURE 1. The tropical biome at the Eden Project, Cornwall showcasing the vegetation structure of the greenhouse.

FIGURE 2. The interception trap set in the West Africa zone of the Eden Project's Rainforest Biome illustrating the habitat where *S. emmae* was found.

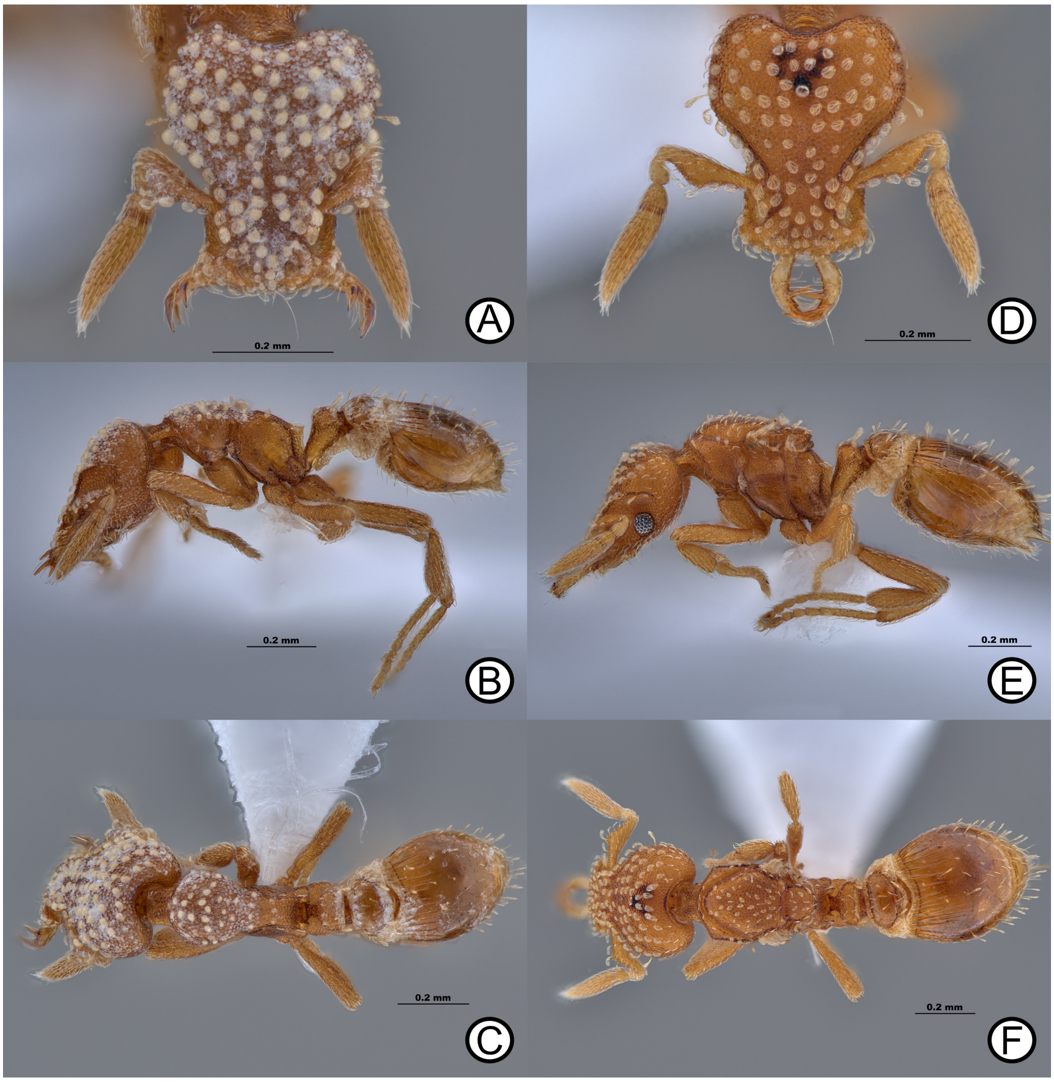

FIGURE 3. *Strumigenys emmae* worker and queen specimens. A) *S. emmae* worker full face view, B) *S. emmae* worker lateral view, C) *S. emmae* worker dorsal view. D) *S. emmae* queen full face view, E) *S. emmae* queen lateral view, F) *S. emmae* queen dorsal view.

Measurements

Worker (n=1): TL 1.72; HL 0.448; HW 0.354; ML 0.108; SL 0.189; PW 0.211; WL 0.442; CI 79.02; SI 53.39; MI 24.11.

Queen (n=1): TL 1.95; HL 0.456; HW 0.373; ML 0.13; SL 0.21; PW 0.255; WL 0.516; CI 81.80; SI 56.30; MI 28.51.

Material examined

Worker (n=1): UK: VC2 East Cornwall; St. Austell, Eden Project, Rainforest Biome, artificial dome habitat, 50.362519N, -4.74538W, (UK GRIDREF: SX 04834 55006), 30 December 2014—09 July 2016, coll. C. R. Turner, top cheese pitfall trap. ANTWEB1010138

Queen (n=1): UK: VC2 East Cornwall; St. Austell, Eden Project, Rainforest Biome, artificial dome habitat, 50.362519N, -4.74538W, (UK GRIDREF: SX 04834 55006), 11 December 2022, coll. C.R. Turner, top flight interception trap (FIT). ANTWEB1010137

Taxonomic key of the native and introduced *Strumigenys* species known from Europe

This key is adapted from Hamer *et al*., (2021). An additional couplet (couplet 3) is provided here to enable identification of *S. emmae* within the European *Strumigenys* fauna. Italicised figure citations refer to figures within Hamer *et al*., (2021).

1 Mandibles narrow, MI 24–58, linear or bowed. At full closure mandibles engage only at their extreme apices and enclose an open space between them. Apicodorsal tooth of mandible long and spiniform, strongly crossing over the tooth from the opposite mandible when closed. Inner margin of mandible with 1–4 teeth or denticles (*figure 6 A–D*) **2**

\- Mandibles triangular, MI 15–20. At full closure mandibles engage throughout their visible length, without an open space between them. Tooth at apex of mandible small and inconspicuous, not spiniform, not strongly crossing over the tooth from the opposite mandible when closed. Inner margin of mandible with 12–14 teeth and denticles, some of which may be minute (*figure 6 E–H*) **5**

2 Pronotal humeral hair absent. Dorsum of mesosoma without standing hairs (*figure 7 A*). Mandibles each with 3–4 preapical denticles. When mandibles fully closed the labral lobes are visible between them as a pair of elongate narrow triangles (*figure 7 B*). (Austria, Azerbaijan, Bulgaria, Croatia, Czech Republic, France (southern mainland & Corsica), Georgia, Germany, Greece, Hungary, Israel, Italy (mainland, Sardinia & Sicily), Malta, Morocco, Russia (Caucasus), Serbia, Spain, Switzerland, Tunisia, Turkey) . . . . ***argiola*** (native)

\- Pronotal humeral hair present (*figure 7 C*). Dorsum of mesosoma with at least one pair of standing hairs (*figure 7 C & E*). Mandibles each with 1–2 preapical teeth. When mandibles fully closed the labral lobes are not visible or at most appear between them as a pair of minute points basally (*figure 7 D & F*). **3**

3 Head dorsum covered in orbicular hairs (figure 3 A); antennae with four segments (including scape) (figure 3 A); scape short and expanded into convex lobe in median third of length (figure 3 A); leading edge of scape with orbicular hairs (figure 3 A); mandibles averaging shorter, MI 24-35 (United Kingdom, Poland, The Netherlands) . . . .***emmae*** (non-native[indoors])

\- Head dorsum without orbicular hairs; antennae with six segments (including scape); scape long and linear, lacking convex median lobe; leading edge of scape without orbicular hairs; mandibles averaging longer, MI 34-57. 4

4 Ventrolateral margin of head interrupted by a deep, strongly incised preocular notch; in dorsal view anterior portion of eye is detached from side of head (*figure 8 A & B*). With head in ventral view the preocular notch forms the apex of a transverse impression in the ventral surface of the head capsule that extends toward the midline, well behind the postbuccal impression. First gastral sternite without a basal spongiform pad. Apicoscrobal hair absent. Pronotal humeral hair flagellate (*figure 7 C*). Mandibles each with 2 short preapical teeth, located close to the apicodorsal tooth, and the proximal preapical tooth longer than the distal (*figure 6 B*) (United Kingdom, Germany, Denmark, Norway) . . . . ***rogeri*** (non-native[indoors])

\- Ventrolateral margin of head uninterrupted to anterior margin of eye; in dorsal view anterior portion of eye is not detached from side of head (*figure 8 C & D*). With head in ventral view without a transverse impression in the ventral surface of the head capsule posterior to the postbuccal impression. First gastral sternite with a basal spongiform pad. Apicoscrobal hair present. Pronotal humeral hair straight and simple. Mandibles either with 1 spiniform preapical tooth, located close to the apicodorsal tooth, or also with a denticle close to the midlength which is much shorter than the spiniform preapical tooth (*figure 6 C & D*) **5**

5 Leading edge of scape with all hairs curved toward the apex of the scape (*figure 9 B*). Ventral surface of petiole with a conspicuous strip or curtain of spongiform material (*figure 9 A*). Mandible with a single spiniform preapical tooth, located close to the apicodorsal tooth, without an additional denticle close to the midlength (*figure 9 B*). Dorsum of mesosoma obviously with more than one pair of standing hairs, on pronotum and mesonotum. Mandibles relatively slightly shorter, MI 34–48. (Guernsey [British Channel Islands]). . . . . ***perplexa*** (non-native[outdoors])

\- Leading edge of scape with 2 or more hairs curved toward the base of the scape (*figure 9 D*). Ventral surface of petiole entirely lacks spongiform material (*figure 9 C*). Mandible with a single spiniform preapical tooth, located close to the apicodorsal tooth, and also with an additional denticle close to the midlength (*figure 9 D*). Dorsum of mesosoma with only a single pair of standing hairs, on the mesonotum. Mandibles relatively slightly longer, MI 50–57 (Portugal [Madeira], southern Atlantic Islands, Leiria district) . . . . ***silvestrii*** (non-native[outdoors])

6 Humerus without a projecting hair; pronotum dorsolaterally with sharp raised margination (*figure 10 A*). Dorsal mesosoma and first gastral tergite without standing hairs (*figure 10 A*). Leading edge of scape with 1–2 hairs near the subbasal bend that are distinctly curved toward the scape base (*figure 10 B*). Dorsal surface of mandible basally with a very distinct transverse sharp edge or rim that extends across its width, parallel to and in front of the anterior clypeal margin (figure 10 B). CI 84–90, SI 51–57. (France, Spain, Italy, Greece, Turkey, Norway) . . . . ***membranifera*** (non-native[outdoors & indoors])

\- Humerus with a projecting simple hair; pronotum dorsolaterally without sharp raised margination (*figure 10 C*). Dorsal mesosoma and first gastral tergite with standing hairs (*figure 10 C*). Leading edge of scape with all hairs curved or inclined toward the scape apex (*figure 10 D*). Dorsal surface of mandible basally without a transverse sharp edge or rim running across its width (*figure 10 D*). CI 66–72, SI 69–76. . . . . **7**

7 Dorsum of clypeus in full-face view densely clothed with conspicuous broadly spatulate to spoon-shaped hairs; in profile these hairs parallel with the surface from which they arise and closely applied (*figure 11 A*). Medially curved ground-pilosity bordering the upper scrobe margins distinctly spatulate. (Algeria, Armenia, Bulgaria, Croatia, France (southern mainland & Corsica), Greece, Hungary, Italy (mainland, Sardinia & Sicily), Macedonia, Malta, Montenegro, Morocco, Romania, Russia, Serbia, Spain, Switzerland, Tunisia, Turkey) . . . . ***baudueri*** (native)

- Dorsum of clypeus in full-face view clothed with slender hairs that are very narrowly spatulate or simple and cylindrical; in profile these hairs markedly elevated and either arched or inclined anteriorly (*figure 11 B*). Medially curved ground-pilosity bordering the upper scrobe margins fine and simple **8**

8 Hairs on clypeal dorsum narrowly spatulate; in profile the hairs distinctly anteriorly curved or anteriorly arched (*figure 12 A*). (Bulgaria, France (mainland & Corsica), Greece, Italy, Spain, Turkey) . . . .***tenuipilis*** (native)

- Hairs on clypeal dorsum simple, fine and cylindrical throughout their length and tapered or truncated apically; in profile the hairs mostly straight, inclined anteriorly (*figure 12 B*). (France (Corsica), Greece) . . . . ***tenuissima*** (native)

Discussion

Strumigenys emmae is the third *Strumigenys* species known from Britain, following *S. rogeri* (Donisthorpe 1908; Donisthorpe 1915; Hamer *et al*., 2023), and *S. perplexa* (Hamer *et al*., 2021). The record outlined within this paper represents the third mention for *S. emmae* in Europe, after being collected in The Netherlands and Poland (Noordijk & Heijerman, 2021; Michlewicz 2022). Records from Mainland Europe are all located within artificially heated greenhouses and therefore correspond well with the record outlined here. Although both studies pre-date this publication, one record provided here (ANTWEB1010138), from 2014, pre-dates the records given in Noordijk & Heijerman (2021) and Michlewicz (2022), both being from 2018. While time between introductions and first detection for exotic species can span years, making it difficult to determine which of these introductions occurred first, the UK record presented here represents the earliest established population recorded from Europe so far. Additionally, as both records from the same locality were separated by 8 years and with the latest from a reproductive gyne, this suggests that the population is well-established and already reproducing. Sampling methodology and efforts within artificially heated greenhouses across Europe are not equal, and sampling in some nations may not take place at all. Considering the global distribution of *S. emmae* (Wetterer 2012), and the long history of the horticultural trade networks (c. three centuries), it therefore seems reasonable to assume that populations may have existed across Europe before this and other publications. The lack of previous records could be as a result of the species cryptobiotic nature and the lack of sampling effort towards greenhouses and other climatically buffered infrastructure (as addressed above, see Wong *et al.*, 2023).

Thought to be of Australasian origin (Brown 1949; Bolton 2000), *S. emmae* has achieved a pantropical distribution via human commerce (Wetterer 2012). Outside of artificially heated infrastructure, specimens are often from within disturbed, mesic and xeric habitats, including forests, urban and agricultural areas, and nearly always within leaf litter. Colonies are small, with Deyrup and Deyrup (1999) finding several colonies in acorns with fewer than 50 workers. Although information is scant regarding the feeding preferences of *S. emmae*, Deyrup & Deyrup (1999) found observed larvae feeding upon entomobryid Collembola. Moreover, *S. emmae* is capable of parthenogenetic reproduction (though Deyrup & Deyrup (1999) collected a putative male in Florida from a flight interception trap), as are many tramp *Strumigenys* species, which likely contributes to their adventive success (Wang *et al*., 2023). Considering the species climatic requirement, it is unlikely to establish outdoors in Britain, and could in fact be acting as an important leaf litter predator within the humid tropical biomes at the Eden Project. However, the horticultural trade between greenhouses may enable the spread of this species across the region.

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