Correspondence

The invasive ant *Solenopsis invicta* is established in Europe

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The red imported fire ant (*Solenopsis invicta*) is classified as one of the worst invasive alien species[1] and as the fifth costliest worldwide[2], impacting ecosystems, agriculture and human health[3]. We report the establishment of *S. invicta* in Europe for the first time, documenting a mature population in Sicily. We use genetic analyses to assess its putative origin, as well as wind tracking and species distribution modelling to predict its potential range on the continent. We show that half of the urban areas in Europe are already suitable and that climate warming expected under current trends will favor the expansion of this invasive ant.

In less than one century, the South American ant *S. invicta* established and spread throughout much of the United States, Mexico, the Caribbean, China, Taiwan and Australia (Figure 1A), while eradication succeeded only in New Zealand[4,5]. In Europe, there have been at least three documented interceptions of *S. invicta*, in Spain, Finland, and the Netherlands[6].

We documented 88 nests extending over about 4.7 ha during winter 2022/2023 in Sicily (Italy), near the city of Syracuse (Figure 1A–C and Data S1A,B). The invaded area, bordering a river estuary, is heavily disturbed, but falls within a larger regional protected site. Locals informed us of frequent ant stings in the area since at least 2019, suggesting a prolonged presence of *S. invicta* that is coherent with the large invaded area and high number of mature nests (Figure 1B,C). How the species reached this site is not clear, but no large landscaping or planting projects seem to have taken place over the last few years and it is highly unlikely that it represents the first arrival point and only location in the area. The proximity of one of the main cargo harbors of the island, the Augusta port (~13 km northward), may be relevant for its introduction.

Long-range dispersal of ant queens during nuptial flights tends to be aided by wind and follow its direction[3]. Locally prevailing wind directions at ground level indicate that, if arrived by flight, queens colonizing the invaded site may have come from the north-west, where further monitoring efforts should be prioritized (Figures 1A and S1). Likewise, swarming queens are likely to be directed south-east and therefore towards the sea, which may represent a limiting factor for further inland spread. Alarmingly, we observed nuptial flights even in winter (Figure 1B), well outside the spring-autumn seasonality typical of the northern hemisphere[3]. *S. invicta* colonies can be either monogynic or polygynic (hosting one or multiple queens, respectively), and the two social forms are characterized by specific alleles of the *Gp-9* gene[7]. Polygynic colonies, which have become prevalent across much of the invaded range, adopt a supplemental short-range dispersal strategy, and may perform long-range flight dispersal less frequently[3]. We confirmed the polygyny of this population by detecting multiple dealate queens per nest and conducting genetic analyses on the *Gp-9* gene. The history of the global invasion of *S. invicta* has been reconstructed through genetic data: they were first introduced from northeastern Argentina into the southern US, while all other alien populations apparently originated from at least nine distinct introductions from North America[8]. The Italian population presents one of the three main mitochondrial haplotypes, widely distributed across invaded areas and in Argentina, named H5 (Figure 1D)[8]. Among invaded areas, this haplotype is particularly frequent in the populations of southern US, mainland China and Taiwan (Figure 1E), the most likely introduction sources considering their top position in the global trade. We assessed environmental suitability for *S. invicta* across Europe and the Mediterranean using ensemble species distribution modeling. Under current environmental conditions, this ant may be able to establish in about 7% of the study region (Figure 1G), mainly occupying agricultural areas and, to a lesser extent, urban and protected areas (Figures 1F and S2, and Data S1C). Remarkably, half of the urban areas are recovered as suitable. This is concerning because most suitable urban areas are coastal Mediterranean cities highly connected by seaports, potentially favoring the spread of the species. Worryingly, future projections depict a far worse scenario, in which the suitable range of *S. invicta* largely increases (Figures 1H,I and S2, and Data S1D).

Coordinated efforts for early detection and action in the region are key for successfully managing this new threat. Citizen science may play a key role in the detection of *S. invicta* considering that it is frequently encountered in urban and peri-urban areas, and due to its painful stings able to cause anaphylactic shocks[9] and the characteristic large nest mounds. Monitoring efforts should be extended to a larger geographic scale, given the species dispersal capability and the presumed existence of an unknown first site of introduction. The establishment of effective detection strategies for alien ant species appears particularly important considering their rising numbers at the European and global scales[5,10].

SUPPLEMENTAL INFORMATION

Supplemental information including two figures, methods, data file and inclusion and diversity statement can be found with this article online at https://doi.org/10.1016/j.cub.2023.07.036.

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DECLARATION OF INTERESTS

The authors declare no competing interests.

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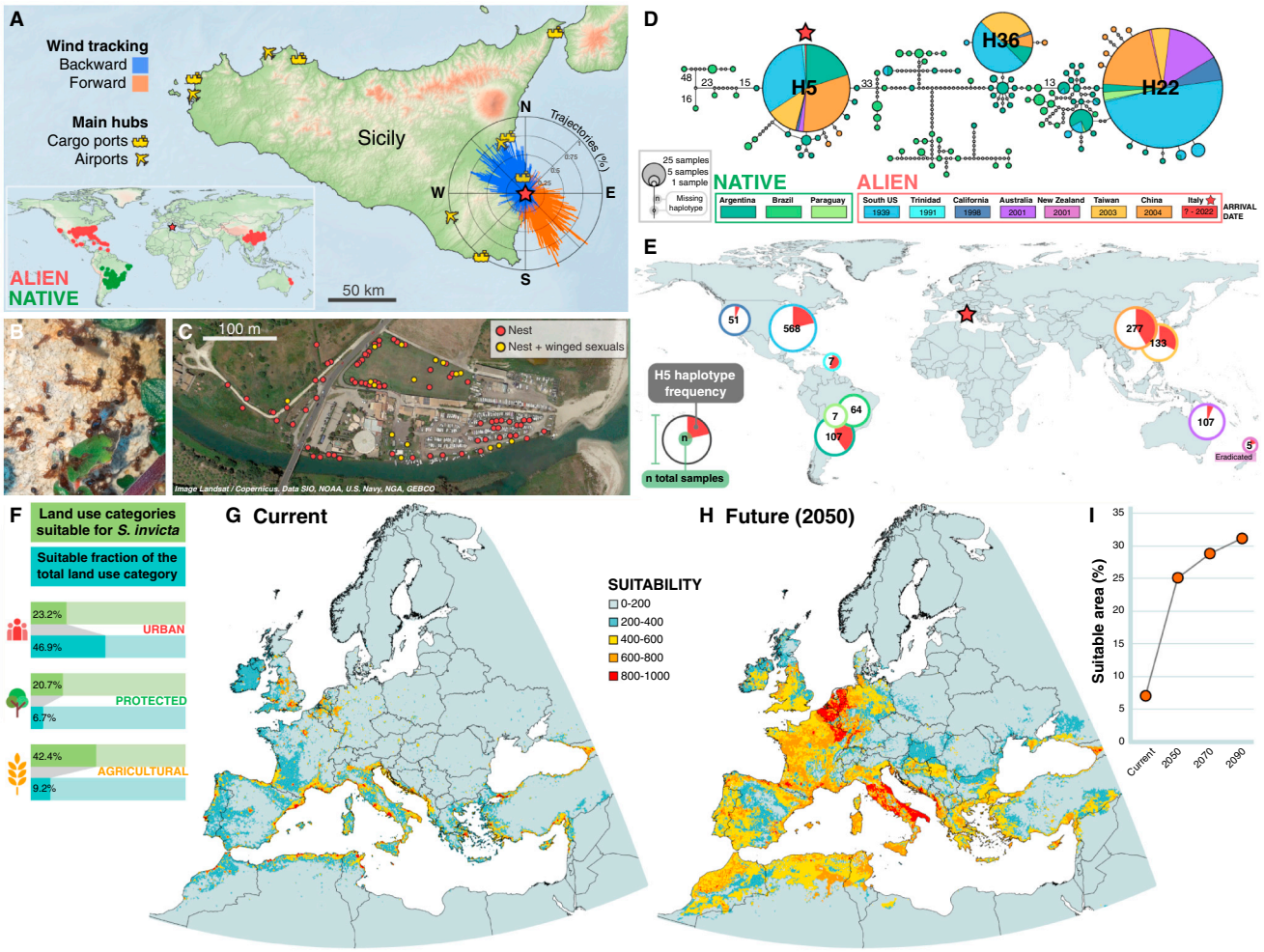

Figure 1. Location, genetic analysis, and modeling of the potential spread of the new alien population of *S. invicta*.
(A) The invaded area in Sicily is marked with a star. The directions of wind trajectories starting from (forward) and arriving at (backward) the study area are indicated as percentages over the total time frame. Main commercial hubs on the island are highlighted. Inset map summarizes the records retrieved for the species alien and native ranges. (B) Nuptial flight recorded in January 2023. (C) Satellite view of the study area (37.055N, 15.267E) and ant nest positions (Data S1A). (D) Haplotype network of mitochondrial sequences. The three main haplotypes are annotated. Colors indicate the sample origin and the sizes of the circles represent the number of samples. (E) Worldwide frequency of the H5 haplotype recorded in Italy, highlighting possible introduction sources. (F) Bars represent suitable area estimated for the species partitioned by land use category (green: % of total area of Europe; blue: % of total area of that category). (G) Ensemble model map prediction under current and future (H) environmental conditions. (I) Future trends of predicted suitable area (% of total area).

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