# The Conquest Continues: First Outdoor Records of *Armadillidium arcangelii* Strouhal, 1929 in the British Isles (Isopoda: Oniscidea: Armadilliididae)

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## Abstract

The pillbug *Armadillidium arcangelii* Strouhal, 1929 is reported from seven garden centres from across the British Isles, as a result of passive surveying of imported plants for non-native invertebrates. These records represent the first outdoor observations for the species across the region, and indicate a potentially large-scale introductory pathway for the species. A brief summary of the species identification against the British members of the Armadillidiidae is provided, in addition to a detailed discussion on the plants potentially responsible for its introduction and its implications for British agriculture.

**Key words:** Isopoda, Onsicidea, *Armadillidium arcangelii*, non-native, tropical plants, Mediterranean.

## Introduction

Extensive surveying of the Eden Project during 2003 and 2010 by various researchers resulted in the discovery of a new pillbug (*Armadillidium*) for Britain, which was collected from within the Mediterranean biome glasshouse (Gregory, 2014). The specimens were provisionally attributed to the widespread western Mediterranean endemic species *A. assimile* Budde-Lund by Gregory (2010), but was later cited as an indeterminate taxon, under "*Armadillidium* sp." due to clear morphological differences, in addition to the difficulty in identifying a corresponding specific taxon (Gregory, 2014). From 2014 to 2021 numerous records of an identical unidentified *Armadillidium* were being collated across Europe and the Mediterranean, from Iberia to the Levant, indicating that this species was undergoing a recent and rapid range expansion (Garcia & Cabanillas, 2021; Noël *et al*, 2022; De Smedt & Van Dijck, 2023). The majority of these records were from outdoor settings in synanthropic habitats, particularly gardens and parks, and in one case from a green roof (De Smedt & Van Dijck, 2023), indicating the dispersal to be anthropochoric via the horticultural industry.

The species *A. arcangelii* Strouhal, an Italian endemic, was given as a proposed identity for these observations after extensive literary examination by Georgios Agapakis in Noël *et al* (2022). The similarity between the newly recorded *Armadillidium* and the literary descriptions for *A. arcangelii* indicates that this is the most appropriate identification for these observations, but with close morphological affinities to other species, notably *A. apenninorum* Verhoeff and *A. marmoratum* Strouhal, and an unknown point of origin, it is still considered a provisional identification until examination of type/topotypic material or phylogenetic analysis is undertaken. As such, the taxon is tentatively treated as *A. arcangelii* like those of other recent publications (De Smedt & Van Dijck, 2023; Fusaro *et al*., 2024).

Despite the large and ever-growing dataset of *A. arcangelii* records from across mainland Europe, the observation from the Eden Project remained as the only record for the species in Britain. Here we report the first outdoor records for the British Isles from seven garden centres across England, Northern Ireland and Scotland, with further evidence linking its dispersal to plant material.

## Records

During 2022 and 2023 the authors visited garden centres, where possible, to sample for non-native invertebrates accidentally introduced on plant material. An additional site was added in 2024. The presence of a country of origin code (D) on EU plant passports incorporated on plant labels or affixed/printed directly onto the pots allowed for easy identification of plants originating from the Mediterranean region, for example Italy (IT) and Spain (ES), or from large horticultural producing regions in northern Europe such as the Netherlands (NL). Specimens were collected by hand by searching the underside of potted plants and the surfaces around them.

**Table 1: Records of *Armadillidium arcangelii* from Garden Centres**

Specimens retained and preserved in 70% Isopropanol/Bioethanol*, maintained in culture**

| County | Country | Date | Plant | Origin | Specimens |
|---|---|---|---|---|---|
| Suffolk | England | 2.viii.2022 | *Trachycarpus fortunai* | Spain | 1♀ |
| Essex | England | 29.iv.2023 | *Melaleuca* (*Callistemon*) *citrinus* | Spain | 1♀, 1♂* |
| Suffolk | England | 6.v.2023 | *Olea europaea* | Italy | 2♀* |
| Suffolk | England | 8.v.2023 | - | - | 1♂* |
| Midlothian | Scotland | 21.vi.2023 | - | - | 1♀* |
| Essex | England | 19.vii.2023 | *Chamaerops humilis* | - | Several observed (none collected) |
| Fermanagh | N. Ireland | 21.vii.2023 | - | - | 1♀**, 1♂** |
| Hertfordshire | England | 13.viii.2023 | *Nerium oleander* | Portugal | Several observed (none collected) |
| Northumberland | England | 30.vi.2024 | *Griselinia littoralis* | Spain | 2♀** (one gravid) |

## Identification

The specimens examined here correspond to the diagnoses and illustrations provided by Gregory (2014), Garcia & Cabanillas (2021) and Noël *et al*. (2022) for the recently expansive species assigned to *A. arcangelii* (Fig. 1). The main external characteristics that enables this species to be separated from the seven Armadillidiid species currently found in Britain is the combination of its small size, <8mm, mottled brown body colouration with paler epimeron and prominent muscle scars, weakly projecting scutellum, eyes comprising numerous ommatidia and the telson being triangular. Confusion is most likely to occur with immature specimens of *A. vulgare*, which can exhibit a similar dorsal colouration, but separation can easily be achieved through examination of the telson which is broadly trapezoidal in *A. vulgare* and triangular in *A.* cf. *arcangelii* (well figured in, De Smedt & Van Dijck, 2023).

### Male sexual characteristics - First Pleopod

The first pleopod endopodite is linear, narrowing posteriorly with a slight outwards curve. Although subtle, this characteristic is only shared with *A. album* and *A. nasatum*, whereas in the other species the endopodite is entirely linear or has a more pronounced curve or bend at its tip. The first pleopod

exopodite is triangular, with a sharp, approximately 60° angle to its apex. The proximal margin is weakly curved and adorned in prominent spines that surpass the apex, extending to just over the posterior margin. The posterior margin has a weak obtuse angle at the internal edge of the tracheal field. The form of the first pleopod exopodite is unlike those represented by any of the British Armadillidiidae. Some species have similar triangular projections, such as *A. album*, *A. depressum* and *A. pictum*, but none have a pronounced sharp angle to the apex, this being more rounded in the other species.

Although *A. arcangelii* can be differentiated from British Armadillidiids based on the aforementioned somatic characteristics, examination of male specimens is considered desirable in confirming species identification, especially for records intended for the BMIG Woodlouse and Waterlouse Recording Scheme.

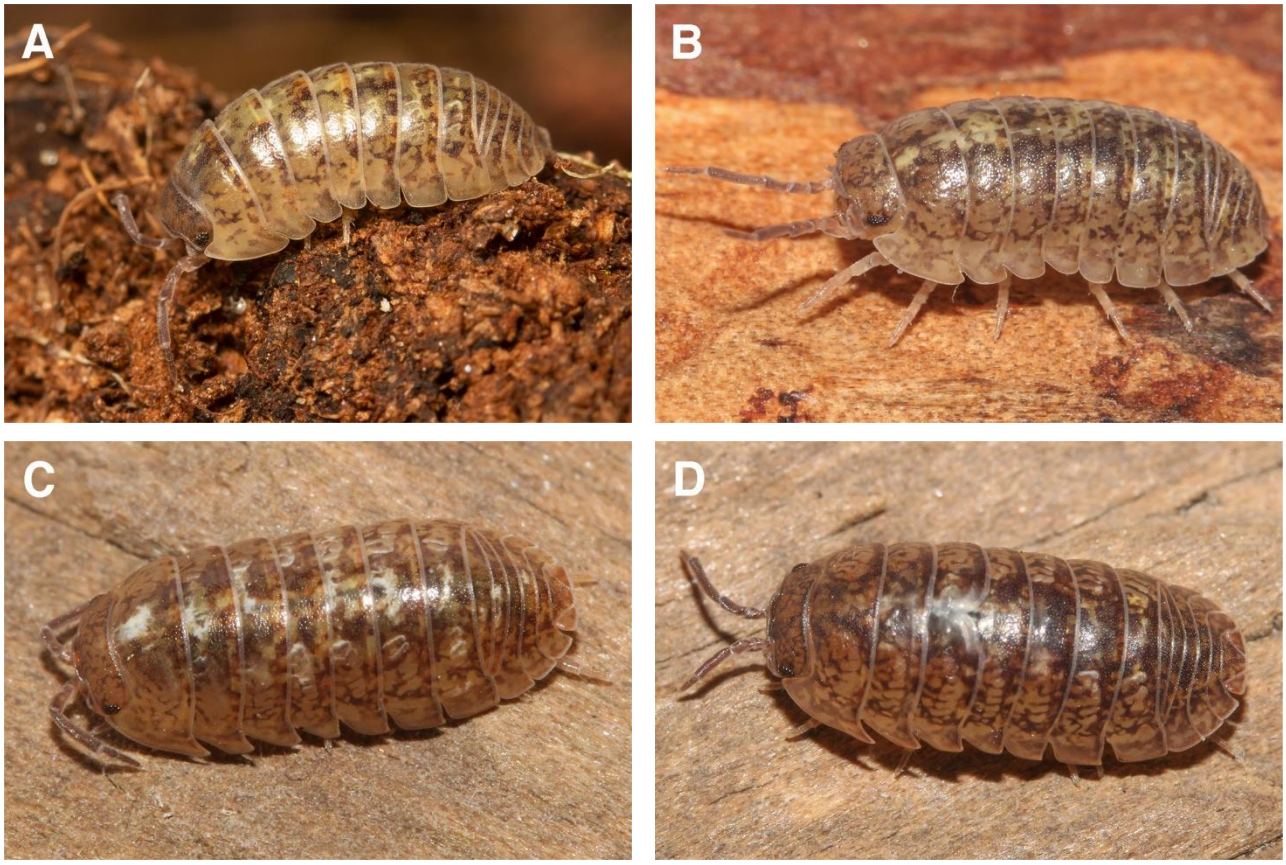


**Figure 1: *Armadillidium* cf. *arcangelii*, live individuals**: **A)** Female, Suffolk, England; **B)** Female, Midlothian, Scotland; **C)** Female, Fermanagh, Northern Ireland; **D)** Male, Fermanagh, Northern Ireland.

## Discussion

*Armadillidium arcangelii* was collected in association with other non-native invertebrates including the ants *Hypoponera eduardi* (Forel), *H. ergatandria* (Forel), *Pheidole pallidula* (Nylander) and *Tapinoma nigerrimum*-complex (Nylander), the weevil *Otiorhynchus cribricollis* (Gyllenhal), the centipede *Lamyctes africanus* (Porat), the millipede *Oxidus gracilis* (C.L. Koch) and the earwig *Euborellia annulipes* (H. Lucas). Sympatric woodlice include native species such as *A. nasatum* Budde-Lund, *A. vulgare* (Latrielle), *Cylisticus convexus* (De Geer), *Oniscus asellus asellus* Linnaeus, *Porcellio scaber* Latreille, *Trichoniscus pusillus* agg. Brandt, in addition to the imported new species *Ctenoscia*

*minima* (Dollfus) (Hughes, 2023; Hughes, 2024; Northfield, 2024). Population densities of *A. arcangelii* were not significantly larger than any of the associated species, but in some circumstances was found to the exclusion of others. Whether this is an indication of competitive exclusion, better survivability under unsuitable conditions, or just coincidence is not determinable from our small sample size. De Smedt & Van Dijck (2023), in contrast, documented a clear rise in the population size of *A. arcangelii* on a green roof in Belgium over a 10 year period, and found that *P. scaber*, the previously dominant species, was gradually replaced by *A. arcangelii*. Noël *et al* (2022) from their large dataset, also speculated that *A. arcangelii* could have a competitive edge over other common, drought-tolerant synanthropic species like *A. nasatum* and *A. vulgare*.

We have presumed a Mediterranean nursery origin for these British outdoor records, evidenced by the thorough searching of both plants of Mediterranean origin and those from British growers. We hypothesised that the ability of *A. arcangelii* to freely move around the plant stages means that they may not be associated with the pots they were originally imported on; however, all finds have been concentrated on or around the pots of plants of Mediterranean origin, and so far none have been found associated with British-grown plants. This could indicate low dispersibility rates in the garden centres, or that these animals are unable to survive our comparably harsher winters so are only ever associated with freshly imported plant material. This is supported by the fact that no outdoor records have been submitted from the British Isles from private gardens, unlike the large numbers from the rest of Europe in recent years.

**Origin of Plant Material**

*Armadillidium arcangelii* was found beneath the pots of *Melaleuca* (*Callistemon*) *citrinus* (Curtis) Dum.Cours., *Chamaerops humilis* Linnaeus, *Griselinia littoralis* Raoul, *Nerium oleander* Linnaeus, *Olea europaea* Linnaeus and *Trachycarpus fortunai* (Hook.) H.Wendl. Of the six plant associations, five had country codes indicating that they were grown in Italy, Portugal or Spain. Although the *C. humilis* lacked country codes, the plant is assumed to have arrived from Mediterranean imports alongside adjacent plants that did have origin data. Previously surveyed *C. humilis* plants showed their country of origin as being Spain. The observations of *A. arcangelii* without plant or origin data were found directly on the wooden stages, in close association with Mediterranean plants.

In addition to these observations, there is a record from Poland in 2019 from a *Lavandula* Linnaeus pot that had been imported from the Netherlands, which later led to the confirmation of specimens that had previously been collected from a garden centre in the Netherlands in 2012 (Noël *et al.*, 2022). The observation in 2019 was, prior to this publication, the only direct record linking *A. arcangelii* to plant importation from abroad. However, the original record from the Eden Project as far back as 2005, and those from a green roof in Belgium which was constructed and planted out in 2012 would indicate that the species has been present within the horticultural industry for a long time, possibly over two decades (De Smedt & Van Dijck, 2023; Gregory 2010; 2014). The significant increase in observations during the past five years could be attributed to the species increase within these horticultural growing regions, allowing it to access more plant material intended for export.

**Implications as an Agricultural Pest**

As demonstrated by Fusaro *et al*. (2024) this species has the capacity to become a threat to agriculture, particularly small-scale organic vegetable producers. Substantial damage to tomatoes, cabbages, and especially melons was reported by organic greenhouse growers, who had also noticed a significant increase in populations of woodlice within their greenhouses. The feeding habits of the woodlice on the stems of seedlings, sometimes in large numbers, typically caused wilting of the plants. On both farms sampled, loss of predominantly melon crops as a result of isopod feeding was estimated at between 40% and 50%. The authors conclude that a number of factors could be responsible for the proliferation of

isopods such as *A. arcangelii* in greenhouse environments. These factors included increases in soil moisture (also a factor influencing isopod reproduction rates outside of artificial environments), external factors such as drought, and population increases exhausting typical food sources such as detritus, prompting the woodlice to utilise secondary food sources.

Reports of woodlouse damage to crops from mainland Europe makes the new observations of *A. arcangelii* presented here of significance to British growers, particularly those that use protected cultivation, such as growers of strawberries. The propensity of this species to colonise anthropogenic habitats, as well as its potential to become a significant crop pest under optimal conditions, indicates that its spread is worth monitoring within the British Isles. However, this may be practically complicated, as the inconspicuous appearance and small size of *A. arcangelii* make it difficult for non-experts to distinguish in the field, particularly when compared with small specimens of *A. vulgare* and *A. nasatum* which can often be found in the same environments. Further awareness within certain key groups such as soil ecologists and plant health controllers, as well as encouragement of casual recording at garden centres, may provide increased awareness and more useful data regarding the population trends of this species within the UK.

## Conclusion

The woodlouse *A. arcangelii* is reported outdoors from across the whole breadth of the British Isles, found in association with Mediterranean plants. From this, it can be concluded that *A. arcangelii* is very likely to be present at every garden centre that regularly imports plants from this region. The ability to competitively exclude other species in synanthropic habitats, in addition to its propensity to become an agricultural pest, makes this species of potential concern for British plant and vegetable growers, and wider ecological impacts on native species. As such, this species should be on the radar of all invertebrate and plant health surveyors (eg; APHA), particularly at interception sites such as point of entry (PoE) and place of destination (PoD), including border control posts (BCPs), garden centres, nurseries and tropical houses. Although we have no records from domestic dwellings, public parks and gardens (as seen elsewhere in Europe) it is possible under current climate predictions (IPCC, 2022) that we can expect more outdoor records to appear from across the British Isles in the coming years.

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