

Rapid Communication**Two alien insect species are new records at the family-level to the Azores archipelago (Portugal)**Mário Boieiro^{1,2,*}, Abrão Leite¹, Carla Rego^{1,2}, Zsófia Varga-Szilay³ and Paulo A.V. Borges^{1,2}¹*cE3c- Centre for Ecology, Evolution and Environmental Changes, Azorean Biodiversity Group, CHANGE – Global Change and Sustainability Institute, Faculty of Agricultural Sciences and Environment, University of the Azores, 9700-042, Angra do Heroísmo, Portugal*²*IUCN SSC Mid-Atlantic Islands Invertebrates Specialist Group, Angra do Heroísmo, Azores, Portugal*³*Doctoral School of Biology, Institute of Biology, ELTE Eötvös Loránd University, Budapest, Hungary*

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OPEN ACCESS**Abstract**

Species introductions are a major issue for biodiversity conservation and human well-being worldwide, but their impact can be particularly severe in oceanic island ecosystems. Here, we report the occurrence of two alien species on Terceira island, *Rivellia syngenesiae* (Fabricius, 1781) (Diptera: Platystomatidae) and *Sceliphron caementarium* (Drury, 1773) (Hymenoptera: Sphecidae), being the first reports of these insect families to the Azores archipelago. We provide the diagnosis of each species, information on their distribution and ecology, and discuss their potential impact on native biodiversity. Furthermore, we anticipate the spread of these species through the Azores islands, benefiting from the high increase in commerce and tourism, and stress the need to set a program for the early detection of alien species in the archipelago.

Key words: species invasions, island biodiversity, Platystomatidae, Sphecidae, *Rivellia syngenesiae*, *Sceliphron caementarium*, Macaronesia

Introduction

Oceanic islands are key areas for nature conservation due to their disproportionate contribution to global biodiversity as they host high numbers of endemic species (Fernández-Palacios et al. 2021). However, many island endemics are threatened with extinction by habitat destruction, climate change, and alien species (Borges et al. 2019). Species introductions are a major problem in many island ecosystems worldwide since they affect not only native biodiversity and natural ecosystems but may have major negative impacts on agriculture, forestry and public health, with significant consequences for economy and human well-being (Reaser et al. 2007; Russell et al. 2017; Borges et al. 2019; Fernández-Palacios et al. 2021). In the last few decades, there has been an increasing number of species introductions in oceanic islands as a result of the exponentially increasing tourism and the transportation of goods from the most diverse origins. The Azores archipelago is no exception to this rule and, during the last decade,

several alien species have been detected for the first time in different islands (Borges et al. 2013, 2022), particularly in those that are the main hubs for tourism and commerce (e.g. São Miguel, Terceira). Most of these introductions are accidental with alien species benefiting from long-distance transport by humans, but once arrived in the archipelago many of these species may spread within and between islands by active or passive dispersal. Only a few number of species were deliberately introduced in the archipelago in the last decades, usually to be used in urban areas (e.g. ornamental plants) or including biological control programs (e.g. pest predators and parasitoids) (Soares et al. 2017; Rondoni et al. 2021).

The ecological impacts of most introduced vertebrate and vascular plant species have been identified and evaluated in several Azorean islands with some monitoring and control programs underway (e.g. projects LIFE Beetles and LIFE IP Azores Natura). However, alien invasive invertebrate species have seldom been targeted for monitoring and control despite several species having been identified as of concern in this and other Macaronesian archipelagos (Silva et al. 2008). Even for the alien invertebrate species classified as the worst invasive in Azores [including the generalist predators *Dysdera crocata* C. L. Koch, 1838 (Araneae, Dysderidae) and *Linepithema humile* (Mayr, 1868) (Hymenoptera, Formicidae)], basic information on their distribution, spread and impacts on native biodiversity and ecosystem processes is still lacking. The arrival of generalist and opportunist alien insect species in the Azores seems problematic as these young and remote islands have species-poor communities being potentially vulnerable to bioinvasions.

Here, we report two introduced species, each one belonging to a new insect family for the Azorean fauna. Moreover, we present the diagnosis, distribution and ecology of the newly introduced species, and discuss their potential impact on the native biodiversity.

Materials and methods

The first findings of the two alien insect species were recorded during ad-hoc surveys carried out in human-disturbed habitats in Terceira island (Azores, Portugal) in 2022. Upon their discovery, additional sampling was performed in the same areas and in other localities of potential occurrence aiming to detect the species. Also, wasp specimens were sent to us by a citizen that feared being in presence of the invasive Asian hornet *Vespa velutina* Lepeletier, 1836. The fly was observed and photographed in the field using a Panasonic DMC-TZ80 digital camera and species identification was made with the help of taxonomic references (Lyneborg 1969; Korneyev 2001). The wasp specimens were observed, collected and then identified to species level in the laboratory using an Olympus SZX7 stereomicroscope and specific taxonomic literature (Bitsch et al. 1997; Pagliano and Negrisoló

2005). All collected specimens were stored in vials with ethanol (70%) and deposited in the Dalberto Pombo entomological collection at the University of the Azores (Angra do Heroísmo, Portugal).

Results

In this study, we report the finding of two previously unrecorded insect species in the Azores, adding also two new families to the Azorean insect fauna. All the records were made in Terceira, one of the islands that experienced a drastic increase in tourism and commerce in recent years.

Rivellia syngenesiae (Fabricius, 1781)

This signal fly (Diptera: Platystomatidae) is relatively widespread in Europe, occurring in various countries such as Portugal, Spain, France, Italy, Netherlands, Czechia, Austria, Germany, Poland, Denmark, Sweden, Norway, Finland and the United Kingdom. The close relative *Rivellia hispanica* Lyneborg, 1969, however, seems to be restricted to the southern region of the Iberian Peninsula. Flies of the genus *Rivellia* have low to medium size (3.0–6.0 mm) with elongated thorax and abdomen with reduced chaetotaxy. Wing veins R4+5 and M are apically parallel or divergent, bm cell is short and closed by an arched vein and the stem vein is bare (Korneyev 2001). These flies have characteristic wing patterns but can be confounded with other tephritoid flies, particularly *Herina* Robineau-Desvoidy and *Urophora* Robineau-Desvoidy species. It is thus important to consider the diagnostic characteristics of the family (Oosterbroek 2006). *Rivellia syngenesiae* is quite similar to *R. hispanica*, without significant differences in the morphology and colouration of the head, thorax and abdomen, but the two species differ in genitalia morphology and in wings and tarsi colouration (Lyneborg 1969). In *R. syngenesiae*, tarsi are predominantly blackish (not yellowish as in *R. hispanica*) and the wing band over the posterior cross vein (m-m) is widely separated from the apical spot leaving a large hyaline area in cell R2+3, between the band and the spot (Lyneborg 1969). The species was found in two different areas in northwestern Terceira, near Serreta and at Biscoitos. Near Serreta, a single individual was found in the margin of a forest plantation dominated by *Pittosporum undulatum* Vent. (Apiales, Pittosporaceae), at the vicinity of a viewpoint (38.780080°N; -27.357399°W), on 2 April 2022. The fly was on a false dandelion flower (*Hypochaeris radicata* L.; Asterales, Asteraceae) and was photographed and observed at hand (Figure 1). Later, we visited the same location, but the species was not detected. At Biscoitos, the species was first detected in a house in a rural area (38.792678°N; -27.256044°W) on 28 June 2022 and a few days later, on 1 July 2022, in a house garden on its vicinities (38.793056°N; -27.255802°W). The signal fly is quite abundant in this area since many individuals were observed on the vegetation and a few were



Figure 1. *Rivellia syngenesiae* found near Serreta (Terceira, Azores) on 2 April 2022. Photo by Mário Boieiro.

collected, photographed in place and then released. Additional sampling targeting plant-visiting insects was carried out in Terceira island, particularly in natural areas (Pico Galhardo), urban parks (Angra do Heroísmo and Praia da Vitória) and wasteland areas (Angra do Heroísmo), but the species was not found.

***Sceliphron caementarium* (Drury, 1773)**

The yellow-legged mud-dauber wasp (Hymenoptera: Sphecidae) is originally from the Nearctic region and has been introduced in many countries worldwide (Pulawski 2022). It is believed that it was introduced multiple times in Europe (mostly by accidental transport in ship cargos), where has been spreading fast, being already reported from many southern and central European countries and the Madeira archipelago (Smit 2008; Demetriou et al. 2022; Pulawski 2022). *Sceliphron* Klug wasps can be recognized by their black body with yellow spots, hyaline wings and elongated petiole. The head has a flattened frons, filiform antennae, mandibles are usually toothless and the third maxillary palpomere is wide (Pagliano and Negrisoló 2005). *Sceliphron caementarium* can be easily separated from the other congeners due to the characteristic dark colour of metathoracic coxa, trochanter and femur and the yellow colour of females' propodeum (Bitsch et al. 1997; Pagliano and Negrisoló 2005). The head and thorax have black or brown pilosity, mandibles have a small tooth in the inner margin, and wings have tawny colour (Bitsch et al. 1997) (Figure 2). The yellow-legged mud-daubers are solitary wasps that build their nests with mud and provision them with spiders. Nests are composed of several individual cells (up to 26), with a single egg being laid in each, and are



Figure 2. A female specimen of *Sceliphron caementarium* collected in Angra do Heroísmo (Terceira, Azores). Photo by Javier Torrent.

constructed in shaded areas in natural environments or man-made structures. The adults are often found feeding on nectar and are not aggressive, except when defending their nests. The species was found in three different locations in Angra do Heroísmo municipality, being first detected in Angra do Heroísmo (1♂; 38.662801°N; -27.212863°W) on 12 June 2022 and later four individuals were collected nearby (1♂, 3♀♀; 38.661745°N; -27.211668°W) during late July and early August by Telmo Alves, a citizen that feared to be in presence of the Asian hornet *Vespa velutina*. This person informed us that the wasps were not rare and were already present in the area in the previous year. More recently, on 1 October 2022, the species was detected by Hélder Nunes on the vegetation near an agricultural field (38.691758°N; °27.352233°W), in Santa Bárbara.

Discussion

The finding of these two alien species with several populations in Terceira island confirms the vulnerability of the Azores to the arrival and establishment of alien species and reinforces the need for the adoption of monitoring programs for species' early detection and control. Species introductions are potentially a major threat to island biodiversity, economy and human well-being as proved in previous examples from the Azores and Macaronesia (Silva et al. 2008; Boieiro et al. 2018; Silva-Rocha et al. 2018). In the Azores, the increase in introduced species is particularly worrisome as changes in native forest communities have already been detected (Borges et al. 2020).

The two alien insect species were found in human-disturbed areas and will probably spread mainly in coastal, low-altitude and urban, suburban and rural areas, benefiting from the mild climate, available resources and

empty niches found there. The dispersal of these species to the native forest seems unlikely in the short term since this biota is located at higher altitudes, where harsher climatic conditions prevail, and resources seem to be low. Nevertheless, their spread to other islands of the central group and São Miguel is expected in the next few years due to the regular inter-island transportation of goods and commodities from Terceira. At present no major ecological impacts have been detected by these two alien species, but both pose some risk to biodiversity, economy and human well-being.

Rivellia Robineau-Desvoidy larvae are known to feed on the root nodules of plants and can severely affect their nitrogen-fixing capability (Foote et al. 1987). Most of their host plants are legumes, including several species that are key in the human food supply. This is of economic significance since many leguminous crops are nitrogen-limited, and the insect infestation may lead to considerable losses in production (Whittington 2019). Also, several studies showed that *Rivellia* species can host shift, and thus may benefit from a broader host spectrum to successfully establish in invaded areas (Foote et al. 1987; Whittington 2019). In Terceira, the host plants of *R. syngenesiae* have not yet been identified, but the rural landscape and extensive areas of pastures with abundant naturalized and cultivated legumes seem to offer favorable ground for this species' spread. In the short term, it is crucial to monitor the spread of this species and collect information on its host associations and potential impacts on the local production of goods.

Concerning the wasp *Sceliphron caementarium*, its spread in Europe and in other invaded areas has been quite fast (Demetriou et al. 2022; Pulawski 2022) and the finding of this species in the remote Azorean archipelago is remarkable, although expected due to the exponential increase in the transportation of goods and commodities from many origins. The adults feed on nectar and the hemolymph of their prey while larvae develop feeding on spiders that were brought to the nest by the female adult. Several studies showed that this species prey upon diverse spider species, mostly of the family Araneidae, and usually ranging from 4–6 mm, but different feeding strategies (along the specialist/generalist gradient) may be adopted at the individual level (Polidori et al. 2007; Powell and Taylor 2017). The species already seems to be established and benefits from stable feeding resources and low competition, predation and parasitism in the more simplified island communities. There are no pompilid and no other sphecid wasps in the archipelago, many common nest parasites are also absent from the Azores, and spiders are quite diverse and abundant as few predatory arthropods (ants, ground beetles) have colonized the archipelago (Borges et al. 2010). In the next few years, the species will most probably spread in human-modified habitats in low-altitude areas, and it is expected to raise concern on local populations since it nests frequently in urban infrastructure, sometimes in large numbers. In the invaded areas, it may

also drive changes in spider species abundance and in the composition of spider communities, potentially affecting several native species such as the endemic orb weaver spider *Gibbaranea occidentalis* Wunderlich, 1989 (Araneae, Araneidae). Nevertheless, the most endangered endemic spider species are associated to the Azorean native forest (Borges and Wunderlich 2008) and for now seem not to be threatened by this new arrival.

The Azores archipelago has a unique biodiversity and interesting native ecological interactions that are under threat by the constant arrival of new alien species. It is mandatory to set up a monitoring program for the early detection of alien species in these islands (e.g. Borges et al. 2018), targeting at least the most frequent introduction pathways (airports and harbours), aiming to collect baseline information to support decision making by the legal authorities and to allow a quick response to biological invasions if needed. The recently arrived and potentially harmful alien species (as the two here reported) should be monitored to assess the biotic and abiotic factors that drive their spread and to evaluate their impact on local biodiversity, economy and human well-being.

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Authors' contribution

All authors collected and interpreted data, and wrote, reviewed, and agreed with the submitted version of the manuscript; MB prepared the original draft and funded APC.

References

- Bitsch J, Barbier Y, Gayubo SF, Schmidt K, Ohl M (1997) Hyménoptères Sphecidae de l'Europe occidentale. Vol. 2. Faune de France, 82. Fédération Française des Sociétés de Sciences Naturelles, Paris, France, 429 pp
- Boieiro M, Catry P, Jardim CS, Menezes D, Silva I, Coelho N, Oliveira P, Gatt MC, Pedro P, Granadeiro JP (2018) Invasive Argentine ants prey on Bulwer's petrels nestlings on the Desertas Islands (Madeira) but do not depress seabird breeding success. *Journal for Nature Conservation* 43: 35–38, <https://doi.org/10.1016/j.jnc.2018.02.013>
- Borges PAV, Wunderlich J (2008) Spider biodiversity patterns and their conservation in the Azorean archipelago, with description of new taxa. *Systematics and Biodiversity* 6: 249–282, <https://doi.org/10.1017/S1477200008002648>
- Borges PAV, Costa A, Cunha R, Gabriel R, Gonçalves V, Martins AF, Melo I, Parente M, Raposeiro P, Rodrigues P, Santos RS, Silva L, Vieira P, Vieira V (ed) (2010) A list of the terrestrial and marine biota from the Azores. Príncipe, Cascais, 432 pp
- Borges PAV, Reut M, da Ponte NB, Quartau JA, Fletcher M, Sousa AB, Pollet M, Soares AO, Marcelino JAP, Rego C, Cardoso P (2013) New records of exotic spiders and insects to the Azores, and new data on recently introduced species. *Arquipélago - Life and Marine Sciences* 30: 57–70

- Borges PAV, Cardoso P, Kreft H, Whittaker RJ, Fattorini S, Emerson BC, Gil A, Gillespie RG, Matthews TJ, Santos AMC, Steinbauer MJ, Thébaud C, Ah-Peng C, Amorim IR, Aranda SC, Arroz AM, Azevedo JM, Boieiro M, Borda-De-Água L, Carvalho JC, Elias RB, Fernández-Palacios JM, Florencio M, González-Mancebo JM, Heaney LR, Hortal J, Kueffer C, Lequette B, Martín-Esquível JL, López H, Lamelas-López L, Marcelino J, Nunes R, Oromí P, Patiño J, Pérez AJ, Rego C, Ribeiro SP, Rigal F, Rodrigues P, Rominger AJ, Santos-Reis M, Schaefer H, Sérgio C, Serrano ARM, Sim-Sim M, Stephenson PJ, Soares AO, Strasberg D, Vanderporten A, Vieira V, Gabriel R (2018) A Global Island Monitoring Scheme (GIMS) for the long-term coordinated survey and monitoring of forest biota across islands. *Biodiversity and Conservation* 27: 2567–2586, <https://doi.org/10.1007/s10531-018-1553-7>
- Borges PAV, Gabriel R, Fattorini S (2019) Biodiversity erosion: causes and consequences. In: Leal Filho W, Azul A, Brandli L, Özuyar P, Wall T (eds), *Life on Land. Encyclopedia of the UN Sustainable Development Goals*, Springer, Switzerland, pp 1–10, https://doi.org/10.1007/978-3-319-71065-5_78-1
- Borges PAV, Rigal F, Ros-Prieto A, Cardoso P (2020) Increase of insular exotic arthropod diversity is a fundamental dimension of the current biodiversity crisis. *Insect Conservation and Diversity* 13: 508–518, <https://doi.org/10.1111/icad.12431>
- Borges PAV, Lamelas-Lopez L, Stüben PE, Ros-Prieto A, Gabriel R, Boieiro M, Tsafack N, Ferreira MT (2022) SLAM project - long term ecological study of the impacts of climate change in the natural forest of Azores: II - A survey of exotic arthropods in disturbed forest habitats. *Biodiversity Data Journal* 10: e81410, <https://doi.org/10.3897/BDJ.10.e81410>
- Demetriou J, Díaz-Calafat J, Kalaentzis K, Kazilas C, Georgiadis C, Turrissi GF, Koutsoukos E (2022) The alien Black-and-yellow Mud Dauber, *Sceliphron caementarium* (Drury, 1773) (Hymenoptera, Sphecidae), continues its spread: new citizen-science records from Eastern Europe and the Balkans. *Check List* 18: 535–543, <https://doi.org/10.15560/18.3.535>
- Fernández-Palacios JM, Kreft H, Irl SD, Norder S, Ah-Peng C, Borges PAV, Burns KC, de Nascimento L, Meyer J-Y, Montes E, Drake DR (2021) Scientists' warning - The outstanding biodiversity of islands is in peril. *Global Ecology and Conservation* 31: e01847, <https://doi.org/10.1016/j.gecco.2021.e01847>
- Foote BA, Bowker BD, McMichael BA (1987) Host plants for North American species of *Rivellia* (Diptera: Platystomatidae). *Entomological News* 93(3): 135–139
- Korneyev AV (2001) A key to genera of Palaearctic Platystomatidae (Diptera), with descriptions of a new genus and new species. *Entomological Problems* 32: 1–16
- Lyneborg L (1969) Some Micropezidae, Psilidae, Platystomidae, Otitidae, Pallopteridae, Odimidae, Aulacigastridae, Asteidae, and Milichiidae (Diptera) collected in Southern Spain with descriptions of six new species. *Entomologiske Meddelelser* 37: 27–46
- Oosterbroek P (2006) The European families of the Diptera: identification, diagnosis, biology. KNNV Publishing, Utrecht, 205 pp, https://doi.org/10.1163/9789004278066_013
- Pagliano G, Negrisoló E (2005) Hymenoptera Sphecidae. Fauna d'Italia, 40, Calderini, Bologna, Italy, 559 pp
- Polidori C, Federici M, Pesarini C, Andrietti F (2007) Factors affecting spider prey selection by *Sceliphron* mud-dauber wasps (Hymenoptera: Sphecidae) in northern Italy. *Animal Biology* 57: 11–28, <https://doi.org/10.1163/157075607780002005>
- Powell EC, Taylor LA (2017) Specialists and generalists coexist within a population of spider-hunting mud dauber wasps. *Behavioral Ecology* 28: 890–898, <https://doi.org/10.1093/beheco/arx050>
- Reaser J, Meyerson L, Cronk Q, De Poorter M, Eldredge L, Green E, Kairo M, Latasi P, Mack R, Mauremootoo J, O'Dowd D, Orapa W, Sastroutomo S, Saunders A, Shine C, Thrainsson S, Vaiutu L (2007) Ecological and socioeconomic impacts of invasive alien species in island ecosystems. *Environmental Conservation* 34: 98–111, <https://doi.org/10.1017/S0376892907003815>
- Rondoni G, Borges I, Collatz J, Conti E, Costamagna AC, Dumont F, Evans EW, Grez AA, Howe AG, Lucas E, Maisonhaute JE, Soares AO, Zaviezo T, Cock MJW (2021) Exotic ladybirds for biological control of herbivorous insects - a review. *Entomologia Experimentalis et Applicata* 169: 6–27, <https://doi.org/10.1111/eea.12963>
- Russell J, Meyer J, Holmes N, Pagad S (2017) Invasive alien species on islands: Impacts, distribution, interactions and management. *Environmental Conservation* 44: 359–370, <https://doi.org/10.1017/S0376892917000297>
- Silva L, Land EO, Rodríguez Luengo JL (eds) (2008) Invasive terrestrial flora & fauna of Macaronesia. TOP 100 in Azores, Madeira and Canaries. ARENA, Ponta Delgada, Portugal, 546 pp
- Silva-Rocha I, Vieira V, Aguiar AF, Boieiro M, Borges PAV, Carretero MA, Cravo D, Jesus J, Matos M, Monteiro M, Rego C, Reino L, Serrano ARM, Soares AO, Sousa A (2018) Animais exóticos e invasores em ecossistemas terrestres. In: Vicente JR, Queiroz AI, Marchante E, Honrado JP, Silva L (eds), *As invasões biológicas em Portugal: história, diversidade e gestão*, Arte e Ciência - Universidade do Porto, Porto, pp 142–158

- Smit J (2008) Sphecidae. In: Borges PAV, Abreu C, Aguiar AMF, Carvalho P, Jardim R, Melo I, Oliveira P, Sérgio C, Serrano ARM, Vieira P (eds), A list of the terrestrial fungi, flora and fauna of Madeira and Selvagens archipelagos. Direcção Regional do Ambiente da Madeira and Universidade dos Açores, Funchal and Angra do Heroísmo, Portugal, pp 356
- Soares AO, Honek A, Martinkova Z, Skuhrovec J, Cardoso P, Borges I (2017) *Harmonia axyridis* failed to establish in the Azores: the role of specie richness, intraguild interactions and resource availability. *BioControl* 62: 423–434, <https://doi.org/10.1007/s10526-017-9794-z>
- Whittington AE (2019) The economic significance of the signal fly genus *Rivellia* Robineau-Desvoidy (Diptera: Platystomatidae). *Israel Journal of Entomology* 49: 135–160, <https://doi.org/10.5281/zenodo.3371321>

Web sites, online databases and software

- Pulawski W (2022) Catalog of Sphecidae sensu lato (= Apoidea excluding Apidae). California Academy of Sciences, San Francisco, <https://www.calacademy.org/scientists/projects/catalog-of-sphécidae> (accessed 31 October 2022)