An updated checklist to the biodiversity data of ladybeetles (Coleoptera: Coccinellidae) of the Azores Archipelago (Portugal)

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Abstract

Background

A recently-published review from 2021 presents a comprehensive checklist of ladybeetles of Portugal, including the Azores and Madeira Archipelagos. Until then, the available information was very scattered and based on a single revision dating back to 1986, a few international catalogues and databases, individual records and studies on communities of agroecosystems. However, no information was available on faunal composition across the Azorean islands and their habitats, using standardised inventories. Here, we present data about the biodiversity of ladybeetles and their distribution and abundance in five Islands of the Azores (Faial, Graciosa, Pico, São Jorge and São Miguel). Surveys included herbaceous and arboreal habitats from native to anthropogenic-managed habitats: ruderal road vegetation, vegetable garden, mixed forest of endemic and non-native host plants, coastal prairies, coastal mixed vegetation, cornfields and urban areas. We aimed to
contribute to the ongoing effort to document the terrestrial biodiversity of Portugal, including the Archipelago of the Azores, within the research project AZORESBIOPORTAL–PORBIOTA (ACORES-01-0145-FEDER-000072).

**New information**

In this study, a total of 1,487 specimens of Coccinellidae belonging to 19 species are reported for several habitats. The listed species are from one single sub-family (Coccinellinae) and six tribes; Chilocorini (one species), Coccidulini (three species), Coccinellini (six species), Noviini (one species), Scymnini (seven species), Stethorini (one species). The number of species collected per island differed; Faial (10 species), Graciosa (four species), Pico (seven species), São Jorge (seven species) and São Miguel (12 species). For six species, new island records are given. Currently, the number of species known to occur in the Azores are 32, including two doubtful records. The majority of species are Scymnini, being *Scymnus (Scymnus) interruptus* (Goeze, 1777) and *Scymnus (Scymnus) nubilus* Mulsant, 1850, the most abundant species (relative abundance 71.1%). This database will be the baseline of a long-term monitoring project allowing assessment of the impact of ongoing global changes in the distribution and abundance of ladybeetles.

**Keywords**

Arthropoda, Ladybeetles, Azores, Faial, Graciosa, Pico, São Jorge, São Miguel

**Introduction**

Insects, like other taxonomic groups, are at high risk of extinction (Harvey et al. 2020). Insects deliver fundamental services to agricultural and forest ecosystems, including pollination, decomposition and pest control, which, in turn, translates into relevant consequences for food production and security (e.g. Ameixa et al. 2018, IPBES 2019, Cardoso et al. 2020).

The family Coccinellidae contains between 6000 and 7000 described species (Seago et al. 2011). Currently the number of Coccinellidae known for Azores is 32, including two doubtful records (Soares et al. 2021b).

Despite being very diverse in terms of morphology, life history traits, habitat use and food relationships (see Hodek et al. 2012 for review), they are primarily top carnivorous predators and thus useful natural enemies of herbivorous arthropods, including aphids (Aphidoidea), scale insects (Coccoidea), whiteflies (Aleyrodoidea) or mites (Acari) (Hodek et al. 2012). Until very recently, this group was thought to exhibit only sexual reproduction. However, it was found that some populations of *Nephus (Nephus) voeltzkowi* Weise, 1910, including the Azorean populations, showed parthenogenetic reproduction, which constitutes the first case of parthenogenesis in ladybeetles (Magro et al. 2019).
Over the past 30 years, rapid declines of formerly common native ladybird species - including in North America (Harmon et al. 2006), Europe (Roy et al. 2012, Honěk et al. 2016) and others (reviewed in Roy et al. 2016) - have been occurring. Most declines are associated with climate change, agricultural intensification and urbanisation and invasions of alien species (Honěk et al. 2017), especially with an increasing density, spread and dominance of the invasive Harmonia axyridis Pallas. Despite its high invasive capacity resulting in its rapid spread and fast establishment under distinct climatic conditions, H. axyridis did not establish in the Azores where it was intentionally and repeatedly released (Soares et al. 2008, Soares et al. 2018), for the same reasons as in other regions, for agricultural pest control purposes. This apparent failure is an interesting case study for invasion biology. Several hypotheses were tested to explain the inability of this species to become invasive (Soares et al. 2017, Alaniz et al. 2020). The lack of high density of their preferred aphid preys may be a key factor hampering its establishment. Indeed, the composition of Coccinellidae fauna seems to be dominated by small species [like Scymuns spp., which require low aphid density (Soares et al. 2017)]. Apparently, the climatic conditions of the Azores do not seem likely to hinder the invasion of H. axyridis, as areas with similar climates have experienced extensive invasion. Indeed, climatic models have predicted the spread of H. axyridis to regions with subtropical conditions (Poutsma et al. 2008, Bidinger et al. 2010). However, for the Azores and contrary to that prediction, the absence of suitable temperature to overwinter will force adults to become active during the winter season and females will not find enough suitable food (in quantity and quality) to reproduce and this will hinder the build-up of the first generation (Alaniz et al. 2020).

General description

Purpose: We aimed to contribute to characterise the richness and abundance of ladybeetles in several herbaceous and arboreal habitats, from native to anthropogenic-managed habitats. We also aimed to contribute to address two key shortfalls: i) the need for improving current information on the local and regional distribution of Azorean arthropods (the Wallacean shortfall); and ii) the need for collecting abundance data for future monitoring purposes (the Prestonian shortfall) (see Cardoso et al. 2011).

In addition, we provide an updated checklist of Azorean ladybeetles with their known distribution in the nine Azorean islands.

Project description

Title: AZORESBIOPORTAL–PORBIOTA: inventory of ladybeetles of the Azores (Portugal)

Personnel: António O. Soares, Isabel Borges and Hugo R. Calado collected the samples and managed the database. Paulo A.V. Borges assisted us in managing the database to GBIF.
Study area description: We focused the inventory on five islands of the Azores (Table 1), these being five of the nine islands from the Azores Archipelago. The climate in the Azores is temperate oceanic, with regular and abundant rainfall, high levels of relative humidity and persistent winds, mainly during winter and autumn seasons. The landscape of the islands is composed by a mosaic of habitats, ranging from herbaceous to arboreal habitats and from native to anthropogenic-managed habitats. The surveys were done on ruderal road vegetation, vegetable garden, mixed forest of endemic and non-native host plants, coastal prairies, coastal mixed vegetation, cornfields and urban areas.

| Island  | Habitat                                           | Locality          | Elevation (m) | Latitude    | Longitude   |
|---------|---------------------------------------------------|-------------------|---------------|-------------|-------------|
| Faial   | Citrus orchard                                    | Castelo Branco    | 57            | 38.5231     | -28.68917   |
|         | Corn field                                        | Cedros            | 166           | 38.62475    | -28.68011   |
|         | Coastal mixed vegetation                          | Norte Pequeno     | 12            | 38.59263    | -28.82711   |
|         | Coastal prairies                                  | Pasteleiro        | 67            | 38.53005    | -28.647701  |
|         | Coastal prairies                                  | Praia do Almoxarife | 5            | 38.5541     | -28.61053   |
|         | Coastal prairies                                  | Varadouro         | 8             | 38.56639    | -28.77042   |
|         | Mixed forest of endemic and non-native host plants | Varadouro         | 175           | 38.57394    | -28.77713   |
|         | Mixed forest of endemic and non-native host plants | Norte Pequeno     | 128           | 38.59433    | -28.81541   |
|         | Ruderal road vegetation                           | Pasteleiro        | 93            | 38.53605    | -28.64981   |
|         | Ruderal road vegetation                           | Varadouro         | 198           | 38.57952    | -28.78283   |
|         | Urban poplar grove                                | Angústias         | 39            | 38.52806    | -28.6367    |
|         | Vegetable garden                                  | Feteira           | 37            | 38.52494    | -28.88179   |
| Graciosa| Abandoned vineyards                               | Beira Mar         | 10            | 39.02123    | -28.00697   |
|         | Coastal prairies                                  | Beira Mar         | 7             | 39.021      | -28.00711   |
|         | Coastal prairies                                  | Beira Mar         | 21            | 39.02373    | -28.00686   |
|         | Coastal prairies                                  | Sta. Cruz da Graciosa | 25          | 39.09572    | -28.03441   |
|         | Coastal Prairies, dominated by Canica sp.         | Carapacho         | 17            | 39.01185    | -27.97651   |
|         | Pasture: Medicago sativa L.                       | Jorge Gomes       | 58            | 39.0607     | -28.06173   |
| Island       | Habitat                                      | Locality       | Elevation (m) | Latitude  | Longitude |
|--------------|----------------------------------------------|----------------|---------------|-----------|-----------|
|              | Nerium oleander L. and Hibiscus rosa-        | Alto do Sul    | 29            | 39.01192  | -27.97911 |
|              | sinensis L.                                 |                |               |           |           |
|              | Ruderal road vegetation: herbaceous          | Bom Jesus      | 9             | 39.08346  | -28.05213 |
|              | vegetation                                   |                |               |           |           |
|              | Ruderal road vegetation: herbaceous          | Bom Jesus      | 13            | 39.08189  | -28.0542  |
|              | vegetation                                   |                |               |           |           |
|              | Ruderal road vegetation: herbaceous          | Bom Jesus      | 19            | 39.08094  | -28.05473 |
|              | vegetation                                   |                |               |           |           |
|              | Ruderal road vegetation: herbaceous          | Jorge Gomes    | 69            | 39.06235  | -28.06227 |
|              | vegetation                                   |                |               |           |           |
|              | Trees of Tamarix sp.                         | Bom Jesus      | 8             | 39.08376  | -28.0524  |
|              |                                               |                |               |           |           |
|              | Vegetable garden                             | Porto da Barra | 8             | 39.08469  | -27.99925 |
| Pico         | Citrus orchard                               | Sete Cidades   | 119           | 38.52796  | -28.50286 |
|              |                                               |                |               |           |           |
|              | Corn field                                   | Monte          | 69            | 38.49832  | -28.52976 |
|              |                                               |                |               |           |           |
|              | Corn field                                   | São Vicente    | 113           | 38.54541  | -28.36608 |
|              |                                               |                |               |           |           |
|              | Corn field                                   | Sete Cidades   | 116           | 38.5286   | -28.50279 |
|              |                                               |                |               |           |           |
|              | Coastal prairies                             | Madalena       | 3             | 38.52013  | -28.53784 |
|              |                                               |                |               |           |           |
|              | Coastal prairies                             | Madalena       | 8             | 38.53957  | -28.52029 |
|              |                                               |                |               |           |           |
|              | Evergreen forest                             | Toledos        | 15            | 38.54746  | -28.50961 |
|              |                                               |                |               |           |           |
|              | Evergreen of endemic and exotic forest       | Campo Raso     | 36            | 38.44743  | -28.49908 |
|              |                                               |                |               |           |           |
|              | Pine trees                                   | Sete Cidades   | 29            | 38.53353  | -28.52339 |
|              |                                               |                |               |           |           |
|              | Pine trees                                   | Sete Cidades   | 884           | 38.4976   | -28.41566 |
|              |                                               |                |               |           |           |
|              | Ruderal road vegetation                       | Farrobo        | 114           | 38.54266  | -28.42825 |
|              | Ruderal road vegetation: Arundo donax L.     | Silveira       | 90            | 38.41783  | -28.29147 |
|              |                                               |                |               |           |           |
|              | Ruderal road vegetation: Evergreen of         | Cachorro       | 26            | 38.55574  | -28.44033 |
|              | endemic and exotic Forest                     |                |               |           |           |
|              |                                               |                |               |           |           |
|              | Ruderal road vegetation: Herbaceous plants   | Cachorro       | 26            | 38.55574  | -28.44033 |
|              |                                               |                |               |           |           |
|              | Ruderal road vegetation: Tamarix sp.         | Madalena       | 3             | 38.52013  | -28.53784 |
|              |                                               |                |               |           |           |
|              | Vegetable garden: cabbage                    | São Mateus     | 48            | 38.43294  | -28.45794 |
|              |                                               |                |               |           |           |
|              | Vegetable garden: cabbage                    | São Vicente    | 113           | 38.54541  | -28.36608 |
|              |                                               |                |               |           |           |
| Island       | Habitat                              | Locality            | Elevation (m) | Latitude  | Longitude   |
|-------------|--------------------------------------|---------------------|---------------|-----------|-------------|
| São Jorge   | Citrus orchard                       | Fajã de S. Amaro    | 60            | 38.66226  | -28.17184   |
|             | Citrus orchard                       | Fajã de S. Amaro    | 78            | 38.66261  | -28.17155   |
|             | Coastal herbaceous plants: Erica and Myrica | Portinho da Queimada | 18        | 38.66651  | -28.18714   |
|             | Coastal prairies                     | Queimada            | 14            | 38.67241  | -28.19456   |
|             | Coastal prairies                     | Velas               | 27            | 38.6889   | -28.2188    |
|             | Coastal prairies: Tamarix sp.        | Velas               | 34            | 38.68693  | -28.21873   |
|             | Vegetable garden: cabbage, bean and cucumber | Urzelina          | 60            | 38.64404  | -28.1194    |
|             | Vegetable garden: cabbage, bean and cucumber | Velas               | 40            | 38.68181  | -28.20469   |
|             | Wood: Acacia trees                   | Urzelina            | 59            | 38.64813  | -28.12971   |
|             | Wood: Pinus trees                    | Urzelina            | 58            | 38.64383  | -28.11937   |
| São Miguel  | Ruderal road vegetation: Arundo donax L. | Arrifres           | 130           | 37.75388  | -25.70472   |
|             | Ruderal road vegetation: Arundo donax L. | Calhetas           | 18            | 37.82279  | -25.61368   |
|             | Ruderal road vegetation: Arundo donax L. | São Roque          | 13            | 37.75152  | -25.61896   |
|             | Ruderal road vegetation: Arundo donax L. | São Roque          | 13            | 37.75205  | -25.62264   |
|             | Ruderal road vegetation: Arundo donax L. | São Roque          | 14            | 37.75205  | -25.62264   |
|             | Coastal prairies                     | Fenais da Luz      | 30            | 37.83083  | -25.635     |
|             | Coastal prairies                     | Pópulo              | 30            | 37.75023  | -25.62106   |
|             | Coastal prairies                     | Rabo de Peixe      | 18            | 37.81583  | -25.56694   |
|             | Coastal prairies                     | Rabo de Peixe      | 35            | 37.81378  | -25.56706   |
|             | Coastal prairies                     | Relva               | 30            | 37.73737  | -25.69819   |
|             | Coastal prairies                     | Relva               | 30            | 37.74711  | -25.71359   |
|             | Coastal prairies                     | Santa Clara         | 30            | 37.7333   | -25.686     |
|             | Coastal prairies                     | Santa Clara         | 30            | 37.73495  | -25.69359   |
|             | Coastal prairies                     | São Roque           | 13            | 37.75152  | -25.61896   |
|             | Corn field                           | Fenais da Luz      | 18            | 37.82666  | -25.63194   |
|             | Corn field                           | Ribeira Seca       | 18            | 37.81659  | -25.53795   |
|             | Corn field                           | São Sebastião       | 87            | 37.75424  | -25.67236   |
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Sampling methods

Study extent: Five Islands of the Azores (Portugal): São Miguel, Graciosa, Faial, Pico and São Jorge.

Sampling description: The sampling programme in Faial, Graciosa, Pico and São Jorge consisted of travelling through each Island by car, for 3 to 4 days depending on the size of the Island. For São Miguel, we also included results taken in 2012 (Borges et al. 2011) in which fieldwork included a similar sampling effort. The samplings took place in representative habitats of the vegetation cover of the Islands that are visited by ladybeetles. The methods used to collect the samples were sweeping, beating and direct observations. Sampling from the herbaceous plants and canopy up to a height of ca. 3 m was standardised by using a standard sweep net (35-cm diameter, 140-cm handle) operated by António O. Soares, Isabel Borges and Hugo R. Calado. Independently of the method, the sampling effort was standardised in terms of the number of persons per unit of time (e.g. 1 person per 2 hours, 1 person per 30’, 1 person per 15’). Fieldwork occurred between 09:00 h and 16 :00 h on sunny and calm days. Ladybeetle adults were identified immediately and were released at the site and Scymnus spp were brought back to laboratory to identification.

Geographic coverage

Description: Azores Islands (Portugal): Faial, Graciosa, Pico, São Jorge and São Miguel

Coordinates: 36.906 and 39.589 Latitude; -24.961 and -31.311 Longitude.
**Taxonomic coverage**

**Description:** The sampling programme targeted ladybeetles (Coleoptera: Coccinellidae)

**Taxa included:**

| Rank | Scientific Name | Common Name                        |
|------|-----------------|------------------------------------|
| family | Coccinellidae   | Ladybeetles/ ladybirds/ ladybird beetles/ ladybugs |

**Traits coverage**

There are no trait data associated.

**Temporal coverage**

**Notes:** 20 April 2012 to 6 July 2020

**Collection data**

**Collection name:** Ladybeetles of the Azores

**Collection identifier:** ladybeetles

**Specimen preservation method:** Ethanol 96%

**Curatorial unit:** University of the Azores, Faculty of Sciences and Technology

**Usage licence**

**Usage licence:** Creative Commons Public Domain Waiver (CC-Zero)

**Data resources**

**Data package title:** Biodiversity data of ladybeetles (Coleoptera: Coccinellidae) of the Azores Archipelago (Portugal)

**Resource link:** [https://www.gbif.org/dataset/2292e622-129e-4c66-9ad6-fccaa377ff58](https://www.gbif.org/dataset/2292e622-129e-4c66-9ad6-fccaa377ff58)

**Alternative identifiers:** [http://ipt.gbif.pt/ipt/resource?r=coccinellidae_azores&v=1.5](http://ipt.gbif.pt/ipt/resource?r=coccinellidae_azores&v=1.5)

**Number of data sets:** 2

**Data set name:** Table of Sampling Events

**Download URL:** [http://ipt.gbif.pt/ipt/resource?r=coccinellidae_azores&v=1.5](http://ipt.gbif.pt/ipt/resource?r=coccinellidae_azores&v=1.5)
**Data format:** Darwin Core Archive

**Data format version:** version 1.5

**Description:** The following data table includes all the records for which a taxonomic identification of the species was possible. The dataset submitted to GBIF (Global Biodiversity Information Facility) is structured as a sample event dataset, with two tables: in the current event table, the data in this sampling event resource have been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data file contains 98 records (eventID). This IPT (integrated publishing toolkit) archives the data and thus serves as the data repository. The data and resource metadata are available for download from Soares et al. (2021a).

| Column label     | Column description                                                                 |
|------------------|-------------------------------------------------------------------------------------|
| id               | Unique identification code for species abundance data. Equivalent here to eventID. |
| eventID          | Identifier of the events, unique for the dataset.                                  |
| samplingProtocol | The sampling protocol used to capture the species.                                 |
| samplingEffort   | The numeric amount of time spent in each sampling.                                 |
| eventDate        | Date or date range the record was collected.                                       |
| year             | Year of the event.                                                                 |
| month            | Month of the event.                                                               |
| day              | Day of the event.                                                                |
| habitat          | The habitat of the sample.                                                       |
| fieldNumber      | An identifier given to the event in the field. Serves here as a link between field notes and the Event. |
| locationID       | Identifier of the location.                                                     |
| islandGroup      | Name of archipelago.                                                            |
| island           | Name of the island.                                                               |
| country          | Country of the sampling site.                                                   |
| countryCode      | ISO code of the country of the sampling site.                                     |
| stateProvince    | Name of the region of the sampling site.                                          |
| municipality     | Municipality of the sampling site.                                               |
| locality         | Name of the locality.                                                            |
| verbatimLocality | The original textual description of the place.                                   |
| maximumElevationInMetres | The upper limit of the range of elevation (altitude, usually above sea level), in metres. |
**Data set name:** Table of Species Occurrence

**Download URL:** [http://ipt.gbif.pt/ipt/resource?r=coccinellidae_azores&v=1.5](http://ipt.gbif.pt/ipt/resource?r=coccinellidae_azores&v=1.5)

**Data format:** Darwin Core

**Data format version:** version 1.5

**Description:** The following data table includes all the records for which a taxonomic identification of the species was possible. The dataset submitted to GBIF (Global Biodiversity Information Facility) is structured as a sample event dataset, with two tables: in the current occurrences table, the data in this sampling event resource have been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data file contains 218 records (occurrenceID). This IPT (integrated publishing toolkit) archives the data and thus serves as the data repository. The data and resource metadata are available for download from Soares et al. (2021a).

| Column label          | Column description                                                                 |
|-----------------------|-----------------------------------------------------------------------------------|
| id                    | Unique identification code for species abundance data. Equivalent here to eventID. |
| type                  | Type of the record, as defined by the Public Core standard.                       |
| licence               | Reference to the licence under which the record is published.                     |
| institutionID         | The identity of the institution publishing the data.                              |
| collectionID          | The identity of the collection publishing the data.                               |
| institutionCode       | The code of the institution publishing the data.                                  |
| collectionCode        | The code of the collection where the specimens are conserved.                     |
| datasetName           | Name of the dataset.                                                             |
A total of 1,487 specimens of Coccinellidae belonging to 19 species were sampled (see Table 2). The listed species are from one single sub-family (Coccinellinae) and four tribes; Chilocorini (one species), Coccidulini (11 species), Coccinellini (six species) and Noviini (one species). The number of species collected from each island differed; São Miguel (12 species), Graciosa (four species), Faial (four species), Pico (seven species) and São Jorge (seven species).
| Species                     | Tribe                  | FAI | GRA | PIC | SJG | SMG | Total |
|-----------------------------|------------------------|-----|-----|-----|-----|-----|-------|
| *Adalia bipunctata* (Linnaeus, 1758) | Coccinellini           | 2   | 0   | 0   | 0   | 0   | 2     |
| *Adalia decempunctata* (Linnaeus, 1758) | Coccinellini           | 0   | 0   | 0   | 0   | 4   | 4     |
| *Chilocorus bipustulatus* (Linnaeus, 1758) | Chilocorini            | 0   | 0   | 0   | 0   | 25  | 25    |
| *Clitostethus arcuatus* (Rossi, 1794) | Scymnini               | 0   | 0   | 32  | 1   | 0   | 33    |
| *Coccinella undecimpunctata* Linnaeus, 1758 | Coccinellini           | 0   | 0   | 0   | 0   | 7   | 7     |
| *Myrrha octodecimguttata* (Linnaeus, 1758) | Coccinellini           | 0   | 0   | 3   | 0   | 0   | 3     |
| *Nephus (Geminosipho) reunioni* (Fürsch 1974) | Scymnini               | 0   | 0   | 0   | 0   | 1   | 1     |
| *Nephus (Nephus) voeltzkowi* Weise, 1910 | Scymnini               | 8   | 2   | 0   | 1   | 147 | 158   |
| Novius cardinalis* (Mulsant, 1850) | Noviini                | 5   | 0   | 29  | 6   | 0   | 40    |
| *Oenopia doublieri* (Mulsant, 1846) | Coccinellini           | 6   | 0   | 0   | 0   | 0   | 6     |
| *Propylea quatuordecimpunctata* (Linnaeus, 1758) | Coccinellini           | 1   | 0   | 0   | 0   | 0   | 1     |
| *Rhyzobius chrysomeloides* (Herbst, 1792) | Coccidulini            | 0   | 0   | 0   | 0   | 25  | 25    |
| *Rhyzobius litura* (Fabricius, 1787) | Coccidulini            | 1   | 0   | 0   | 0   | 63  | 64    |
| *Rhyzobius lophanthae* (Blaisdell, 1892) | Coccidulini            | 0   | 0   | 3   | 3   | 0   | 6     |
| Scymnus (Pullus) subvillosus* (Goeze, 1777) | Scymnini               | 1   | 0   | 0   | 0   | 4   | 5     |
| *Scymnus (Pullus) suturalis* Thunberg 1795 | Scymnini               | 0   | 0   | 0   | 0   | 6   | 6     |
| Scymnus (Scymnus) interruptus* (Goeze, 1777) | Scymnini               | 20  | 21  | 22  | 25  | 322 | 410   |
| Scymnus (Scymnus) nubilus* Mulsant, 1850 | Scymnini               | 66  | 149 | 218 | 35  | 180 | 648   |
| *Stethorus pusillus* (Herbst, 1797) | Stethorini             | 5   | 2   | 26  | 6   | 4   | 43    |

Propylea quatuordecimpunctata (Linnaeus, 1758), despite being previously listed to the Azores, but without island details by Soares et al. (2021b), is now recorded for the first time to Faial island. Öenopia doublieri (Mulsant, 1846) was recently recorded as new for the Azores by Borges et al. (2018) (Terceira Island in Paúl da Praia da Vitória) and now is recorded to an additional island (Faial). Three additional species, Rhyzobius lophanthae (Blaisdell, 1892), Scymnus (Pullus) suturalis Thunberg 1795 and Stethorus pusillus (Herbst, 1797), are new records to Pico, S. Miguel and Graciosa Islands, respectively.

Currently, the number of known species of ladybeetles in the Azores is 32 species (Soares et al. 2021b). The current list includes 30 confirmed species and two doubtful records (Table 3) and most of them considered exotic introduced species (n = 24) and only eight
species are considered native. Two of the native species are endemic from the Macaronesian Region (*Nephus flavopictus* (Wollaston, 1854) and *Pharoscymnus decemplagiatus* (Wollaston, 1857)) (see Table 3).

| Scientific name                                          | Col. | AZ | COR | FLO | FAI | PIC | GRA | SJG | TER | SMG | SMR |
|-----------------------------------------------------------|------|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| *Adalia bipunctata* (Linnaeus, 1758)                      | INTR |    |     |     | FAI |     |     |     |     |     | SMG |
| *Adalia decempunctata* (Linnaeus, 1758)                   | INTR | COR| FLO | FAI |     | PIC |     |     |     |     | SMG |
| *Ceratomegilla undecimnotata* (Schneider, 1792)           | INTR |    |     |     |     |     |     |     |     | SMG |
| *Chilocorus bipustulatus* (Linnaeus, 1758)                | INTR |    |     |     |     |     | SMG |     |     |     | SMR |
| *Clitostethus arculus* (Rossi, 1794)                     | INTR | FAI| PIC | GRA | SJG |     |     |     |     |     | SMG |
| *Coccinella septempunctata* Linnaeus, 1758*               | INTR |    |     |     |     |     |     |     |     |     |     |
| *Coccinella undecimpunctata* Linnaeus, 1758               | INTR | COR| FLO | FAI | PIC |     |     | GRA |     |     | SMG |
| *Delphastus catalinae* (Horn, 1895)                      | INTR |     |     |     |     |     |     |     | SMG |
| *Eriopis connexa* (Germar, 1824)*                        | INTR |    |     |     |     |     |     |     |     | SMG |
| *Hippodamia variegata* (Goeze, 1777)                     | INTR | AZ |     |     |     |     |     |     |     |
| *Myrrha octodecimguttata* (Linnaeus, 1758)                | INTR |    |     |     |     |     | SMG |     |     |     | SMR |
| *Nephus (Bipunctatus) bisignatus* (Boheman, 1850)        | INTR |    |     |     |     |     |     |     | SMG |
| *Nephus (Geminosipho) reunioni* (Fürsch, 1974)           | INTR |     |     |     |     |     |     |     |     | SMG |
| *Nephus (Nephus) flavopictus* (Wollaston, 1854)          | MAC  |     |     |     |     |     |     |     |     |     |     |
| *Nephus (Nephus) voeltzkowi* Weise, 1910                 | INTR | COR| FLO | FAI | PIC |     |     |     |     |     | SMG |
| *Novius cardinalis* (Mulsant, 1850)                      | INTR | COR| FLO | FAI | PIC |     |     |     |     | SMG |
| *Oenopia doublieri* (Mulsant, 1846)                      | INTR |    |     |     | FAI |     |     |     |     |     | TER |
| *Pharoscymnus decemplagiatus* (Wollaston, 1857)          | MAC  | AZ |     |     |     |     |     |     |     |     |
| *Propylea quatuordecimpunctata* (Linnaeus, 1758)         | INTR |    |     |     |     |     |     |     | FAI |
| *Rhyzobius chrysomeloides* (Herbst, 1792)                | NAT  |     |     |     |     |     |     |     |     | SMG |
Doubtful records include *Eriopis connexa* (Germar, 1824) and *Coccinella septempunctata* Linnaeus, 1758. We never collected these species in our extensive sampling programmes. With regard to *E. connexa*, it could result from misidentification given that this Neotropical species was never recorded outside its native region. In the case of *C. septempunctata*, although its previous presence in the Azores is well documented, its extinction may have occurred after the end of the cultural cycle of cereals, these being preferential habitats of the species (Soares et al. 2018).

The three Islands with highest economic activity are the ones with more species recorded (S. Miguel -22; Terceira - 16 and Faial - 13). The exception is Santa Maria that also has many species recorded (17), that can be explained by the proximity to S. Miguel and commercial exchanges between both Islands.

Interestingly, the same Islands are also the most diverse in the native fauna: S. Miguel - 7; Terceira - 6; Faial - 5; Santa Maria - 5. Only S. Jorge Island also has similar native species richness (five species) (Table 3).

Five alien species to the Palearctic Region were introduced in this region, as biological control agents of crop pests: *Delphastus catalinae* (Horn, 1895), *Nephus (Geminosipho) reunioni* (Fürsch, 1974), *Novius cardinalis* (Mulsant, 1850), *Rhyzobius forestieri* (Mulsant, 1853) and *Rhyzobius lophanthae* (Blaisdell, 1892) (Soares et al. 2021b).

The majority of the specimens was collected on herbaceous plants, including coastal prairies and ruderal road vegetation.
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