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Data Paper

Monitoring Arthropods in Azorean Agroecosystems: the project AGRO-ECOSERVICES

Paulo A. V. Borges[‡], Rui Nunes[‡], Lucas Lamelas-López[‡], Enésima Pereira[‡], Ricardo Costa[‡], Paulo Monjardino[§], David H. Lopes[‡], António Onofre Soares[|], Artur Gil[¶,|], François Rigal[#], Marco Ferrante[‡], Gabor L. Lövei[¤,‡]

‡ cE3c – Centre for Ecology, Evolution and Environmental Changes/ Azorean Biodiversity Group and Universidade dos Açores, Rua Capitão João d'Ávila, São Pedro, 9700-042, Angra do Heroísmo, Azores, Portugal
§ CBA – Biotechnology Centre of Azores, University of Azores, Faculty of Agriculture and Environment, Rua Capitão João D'Avila, 9701-042, Angra do Heroísmo, Azores, Portugal
| cE3c – Centre for Ecology, Evolution and Environmental Changes/ Azorean Biodiversity Group and Universidade dos Açores, Faculty of Sciences and Technology, 9500-321, Ponta Delgada, Azores, Portugal
¶ IVAR - Research Institute in Volcanology and Risk Assessment | University of the Azores, Ponta Delgada, Azores, Portugal
# CNRS - Université de Pau et des Pays de l'Adour, Institut des Sciences Analytiques et de Physico-Chimie pour l'Environnement et les Matériaux, E2S, UMR 5254, BP, Pau Cedex, Pau, France
¤ Department of Agroecology, Aarhus University, Flakkebjerg Research Centre, Forsoegsvej 1, DK-4200, Slagelse, Denmark

Corresponding author: Paulo A. V. Borges (paulo.av.borges@uac.pt)

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Abstract

Background

The data we present are part of the AGRO-ECOSERVICES project (Assessing ecosystem services and disservices provided by arthropod species in Azorean agroecosystems). The project aims to evaluate the relative importance of native and non-native organisms as ecosystem services (ES) and disservices (ED) providers, by combining novel, direct and quantitative tools for monitoring agro-biodiversity. Ecosystem services include evaluation of natural pest control by predation, seed predation on weed plants, pollination, decomposition and ecosystem disservices, herbivory and seed predation on crop plants. Active Aerial Searching (AAS) (only in maize-fields) and pitfall traps were used to sample the arthropod biodiversity (predatory spiders, true-bugs and beetles and main insect pests)

on four agricultural habitats of Terceira Island, namely citrus orchards, low and high elevation maize fields and vineyards.

New information

We provided an inventory of all arthropods recorded in four Azorean agroecosystems (citrus orchards, low and high elevation maize fields and vineyards) from Terceira Island. A total of 50412 specimens were collected, belonging to four classes, 20 orders, 81 families and 200 identified species of arthropods. A total of 127 species are considered introduced (n = 22646) and 69 native non-endemic (n = 24117). Four endemic species were recorded with very few specimens (n = 14) and 3635 specimens belong to unidentified taxa recorded only at genus or family level. Five species are new records for Terceira Island, with *Lagria hirta* (Linnaeus, 1758) (Coleoptera, Tenebrionidae) being also a new record for the Azores. This publication contributes to a better knowledge of the arthropods communities present in agro-ecosystems of Terceira Island and will serve as a baseline for future monitoring schemes targeting the long-term change in arthropod diversity and abundance.

Keywords

Active Aerial Searching (AAS), citrus, dataset, invertebrates, island diversity, Macaronesia, maize, occurrence, orchards, pitfall traps, vineyards.

Introduction

Land-use transformation with associated habitat degradation, is one of the major drivers of biodiversity loss worldwide (Vitousek et al. 1997, Barnosky et al. 2011, Borges et al. 2019a, Harvey et al. 2020). In the case of Azores, since Portuguese colonisation in the 15th century, the original landscape has suffered severe transformations, with the replacement of native forests by exotic tree plantations, pastures, agricultural and urban areas (Gaspar et al. 2008, Borges et al. 2019a, Borges et al. 2019b, Norder et al. 2020).

However, although exotic species have a competitive advantage to colonise new human-altered habitats given that their tolerance to wide range of environmental conditions and habitats (e.g. generalist behaviour) (Rigal et al. 2017), these non-natural habitats also offer opportunities to native biota (McKinney and Lockwood 1999, Blackburn et al. 2004, Sax 2008, Tsafack et al. 2021).

Many species were also introduced because of human settlement (Frutuoso 2011). The current remnants of native forests represent less than 5% of the total area of the archipelago (Gaspar et al. 2008). Currently, the Azorean economy depends greatly on agroecosystems (Gil et al. 2017). Agrosecoystems with the largest area are pastures, followed by maize, with the two crops usually grown in rotation. Due to their long co-existence and close taxonomic relationship between pastures and maize (both are grasses), several pests interact with both crops all year round (P. Monjardino, pers.

observ.). These interactions need to be further understood, because of ongoing current significant yield losses in both agroecosystems (P. Monjardino, pers. observ.). Vineyards and citrus orchards are amongst the most important crops on the Azores. Both crops have significant pest and disease problems due to the benign environmental conditions and to improper cultural practices (Lopes et al. 2009).

Azorean terrestrial arthropod fauna have been extensively surveyed in the last two decades. Although most surveys have been conducted in native forests (e.g. Borges et al. 2005, Ribeiro et al. 2005, Borges et al. 2006), several also included anthropogenic habitats, as exotic forest plantations, pastures for cattle grazing and other agricultural areas (Cardoso et al. 2009, Florencio et al. 2015, Rigal et al. 2017, Marcelino et al. 2021, Tsafack et al. 2021).

In 2019 and 2020, we started the project "Assessing Ecosystem Services and Disservices provided by Arthropod species in Azorean Agroecosystems" (AGRO-ECOSERVICES). This project aims to: (i) initiate the monitoring of terrestrial arthropods in agricultural habitats, (ii) implement novel, direct and quantitative tools to quantify ecosystem services (ES) and disservices (ED) and (iii) evaluate the relative importance of native and non-native organisms as ES/ED providers.

Arthropods, especially insects, support ecosystem stability and functioning (Allan et al. 2015, Bennett et al. 2015). Due to their high species richness and abundance, as well as their importance for several ES and ED (Zhang et al. 2007, Ameixa et al. 2018, Noriega et al. 2018, Ecosystem Services 2019), arthropods play a key role in all terrestrial ecosystems. Evaluating the total effect of arthropods that are providers of both ES and ED is challenging (Shapiro and Báldi 2014). For example, when they prey on pests, generalist predators provide biological control, an ES valued at $400 billion/y (Costanza et al. 1997), while their intraguild predation (Lövei and Ferrante 2017) constitutes an ED. A second great challenge is to assess the role of native vs. exotic biodiversity in providing ES/ED, which is essential to manage sustainable landscapes and an important frontier in theoretical ecology. Exotic species often alter ecological processes and cause severe biodiversity loss (Simberloff et al. 2013). Nevertheless, these species may also provide ES: alien plants can increase microbial activity (Vilà et al. 2011), introduced natural enemies can control pests (Heimpel and Mills 2017) or provide ecological "insurance" after the decline of native species (Stavert et al. 2018).

Oceanic islands have a high proportion of endemic species, being very sensitive to biotic disturbance, such as invasions and land-use changes (Stachowicz and Tilman 2005, Kier et al. 2009) - the perfect setting to test the response of ecological communities to disturbance and its effects on ecosystem processes. Several factors contribute to arthropod decline in the Azores (Borges et al. 2019b), including native forest destruction (Triantis et al. 2010), lack of connectivity between forest patches (Aparício et al. 2018) and climate change (Ferreira et al. 2016).

This publication contributes not only to a better knowledge of the arthropods present in agroecosystems of Terceira Island, but will also contribute as a baseline for future monitoring schemes in Azorean agroecosystems targeting the long-term change in arthropod diversity and abundance.

General description

Purpose: To provide an arthropod inventory of agro-ecosystems from Terceira Island (Azores), based on data collected in four agro-ecosystems, citrus orchards, low and high elevation maize fields and vineyards. This study will contribute to a better knowledge of the arthropods present in agro-ecosystems and will serve as a baseline for future monitoring schemes in Azorean agro-ecosystems targeting the long-term change in arthropod diversity and abundance.

Additional information: The study was conducted between July 2019 and September 2021 in Terceira Island. Active Aerial Searching (only in maize-fields) and pitfall traps were used to sample the arthropod biodiversity (pollinators and predatory spiders, true-bugs and beetles and main insect pests) on four agricultural habitats, namely citrus orchards, vineyards, low elevation maize fields and high elevation maize fields. Information on ecosystem services (ES) and disservices (ED) providers will be the subject of another publication.

Project description

Title: AgEcSe- AGRO-ECOSERVICES - Assessing ecosystem services and disservices provided by arthropod species in Azorean Agroecosystems (ACORES-01-0145-FEDER-000073)

Personnel: Project leaders: Paulo A. V. Borges and António Onofre Soares

Team members: Marco Ferrante, Artur Gil, Marco Girardello, David H. Lopes, Paulo Monjardino, Rui Nunes.

External Consultants: Sven Bacher, Gabor Lövei, François Rigal

Parataxonomists: Jonne Bonnet, Ricardo Costa, Rui Nunes

Darwin Core Database management: Paulo A. V. Borges, Lucas Lamelas-López, Enésima Pereira

Study area description: Terceira Island (area: 400.2 km²; elevation: 1021 m a.s.l.) is located in the central group of the Azores Archipelago (North Atlantic), roughly at 38.638 N and -27.0150 W (Fig. 1). Similar to all islands in Azores, Terceira is volcanic and of recent origin (0.4 Ma, see Florencio et al. 2021). The climate is temperate oceanic, with regular and abundant rainfall, high levels of relative humidity and persistent winds, mainly during the winter and autumn seasons.

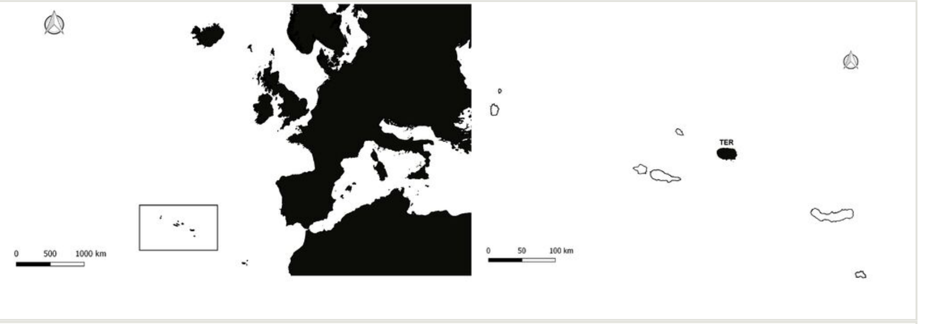

Figure 1. doi

Map of the Azores Archipelago location in mid-Atlantic with the studied island TER - Terceira, marked in black (Credit: Enésima Pereira).

Design description: The sampled habitats included citrus orchards, vineyards and low elevation maize fields, all located at low elevation areas and high elevation maize fields (Fig. 2, Table 1). The two types of maize fields differ not only in the elevation, but principally in crop management, the low elevation being an annual rotation of maize and Italian ryegrass and the high elevation (located at intermediate elevation in the Island) being a perennial rotation of maize and perennial ryegrass.

Table 1.

Description of the habitat, locality, elevation and coordinates of the 18 sampled sites on Terceira Island, Azores.

Code Site	Habitat	Location ID	Locality	Elevation (m a.s.l.)	Latitude	Longitude
C1	Citrus	TER_CITRUS_T1_T206	Pico da Urze	117	38.66989	-27.24047
C2	Citrus	TER_CITRUS_T2_T207	Qt. Rosário	158	38.68111	-27.26206
C3	Citrus	TER_CITRUS_T3_T208	S. Bartolomeu	189	38.6827	-27.27555
C4	Citrus	TER_CITRUS_T4_T209	S. Bento	66	38.66287	-27.21019
C5	Citrus	TER_CITRUS_T5_T210	S. Carlos	69	38.6625	-27.24961
ML1	Maize Low	TER_MAIZE_LOW_T2_T221	Atalaia	111	38.65631	-27.18368
ML2	Maize Low	TER_MAIZE_LOW_T1_T220	Cinco Ribeiras	90	38.6758	-27.30998
ML3	Maize Low	TER_MAIZE_LOW_T3_T222	S. Mateus	42	38.66304	-27.28962
ML4	Maize Low	TER_MAIZE_LOW_T4_T223	Universidade dos Açores - Campus do Pico da Urze	36	38.659	-27.23555

Code Site	Habitat	Location ID	Locality	Elevation (m a.s.l.)	Latitude	Longitude
ML5	Maize Low	TER_MAIZE_LOW_T5_T224	Vinha Brava	167	38.67593	-27.21684
MH1	Maize High	TER_MAIZE_HIGH_T1_T215	Casa da Mina	314	38.68602	-27.1974
MH2	Maize High	TER_MAIZE_HIGH_T2_T216	Escampadouro	309	38.70159	-27.2852
MH3	Maize High	TER_MAIZE_HIGH_T3_T217	Granja	385	38.70083	-27.17019
MH4	Maize High	TER_MAIZE_HIGH_T4_T218	Juncal	321	38.69996	-27.12048
MH5	Maize High	TER_MAIZE_HIGH_T5_T219	Poejo	275	38.6768	-27.14616
V1	Vineyards	TER_VINE_F1_T211	Biscoitos Vinha_F1	23	38.79793	-27.25567
V2	Vineyards	TER_VINE_F2_T212	Biscoitos Vinha_F2	52	38.79664	-27.26302
V3	Vineyards	TER_VINE_F3_T213	Biscoitos Vinha_F3	28	38.80066	-27.26842

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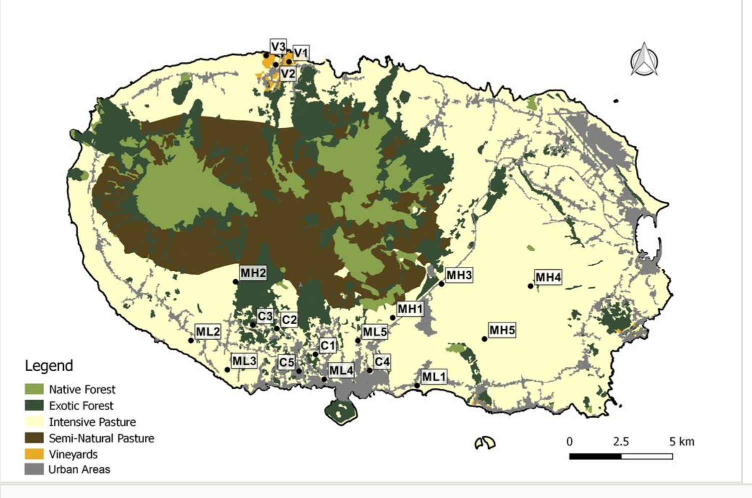

Figure 2. doi

Map of the study area (Terceira Island, Azores). Codes of sites as in Table 1. Maize fields are located in intensive pasture since they are only operating in summer, with the two crops usually grown in rotation (Land-use data extracted from Cruz et al. 2007).

Sampling methods

Study extent: The study was conducted in four agro-ecosystems of Terceira Island (Fig. 2): citrus orchards (Fig. 3), vineyards (Fig. 4), low elevation maize fields (Fig. 5) and high elevation maize fields (Fig. 6). Five citrus orchards were selected, located at low elevation areas. Ten maize fields, five of which are located inland at higher elevation and five other closer to the coast in low elevation areas. Finally, three vineyards located on the coast, north of the Island were sampled (see also Table 1).

Figure 3. doi

A citrus orchard in Terceira Island (C5 - S. Carlos) (Credit: Rui Nunes).

Figure 4. doi

The vineyards in Terceira Island (V3 - Biscoitos) (Credit: Rui Nunes).

Figure 5. doi

A low elevation maize field in Terceira Island (ML3 - S. Mateus) (Credit: Rui Nunes).

Figure 6. doi

A high elevation maize field in Terceira Island (MH5 -Poejo) (Credit: Rui Nunes).

Sampling description: Active Aerial Searching (AAS) and pitfall traps were used to sample arthropod diversity. The following main functional groups were collected: predatory arthropods (mostly spiders, true-bugs, beetles and bugs), phytophagous insects and saprophagous arthropods (mostly millipedes and beetles).

AAS consists in picking arthropods found above knee-level by hand, using forceps, pooter or brush and immediately transferring them into vials containing ethanol 96%. It was implemented in five low- and five high-elevation maize fields. Four 1-hour samples were obtained during the night when the main predators are more active. Sampling was performed in the summer when the maize plants were at maximum development. Samples were taken by Paulo A. V. Borges and Rui Nunes (two hours each per site).

Pitfall traps were standard 330 ml plastic cups, 8 cm wide at the top and approximately 12 cm deep - European standard plastic cups (Fig. 7), partially filled with propylene glycol. The traps were deployed for 14 consecutive days.

Figure 7. doi

Detail of a pitfall trap (standard 330 ml plastic cups, 8 cm wide at the top and approximately 12 cm deep) (Credit: Rui Nunes).

In each of five citrus orchards and six (of ten available) maize fields (three in low- and three in high-elevation areas), 16 pitfall traps organised in sets of two connected with a grid (Fig. 8) were deployed, along a transect, from the point closest to the crop edge. The eight sets of two pitfall traps were separated by at least 10 metres. A total of 80 and 96 pitfall traps were deployed on citrus orchards and maize fields, respectively.

For vineyards, a different strategy had to be followed since Azorean vineyards are formed by small rocky enclosures (between 6-20 m^2) (Fig. 4) and pitfall traps were deployed in the interior of these enclosures. Following a transect, a total of 144 individual pitfall traps were deployed in three vineyards (48 in each site).

Sampling methods used in citrus and vineyards (pitfall traps) only provide information on the soil-related arthropods; most of crop insect pests (canopy associated species) are not sampled by this sampling technique.

Quality control: All sampled specimens were first sorted by trained paratoxonomists (Jonne Bonnet, Ricardo Costa, Rui Nunes). All specimens were allocated to a taxonomic species by Paulo A. V. Borges. Juveniles were also included in the data presented in this paper since the low diversity of species in Azores allows their reliable identification.

Colonisation status for each identified species is based on Borges et al. 2010 (END - Endemic; NAT - native non-endemic; INTR -introduced).

Figure 8. doi

Pitfall traps used in citrus orchards and maize fields (sets of two connected with a grid) (Credit: Rui Nunes).

Step description: A reference collection for Azorean arthropods (deposited at the Dalberto Teixeira Pombo Insect Collection, University of Azores) started to be prepared in 1999 by one of us (PAVB) and many taxonomists contributed since then in the identification of species. For all the specimens for which adequate identification was not possible, a new "morphospecies code" was created.

Geographic coverage

Description: Terceira Island, Azores, Portugal.

Coordinates: 38.638 and 38.814 Latitude; -27.394 and -27.0150 Longitude.

Taxonomic coverage

Description: The following classes and orders of arthropods are covered: Arachnida: Araneae, Opiliones, Pseudoscorpiones; Chilopoda: Geophilomorpha, Lithobiomorpha, Scolopendromorpha, Scutigeromorpha; Diplopoda: Chordeumatida, Julida, Polydesmida; and Insecta: Archaeognatha, Coleoptera, Dermaptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera, Orthoptera, Psocoptera, Thysanoptera.

Taxa included:

Rank	Scientific Name	Common Name
class	Araneae	Spiders
class	Opiliones	Opilions
class	Pseudoscorpiones	Pseudoscorpions
class	Diplopoda	Millipedes
class	Chilopoda	Centipedes
order	Archaeognatha	Bristletails
order	Dermaptera	Earwigs
order	Orthoptera	Crickets, Grasshoppers
order	Psocoptera	Barklice
order	Thysanoptera	Thrips
order	Hemiptera	Bugs
order	Neuroptera	Lacewings
order	Coleoptera	Beetles
order	Hymenoptera	Ants
order	Lepidoptera	Moths

Traits coverage

No data available.

Temporal coverage

Notes: 16 July 2019 to 9 June 2021

Collection data

Collection name: Entomoteca Dalberto Teixeira Pombo at University of Azores

Collection identifier: DTP

Specimen preservation method: All specimens were preserved in 96% ethanol.

Curatorial unit: Dalberto Teixeira Pombo insect collection at the University of the Azores (Curator: Paulo A. V. Borges)

Usage licence

Data resources

Data package title: Monitoring Arthropods in Azorean Agroecosystems: the project AGRO-ECOSERVICES (AgEcSe)

Resource link: https://www.gbif.org/dataset/822f3765-6950-40c5-9353-1f335599007c

Alternative identifiers: https://doi.org/10.15468/mvtmyx

Number of data sets: 1

Data set name: Monitoring Arthropods in Azorean Agroecosystems: the project AGRO-ECOSERVICES

Download URL: http://ipt.gbif.pt/ipt/resource?r=arthropods_agroecoservices

Data format: Darwin Core Archive

Data format version: version 1.10

Description: The dataset is available on the Global Biodiversity Information Facility platform, GBIF (Borges et al. 2021). The following data table includes all the records for which a taxonomic identification of the species was possible. The dataset submitted to GBIF is structured as a sample event dataset, with two tables: event (as core) and occurrences (abundance data). 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 358 records (eventID) and the occurrences file 5134 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 Borges et al. (2021).

Column label	Column description
Table of Sampling Events	Table with sampling events data (beginning of table).
eventID	Identifier of the events, unique for the dataset.
stateProvince	Name of the region of the sampling site.
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.
municipality	Municipality of the sampling site.
decimalLongitude	Approximate centre point decimal longitude of the field site in GPS coordinates.
decimalLatitude	Approximate centre point decimal latitude of the field site in GPS coordinates.
geodeticDatum	The ellipsoid, geodetic datum or spatial reference system (SRS) upon which the geographic coordinates given in decimalLatitude and decimalLongitude are based.
coordinateUncertaintyInMetres	Uncertainty of the coordinates of the centre of the sampling plot.
coordinatePrecision	Precision of the coordinates.
georeferenceSources	A list (concatenated and separated) of maps, gazetteers or other resources used to georeference the Location, described specifically enough to allow anyone in the future to use the same resources.
locationID	Identifier of the location.
fieldNumber	Code of the sample
locality	Name of the locality.
minimumElevationInMetres	The lower limit of the range of elevation (altitude, usually above sea level), in metres.
habitat	The habitat of the sample.
year	Year of the event.
month	Month of the event.
day	Day of the event.
samplingEffort	The amount of effort expended during an Event.
eventDate	Date or date range the record was collected.
samplingProtocol	The sampling protocol used to capture the species.
Occurrence Table	Table with species abundance data (beginning of new table).
eventID	Identifier of the events, unique for the dataset.
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.
institutionCode	The code of the institution publishing the data.
collectionID	The identity of the collection publishing the data.
collectionCode	The code of the collection where the specimens are conserved.
datasetName	Name of the dataset.
basisOfRecord	The nature of the data record.
occurrenceID	Identifier of the record, coded as a global unique identifier.
recordedBy	A list (concatenated and separated) of names of people, groups or organisations who performed the sampling in the field.
identifiedBy	A list (concatenated and separated) of names of people, groups or organisations who assigned the Taxon to the subject.
dateIdentified	The date on which the subject was determined as representing the Taxon.
organismQuantity	A number or enumeration value for the quantity of organisms.
organismQuantityType	The type of quantification system used for the quantity of organisms.
sex	The sex and quantity of the individuals captured.
lifeStage	The life stage of the organisms captured.
scientificName	Complete scientific name including author and year.
scientificNameAuthorship	Name of the author of the lowest taxon rank included in the record.
kingdom	Kingdom name.
phylum	Phylum name.
class	Class name.
order	Order name.
family	Family name.
genus	Genus name.
specificEpithet	Specific epithet.
infraspecificEpithet	Infrapecific epithet.
taxonRank	Lowest taxonomic rank of the record.
establishmentMeans	The process of establishment of the species in the location, using a controlled vocabulary: 'native', 'introduced', 'endemic', "unknown".
identificationRemarks	Information about morphospecies identification (code in Dalberto Teixeira Pombo Collection).

Additional information

We collected a total of 50412 specimens, belonging to four classes, 20 orders and 81 families of arthropods. A total of 127 species are considered introduced (n = 22646) and 69 native non-endemic (n = 24117). Four endemic species were recorded with very few specimens (n = 14) and 3635 specimens belong to unidentified taxa recorded only at genus or family level.

Arachnids belonged to three orders, Araneae being the most abundant (95% of arachnid specimens belonged to this order). Chilopoda and Diplopoda classes recorded four and three orders, being Lithobiomorpha and Julida, respectively, the most abundant. Insecta was the most abundant class (n = 39590) recorded in the studied agro-ecosystems, with Coleoptera the most abundant order (38% of specimens).

A total of 200 species were identified (Table 2) and an additional 73 morphospecies need proper identification, totalling potentially 273 species (see Suppl. material 1).

Table 2.

Inventory of arthropods collected in four agroecosystems in Terceira Island (Azores, Portugal) following an elevation gradient: vineyards (Vine), citrus orchards (Citrus), maize fields at low elevation (Maize L) and at high elevation (Maize H). The list includes only the specimens identified at species-level. Class, order, family, scientific name follow alphabetical sequence. Colonisation status based on Borges et al. 2010 (Origin: END - Endemic; NAT - native non-endemic; INTR - introduced) and abundance per habitat type are provided. Bold scientific names constitute new records for Terceira Island. * - New record for Azores.

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Arachnida	Araneae	Agelenidae	*Tegenaria domestica* (Clerck, 1757)	INTR				1	1
Arachnida	Araneae	Agelenidae	*Tegenaria pagana* C.L. Koch, 1840	INTR		3			3
Arachnida	Araneae	Araneidae	*Agalenatea redii* (Scopoli, 1763)	INTR			7	2	9
Arachnida	Araneae	Araneidae	*Araneus angulatus* Clerck, 1757	INTR			30		30
Arachnida	Araneae	Araneidae	*Argiope bruennichi* (Scopoli, 1772)	NAT			37	50	87
Arachnida	Araneae	Araneidae	*Gibbaranea occidentalis* Wunderlich, 1989	END				1	1
Arachnida	Araneae	Araneidae	*Mangora acalypha* (Walckenaer, 1802)	INTR				1	1
Arachnida	Araneae	Araneidae	*Neoscona crucifera* (Lucas, 1838)	INTR			2	2	4
Arachnida	Araneae	Araneidae	*Zygiella x-notata* (Clerck, 1757)	INTR			6	12	18
Arachnida	Araneae	Clubionidae	*Clubiona terrestris* Westring, 1851	INTR		2			2

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Arachnida	Araneae	Clubionidae	*Porrhoclubiona decora* (Blackwall, 1859)	NAT			25	4	29
Arachnida	Araneae	Clubionidae	*Porrhoclubiona genevensis* (L. Koch, 1866)	INTR			1		1
Arachnida	Araneae	Dictynidae	*Lathys dentichelis* (Simon, 1883)	NAT		1			1
Arachnida	Araneae	Dictynidae	*Nigma puella* (Simon, 1870)	INTR			3		3
Arachnida	Araneae	Dysderidae	*Dysdera crocata* C.L. Koch, 1838	INTR	4	70	20	15	109
Arachnida	Araneae	Gnaphosidae	*Marinarozelotes lyonneti* (Audouin, 1826)	INTR	15		15		30
Arachnida	Araneae	Linyphiidae	*Agyneta decora* (O. Pickard-Cambridge, 1871)	INTR			1		1
Arachnida	Araneae	Linyphiidae	*Agyneta fuscipalpa* (C. L. Koch, 1836)	INTR	28	7	396	18	449
Arachnida	Araneae	Linyphiidae	*Erigone atra* Blackwall, 1833	INTR	1	3	3	13	20
Arachnida	Araneae	Linyphiidae	*Erigone autumnalis* Emerton, 1882	INTR	1	309	333	95	738
Arachnida	Araneae	Linyphiidae	*Erigone dentipalpis* (Wider, 1834)	INTR		2	176	484	662
Arachnida	Araneae	Linyphiidae	*Mermessus bryantae* (Ivie & Barrows, 1935)	INTR		2	3	2	7
Arachnida	Araneae	Linyphiidae	*Mermessus fradeorum* (Berland, 1932)	INTR		117	7	53	177
Arachnida	Araneae	Linyphiidae	*Neriene clathrata* (Sundevall, 1830)	INTR		3	2	2	7
Arachnida	Araneae	Linyphiidae	*Oedothorax fuscus* (Blackwall, 1834)	INTR		4	80	577	661
Arachnida	Araneae	Linyphiidae	*Ostearius melanopygius* (O. Pickard-Cambridge, 1880)	INTR		1	6	17	24
Arachnida	Araneae	Linyphiidae	*Palliduphantes schmitzi* (Kulczynski, 1899)	NAT	7	1	1	2	11
Arachnida	Araneae	Linyphiidae	*Pelecopsis parallela* (Wider, 1834)	INTR	32		1		33
Arachnida	Araneae	Linyphiidae	*Prinerigone vagans* (Audouin, 1826)	INTR			130	229	359
Arachnida	Araneae	Linyphiidae	*Tenuiphantes tenuis* (Blackwall, 1852)	INTR		132	104	177	413
Arachnida	Araneae	Lycosidae	*Arctosa perita* (Latreille, 1799)	INTR			1		1

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Arachnida	Araneae	Lycosidae	*Pardosa acorensis* Simon, 1883	END		6		3	9
Arachnida	Araneae	Oecobiidae	*Oecobius navus* Blackwall, 1859	INTR	5		5		10
Arachnida	Araneae	Salticidae	*Chalcoscirtus infimus* (Simon, 1868)	INTR	14				14
Arachnida	Araneae	Salticidae	*Heliophanus kochii* Simon, 1868	INTR		1			1
Arachnida	Araneae	Salticidae	*Macaroeris diligens* (Blackwall, 1867)	NAT			1	2	3
Arachnida	Araneae	Salticidae	*Pseudeuophrys vafra* (Blackwall, 1867)	INTR	3				3
Arachnida	Araneae	Salticidae	*Salticus mutabilis* Lucas, 1846	INTR			1		1
Arachnida	Araneae	Salticidae	*Synageles venator* (Lucas, 1836)	INTR		1			1
Arachnida	Araneae	Scytotidae	*Scytodes thoracica* (Latreille, 1802)	INTR			1		1
Arachnida	Araneae	Segestriidae	*Segestria florentina* (Rossi, 1790)	INTR				1	1
Arachnida	Araneae	Tetragnathidae	*Pachygnatha degeeri* Sundevall, 1830	INTR			1	55	56
Arachnida	Araneae	Theridiidae	*Cryptachaea blattea* (Urquhart, 1886)	INTR		5	2	11	18
Arachnida	Araneae	Theridiidae	*Neottiura bimaculata* (Linnaeus, 1767)	INTR	1				1
Arachnida	Araneae	Theridiidae	*Parasteatoda tepidariorum* (C. L. Koch, 1841)	INTR			8	69	77
Arachnida	Araneae	Theridiidae	*Steatoda grossa* (C. L. Koch, 1838)	INTR			16	71	87
Arachnida	Araneae	Theridiidae	*Steatoda nobilis* (Thorell, 1875)	INTR				2	2
Arachnida	Araneae	Theridiidae	*Theridion melanostictum* O. Pickard-Cambridge, 1876	INTR		1	3		4
Arachnida	Araneae	Theridiidae	*Theridion musivivum* Schmidt, 1956	NAT		1			1
Arachnida	Araneae	Thomisidae	*Xysticus nubilus* Simon, 1875	INTR			3		3
Arachnida	Araneae	Zodariidae	*Zodarion atlanticum* Pekár & Cardoso, 2005	INTR	934	7	14	1	956
Arachnida	Opiliones	Phalangiidae	*Homalenotus coriaceus* (Simon, 1879)	NAT	1	156		20	177

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Arachnida	Opiliones	Phalangiidae	*Leiobunum blackwalli* Meade, 1861	NAT		7		12	19
Arachnida	Pseudoscorpiones	Chthoniidae	*Chthonius ischnocheles* (Hermann, 1804)	INTR	8	10	4		22
Arachnida	Pseudoscorpiones	Chthoniidae	*Ephippiochthonius tetrachelatus* (Preyssler, 1790)	INTR	18	9			27
Arachnida	Pseudoscorpiones	Neobisiidae	*Neobisium maroccanum* Beier, 1930	INTR	1	2			3
Chilopoda	Geophilomorpha	Linotaeniidae	*Strigamia crassipes* (C.L. Koch, 1835)	NAT		2			2
Chilopoda	Lithobiomorpha	Lithobiidae	*Lithobius pilicornis pilicornis* Newport, 1844	NAT	15	4	1	1	21
Chilopoda	Scolopendromorpha	Cryptopidae	*Cryptops hortensis* (Donovan, 1810)	NAT	6	1	2		9
Chilopoda	Scutigeromorpha	Scutigeridae	*Scutigera coleoptrata* (Linnaeus, 1758)	INTR	34	205	171	27	437
Diplopoda	Chordeumatida	Haplobainosomatidae	*Haplobainosoma lusitanum* Verhoeff, 1900	INTR		6			6
Diplopoda	Julida	Blaniulidae	*Blaniulus guttulatus* (Fabricius, 1798)	INTR		1			1
Diplopoda	Julida	Blaniulidae	***Nopoiulus kochii* (Gervais, 1847)**	INTR			3		3
Diplopoda	Julida	Blaniulidae	*Proteroiulus fuscus* (Am Stein, 1857)	INTR		3			3
Diplopoda	Julida	Julidae	*Brachyiulus pusillus* (Leach, 1814)	INTR		138			138
Diplopoda	Julida	Julidae	*Cylindroiulus latestriatus* (Curtis, 1845)	INTR		1			1
Diplopoda	Julida	Julidae	*Cylindroiulus propinquus* (Porat, 1870)	INTR	4	14			18
Diplopoda	Julida	Julidae	*Ommatoiulus moreleti* (Lucas, 1860)	INTR	221	1740	35	217	2213
Diplopoda	Polydesmida	Polydesmidae	*Brachydesmus superus* Latzel, 1884	INTR		1			1
Diplopoda	Polydesmida	Polydesmidae	*Polydesmus coriaceus* Porat, 1870	INTR	8	470	12	53	543
Insecta	Archaeognatha	Machilidae	*Dilta saxicola* (Womersley, 1930)	NAT			3	4	7

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Coleoptera	Anthicidae	*Hirticollis quadriguttatus* (Rossi, 1792)	NAT	1		166	176	343
Insecta	Coleoptera	Apionidae	*Aspidapion radiolus* (Marsham, 1802)	NAT	1		1		2
Insecta	Coleoptera	Apionidae	***Ischnopterapion virens*** **(Herbst, 1797)**	INTR			6	2	8
Insecta	Coleoptera	Carabidae	*Acupalpus dubius* Schilsky, 1888	NAT			37	8	45
Insecta	Coleoptera	Carabidae	*Acupalpus flavicollis* (Sturm, 1825)	NAT			47	1	48
Insecta	Coleoptera	Carabidae	*Agonum muelleri muelleri* (Herbst, 1784)	INTR				38	38
Insecta	Coleoptera	Carabidae	*Amara aenea* (De Geer, 1774)	INTR		1	6	15	22
Insecta	Coleoptera	Carabidae	*Anisodactylus binotatus* (Fabricius, 1787)	INTR		1	3	65	69
Insecta	Coleoptera	Carabidae	*Calosoma olivieri* Dejean, 1831	NAT			14	41	55
Insecta	Coleoptera	Carabidae	*Harpalus distinguendus distinguendus* (Duftschmid, 1812)	INTR		1	3	40	44
Insecta	Coleoptera	Carabidae	*Laemostenus complanatus* (Dejean, 1828)	INTR	5	41		1	47
Insecta	Coleoptera	Carabidae	***Microlestes negrita negrita*** **(Wollaston, 1854)**	NAT			6		6
Insecta	Coleoptera	Carabidae	*Notiophilus quadripunctatus* Dejean, 1826	NAT				1	1
Insecta	Coleoptera	Carabidae	*Ocys harpaloides* (Audinet-Serville, 1821)	NAT		5			5
Insecta	Coleoptera	Carabidae	*Paranchus albipes* (Fabricius, 1796)	INTR		1		16	17
Insecta	Coleoptera	Carabidae	*Pseudoophonus rufipes* (De Geer, 1774)	INTR	7	74	55	6995	7131
Insecta	Coleoptera	Carabidae	*Pterostichus vernalis* (Panzer, 1796)	INTR				25	25
Insecta	Coleoptera	Chrysomelidae	*Chaetocnema hortensis* (Fourcroy, 1785)	INTR		1	2		3
Insecta	Coleoptera	Chrysomelidae	*Chrysolina bankii* (Fabricius, 1775)	NAT		10			10
Insecta	Coleoptera	Chrysomelidae	*Epitrix cucumeris* (Harris, 1851)	INTR	53	4			57

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Coleoptera	Chrysomelidae	*Longitarsus kutscherai* (Rye, 1872)	INTR			1		1
Insecta	Coleoptera	Coccinellidae	*Scymniscus helgae* (Fürsch, 1965)	INTR		1			1
Insecta	Coleoptera	Corylophidae	*Sericoderus lateralis* (Gyllenhal, 1827)	INTR	15	61	268	96	440
Insecta	Coleoptera	Curculionidae	*Calacalles subcarinatus* (Israelson, 1984)	END		1			1
Insecta	Coleoptera	Curculionidae	*Cathormiocerus curvipes* (Wollaston, 1854)	NAT		18			18
Insecta	Coleoptera	Curculionidae	*Coccotrypes carpophagus* (Hornung, 1842)	INTR		71	3	2	76
Insecta	Coleoptera	Curculionidae	*Naupactus cervinus* (Boheman, 1840)	INTR		4			4
Insecta	Coleoptera	Curculionidae	*Orthochaetes insignis* (Aubé, 1863)	NAT	1	21			22
Insecta	Coleoptera	Curculionidae	*Otiorhynchus cribricollis* Gyllenhal, 1834	INTR		5			5
Insecta	Coleoptera	Curculionidae	*Otiorhynchus rugosostriatus* (Goeze, 1777)	INTR	4	1			5
Insecta	Coleoptera	Curculionidae	*Pseudophloeophagus tenax* Wollaston, 1854	NAT		2			2
Insecta	Coleoptera	Curculionidae	*Xyleborinus alni* Nijima, 1909	INTR				1	1
Insecta	Coleoptera	Dryophthoridae	*Cosmopolites sordidus* (Germar, 1824)	INTR		1			1
Insecta	Coleoptera	Dryophthoridae	*Sphenophorus abbreviatus* (Fabricius, 1787)	INTR		4	2	51	57
Insecta	Coleoptera	Elateridae	*Aeolus melliculus moreleti* Tarnier, 1860	INTR			8		8
Insecta	Coleoptera	Elateridae	*Heteroderes azoricus* (Tarnier, 1860)	END			2	1	3
Insecta	Coleoptera	Elateridae	*Heteroderes vagus* Candèze, 1893	INTR			3	13	16
Insecta	Coleoptera	Elateridae	*Melanotus dichrous* (Erichson, 1841)	INTR			14		14
Insecta	Coleoptera	Histeridae	*Carcinops pumilio* (Erichson, 1834)	INTR	1				1

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Coleoptera	Hydrophilidae	*Sphaeridium bipustulatum* Fabricius, 1781	INTR			1	1	2
Insecta	Coleoptera	Latridiidae	*Cartodere nodifer* (Westwood, 1839)	INTR		2	1		3
Insecta	Coleoptera	Leiodidae	*Catops coracinus* Kellner, 1846	NAT			1		1
Insecta	Coleoptera	Malachiidae	*Attalus lusitanicus lusitanicus* Erichson, 1840	NAT			2		2
Insecta	Coleoptera	Mycetophagidae	*Litargus balteatus* Le Conte, 1856	INTR		1		1	2
Insecta	Coleoptera	Mycetophagidae	*Typhaea stercorea* (Linnaeus, 1758)	INTR	1		642	5	648
Insecta	Coleoptera	Nitidulidae	*Carpophilus fumatus* Boheman, 1851	INTR		1			1
Insecta	Coleoptera	Nitidulidae	*Epuraea biguttata* (Thunberg, 1784)	INTR	49	22		1	72
Insecta	Coleoptera	Nitidulidae	*Phenolia limbata tibialis* (Boheman, 1851)	INTR	15	6	1	1	23
Insecta	Coleoptera	Nitidulidae	*Stelidota geminata* (Say, 1825)	INTR			128	18	146
Insecta	Coleoptera	Phalacridae	*Stilbus testaceus* (Panzer, 1797)	NAT		1	24	1	26
Insecta	Coleoptera	Ptiliidae	*Ptenidium pusillum* (Gyllenhal, 1808)	INTR	4	6	2		12
Insecta	Coleoptera	Scarabaeidae	*Calamosternus granarius* (Linnaeus, 1767)	INTR			7		7
Insecta	Coleoptera	Scarabaeidae	*Onthophagus vacca* (Linnaeus, 1767)	INTR				6	6
Insecta	Coleoptera	Scarabaeidae	*Popillia japonica* Newman, 1838	INTR				4	4
Insecta	Coleoptera	Silvanidae	*Cryptamorpha desjardinsii* (Guérin-Méneville, 1844)	INTR		3			3
Insecta	Coleoptera	Staphylinidae	*Aleochara bipustulata* (Linnaeus, 1760)	INTR	1		1	4	6
Insecta	Coleoptera	Staphylinidae	*Aloconota sulcifrons* (Stephens, 1832)	NAT			11		11
Insecta	Coleoptera	Staphylinidae	*Amischa analis* (Gravenhorst, 1802)	INTR	1	8	48	1321	1378

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Coleoptera	Staphylinidae	*Anotylus nitidifrons* (Wollaston, 1871)	INTR	10	377	4	8	399
Insecta	Coleoptera	Staphylinidae	*Anotylus nitidulus* (Gravenhorst, 1802)	INTR		2			2
Insecta	Coleoptera	Staphylinidae	*Astenus lyonessius* (Joy, 1908)	NAT			10		10
Insecta	Coleoptera	Staphylinidae	*Atheta aeneicollis* (Sharp, 1869)	INTR	1	2			3
Insecta	Coleoptera	Staphylinidae	*Atheta fungi* (Gravenhorst, 1806)	INTR	1	76	66	49	192
Insecta	Coleoptera	Staphylinidae	*Carpelimus corticinus* (Gravenhorst, 1806)	NAT		1			1
Insecta	Coleoptera	Staphylinidae	*Coproporus pulchellu*s (Erichson, 1839)	INTR		6			6
Insecta	Coleoptera	Staphylinidae	*Cordalia obscura* (Gravenhorst, 1802)	INTR	20	17	256	316	609
Insecta	Coleoptera	Staphylinidae	*Euplectus infirmus* Raffray, 1910	INTR	1	2			3
Insecta	Coleoptera	Staphylinidae	*Gabrius nigritulus* (Gravenhorst, 1802)	INTR			2	3	5
Insecta	Coleoptera	Staphylinidae	*Medon apicalis* (Kraatz, 1857)	NAT		1			1
Insecta	Coleoptera	Staphylinidae	*Ocypus aethiops* (Waltl, 1835)	NAT		308		1	309
Insecta	Coleoptera	Staphylinidae	*Ocypus olens* (Müller, 1764)	NAT		59		45	104
Insecta	Coleoptera	Staphylinidae	*Oligota pumilio* Kiesenwetter, 1858	NAT	7	70	178	12	267
Insecta	Coleoptera	Staphylinidae	*Phloeonomus punctipennis* Thomson, 1867	NAT		1			1
Insecta	Coleoptera	Staphylinidae	*Proteinus atomarius* Erichson, 1840	NAT		10			10
Insecta	Coleoptera	Staphylinidae	*Pseudoplectus perplexus* (Jacquelin du Val, 1854)	NAT	22	4		41	67
Insecta	Coleoptera	Staphylinidae	*Quedius curtipennis* Bernhauer, 1908	NAT				1	1
Insecta	Coleoptera	Staphylinidae	*Rugilus orbiculatus* (Paykull, 1789)	NAT		2	365	757	1124
Insecta	Coleoptera	Staphylinidae	*Sepedophilus lusitanicus* Hammond, 1973	NAT		4			4
Insecta	Coleoptera	Staphylinidae	*Stenomastax maderae* Assing, 2003	NAT		127			127

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Coleoptera	Staphylinidae	*Tachyporus chrysomelinus* (Linnaeus, 1758)	INTR	1				1
Insecta	Coleoptera	Staphylinidae	*Tachyporus nitidulus* (Fabricius, 1781)	INTR	1	2	5	3	11
Insecta	Coleoptera	Staphylinidae	*Trichiusa immigrata* Lohse, 1984	INTR	3				3
Insecta	Coleoptera	Staphylinidae	*Xantholinus longiventris* Heer, 1839	INTR			3	1	4
Insecta	Coleoptera	Tenebrionidae	*Blaps lethifera* Marsham, 1802	INTR			1		1
Insecta	Coleoptera	Tenebrionidae	***Lagria hirta* (Linnaeus, 1758)***	INTR			1		1
Insecta	Dermaptera	Anisolabididae	*Euborellia annulipes* (Lucas, 1847)	INTR	2	116		26	144
Insecta	Dermaptera	Forficulidae	*Forficula auricularia* Linnaeus, 1758	INTR		2	155	232	389
Insecta	Hemiptera	Anthocoridae	*Anthocoris nemoralis* (Fabricius, 1794)	NAT			1		1
Insecta	Hemiptera	Anthocoridae	*Orius laevigatus laevigatus* (Fieber, 1860)	NAT			1		1
Insecta	Hemiptera	Aphididae	*Rhopalosiphoninus latysiphon* (Davidson, 1912)	INTR	6	43			49
Insecta	Hemiptera	Cicadellidae	*Anoscopus albifrons* (Linnaeus, 1758)	NAT	1	3	6		10
Insecta	Hemiptera	Cicadellidae	***Cicadella viridis* (Linnaeus, 1758)**	INTR		3			3
Insecta	Hemiptera	Cicadellidae	*Euscelidius variegatus* (Kirschbaum, 1858)	NAT			72	10	82
Insecta	Hemiptera	Cicadellidae	*Sophonia orientalis* (Matsumura, 1912)	INTR		1			1
Insecta	Hemiptera	Cydnidae	*Geotomus punctulatus* (A. Costa, 1847)	NAT	33	3	3	1	40
Insecta	Hemiptera	Delphacidae	*Kelisia ribauti* Wagner, 1938	NAT		8	41	116	165
Insecta	Hemiptera	Delphacidae	*Megamelodes quadrimaculatus* (Signoret, 1865)	NAT		1			1
Insecta	Hemiptera	Lygaeidae	*Aphanus rolandri* (Linnaeus, 1758)	NAT	7		3		10
Insecta	Hemiptera	Lygaeidae	*Heterogaster urticae* (Fabricius, 1775)	NAT			1		1

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Hemiptera	Lygaeidae	*Kleidocerys ericae* (Horváth, 1909)	NAT	1				1
Insecta	Hemiptera	Lygaeidae	*Oxycarenus lavaterae* (Fabricius, 1787)	INTR			1		1
Insecta	Hemiptera	Lygaeidae	*Scolopostethus decoratus* (Hahn, 1833)	NAT	6	33	1	1	41
Insecta	Hemiptera	Microphysidae	*Loricula elegantula* (Bärensprung, 1858)	NAT		1			1
Insecta	Hemiptera	Miridae	*Campyloneura virgula* (Herrich-Schaeffer, 1835)	NAT				1	1
Insecta	Hemiptera	Miridae	*Heterotoma planicornis* (Pallas, 1772)	NAT			4		4
Insecta	Hemiptera	Miridae	*Pilophorus confusus* (Kirschbaum, 1856)	NAT			1		1
Insecta	Hemiptera	Miridae	*Trigonotylus caelestialium* (Kirkaldy, 1902)	NAT			493	231	724
Insecta	Hemiptera	Nabidae	*Nabis pseudoferus ibericus* Remane, 1962	NAT			7	46	53
Insecta	Hemiptera	Pentatomidae	*Nezara viridula* (Linnaeus, 1758)	INTR			5	6	11
Insecta	Hemiptera	Reduviidae	*Empicoris rubromaculatus* (Blackburn, 1889)	INTR		10	1		11
Insecta	Hemiptera	Reduviidae	*Ploiaria domestica* Scopoli, 1786	INTR			1		1
Insecta	Hemiptera	Saldidae	*Saldula palustris* (Douglas, 1874)	NAT				1	1
Insecta	Hemiptera	Tingidae	*Acalypta parvula* (Fallén, 1807)	NAT	5	4			9
Insecta	Hymenoptera	Apidae	*Bombus terrestris* (Linnaeus, 1758)	INTR			1	1	2
Insecta	Hymenoptera	Formicidae	*Hypoponera eduardi* (Forel, 1894)	NAT	12	32	37	99	180
Insecta	Hymenoptera	Formicidae	*Lasius grandis* Forel, 1909	NAT	10283	3058	1444	1091	15876
Insecta	Hymenoptera	Formicidae	*Linepithema humile* (Mayr, 1868)	INTR			2		2
Insecta	Hymenoptera	Formicidae	*Monomorium carbonarium* (Smith, 1858)	NAT	272	367		1	640
Insecta	Hymenoptera	Formicidae	*Tetramorium caespitum* (Linnaeus, 1758)	NAT	327	1329	1202	451	3309
Insecta	Hymenoptera	Formicidae	*Tetramorium caldarium* (Roger, 1857)	INTR	215	135	1		351

class	order	family	scientificName	Origin	VINE	CITRUS	MAIZE L	MAIZE H	Total
Insecta	Lepidoptera	Noctuidae	*Mythimna unipuncta* (Haworth, 1809)	NAT				1	1
Insecta	Orthoptera	Gryllidae	*Eumodicogryllus bordigalensis* (Latreille, 1804)	INTR	1	1		1559	1561
Insecta	Orthoptera	Gryllidae	*Gryllus bimaculatus* De Geer, 1773	INTR		10			10
Insecta	Orthoptera	Phaneropteridae	*Phaneroptera nana* Fieber, 1853	NAT				2	2
Insecta	Psocoptera	Caeciliusidae	*Valenzuela flavidus* (Stephens, 1836)	NAT	1		27	1	29
Insecta	Psocoptera	Ectopsocidae	*Ectopsocus briggsi* McLachlan, 1899	INTR		1	28	18	47
Insecta	Psocoptera	Ectopsocidae	*Ectopsocus strauchi* Enderlein, 1906	NAT	1				1
Insecta	Psocoptera	Trichopsocidae	*Trichopsocus clarus* (Banks, 1908)	NAT		2			2
Insecta	Thysanoptera	Thripidae	*Hercinothrips bicinctus* (Bagnall, 1919)	INTR	3			1	4
			Grand Total		**12763**	**10062**	**7622**	**16390**	**46837**

The five most abundant species account for 64% of all identified specimens and include two ant species: *Lasius grandis* Forel, 1909 (Hymenoptera: Formicidae) (n = 15876) and *Tetramorium caespitum* (Linnaeus, 1758) (Hymenoptera: Formicidae) (n = 3309), the ground-beetle *Pseudoophonus rufipes* (De Geer, 1774) (Coleoptera, Carabidae (n = 7131), the millipede (Diplopoda: Julida) *Ommatoiulus moreleti* (Lucas, 1860) (n = 2213) and the cricket (Orthoptera: Gryllidae) *Eumodicogryllus bordigalensis* (Latreille, 1804) (n = 1561).

Within the non-identified morphospecies, the most abundant taxa was a millipede (MF 1006) with 1959 specimens mostly sampled in high elevation maize fields (see Suppl. material 1).

Considering only identified species, a total of 10062 (21.48%), 7622 (16.27%), 16390 (34.99%) and 12763 (27.27%) specimens were collected and identified at species level in citrus orchards, low elevation maize fields, high elevation maize fields and vineyards, respectively (Table 2).

The most abundant species in vineyards were the native ant *Lasius grandis* (n = 10283), the introduced spider *Zodarion atlanticum* Pekár & Cardoso, 2005 (n = 934) and the native ant *Tetramorium caespitum* (n = 327) (Table 2).

The most abundant species in citrus orchards were the native ant *L. grandis* (n = 3058), the introduced millipede *Ommatoiulus moreleti* (n = 1740) and the native ant *T. caespitum* (n = 1329) (Table 2).

The most abundant species in low elevation maize fields were also ants, *L. grandis* (n = 1444) and *T. caespitum* (n = 1202), followed by the exotic beetle *Typhaea stercorea* (Linnaeus, 1758) (n = 642) and the mirid bug *Trigonotylus caelestialium* (Kirkaldy, 1902) (n = 493) (Table 2).

Finally, the most abundant species in high elevation maize fields were the introduced ground-beetle *Pseudoophonus rufipes* (n = 6995), the introduced cricket *Eumodicogryllus bordigalensis* (n = 1559), the two rove-beetles *Amischa analis* (Gravenhorst, 1802) (n = 1321) and *Rugilus orbiculatus* (Paykull, 1789) (757) and also the ant *L. grandis* (n =1091). Two spiders usually very abundant in intensive pastures are also relatively abundant, *Oedothorax fuscus* (Blackwall, 1834) (n = 577) and *Erigone dentipalpis* (Wider, 1834) (n = 484) (Table 2).

Although the introduced species potentially have the ability to colonise and spread in human-disturbed habitats (e.g. Rigal et al. 2017), our results showed that Azorean agroecosystems represent habitat opportunities for native arthropods. Some of the most abundant species are generalist predators with omnivorous behaviour, like the ants and the ground-beetle *P. rufipes*. Remarkable was the high abundance of the predatory spider *Z. atlanticum* in vineyards that feed on ants and may act as an ED provider. Most other predators potentially provide an ES to the Azorean agroecosystem habitats, particularly in maize fields and vineyards, through biological control of pests (e.g. Heimpel and Mills 2017). Introduced species can also affect native species of arthropods, for example, through opportunistic predation. However, introduced species may also supplement the functional traits lost after the decline of native species in these habitats (e.g. Stavert et al. 2018).

Five species are new records for Terceira Island: three beetles (Coleoptera), one millipede (Diplopoda: Julida) and one true bug (Hemiptera). The new beetle records included one specimen sampled of *Lagria hirta* (Linnaeus, 1758), eight of *Ischnopterapion virens* (Herbst, 1797) and six of *Microlestes negrita negrita* (Wollaston, 1854). All these individuals were collected in maize fields. The new millipede record included three specimens of *Nopoiulus kochii* (Gervais, 1847), also collected in maize fields, but at low elevation. Finally, the new hemipteran record included three specimens of *Cicadella viridis* (Linnaeus, 1758) from a citrus orchard. All new records belong to introduced species, with the exception of *M. negrita negrita*, which is native to the Azores.

Lagria hirta (Coleoptera, Tenebrionidae) is a new record for Azores. We have also recently sampled this species in the Island of Santa Maria. This seems to be a recent introduction in Azores, being still rare in Terceira, but already widespread in Santa Maria.

Future perspectives

Importantly, the EU Biodiversity Strategy 2020 lists, as a priority, the mapping and assessment of the state of biodiversity, ecosystems and their services in all EU member states (Maes et al. 2016). Azores are part of Europe's nine Outermost Regions (ORs) for which there is a general lack of ES mapping and assessment as compared with mainland Europe (Sieber et al. 2018).

By focusing on Azorean Island agroecosystems (e.g. maize fields, vineyards, citrus orchards) and having the current baseline monitoring data, we aim to develop in the near future a multifaceted approach to gain more insight to evaluate the relative importance of native and exotic arthropod organisms as ecosystem services (ES)/ ecosystem disservices (ED) providers. In this way, it will be possible to understand the ecosystem processes and functions and the goods and services arthropods provide for improving the resilience of Azorean agro-ecosystems, as well as human well-being.

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Author contributions

PAVB, PM, DHL, AOS, AG, FR, GL and MF contributed to study conceptualisation. PAVB, LLL, RN, PM, DHL and MF performed the fieldwork. PAVB, RN and RC performed the species sorting and identification. PAVB, EP and LLL contributed to dataset preparation and data analysis. All authors contributed to manuscript writing.

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Supplementary material

Suppl. material 1: Complete list of sampled species and mophospecies doi

Authors: Paulo A. V. Borges
Data type: Occurrences
Brief description: Detailed complete list of sampled species and mophospecies with indication of the morphospecies codes in the column (Identification Remarks)
Download file (24.93 kb)